



DRAFT
Missouri River Recovery
Management Plan and
Environmental Impact Statement

VOLUME 1
December 2016



Intentionally Left Blank

MISSOURI RIVER RECOVERY MANAGEMENT PLAN AND ENVIRONMENTAL IMPACT STATEMENT

Mark Harberg, Project Manager
United States Army Corps of Engineers, Omaha District
1616 Capitol Avenue
Omaha, Nebraska 68102
email: cenwo-planning@usace.army.mil.

Abstract

On January 18, 2013, the United States Army Corps of Engineers (USACE) issued a Notice of Intent to prepare an environmental impact statement for the Missouri River Recovery Management Plan (MRRMP-EIS). The MRRMP-EIS is a joint effort between the Omaha and Kansas City Districts of the USACE, in cooperation with the United States Fish and Wildlife Service. The purpose of the MRRMP-EIS is to develop a suite of actions that meets Endangered Species Act (ESA) responsibilities for the piping plover, the interior least tern, and the pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of the Water Resources Development Act (WRDA) 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007, although alternatives formulation was not limited to these authorities.

The document is divided into six chapters. "Chapter 1.0: Purpose, Need and Problem Definition" describes why USACE is taking action at this time and what USACE intends to achieve. "Chapter 2.0: Alternatives" presents the approach to developing and screening alternatives and six alternatives examined in-detail—five action alternatives and the no-action alternative. The alternatives evaluated provide different approaches to addressing the need for the EIS and meeting species objectives. "Chapter 3.0: Affected Environment and Environmental Consequences" describes the existing conditions of 22 resource topics including physical, natural, and human consideration resources and the projected impacts to those resources from the six alternatives evaluated. "Chapter 4.0: Implementation of Preferred Alternatives under Adaptive Management" describes how adaptive management would be used to adjust the initial suite of actions over time based on new understanding of biological responses. The accompanying Draft Science and Adaptive Management Plan details the full adaptive management plan for the MRRP. "Chapter 5.0: Tribal, Agency, and Public Involvement" describes the public involvement process and the Tribal and state consultation processes that contributed to the development of the Draft MRRMP-EIS. Finally, "Chapter 6.0: Compliance with Other Environmental Laws" describes how the USACE has complied with or will comply with other laws prior to implementing any decision.

The six alternatives considered in this Draft MRRMP-EIS include the following: Alternative 1—no action alternative, as required by the National Environmental Policy Act and based on the current system operation and current implementation of the Missouri River Recovery Program; Alternative 2—USFWS 2003 BiOp Projected Actions; Alternative 3—Mechanical Construction Only; Alternative 4—Spring Emergent Sandbar Habitat (ESH) Creating Release; Alternative 5—Fall ESH Habitat Creating Release; and Alternative 6—Pallid Sturgeon Spawning Cue.

The Draft MRRMP-EIS evaluates the direct, indirect, and cumulative impacts of the six alternatives. Based on these projected impacts, the ability to meet the plan's purpose, need, and species objectives, and other decision criteria, USACE has identified Alternative 3—Mechanical Construction Only as its preferred alternative. Importantly, Alternative 3 would be implemented under the science and adaptive management framework summarized in Chapter 4.0 of the Draft MRRMP-EIS and detailed within the Draft Science and Adaptive Management Plan.

Intentionally Left Blank

**Missouri River Recovery Management Plan
and Environmental Impact Statement**

Volume 1

Intentionally Left Blank

EXECUTIVE SUMMARY

Introduction

The Kansas City and Omaha Districts of the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS or Management Plan). This document is a programmatic assessment of

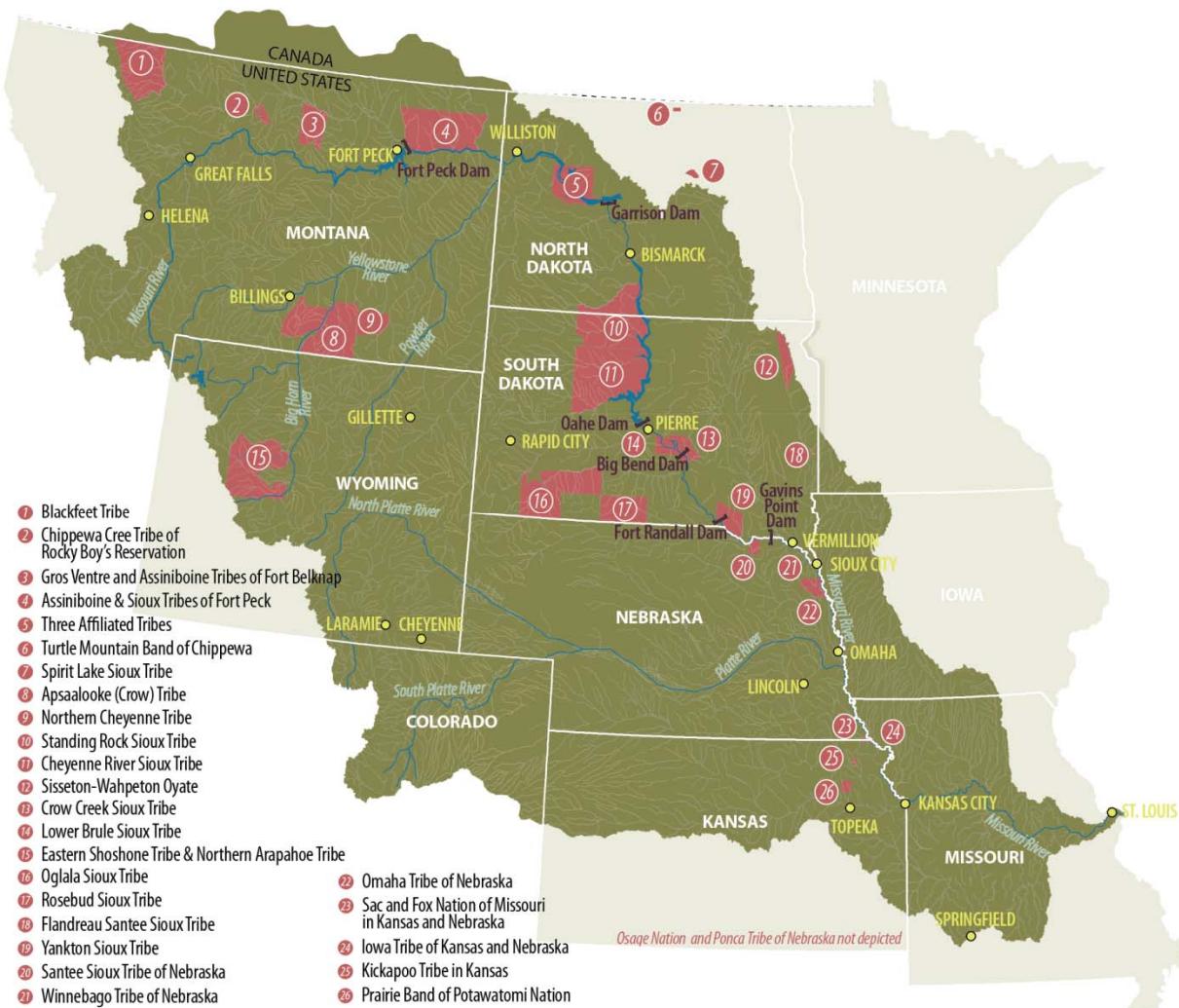
1. major federal actions necessary to avoid a finding of jeopardy to the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sterna antillarum athalassos*), and the Northern Great Plains piping plover (*Charadrius melodus*) caused by operation of the Missouri River Mainstem and Kansas River Reservoir System and operation and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP) in accordance with the Endangered Species Act (ESA) of 1973, as amended; and
2. the Missouri River BSNP fish and wildlife mitigation plan described in the 2003 Record of Decision (ROD) and authorized by the Water Resources Development Act (WRDA) of 1986, 1999, and 2007.

Background

The Missouri River flows for 2,341 miles from Three Forks, Montana at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains through the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. It is the longest river in the United States. USACE operates six dams and reservoirs with a capacity to store 72.4 million acre-feet (MAF) of water, the largest reservoir system in North America. USACE operates the System to serve eight congressionally authorized project purposes of flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife. Runoff from the upper Missouri River Basin is stored in reservoirs behind the mainstem dams: Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point. Released water from the lowest dam in the System, Gavins Point Dam, flows down the Lower River from Sioux City, Iowa to St. Louis, Missouri (shown in the figure below). USACE operates the System in accordance with the policies and procedures prescribed in the *Missouri River Mainstem Reservoir System Master Water Control Manual* (Master Manual).

USACE also constructed and maintains the Missouri River Bank Stabilization and Navigation Project (BSNP). The BSNP consists mainly of rock structures and revetments along the outsides of bends and dikes along the insides of bends to force the river into a channel alignment that is self-maintaining.

In order to maintain System benefits, the construction, operation, and maintenance of the System and the BSNP have resulted in hydrologic alterations to the Missouri River ecosystem including changes to the natural seasonal pattern of river flow and sediment transport. Alteration and loss of aquatic and terrestrial habitat have also occurred.



Missouri River Mainstem Reservoir System

The pallid sturgeon, interior least tern, and Northern Great Plains piping plover occupy the Missouri River. The pallid sturgeon is a large, long-lived benthic (i.e., bottom-dwelling) fish that inhabits the turbid, fast-flowing rivers of the Missouri and Mississippi River basins. The interior least tern and piping plover are migratory birds that occur on the Missouri River during the breeding season and nest on emergent sandbar habitat. Declines in the populations of these species led to the USFWS listing of the interior least tern as endangered in 1985, the Northern Great Plains piping plover as threatened in 1985, and the pallid sturgeon as endangered in 1990 under the ESA.

USACE has a responsibility under the ESA to take actions to ensure that the operation of the Missouri River is not likely to jeopardize the continued existence of threatened and endangered

Jeopardy: Occurs when an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Recovery: An improvement in the status of listed species to the point at which listing is no longer appropriate under the ESA.

species or adversely modify critical habitat. Beginning in 1989, in compliance with Section 7 of the ESA, USFWS and USACE conducted informal and formal consultations on management actions that were being proposed as part of the Master Manual update. In the 2000 BiOp, USFWS concluded that operating the System, operating and maintaining the BSNP, and operating the Kansas River Reservoir System, as proposed, would jeopardize the continued existence of the federally listed pallid sturgeon, interior least tern, and piping plover. The BiOp, which applies to the portion of the Missouri River from Fort Peck, Montana, to St. Louis, Missouri, identified a Reasonable and Prudent Alternative (RPA) to avoid a finding of jeopardy consisting of several actions to be taken by USACE. In 2003, USACE reinitiated formal consultation with USFWS and provided a Biological Assessment with new proposed actions in November 2003. The 2003 Biological Assessment was provided because of new information concerning the effects of USACE actions that had previously not been considered and because USACE believed certain components of the RPA did not comport with the regulatory criteria for an RPA (USACE 2003a). Additionally, critical habitat had been designated for the piping plover, new information on the mortality of interior least terns and piping plovers was available, and an updated hydrology and hydraulics analysis indicated that some flow modifications could erode more emergent sandbar habitat than they would create. In 2003, USFWS provided a determination that the new USACE proposed action would avoid jeopardizing the continued existence of the two listed bird species, but continued to appreciably reduce the likelihood of both survival and recovery of the pallid sturgeon, thus jeopardizing its continued existence in the wild (USFWS 2003). USFWS then amended the 2000 BiOp to remove the flow modifications previously provided in the RPA, and concluded that mechanical and artificial creation for replacement of emergent sandbar habitat were acceptable means to avoid a finding of jeopardy to the interior least tern and piping plover. The 2003 Amended BiOp retained the majority of RPA actions described in the 2000 BiOp; however, it added new RPA elements to the flow enhancement action. Fifteen new RPMs were provided in the 2003 amended BiOp replacing the RPMs in the 2000 BiOp to minimize take of interior least terns and piping plovers.

Missouri River Recovery Program and the Missouri River Recovery Implementation Committee

The Missouri River Recovery Program (MRRP) was established by USACE in 2005. It is the umbrella program that coordinates the USACE efforts in the following:

- Compliance with the USFWS 2003 Amended BiOp on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the BSNP, and Operation of the Kansas River Reservoir System;
- Acquiring and developing lands to mitigate for lost habitats as authorized in Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (collectively known as the BSNP Fish and Wildlife Mitigation Project); and
- Implementation of WRDA 2007 including the Missouri River Recovery Implementation Committee (MRRIC) and Section 3176, which allowed USACE to use recovery and mitigation funds in the upper basin states of Montana, Nebraska, North Dakota, and South Dakota.

The MRRIC makes recommendations and provides guidance to federal agencies on the existing MRRP. The MRRIC is composed of over 70 members representing various interests, Tribes, states, and agencies from within the Missouri River basin.

In 2011, the MRRIC and USACE established the Independent Science Advisory Panel (ISAP). This panel is charged with independent science support and technical oversight by providing advice on specific topics. The first topic charged to ISAP was Missouri River spring pulse management. The Final ISAP report, published in November 2011, found the spring pulse management action as implemented was not effective at achieving pallid sturgeon objectives and called for a more formal adaptive management plan. It also called for an analysis of the effects of USACE management

actions on pallid sturgeon including further examination of various flow management actions and their relationship to habitat creation. Based on this report, the MRRIC recommended seven actions to USACE and USFWS in August 2012:

1. An effects analysis should be developed that incorporates new knowledge accrued since the 2003 Amended BiOp. As part of this analysis:
 - The effects of the Missouri and Kansas River operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species;
 - The quantitative effects of potential management actions on the listed species should be documented to the extent possible; and
 - These potential management actions should be incorporated into the conceptual ecological models (CEMs).
2. CEMs should be developed for each of the three listed species and these models should articulate the effects of stressors and mitigative actions (including, but not limited to, flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and adaptive management plans should be evaluated as guidance in development of the CEMs and adaptive management strategy.
4. An overarching adaptive management strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction. This strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
5. Monitoring programs along the Missouri River should be reviewed to determine whether hypothesized outcomes are occurring and the extent to which the outcomes are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.

Effects Analysis

USACE initiated an effects analysis subsequent to receiving the MRRIC recommended actions. The concept of an effects analysis is rooted in the requirement within the ESA to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat, using the best available science. Completion of an effects analysis is preceded by problem formulation, which includes defining the proposed action, identifying the area affected, and developing conceptual models with written descriptions and visual representations of the physical and biological relationships between actions and species responses (Murphy and Weiland 2011). The effects analysis results and products informed the development of the MRRMP-EIS alternatives and the comprehensive adaptive management approach recommended by the ISAP.

Need for the Plan

“Need” includes the identification and description of the conditions that require action. A description of the need for an action also serves to provide evidence that action is warranted. Alteration of the ecosystem and loss of aquatic and terrestrial habitats due to USACE operation of the System and BSNP have contributed to the ESA-listing of the pallid sturgeon, piping plover, and interior least tern, species that inhabit the Missouri River. A substantial amount of new knowledge about the species, their habitats, and management opportunities has been developed since the 2003 Amended BiOp for the three listed species was published. As discussed previously, in 2011 the ISAP recommended developing a new adaptive management plan that would anticipate implementation of combined flow management actions and mechanical habitat construction. Under the ISAP recommendations, this new plan would be used to guide future management actions, monitoring, research, and assessment. The ISAP also recommended basing the AM plan on an effects analysis, which would precede the development of the plan and incorporate new knowledge about the species accrued since the 2003 Amended BiOp (Doyle et al. 2011). Since the 2011 ISAP recommendation, effects analyses have been conducted for pallid sturgeon (Jacobson et al. 2016) interior least tern and piping plover (Buenau et al., in prep.), and associated habitat analyses (Fischchenich et al., in prep.). The effects analysis synthesized and assessed new scientific information since the 2003 Amended BiOp. The emergence of this new information created a need for its evaluation and integration into USACE management actions on the Missouri River for the listed species and the associated adaptive management plan.

The following sections describe the need for the proposed action relative to each listed species.

- **Pallid Sturgeon:** There is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis that provides an adaptive framework to address the uncertainty associated with potential pallid sturgeon limiting factors. Development of a management plan which balances the substantial uncertainty regarding the beneficial effect of actions with the need to implement actions for a meaningful biological response is difficult and requires development of a robust adaptive management plan.
- **Interior Least Tern and Piping Plover:** As with the pallid sturgeon, there is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis that provides an adaptive framework to address the uncertainty associated with piping plover and interior least tern management.

Purpose of the Plan

The purpose of this MRRMP-EIS is to develop a suite of actions that meets ESA responsibilities for the piping plover, the interior least tern, and the pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities.

Plan Objectives

USFWS provided fundamental objectives, sub-objectives, targets, and metrics for each of the three listed species pursuant to their responsibilities for administering the ESA, and special expertise as a cooperating agency on this MRRMP-EIS. These objectives were informed by the effects analysis products. Achieving these objectives would meet the purpose and fulfill the need of the plan.

Pallid Sturgeon Fundamental Objective: Avoid jeopardizing the continued existence of the pallid sturgeon from the USACE actions on the Missouri River.

The following sub-objectives must be attained to ultimately achieve the stated “fundamental objective.” The intent of the sub-objectives is to provide direction in the short term, provide objectives meaningful for adaptive management, and focus efforts on the desired short-term outcomes while working toward the fundamental objective.

Pallid Sub-Objective 1: Increase pallid sturgeon recruitment to age 1.

Pallid Sub-Objective 2: Maintain or increase numbers of pallid sturgeon of age 2 and older until sufficient and sustained natural recruitment occurs.

Piping Plover Fundamental Objective: Avoid jeopardizing the continued existence of the piping plover due to USACE actions on the Missouri River.

Piping Plover Sub-Objective 1 (Distribution): Maintain a geographic distribution of plovers in the river and reservoirs in which they currently occur in both the Northern and Southern River Regions.

Piping Plover Sub-Objective 2 (Population): Maintain a population of Missouri River piping plovers with a modeled 95% probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.

Piping Plover Sub-Objective 3 (Population Dynamics): Maintain a stable or increasing long-term trend in population size in both regions.

Piping Plover Sub-Objective 4 (Reproduction): Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

Interior Least Tern Fundamental Objective: Avoid jeopardizing the continued existence of the endangered interior least tern due to USACE actions on the Missouri River.

For purposes of this MRRMP-EIS, it is assumed that achieving the stated objectives for the piping plover would also achieve the fundamental objective for the interior least tern.

Scope of the Plan and Environmental Impact Statement

This EIS assesses the programmatic effects of alternatives for implementing the MRRP which include actions necessary to avoid a finding of jeopardy to the federally listed species and associated actions which comply with the BSNP mitigation plan during the implementation timeframe for this EIS.

This EIS provides the necessary information for the decision maker to fully evaluate a range of alternatives to best meet the purpose and need of the MRRMP. It fully addresses the potential impacts of alternatives as required under the NEPA of 1969, as amended (42 U.S. Code (USC) 4321 et seq.); the President’s Council on Environmental Quality (CEQ) Regulations (40 CFR 1500 – 1508); and USACE ER 200-2-2 (33 CFR 230). This plan will be reviewed on a regular basis to ensure compliance with applicable laws and regulations, and that circumstances have not changed that would impact the analysis and conclusions reached in the document.

Geographic, Temporal, and Substantive Scope

To facilitate plan development, an implementation timeframe of 15 years was chosen for this planning process and EIS. This is a reasonable timeframe for identification of actions which, based on the current state of the science, may provide meaningful biological responses while recognizing the potential, based on adaptive management, that substantive changes to the suite of actions identified in this MRRMP-EIS may be necessary in 15 years. However, effects to resources were based on an 82-year hydrologic period of record (POR) in order to provide an indication of the potential range of effects under the variable hydrologic conditions occurring in the Missouri River basin. The geographic scope of the federal action includes the Missouri River within its meander belt from Fort Peck Dam in Montana to its confluence with the Mississippi River near St. Louis, Missouri, and the Yellowstone River from Intake Dam at Intake, Montana to the confluence with the Missouri River.

Alternatives

NEPA requires federal agencies to evaluate and consider a range of reasonable alternatives that address the purpose of and need for action. Alternatives under consideration must include a “No Action” alternative in accordance with CEQ regulations (40 CFR 1502.14). As described in CEQ *Forty Most Asked Questions Concerning CEQ’s NEPA Regulations* (Question 3), “No Action” is best defined as “no change” from current management direction or level of management intensity in situations that involve updating management plans or ongoing programs. For this plan, the No Action alternative does not mean taking no action at all, it is a continuation of the actions currently being used to comply with the 2003 Amended BiOp (USFWS 2003). Differences between alternatives are shown by comparing the impacts of the No Action alternative and the action alternatives.

An interdisciplinary planning team made up of experts from multiple federal agencies in collaboration with basin stakeholders and Tribes participated in alternatives development. Alternatives were developed in accordance with the CEQ’s NEPA implementing regulations (40 CFR 1500-1508). The goal was to formulate a set of reasonable alternatives to meet the species objectives and clearly articulate the effects of those alternatives to provide necessary information to decision makers, stakeholders, Tribes and the public. The team used an iterative development process to identify and screen management actions.

Plan Alternatives Carried Forward for Detailed Evaluation

Six plan alternatives (the No Action alternative and five action alternatives) were carried forward for detailed evaluation. The names of each alternative correspond to the concept or feature that distinguishes them from all other alternatives. Some of the alternatives share management actions.

Actions Common to All Plan Alternatives

The following management actions would be implemented as part of all plan alternatives carried forward for detailed evaluation in this draft MRRMP-EIS including the No Action alternative.

- **Mechanical Emergent Sandbar Habitat (ESH) Construction for Piping Plovers and Least Terns:** All alternatives include mechanical ESH construction as a management action; however, the amounts of ESH that would be constructed mechanically vary by alternative and those differences are described in the respective section for each alternative. Mechanical construction amounts vary because this management action would be used to construct enough ESH to meet bird habitat targets after accounting for the amount of ESH created by a flow release in several alternatives. Therefore, because the amount of ESH

created by a flow release varies by alternative, so does the amount of mechanical ESH construction needed to achieve targets.

- **Vegetation Management, Predator Management, and Human Restriction Measures to benefit Piping Plovers and Least Terns:** The primary and preferred method of vegetation control and removal is application of pre- and/or post emergent herbicides to selected sandbars. Additional vegetation control and removal methods include cutting, mulching, disk ing, mowing, raking, and removing vegetation from sandbars. Post-treatment removal using these additional methods may be necessary depending on the height and density of the vegetation on the selected sandbar. Vegetation that is woody with large stems may need post treatment breakdown and removal.

Predator management actions include the lethal or non-lethal removal of predators. Targeted species such as raccoons, coyotes, mink, and great horned owls are either lethally or non-lethally removed depending on the species and situation. Typically state and federal wildlife control specialists are responsible for the non-lethal and lethal removal activities of targeted species. Indirect management actions may include caging, fencing, or hazing which dissuades predators from breeding sites and are deployed when predation activities are present but not severe. Nests at risk of predation are primarily protected by placing exclosure cages around them. Exclosure cages can only be used to protect plover nests; terns frequently fly to and from their nests and are less likely to walk through the enclosure.

Human restriction measures taken to reduce disturbance to the birds include posting signs and placing barricades to restrict access to breeding areas and outreach efforts.

- **Flow Management to Reduce Take of Piping Plovers and Least Terns:** This action involves the adjustment of reservoir releases during the nesting season to reduce take of nests, eggs, and/or chicks by rising water levels. It is referred to as Steady Release-Flow to Target and is a current management practice that would continue under each of the alternatives.
- **Piping Plover and Least Tern Monitoring and Research:** USACE conducts annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River mainstem. The monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take. USACE also performs habitat monitoring. Monitoring results are used to determine the effectiveness of management actions for terns and plovers. In addition, USACE funds focused research projects on various aspects of least tern and piping plover demographics and habitat use.
- **Pallid Sturgeon Propagation and Augmentation:** The authority and responsibility for hatchery management lie with the USFWS for those facilities operated by the USFWS; states are responsible for the operation of their hatcheries. USACE support of pallid sturgeon propagation and augmentation efforts would continue at current levels under all plan alternatives.
- **Pallid Sturgeon Population Assessment Project (PSPAP):** The Pallid Sturgeon Population Assessment Project (PSPAP) has been the primary fish monitoring element for the BiOp and the MRRP and would continue in some form under all plan alternatives. Data collected through the PSPAP are used to provide long-term assessment of fish metrics.
- **Monitoring and Evaluation of Pallid Sturgeon Recruitment:** Under all plan alternatives, USACE would conduct the monitoring and assessment complimentary of that for which the Bureau of Reclamation has responsibility to determine if modifications for fish passage at Intake Diversion Dam are meeting pallid sturgeon objectives. The Bureau of Reclamation is responsible for monitoring the success of fish passage at Intake following implementation of fish passage measures. USACE would be responsible for ensuring that MRRP monitoring

and assessment can determine if successful fish passage at Intake is contributing to the upper river pallid sturgeon population.

- **Lower River Pallid Sturgeon Early Life Stage Habitat Construction:** All plan alternatives include channel reconfiguration for the creation of early life stage pallid sturgeon habitat; however, the amounts and types of habitat that would be created vary by alternative and those differences are described in the respective section for each alternative. This action includes the physical manipulation of the river bed or bank to create or improve areas for provision of specific pallid sturgeon habitats thought to be limiting. Examples include adjustments to navigation training or bank stabilization structures, channel widening (i.e., top-width widening), floodplain modifications or other adjustments to channel geometry, placement of structures to encourage development of needed habitat or habitat complexity, chute development, or adjustments to existing chutes.
- **Habitat Development and Land Management on MRRP Lands:** All plan alternatives include habitat development and land management on MRRP lands; however, the amount of land acquisition varies by alternative as would the magnitude of this action. The land requirements for implementation of habitat creation can occur (1) on existing public lands if the state or federal agency owning the property is willing to cooperate with USACE on the project; or (2) on land acquired in fee title from willing sellers.

Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under the No Action alternative, the MRRP would continue to be implemented as it is currently. In addition to the description of actions common to all plan alternatives the USACE would implement the following under Alternative 1:

- **Mechanical ESH Construction:** USACE would mechanically construct ESH annually at an average rate of 107 acres per year across the Garrison and Gavins Point reaches.
- **Early Life Stage Habitat Construction for Pallid Sturgeon:** Under the No Action alternative, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the shallow water habitat (SWH) program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under the No Action alternative, the USACE would achieve the low end of this acreage target (i.e., 20 acres per river mile between Ponca, Nebraska, and the mouth).
- **Spawning Cue Release for Pallid Sturgeon:** For purposes of modeling the No Action alternative, USACE assumed implementation of the plenary spring pulse as described in the Master Manual (USACE 2006) would occur. This action would include a March and May Spring Pulse from Gavins Point Dam.
- **Monitoring, Research and Adaptive Management:** In addition to the PSPAP described under actions common to all plan alternatives it was also assumed the other current USACE monitoring and research programs for pallid sturgeon would continue including the Habitat Assessment and Monitoring Program (HAMP) and focused pallid sturgeon research. USACE would also continue to implement the adaptive management approach that has been in place since 2009. It consists of two primary components: the Adaptive Management Plan for ESH (USACE 2011) and the adaptive management strategy developed for SWH creation (USACE 2012c).

Alternative 2 – U.S. Fish and Wildlife Service 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA (USFWS 2003). Whereas the No Action

alternative only includes the continuation of management actions the USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. In addition to the description of actions common to all plan alternatives the USACE would implement the following under Alternative 2:

- **Mechanical ESH Construction:** USACE would mechanically construct an average of 3,546 acres of ESH annually across the Garrison, Fort Randall, Gavins Point, and Lewis and Clark Lake reaches.
- **Spring Habitat-Forming Flow Release:** A spring reservoir release for the purposes of ESH is not included in Alternative 2; however the timing and magnitude of the pallid spring flow release would provide ESH creating benefits which were accounted for in the habitat modeling.
- **Lowered Nesting Season Flows:** The low summer flow described for pallid sturgeon would also serve as a lowered nesting season flow for the benefit of least terns and piping plovers under Alternative 2.
- **Early Life Stage Habitat Construction for Pallid Sturgeon:** Under Alternative 2, the USACE would achieve the high end of the 2003 Amended BiOp acreage target (i.e., 30 acres per river mile between Ponca, Nebraska, and the mouth).
- **Spring Pallid Sturgeon Flow Release:** USFWS determined in the 2003 Amended BiOp that restoration of a normalized river hydrograph below Gavins Point Dam was necessary to avoid jeopardizing the continued existence of the pallid sturgeon. Several biologically relevant features were identified for a flow action below Gavins Point Dam including (1) flows to cue spawning that are sufficiently high for an adequate duration; and (2) flows that provide for connection of low-lying lands adjacent to the channel. The spring pallid sturgeon flow release from Gavins Point Dam would be bimodal (i.e., consisting of two separate flow pulses) and would be implemented in every year if conditions are met.
- **Low Summer Flow:** The USFWS 2003 Amended BiOp also called for modification of System operations to allow for flows that are sufficiently low to provide for SWH as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon. Alternative 2 includes a low summer flow that would be implemented to meet those purposes.
- **Floodplain Connectivity:** The USACE coordinated with the USFWS during alternatives development to identify criteria for clarification of the floodplain connectivity management action stated in the USFWS 2003 Amended BiOp. The criteria submitted to the USACE from the USFWS for Alternative 2 stated that this management action should maximize floodplain habitat by ensuring that 77,410 acres of connected floodplain are inundated at a 20 percent annual chance exceedance.
- **Monitoring, Research and Adaptive Management:** Monitoring and research efforts under Alternative 2 would be the same as described for Alternative 1. The adaptive management approach for Alternative 2 was assumed to be similar to the adaptive management approach that USACE has been implementing since 2009 and described for Alternative 1. The adaptive management approach for Alternative 2 would be the same as for Alternative 1 but would be modified to address specific alterations in proposed management actions as described by the USFWS in a November 5, 2015, Planning Aid Letter to the USACE.

Alternative 3 – Mechanical Construction Only

Under Alternative 3, current System operations as described in the Master Manual would continue except the spring plenary pulse and reservoir unbalancing would not be implemented. In addition to

the description of actions common to all plan alternatives the USACE would implement the following under Alternative 3:

- **Adaptive Management:** Under Alternative 3, the USACE would follow the Science and Adaptive Management Plan (AM Plan) that was developed based on the results of the effects analysis. The AM Plan is a companion document to the MRRMP-EIS. The AM Plan identifies the process and criteria to implement the initial management actions, assess hypotheses, and introduce new management actions should they become necessary.
- **Level 1 and 2 Studies:** As part of the AM Plan, USACE would implement Level 1 and 2 studies for better understanding of limiting factors associated with pallid sturgeon. Level 1 studies are research focused and do not change river conditions (laboratory studies or field studies under ambient conditions). Level 2 studies would focus on in-river testing of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response. The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.
- **Spawning Habitat Construction:** Under Alternative 3, USACE would construct up to three spawning habitat sites and monitor the effectiveness of this action in terms of the relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators.
- **Mechanical ESH Construction:** Under Alternative 3, the USACE would only create ESH habitat through mechanical means at an average rate of 391 acres per year, in years where construction is needed, across the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH.
- **Early Life Stage Habitat Construction:** Under Alternative 3, construction of habitat to support early life stage requirements of pallid sturgeon would occur following the IRC (interception and rearing complex) concept. During the first 6–7 years of implementation, 12 site pairs (experimental IRC site and control site) would be implemented in an experimental design to evaluate whether young fish are intercepted and retained. In addition to the IRC experiment, existing SWH sites would be evaluated to determine if they are presently functioning as IRC habitat. Those that can be most efficiently modified to provide IRC habitat would be refurbished.

Alternative 4 – Spring ESH Creating Release

Alternative 4 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The spring ESH-creating flow release is the management action unique to Alternative 4.

- **Spring ESH Creating Release:** Alternative 4 would include a high spring release designed to create ESH for piping plovers and least terns. In any year, the implementation of this release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded.

- **Mechanical ESH Construction:** The average amount of ESH that would need to be constructed under Alternative 4 is less than Alternative 3 because of ESH created by the spring release. Alternative 4 would include the construction of an average of 240 acres annually across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Alternative 5 – Fall ESH Creating Release

Alternative 5 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The fall ESH-creating flow release is the management action unique to Alternative 5.

- **Fall ESH Creating Release:** Alternative 5 would include a high fall release designed to create ESH for piping plovers and least terns. In any year, the implementation of this release would occur on October 17 if System storage is at 54.5 MAF or greater, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow limits are not exceeded.
- **Mechanical ESH Construction:** The average amount of ESH that would need to be constructed under Alternative 5 is less than Alternative 3 because of ESH created by the fall release. Alternative 5 would include the construction of an average of 309 acres per year in across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes those actions identified as common to all alternatives and also includes the adaptive management approach described for Alternative 3, Level 1 and 2 studies (except one-time spawning cue test release), spawning habitat construction, and early life stage pallid sturgeon habitat as specified under Alternative 3. The spring pallid sturgeon spawning cue flow release is the management action unique to Alternative 6.

- **Spring Pallid Sturgeon Spawning Cue Flow Release:** Alternative 6 would attempt a spawning cue release every 3 years consisting of a bimodal pulse in March and May. These spawning cue releases would not be started or would be terminated whenever downstream flow limits are reached.
- **Mechanical ESH Construction:** The average amount of ESH that would need to be constructed under Alternative 6 is less than Alternative 3 because of incidental ESH created by the spring spawning cue release. Alternative 6 would include the construction of an average of 304 acres per year across the Garrison, Fort Randall, and Gavins Point reaches in years where construction is needed.

Summary of Key Uses / Resources and Impacts Assessment Methods

The management actions in this MRRMP-EIS that could potentially affect resources are generally construction-type activities or changes in reservoir system releases. In addition to understanding the temporary or short-term impacts that could result from these actions, it is prudent to consider long-term impacts that could occur in conjunction with the substantial hydrologic variability that exists in the Missouri River basin. Therefore, the discussion of potential impacts for many resources includes an analysis based on the results of modeling the alternatives over an 82-year (1931–2012) hydrologic POR for the Missouri River basin.

The USACE HEC River Analysis System (HEC-RAS) model uses the outputs of the Reservoir System Simulation (ResSim) model to calculate river flow and water surface elevations of the

Missouri River that were routed down the Missouri River mainstem, through thousands of river cross sections and hundreds of miles to the mouth at St. Louis. These cross sections were based on 2012 channel geometry and revised to reflect extent of early life stage pallid habitat for each alternative. It was assumed this revised geometry was in place every year of the POR. The geometry does not include any forecast of the extent of channel aggradation or degradation that might occur in the future. It is important to compare the effects of the alternatives based on conditions that are relevant to the near-term (15-year) implementation timeframe of this planning process. Therefore, speculation on the exact extent of long-term channel aggradation or degradation that might occur and which is not associated with the management actions included in the alternatives was not attempted.

One might expect the modeling output for the No Action alternative (which reflects existing operation of the system and current implementation of MRRP actions) from either ResSim or HEC-RAS to match actual observed conditions. However, this is not the case. The following is a description of the primary reasons why the modeled outputs for the No Action alternative do not match what actually occurred in the past.

- **Operational Differences:** The No Action alternative is a simulation of how the system is currently operated, including current MRRP actions, but does not and cannot take into account the numerous minor adjustments to basic rules that the USACE actually makes to reasonably address critical short-term situations (e.g., increase releases for water supply, reducing releases for ice jams, etc.) In addition to the short-term changes, the basic operational rules have changed throughout the POR. For example, drought conservation criteria have been changed as recently as 2004 and were included in simulating operation for the entire POR.
- **River Geometry Changes:** The bed profile of the Missouri River is constantly changing: eroding (“degrading”) in some places and accumulating (“aggrading”) in others. Long-term stage trends not associated with the management actions included in the alternatives are known to be occurring in many locations under existing operation. For the purposes of comparing the effects of the alternatives, the models were developed with the best available survey data and calibrated to the 2012 condition. This geometry was assumed for each year of the POR.
- **Depletions:** All historic POR runoff levels were adjusted for consumptive water use to the current level of depletions. Depletions consist of water use by irrigation, municipal, evaporation, etc. This assumes the current 2012 level of water use projected from 1931 including evaporation from the mainstem reservoirs.

Therefore, modeling results of the No Action alternative do not reflect actual past or future conditions but serve as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.

The POR is characterized by substantial variability in hydrologic conditions, which includes periods of drought (e.g., 1930s) and high runoff (e.g., 1997, 2011). This hydrologic variability results in substantial changes to resources and uses over the POR with all the alternatives, including the No Action alternative. These changes are not associated with the species management actions included in the alternatives, and therefore the following impact analyses are focused on comparing the difference the action alternatives have on resources compared to the No Action alternative. The “rules” governing system operation during periods of drought and high runoff for the action alternatives are generally the same as current system operation under the No Action alternative. Therefore, the effects of the action alternatives on reservoir elevations and releases are relatively small compared to the variation caused by the extreme hydrologic events in the POR.

Relative differences among the alternatives are important to understand. The MRRMP-EIS environmental consequences chapter presents the relative impacts of each alternative on each specific resource in order to focus on this perspective. Summary descriptions of each resource topic

are presented below followed by a summary table of the environmental consequences of the different alternatives.

River Infrastructure and Hydrologic Processes

The flow of the mainstem Missouri River is influenced by precipitation and seasonal snowmelt that occurs throughout the basin, as well as flow regulation from mainstem dams. Total annual runoff from the Missouri River varies considerably from year to year because of large variations in precipitation. The magnitude, frequency, timing, duration, and rates of change of river flows affect the geomorphology, chemistry, and biological processes in the Missouri River and groundwater elevation is a key factor in the composition and spatial distribution of vegetation communities and their associated fauna across the floodplain. The operation of the System is guided by the Master Manual (USACE 2006a). This Master Manual records the basic water control plan and objectives for the integrated operation of the mainstem reservoirs. The reservoir stage and flow releases vary throughout the year as a result of reservoir operations that follow the Master Manual.

The analysis of impacts of the alternatives to river infrastructure and hydrologic processes focuses on the impacts to hydrology, geomorphology, and infrastructure in the river, as well as groundwater along the river. Primary geomorphological processes that are relevant for the proposed management actions consist of degradation and bank erosion, reservoir sediment deposition and aggradation, reservoir shoreline erosion, and ice dynamics.

Pallid Sturgeon

The pallid sturgeon was listed as endangered under the ESA on September 6, 1990 (55 FR 36641–36647). A recent revision of the species recovery plan notes that the species status has improved and is currently stable as a result of artificial propagation and stocking efforts (USFWS 2014). If stocking were to cease, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014). USFWS (2014) states that pallid sturgeon will be considered for reclassification from endangered to threatened when the listing/recovery factor criteria are sufficiently addressed such that a self-sustaining, genetically diverse population of 5,000 adult pallid sturgeon is realized and maintained within each management unit for two generations (20–30 years). The potential impacts of each alternative on the Missouri River pallid sturgeon population were assessed with special emphasis on the potential to increase survival of age-0 pallid sturgeon and increase recruitment.

Piping Plover and Interior Least Tern

The Northern Great Plains piping plover was listed as threatened on January 10, 1986, under provisions of the ESA (USFWS 1985). The breeding population of the piping plover extends from Nebraska north along the Missouri River through South Dakota, North Dakota, and eastern Montana, and on alkaline lakes along the Missouri River Coteau in North Dakota, Montana, and extending into Canada. Interior least terns were listed as endangered under the ESA in 1985 (USFWS 2013). The breeding population of least terns extends across the interior of the United States along the Mississippi, Missouri, and Rio Grande Rivers and their tributaries. Nesting habitat for both species includes sparsely vegetated river sandbars, sandpits, and reservoir beaches. The USFWS provided objectives, metrics, and targets for the Northern Great Plains piping plover under the MRRMP-EIS with the assumption that managing for sufficient nesting habitat to sustain a Northern Great Plains piping plover population in the Missouri River will also provide sufficient nesting habitat for the interior least tern in the Missouri River (USFWS Planning Aid Letter 2015).

A habitat/population model was used to evaluate the effectiveness of the proposed management actions and alternatives at meeting the objectives for the piping plover and least tern. ESH was calculated for each alternative along with the following metrics:

- Number of adults

- Number of fledglings
- Fledge rate
- Population growth rate
- Extinction probability (throughout the geographic scope, north region, and south region)

Fish and Wildlife Habitat

The Missouri River and its floodplain have historically consisted of a multitude of aquatic and terrestrial habitat types that sustained rich assemblages of fish and wildlife species. These assemblages include species that live year-round within the river and its floodplain as well as migratory species for which the ecosystem provides vital seasonal habitat (e.g., wintering and breeding), movement corridors, and stopover habitats. Aquatic habitats generally include open water habitats of varying depths (i.e., main channel, secondary channels and chutes, backwaters, floodplain lakes/oxbows). Terrestrial habitats include emergent wetlands, forests, woodlands, grasslands, and shrublands.

The environmental analysis for fish and wildlife focused on changes in terrestrial and aquatic habitat and considered the actions included under each alternative and their impacts to fish and wildlife habitats. Fish and wildlife habitat metrics were modeled within eight study reaches within two larger geographic regions, upstream of Gavins Point Dam to Fort Peck Dam, and downstream from Gavins Point Dam to the confluence with the Mississippi River. The eight smaller study reaches are based on logical divisions within the existing Missouri River (e.g., inter-reservoir reaches) or broad ecological similarities. For the purposes of the model, habitats were broadly categorized into six types (open water, emergent wetland, scrub shrub wetland, riparian woodland/forested wetland, forest, and upland grasslands). The results of the modeling effort only reflect the modeled flow actions, simulated conditions on the river, and associated constraints as defined under the alternatives.

Other Special-Status Species

The MRRMP-EIS assesses the potential impacts to special status species that could occur in the Missouri River and its floodplain in several ways. The EIS provides a general analysis of these species and the potential impacts that could occur from the alternatives being considered, but provides a more specific analysis of five species that were identified based on the potential for impacts that could occur to individuals, populations, or their habitat in areas where management could occur. These species include: the whooping crane, bald eagle, northern long-eared bat, Indiana bat, and western prairie fringed orchid. These species were identified because of their association with habitats in the Missouri River and its floodplain.

Impacts were analyzed based on changes to the habitat associated with the species. The associated habitat was based on the fish and wildlife habitat classes modeled in all study reaches for the POR. Thus, habitat impacts were used as a proxy for impacts to other special-status species.

Water Quality

Water quality and sources of pollution can vary greatly along the length of Missouri River. Humans have modified the Missouri River ecosystem and the resulting changes in land uses, landscape cover types, and their associated nutrient and pollutant sources within the basin influence water quality. The primary sources of pollution, both point and nonpoint sources, along the Missouri River are from urban, agricultural, and industrial land uses. The construction of the dams and impoundments trap suspended sediment and particulates, modify the flow regime of the river, and influence water quality within the reservoirs and the downstream free-flowing reaches. Additionally, the natural river flows, stages, and channel geometry can influence water quality within the river. The

physicochemical water quality parameters identified for assessment include: water temperature, dissolved oxygen, nutrients (nitrogen and phosphorus), sediment and turbidity, and other pollutants including metals/metalloids. These parameters are common water quality assessment metrics and are important for the health of ecological communities and the human uses of the river.

Air Quality

The main causes of air pollution include mobile sources such as automobile emissions along major highways as well as stationary sources such as coal-fired power plants. Other sources include diesel-powered watercraft and various industrial emissions in heavy urbanized areas such as Kansas City, Omaha, and Sioux City (USEPA 2015a). Six designated non-attainment and partial non-attainment areas exist within the lower portion of the river in Pottawattamie County, Iowa and in Missouri in Franklin County, St. Charles County, Jackson County, St. Louis County, and St. Louis City.). Greenhouse gasses are also produced from mobile sources in the project area. These sources include motor vehicles such as trucks and boats utilized for transportation of goods and materials along the Missouri River. Emissions from these vehicles impact regional air quality incrementally through contributions to levels of criteria air pollutants such as carbon monoxide, nitrogen oxide, and volatile organic compounds.

The analysis of impacts to air quality considers the potential for actions to adversely affect air quality through emissions from mobile sources of criteria air pollutants and the contribution to greenhouse gas emissions associated with habitat construction. The impacts from management actions on air quality are common to all alternatives and are not assessed individually for each alternative.

Cultural Resources

The USACE Planning Guidance Notebook (ER 1105-2-100) defines cultural resources in terms of “historic properties” as follows:

An historic property is any prehistoric or historic district, site, building, structure or object included in or eligible for inclusion on the National Register of Historic Places (National Register). Such properties may be significant for their historic, architectural, engineering, archeological, scientific, or other cultural values, and may be of national, regional, state, or local significance. The term includes artifacts, records, and other material remains related to such a property or resource. It may also include sites, locations, or areas valued by Native Americans, Native Hawaiians, and Alaska Natives because of their association with traditional religious or ceremonial beliefs or activities.

USACE has a federal compliance and stewardship responsibility to ensure the preservation and protection of cultural resource sites located on federal lands and for historic properties that may be affected by USACE undertakings, as outlined in the National Historic Preservation Act of 1966 (NHPA) and other pertinent laws, regulations, and policies, as described in Chapter 6 of this EIS. Numerous cultural resource sites have been identified within the Missouri River Basin. Most of these cultural resource sites included represent archaeological sites, historic structures, and/or shipwrecks. Within the upper Missouri River Basin, USACE has inventoried the mainstem reservoir system. State Historic Preservation Offices (SHPOs) within the basin provided inventory data for sites in riverine settings (i.e., downstream of Gavins Point Dam, as well as riverine reaches between the mainstem reservoirs). These inventories of cultural resource sites in riverine settings (developed largely through an accumulation of site-specific compliance with NHPA) are less thorough than the inventories at the reservoirs. The analysis of effects on cultural resources differentiated two categories of cultural resource sites. “Reservoir sites” were sites located on federal fee-owned lands of the six USACE-managed Missouri River mainstem reservoirs. “Riverine sites” were all sites located within the bluff-to-bluff Missouri River floodplain that were not already included in the inventories of USACE-managed Missouri River mainstem reservoir sites. These riverine sites are

located in the Missouri River floodplain south of Gavins Point Dam and on sections of the river between the mainstem reservoirs. Impacts were primarily assessed in relation to modifications of flow and changes in reservoir pool elevations that could change the frequency of risk of erosion and/or vandalism and looting.

Land Use and Ownership

Land ownership within the Missouri River floodplain includes federal, state, and local government lands, Tribal lands, and private lands. Various land uses are present within the Missouri River floodplain, including developed lands, agricultural lands, open water, and other types of use. Developed lands refers to communities, towns, and cities, including commercial, industrial, and residential uses, as well as lands developed to support transportation (highways, roads, bridges, railroads) and other infrastructure. Agriculture is the dominant land use in the floodplain between Gavins Point Dam and the mouth, accounting for between 63 to 72 percent of floodplain land. Federal conservation lands and lands managed for natural habitat and recreation include those administered under the USACE MRRP, U.S. National Park Service lands, and USFWS National Wildlife Refuge lands, among others. There are also state and local government-owned lands, Tribal lands, and private lands managed for conservation and recreation within the floodplain.

The impacts as a result of the federal government acquiring lands from willing sellers to construct pallid sturgeon early life stage habitat are evaluated using two of the four planning accounts: Regional Economic Development (RED) and Other Social Effects (OSE).

Commercial Sand and Gravel Dredging

The volume of commercial sand and gravel dredged on the Missouri River fluctuates annually based on economic conditions (primarily market demand), availability of materials in the river system, and other factors. Approximately 92 percent of commercial sand and gravel from the Missouri River is used by the general public for residential and nonresidential construction (excluding state transportation projects). Commercial sand and gravel production primarily serves 40 counties across the three states of Kansas, Missouri, and Iowa, with a population of nearly 5.1 million.

River flows, the volume of water in the river, and sediment conditions directly affect whether dredges are able to operate and how much sediment is being transported for extraction. Changes in those physical conditions can directly affect access to sand and gravel.

The commercial sand and gravel dredging impacts analysis primarily focuses on determining if changes in river and reservoir conditions could result in an impact to commercial sand and gravel dredging operations. The impacts to commercial sand and gravel dredging are evaluated using the NED, RED, and OSE accounts.

Flood Risk Management and Interior Drainage

A main objective of Mainstem Reservoir System is to regulate the reservoirs to reduce the risk of Missouri River flows from contributing to flood damage in the reaches downstream from dams. Regulation of individual reservoirs is coordinated to reduce flood risk from a particular reservoir. The usual reservoir operation is to store flood inflows, which generally extend from March through July, and to release them during the remainder of the year. Most of these releases are made before December. Winter releases are restricted due to the formation of ice bridges and the associated higher river stages. The objective is to have reservoir levels lowered to the bottom of the annual flood control and multiple use zone by March 1 of each year. Operations during the winter require special consideration because ice bridges restrict channel capacity. Upstream from Gavins Point, releases from Fort Peck, Garrison, Oahe, and Fort Randall Dams are reduced during periods of ice formation until an ice cover is formed, after which releases can be gradually increased. Minimal ice problems exist directly downstream from Big Bend Dam due to its proximity to Lake Francis Case. Operation of the reservoirs for flood risk management must take into account highly variable flows

from numerous tributaries. During any flood season, the existence of upstream tributary storage reduces mainstem flood volumes to some extent. Normally, the natural crest flows on the mainstem reservoirs will also be reduced by the existence of tributary reservoir storage, provided significant runoff contributing to the crest flows originates above the tributary projects.

Levees also play a role in flood risk management along the Missouri River. Federal agricultural levee construction in accordance with the 1941 and 1944 Flood Control Acts began in 1947. Most existing federal levees are in the reach located between Omaha and Kansas City. The levees help to manage flood risk to these localities during the most severe flood events of record. Between Sioux City and the mouth of the Missouri River, local interests have built many miles of levees, consisting of about 500 non-federal levee units through this reach of the river. Most of these levees are inadequate to withstand major floods, but generally protect against floods smaller than a 5 percent annual chance of exceedance event (20-year).

Water surface elevations within the landward side of federal levee areas are affected by the ability to drain interior runoff into the Missouri River. High water can result in poor drainage, higher groundwater, blocked access, and associated damage and inconvenience. Hundreds of individual gravity drainage structures (e.g., culverts with flapgates) and pumping plants exist along levees near the Missouri River. The Kansas City and Omaha USACE districts have survey data on approximately 1,400 individual interior drainage structures across approximately 115 Missouri River levee segments. Most of the interior drainage issues occur along leveed areas below Omaha to the mouth of the Missouri River, with over 70 percent of the flapgates located between Rulo and the mouth of the Missouri River.

Land, property (both urban and rural), infrastructure, and people in the floodplain can be affected by Missouri River flooding. Approximately 167,000 people reside along the Missouri River floodplain with the majority of these populations living in the lower river, including the cities of Omaha, St. Joseph, Kansas City, and St. Louis. There are over 56,300 residential and 11,400 nonresidential structures in the floodplain. The total estimated value of these structures is \$23.1 billion. The Missouri River from Rulo to the mouth of the Missouri River was divided into four reaches: Rulo to Platte River (St. Joseph Reach), Platte River to Grand River (Kansas City Reach), Grand River to Osage River (Boonville Reach), and Osage River to the mouth of the Missouri River (Hermann Reach).

The alternatives evaluated include management actions with potential to affect river flows, channel form, and river stage. The flood risk management impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the alternatives could result in an impact to risk of flooding. The impacts to flood risk management are evaluated using three of the four accounts (NED, RED, and OSE). An interior drainage analysis was conducted on a subset of federal levees to evaluate elevations within the landward side of federal levee areas along the Missouri River.

Hydropower

The Missouri River hydropower system contains six USACE facilities with a combined nameplate capacity of 2,500 megawatts (MW). Mainstem dams hold water in the river reservoir system, passing water through the hydropower plants electricity-generating turbines and creating a source of low cost, renewable energy. Hydropower generation is dependent on three primary features of the Missouri River system: river flows (dam releases), water elevations, and reservoir system storage. Changes in available water, including daily and hourly river flows and system storage to meet other needs, can impact both the magnitude of normal seasonal generating patterns and reduce the flexibility to meet hourly peaking demands. The value associated with hydropower is based on the accrued cost of the most likely energy source that would replace lost hydropower generation. In the Missouri River Basin, peak energy loads (demand) increase in the summer months, when temperatures are highest and farm communities may be pumping water for irrigation or operating

grain-drying machinery. These loads are intended to be met by generating the maximum amount of energy during the month of August.

Hydropower generation on the Missouri River depends primarily on river flows and dam releases, reservoir elevations, and system storage. Changes in available water can impact both the magnitude of normal seasonal generating patterns and reduce the flexibility to meet hourly peaking demands. The analysis used the HEC-ResSim Missouri River model that simulates reservoir operations over an 82-year POR, as well as the Missouri River Hydropower Benefits Calculator model to calculate impacts to generation and capacity for each of the six mainstem dams.

Irrigation

Irrigators in 42 counties in Montana, North Dakota, South Dakota, and Nebraska hold permits to use water from the Missouri River for the purpose of agriculture production. This generally includes the area extending from Fort Peck Reservoir to Rulo, Nebraska. A majority (94 percent) of the 816 irrigation intakes along the reservoir system are located in Montana, North Dakota, and South Dakota, while North Dakota has the greatest number of permitted acres of the four states (89,106 acres in 2015). Of 12.5 million acres of cropland harvested in these 42 counties in 2012, approximately 2,266,000 acres, or 18.1 percent, consisted of irrigated cropland. In the upper reaches of the river, the irrigation season lasts approximately from May through September. In the lower river reaches, in Nebraska, the growing season also begins in May but typically extends through October.

In addition to the above, Tribes irrigate an estimated 350,000 acres of agricultural lands using water from either the Missouri River or mainstem reservoirs. Many of the mechanical intakes used for water extraction by the Tribes are outdated and are prohibitively expensive to repair, and may need to be replaced in order to accommodate changing levels of sediment, high levels of erosion, or reduced access to water.

The environmental consequences analysis for irrigation intakes focuses on changes in river and reservoir conditions associated with each of the alternatives. The environmental consequences to irrigation intakes were evaluated using three of the four accounts (NED, RED, and OSE). As river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to farm operations (including private farms, Tribes, and commercial operations). This, in turn, can result in changes to net farm income.

Navigation

The navigation channel in the mainstem of the Missouri River stretches 735 miles, from Sioux City, Iowa to St. Louis. This stretch of the river includes a navigation channel measuring nine feet deep and 300 feet wide. In 2014, there were about 48 docks and terminals along the lower river. The navigation season is limited to periods of time when the river is ice-free. While the length of the flow supported season varies along the river, a full-length season is considered eight months long. Navigation service on the lower river is provided by a combination of water from major tributaries and the release of water from Gavins Point Dam necessary to maintain 8 to 9 feet of water depth in the navigation channel.

The level of navigation service (full, reduced, or minimum) depends on the level of system releases. These full-service flows generally provide the authorized 9-foot navigation channel, and they allow the capability to load barges to an 8.5-foot draft. The level of navigation service provided is determined according to how much water is available in storage on two constant key dates of each year (March 15 and July 1). On March 15, if total system storage is greater than 54.5 MAF, then full service is provided. If system storage is between 31.0 and 49.0 MAF, then minimum service is provided. If system storage is below 31.0 MAF, no service level is computed and there will be no navigation season. The navigation impacts analysis focuses on determining if changes in river and

reservoir conditions associated could result in an impact to service level and season length. The impacts to navigation are evaluated using three of the four accounts (NED, RED, and OSE).

Recreation

The Missouri River corridor between Fort Peck Lake and St. Louis, Missouri, supports a wide range of water, land, and wildlife-related recreational activities and is a popular destination for outdoor enthusiasts, attracting millions of visitors each year. Recreational opportunities, settings, and access to public facilities vary considerably along the river and can be divided into three main geographic locations: mainstem reservoirs; inter-reservoir river reaches; and the lower river below Gavins Point Dam to the confluence with the Mississippi River. Water-based recreation includes shoreline fishing, boat fishing, power boating, waterskiing, tube towing, jet skiing, tubing, canoeing, kayaking, and swimming. Sport fishing (i.e., fishing for sport or recreation) is a prevalent activity in all locations along the Missouri River and its reservoirs, including cold water and cool water reservoir fishing for salmon and walleye; rainbow trout fishing along the river reaches of Montana; and warm water fishing for bass and catfish. The wetlands and shoreline along the river corridor provide waterfowl habitat that supports waterfowl hunting and bird watching. Camping and picnicking are very popular activities at many of the recreation areas during the warmer months. The natural landscapes and viewscapes of the Missouri River reservoirs and inter-reservoir river reaches also attract a large number of sightseers. Visitation to the reservoirs varies from year to year in response to environmental conditions and water elevations, which can affect fishing opportunities and access to shoreline facilities and boat ramps.

The environmental consequences analysis for recreation focuses on how changes in the prevalence of habitat and river and reservoir conditions could affect visitation, recreational opportunities, and the value of the recreational experiences. Environmental consequences were evaluated using three of the four accounts (NED, RED, and OSE).

Thermal Power

There are 22 thermal power plants (3 nuclear and 19 coal-fired power plants) located along the mainstem of the Missouri River or its reservoirs. One power plant is located on Lake Sakakawea in North Dakota; six are located on the river below Garrison Dam in North Dakota; and the remaining power plants are located on the river downstream of Sioux City, Iowa. Nineteen of the Missouri River power plants are coal-fired plants, while three are nuclear plants. Of the 22 power plants, 9 have units with recirculating cooling systems or cooling ponds, while 13 plants withdraw water from the river for once-through cooling. River flows and associated water surface elevations can affect the amount, timing, frequency, and duration of access to water through the intakes. Low river flows and high river water temperatures can affect plant operational efficiency as well as the ability of the plants to meet their National Pollutant Discharge Elimination System (NPDES) effluent and temperature requirements. The NPDES permit of a thermal power facility includes temperature limits for maximum river water temperature and maximum change in river water temperature within the mixing zone (the volume and flow of the receiving water below the outfall). Critical low flow conditions are used to define mixing zones and the effluent requirements.

The environmental consequences analysis for thermal power plants focuses on changes in river and reservoir conditions associated with each of the alternatives. Environmental consequences were evaluated using three of the four accounts (NED, RED, and OSE). The analysis focuses on the costs (replacement costs of reduced power generation, capital costs for lost capacity, and variable costs) to power plants and utilities to adapt to changing river and reservoir conditions.

Water Supply

Water is withdrawn from the Missouri River and its mainstem lakes for multiple purposes including municipal, industrial, and commercial water supply as well as domestic and public uses. Municipal

water supply includes Tribal and public supply of water to reservations, residents of cities and towns, and customers of rural water districts and associations. Commercial and industrial use includes self-supplied water for commercial, manufacturing, and other processing uses other than thermal power use. There are an estimated 52 municipal intakes and 3 commercial/industrial water supply intakes on the reservoirs and river reaches of the Missouri River mainstem. Water supply for municipal and industrial/commercial uses along the Missouri River can be affected by conditions such as river flows and stages, reservoir water surface elevations, river water chemistry including sediment, and channel locations. Changes to these physical components, in turn, lead to changes in the interrelated water supply conditions of access to water, operation and maintenance, and water treatment requirements.

The water supply impacts analysis focuses on determining if changes in river and reservoir conditions associated with each of the alternatives could result in an impact to water supply intakes. The impacts to water supply are evaluated using three of the four accounts (NED, RED, and OSE). The analysis focuses on the costs to water supply intake operators to adapt to changing river and reservoir conditions.

Wastewater Facilities

Several facilities discharge treated wastewater to the Missouri River and its reservoirs. The facilities include publicly owned treatment works (POTWs) or sewerage facilities and other types of industrial discharges from fertilizer and agricultural chemical companies and meat processing facilities. Several Tribes also discharge treated wastewater into the Missouri River and its tributaries after using wastewater plants or lagoons to treat the water. There are 37 major wastewater facilities discharging to the Missouri River. Most of the discharging facilities are located in the lower river below Gavins Point Dam. These facilities can be affected by river flows, stages, and channel geometry.

Wastewater facilities require a NPDES permit to discharge wastewater, which specifies the effluent requirements for the relevant parameters for the facilities. The parameters typically regulated by water quality-based effluent limits include ammonia, total residual chlorine, whole effluent toxicity tests, and acute toxicity. Wastewater discharge facility operations can be sensitive to changes in river flows. For facilities with water quality-based effluent limits, low river flows can have a direct relationship with the effluent limits and resulting wastewater treatment requirements. A low-flow criteria analysis was conducted on modeled rivers flows under the alternatives for locations close to the wastewater discharge facilities. The scope of analysis included facilities in Iowa, Nebraska, Kansas, and Missouri. Twenty-nine major wastewater facilities that discharge to the Missouri River were identified in these four lower river states. Each of the wastewater facilities discharging to the Missouri River in Iowa, Nebraska, Kansas, and Missouri were evaluated and facilities were removed from further analysis if they met a set of criteria. The result was five facilities (two in Iowa and three in Missouri) that could potentially be affected under the alternatives.

Tribal Resources

The Tribes of the Missouri River basin are diverse in their histories and their perspectives regarding the Missouri River. There are a total of 29 Tribes located within or having expressed significant interest in their historical connection to the Missouri River Basin. These Tribes maintain current and ancestral ties to the Missouri River and possess cultural, economic, and social interests in the river. Federal agencies planning and implementing recovery and mitigation actions on the river have a trust responsibility to work with Tribes on a government-to-government basis in recognition of Tribal sovereignty. Thirteen of the Tribal reservations (as well as a portion of the Ponca trust land) are adjacent to the river and/or partially within the floodplain. Additional Tribes with ancestral ties to the basin are being contacted to determine their consulting interest.

Tribes of the Missouri River Basin have an interest in many of the resources described elsewhere in this document, including agriculture, irrigation, water supply, thermal power, recreation, flood risk management, and fish and wildlife. There are also additional connections to the Missouri River that are unique to Tribal members. Tribal reservations are located in rural areas, where opportunities for fishing, hunting, and trapping can be essential for Tribal members. Through subsistence hunting, fishing, and gathering, some Tribal members use the fish, wildlife, and vegetation of the Missouri River and its floodplain to account for a significant portion of their food supply. Many Tribal members also gather native plants for medicinal and ceremonial uses. The availability of resources that allow for subsistence and/or traditional cultural practices contributes to the cultural identity of many Tribal members.

Many Tribal members use the Missouri River and its floodplain for traditional cultural practices, including traditional Tribal ways of daily life (which may include seeing and interacting with the river throughout the day) and sacred/spiritual values through ceremonies, sundances, vision quests, and sweat lodges. Protection of cultural resources and preservation of cultural practices are paramount for many Tribal members. These values and ways of life are affected by the physical components of the Missouri River and its floodplain, including its effect on physical resources such as plants, berries, trees, and water. Natural aquatic and floodplain habitats resemble the conditions under which traditional cultural practices were developed. Similarly, the educational opportunities are improved by natural aquatic and floodplain habitats on current and historic Tribal land.

Alternatives are evaluated for their effects on subsistence hunting, fishing, and gathering, as well as traditional cultural practices and educational opportunities. Some of these effects are specific to reservations, while some effects occur on other parts of the Missouri River but are relevant to Tribes nonetheless. The impacts to these specific Tribal interests are evaluated using the OSE account.

Human Health and Safety

Mosquitoes are serious nuisance pests that affect the health and well-being of humans, companion animals, livestock, and wildlife with their persistent biting behavior. Accordingly, human health and safety could be affected by the implementation of actions associated with this MRRMP-EIS if they result in changes in the availability of mosquito breeding habitat along the mainstem Missouri River that lead to the potential for increased risk of transmission of disease.

The most common mosquito-transmitted disease within the Missouri River Basin, and in the United States as a whole, is West Nile Virus. Other mosquito-transmitted diseases that are less prevalent but known to occur within the mainstem Missouri River states include St. Louis encephalitis, western equine encephalitis, and LaCrosse encephalitis. The Zika virus, while not yet known to be transmitted within the Missouri River Basin, represents an emerging threat to human health and safety in states along the mainstem Missouri River and throughout the country.

The most common nuisance mosquitoes in all of the mainstem Missouri River states include *Aedes vexans* and several different species within the *Culex* genus. These species use both natural and man-made breeding habitats that include tree holes, standing pools in agricultural fields, roadside ditches, cans, buckets, birdbaths, discarded tires, and clogged gutters. *Aedes vexans* typically lays its eggs on moist soil in vegetated areas just above the waterline in floodplains and pothole depressions. The eggs hatch into larvae when inundated by flooding.

The alternatives analyzed may have the potential to affect the health and safety of residents of communities along the Missouri River. More traditional human health and safety issues associated with the use of construction equipment and other occupational hazards involved in ESH construction and early life stage pallid habitat construction are discussed in previous USACE NEPA documents (USACE 2009 and 2012). The analysis of impacts to human health and safety focuses on the potential for increased risk of mosquito-borne diseases as a consequence of implementing any of the alternatives and considers the potential for actions to affect the availability of mosquito breeding habitat, which could in turn affect the transmission of the mosquito-borne arboviruses.

Environmental Justice

Executive Order 12898, issued in 1994, directs federal agencies to incorporate environmental justice as part of their mission by identifying and addressing the effects of programs, policies, and activities on minority and low-income populations.

The vast majority of environmental justice populations in the project area are located in the states of Nebraska and Missouri, with approximately 150,084 affected residents located in identified environmental justice communities in both states. These populations are largely concentrated within the Omaha-Council Bluffs metropolitan area and the urban areas of Kansas City, St. Louis, St. Joseph, and Jefferson City, Missouri. The environmental justice populations are predominantly located within rural counties on Tribal lands or within larger cities in urbanized areas, having high concentrations of both minority and low-income populations.

The impact analysis for environmental justice focuses on determining if any of the management actions described under the alternatives would have disproportionate impacts on environmental justice populations. The environmental justice assessment evaluated the nature and extent of impacts evaluated under the other resource areas addressed in the EIS (including flood risk management, water supply, thermal power, hydropower, land acquisition, irrigation, recreation, navigation, water quality, and others) and then evaluated whether these impacts would fall disproportionately on potential environmental justice populations that live within the floodplain.

Ecosystem Services

Although modified, the Missouri River ecosystem provides a steady flow of environmental benefits that sustain life and bestow values for humans. These benefits include tangible goods and intangible services that are often referred to as ecosystem services. Ecosystem services provided by the Missouri River support economic activity and contribute to regional quality of life. These environmental goods and services contribute in ways that may or may not be considered in market transactions or economic activity. Some of the notable ecosystem services provided by the Missouri River ecosystem include natural resource goods (food, fiber, fuel, construction materials, etc.), water supply, water quality, waste assimilation and nutrient regulation (recycling of nutrients and removal of pollutants by ecological processes), flood attenuation, recreation, and other cultural services.

Benefits derived from ecosystem services include those from both their direct and indirect uses or through their intrinsic values (not tied to uses). For example, cool-water fisheries along the Missouri River provide direct use benefits to anglers who visit the area, and indirect benefits to people who may enjoy watching fishing programs at home. Non-use values (passive use values), are values that are not associated with actual use, nor are they directly valued in the market. Non-use values stem from a desire to preserve or improve a resource (e.g., restored ecosystem, endangered species) as a public good, for future use, or for enjoyment by future generations. Since impacts to many ecosystem services are discussed in other sections, this analysis of impacts focuses on the effects to climate regulation and carbon sequestration, other cultural services, and non-use values.

Mississippi River Impacts

The middle Mississippi River is the portion of the Mississippi River that lies between the confluence with the Ohio River at Cairo, Illinois and the confluence with the Missouri River at St. Louis. The Missouri River contributes almost 50 percent of the flow of the middle Mississippi River and contributes approximately 75 to 95 percent of the suspended sediment load.

The Mississippi River basin has been shaped over time by a variety of actions, including urbanization, agriculture, levee construction, dam construction, and river training structure placement. Many of the changes in the middle Mississippi River which have led to its current condition are due to improvements made for navigation including river training structure placement and associated sedimentation patterns. These alterations in structure and condition affect the

biological resources in the middle Mississippi River. Similar to the Missouri River, variety of habitat types are found in the middle Mississippi River, which support a large diversity of macroinvertebrate and fish communities. Side channel habitats in particular are known to support a greater abundance of macrohabitat generalists compared to other macrohabitat types, likely due to the shallow, low-velocity habitat they provide at certain river stages. Side channels provide a well-defined gradient between flowing to non-flowing water, depending on their level of connectivity to the main channel. Flowing side channels, those connected to the main channel, generally have a sand and gravel substrate and support large river aquatic species (suckers, minnows, and darters) tolerant of current and/or turbidity. This diversity of habitat provides important feeding, spawning, nursery, and overwintering habitat for fish, and habitat for other environmentally sensitive macroinvertebrates, fish, and wildlife. As such, side channels are important to the health of the river ecosystem as a whole, and are even more important in the middle Mississippi River because of the loss of connectivity between the river and floodplain.

Biological Resources: Impacts to biological resources in the middle Mississippi River were analyzed based on stage and flow simulated for each alternative by modeling the alternative operation over the POR (USACE H&H Tech Report 2016). Side channel habitat has been identified as the most diverse and representative habitat in the middle Mississippi River that supports the highest abundance of aquatic species. Impacts to the three representative side channels were quantitatively analyzed in terms of how changes in stage may potentially alter or impact side channel habitat through altering connectivity with the main channel. It is assumed that changes in stage can alter or impact the condition and accessibility of side channel habitat. It is assumed that the changes in stage modeled under each alternative at the St. Louis gage is representative of the Middle Mississippi River and each of the representative side channels.

Flood Risk Management: Within the Middle Mississippi River floodplain between St. Louis and Thebes, Illinois, a majority of the area is leveed. A total of 13 levee systems comprised of 20 levee districts protect over 310,000 acres of floodplain. Nineteen of these levees were federally constructed. Additional flood risk reduction is realized through flood storage in the many reservoirs in the Missouri, Upper Mississippi, and Kaskaskia River basins. This series of levee systems is very robust. Since they were completed, only four of the federal systems have been overtopped and breached, which occurred during the record-breaking flood of 1993. Analysis of the potential for flood risk management impacts along the middle Mississippi River downstream of St. Louis was conducted through comparison of change in flood flow frequency curves at St. Louis. Data for this analysis were taken from hydraulic modeling conducted as part of this study. Flow frequency curves were calculated with a procedure matching that used in the Upper Mississippi River Flow Frequency Study (USACE 2004).

Given the more-detailed hydrology and hydraulics modeling from the confluence of the Missouri River to St. Louis, the assessment of impacts upstream of St. Louis follows the impacts assessment for the Missouri River more closely than downstream of St. Louis where detailed channel cross-sections were not available. Approximately 17,994 people reside in the middle Mississippi River reach upstream of St. Louis. Residential and nonresidential structures located in areas along the Mississippi River are subject to flood risk. There are 6,501 residential and 686 nonresidential structures identified in the floodplain. Total estimated value of these structures is \$2.0 billion.

Navigation: Navigation on the middle Mississippi River includes the transport of commodities using various types of vessels, including towboats and barges. The towboats on the upper Mississippi River are usually 160-foot towboats with 3,000 to 5,000 horsepower. Towboats on the lower Mississippi River can reach 180 feet in length and have an engine with 8,000 to 10,000 horsepower. The barge sizes are fairly typical in comparison to other rivers, measuring 35 feet wide by 195 feet long. Additionally, the average tow configuration on the lower Mississippi River may consist of 30 to 35 barges. The middle Mississippi River can handle these larger arrangements for much of its 195 miles, but typically averages around 25 barges per tow. Commodities transported on the middle Mississippi River include crude petroleum, petroleum products, grain and grain products, chemicals,

aggregates, non-metallic ores and minerals, iron ore and iron and steel products, and coal. These commodities are shipped or received throughout numerous states that touch the middle Mississippi River. Between 2005 and 2014, the top three receiving states are (1) Louisiana (53.9 million tons), (2) Illinois (15.3 million tons), and (3) Pennsylvania (6.2 million tons) and the top shipping states were (1) Illinois (49.7 million tons), (2) Missouri (20.6 million tons), and (3) Louisiana (15.3 million tons). The navigation impact analysis focuses on determining if changes in river and reservoir conditions associated with each of the alternatives could affect commodities traveling on the middle Mississippi River.

Water Supply and Thermal Power: Water is withdrawn from the Mississippi River for multiple purposes including municipal, industrial, and commercial water supply as well as for cooling purposes for power plants. There are four thermal power plants or generating stations and three permanent/fixed water supply intakes located along middle Mississippi River between St. Louis to Cairo. As river flows or stages fall below minimum operating requirements, water can no longer be accessed through intakes, with adverse impacts to municipalities, commercial operations, and power plants. This in turn can drive changes in costs to operate intakes and replace power, and possibly affect capital costs to address water access issues. In addition, relatively lower river flows in the summer can affect operational efficiencies of power plants that use once through cooling and affect the ability of the plants to meet NPDES requirements. In addition, power plants can also be affected by river temperature with higher temperatures during the peak summer months causing reduced operating efficiencies and difficulties in meeting NPDES permit requirements. As a result, power plants may need to reduce their power generation.

The impact analysis for water intakes used two approaches to describe the potential impacts to water supply facilities and power plants along the middle Mississippi river. To assess the impacts of the facilities or plants when river stages fall below critical operating elevations, river stage thresholds were used from the USACE Master Manual Mississippi River Studies Volume 13 (USACE 1998, Appendix C). The analysis used these critical stages along with the outputs from the HEC-RAS Missouri River models of simulated river flows at the confluence of the Missouri and Mississippi Rivers in St. Louis at river mile 180. The impacts to thermal power facilities on the Mississippi River were also analyzed.

Regional Economic Effect of Program Expenditures

Program expenditures were used to evaluate the regional economic benefits of the MRRMP-EIS alternatives. Many types of actions and activities were included in the list of costs, including habitat construction; program management, integration, and coordination; MRRIC; among many others. Detailed costs categories can be found in Appendix E: Missouri River Recovery Management Plan, EIS Alternatives – Cost Estimates. Program costs were grouped based on the time-period in which they are anticipated to be incurred. Two periods were associated with the timing of the costs: the implementation period (year 0 to year 15) and the operations and maintenance period (year 0 to year 50). The annual costs for each year over 50 years were obtained for each cost category, and annualized using the Fiscal Year 2016 federal interest rate of 3.125 percent and an amortization rate based on the type of cost. USACE staff familiar with implementation of projects under MRRP identified two regions where spending was likely to occur: the upper river, including the states of Montana, North Dakota, and South Dakota; and the lower river, including Iowa, Missouri, Kansas, and Nebraska.

Environmental Consequences of Action Alternatives

The following table provides a summary comparison of the general environmental consequences of each action alternative compared to Alternative 1—the No Action alternative—in terms of being beneficial or adverse. The impacts of the No Action Alternative and the Action Alternatives are provided in-detail under each resource topic in Chapter 3-Affected Environment and Environmental Consequences.

In this table, the “Dir” column clarifies the directionality of the numbers for each performance measure. “H” indicates that the higher the numerical value, the better for that interest; “L” indicates the lower the value, the better. For example, some NED values (hydropower, recreation, irrigation, and navigation) are quantified in terms of benefits that the river provides. In these cases, the higher the number, the better. Other NED values (flood risk management, thermal power, water supply, and program implementation costs) are calculated in terms of costs from a hypothetical condition where no costs are incurred to that resource. For these interests, the lower the number, the better.

Although absolute values provide important context, it is more relevant to decision-makers to consider the estimated differences between each of the action alternatives and Alternative 1. The table shows the differences in the performance of Alternatives 2 to 6 in relation to Alternative 1. To make reading the table easier and to facilitate comprehension of relative beneficial and adverse effects, a color-coding scheme has been introduced.

- Differences that are improvements from Alternative 1 are shaded **green** and indicate a beneficial impact.
- Differences that are adverse impacts relative to Alternative 1 are shaded **red** and indicate an adverse impact.
- No differences are indicated by white cells.

Rows for which a -2, -1, 0, +1, +2 scale is used employ a color scheme as follows: -2=dark red (large adverse impact); -1=light red (small adverse impact); 0=white (no or negligible impact); +1=light green (small beneficial impact); and +2=dark green (large beneficial impact).

In all other cases, for any given row, a cell is dark red if it is associated with the largest adverse impact across the range of alternatives and if a cell is dark green it is associated with the largest beneficial impact across the range of alternatives. The shading of red for other alternatives with adverse impacts is linearly scaled relative to the difference between 0 and the value associated with the darkest shade. The shading of green for other alternatives with beneficial impacts is linearly scaled relative to the difference between 0 and the value associated with the darkest shade of green.

Environmental Consequences of the Actions Alternatives Compared to No Action

SPECIES OBJECTIVES					Difference from Alt 1						
					Dir	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
							YES EXCEEDS	YES MEETS	YES MEETS	YES MEETS	YES MEETS
SPP OBJ	Pallid Sturgeon	Addresses Critical EA Pallid Hypotheses		NO							
SPP OBJ	Piping Plover and Least Tern	Expected to Meet Revised Bird Targets		NO							
IMPACTS											
EQ	Fish and Wildlife	-2 to +2 rating	H	REF. COND.		+2	+1	+1	+1	+1	
EQ	Other Special Status Species	-2 to +2 rating	H	REF. COND.		+2	+1	+1	+1	0	
EQ	Water Quality	-2 to +2 rating	H	REF. COND.		-2	0	-1	-1	-1	
EQ	Air Quality	-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
EQ	Cultural Resources	Site-days at Risk	L	65,464		1,164	-82	1,817	284	1,631	
RED	Land Use and Ownership	Regional Employment (At End of Impl'n (15 years))	H	-26		-134	18	18	18	18	
RED		Regional Income (\$000, At End of Impl'n (15 years))	H	\$ -1,153		\$ -6,243	\$ 852	\$ 852	\$ 852	\$ 852	
RED		Tax Revenues (\$000, At End of Impl'n (15 years))	H	\$ -75		\$ -480	\$ 65	\$ 65	\$ 65	\$ 65	
Commercial Sand and Gravel Dredging											
See text											
NED	Flood Risk Management	Ave \$ 000 NED / yr	L	\$ 60,958		\$ -691	\$ -483	\$ 964	\$ -287	\$ 505	
RED		Regional Employment (Ave)	H	-140		2	1	0	0	0	
RED		Ave \$ 000 RED / yr Income	H	\$ -6,795		\$ 64	\$ 7	\$ -19	\$ -27	\$ -58	
OSE		Population at Risk	L	709		-6	-9	25	-8	0	
OSE	(FRM - Channel Exceedances)	Sum of Ft Randall and Garr Exceeds in POR	L	5,402		708	19	605	422	221	
NED	Hydropower	Ave \$ 000 NED / yr	H	\$ 525,707		\$ -5,426	\$ -256	\$ -4,044	\$ -1,784	\$ -2,092	
RED		Benefits to WAPA (Typ gen yr \$ 000 / yr)	H	\$ 27,832		\$ -3,784	\$ -691	\$ -837	\$ -3,354	\$ 5,461	
OSE		Ave Change in CO2 (kg/yr)	L	55,292		-3,656	52,186	17,693	20,473		
NED	Irrigation	Ave \$ 000 NED / yr	H	\$ 5,921		\$ -136	\$ 25	\$ -210	\$ -4	\$ -135	
RED		Regional Employment (Ave)	H	343		-1	1	-2	0	-1	
RED		Ave \$ 000 RED / yr Income	H	\$ 10,489		\$ -224	\$ -150	\$ -244	\$ -165	\$ -224	
OSE		-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
NED	Navigation	Ave \$ 000 NED / yr	H	\$ 715		\$ -28	\$ 3	\$ -45	\$ -6	\$ -41	
RED		Regional Employment (Ave)	H	284		-7	1	-4	1	-3	
RED		Ave \$ 000 RED / yr Income	H	\$ 19,254		\$ -535	\$ 33	\$ -326	\$ 33	\$ -219	
OSE		Particulates (1000 g / mile)	L	.5		.5	-.1	.4	-.1	.3	
NED	Recreation	Ave \$ 000 NED / yr	H	\$ 38,271		\$ 163	\$ 23	\$ -407	\$ -28	\$ -265	
RED		Regional Employment (Ave)	H	1,235		-14	1	-21	-3	-15	
RED		Ave \$ 000 RED / yr Income	H	\$ 29,184		\$ -334	\$ 17	\$ -514	\$ -68	\$ -354	
OSE		-2 to +2 rating	H	REF. COND.		-1	0	-1	0	-1	
NED	Thermal Power	Ave \$ 000 NED / yr	L	\$ 52,933		\$ 28,163	\$ -1,367	\$ 422	\$ -1,063	\$ -1,301	
RED		-2 to +2 rating	H	REF. COND.		-2	0	0	0	0	
OSE		-2 to +2 rating	H	REF. COND.		-2	0	0	0	0	
NED	Water Supply	Ave \$ 000 NED / yr	L	\$ 376		\$ 5	\$ -4	\$ 13	\$ -1	\$ 8	
OSE		-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
NED	Wastewater	-2 to +2 rating	H	REF. COND.		-1	0	0	0	0	
OSE	Tribal Interests (Other)	-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
OSE	Health & Safety	-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
OSE	Environmental Justice	-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
EQ	Ecosystem services	-2 to +2 rating	H	REF. COND.		+1	+1	+1	+1	+1	
Missipp R	Biological Resources	-2 to +2 rating	H	REF. COND.		0	0	0	0	0	
Missipp R	Flood Risk Management	-2 to +2 rating	H	REF. COND.		+1	+1	-1	+1	+1	
Missipp R	Navigation	-2 to +2 rating	H	REF. COND.		-1	+1	-1	+1	-1	
Missipp R	Water Intakes	-2 to +2 rating	H	REF. COND.		0	+1	-1	+1	-1	
NED	Program Expenditures	Ave \$ 000 NED / yr	L	\$ 73,825		\$ 263,700	\$ -4,618	\$ -13,417	\$ -9,565	\$ -8,483	
RED		Regional Employment Ave	H	1,278		4,029	-129	-255	-200	-184	
RED		Ave \$ 000 RED / yr Income	H	\$ 66,552		\$ 197,502	\$ -7,287	\$ -13,258	\$ -10,644	\$ -9,910	

Note: Commercial sand dredging, wastewater discharges and interior drainage are treated differently for NED/RED. See Chapter 3.

Note: All NED impacts were calculated at FY2016 price levels.

Note: MRRP Expenditures were calculated using a 50-year period of analysis and the FY2016 federal discount rate of 3.125%.

Note: For -2 to +2 scales, relative to No Action (Alt 1): -2 = "Large adverse change", -1 = "Small adverse change"

0 = "No or negligible change", +1 = "Small beneficial change", +2 = "Large beneficial change"

Dir = Numerical direction of preferred difference: H = Higher is Better, L = Lower is Better

Tribal Interests are addressed within multiple resource areas; 'Tribal Interests (Other)' reflects additional connections to the Missouri River that are unique to Tribal members.

Plan Selection – Preferred Alternative

Alternative 3 has been identified as the **preferred alternative** in this MRRMP-EIS.

In addition to the actions common to Alternatives 3–6 described above (including active adaptive management; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCS), under Alternative 3, USACE would create ESH through mechanical means at an average rate of 391 acres per year in the Garrison, Fort Randall, and Gavins Point river reaches in years where construction is needed. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. Alternative 3 would also include the provision for a one-time spawning cue test release from Gavins Point Dam if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important.

Alternative 3 has a wide range of benefits relative to Alternative 1, including certain benefits to endangered species, reduced program expenditures, and increased performance for most HCs. Hydrologically, the effects of Alternative 3 would be very close to those for Alternative 1 but without the specification for spawning cue releases in March and May. Hydrological differences would be reduced flows relative to Alternative 1 in approximately 30 to 50 percent of years in late March and late April/early May, and corresponding increased flows relative to Alternative 1 during one or two weeks in October or November. The differences in magnitude of these flows would be small compared to those associated with the other alternatives. Alternative 3 would have less channel reconfiguration for pallid sturgeon early life stage habitat relative to Alternative 1, and this would have implications on flow routing and assumed stage-discharge relationships at certain locations.

Although Alternative 3 would not be the most efficient alternative from an overall National Economic Development (NED) standpoint, its lack of adverse NED impacts compared to Alternative 1 is a good balance between overall efficiency and impacts to specific NED resources. Although there are uncertainties associated with its effectiveness in meeting the species objectives (in common with all alternatives), Alternative 3 clearly demonstrates it would be the least impactive means of meeting species objectives across the full range of interests. A further description of the rationale for identifying Alternative 3 as the preferred alternative is provided in the MRRMP-EIS, Section 2.9 of Chapter 2.

Implementation of Preferred Alternative under Adaptive Management

USACE would implement the preferred alternative under the AM Plan recognizing the remaining uncertainty associated with many of the proposed management actions and with the ecology of the listed species (particularly for the pallid sturgeon). The AM Plan is a companion document to the MRRMP-EIS and includes the process and criteria to implement the initial set of actions included in the preferred alternative. NEPA and adaptive management are complementary processes as both emphasize collaboration and working with stakeholders. Adaptive management is consistent with NEPA's goal of informed decision-making and takes the NEPA process further in addressing uncertainties and data gaps that may be revealed during implementation of the preferred alternative.

The preferred alternative represents the initial set of actions the agencies believe will accomplish the objectives (avoid a finding of jeopardy to the listed species) and will allow USACE to fulfill its other statutory requirements. The AM Plan is designed to guide the implementation process and help meet Endangered Species Act (ESA) requirements while minimizing impacts on human considerations (HC), which includes the authorized purposes of the Missouri River as well as the many other services afforded by the river system.

The AM Plan provides detailed information on the strategy for addressing uncertainties for each species, provides a governance structure for the program, defines the roles and responsibilities of

the participants, and describes both how data are managed and how program actions and results will be communicated and reported.

Primary components of the AM Plan include the following:

- Monitoring program associated with the management actions and broader river system;
- Research and study activities including those to address hypotheses for which specific management actions have not yet been identified;
- Assessment methods and processes to evaluate the effectiveness of actions implemented under the preferred alternative;
- Decision criteria used to determine if changes to the preferred alternative are necessary; and
- Governance approach to be used in collaboration with stakeholders, states, and Tribes to make decisions.

The preferred alternative includes the initial suite of management actions, research, and monitoring USACE would implement over the 15 years post approval of the Record of Decision (ROD) aimed at achieving objectives for the pallid sturgeon, piping plover, and interior least tern. The initial set of actions were chosen after careful consideration of species needs, remaining critical management uncertainties, anticipated impacts to authorized purposes and other socioeconomic impacts, and existing impediments to implementation of management actions contained within the other alternatives. The AM Plan serves as the repository of knowledge related to management hypotheses, associated management actions, and remaining uncertainties and impediments. It is possible that in the future, the adaptive management process will conclude that actions which were not part of the preferred alternative may be warranted and feasible.

The ability to incorporate and adjust to new information is a central concept for successful adaptive management; therefore, if these activities lead to an adjustment in the implementation strategy laid out in the preferred alternative, a supplemental NEPA process may be necessary prior to the end of the 15-year period.

Intentionally Left Blank

Table of Contents

1.0 Purpose, Need, and Problem Definition	1-1
1.1 Background	1-1
1.1.1 Missouri River Mainstem Reservoir System	1-2
1.1.2 Kansas River Reservoir System	1-3
1.1.3 Missouri River Bank Stabilization and Navigation Project.....	1-4
1.1.4 Endangered Species Act Compliance	1-5
1.1.5 BSNP Fish and Wildlife Mitigation Project	1-7
1.1.6 Missouri River Recovery Program and the Missouri River Recovery Implementation Committee	1-8
1.1.7 Effects Analysis.....	1-9
1.1.8 Adaptive Management	1-10
1.2 PrOACT Process.....	1-12
1.2.1 Problem Definition.....	1-13
1.3 Need for the Plan	1-14
1.3.1 Pallid Sturgeon.....	1-15
1.3.2 Interior Least Tern and Piping Plover	1-17
1.4 Purpose of the Plan.....	1-21
1.5 Plan Objectives	1-22
1.5.1 Pallid Sturgeon Objectives.....	1-22
1.5.2 Piping Plover Objectives	1-23
1.5.3 Interior Least Tern Objectives.....	1-25
1.6 Scope of the Plan and Environmental Impact Statement.....	1-25
1.6.1 Geographic, Temporal, and Substantive Scope	1-25
1.6.2 Adaptive Management and National Environmental Policy Act	1-26
1.6.3 Tiering and Future National Environmental Policy Act Compliance.....	1-27
2.0 Alternatives	2-1
2.1 Overview of Alternative Development Process	2-1
2.2 Effects Analysis Products and Results.....	2-2
2.3 Identification of Management Hypotheses	2-5
2.4 Models Supporting Alternatives Development	2-10
2.4.1 Hydrologic Engineering Center – Reservoir System Simulation Model	2-10
2.4.2 Hydrologic Engineering Center – River Analysis System Models.....	2-11
2.4.3 Bird Habitat/Population Modeling.....	2-12

2.4.4	Pallid Sturgeon 2-Dimensional Hydrodynamic Models	2-13
2.4.5	Human Considerations Modeling	2-13
2.5	Management Actions.....	2-14
2.5.1	Least Tern and Piping Plover.....	2-14
2.5.2	Upper River Pallid Sturgeon	2-22
2.5.3	Lower River Pallid Sturgeon	2-27
2.5.4	Habitat Development and Land Management on MRRP Lands	2-31
2.6	Pallid Sturgeon Alternatives Development.....	2-32
2.6.1	Identification of Lower Pallid Sturgeon Limiting Factors	2-32
2.6.2	Drift Dynamics Limiting Factor	2-34
2.6.3	Concept of the “Interception and Rearing Complex”	2-35
2.6.4	Lower Pallid Sturgeon Framework and U.S. Fish and Wildlife Service Jeopardy Avoidance Criteria	2-36
2.7	Bird Alternatives Development.....	2-37
2.7.1	Development of the Bird “Test Alternatives”	2-38
2.7.2	Initial Iterations of Habitat-Creating Flow Releases	2-39
2.7.3	Habitat-Forming Flow Releases Developed as Bird “Test Alternatives”	2-40
2.7.4	Reservoir Unbalancing “Test Alternative” (Oahe Unbalance)	2-42
2.7.5	Round 1 Alternatives.....	2-43
2.7.6	Round 1 Bird Alternative Screening	2-44
2.7.7	Round 2 Alternatives.....	2-44
2.7.8	Round 2 Bird Alternative Screening	2-47
2.8	Plan Alternatives Carried Forward for Detailed Evaluation	2-48
2.8.1	Actions Common to All Plan Alternatives.....	2-48
2.8.2	Alternative 1 – No Action (Current System Operation and Current MRRP Implementation).....	2-55
2.8.3	Alternative 2 – USFWS 2003 Biological Opinion Projected Actions	2-60
2.8.4	Alternative 3 Mechanical Construction Only	2-66
2.8.5	Alternative 4 – Spring ESH Creating Release	2-69
2.8.6	Alternative 5 – Fall ESH Creating Release	2-72
2.8.7	Alternative 6 – Pallid Sturgeon Spawning Cue	2-73
2.9	Comparison of Alternatives	2-74
2.9.1	Average Annual Consequence Tables	2-74
2.9.2	Discussion of Consequences	2-78
2.10	Summary of Preferred Alternative	2-89

2.10.1 Pallid Sturgeon.....	2-90
2.10.2 Least Tern and Piping Plover.....	2-92
3.0 Affected Environment and Environmental Consequences	3-1
3.1 Introduction	3-1
3.1.1 Impact Assessment Methodology	3-2
3.1.2 “Human Considerations” and USACE Planning Accounts	3-5
3.1.3 Cumulative Impacts	3-5
3.2 River Infrastructure and Hydrologic Processes	3-11
3.2.1 Affected Environment.....	3-11
3.2.2 Environmental Consequences	3-24
3.3 Pallid Sturgeon.....	3-55
3.3.1 Affected Environment.....	3-55
3.3.2 Environmental Consequences	3-65
3.4 Piping Plover and Least Tern	3-84
3.4.1 Affected Environment.....	3-84
3.4.2 Environmental Consequences	3-94
3.5 Fish and Wildlife Habitat.....	3-107
3.5.1 Affected Environment.....	3-107
3.5.2 Environmental Consequences	3-112
3.6 Other Special-Status Species	3-144
3.6.1 Affected Environment.....	3-144
3.6.2 Environmental Consequences	3-148
3.7 Water Quality	3-181
3.7.1 Affected Environment.....	3-181
3.7.2 Environmental Consequences	3-191
3.8 Air Quality.....	3-205
3.8.1 Affected Environment.....	3-205
3.8.2 Environmental Consequences	3-206
3.9 Cultural Resources.....	3-209
3.9.1 Affected Environment.....	3-209
3.9.2 Environmental Consequences	3-214
3.9.3 Summary of Environmental Consequences.....	3-215
3.10 Land Use and Ownership.....	3-229
3.10.1 Affected Environment.....	3-229
3.10.2 Environmental Consequences	3-234

3.11 Commercial Sand and Gravel Dredging.....	3-245
3.11.1 Affected Environment.....	3-245
3.11.2 Environmental Consequences	3-249
3.12 Flood Risk Management and Interior Drainage.....	3-261
3.12.1 Affected Environment.....	3-261
3.12.2 Environmental Consequences	3-264
3.12.3 Environmental Consequences: Flood Risk Management	3-267
3.12.4 Environmental Consequences: Interior Drainage	3-310
3.13 Hydropower	3-328
3.13.1 Affected Environment.....	3-328
3.13.2 Environmental Consequences	3-333
3.14 Irrigation	3-357
3.14.1 Affected Environment.....	3-357
3.14.2 Environmental Consequences	3-360
3.15 Navigation	3-383
3.15.1 Affected Environment.....	3-383
3.15.2 Environmental Consequences	3-390
3.16 Recreation.....	3-421
3.16.1 Affected Environment.....	3-421
3.16.2 Environmental Consequences	3-429
3.17 Thermal Power	3-464
3.17.1 Affected Environment.....	3-464
3.17.2 Environmental Consequences	3-467
3.18 Water Supply.....	3-500
3.18.1 Affected Environment.....	3-500
3.18.2 Environmental Consequences	3-503
3.19 Wastewater Facilities	3-525
3.19.1 Affected Environment.....	3-525
3.19.2 Environmental Consequences	3-528
3.20 Tribal Interests (Other)	3-537
3.20.1 Affected Environment.....	3-537
3.20.2 Environmental Consequences	3-542
3.21 Human Health and Safety	3-553
3.21.1 Affected Environment.....	3-553
3.21.2 Environmental Consequences	3-557

3.22 Environmental Justice	3-563
3.22.1 Affected Environment.....	3-563
3.22.2 Environmental Consequences	3-569
3.23 Ecosystem Services	3-574
3.23.1 Affected Environment.....	3-574
3.23.2 Environmental Consequences	3-578
3.24 Mississippi River Impacts	3-585
3.24.1 Affected Environment.....	3-585
3.24.2 Riverine Infrastructure and Hydrologic Processes	3-585
3.24.3 Biological Resources	3-595
3.24.4 Flood Risk Management	3-602
3.24.5 Navigation	3-609
3.24.6 Water Intakes	3-623
3.24.7 Climate Change	3-629
3.24.8 Cumulative Impacts Associated with all Alternatives	3-630
3.25 Regional Economic Effect of Program Expenditures	3-631
3.26 Unavoidable Adverse Impacts.....	3-638
3.27 Relationship between Short-Term Uses and Long-Term Productivity	3-641
3.28 Irreversible and Irretrievable Commitment of Resources	3-642
4.0 Implementation of Preferred Alternative under Adaptive Management	4-1
4.1 Introduction	4-1
4.2 Overview and Context of Missouri River Recovery Program Science and Adaptive Management Plan	4-1
4.3 Description of Preferred Alternative	4-3
4.4 Adaptive Management Plan for Initial Actions Included in the Preferred Alternative to Avoid a Finding of Jeopardy for Pallid Sturgeon in the Missouri River.....	4-3
4.4.1 Plan and Design.....	4-4
4.4.2 Implementation	4-6
4.4.3 Monitoring	4-10
4.4.4 Evaluation	4-13
4.4.5 Adjustment Decisions	4-15
4.5 Adaptive Management Plan for Initial Actions Included in the Preferred Alternative to Avoid a Finding of Jeopardy for Piping Plovers and Interior Least Terns on the Missouri River	4-17
4.5.1 Plan and Design.....	4-17

4.5.2	Implementation	4-18
4.5.3	Monitoring	4-20
4.5.4	Evaluation	4-23
4.5.5	Adjustment Decisions and Planning Contingencies	4-25
4.6	Governance of the AM Program.....	4-25
4.6.1	Annual Work Plan	4-27
4.6.2	Reporting and Communications.....	4-29
4.7	Human Considerations.....	4-29
4.8	Implementation Costs.....	4-31
4.9	Future NEPA and Other Environmental Compliance Requirements.....	4-33
4.9.1	Tiering	4-33
4.9.2	Supplemental NEPA Documentation	4-33
4.9.3	Standalone NEPA Documentation	4-34
5.0	Tribal, Agency, and Public Involvement.....	5-1
5.1	Missouri River Recovery Implementation Committee	5-1
5.2	Tribal Coordination and Consultation.....	5-3
5.3	Agency Coordination and Public Scoping	5-4
5.3.1	Cooperating Agencies.....	5-4
5.3.2	Public and Agency Scoping	5-5
6.0	Compliance with Other Environmental Laws.....	6-1
6.1	Threatened and Endangered Species.....	6-1
6.1.1	Endangered Species Act	6-1
6.1.2	Bald and Golden Eagle Protection Act.....	6-1
6.2	Fish and Wildlife Conservation.....	6-2
6.2.1	Fish and Wildlife Coordination Act	6-2
6.2.2	Migratory Bird Treaty Act	6-2
6.3	Water Resources and Wetlands Conservation	6-2
6.3.1	Clean Water Act.....	6-2
6.3.2	Executive Order 11988 Flood Plain Management	6-3
6.4	Cultural Resources and Heritage	6-3
6.4.1	National Historic Preservation Act.....	6-3
6.4.2	Archaeological Resources Protection Act	6-4
6.4.3	Native American Graves Protection and Repatriation Act	6-4
6.4.4	American Indian Religious Freedom Act.....	6-4
6.4.5	Executive Order 13007 Indian Sacred Sites	6-4

6.5 Water Rights	6-4
6.6 Environmental Justice	6-5
6.7 Farmland Protection.....	6-5
6.8 Air Quality.....	6-6
6.9 Navigation	6-6
6.10 Recreation.....	6-6
6.10.1 Wild and Scenic Rivers Act.....	6-6
6.10.2 Federal Water Project Recreation Act.....	6-7
7.0 References	7-1
8.0 Glossary	8-1
9.0 List of Preparers.....	9-1
Index	I-1

Appendices

- Appendix A: Human Considerations Proxies and Round 1 and 2 Bird Alternative Proxy Results
- Appendix B: Fish and Wildlife Coordination Act Correspondence
- Appendix C: Cumulative Actions Descriptions
- Appendix D: Hydrologic Period of Record Analysis of Alternatives
- Appendix E: Other Special-Status Species
- Appendix F: Missouri River Recovery Management Plan-EIS Alternatives – Cost Estimates
- Appendix G: MRRIC Recommendations
- Appendix H: Tribal Engagement
- Appendix I: Endangered Species Act Correspondence

Supporting Reports

(available online at www.moriverrecovery.org)

Draft Science and Adaptive Management Plan

Human Considerations Technical Reports

- Commercial Sand and Gravel Dredging
- Irrigation
- Land Use and Ownership
- Fish and Wildlife
- Flood Risk Management
- Hydropower
- Agriculture and Interior Drainage
- Recreation
- Thermal Power
- Water Supply
- Navigation
- Cultural Resources

Hydrology and Hydraulics Technical Reports

- Hydrology and Hydraulics Summary Report
- Period of Record Development
- HEC-ResSim Alternatives Report
- HEC-RAS Alternatives Report
- HEC-ResSim Modeling Report
- HEC-RAS Calibration Report
- Climate Change Assessment – Missouri River Basin
- Water Quality

Related Documents:

- Notice of Availability
- Scoping Summary Report
- Missouri River Effects Analysis Reports
 - Missouri River Pallid Sturgeon Effects Analysis – Integrative Report
 - Science Information to Support Missouri River Pallid Sturgeon Effects Analysis
 - Development of Conceptual Ecological Models Linking Management of the Missouri River to Population Dynamics of Pallid Sturgeon
 - Development of Working Hypotheses Linking Management of the Missouri River to Population Dynamics of Pallid Sturgeon
 - Conceptual Ecological Models and Hypotheses for Piping Plovers and Interior Least Terns on the Missouri River
 - Science Information to Support Missouri River Piping Plover and Least Tern Effects Analysis
 - Modeling to Support the Development of Habitat Targets for Piping Plovers on the Missouri River
 - Interim Missouri River Effects Analysis Integrated Report: Piping Plovers and Least Terns
 - Models, Data, and Literature to Support Habitat Analyses for the Missouri River Effects Analysis

List of Figures

Figure 1-1. The Interior Least Tern (left), Pallid Sturgeon (top right), and Piping Plover (bottom right): Federally Listed Species Found along the Missouri River	1-1
Figure 1-2. Missouri River Mainstem Reservoir System.....	1-3
Figure 1-3. Changes to the River from Missouri River Bank Stabilization and Navigation Project Construction (Indian Cave Bend, Nebraska).....	1-4
Figure 1-4. Changes to the Missouri River near Nebraska City, Nebraska from 1890 to 2012	1-5
Figure 1-5. Timeline of Events Leading to the Missouri River Recovery Management Plan and Environmental Impact Statement	1-11
Figure 1-6. Simplified Depiction of the Adaptive Management Process	1-12
Figure 1-7. PrOACT Process	1-13
Figure 1-8. Pallid Sturgeon	1-15
Figure 1-9. Cumulative Number of Scientific Publications on Pallid Sturgeon Since 1990.....	1-16
Figure 1-10. Interior Least Tern	1-18
Figure 1-11. Piping Plover	1-19
Figure 2-1. Example Conceptual Ecological Model for Piping Plover and Least Tern.....	2-3
Figure 2-2. Pallid Sturgeon Generalized Population-Level Conceptual Ecological Model.....	2-4
Figure 2-3. Upper Missouri River Locations Influencing Drift Distance Availability	2-24
Figure 2-4. Interception and Rearing Complex Visualization.....	2-36
Figure 3-1. Model Outputs for the Missouri River Recovery Plan – Environmental Impact Statement	3-3
Figure 3-2. Annual Runoff in the Missouri River Upstream of Sioux City, Iowa (1898–2015)	3-12
Figure 3-3. Missouri River Mainstem System Storage Zones and Allocations	3-14
Figure 3-4. Typical System Operation Cycle	3-15
Figure 3-5. Unchannelized Missouri River near the Confluence with the Niobrara River, 17 River Miles Upstream of Lewis and Clark Lake.....	3-17
Figure 3-6. Typical Structures of the Bank Stabilization and Navigation Project in the Lower Missouri River.....	3-18
Figure 3-7. Channelized Missouri River near Little Sioux, Iowa (RM 672), Prior to Implementation of the Deer Island Top Width Widening Project (Looking Downstream)	3-18

Figure 3-8. Common River Channel Geometry in Channelized River; Floodway Location with Respect to Levee and Channel Varies Significantly	3-19
Figure 3-9. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 2, Simulated Based on Hydrologic Conditions in 1966	3-32
Figure 3-10. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 2, Simulated Based on Hydrologic Conditions in 1966.....	3-32
Figure 3-11. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 3, Simulated Based on Hydrologic Conditions in 1963	3-33
Figure 3-12. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 3, Simulated Based on Hydrologic Conditions in 1963.....	3-34
Figure 3-13. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 4, Simulated Based on Hydrologic Conditions in 1974	3-35
Figure 3-14. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 5, Simulated Based on Hydrologic Conditions in 1974	3-35
Figure 3-15. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1975.....	3-36
Figure 3-16. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1974	3-36
Figure 3-17. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1, 4, and 5, Simulated Based on Hydrologic Conditions in 1975	3-37
Figure 3-18. Flows of Missouri River at Gavins Point Dam, Omaha, and Kansas City under Alternatives 1 and 6, Simulated Based on Hydrologic Conditions in 1975	3-38
Figure 3-19. Elevations in Fort Peck Lake, Lake Sakakawea, and Lake Oahe under Alternatives 1 and 6, Simulated Based on Hydrologic Conditions in 1975.....	3-39
Figure 3-20. Shovelnose Sturgeon (left) and Pallid Sturgeon (right)	3-55
Figure 3-21. Pallid Sturgeon Natural Geographic Distribution (A) and Current Distribution (B).....	3-57
Figure 3-22. Documented Pallid Sturgeon Spawning Sites in the Lower Missouri River (2007–2014)	3-60
Figure 3-23. Northern Great Plains Piping Plover Adult	3-84

Figure 3-24. Interior Least Tern Adults	3-85
Figure 3-25. Geographic Scope of USACE Management for Terns and Plovers	3-86
Figure 3-26. Map of Piping Plover Breeding Populations	3-88
Figure 3-27. Map of Interior Least Tern Breeding Range	3-89
Figure 3-28. Estimated Acreage of Available Emergent Sandbar Habitat (1998–2013).....	3-90
Figure 3-29. Piping Plover Adult Census and Fledge Ratios for Missouri River (1993–2015)	3-92
Figure 3-30. Interior Least Tern Adult Census and Fledge Ratios for the Missouri River (1993–2015).....	3-93
Figure 3-31. Overall Change from Alternative 1 in Fish and Wildlife Habitat Classes	3-115
Figure 3-32. Overall Change from Alternative 1 in Wetland Habitat Classes	3-115
Figure 3-33. Overwintering Late Period Overall Change from Alternative 1 in Acres of Depth Classes	3-115
Figure 3-34. Early Spawning Period Overall Change from Alternative 1 in Acres of Depth Classes.....	3-116
Figure 3-35. Late Spawning Period Overall Change from Alternative 1 in Acres of Depth Classes.....	3-116
Figure 3-36. Summer Rearing Period Overall Change from Alternative 1 in Acres of Depth Classes	3-117
Figure 3-37. Overwintering Period Overall Change from Alternative 1 in Acres of Depth Classes.....	3-117
Figure 3-38. Modeled Acres of Fish and Wildlife Habitat Classes for Alternative 1	3-121
Figure 3-39. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River	3-124
Figure 3-40. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River	3-124
Figure 3-41. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River	3-128
Figure 3-42. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River	3-129
Figure 3-43. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River	3-131
Figure 3-44. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River	3-131

Figure 3-45. Modeled Changes in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River	3-134
Figure 3-46. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River	3-134
Figure 3-47. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Upper River	3-137
Figure 3-48. Modeled Change in Acres of Fish and Wildlife Habitat Classes Compared to Alternative 1 – Lower River	3-137
Figure 3-49. Whooping Crane Sighting Corridor.....	3-145
Figure 3-50. Missouri River Floodplain	3-210
Figure 3-51. Missouri River Average Annual Tonnage Dredged from 2010 to 2015	3-246
Figure 3-52. North American Reliability Corporations Interconnections	3-329
Figure 3-53. Percent of Nameplate Capacity to Total Capacity by Generating Source for Extended Midwest Reliability Organization Region (1990–2013).....	3-330
Figure 3-54. Average Monthly Generation in Gigawatt Hours (GWh) (1968–2014) for USACE Hydropower Facilities on the Missouri River Mainstem	3-331
Figure 3-55. Example Hourly Summer and Winter Generation Schedule for USACE Hydropower Facilities on the Missouri River Mainstem.....	3-332
Figure 3-56. Western Area Power Administration 2015 Firm Sales by Customer	3-333
Figure 3-57. Map of Navigable Portion of the Missouri River	3-384
Figure 3-58. Total Navigation Tonnage and System Supported Length of Season (1960– 2014)	3-385
Figure 3-59. Commercial Tonnage by Category, 1960–2014	3-387
Figure 3-60. Five-Year Average (2010–2014) Annual Tonnage including Sand and Gravel by River Segment	3-388
Figure 3-61. Relationship between Navigation Service Level Flows and Navigation Benefits	3-418
Figure 3-62. Map of Reservations Located Within or Around the Missouri River Basin	3-538
Figure 3-63. Mean Annual Discharge Rates for the Missouri River and Mississippi River at their Confluence in St Louis, Missouri	3-586
Figure 3-64. Daily Average Middle Mississippi River Flows and Stages at St. Louis over the Period 1967 to 2015	3-587
Figure 3-65. Average Planform Width of the Middle Mississippi River from 1817 to 2011 ...	3-589
Figure 3-66. Flows of Missouri River at Hermann, MO, and flows and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under	

Alternative 1 and Alternative 2, simulated based on hydrologic conditions in year 1966.....	3-592
Figure 3-67. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 4, simulated based on hydrologic conditions in year 1974.....	3-593
Figure 3-68. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 5, simulated based on hydrologic conditions in year 1974.....	3-593
Figure 3-69. Flows of Missouri River at Hermann, MO, and flow and stage at St. Louis, MO (downstream of the confluence with the Missouri River) under Alternative 1 and Alternative 6, simulated based on hydrologic conditions in year 1975.....	3-594
Figure 3-70. Total Annual Tons Travel and 15-Year Average on Middle Mississippi	3-610
Figure 3-71. Ten-Year (2005 to 2014) Average Tons Received and Shipped by State for Commodities Traveling on Middle Mississippi River	3-612
Figure 4-1. Simplified Depiction of the Adaptive Management Process	4-2
Figure 4-2. Four-Level Pallid Sturgeon Framework	4-5
Figure 4-3. Overview of Decision Criteria for Various Decisions in the Pallid Sturgeon Framework	4-5
Figure 4-4. Proposed Schedule for Implementation of Actions in Upper Missouri River	4-7
Figure 4-5. Proposed Schedule for Implementation of Actions in Lower Missouri River	4-8
Figure 4-6. Workflow for Decision to Move between Pallid Sturgeon Implementation Levels	4-16
Figure 4-7. Factors Affecting Adaptive Management Decisions for Birds and the Nature of those Decisions	4-18
Figure 4-8. Standardized (squares) and Available Acreage Exceedance Targets (circles) with Confidence Bounds (light blue squares, dashed lines)	4-24
Figure 4-9. Proposed Governance Structure for Adaptive Management of the Missouri River Recovery Program	4-26
Figure 4-10. General Engagement Process for Science and Development of the Work Plan	4-28
Figure 4-11. Integration of the National Environmental Policy Act and Environmental Compliance Process in the Adaptive Management Framework.....	4-34

List of Tables

Table 1-1. Piping Plover Targets for Sub-Objective 2.....	1-24
Table 2-1. Least Tern and Piping Plover Management Hypotheses and Associated General Management Actions.....	2-5
Table 2-2. Upper River Pallid Sturgeon Management Hypotheses and Associated General Management Actions.....	2-7
Table 2-3. Lower River Pallid Sturgeon Management Hypotheses and Associated General Management Actions.....	2-7
Table 2-4. Lower River Pallid Sturgeon Limiting Factors Associated with the Management Hypotheses	2-33
Table 2-5. Lower River Pallid Sturgeon Limiting Factors	2-34
Table 2-6. Pallid Sturgeon Framework for Lower River	2-37
Table 2-7. Flow Duration Needed to Create 500 acres of Emergent Sandbar Habitat as a Function of Existing Emergent Sandbar Habitat.....	2-41
Table 2-8. Bird “Test Alternatives”	2-42
Table 2-9. Round 1 Bird Alternatives	2-43
Table 2-10. Round 2 Bird Alternatives	2-45
Table 2-11. Summary of Features Comprising the MRRMP-EIS Alternatives Carried Forward for Detailed Consideration.....	2-51
Table 2-12. Summary of Emergent Sandbar Habitat Construction by Alternative	2-53
Table 2-13. Summary of Projected Shallow Water Habitat Creation Under Alternative 1	2-56
Table 2-14. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 1	2-56
Table 2-15. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 1.....	2-57
Table 2-16. Downstream Flow Limits During the Spring Pulse Under the No Action Alternative	2-58
Table 2-17. Summary of Projected Shallow Water Habitat Creation Under Alternative 2	2-62
Table 2-18. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 2	2-62
Table 2-19. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 2.....	2-63
Table 2-20. Summary of Projected Channel Widening Under Alternatives 3–6	2-68

Table 2-21. Land Acquisition Requirements to Implement Channel Widening Under Alternatives 3–6.....	2-69
Table 2-22. Downstream Flow Limits During Habitat-Creating Release.....	2-70
Table 2-23. Estimated Durations of Habitat-Creating Flow Release.....	2-70
Table 2-24. Relation of Target Discharges to Service Level.....	2-70
Table 2-25. Full-Service Flood Target Flows	2-71
Table 2-26. Minimum-Service Flood Target Flows	2-71
Table 2-27. Example Navigation and Flood Target Discharges for a 40.0 kcfs Service Level Under Current Operations	2-72
Table 2-28. Alternative 6 March Pulse Downstream Flow Limits.....	2-73
Table 2-29. Alternative 6 May Pulse Downstream Flow Limits.....	2-74
Table 2-30. Absolute Values of the Alternatives	2-76
Table 2-31. Summary of the Alternatives Impacts (Alternative Absolute Value Minus Alternative 1 Absolute Value).....	2-77
Table 3-1. Cumulative Actions and Potential Impacts to Resources in the Project Area.....	3-7
Table 3-2. Inter-Reservoir Reaches in Upper Missouri River	3-16
Table 3-3. Environmental Consequences Relative to River Infrastructure and Hydrologic Processes.....	3-26
Table 3-4. Summary of Releases Simulated under the Six Alternatives over the Period of Record	3-27
Table 3-5. Summary of Influence of Climate Change on Alternatives	3-50
Table 3-6. Pallid Sturgeon Life Stages	3-58
Table 3-7. Existing Shallow Water Habitat Acres	3-64
Table 3-8. Environmental Consequences Relative to Pallid Sturgeon	3-66
Table 3-9. Summary of Environmental Consequences Related to Piping Plover.....	3-97
Table 3-10. Missouri River Study Reaches.....	3-108
Table 3-11. Flow Occurrences Below 9,000 cfs in the Fort Randall to Gavins Point Reach	3-113
Table 3-12. Environmental Consequences Relative to Fish and Wildlife	3-114
Table 3-13. Total Acres of Modeled Fish and Wildlife Habitat Classes under Alternative 1 ..	3-119
Table 3-14. Modeled Acres of Depth Classes for Alternative 1	3-119
Table 3-15. Summary of Impacts to Other Special-Status Species	3-150

Table 3-16. Mean Monthly Water Temperature (°C) in the Inter-Reservoir Reaches (2012–2014)	3-183
Table 3-17. Mean Monthly Dissolved Oxygen Concentrations (mg/L) in the Inter- Reservoir Reaches (2012–2014)	3-184
Table 3-18. Turbidity and Nutrients in the Inter-Reservoir Reaches (2010–2014).....	3-185
Table 3-19. Mean Monthly Water Temperature (°C) in the Lower Missouri River	3-188
Table 3-20. Mean Monthly Dissolved Oxygen Concentrations (mg/L) in the Lower Missouri River.....	3-188
Table 3-21. Turbidity in the Lower Missouri River (2012–2014)	3-189
Table 3-22. Nutrient Concentrations in the Lower Missouri River (2012–2014)	3-190
Table 3-23. Environmental Consequences for Water Quality	3-192
Table 3-24. Recorded Cultural Resource Sites in Analysis	3-209
Table 3-25. Affected Sites (Outside Normal Pool Elevation)	3-213
Table 3-26. Summary of Affected Floodplain Sites.....	3-214
Table 3-27. Total Number of Individual Reservoir Sites Affected	3-215
Table 3-28. Total Number of Individual Riverine Sites Affected	3-215
Table 3-29. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 2, Compared to Alternative 1 (Modeled over the POR).....	3-218
Table 3-30. Change in Risk to Sites within Riverine Reaches for Alternative 2, Compared to Alternative 1 (Modeled over the POR).....	3-219
Table 3-31. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 3, Compared to Alternative 1 (Modeled over the POR).....	3-220
Table 3-32. Change in Risk to Sites within Riverine Reaches for Alternative 3, Compared to Alternative 1 (Modeled over the POR).....	3-221
Table 3-33. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 4, Compared to Alternative 1 (Modeled over the POR).....	3-222
Table 3-34. Change in Risk to Sites within Riverine Reaches for Alternative 4, Compared to Alternative 1 (Modeled over the POR).....	3-222
Table 3-35. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 5, Compared to Alternative 1 (Modeled over the POR).....	3-224
Table 3-36. Change in Risk to Sites within Riverine Reaches for Alternative 5, Compared to Alternative 1 (Modeled over the POR).....	3-224
Table 3-37. Change in Risk to Sites within the Mainstem Reservoir System for Alternative 6, Compared to Alternative 1 (Modeled over the POR).....	3-225

Table 3-38. Change in Risk to Sites within Riverine Reaches for Alternative 6, Compared to Alternative 1 (Modeled over the POR).....	3-226
Table 3-39. Land Cover Acres as Percent of Missouri River Floodplain.....	3-229
Table 3-40. Protected Federal, State, and Native American Lands, and Other Conservation and Recreation Lands in the Floodplain, 2012.....	3-231
Table 3-41. Percent of Agriculture Acreage by Crop in the Missouri River Floodplain by State	3-233
Table 3-42. Environmental Consequences Relative to Land Acquisition, 2016 Dollars	3-236
Table 3-43. Reduction in Regional Economic Activity from Agricultural Land Acquisition under Alternative 1, 2016 Dollars	3-237
Table 3-44. Change in Property Tax under Alternative 1 from Agricultural Land Acquisition, 2016 Dollars	3-237
Table 3-45. Change in Regional Economic Activity under Alternative 2 Relative to Alternative 1, 2016 Dollars	3-239
Table 3-46. Change in Property Tax under Alternative 2 Relative to Alternative 1, 2016 Dollars	3-240
Table 3-47. Change in Regional Economic Activity under Alternatives 3–6 Relative to Alternative 1, 2016 Dollars	3-241
Table 3-48. Change in Property Tax per Year under Alternatives 3–6 Relative to Alternative 1, 2016 Dollars	3-242
Table 3-49. Annual Production of Construction Sand and Gravel from the Missouri River (2010–2015), Production in Tons	3-246
Table 3-50. Dredging Permits by Ton until 2020 (Measured in Tons)	3-247
Table 3-51. Environmental Consequences Relative to Commercial Sand and Gravel Dredging	3-251
Table 3-52. Sediment Accumulation Compiled by Reach: Alternative 1.....	3-252
Table 3-53. Sediment Accumulation Compiled by Reach: Alternative 2.....	3-253
Table 3-54. Sediment Accumulation Compiled by Reach: Alternative 3.....	3-255
Table 3-55. Sediment Accumulation Compiled by Reach: Alternative 4.....	3-256
Table 3-56. Sediment Accumulation Compiled by Reach: Alternative 5.....	3-258
Table 3-57. Sediment Accumulation Compiled by Reach: Alternative 6.....	3-259
Table 3-58. Population and Estimated Structure Value of the Floodplain by River Reach....	3-262
Table 3-59. Infrastructure in the Missouri River Floodplain	3-263
Table 3-60. Population and Structure Value at Risk for Tribal Reservations.....	3-264

Table 3-61. Environmental Consequences Relative to Flood Risk Management.....	3-267
Table 3-62. Frequency of Releases Simulated to Equal or Exceed Channel Capacity	3-269
Table 3-63. Summary of Damages for No Action	3-270
Table 3-64. RED Effects Associated with Agricultural Damage: No Action, 2016 Dollars	3-273
Table 3-65. Population at Risk under No Action	3-274
Table 3-66. Critical Infrastructure Impacted under No Action	3-274
Table 3-67. Summary of National Economic Development Analysis for Alternative 2	3-276
Table 3-68. Impacts from Modeled Flow Releases under Alternative 2 Compared to No Action	3-278
Table 3-69. RED Impacts Associated with Agricultural Damage under Alternative 2 and Compared to No Action, 2016 Dollars	3-280
Table 3-70. Population at Risk under Alternative 2.....	3-281
Table 3-71. Critical Infrastructure Impacted under Alternative 2.....	3-281
Table 3-72. Summary of National Economic Development Analysis for Alternative 3.....	3-283
Table 3-73. RED Impacts Associated with Agricultural Damage under Alternative 3 Compared to No Action, 2016 Dollars	3-285
Table 3-74. Population at Risk under Alternative 3.....	3-286
Table 3-75. Critical Infrastructure Impacted under Alternative 3.....	3-286
Table 3-76. Summary of National Economic Development Analysis for Alternative 4	3-288
Table 3-77. Impacts from Modeled Flow Releases under Alternative 4 Compared to No Action	3-289
Table 3-78. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 4 Compared to No Action, 2016 Dollars	3-291
Table 3-79. Population at Risk under Alternative 4.....	3-292
Table 3-80. Critical Infrastructure Impacted under Alternative 4.....	3-293
Table 3-81. Summary of National Economic Development Analysis for Alternative 5.....	3-294
Table 3-82. Impacts from Modeled Flow Releases under Alternative 5 Compared to No Action	3-295
Table 3-83. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 5 Compared to No Action, 2016 Dollars	3-297
Table 3-84. Population at Risk under Alternative 5.....	3-298
Table 3-85. Critical Infrastructure Impacted under Alternative 5.....	3-298

Table 3-86. Summary of National Economic Development Analysis for Alternative 6.....	3-300
Table 3-87. Impacts from Modeled Flow Releases under Alternative 6 Compared to No Action	3-301
Table 3-88. Regional Economic Development Impacts Associated with Agricultural Damage under Alternative 6 Compared to No Action, 2016 Dollars	3-303
Table 3-89. Population at Risk under Alternative 6.....	3-304
Table 3-90. Critical Infrastructure Impacted under Alternative 6.....	3-305
Table 3-91. Impacts to Tribal Reservations	3-306
Table 3-92. Discussion of Risk to Flood Risk Management from Climate Change Variables for No Action and Alternative 2	3-307
Table 3-93. Discussion of Risk to Flood Risk Management from Climate Change Variables for Alternative 3	3-308
Table 3-94. Discussion of Risk to Flood Risk Management from Climate Change Variables for Alternative 4, Alternative 5, and Alternative 6	3-308
Table 3-95. Environmental Consequences Relative to Interior Drainage	3-312
Table 3-96. Summary of Interior Drainage Impacts under No Action	3-314
Table 3-97. No Action PAR at Interior Drainage Sites	3-314
Table 3-98. Summary of Interior Drainage National Economic Development Analysis for Alternative 2	3-315
Table 3-99. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 2	3-316
Table 3-100. Alternative 2 PAR at Interior Drainage Sites.....	3-316
Table 3-101. Summary of Interior Drainage National Economic Development Analysis for Alternative 3	3-317
Table 3-102. Alternative 3 PAR at Interior Drainage Sites.....	3-317
Table 3-103. Summary of Interior Drainage National Economic Development Analysis for Alternative 4	3-318
Table 3-104. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 4	3-319
Table 3-105. Alternative 4 PAR at Interior Drainage Sites.....	3-319
Table 3-106. Summary of Interior Drainage National Economic Development for Alternative 5	3-320
Table 3-107. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 5	3-321

Table 3-108. Alternative 5 PAR at Interior Drainage Sites.....	3-321
Table 3-109. Summary of Interior Drainage National Economic Development Analysis for Alternative 6	3-322
Table 3-110. Alternative 6 Population at Risk.....	3-322
Table 3-111. Impacts from Modeled Flow Releases on Interior Drainage under Alternative 6	3-323
Table 3-112. Discussion of Risk to Interior Drainage from Climate Change Variables for No Action and Alternative 2	3-324
Table 3-113. Discussion of Risk to Interior Drainage from Climate Change Variables for Alternative 3	3-325
Table 3-114. Discussion of Risk to Interior Drainage from Climate Change Variables for Alternative 4, Alternative 5, and Alternative 6.....	3-325
Table 3-115. Hydropower Plant Characteristics for USACE Projects on the Mainstem of the Missouri River.....	3-328
Table 3-116. Consequences Relative to Hydropower	3-335
Table 3-117. Summary of Hydropower National Economic Development Analysis for Alternative 1 (2016 Dollars).....	3-337
Table 3-118. Summary of National Economic Development Analysis for Alternative 2 (2016 Dollars).....	3-339
Table 3-119. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1 (2016 Dollars).....	3-340
Table 3-120. Summary of Other Social Effects Analysis for Alternative 2	3-341
Table 3-121. Summary of National Economic Development Analysis for Alternative 3 (2016 Dollars).....	3-342
Table 3-122. Summary of Other Social Effects Analysis for Alternative 3	3-344
Table 3-123. Summary of National Economic Development Analysis for Alternative 4 (2016 Dollars).....	3-345
Table 3-124. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1 (2016 Dollars).....	3-346
Table 3-125. Summary of Other Social Effects Analysis for Alternative 4	3-347
Table 3-126. Impacts from Modeled Flow Releases under Alternative 5 (2016 Dollars).....	3-349
Table 3-127. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1 (2016 Dollars).....	3-349
Table 3-128. Summary of Other Social Effects Analysis for Alternative 5	3-351
Table 3-129. Impacts from Modeled Flow Releases under Alternative 6 (2016 Dollars).....	3-352

Table 3-130. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1 (2016 Dollars)	3-352
Table 3-131. Summary of Other Social Effects Analysis for Alternative 6	3-354
Table 3-132. Precipitation, Irrigated Crop Acreage, and Intakes for the 42-County Area.....	3-357
Table 3-133. Irrigation Intakes and Permitted Acres by State	3-359
Table 3-134. Harvested Acres Irrigated in the 42-County Area, 2012	3-359
Table 3-135. Estimated Harvested Crop Acreage Irrigated by Missouri River, 2015.....	3-360
Table 3-136. Environmental Consequences Relative to Irrigation, 2016 Dollars.....	3-362
Table 3-137. National Economic Development Analysis for Alternative 1, 2016 Dollars	3-365
Table 3-138. RED Analysis for Average Revenue Year for Irrigated Agriculture Using Missouri River Water - Alternative 1, 2016 Dollars.....	3-365
Table 3-139. Summary of National Economic Development Analysis for Alternative 2, 2016 Dollars	3-367
Table 3-140. Impacts from Modeled Flow Releases to Net Farm Income in the Eight County Area under Alternative 2 Compared to Alternative 1, 2016 Dollars ...	3-367
Table 3-141. Economic Benefits of Irrigated Agriculture Production - Alternative 2, 2016 Dollars	3-368
Table 3-142. Summary of National Economic Development Analysis for Alternative 3, 2016 Dollars	3-370
Table 3-143. Economic Benefits of Irrigated Agriculture Production - Alternative 3, 2016 Dollars	3-371
Table 3-144. Summary of National Economic Development Analysis for Alternative 4, 2016 Dollars	3-372
Table 3-145. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 4 Compared to Alternative 1, 2016 Dollars	3-373
Table 3-146. Economic Benefits of Irrigated Agriculture Production - Alternative 4, 2016 Dollars	3-374
Table 3-147. Summary of National Economic Development Analysis for Alternative 5, 2016 Dollars	3-375
Table 3-148. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 5 Compared to Alternative 1, 2016 Dollars	3-376
Table 3-149. Economic Benefits of Irrigated Agriculture Production: Alternative 5, 2016 Dollars	3-376
Table 3-150. Summary of National Economic Development Analysis for Alternative 6, 2016 Dollars	3-378

Table 3-151. Impacts to Net Farm Income in the Eight County Area from Modeled Flow Releases under Alternative 6 Compared to Alternative 1.....	3-378
Table 3-152. Economic Benefits of Irrigated Agriculture Production - Alternative 6, 2016 Dollars	3-379
Table 3-153. Percentage of Average Sand and Gravel Tonnage (2010 to 2014)	3-385
Table 3-154. Relation of Service Level to the Volume of Water in System Storage	3-389
Table 3-155. Relation of System Storage to Season Length.....	3-390
Table 3-156. Season Open and Close Dates for Missouri River Sections.....	3-390
Table 3-157. Environmental Consequences Relative to Navigation	3-392
Table 3-158. Transportation Savings, R, R, & R costs, and Net NED for Alternative 1 (2016 \$)	3-395
Table 3-159. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 1 (thousands of 2016\$)	3-396
Table 3-160. Baseline Tonnage off the Water and Total and Annual Change in Emissions for Alternative 1 by Reach.....	3-397
Table 3-161. Transportation Savings, R, R, & R Costs, and Net NED for Alternative 2 (2016 \$)	3-398
Table 3-162. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1	3-399
Table 3-163. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 2 and Compared to Alternative 1 (Thousands of 2016 Dollars) ...	3-400
Table 3-164. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 2 by Reach	3-401
Table 3-165. Transportation Savings, R, R, & R costs, and Net NED for Alternative 3 (2016 \$)	3-402
Table 3-166. Impacts from Modeled Flow Releases under Alternative 3 Compared to Alternative 1	3-403
Table 3-167. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 3 and Compared to Alternative 1 (Thousands of 2016 Dollars) ...	3-403
Table 3-168. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 3 and Alternative 5 By Reach	3-404
Table 3-169. Transportation Savings, R, R, & R costs, and Net NED for Alternative 4 (FY 2016 \$)	3-405
Table 3-170. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1	3-406

Table 3-171. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 4 and Compared to Alternative 1 (thousands of 2016\$).....	3-407
Table 3-172. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 4 by Reach	3-408
Table 3-173. Transportation Savings; R, R, & R costs, and Net NED for Alternative 5 (2016 \$)	3-409
Table 3-174. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1	3-410
Table 3-175. Years within Alternative 5 with Fall Release and Impacts in Proceeding Years	3-410
Table 3-176. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 5 and Compared to Alternative 1 (thousands of 2016\$).....	3-411
Table 3-177. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 3 and Alternative 5 by Reach	3-412
Table 3-178. Transportation Savings; R, R, & R costs, and Net NED for Alternative 6 (2016 \$)	3-413
Table 3-179. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1	3-414
Table 3-180. Years with Full or Partial Spawning Cue Releases in Alternative 6.....	3-414
Table 3-181. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 6 and Compared to Alternative 1 (thousands of 2016 \$).....	3-415
Table 3-182. Tonnage off the Water and Total and Annual Change in Emissions for Alternative 6 by Reach	3-416
Table 3-183. Discussion of Risk to Navigation from Climate Change Variables for Alternatives 1–6.....	3-418
Table 3-184. Annual Recreation Visitor Days on the Reservoirs, 2012	3-422
Table 3-185. Average Annual Visitation on the Reservoirs during Low, Middle, and High Water Years	3-422
Table 3-186. Recreation Facilities at Mainstem Reservoirs.....	3-423
Table 3-187. Residency of Visitors to the Reservoirs	3-424
Table 3-188. Recreation Facilities at Inter-Reservoir River Reaches	3-425
Table 3-189. Average Annual Visits to Inter-Reservoir River Reaches	3-425
Table 3-190. Recreation Visitor Days in the Inter-Reservoir River Reaches, 2009	3-425
Table 3-191. Recreation Facilities in the Lower River	3-427
Table 3-192. Annual Visits to the Lower River, 2004	3-427

Table 3-193. Recreation Visitor Days in the Lower River, 2004	3-428
Table 3-194. Summary of Environmental Consequences for Recreation	3-432
Table 3-195. Summary of National Economic Development Analysis for Alternative 1, 1932–2012 (thousands of 2016 dollars)	3-436
Table 3-196. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 1 (thousands of 2016 Dollars)	3-437
Table 3-197. Summary of National Economic Development Analysis for Alternative 2, 1932–2012 (thousands of 2016 dollars)	3-440
Table 3-198. Changes in NED Benefits from Flow Releases under Alternative 2 Compared to Alternative 1 (thousands of 2016 dollars)	3-441
Table 3-199. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 2 Relative to Alternative 1 (Thousands of 2016 Dollars)	3-442
Table 3-200. Summary of National Economic Development Analysis for Alternative 3, 1932–2012 (thousands of 2016 dollars)	3-445
Table 3-201. Economic Benefits of Non-Local Visitor Spending at the Three Reservoirs under Alternative 3 (thousands of 2016 Dollars)	3-445
Table 3-202. Summary of National Economic Development Analysis for Alternative 4, 1932–2012 (thousands of 2016 dollars)	3-449
Table 3-203. Changes in NED Benefits from Flow Releases under Alternative 4 Compared to Alternative 1 (thousands of 2016 dollars)	3-449
Table 3-204. Economic Benefits of Non-Local Visitor Spending for the Reservoirs under Alternative 4 Relative to Alternative 1 (Thousands of 2016 Dollars)	3-450
Table 3-205. Summary of National Economic Development Analysis for Alternative 5, 1932–2012 (thousands of 2016 dollars) Benefits or Costs	3-453
Table 3-206. Changes in NED Benefits from Flow Releases under Alternative 5 Compared to Alternative 1 (thousands of 2016 dollars)	3-454
Table 3-207. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 5 (thousands of 2016 Dollars)	3-455
Table 3-208. Summary of National Economic Development Analysis for Alternative 6, 1932–2012 (thousands 2016 dollars)	3-457
Table 3-209 Changes in NED Benefits from Flow Releases under Alternative 6 Compared to Alternative 1 Thousands of 2016 dollars)	3-458
Table 3-210. Economic Benefits of Non-Local Visitor Spending at the Reservoirs under Alternative 6 Relative to Alternative 1 (Thousands of 2016 Dollars)	3-459
Table 3-211. Gross Capacity of Missouri River Power Plants	3-465

Table 3-212. Average Daily Net Generation for Missouri River Thermal Power Plants by Season	3-466
Table 3-213. Environmental Consequences Relative to Thermal Power.....	3-470
Table 3-214. Summary of National Economic Development Analysis for Alternative 1	3-473
Table 3-215. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 1	3-474
Table 3-216. Summary of National Economic Development Analysis for Alternative 2.....	3-478
Table 3-217. Impacts from Flow Releases under Alternative 2 Compared to Alternative 1...3-479	
Table 3-218. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 2	3-480
Table 3-219. Summary of National Economic Development Analysis for Alternative 3.....	3-482
Table 3-220. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 3	3-484
Table 3-221. Summary of National Economic Development Analysis for Alternative 4.....	3-486
Table 3-222. Impacts from Flow Releases under Alternative 4 Compared to No Action	3-487
Table 3-223. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 4	3-488
Table 3-224. Summary of National Economic Development Analysis for Alternative 5.....	3-490
Table 3-225. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 5	3-491
Table 3-226. Summary of National Economic Development Analysis for Alternative 6.....	3-493
Table 3-227. Impacts from Flow Releases under Alternative 6 Compared to No Action	3-494
Table 3-228. Missouri River Power Plant Worst-Case Season Reduction in Power Generation as a Percent of RTO Power Generation with No Adverse Conditions under Alternative 6	3-495
Table 3-229. Number of Water Supply Intakes by River/Reservoir Location.....	3-500
Table 3-230. Range of Flow and Elevations Associated with Municipal and Commercial/Industrial Water Supply Intakes.....	3-502
Table 3-231. Environmental Consequences Relative to Water Supply	3-505
Table 3-232. Summary of National Economic Development Analysis for Alternative 1	3-508

Table 3-233. Summary of National Economic Development Analysis for Alternative 2.....	3-510
Table 3-234. Impacts from Modeled Flow Releases under Alternative 2 Compared to Alternative 1	3-511
Table 3-235. Summary of National Economic Development Analysis for Alternative 3.....	3-513
Table 3-236. Summary of National Economic Development Analysis for Alternative 4.....	3-514
Table 3-237. Impacts from Modeled Flow Releases under Alternative 4 Compared to Alternative 1	3-516
Table 3-238. Summary of National Economic Development Analysis for Alternative 5.....	3-517
Table 3-239. Impacts from Modeled Flow Releases under Alternative 5 Compared to Alternative 1	3-518
Table 3-240. Summary of National Economic Development Analysis for Alternative 6.....	3-520
Table 3-241. Impacts from Modeled Flow Releases under Alternative 6 Compared to Alternative 1	3-521
Table 3-242. Missouri River Major Wastewater Facilities	3-525
Table 3-243. Critical Low-Flow Conditions Used to Determine Discharge Limits for National Pollutant Discharge Elimination System Permits	3-527
Table 3-244. Environmental Consequences for Wastewater Facilities.....	3-529
Table 3-245. Tribal Reservation Land within the Missouri River Floodplain	3-539
Table 3-246. Average Hunting and Fishing Days in 2001 by Adult Residents of Missouri River States	3-541
Table 3-247. Consequences Relative to Tribal Interests	3-544
Table 3-248. Incidence of West Nile Virus, St. Louis Encephalitis Virus, and Zika Virus in Mainstem Missouri River States	3-555
Table 3-249. Environmental Consequences Relative to Human Health and Safety	3-558
Table 3-250. Missouri River Basin States Racial Composition and Minority Presence, 2006–2010 5-year Estimates	3-564
Table 3-251. Missouri River Basin States Poverty Levels, 2006–2010 5-year Estimates	3-565
Table 3-252. Missouri River Populations and Environmental Justice Populations, 2006– 2010 5-year Estimates	3-565
Table 3-253. Environmental Justice Populations Located in Missouri River Floodplain in Montana, 2006–2010 5-year Estimates.....	3-566
Table 3-254. Environmental Justice Populations Located in Missouri River Floodplain in North Dakota, 2006–2010 5-year Estimates	3-566

Table 3-255. Environmental Justice Populations Located in Missouri River Floodplain in South Dakota, 2006–2010 5-year Estimates	3-567
Table 3-256. Environmental Justice Populations Located in Missouri River Floodplain in Iowa, 2006–2010 5-year Estimates	3-567
Table 3-257. Environmental Justice Populations Located in Missouri River Floodplain in Nebraska, 2006–2010 5-year Estimates	3-568
Table 3-258. Environmental Justice Populations Located in Missouri River Floodplain in Kansas, 2006–2010 5-year Estimates.....	3-568
Table 3-259. Environmental Justice Populations Located in Missouri River Floodplain in Missouri, 2006–2010 5-year Estimates	3-569
Table 3-260. Environmental Consequences to Environmental Justice Populations	3-570
Table 3-261. Environmental Consequences for Ecosystem Services	3-579
Table 3-262. Changes in Aquatic/Floodplain Habitat Classes	3-580
Table 3-263. Annual Exceedance Probability: Mississippi River at St. Louis, Missouri	3-588
Table 3-264. Stages with Action Levels for Navigation at St. Louis, Missouri	3-590
Table 3-265. Environmental Consequences Relative to River Infrastructure and Hydrologic Processes	3-590
Table 3-266. Median Monthly Stage (feet) in 2014 and Chokepoint Elevations for Each of the Three Side Channels.....	3-596
Table 3-267. Environmental Consequences Relative to Biological Resources	3-597
Table 3-268. Alternative 1 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels.....	3-598
Table 3-269. Alternative 2 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels.....	3-598
Table 3-270. Alternative 3 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels.....	3-599
Table 3-271. Alternative 4 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels.....	3-600
Table 3-272. Alternative 5 Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels	3-601
Table 3-273. Alternative 6 Modeled Average Monthly Stages (feet) at the St. Louis Gage with Connectivity Status for Each of the Evaluated Side Channels.....	3-602
Table 3-274. Population and Estimated Structure Value of the Middle Mississippi River Floodplain	3-603
Table 3-275. Percent of Agriculture Acreage by Crop in the Middle Mississippi River	3-603

Table 3-276. Critical Infrastructure at Risk in the Middle Mississippi River.....	3-603
Table 3-277. Environmental Consequences Relative to Flood Risk Management.....	3-605
Table 3-278. Summary of National Economic Development Analysis	3-606
Table 3-279. Summary of Population at Risk	3-606
Table 3-280. St. Louis Flow Frequency Alternatives Comparison	3-609
Table 3-281. Middle Mississippi River Waterborne Tonnage by Commodity and Year (in thousands of tons).....	3-611
Table 3-282. Top Three Origin and Destination Pairs for Commodities Traveling on the Middle Mississippi	3-613
Table 3-283. Middle Mississippi River Commodity Tonnages by Draft Depth (in thousands of tons).....	3-613
Table 3-284. Difference in Average Tonnage Affected by Periods Below -3 on St. Louis Gage Between Alternative 1 and Other Alternatives	3-615
Table 3-285. Alternative 1 Affected Tons Statistics by Month	3-616
Table 3-286. Alternative 2 Affected Tons Statistics by Month	3-617
Table 3-287. Alternative 3 Affected Tons Statistics By Month	3-618
Table 3-288. Alternative 4 Affected Tons Statistics by Month	3-620
Table 3-289. Alternative 5 Affected Tons Statistics by Month	3-621
Table 3-290. Alternative 6 Affected Tons Statistics by Month	3-622
Table 3-291. Thermal Plants and Water Supply Intakes along the Middle Mississippi River	3-624
Table 3-292. Environmental Consequences Relative to Water Supply and Thermal Power	3-626
Table 3-293. Impacts of Alternative 1 on Water Supply and Thermal Power Intakes	3-626
Table 3-294. Impacts of Alternative 2 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in St. Louis	3-627
Table 3-295. Impacts of Alternative 3–6 Relative to Alternative 1 on Water Supply and Thermal Power Facilities in St. Louis	3-628
Table 3-296. RED Environmental Consequences for Program Expenditures	3-631
Table 3-297. Annual Economic Benefits of Program Expenditures – Alternative 1	3-632
Table 3-298. Annual Economic Benefits of Program Expenditures – Alternative 2	3-633
Table 3-299. Annual Economic Benefits of Program Expenditures – Alternative 3	3-634
Table 3-300. Annual Economic Benefits of Program Expenditures – Alternative 4	3-635

Table 3-301. Annual Economic Benefits of Program Expenditures – Alternative 5	3-636
Table 3-302. Annual Economic Benefits of Program Expenditures – Alternative 6	3-637
Table 3-303. Unavoidable Adverse Impacts to Resources	3-638
Table 4-1. Summary of Time Limits for Level 3 Implementation and Scope of Actions.....	4-9
Table 4-2. Metrics for Implementation, Process / Action Effectiveness and Population Monitoring for Level 2 and Level 3 Actions.....	4-10
Table 4-3. Summary of Methods for Evaluating the Effectiveness of Level 3 Actions (some of these actions also have Level 2 management experiments).....	4-13
Table 4-4. Supplemental Lines of Evidence Strategy for Triggering Level 3 Implementation	4-15
Table 4-5. Summary of Modeled Construction for the Preferred Alternative	4-19
Table 4-6. Standardized and Available ESH Targets for the Northern and Southern Regions	4-19
Table 4-7. Estimated Cost for the Preferred Alternative	4-31

Acronyms

AIRFA	American Indian Religious Freedom Act
AM	adaptive management
AM Plan	Science and Adaptive Management Plan
BA	biological assessment
BGEPA	Bald and Golden Eagle Protection Act
BiOp	Biological Opinion
BMP	best management practice
BSNP	Missouri River Bank Stabilization and Navigation Project
CAP	Continuing Authority Program
CDC	Centers for Disease Control
CEM	conceptual ecological model
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPUE	catch per unit effort
CSP	Conservation Stewardship Program
CSAPR	Cross-State Air Pollution Rule
CSRP	Comprehensive Sturgeon Research Project
CWA	Clean Water Act
CWMP	comprehensive fish and wildlife habitat management plan
ECHO	EPA Enforcement and Compliance History Online
EGM	Economic Guidance Memorandum
EIA	Energy Information Administration
EIS	environmental impact statement
EJ	environmental justice
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
EQ	environmental quality
EQIP	Environmental Quality Incentives Program
ER	Engineering Regulation
ERDC	Engineering Research and Development Center
ESA	Endangered Species Act
ESH	emergent sandbar habitat
EWPP-FPE	Emergency Watershed Protection Program - Floodplain Easements
EWRP	Emergency Wetland Reserve Program
FCA	1944 Flood Control Act
FL	fork length
FR	Federal Register
FWCA	Fish and Wildlife Coordination Act
FY	fiscal year
gpd	gallons per day
H&H	hydrologic and hydraulic

HBC	hydropower benefits calculator
HC	human considerations
HEC	Hydrologic Engineering Center
HEC-EFM	Hydrologic Engineering Center – Ecosystem Functions Model
HEC-FIA	Hydrologic Engineering Center – Flood Impact Analysis
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEC-ResSim	Hydrologic Engineering Center – Reservoir Simulation
IRC	interception and rearing complex
ISAP	Independent Science Advisory Panel
ISETR	Independent Socio-Economic Technical Review
kcf s	thousands of cubic feet per second
km	kilometers
kWh	kilowatt hours
m/s	meters per second
MAF	million acre-feet
Master Manual	Missouri River Basin Mainstem Reservoir System Master Water Control Manual
MATS	Mercury and Air Toxics Standards
MBTA	Migratory Bird Treaty Act
mg/L	milligram per liter
MISO	Midcontinent Independent System Operator
MNRR	Missouri National Recreational River
MRLS	Missouri River Levee System
MRO	Midwest Reliability Organization
MRRIC	Missouri River Recovery Implementation Committee
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
MRRP	Missouri River Recovery Program
Mt/yr	metric tons per year
MW	megawatt
MWh	megawatt-hour
NAAQS	national ambient air quality standards
NAGPRA	Native American Graves Protection and Repatriation Act
NASS	National Agricultural Statistics Service
NED	National Economic Development
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NHPA	National Historic Preservation Act of 1966
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NSI	National Structure Inventory
NSM	Nutrient Simulation Modules
NTU	Nephelometric Turbidity Units
NWR	National Wildlife Refuge

OMBIL	Operation and Maintenance Business Information Link
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
OSE	other social effects
P.L.	Public Law
PAD-US	Protected Areas Database of the United States
PAR	population at risk
PCB	polychlorinated biphenyl
PDT	project delivery team
PEIS	Programmatic Environmental Impact Statement
PILT	payments in lieu of taxes
POR	period of record
POTW	publicly owned treatment works
PROACT	Problem Definition, Objectives, Alternatives, Consequences, and Tradeoffs
PSCAP	Pallid Sturgeon Conservation Augmentation Program
PSPAP	Pallid Sturgeon Population Assessment Project
R, R, & R	repair, replacement, and rehabilitation
RECONS	Regional Economic System
RED	Regional Economic Development
ResSim	Reservoir System Simulation
RM	river mile
ROD	record of decision
RPA	reasonable and prudent alternative
RPM	reasonable and prudent measure
RTO	Regional Transmission Organization
SCC	social cost of carbon
SEIS	supplemental environmental impact statement
SHPO	State Historic Preservation Officer
SPP	Southwest Power Pool
SWH	shallow water habitat
System	Missouri River Mainstem Reservoir System
TCP	traditional cultural property
THPO	Tribal Historic Preservation Officer
UDV	unit day value
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAPA	Western Area Power Administration
WHIP	Wildlife Habitat Incentive Program
WRDA	Water Resources Development Act
WRP	Wetland Reserve Program

1.0 Purpose, Need, and Problem Definition

1.1 Background

The Kansas City and Omaha Districts of the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS or Management Plan). This document is a programmatic assessment of (1) major federal actions necessary to avoid a finding of jeopardy to the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sterna antillarum athalassos*), and the Northern Great Plains piping plover (*Charadrius melodus*) caused by operation of the Missouri River Mainstem and Kansas River Reservoir System and operation and maintenance of the Missouri River Bank Stabilization and Navigation Project (BSNP) in accordance with the Endangered Species Act (ESA) of 1973, as amended; and (2) the Missouri River BSNP fish and wildlife mitigation plan described in the 2003 Record of Decision (ROD) and authorized by the Water Resources Development Act (WRDA) of 1986, 1999, and 2007. A programmatic approach to NEPA assessment has the value of setting out the broad views of environmental impacts and benefits for groups of related actions which can later be referenced when making site or project specific decisions (CEQ 2014a). A programmatic NEPA review allows an agency to subsequently tier to this analysis, and analyze narrower, site- or proposal-specific issues. This avoids repetitive broad-level analyses in subsequent tiered NEPA reviews and provides a more comprehensive picture of the consequences of multiple proposed actions. The alternatives evaluated in the MRRMP-EIS include actions that could be immediately implemented upon signing a ROD as well as actions that may require additional site- or proposal-specific NEPA assessment prior to later implementation.

The pallid sturgeon, interior least tern, and Northern Great Plains piping plover occupy the Missouri River (Figure 1-1). The pallid sturgeon is a large, long-lived benthic (i.e., bottom-dwelling) fish that inhabits the turbid, fast-flowing rivers of the Missouri and Mississippi River basins. The interior least tern and piping plover are migratory birds that occur on the Missouri River during the breeding season and nest on emergent sandbar habitat. Declines in the



Figure 1-1. The Interior Least Tern (left), Pallid Sturgeon (top right), and Piping Plover (bottom right): Federally Listed Species Found along the Missouri River

populations of these species led to the USFWS listing of the interior least tern as endangered in 1985, the Northern Great Plains piping plover as threatened in 1985, and the pallid sturgeon as endangered in 1990 under the ESA.

This section provides background information on the Missouri River Mainstem Reservoir System (System), Kansas Reservoir System, the BSNP, past ESA consultation associated with the System and BSNP, the BSNP mitigation program, and other information relevant to understanding the proposed action described in this MRRMP-EIS. The remaining sections of Chapter 1.0 describe the ProACT structured decision-making process; the purpose and need for the plan, objectives of the plan, and scope of the MRRMP-EIS.

1.1.1 Missouri River Mainstem Reservoir System

The Missouri River flows for 2,341 miles from Three Forks, Montana at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains through the states of Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri. It is the longest river in the United States. USACE operates the System consisting of six dams and reservoirs with a capacity to store 72.4 million acre-feet (MAF) of water, the largest reservoir system in North America. The 1944 Flood Control Act (FCA) authorized the construction and operation of five large dams on the Missouri River mainstem. The projects authorized by the FCA, along with their reservoirs, are Garrison Dam/Lake Sakakawea in North Dakota (dam closure completed 1953); and Oahe Dam/Lake Oahe (dam closure completed in 1958), Big Bend Dam/Lake Sharpe (dam closure completed 1963), Fort Randall Dam/Lake Francis Case (dam closure completed 1952) and Gavins Point Dam/Lewis and Clark Lake (dam closure completed 1955) in South Dakota. The construction of Fort Peck Dam/Fort Peck Lake in Montana was authorized in the Rivers and Harbors Act of 1935 (embankment closure was completed in 1937); however, the 1944 FCA incorporated the Fort Peck Dam along with the other five dams and reservoirs to form the System. Today, the System is operated by USACE as an integrated system for eight congressionally authorized purposes, which include flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife. Combined, the System controls runoff from 279,480 square miles of the upper Missouri River basin (Figure 1-2). USACE operates the System in accordance with the policies and procedures prescribed in the *Missouri River Mainstem Reservoir System Master Water Control Manual* (Master Manual) (USACE 2006a).

In order to provide System benefits, the construction, operation, and maintenance of the System have resulted in hydrologic alterations to the Missouri River ecosystem including changes to the natural seasonal pattern of river flow and sediment transport. Construction of the six dams converted approximately one third of the mainstem Missouri River to reservoirs. Dams block upstream passage of native fish species. Dams also trap suspended sediments and closure of the dams coincided with a decline in suspended sediment loads in downstream reaches.

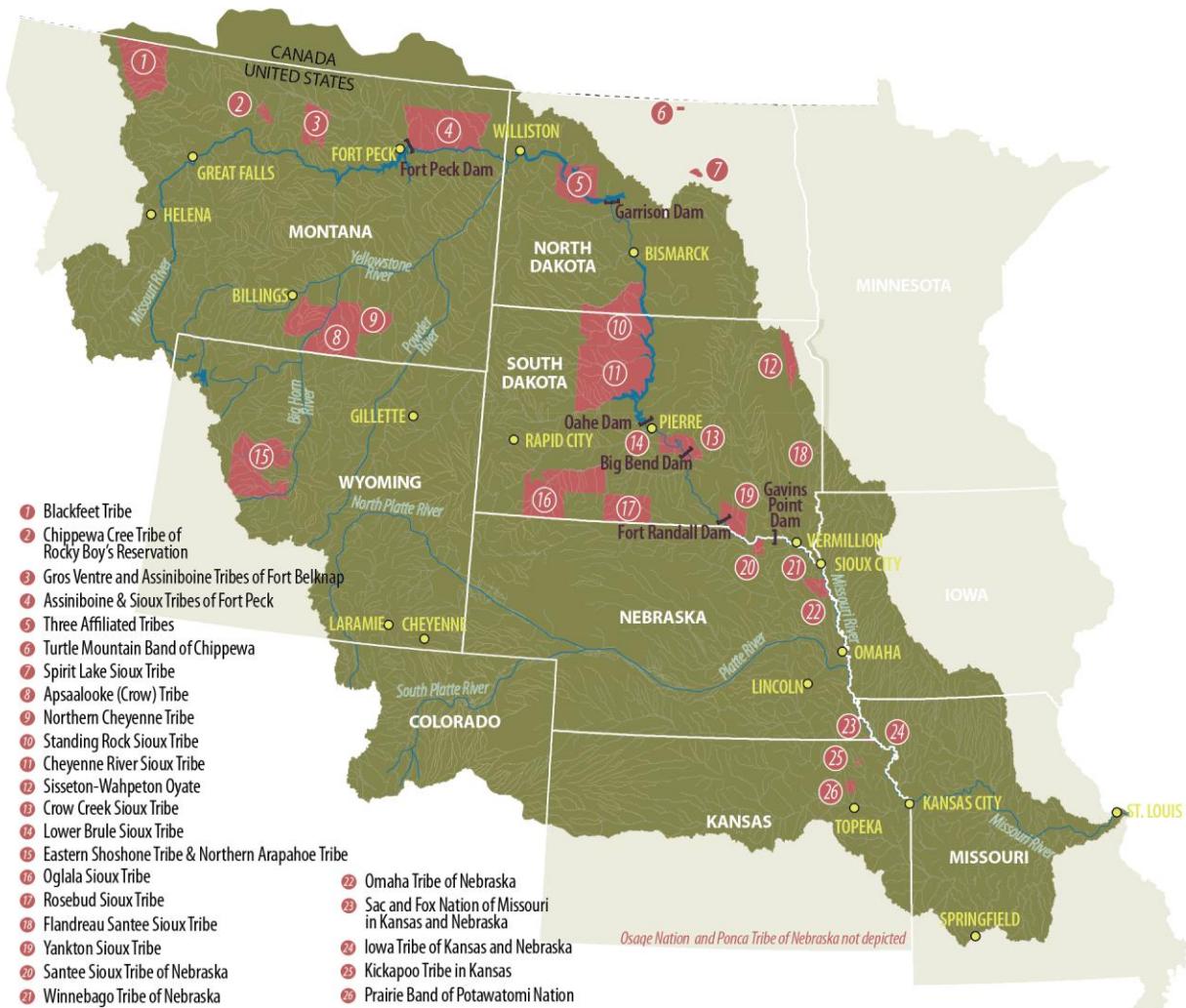


Figure 1-2. Missouri River Mainstem Reservoir System

1.1.2 Kansas River Reservoir System

Clinton, Perry, Tuttle Creek, Milford, Waconda, Wilson, and Kanopolis are the primary downstream flood control dams in the Kansas River basin. Each is located on one of the major tributaries. Waconda is managed by the U.S. Bureau of Reclamation, and the other structures are USACE projects. The USACE projects are authorized for flood control, water supply, water quality, recreation, and fish and wildlife. Milford, Tuttle Creek, and Perry are also authorized to support navigation flows on the Missouri River. Harlan County, Waconda, and the other Bureau of Reclamation projects are authorized for irrigation. The Kansas River Reservoir System controls runoff from approximately 60,000 square miles of northern Kansas, southern Nebraska and northeastern Colorado (Sanders et al. 1993). Operation of the federal reservoirs on Kansas River tributaries has decreased the frequency of very high and very low flows while increasing the frequency of moderate flows. Construction and operation of the federal reservoirs on the Kansas River Reservoir System have trapped tributary sediment, precluding its introduction into the mainstem (USFWS 2000).

1.1.3 Missouri River Bank Stabilization and Navigation Project



Shortly after Lewis and Clark explored the Missouri River, the Federal Government started efforts to modify the Missouri River to support navigation. Starting as early as 1819, funds were appropriated by Congress to survey the river; remove key river habitat features, such as snags, and remove other natural features viewed as obstructive; and to confine the river by locking its banks at specified locations. Beginning in 1912, Congress passed the first of several laws (Rivers and Harbors Acts of 1912, 1925, 1927, 1935, and 1945) to fund work by USACE to further control the lower Missouri River. This work would later become known as the BSNP. The BSNP features authorized by these laws would further confine the natural river by providing for a comparably static, targeted depth, width, and length. From 1932 to 1973, USACE regularly dredged areas of the navigation channel that were prone to deposition. The BSNP consists mainly of rock pile structures and revetments along the outsides of bends and transverse dikes along the insides of bends to force the river into a channel alignment that is self-maintaining or self-scouring. This is different from most inland navigation systems, which are managed through the use of locks with some associated dredging. Training structures permit an open condition for the entire length of the project with no dredging required under normal flow conditions. As authorized, the BSNP provides a 9-foot-deep channel with a minimum width of 300 feet during the navigation season from April 1 to November 30 between Sioux City, Iowa, and the mouth near St. Louis, Missouri. The need for maintenance dredging dropped sharply in the early 1970s as a result of the structures' confining features. Construction on the BSNP was completed in 1981. The Missouri River was shortened by approximately 45 miles between Rulo, Nebraska, and the mouth between 1879 and 1972, due in large part to the construction of the BSNP (Funk and Robinson 1974). Figure 1-3 and Figure 1-4 illustrate the changes over time that resulted from construction of the BSNP.

Figure 1-3. Changes to the River from Missouri River Bank Stabilization and Navigation Project Construction (Indian Cave Bend, Nebraska)

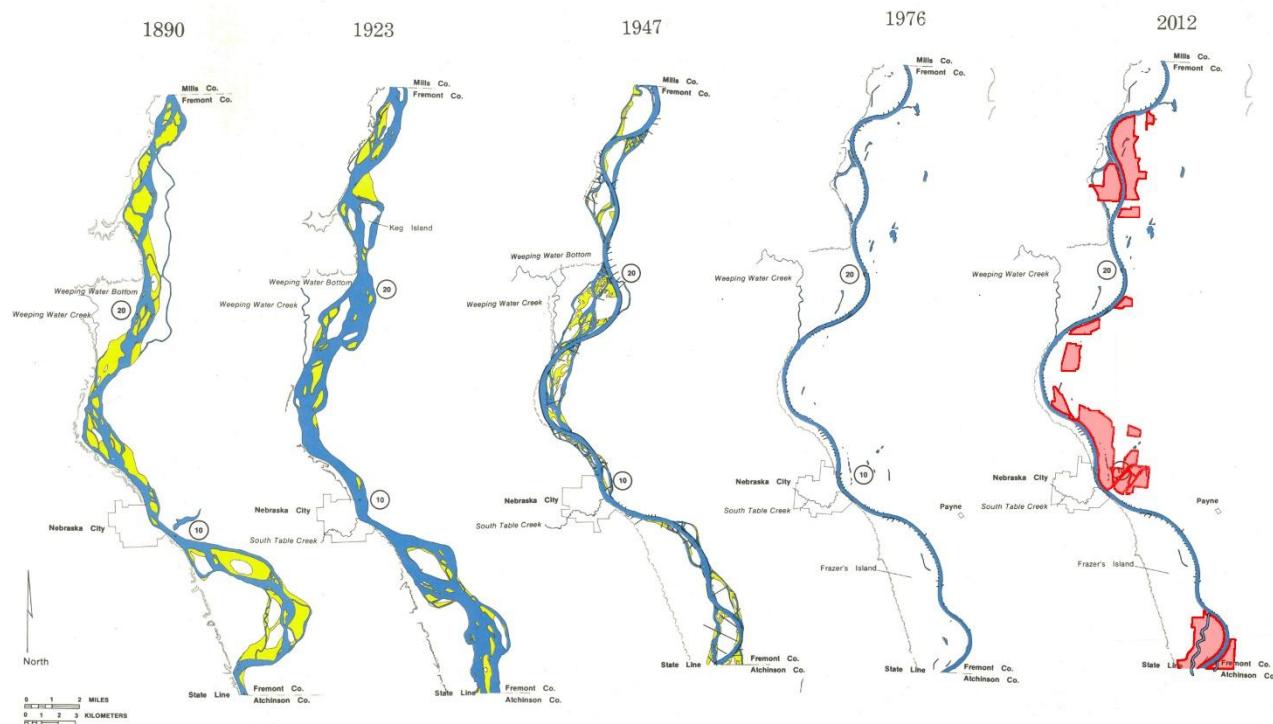


Figure 1-4. Changes to the Missouri River near Nebraska City, Nebraska from 1890 to 2012

1.1.4 Endangered Species Act Compliance

USACE has a responsibility under the ESA to take actions to ensure that the operation of the Missouri River is not likely to jeopardize the continued existence of threatened and endangered species or adversely modify critical habitat. Beginning in 1989, in compliance with Section 7 of the ESA, USFWS and USACE conducted informal and formal consultations on management actions that were being proposed as part of the Master Manual update. This culminated in November 2000 when USFWS issued the *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* (USFWS 2000). The 2000 BiOp concluded that operating the System, operating and maintaining the BSNP, and operating the Kansas River Reservoir System, as proposed, would jeopardize the continued existence of the federally listed pallid sturgeon, interior least tern, and piping plover.

The BiOp, which applies to the portion of the Missouri River from Fort Peck, Montana, to St. Louis, Missouri, identified a Reasonable and Prudent Alternative (RPA) to avoid a finding of jeopardy; the RPA consists of several actions to be taken by USACE. Any incidental take of listed species that could occur by implementing an RPA and the agency's action is also

Jeopardy: Occurs when an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

Recovery: An improvement in the status of listed species to the point at which listing is no longer appropriate under the ESA.

addressed in the incidental take statement of the BiOp. The incidental take statement provides nondiscretionary measures that are necessary and appropriate to minimize the impact of incidental take. These reasonable and prudent measures (RPMs) are to be taken within the action area, involve only minor changes to the project, and reduce the level of take associated with project activities.

The RPA in the 2000 BiOp consisted of six major actions: (1) AM and monitoring; (2) flow enhancement; (3) unbalanced intrasystem regulation; (4) habitat restoration, creation, and acquisition (includes construction of shallow water habitat to benefit the pallid sturgeon and emergent sandbar habitat for the benefit of least terns and piping plovers); (5) interior least tern and piping plover species-specific actions; and (6) pallid sturgeon propagation, augmentation, and population/habitat assessment. The habitat restoration, creation, and acquisition would, in part, be implemented through the existing fish and wildlife mitigation project which is required to offset portions of the impacts caused by the BSNP. In addition, the 2000 BiOp included 11 RPMs to minimize the take of bald eagles, interior least terns, piping plovers, and pallid sturgeon.

Reasonable and Prudent Alternative:

A recommended alternative action that can be

- *implemented in a manner consistent with the intended purpose of the federal action*
- *implemented consistent with the scope of the federal agency's legal authority and jurisdiction*
- *economically and technologically feasible*

and that USFWS believes would avoid the likelihood of jeopardizing the continued existence of a listed species or the destruction or adverse modification of designated critical habitat.

The flow enhancement plan presented in the 2000 BiOp RPA consisted of a spring rise and a lowered summer flow downstream of Gavins Point Dam. This was hypothesized to create a spawning cue for fish, maintain and develop sandbar habitat for birds and fish, and improve the connection between the main channel and backwaters and side channels, among other benefits. A spring rise was also identified below Fort Peck Dam. These spring rises were scheduled to start no later than 2003. However, these spring rises were never implemented. In 2003, USACE reinitiated formal consultation with USFWS and provided a Biological Assessment with new proposed actions in November 2003. The 2003 Biological Assessment was provided because of new information concerning the effects of USACE actions that had previously not been considered and because USACE believed certain components of the RPA did not comport with the regulatory criteria for an RPA (USACE 2003a). Additionally, critical habitat had been designated for the piping plover, new information on the mortality of interior least terns and piping plovers was available, and an updated hydrology and hydraulics analysis indicated that some flow modifications could erode more emergent sandbar habitat than they would create. In 2003, USFWS provided a determination that the new USACE proposed action would avoid jeopardizing the continued existence of the two listed bird species, but continued to appreciably reduce the likelihood of both survival and recovery of the pallid sturgeon, thus jeopardizing its continued existence in the wild (USFWS 2003). USFWS then amended the 2000 BiOp to remove the flow modifications previously provided in the RPA, and concluded that mechanical and artificial creation for replacement of emergent sandbar habitat were acceptable means to avoid a finding of jeopardy to the interior least tern and piping plover. The 2003 Amended BiOp retained the majority of RPA actions described in the 2000 BiOp; however, it added new RPA elements to the flow enhancement action. Fifteen new RPMs were provided in the 2003 amended BiOp replacing the RPMs in the 2000 BiOp to minimize take of interior least terns and piping plovers.

1.1.5 BSNP Fish and Wildlife Mitigation Project

The Fish and Wildlife Coordination Act (16 USC 661 et seq.) contemplates land acquisition for project mitigation, within the parameters of specific language in individual project authorizations. The Fish and Wildlife Coordination Act requires federal agencies to undergo consultation with USFWS for all projects that control, modify, or divert water prior to carrying out the project. In 1958, an amendment to early forms of this law (P.L. 85-624, August 12, 1958, 72 Stat. 563) gave the Act its current name, established most of its structure, and required equal consideration and coordination of wildlife conservation with other water resource development programs. It also required any report to Congress supporting a recommendation for authorization of a project to include an estimation of the wildlife benefits or losses, the cost of offsetting wildlife losses and other related information. In addition to new projects, those projects that were less than 60 percent complete in 1958 were subject to consultation within this framework of consideration. The BSNP between Kansas City and the mouth of the Missouri River was 58 percent complete on August 12, 1958, the day the Act was signed into law. As the BSNP neared completion, USACE commenced work on a Chief of Engineers' Report to Congress (Chief's Report) pursuant to the Fish and Wildlife Coordination Act. The Chief's Report, submitted April 24, 1984, set forth a recommended plan for the BSNP to achieve its mitigation as identified in the *Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Environmental Impact Statement for the Fish and Wildlife Mitigation Plan* (completed in 1981). It recommended mitigation measures to offset some of the adverse impacts to fish and wildlife habitat caused by the BSNP.

Section 601 of WRDA 1986 adopted this plan and established the mitigation program "for mitigation of fish and wildlife losses" as identified in the Chief's Report. It also required the Chief of Engineers to study the need for additional mitigation measures and report back. Congress authorized the Missouri River BSNP Fish and Wildlife Mitigation Project in the WRDA of 1986, Section 610 (a) for a total of 48,100 acres of fish and wildlife habitat. Beginning in 1992, Congress appropriated funds for project construction through the Energy and Water Appropriations Act to mitigate for adverse impacts caused by the BSNP. Section 334 of WRDA 1999 increased the acreage of habitat to be mitigated for the Mitigation Project by 118,650 bringing the total acres to be mitigated to 166,750 acres. This authorized acreage is roughly 32% of the 474,600 acres of fish and wildlife habitat lost between 1912 and 1980 due to construction of the BSNP (USFWS 1980). The BSNP Mitigation Project authority was further amended in Section 3176(a) of WRDA 2007 allowing funds made available for recovery or mitigation activities in the lower basin of the Missouri River to be used in the upper basin of the Missouri River, including the states of Montana, Nebraska, North Dakota, and South Dakota. Approximately 66,000 acres have been acquired in fee title or easement towards the BSNP mitigation authority.

Since the WRDA 1986 authorization, the pallid sturgeon was federally listed as an endangered species under the ESA. USFWS identified aquatic habitat development as a critical element of the RPA contained in the 2003 Amended BiOp. Specifically, the critical element is to achieve a shallow water habitat goal of 20–30 acres per mile over the length of the 735-mile Missouri River BSNP. The land acquisition authority used by the Missouri River Recovery Program (MRRP) for BiOp compliance is derived from Section 601 of WRDA 1986, as amended by Section 334 of WRDA 1999 and Section 3176 of WRDA 2007. This authority is a result of USACE obligations to mitigate significant effects of the BSNP and therefore cannot be separated from the requirement that lands acquired also serve to offset the impacts of the BSNP. USACE has no independent authority to acquire land for ESA compliance along the Missouri River, but USACE is able to acquire lands in areas that also constitute a necessary

and proper expense under the WRDA land acquisition authority. It is similarly important to note that mere land acquisition, in and of itself, does not necessarily equate to mitigation under the authorizations. Land acquisition itself is a means to accomplish mitigation in that it allows for USACE to restore or preserve lost fish and wildlife habitat of the lower Missouri River, which accomplishes the authorization's purpose of replacement of fish and wildlife losses.

1.1.6 Missouri River Recovery Program and the Missouri River Recovery Implementation Committee

The MRRP was established by USACE in 2005. It is the umbrella program that coordinates USACE efforts in the following:

- Compliance with the USFWS 2003 *Amended BiOp on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the BSNP, and Operation of the Kansas River Reservoir System*;
- Acquiring and developing lands to mitigate for lost habitats as authorized in Section 601(a) of WRDA 1986 and modified by Section 334(a) of WRDA 1999 (collectively known as the BSNP Fish and Wildlife Mitigation Project); and
- Implementation of WRDA 2007 including the Missouri River Recovery Implementation Committee (MRRIC) and Section 3176, which allowed USACE to use recovery and mitigation funds in the upper basin states of Montana, Nebraska, North Dakota, and South Dakota.

On July 1, 2008, the Assistant Secretary of the Army for Civil Works provided implementation guidance thereby adopting the MRRIC charter pursuant to congressional authorization set forth in WRDA 2007. The MRRIC makes recommendations and provides guidance to federal agencies on the existing MRRP. The MRRIC is composed of over 70 members representing various interests, Tribes, states, and agencies from within the Missouri River basin.

In 2011, the MRRIC and USACE established the ISAP. This panel is charged with independent science support and technical oversight by providing advice on specific topics. The first topic charged to ISAP was Missouri River spring pulse management. The Final ISAP report, published in November 2011, found the spring pulse management action as implemented was not effective at achieving pallid sturgeon objectives and called for a more formal adaptive management (AM) plan. It also called for an analysis of the effects of USACE management actions on pallid sturgeon including further examination of various flow management actions and their relationship to habitat creation. Based on this report, the MRRIC recommended seven actions to USACE and USFWS in August 2012.

Adaptive Management: A decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.

1. An effects analysis should be developed that incorporates new knowledge accrued since the 2003 Amended BiOp. As part of this analysis:
 - The effects of the Missouri and Kansas River operations on the listed species should be reviewed and analyzed in the context of other stressors on the listed species;
 - The quantitative effects of potential management actions on the listed species should be documented to the extent possible; and
 - These potential management actions should be incorporated into the conceptual ecological models (CEMs).
2. CEMs should be developed for each of the three listed species and these models should articulate the effects of stressors and mitigative actions (including, but not limited to, flow management, habitat restoration actions, and artificial propagation) on species performance.
3. Other managed flow programs and AM plans should be evaluated as guidance in development of the CEMs and AM strategy.
4. An overarching AM strategy should be developed that anticipates implementation of combined flow management actions and mechanical habitat construction. This strategy should be used to guide future management actions, monitoring, research, and assessment activities within the context of regulatory and legal constraints.
5. Monitoring programs along the Missouri River should be reviewed to determine whether hypothesized outcomes are occurring and the extent to which the outcomes are attributable to specific management actions.
6. The agencies should identify decision criteria (trigger points) that will lead to continuing a management action or selecting a different management action. A formal process should be designed and implemented to regularly compare incoming monitoring results with the decision criteria.
7. Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.

1.1.7 Effects Analysis

USACE initiated an effects analysis subsequent to receiving the MRRIC recommended actions. The concept of an effects analysis is rooted in the requirement within the ESA to evaluate the effects of actions proposed by federal agencies on listed species or designated critical habitat, using the best available science. Completion of an effects analysis is preceded by problem formulation, which includes defining the proposed action, identifying the area affected, and developing conceptual models with written descriptions and visual representations of the physical and biological relationships between actions and species responses (Murphy and Weiland 2011). Murphy and Weiland (2011) advocated for a rigorous approach to the effects analysis that consists of three primary steps. The first step is to collect reliable scientific information, including observations about the stressor and the range of stressor conditions and information on population sizes and trends. The second step includes assessment of the data, including using quantitative models to integrate existing information and identifying and

representing uncertainties. The third step is to analyze the effect of the actions on the species to determine costs and benefits and identify alternatives.

The effects analysis team formed to support the MRRP efforts has been responsible for development of CEMs as well as the three primary steps described previously. Comprehensive CEMs were developed to link species' population dynamics to potential management actions and other stressors, based on current scientific understanding. These CEMs provide a broad framework of the factors affecting species population dynamics and are the foundation for developing hypotheses and predictive models. CEMs are explained in more detail in Chapter 2.0. Concurrently, available scientific literature, databases, and models on the three species were compiled, reviewed, and synthesized, and will be updated over time. Based on the CEMs and literature synthesis, hypotheses were developed about the effects of potential management actions on each species and their habitat. The effects analysis has also developed predictive and quantitative models that explore system dynamics and population responses to alternative management actions, and analyze and assess the effects of potential management actions on species populations and habitats. The effects analysis results and products form the foundation for development of the MRRMP-EIS alternatives and the comprehensive AM approach recommended by the ISAP. Figure 1-5 illustrates the timeline of events leading to this MRRMP-EIS.

1.1.8 Adaptive Management

AM is a systematic approach for improving resource management by learning from management outcomes. An AM approach is being followed in this instance because of science and management uncertainties associated with the pallid sturgeon, least tern, and piping plover. AM copes with uncertainty through implementation despite lingering concerns about the best course of action. Progress can be expected through iterative application of learning and adjustment. AM leads to a better understanding of the resource or system, which in turn leads to improvements in management decisions and their results over time. Three factors are essential for AM to occur: (1) a critical uncertainty, (2) an opportunity to learn, and (3) the ability to adapt decisions based on what was learned.

Using an AM approach, management actions are designed and implemented to test hypotheses and reduce critical uncertainties for the purpose of better informing management decisions. It can be characterized as a cycle of assessing the state of knowledge about species needs and management effectiveness and identifying uncertainties, careful planning and designing of actions to reduce these uncertainties, implementing the planned actions, monitoring and evaluating the results, and then adjusting based on what is learned (Figure 1-6). Allowing for management flexibility as new learning occurs is a central AM concept. Importantly, the set of management actions that ultimately make up the selected plan could be adjusted over time based on new information entering the decision-making process.

Chapter 2.0 describes how AM applies to the proposed alternatives, while Chapter 4.0 summarizes the AM plan under the preferred alternative. The Science and Adaptive Management Plan (AM Plan) accompanying this EIS is a detailed description of: the governance structure used for making decisions; the AM framework consisting of management actions, research, monitoring, and evaluation to reduce uncertainties and test hypotheses; human consideration effects monitoring and evaluation; and how scientific information and data will be managed and communicated.



Figure 1-5. Timeline of Events Leading to the Missouri River Recovery Management Plan and Environmental Impact Statement

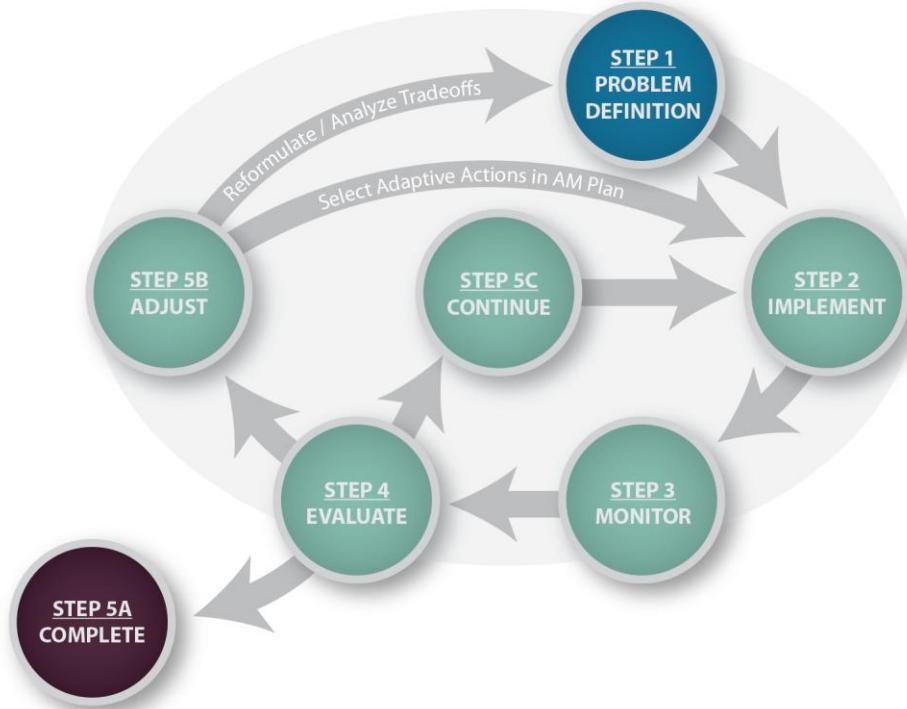


Figure 1-6. Simplified Depiction of the Adaptive Management Process

1.2 PrOACT Process

USACE selected a structured decision-making process called PrOACT to assist with the planning and coordination of this MRRMP-EIS. PrOACT provides a systematic approach for making decisions. The process as implemented for this MRRMP-EIS involves six steps (Figure 1-7):

- Problem Definition
- Objectives
- Alternatives
- Consequences
- Trade-Offs
- Decision – Take Action

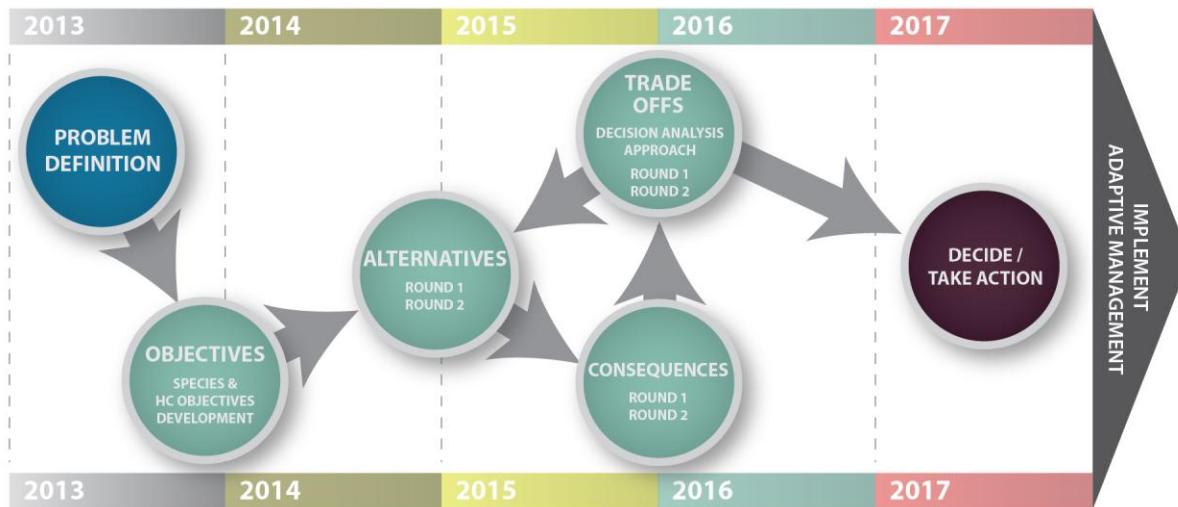


Figure 1-7. PrOACT Process

Based in decision theory, PrOACT encompasses a simple set of concepts and helpful steps rather than a rigidly prescribed approach to problem solving. Additional benefits include PrOACT's emphasis on collaborative and facilitated decision-making and focus on stakeholder and Tribal involvement in key steps of the planning process. Key concepts include making decisions based on clearly articulated fundamental objectives, dealing with scientific uncertainty, and responding to legal mandates as well as Tribal and public preferences as values in decision making. Thus, PrOACT integrates science and policy directly into the decision-making process. For the evaluation of alternatives, PrOACT confronts uncertainty and the likelihood of multiple outcomes and their possible consequences to help agency decision makers, stakeholders, Tribes, and the public understand the risk associated with each alternative. USACE and USFWS collaboratively have tailored the generic PrOACT approach to meet the needs of this MRRMP-EIS planning process. The National Environmental Policy Act (NEPA) requires federal agencies to prepare an EIS for major federal actions that could significantly impact the quality of the human environment (i.e., natural, social, and economic resources). This EIS fulfills that requirement while incorporating documentation of the PrOACT process.

1.2.1 Problem Definition

The first step in the PrOACT process is to clearly define the problem to be solved. USACE and USFWS established the problem definition for this MRRMP-EIS. The problem definition for this MRRMP-EIS informs the purpose of the plan and provides important considerations to be evaluated

Problem Definition

Develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, interior least tern, and pallid sturgeon, and that

- *Complies with the authorization requirements from Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007.*
- *Continues to serve the Missouri River authorized purposes and accounts for human considerations; and*
- *Includes an EIS and establishes an AM process for implementing the preferred alternative.*

during the decision-making process. Subsequent PrOACT steps are described in those MRRMP-EIS chapters that pertain to each step.

1.3 Need for the Plan

“Need” includes the identification and description of the conditions that require action. A description of the need for an action also serves to provide evidence that action is warranted. “Need” answers the question: “Why is the agency taking action?”

Alteration of the ecosystem and loss of aquatic and terrestrial habitats due to USACE operation of the System and BSNP have contributed to the ESA-listing of the pallid sturgeon, piping plover, and interior least tern, species that inhabit the Missouri River. A substantial amount of new knowledge about the species, their habitats, and management opportunities has been developed since the 2003 Amended BiOp for the three listed species was published. As discussed previously, in 2011 the ISAP recommended developing a new AM plan that would anticipate implementation of combined flow management actions and mechanical habitat construction. Under the ISAP recommendations, this new plan would be used to guide future management actions, monitoring, research, and assessment. The ISAP also recommended basing the AM plan on an effects analysis, which would precede the development of the plan and incorporate new knowledge about the species accrued since the 2003 Amended BiOp (Doyle et al. 2011). Since the 2011 ISAP recommendation, effects analyses have been completed and documented for pallid sturgeon (Jacobson et al. 2016a) interior least tern and piping plover (Buenau et al., 2014c), and associated habitat analyses (Fischenich et al. 2014). The effects analysis synthesized and assessed new scientific information since the 2003 Amended BiOp. The emergence of this new information created a need for its evaluation and integration into USACE management actions on the Missouri River for the listed species and the associated AM Plan.

The effects analysis outlines and discusses the hypotheses needed to guide the development of alternatives for this EIS and for developing an AM plan. There is also a need to assess land acquisition priorities in response to the results of the effects analysis. Land acquisition since 2003 has focused on areas that were most conducive to the creation or enhancement of shallow water habitat as defined in the BiOp or subsequent USFWS clarified definition.

The need to acquire and develop riparian and aquatic habitat on 166,750 acres of land as authorized by Section 601a of WRDA 1986 and Section 334 of WRDA 1999 and recommended and described in the 2003 ROD for the BSNP Mitigation Project is considered still relevant and remains unchanged. Implementation of the mitigation project was projected to take in excess of thirty years but an annual rate of implementation was not specified due to budget uncertainty. Due to current and anticipated future administration budget priorities it is assumed that land acquisition over the implementation timeframe for the scope of the MRRMP-EIS would continue to be focused on lands that can be used to meet endangered species objectives while also contributing to BSNP mitigation. Habitat development would be implemented on any acquired lands which would be credited toward the BSNP mitigation requirements.

The following sections describe the need for the proposed action relative to each listed species.

1.3.1 Pallid Sturgeon

A recent revision of the pallid sturgeon recovery plan notes that the species status has improved since listing under the ESA and it is currently stable as a result of artificial propagation and stocking efforts (USFWS 2014) (Figure 1-8). If stocking were to cease, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014). In the BiOp (USFWS 2000), USFWS stated that System operations, as well as the operations and maintenance of the BSNP affect pallid sturgeon by decreasing the quantity and quality of aquatic habitat in the Missouri River, thus, (1) reducing larval and juvenile rearing habitat; (2) reducing the availability of seasonal refugia; (3) reducing the forage base of pallid sturgeon by reducing nutrient cycling and habitat diversity in the Missouri River; (4) reducing pallid sturgeon staging and spawning cues; and (5) increasing hybridization with the shovelnose sturgeon.

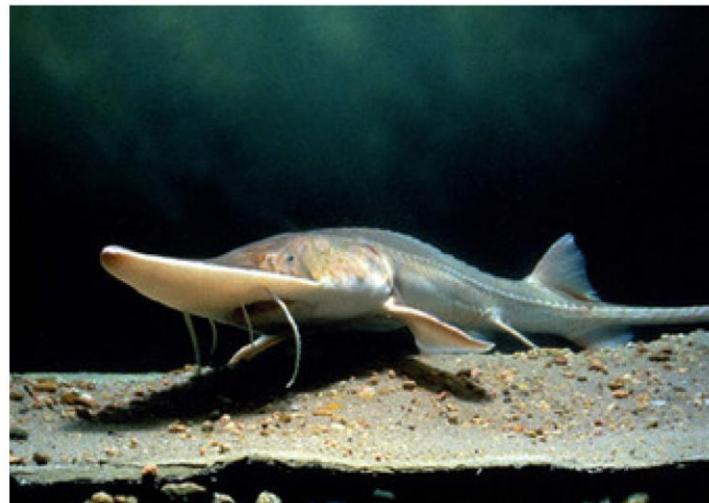


Figure 1-8. Pallid Sturgeon

System operations on the Missouri River have altered river dynamics and negatively impacted pallid sturgeon (USFWS 2000). Under a natural hydrograph, flood flows would rearrange sediment into natural morphological channel features which would act as fish habitat. The current modified hydrograph lacks those habitat-creating flows, which, over time, have negatively impacted pallid sturgeon and habitat availability. Furthermore, unnaturally high summer and fall operational flows minimize the amount of suitable habitat available for young-of-the-year fish, reducing potential recruitment (USFWS 2000).

In the BiOp, USFWS stated that dam operations on the mainstem negatively impact pallid sturgeon survival by altering magnitude, velocity, and timing of flows in the river (USFWS 2000). Due to these operational flows, USFWS concluded that it is likely spawning cues for pallid sturgeon are no longer present in some upper basin reaches under current dam operations (USFWS 2000). Also, mainstem dams discharge hypolimnetic releases from reservoirs (i.e., cold water from the bottom layer of the reservoir) that stratify the water column, significantly decreasing water temperatures downstream of those dams during ice-free periods. This decrease in water temperature is harmful to pallid sturgeon, as relatively warm water is required by the species to successfully spawn. Mainstem dams operating for daily hydropower needs cause daily water-level fluctuations in tailwater areas by as much as 6.5 to 10 feet (2-3 meters). Those fluctuations and associated increases in water velocity can disrupt the macroinvertebrate community and larval fish rearing areas for miles downstream of the dams by alternately flooding and dewatering habitats.

In addition to System operations, the BiOp (USFWS 2000) stated that bank stabilization was responsible for impacts to pallid sturgeon survival. Bank stabilization has largely arrested meander cuts and bank erosion. Maintaining revetments and structures to stabilize the banks eliminates a major source of sediment and snags to provide diverse aquatic habitats and further

support the riverine forage base. In addition, preventing bank erosion and channel migration encourages floodplain development that, in general, results in land changes (i.e., deforestation, wetland drainage) that degrade fish and wildlife habitat in and adjacent to the river.

Furthermore, in the BiOp, USFWS stated that the loss of habitat quality, quantity, and diversity are believed to be affecting the genetics of pallid sturgeon in the Missouri River by contributing to increased pallid sturgeon hybridization with shovelnose sturgeon (USFWS 2000).

Since the 2000 BiOp and 2003 Amended BiOp were published, a substantial amount of research has generated new knowledge regarding pallid sturgeon (Figure 1-9; Jacobson et al. 2015a). This new science was synthesized in the pallid sturgeon effects analysis (Jacobson et al. 2016b). There is a need to incorporate this updated and relevant information into USACE management actions for BiOp compliance and avoiding a finding of jeopardy to the pallid sturgeon.

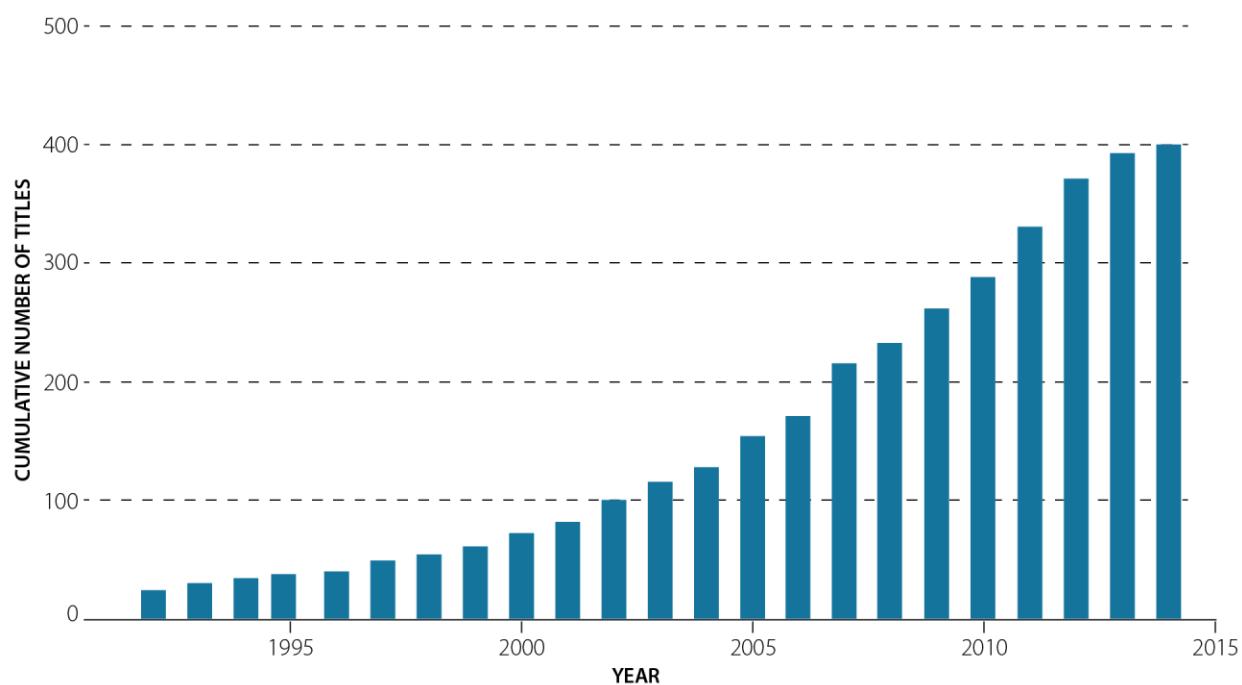


Figure 1-9. Cumulative Number of Scientific Publications on Pallid Sturgeon Since 1990

The pallid sturgeon CEMs developed in the effects analysis indicate the significant physical and biological differences between pallid sturgeon in the upper river and the lower river. The upper river is characterized by a distinct genetic group of fish whose reproductive range is constrained by Fort Peck Dam, Vandalia Dam on the Milk River, Intake Dam on the Yellowstone River, and the headwaters of Lake Sakakawea (Jacobson et al. 2015a). The lower river, downstream of Gavins Point Dam, differs significantly in several respects, including having genetically different groups of pallid sturgeon, and differences in alteration of the flow regime, temperature regime, water quality, channel morphology, and longitudinal and lateral connectivity. The effects analysis identified hypotheses that link management actions to pallid sturgeon population dynamics, documented lines of evidence relating to each, and the degree of uncertainty associated with each hypothesis (Jacobson et al. 2016b). The hypotheses are geographically associated to either the upper or lower river pallid sturgeon populations (see Chapter 2.0; Jacobson et al. 2016a).

Although there has been a large increase in knowledge since the release of the BiOp, fundamental uncertainties remain about the limiting factors affecting the pallid sturgeon and the associated potential management actions. Hypotheses in the upper Missouri River range from flow, temperature, and turbidity manipulation to improved stocking strategies and drawdown of Lake Sakakawea. The uncertainty for the hypotheses that include flow, temperature, and turbidity manipulation is moderate to high due to lack of evidence supporting several assumptions driving these potential actions. Improved stocking strategies are associated with a lower level of uncertainty because they are supported by numerous studies, data, and presently available genetic tools. The hypothesis involving the drawdown of Lake Sakakawea is associated with substantial uncertainty due to both structural components in the currently available pallid sturgeon population model and biological assumptions incorporated into the model.

Lower Missouri River hypotheses include flow and temperature manipulations, channel reconfigurations, and improved stocking strategies. Similar to the upper river, flow and temperature actions are associated with moderate to high uncertainty. The level of uncertainty for channel reconfigurations is undefined, with the greatest source of uncertainty being whether age-0 pallid sturgeon are actually limited by food and foraging habitat or whether interception habitat is limiting to the pallid sturgeon population. For the lower Missouri River, there is a need to demonstrate successful fertilization, incubation, and hatching, which would then guide decisions on the effectiveness of flow manipulations, channel reconfigurations, and stocking densities. In the lower river, uncertainty exists about whether velocities and turbulence are lethal to drifting free embryos. Another key uncertainty for pallid sturgeon in the lower Missouri River is whether food is limited in the channel margin habitats.

USFWS provided criteria for avoiding a finding of jeopardy for pallid sturgeon. USFWS stated that the suite of proposed actions within any plan alternative must have meaningful actions proposed for implementation at a level that USFWS believes will have positive biological effects on the species and abate the effects of federal actions that may have contributed to a finding of jeopardy. Additional aspects of the criteria relate to alternatives formulation and are discussed in Chapter 2.0.

Development of a management plan which balances the substantial uncertainty regarding the beneficial effect of actions with the need to implement actions for a meaningful biological response is difficult and requires development of a robust Adaptive Management Plan.

There is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis, that provides an adaptive framework to address the uncertainty associated with potential pallid sturgeon limiting factors. Development of a management plan which balances the substantial uncertainty regarding the beneficial effect of actions with the need to implement actions for a meaningful biological response is difficult and requires development of a robust AM plan.

1.3.2 Interior Least Tern and Piping Plover

Management actions and associated habitat responses are important to interior least tern (Figure 1-10) and piping plover (Figure 1-11) reproduction, growth, and survival on the Missouri River. The effects of USACE operations on the Missouri River ecosystem and the BSNP were documented in the BiOp (USFWS 2000). Effects on terns and plovers have remained largely consistent since 2000. Lack of sediment transport, channel degradation, navigation structures, and bank stabilization have contributed to the loss of sandbars and sandbar complexes,

channel chutes, oxbow lakes, and wetlands (USACE 1981), which in turn affects tern and plover habitat and forage base.

The USFWS 2000 BiOp stated that current operations do not provide the pulse flows necessary for channel maintenance, sandbar creation, and vegetation scouring, nor do they alleviate the accumulation of sand and gravel behind the mainstem dams (USFWS 2000). Such sediment and pulse flows are the foundation of sandbar creation, scouring, and covering of vegetation. Current operations are not expected to create meaningful amounts of shallow-water and sandbar complexes that are essential to the survival of the interior least tern and piping plover. Maintenance of existing navigation structures prevents potential nesting habitat from redeveloping. Fluctuations of releases for water conservation and hydropower have also contributed to a loss of sandbar habitat. Sandbar erosion, due in part to dam operations (fluctuation extremes and intensity of releases), also has caused the loss of habitat and nests on the Missouri River. Habitat loss and its associated additive impacts affect productivity and could limit population stability and potential recovery.

As stated by USFWS in the BiOp, regulation of the mainstem Missouri River, as well as construction and maintenance of the BSNP, have resulted in greatly altered channel hydraulics (USFWS 2000). In certain reservoirs and tributary confluences, sediments are building up without the opportunity to be scoured or redeposited downstream. Flood control measures for the lower river can cause the loss of eggs or chicks. When downstream flooding occurs on the lower river, flows are held back from project dams to minimize flooding impacts downstream raising stages in the reservoirs and impacting birds nesting along the shoreline. Tern and plover egg (nest inundation) and chick (stranding) losses below the dams can occur when flows are returned to support navigation. Fluctuations in power peaking flows can be drastic, and in combination with weather events or tributary inflows, can result in water levels at nesting sites that result in the loss of eggs or the possible stranding of chicks.



Photo Credit: U.S. Army Corps of Engineers

Figure 1-10. Interior Least Tern

Channel incision appears to be partly responsible for vegetation encroachment on islands and sandbars. Lowering of the riverbed has created relatively higher islands, thus increasing the flow necessary to overtop those islands (USACE 1989). In most years, System regulation does not provide flows necessary to scour many of these islands, and encroaching vegetation makes the habitat unsuitable for interior least terns and piping plovers. The USFWS BiOp stated that Missouri River operations were expected to continue to foster conditions that contribute to predation (USFWS 2000). For example, increased vegetation or vegetative encroachment on islands provides habitat that is attractive to predators, and with less available sandbar habitat, interior least terns and piping plovers have to compete for available space with predators.

Currently, the criteria necessary for the interior least tern to be removed from the endangered species list as stated in the 1990 Recovery Plan is a range-wide population of at least 7,000 individuals (USFWS 1990). According to the 2013 5-year review (USFWS 2013), the population has not only reached 7,000 individuals but has exceeded this number for the years 1994–2012, resulting in a recommendation of delisting for interior least terns. However, most of the population increases that achieved the population criteria are located within lower Mississippi River populations, not the Missouri River. Interior least terns within two of three Missouri River reaches have been stable compared to the criteria set in the 1990 Recovery Plan. A 2013 adult census on the Missouri River counted a total of 742 interior least tern and 827 piping plover individuals (USACE 2014a).

As part of the interior least tern delisting process, under the conservation mandate of Section 7(a)1 of the ESA, there are efforts underway to develop conservation plans throughout the least tern population range. Section 7(a)1 of the ESA requires federal agencies to use their authorities to develop and carry out conservation programs for listed species. USACE Mississippi Valley Division on the lower Mississippi River, the Louisville District for the lower Ohio River, and the Southwestern Division for the Red and Arkansas rivers are developing 7(a)1 plans with post-delisting management commitments. After USACE management strategies are drafted, there will be a 7(a)1 consultation with the relevant USFWS office. When these management plans are finalized, nearly all of the interior least tern population will be covered under post-delisting management commitments. USFWS is anticipating that the MRRMP-EIS would serve as the conservation plan that would meet the interior least tern delisting requirement for the Missouri River. USFWS has stated to USACE in a Planning Aid Letter dated November 13, 2015 that managing for sufficient nesting habitat to sustain a piping plover population in the Missouri River would also provide sufficient nesting habitat for the interior least tern in the Missouri River. Piping plovers and least terns are sympatric nesters, often using the same breeding sites throughout the Missouri River basin. Therefore, meeting the needs of the piping plover in the Missouri River would also meet the needs of the interior least tern in the Missouri River. Development of management actions in this MRRMP-EIS need to



Photo Credit: MDF Wikimedia

Figure 1-11. Piping Plover

demonstrate benefits to the interior least tern to comply with the conservation plan requirements of Section 7(a)1.

Since the 2003 Amended BiOp was published, there has been an emergence of new information regarding the piping plover (Doyle et al. 2011). In 2013, USACE and USFWS developed CEMs which provided the foundation for the effects analysis. The CEMs, in the form of diagrams and narrative, describe the current understanding of the relationships between river structure and management, habitat and ecological processes, and species dynamics. A set of hypotheses relating river structure and operations to species dynamics were derived from the CEMs. In order to evaluate the CEM-derived hypotheses, numerical models were refined and developed to predict the effects of management actions on habitat availability and piping plover. The predictive models were assessed to determine the quality of results, further refine the models as needed, and assess the hypotheses through model predictions. The model predictions were then synthesized, along with other lines of evidence such as published studies and data analysis that evaluated the hypothesized relationships between management actions and species dynamics. The outcome of this hypothesis development, assessment, and evaluation is documented in the effects analysis integrative report for least tern and piping plover (Buenau et al. 2014c). The effects analysis team has also created new population and habitat models that relate flows to habitat availability, which has advanced the ability to assess the effectiveness of potential management actions for piping plover.

This effects analysis identified and evaluated 14 hypotheses linking management actions to bird population dynamics. Hypotheses range in level of uncertainty from low to high. These hypotheses were developed by identifying management actions related to the dominant biological hypotheses that would improve the current condition of the species. These hypotheses are aimed at addressing the efficacy of creating new habitat, increasing habitat availability, and increasing nest survival. Hypotheses focused on habitat creation actions such as channel modification to increase channel width, sediment redistribution, flows to create habitat, mechanical habitat creation on rivers, and mechanical habitat creation on reservoirs. Hypotheses focused on habitat availability included the use of habitat conditioning flows, reservoir water level management, reduced summer flows, augmentation of existing sandbars, and vegetation removal. Finally, hypotheses focused on increasing nest, chick, and egg survival include steady or declining flows during nesting season, predator removal, nest caging, and human deterrence.

As with the pallid sturgeon, there is a demonstrated need to develop a management plan comprised of actions informed by best available science, as presented in the effects analysis, that provides an adaptive framework to address the uncertainty associated with piping plover and interior least tern management.

1.4 Purpose of the Plan

Purpose defines what the lead agency, in collaboration with cooperators, intends to fulfill by taking action. The purpose should be characterized broadly enough to allow consideration of all reasonable alternatives.

The purpose of this MRRMP-EIS is to develop a suite of actions that meets USACE ESA responsibilities for the pallid sturgeon, piping plover, and interior least tern. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided in Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities. In accordance with ESA Section 7 regulations (Part 50 of the Code of Federal Regulations [CFR], Section 402.02), the management actions ultimately implemented by USACE for the benefit of the pallid sturgeon, least tern, and piping plover resulting from ESA consultation should be implementable within the scope of USACE legal authority and jurisdiction.

The purpose of this MRRMP-EIS is to develop a suite of actions that meets ESA responsibilities for the piping plover, the interior least tern, and the pallid sturgeon. Authorities used to meet this purpose may include existing USACE authorities related to Missouri River System operations for listed species and acquisition and development of land needed for creation of habitat for listed species provided by Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007 although alternatives formulation was not limited to these authorities.

This MRRMP-EIS focuses primarily on requirements found in Section 7 of the ESA. Section 7(a)(1) indicates that all federal agencies shall use their authorities in furtherance of the ESA. It further directs agencies to carry out their programs for the conservation of endangered species and threatened species. This MRRMP-EIS considers specific, short- and long-term management actions for the benefit of three listed species. The results of the plan will contribute directly to furthering the purposes of the ESA. Although Section 7(a)(1) applies to ESA-listed species, actions identified to meet the purpose of this plan could also benefit other native species and will provide some mitigation for the loss of habitat of other native species. To accomplish this, the alternatives will focus on specific requirements found in Section 7(a)(2) of the ESA and USFWS policy for implementing ESA consultation.

Section 7(a)(2) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of any threatened or endangered species. The act requires consultation with USFWS in the event that an agency's action may affect a listed species. Through this consultation the agency determines if the actions may result in an adverse effect and if so requests formal consultation and the issuance of a BiOp. USFWS must determine whether the effects of the actions could jeopardize the continued existence of the listed species. The USACE has prepared this draft MRRMP-EIS in collaboration with the USFWS. It analyzes the potential impacts of alternatives that could potentially be implemented to benefit the three listed species. After the public comment period, the MRRMP-EIS and its supporting technical analyses and reports will serve as an information base for a Biological Assessment (BA) to be prepared by the USACE and a subsequent BiOp to be prepared by the USFWS. The actions described in the BiOp will be reflected in the final MRRMP-EIS and ROD.

Section 1.1.4 describes the nature of the RPAs and other actions included in the 2003 Amended BiOp. One of those RPAs included adopting an AM approach. Establishing and implementing a formal AM plan would allow USACE and USFWS to determine if the suite of actions being taken are meeting species objectives that would justify avoiding a finding of jeopardy, and if not, to allow for adjustments to those actions or identification of new actions within an AM framework.

1.5 Plan Objectives

USFWS provided fundamental objectives, sub-objectives, targets, and metrics for each of the three listed species pursuant to their responsibilities for administering the ESA, and special expertise as a cooperating agency on this MRRMP-EIS. These objectives were informed by the effects analysis products. Achieving these objectives would meet the purpose and fulfill the need of the plan.

1.5.1 Pallid Sturgeon Objectives

Pallid Sturgeon Fundamental Objective: Avoid jeopardizing the continued existence of the pallid sturgeon from USACE actions on the Missouri River.

The following sub-objectives must be attained to ultimately achieve the stated “fundamental objective.” The intent of the sub-objectives is to provide direction in the short term, provide objectives meaningful for AM, and focus efforts on the desired short-term outcomes while keeping the fundamental objective in mind.

Pallid Sub-Objective 1: Increase pallid sturgeon recruitment to age 1.

Metric: population estimates of age 0 and age 1 pallid sturgeon; catch rates of age 0 and age 1 pallid sturgeon (to maintain legacy data); field and model-based estimates of survival of hatchery and naturally reproducing fish to age 1; model-based estimates of the probability of persistence over 50 years and the probability of reaching recovery goals (using abundance and survival estimates for all ages of pallid sturgeon).

Target: Short-term measurable recruitment, long-term informed by the effects analysis and population models. Possible targets could include a modeled egg to age-1 survival rates sufficient to result in growth and sustainable population size.

Pallid Sub-Objective 2: Maintain or increase numbers of pallid sturgeon of age 2 and older until sufficient and sustained natural recruitment occurs.

Metric: Population estimates for pallid sturgeon for all age classes, particularly for ages 2 to 3 to assess recent trends in recruitment; catch rates of all pallid sturgeon by size class (to maintain legacy data).

Target: The target values, by reach, would be informed by the population models. Possible targets could include: 1) positive population growth rates (i.e., $\lambda > 1$) of pallid sturgeon age 2 and older; 2) estimated survival rates of all size/age classes sufficient to provide a stable population of pallid sturgeon age 2 and older; and 3) acceptable probabilities of persistence and recovery over a 50 to 100 year time frame.

1.5.2 Piping Plover Objectives

The fundamental objectives for the piping plover and least tern identified in this section are consistent with USFWS current established recovery goals for the piping plover and least tern; however, they were developed specifically to avoid a finding of jeopardy to the species due to USACE operation and maintenance of the System. The fundamental objectives and subsequent sub-objectives described later in this section are USFWS desired outcomes from USACE actions to be evaluated as part of the MRRMP-EIS. The methods used to derive targets and their application are discussed further in Section 3 of the AM Plan. USFWS believes that if the targets for the sub-objectives described are attained, it will result in the achievement of the stated fundamental objectives. USFWS anticipates regular assessment and refinement of the sub-objectives, means objectives, performance metrics, and targets through the AM process.

The effects analysis, including the hydraulic emergent sandbar habitat (ESH) and population models, provided an empirical relationship linking hydrology, habitat, and bird populations. These models, created specifically for the Missouri River, consider the dynamic river processes and variable amounts of nesting habitat from year to year along with density dependent reproductive rates to calculate the acres of ESH necessary for a resilient population of piping plovers. Population resiliency is primarily determined by habitat availability rather than an initial population size (Buenau et al. 2015). As a result, and as indicated in the targets, USFWS proposed using acres of ESH as a target to ensure a resilient population of birds on the Missouri River. Acres of ESH are calculated in two ways:

- Standardized ESH: The area above water when releases from Gavins Point Dam are 31.6 kcfs, Fort Randall Dam are 30.5 kcfs, and Garrison Dam are 23.9 kcfs. Estimating ESH acreage at constant flows each year allows for the detection of changes in sandbar structure due to erosion, deposition, construction, or mechanical modification.
- Available ESH: The area above water during maximum July release for a specified year. This is an estimate of usable habitat for the birds during the nesting season. It is reported as the acreage of ESH exceeded during a percentage of years (e.g., 10, 25, 50, or 75 percent).

Geographic distribution of the Missouri River piping plover population (sub-population of the Northern Great Plains population) is described by two distinct geographic regions:

- Northern Rivers Region: the Missouri River from Fort Peck Lake, Montana to Fort Randall Dam, South Dakota.
- Southern Rivers Region: the Missouri River from Fort Randall Dam, South Dakota to Ponca, Nebraska.

Piping Plover Fundamental Objective: Avoid jeopardizing the continued existence of the piping plover due to USACE actions on the Missouri River.

Sub-Objective 1 (Distribution): Maintain a geographic distribution of plovers in the river and reservoirs in which they currently occur in both the Northern and Southern River Regions.

Means Objective: Meet sub-objectives 2, 3, and 4 in both the Northern and Southern Regions.

Sub-Objective 2 (Population): Maintain a population of Missouri River piping plovers with a modeled 95% probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.

Means Objective (ESH): Provide sufficient ESH (in-channel riverine habitat) on the Missouri River to meet the persistence target.

Metric: Number of standardized and available ESH acres measured annually.

Target: Targets are shown in Table 1-1.

Timeframe: Median standardized ESH targets met for 3 out of 4 years. Median available acres met or exceeded for the specified percent of years over a running 12-year interval.

Table 1-1. Piping Plover Targets for Sub-Objective 2

		Acres of Emergent Sandbar Habitat					
		Northern Region			Southern Region		
		2.5 Percentile	Median	97.5 Percentile	2.5 Percentile	Median	97.5 Percentile
Standardized ESH Acres		200	428	1,996	264	782	3,907
Available ESH Acres Exceeded for Percentage of Years	75%	140	210	470	280	370	700
	50%	380	630	1,000	460	720	1,580
	25%	770	1,420	2,010	780	1,370	3,285
	10%	1,340	2,230	3,625	1,130	2,320	5,275

Sub-Objective 3 (Population Dynamics): Maintain a stable or increasing long-term trend in population size in both regions.

Metric: Population growth rate (λ): the ratio of population size N between the current year and previous year (N_t/N_{t-1}); calculated annually.

Target: $\lambda \geq 1$ (a growth rate greater than or equal to 1).

Sub-Objective 4 (Reproduction): Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

Metric: Fledge Ratio: Number of fledglings observed/(number of breeding adults/2), calculated annually.

Target: ≥ 1.14 chicks fledged per breeding pair

Timeframe: The fledge ratio target met as a 3-year running arithmetic mean.

1.5.3 Interior Least Tern Objectives

USFWS has identified a fundamental objective for the interior least tern:

Interior Least Tern Fundamental Objective: Avoid jeopardizing the continued existence of the endangered interior least tern due to USACE actions on the Missouri River.

As described in Section 1.5.2, meeting the purpose and need for piping plovers would also achieve the same for the interior least tern. Therefore, sub-objectives, means objectives, metrics and targets for the interior least tern have not been specified. For purposes of this MRRMP-EIS, it is assumed that achieving the stated objectives for the piping plover would also achieve the fundamental objective for the interior least tern.

1.6 Scope of the Plan and Environmental Impact Statement

This EIS assesses the programmatic effects and cumulative effects of alternatives for implementing the MRRP which include actions necessary to avoid a finding of jeopardy to the federally listed species and associated actions which comply with the Missouri River BSNP mitigation plan during the implementation timeframe for this EIS.

This document supersedes the previous MRRP NEPA document entitled: *Final Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (USACE 2011a). This document does not re-evaluate the entire BSNP Mitigation project but addresses the effects of land acquisition during the implementation timeframe of this EIS. The land acquisition authority and types of habitat development as described in the *Final Supplemental EIS for the Missouri River Fish and Wildlife Mitigation Project* (USACE 2003a), and the *Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Final EIS for the Fish and Wildlife Mitigation Plan* (USACE 1981) are still considered to be adequate and reasonable to mitigate the effects of the BSNP.

This EIS provides the necessary information for the decision maker to fully evaluate a range of alternatives to best meet the purpose and need of the MRRMP. It fully addresses the potential impacts of alternatives as required under the NEPA of 1969, as amended (42 United States Code (USC) 4321 et seq.); the President's Council on Environmental Quality (CEQ) Regulations (40 CFR 1500 – 1508); and USACE ER 200-2-2 (33 CFR 230). This plan will be reviewed on a regular basis to ensure compliance with applicable laws and regulations, and that circumstances have not changed that would impact the analysis and conclusions reached in the document.

1.6.1 Geographic, Temporal, and Substantive Scope

Project scope is one of the key aspects to fully and accurately define a project's purpose and need. The project's scope provides the important parameters for what is and is not included within the project or study. Scope includes three parameters:

- Temporal scope—the time horizon for this MRRMP-EIS
- Spatial or geographic scope—the area of the plan under analysis and consideration
- Substantive scope—the proposed federal action and focus of the plan

To facilitate plan development, an implementation timeframe of 15 years was chosen for this planning process and EIS. This is a reasonable timeframe for identification of actions which, based on the current state of the science, may provide meaningful biological responses while recognizing the potential, based on AM, that substantive changes to the suite of actions identified in this MRRMP-EIS may be necessary in 15 years. However, effects to resources were based on an 82-year hydrologic period of record (POR) in order to provide an indication of the potential range of effects under the variable hydrologic conditions occurring in the Missouri River basin. The geographic scope of the federal action includes the Missouri River within its meander belt from Fort Peck Dam in Montana to its confluence with the Mississippi River near St. Louis, Missouri, and the Yellowstone River from Intake Dam at Intake, Montana, to its confluence with the Missouri River.

Although prior ESA consultation on System operations included consideration for Kansas River System operations, the scope of this EIS did not consider actions on the Kansas River because of low numbers and low productivity of nesting piping plovers and least terns on the Kansas River and minimal impacts on least tern and piping plover populations when they have been present (USACE 2006c). Additionally, historic catch records for pallid sturgeon are scarce for the Kansas River. In general, pallid sturgeon researchers assume at this time that tributaries are primarily for foraging and/or spawning and it is highly unlikely that this species currently occurs in the Kansas River due to habitat modifications and physical barriers except under conditions of high flows (USFWS 2003).

1.6.2 Adaptive Management and National Environmental Policy Act

AM is a process to address uncertainty when managing natural resources (Williams and Shapiro 2009). The National Research Council (NRC) describes AM as follows:

Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a ‘trial and error’ process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders. (NRC 2004)

The first element of the RPA from the BiOp requires USACE to use AM as one tool to preclude a finding of jeopardy to interior least terns, piping plovers, and pallid sturgeon. USACE and USFWS agree that future resource management actions in the Missouri River should use an AM framework that recognizes the uncertainties of ecosystem and species responses and attempts to structure management actions to best address those uncertainties. This requires development of objectives and targets, testable hypotheses, predictive modeling, monitoring, assessment, and feedback to decision making so that management actions can be adjusted. In

that regard, AM is viewed as a continuous process of actions based on testing, evaluating, informing, and improving.

AM is a discretionary management approach that could be used in conjunction with the NEPA process and is encouraged by the CEQ for appropriate federal actions (NEPA Task Force 2003). AM and NEPA are similar in that each emphasizes collaboration principles and working with stakeholders and Tribes. AM is consistent with NEPA's goal of informed decision-making: by taking the NEPA process further in addressing uncertainties, data gaps, and potential impacts of AM actions that may be revealed during the AM process so that mid-course corrections can be made based on new learning. By addressing uncertainties and potential impacts associated with potential future AM actions as part of the NEPA process, the need to supplement or prepare additional NEPA documents in the future may be reduced.

1.6.3 Tiering and Future National Environmental Policy Act Compliance

A programmatic NEPA EIS is a strategic approach to meeting an agency's NEPA responsibilities in a cost effective, streamlined manner. Due to the nature of the interrelated federal actions on the Missouri River, a programmatic EIS enables USACE to tier future project proposals from the overarching programmatic EIS analysis, helping to streamline environmental reviews in the future. Tiering, as defined by the CEQ regulations, is covering "general matters" in policy or program EISs with subsequent tiered or narrower environmental analyses, while referencing the general discussion and focusing on the project-specific impacts important to the decision maker. It is important that a programmatic EIS is developed in a way that considers how it will be used as well as how future projects will be considered, reviewed, and implemented. The programmatic approach sets the tone for defining the purpose and need for taking action as well as the development of the alternatives. The versatility of a programmatic EIS allows immediate actions to be implemented upon completion of the ROD, given site specific analysis was performed, as well as expediting implementation of future actions under tiered environmental review. A programmatic approach is well suited for the MRRP and it integrates very well with an AM plan. A programmatic EIS allows managers to make decisions more rapidly to change federal actions when monitoring indicates that objectives are not being met, thus strengthening the implementation of an AM plan.

This MRRMP-EIS and the AM Plan incorporate the components of the MRRP AM process, which have been revised and formalized following the recommendations of the MRRIC. Implementation of specific plans or management actions may require subsequent analysis that can be tiered from this EIS. Additional NEPA analysis would likely be required if the AM process identifies a need for an action that was not included within the range of impacts and alternatives considered in this EIS or new and significant information affecting the decision and relevant to environmental concerns. These considerations are described further in Chapter 4.0.

Intentionally Left Blank

2.0 Alternatives

The National Environmental Policy Act (NEPA) requires federal agencies to evaluate and consider a range of reasonable alternatives that address the purpose of and need for action. Alternatives under consideration must include a “No Action” alternative in accordance with Council on Environmental Quality (CEQ) regulations (40 CFR 1502.14). As described in CEQ’s *Forty Most Asked Questions Concerning CEQ’s NEPA Regulations* (Question 3), “No Action” is best defined as “no change” from current management direction or level of management intensity in situations that involve updating management plans or ongoing programs. For this plan, the No Action alternative does not mean taking no action at all, it is a continuation of the actions currently being used to comply with the 2003 Amended Biological Opinion (BiOp) (USFWS 2003). Differences between alternatives are shown by comparing the impacts of the No Action alternative and the action alternatives.

This chapter describes the alternatives development process and decision-making rationale used for this Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS). Chapter 1.0 described problem definition and identification of species objectives, the first two steps of the PrOACT process. The last three steps of the PrOACT process—alternatives, consequences, and tradeoffs—are documented in this chapter. The No Action alternative and five action alternatives are described. Alternatives 1 and 2 focus on implementing the current BiOp; whereas Alternatives 3–6 represent alternative means to meet the purpose and need for taking action. Actions and alternatives that were considered but eliminated from detailed analysis are also discussed.

2.1 Overview of Alternative Development Process

An interdisciplinary planning team made up of experts from multiple federal agencies in collaboration with basin stakeholders and Tribes participated in alternatives development. Alternatives were developed in accordance with the CEQ’s NEPA implementing regulations (40 CFR 1500–1508). The goal was to formulate a set of reasonable alternatives to meet the species objectives described in Chapter 1.0 and clearly articulate the effects of those alternatives to provide necessary information to decision makers, stakeholders, Tribes, and the public. The team used an iterative development process to identify and screen management actions and alternatives within the overall PrOACT structured decision-making process. Alternatives development built on the problem definition and objectives development steps, and was guided by the effects analysis results and products, which provide the scientific foundation for the development and evaluation of management actions. Critical components of the effects analysis process including creation of conceptual ecological models (CEMs), hypotheses development, and development of supporting models are summarized in this chapter.

The formulation of alternatives is an iterative process that increases the level of detail at each iteration so as to allow better decisions about which alternatives to continue to move forward for consideration by decision makers. The alternatives formulation process generally consisted of the following sequence of steps:

- Identification and consideration of general management actions
- Modeling and evaluation of potential management actions
- Screening of management actions

- Formulation of species alternatives
- Modeling and evaluation of potential species alternatives
- Screening of species alternatives
- Selection of plan alternatives for detailed evaluation in the draft EIS

2.2 Effects Analysis Products and Results

The MRRMP-EIS alternatives development process relied on and was substantively informed by the effects analysis. The primary and relevant products of the effects analysis include:

- Conceptual ecological models (CEMs) (Jacobson et al. 2015a; Buenau et al. 2016a).
- Synthesis of existing models and scientific data/information reflecting the state of science for the species and their habitats (Jacobson et al. 2015b; Buenau et al. 2015).
- Hypotheses addressing critical uncertainties (Jacobson et al. 2016a; Buenau et al. 2016a).
- Models of reservoir operations and hydraulic conditions, habitat availability (Jacobson et al. 2016b), and species demographics (Jacobson et al. 2016b; Buenau et al. 2016b).
- A variety of other papers, reports, and methodologies supporting the development of species targets, management actions and alternatives, and a Missouri River Science and Adaptive Management Plan (AM Plan).

The effects analysis and associated products summarize the best available information to evaluate the effectiveness of management actions. USACE and U.S. Fish and Wildlife Service (USFWS) used the effects analysis information to ensure that up-to-date science informed alternatives that were developed and assessed.

CEMs are graphical depictions of an ecosystem that are used to communicate the important components of the system and their relationships. They are a representation of the current scientific understanding of how the system works. They can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. CEMs are frequently cited as a necessary step in formal adaptive management (AM), in which stakeholders, Tribes, and scientists jointly develop a shared understanding of what influences an ecosystem or population, and then apply the model to predictions of system behavior (i.e., hypotheses) under management scenarios (Walters 1986). CEMs were developed by the effects analysis team to link species' population dynamics to potential management actions and other stressors (i.e., actions or factors that have a negative influence on the species population). The CEMs were an important step in the process leading to alternatives development because they formed the basis for identifying hypotheses and developing quantitative predictive models. The CEMs for piping plovers, least terns, and their habitat relate drivers (social, political, legal, economic, climate, geology, and land use) to Missouri River management, hydrology, and habitat. It then relates biotic processes such as nesting behavior, predation and food availability, and dispersal to habitat availability. These biotic factors then affect survival and reproduction to ultimately determine population size. Figure 2-1 illustrates an overview of the CEMs for piping plovers and least terns. The piping plover and least tern CEMs and the process of developing them are documented in Buenau et al. (2016a).

Pallid sturgeon CEMs illustrate population dynamics and show the linkage between management actions, ecological factors, and biological responses. The pallid sturgeon CEMs consist of a generalized population-level CEM (Figure 2-2) and a series of life-stage component CEMs. The generalized population-level CEM demonstrates the conditions, processes, and potential management actions that affect survival at critical life-stage transitions. The pallid sturgeon CEMs and the process of developing them are documented in Jacobson et al. (2015a).

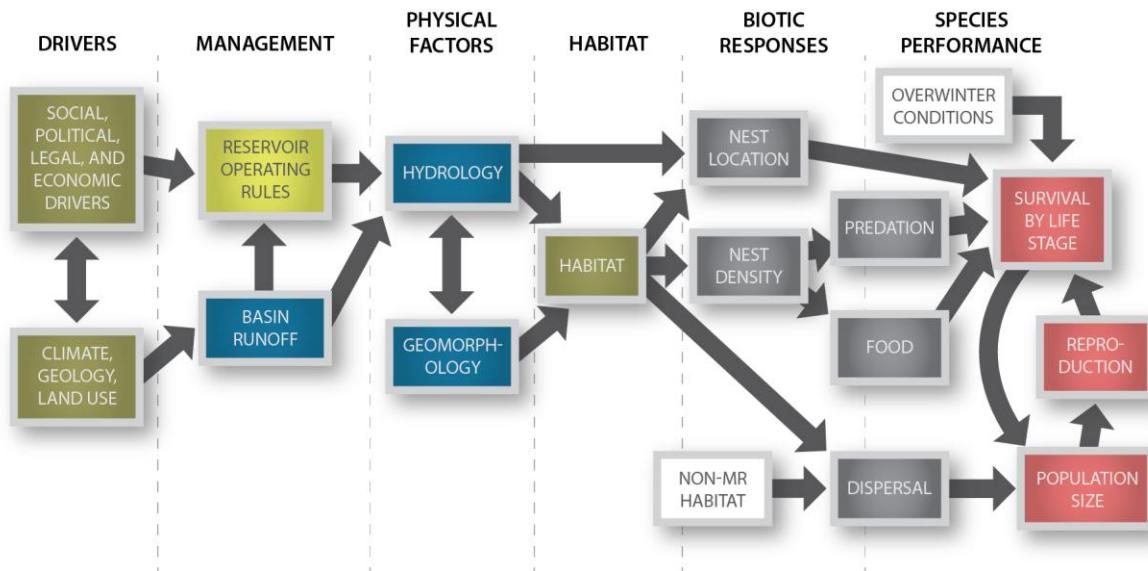


Figure 2-1. Example Conceptual Ecological Model for Piping Plover and Least Tern

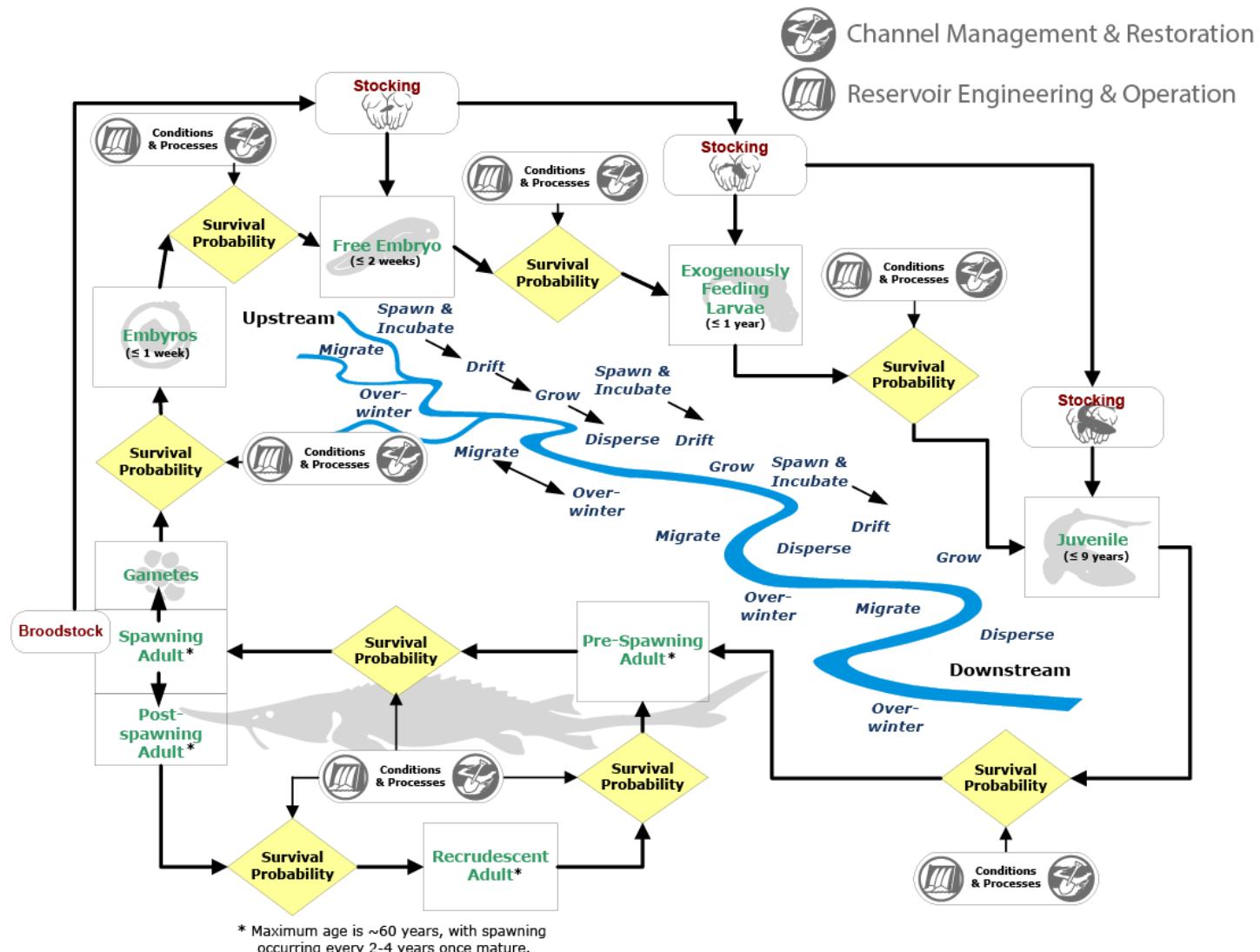


Figure 2-2. Pallid Sturgeon Generalized Population-Level Conceptual Ecological Model

2.3 Identification of Management Hypotheses

The CEMs served as the starting point for development of management hypotheses, which in turn were the basis for identifying general management actions considered in formulating alternatives. Hypotheses were developed directly from the piping plover and least tern CEMs by tracing pathways through CEM components linking physical factors to species performance (Buenau et al. 2016a). Many of the bird management hypotheses are focused on habitat and these hypotheses apply to both piping plovers and least terns. This was an appropriate approach because of the central role of nesting and brood-rearing habitat as a mediating factor between hydrology and geomorphology and the biotic responses in the bird CEMs, as well as the similarities between least tern and piping plover nesting habitat (Buenau et al. 2016a). Table 2-1 identifies the management hypotheses and their associated general management actions for piping plover and least tern. Buenau et al. (2016a) describes the process of developing the bird management hypotheses in more detail.

Table 2-1. Least Tern and Piping Plover Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action(s)
Habitat-creating flows of sufficient magnitude and duration increase the area of nesting/brood rearing habitat and foraging habitat on the river by increasing deposition, assuming sediment is available, thereby increasing fledgling productivity.	Habitat-creating flow release
Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical habitat creation on river
Mechanical habitat creation of sandbars in river segments increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical habitat creation on reservoir shorelines or islands
Mechanical habitat creation of habitat on reservoir shorelines/islands increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Mechanical habitat creation of habitat other than emergent sandbar habitat (ESH) or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation and increasing food availability.	Mechanical creation of hydrologically connected non-ESH habitat on river segments
Mechanical habitat creation of habitat other than ESH or in segments outside of the current ESH scope increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	

Management Hypothesis	General Management Action(s)
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation.	Modification or augmentation of existing sandbars
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability.	
Modification or augmentation of existing sandbars increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of eggs to chicks and chicks to fledglings by reducing predation (by increasing area and by removing cover for predators).	Vegetation removal
Vegetation removal increases nesting/brood-rearing and foraging area, which increases survival of chicks to fledglings by increasing food availability.	
Vegetation removal increases nesting/brood-rearing and foraging area relative to the condition and availability of habitat at other breeding areas, thus increasing the number of adults through net immigration from other areas.	
Habitat-conditioning flows are not of sufficient magnitude and duration to create new sandbars, but scour vegetation or deposit new sediment on existing bars, increasing the area of nesting/brood-rearing habitat, thereby increasing fledgling productivity.	Habitat-conditioning flows
Declining reservoir water levels between years and/or steady or declining water levels during the nesting season increases the area of suitable nesting/brood rearing and plover foraging habitat on the reservoirs, thereby increasing fledgling productivity.	Reservoir water level management
Lowered nesting season flows increase the area of suitable nesting and brood rearing habitat and foraging habitat on the river, thereby increasing fledgling productivity.	Lowered nesting season flows
Steady or declining reservoir levels and/or river flows during the nesting season increases survival from egg to chick and chick to fledgling by reducing the risk of nest inundation and chick stranding and by maintaining or increasing foraging habitat.	Flow management to reduce take
Predator removal increases survival of eggs to chicks and chicks to fledglings.	Predator removal
Nest caging protects plover nests from predators, increasing survival of eggs to chicks, though survival of adults may be negatively affected by cages.	Nest caging
Human restriction measures reduce human activity on nesting and foraging habitat, increasing survival both by decreasing direct mortality and indirect effects on survival caused by stress.	Human restriction measures

The interaction between the System and pallid sturgeon is more complex and as a result, a more intensive filtering process was applied to the identification of pallid sturgeon management hypotheses (Jacobson et al. 2016a). The hypothesis filtering approach was used to determine 21 management hypotheses separated by upper river pallid sturgeon (Table 2-2) and lower river pallid sturgeon (Table 2-3). As with the birds, the process began by identifying the implicit hypotheses from the pallid sturgeon component CEMs. A series of workshops were used to filter these hypotheses and link these hypotheses to management actions (Jacobson et al. 2016a).

Table 2-2. Upper River Pallid Sturgeon Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action(s)
Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and floodplains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.	Alter flow regime at Fort Peck
Attractant flow releases at Fort Peck will result in increased reproductive success through increased aggregation and spawning success of adults.	
Reduction of mainstem Missouri flows from Fort Peck Dam during free embryo dispersal will decrease mainstem velocities and drift distance thereby decreasing mortality by decreasing numbers of free embryos transported into headwaters of Lake Sakakawea.	
Warmer flow releases at Fort Peck will increase System productivity and food resource availability, thereby increasing growth and condition of exogenously feeding larvae and juveniles.	Temperature control, Fort Peck
Warmer flow releases from Fort Peck will increase growth rates, shorten drift distance, and decrease mortality by decreasing free embryos transported into headwaters of Lake Sakakawea.	
Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.	Sediment augmentation, Fort Peck
Fish passage at Intake Diversion Dam on the Yellowstone River will allow access to additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae.	Fish passage at Intake on Yellowstone River
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Upper basin propagation
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.	
Drawdown of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.	Drawdown Lake Sakakawea

Table 2-3. Lower River Pallid Sturgeon Management Hypotheses and Associated General Management Actions

Management Hypothesis	General Management Action(s)
Naturalization of the flow regime at Gavins Point will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.	Alter flow regime at Gavins Point
Naturalization of the flow regime at Gavins Point will improve connectivity with channel-margin habitats and low-lying floodplain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles.	
Naturalization of the flow regime at Gavins Point will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles.	

Management Hypothesis	General Management Action(s)
Alteration of the flow regime at Gavins Point can be optimized to decrease mainstem velocities, decrease effective drift distance, and minimize mortality.	
Operation of a temperature management system at Fort Randall and/or Gavins Point will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.	Temperature management, Gavins Point
Re-engineering of channel morphology in selected reaches will create optimal spawning conditions—substrate, hydraulics, and geometry—to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.	
Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.	Channel reconfiguration
Re-engineering of channel morphology will increase channel complexity and minimize bioenergetics requirements for resting and foraging of exogenously feeding larvae and juveniles.	
Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.	
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Lower basin propagation
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.	

Jacobson et al. (2016a) defined several categories of hypotheses. Global hypotheses are a set of possible, biologically important hypotheses relevant to population dynamics that are derived from the CEMs. These were filtered by the pallid sturgeon effects analysis team to a set of 40 candidate dominant hypotheses that were identified by experts as being important in pallid sturgeon population dynamics. Through a series of workshops and a modified Delphi process, this list of candidate dominant hypotheses was filtered to 23 working dominant hypotheses. The working dominant hypotheses were meant to include plausible, biologically relevant hypotheses without regard to specific management actions. These working dominant hypotheses were then linked to management actions resulting in as many as 176 potential linkages, but when consolidated across life stages led to 53 hypotheses. The list was further reduced through an expert survey to 30 working management hypotheses. Finally, the set of working management hypotheses was filtered by USACE to eliminate actions that were not considered reasonable for the initial scope of implementation due to a current high degree of uncertainty in providing pallid sturgeon benefits, obvious severe effects on the human environment, and/or availability of other management actions that could potentially achieve the same objectives without the same level of uncertainty. This resulted in 21 management hypotheses (termed “initially modeled hypotheses” in Jacobson et al. 2016a). The decision to remove hypotheses from consideration was intended to focus efforts on modeling that would be relevant to decision-making for the scope of the initial proposed actions in this MRRMP-EIS. Any hypothesis that was removed at this step—or any other step in the process—is available later as needed to explain observed pallid sturgeon population changes (Jacobson et al. 2016a). Hypotheses that were not identified as management hypotheses fall into the hypothesis reserve (Jacobson et al. 2016a). These may include hypotheses that were not deemed important to investigate at the time, hypotheses with high uncertainty that require further investigation, obvious severe effects on the human

environment, and/or availability of other management actions that could potentially achieve the same objectives without the same level of uncertainty. All hypotheses developed during the effects analysis process and reserve hypotheses can be re-assessed through the AM process.

The management actions associated with the nine hypotheses eliminated by USACE and rationale for eliminating these hypotheses included:

- **Removal of Fort Peck Dam:** Section 2.5.2 discusses upper river pallid sturgeon management actions considered for plan alternatives and implementation within the 15-year timeframe covered by this MRRMP-EIS. Fort Peck Lake is the third largest USACE reservoir in the United States and drains 57,500 square miles (USACE 2006a). The USACE Master Manual states

Fort Peck's primary water management functions are (1) to capture the mountain and the plains snowmelt and localized rainfall runoffs from the large drainage area above Fort Peck Dam, which are then metered out at controlled release rates to meet the System's authorized purposes while reducing flood damages in the Fort Peck Dam to Lake Sakakawea reach; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control regulation, thus helping to alleviate large reservoir level increases in Garrison, Oahe, and Fort Randall; and (3) to provide the extra water needed to meet all of the System's Congressionally authorized project purposes that draft storage during low-water years.

Fort Peck is an important component of the System that contributes substantially to hydropower production, recreation, water supply, fish and wildlife, and flood control purposes. The rule of reason suggests that removal of Fort Peck dam would result in significant impacts to the human environment, many of which would be unacceptable to basin stakeholders and Tribes. USACE did not consider Fort Peck dam removal reasonable for consideration within the scope of this EIS because of the uncertainties regarding the effectiveness of this management action towards meeting pallid sturgeon objectives and the availability of other actions that would be less impactful.

- **Actions at Intake Dam and Cartersville Dam on Yellowstone River:** Section 2.5.2 discusses upper river pallid sturgeon management actions considered for plan alternatives and implementation within the 15-year timeframe covered by this MRRMP-EIS. Actions at Intake Dam were evaluated as part of a separate NEPA process evaluating various options for fish passage at Intake (Bureau of Reclamation and USACE 2016). Therefore, this hypothesis was not included within the scope of plan formulation for this EIS. The efficacy of any action at Cartersville dam relative to pallid sturgeon in the upper river is dependent on preceding actions being implemented at Intake Dam and documentation of successful fish passage at Intake. Therefore, consideration of actions at Cartersville Dam would be remote and speculative at this time.
- **Water Quality Management:** The contaminants hypothesis involved the regulation of agricultural runoff and municipal waste discharge to decrease exposure of endocrine-disrupting chemicals. Contaminants are listed as a potential threat to pallid sturgeon populations (Dryer and Sandvol 1993), and there is some evidence for contaminant

exposure along the lower Missouri River (DeLonay et al. 2016). However, there are no definitive studies linking contaminants to reproductive failures or disease in the pallid sturgeon (DeLonay et al. 2016). USFWS is in the process of completing a review of this topic and ongoing laboratory research related to water quality and developing pallid sturgeon is included as part of the AM Plan. As a result, USACE did not consider this a reasonable hypothesis to include in developing alternatives for the initial scope of actions to be taken under the Management Plan.

- **Platte River Flow Management:** The Platte River related hypothesis stated that naturalization of the flow regime on the Platte River would allow migration, spawning, and recruitment of pallid sturgeon to the Missouri River population. Tracking efforts since 2007 have documented four spawning events in the Platte River (DeLonay et al. 2016). Expert elicitation performed during the effects analysis identified a high degree of uncertainty associated with this hypothesis (Jacobson et al. 2016a). Given the high degree of uncertainty and availability of other management actions, USACE did not consider this a reasonable hypothesis to include in developing alternatives for the initial scope of actions to be taken under the Management Plan.

2.4 Models Supporting Alternatives Development

The modeling framework for the MRRMP-EIS involves the application of more than two dozen quantitative models. Several models were developed by the effects analysis team to inform the development of management actions and provide information regarding the effectiveness of these actions in achieving objectives. USACE developed hydrologic and hydraulic (H&H) modeling tools including Hydrologic Engineering Center (HEC) Reservoir System Simulation (HEC-ResSim) and River Analysis System (HEC-RAS) models. Outputs from both HEC-ResSim and HEC-RAS were used in effects analysis species modeling and in human considerations (HC) impacts models.

2.4.1 Hydrologic Engineering Center – Reservoir System Simulation Model

HEC-ResSim is a reservoir operations model developed by the USACE HEC. The model incorporates user defined rules with other conditions (i.e., inflow, pool elevation, and downstream flows) to determine reservoir outflow. The model also performs downstream hydrologic channel routing. Water managers, as well as water control manuals and other documentation, help in determining the rules necessary to simulate a reservoir within the model. The Missouri River mainstem HEC-ResSim model was developed and used to simulate System operation of historical flows during a period of record (POR) (1931-2012). Flow-related management actions or alternatives that include altering reservoir operations were simulated and compared to a simulation of current operations to assess effectiveness towards meeting species objectives and the effects on natural, social, cultural, and economic resources of interest. HEC-ResSim simulations provided pool elevations and regulated inflows and outflows of each of the mainstem projects for each alternative simulation. This data was used directly as input to impacts assessment models (i.e., HC models) and available HEC-RAS models that estimate inundation and discharges at locations on free-flowing reaches of the Missouri River.

The Missouri River mainstem HEC-ResSim model was simulated using a daily time interval. The modeling includes the mainstem Missouri River reservoirs and extends downstream to target gages on the lower river. Two models are used to simulate the Missouri River mainstem reservoir operations: a downstream and System model. The Downstream model assumes that storage from all six reservoirs is located within one reservoir at Gavins Point. This is done

because the Missouri River mainstem reservoir operations are performed in a downstream to upstream manner where Gavins Point releases are first set, and then all releases from the upper reservoirs are set so enough storage remains in Gavins Point to meet required releases and maintain desired pool elevations. Therefore, the downstream model contains all the rules needed for downstream operations: service level, navigation season length, flood constraints, water supply, etc., and calculates Gavins Point releases for the POR. Once Gavins Point releases have been calculated for the POR, the System model sets releases for the other five reservoirs upstream of Gavins Point to ensure that enough storage remains in Gavins Point to meet Gavins Point releases calculated from the downstream model. Several of the management actions and alternatives formulated for this draft MRRMP-EIS would require changes to current System operations. To assist in providing context for how the proposed alternatives would change current operation, Section 3.2, River Infrastructure and Hydrologic Processes, includes a summary of mainstem System operations. The USACE HEC Modeling Report (available online at www.moriverrecovery.org) describes the model in detail including scripting rules and an evaluation of model performance.

2.4.2 Hydrologic Engineering Center – River Analysis System Models

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. Common outputs include stage, duration/timing of inundation, water velocities, flow areas/routes, water temperature, and sediment loads. Unsteady flow analysis was chosen as the method of hydraulic modeling due to the need to analyze time series stage and flow data. Both the biological considerations (e.g., seasonal habitat requirements) and the HC (e.g., potential agricultural impacts) are affected by the timing of river flows. HEC-RAS was used to more accurately route discharges from reservoirs and tributaries to points downstream and to simulate impacts of mechanical changes in river channel geometry. These models simulate how proposed alternatives and management actions would impact river stage and discharge over a wide range of basin hydrologic conditions.

Five separate HEC-RAS models were developed for the Missouri River between Fort Peck Dam in Montana and the Mississippi River:

- **Fort Peck to Garrison Dam:** begins with the regulated outflow from Fort Peck Dam in Montana and extends approximately 382 miles downstream, to just upstream of Garrison Dam on Lake Sakakawea, North Dakota.
- **Garrison Dam to Oahe Dam:** begins with the regulated outflow from Garrison Dam in North Dakota and extends approximately 318 miles downstream to just upstream of Oahe Dam on Lake Oahe, South Dakota.
- **Fort Randall Dam to Gavins Point Dam:** begins with the regulated outflow from Fort Randall Dam in South Dakota and extends 69 miles downstream to just upstream of Gavins Point Dam on Lewis and Clark Lake.
- **Gavins Point Dam to Rulo, Nebraska:** begins with the regulated outflow from Gavins Point Dam in South Dakota at river mile (RM) 811.1 and extends approximately 313 miles downstream to Rulo, Nebraska, at RM 498.0.
- **Rulo, Nebraska to the mouth:** includes the lower 498-mile stretch contained within the boundary of the USACE Kansas City District as well as the Mississippi River between Grafton and St. Louis.

The Oahe Dam to Big Bend Dam and Big Bend Dam to Fort Randall Dam reaches were not modeled in HEC-RAS due to the lack of riverine conditions between these dams.

The purpose of the HEC-RAS models was to create a baseline that closely represents current river conditions and to provide a tool to evaluate potential hydraulic changes resulting from proposed management actions or alternatives (e.g., channel reconfiguration and/or flow management). The baseline or existing conditions models were modified to represent a future condition under the No Action and action alternatives. Outputs of the HEC-RAS models were used in concert with other modeling programs such as HEC-Ecosystem Functions Model (HEC-EFM) and HEC-Flood Impact Analysis (HEC-FIA) to perform impacts analysis.

2.4.3 Bird Habitat/Population Modeling

The bird habitat/population models were used to evaluate the effectiveness of management actions and alternatives at meeting the bird objectives. The quantitative modeling framework for the bird species includes components for hydrology, riverine and reservoir shoreline habitat, and population viability. Buenau et al. (2016b) and Fischenich et al. (2014) document the models in detail. Hydrology and reservoir operations were modeled using HEC-ResSim, which routes basin runoff through the Missouri River using specified rules for reservoir operations. These rules were modified to reflect changes to reservoir operations under each alternative. The HEC-ResSim model used historical runoff and depletions from the POR as inputs and provided reservoir elevations, dam releases, and river stage at selected locations. Sequences of output years with randomly selected initial years were used in the habitat models.

Modeling of tern and plover populations as part of the effects analysis divided the river into northern and southern regions, with corresponding subpopulations for each. The northern region consists of Lake Sakakawea, Garrison river reach, and Lake Oahe; the southern region comprises Fort Randall river reach, Lewis and Clark Lake, and Gavins Point river reach. These two regions are notably different, with the north dominated by reservoir habitat and a single river reach, and the south consisting almost entirely of riverine habitat and tributaries. These regions are separated by a relatively large stretch of impounded river (Lake Francis Case and Lake Sharpe), which lacks breeding habitat and acts as a dispersal barrier, especially for piping plovers. Dispersal of both species between the northern and southern breeding areas occurs at a much lower rate than dispersal within those areas (Buenau et al. 2016b).

Emergent sandbar habitat (ESH) under varying flow conditions was predicted using a model that relates the deposition and erosion of sand to river flow and existing ESH area. At low flows, erosion rates are low. Erosion is greatest at moderate flows, then, as flows increase, deposition begins to occur (Fischenich et al. 2014). The amount of sand eroded or deposited and at what flows also depends on the existing ESH area. Models of ESH have been parameterized for each of three riverine reaches (Garrison, Fort Randall, and Gavins Point). They used initial ESH area and monthly river flows as inputs and output both a standardized acreage of ESH and available acreage of ESH. Initial inputs for the model, unless otherwise specified, were the 2014 estimates of population size (1,116 adults and 626 fledglings) and standardized habitat acreage (2,293 acres in Gavins Point, 1,035 acres in Lewis and Clark, 1,250 acres in Fort Randall, and 4,647 acres in Garrison, for a total of 6,613 acres).

Reservoir shoreline habitat is modeled indirectly. Fledgling production on reservoir shorelines is a function of two hydrological metrics: the vertical extent of exposed shoreline that had been inundated for at least 160 days in the past two years and the increase in reservoir elevation during the nesting season. These metrics predict observed bird productivity better than habitat

area, which is challenging to define and quantify on reservoir shorelines. The reservoir habitat-productivity modeling uses the daily time series of predicted reservoir elevations and bird population sizes on the reservoirs as inputs and output the number of fledglings produced.

Bird populations are modeled using viability models that account for the number of fledglings produced per pair of adults, annual survival for life stages (juvenile and adult plovers, juvenile, young adult, and older adult terns) and dispersal between river segments and regions. They use the output of the habitat models as inputs to produce fledge ratios (number of fledglings per pair of adults), population sizes, and associated population growth rates for each year and segment simulated. The population model for plovers is based upon Buenau et al. (2014c), updated to reflect the most current demographic rate estimates available (Buenau et al. 2016b).

The habitat and population models include uncertainty about parameter estimates. The population models also include demographic uncertainty (odds of individuals being born and surviving each year) and observation error. For any given scenario, models are run 5,000 times with random variables representing the uncertainty (using a Monte Carlo simulation methodology) and results are presented as metrics reflecting the distribution of results (e.g., median and confidence intervals).

2.4.4 Pallid Sturgeon 2-Dimensional Hydrodynamic Models

The effects analysis team developed 2-dimensional hydrodynamic models for pallid sturgeon functional habitat assessments to provide an understanding of how the availability of functional habitat varies with flow regime and channel reconfigurations (Jacobson et al. 2016b). These models were used to explore the effects of management actions related to changes in reservoir operations and channel reconfigurations on habitat availability in the lower river. The habitat models are based on the use of two-dimensional hydrodynamic models of Deer Island (pre-construction) and Miami Bend as representative of channelized conditions and of Hamburg and Lisbon-Jameson bends as representative of best available conditions. These models are used to quantify the availability of food-producing and foraging habitats as a function of discharge.

2.4.5 Human Considerations Modeling

The term human considerations (HC) is used to address the interests of stakeholders and Tribes. These include the authorized purposes as well as the many other services afforded by the System. USACE and USFWS have worked closely with the Missouri River Recovery Implementation Committee (MRRIC) since January 2013 to identify the underlying stakeholder interests referred to as “human considerations.” HCs to be assessed when evaluating alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. In January 2013, USACE asked MRRIC and their constituent stakeholders to provide input on the HCs relative to their use of the Missouri River and its resources. USACE requested this feedback to help inform how MRRIC collective interests could be considered in an assessment of consequences associated with management actions for the listed species. The MRRIC formed the Human Considerations Ad Hoc Work Group as a mechanism to provide input on HC. The work group gathered and reviewed input from MRRIC members on the following categories: agriculture; commercial sand and gravel dredging; environmental conservation / fish and wildlife; flood risk management; irrigation; hydropower; local government; navigation; recreation; Tribal and cultural; water quality and water supply; thermal power; and wastewater. In August 2014, the MRRIC made a consensus recommendation to the USACE regarding HC objectives and performance metrics. This recommendation established criteria to ensure that adequate consideration is given to the

possible interactions of management actions with human uses and interests on the river, and that these criteria are used to evaluate the impacts of alternatives in the MRRMP-EIS.

The MRRMP-EIS project delivery team (PDT) developed a suite of models for use in assessing the effects of management actions and alternatives to the HC. A subset of these models was used to calculate “proxy metrics” for the HC. Proxy metrics were used in the alternatives development process to inform PrOACT discussions with MRRIC (Appendix A). Proxy metrics were capable of being efficiently modeled and calculated, responsive to changes in reservoir operations and/or channel geometry modifications, and indicative of the potential for impacts to a HC. In most cases, the proxy metrics assessment did not include the complete impacts analysis as presented in this draft EIS. Additional economic models were developed to facilitate impacts analysis of each alternative carried forward for detailed consideration in this draft EIS. These economic models were also the basis for calculation of National Economic Development (NED) and Regional Economic Development (RED) effects consistent with USACE planning requirements. The models used to evaluate each HC are described in a series of technical reports available at www.moriverrecovery.org.

2.5 Management Actions

This section describes the general management actions that were considered during the alternatives development process. The range of management actions includes those that were directly linked to one of the management hypotheses documented in the effects analysis (Table 2-1 through Table 2-3). Management actions are presented based on applicability to the least tern and piping plover, pallid sturgeon in the upper Missouri River, and pallid sturgeon in the lower Missouri River. The discussion of each management action explains if the action was retained or eliminated from alternatives development with supporting rationale. Effectiveness and efficiency were the primary criteria used in determining whether or not to eliminate a management action from further consideration at this step. Effectiveness refers to the extent to which the management action contributes to meeting the species objective. Efficiency refers to how cost-effective the management action would be at meeting the species objectives. It should be noted that eliminating a management action from further consideration for the alternatives in this draft EIS, which is identifying alternative plans to guide the MRRP over the next 15 years, does not exclude the action from being the subject of further research or study as part of the AM Plan.

2.5.1 Least Tern and Piping Plover

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the least tern and piping plover from USACE actions on the Missouri River. The management action descriptions are largely taken from Buenau et al. (2016b).

2.5.1.1 Emergent Sandbar Habitat Creating Flow Release

Flows that are high relative to the elevation of existing sandbars have the potential to mobilize and deposit sediment at high enough elevations to create new sandbars when water levels recede (Buenau et al. 2016b). High flows must be of sufficient duration to build sandbars to a high enough level to provide suitable habitat at more typical flows. The amount of habitat created depends on the magnitude and duration of the flow release and the area of sandbar present prior to the release (i.e., ambient ESH). This management action would consist of a deliberate reservoir release of flows in either the spring (March through May) or fall (October

through December) for the purpose of creating ESH. Habitat-forming flow releases can be combined with all other least tern and piping plover management actions; however, timing is a consideration. For example, a habitat-forming flow release would not be planned to overlap with mechanical ESH construction within any year because the effectiveness of the flow release would be reduced. This action was retained for alternatives formulation and was the subject of several iterations of modeling and alternative formulation described in Section 2.7, Bird Alternatives Development.

2.5.1.2 Mechanical Habitat Creation on River

Mechanical ESH creation includes any activity constructing in-river habitat without the use of flows. USACE has an existing ESH Program and has constructed ESH in the Gavins Point river reach and upper Lewis and Clark Lake from 2004 to 2010. The ESH Program is currently implemented in compliance with the 2003 Amended BiOp (USFWS 2003) and as specified in the Record of Decision (ROD) for the *Programmatic Environmental Impact Statement for the Mechanical and Artificial Creation and Maintenance of Emergent Sandbar Habitat in the Riverine Segments of the Upper Missouri River* (ESH PEIS, USACE 2011). The MRRMP-EIS ROD will replace the ROD written for the ESH PEIS in 2011; however, this will not invalidate analyses and tools developed during the previous effort.

Methodologies used for construction of sandbars vary by each project site location. The selected contractor is allowed some freedom to choose their preferred construction methodology. Various combinations of dredging and/or heavy equipment such as backhoes, draglines, bulldozers, and scrapers are used to construct the sandbar to specified contours and elevations. The construction season for ESH projects is short as it is limited to the times of year when least terns and piping plovers are not in the area and weather conditions allow. These species typically arrive in mid-April and leave in mid to late August. The ESH Program has contractors ready to begin work as soon as the birds leave the area in late summer and work continues until ice conditions. Construction may not occur in the Missouri National Recreational River segments until after Labor Day. National Park Service (NPS) coordination requirements regarding construction of ESH in the Missouri National Recreational River segment is discussed further in Chapter 6.0.

ESH sites are chosen by a multi-agency team using a number of site selection criteria. One of the main selection criteria is a site where a shallowly submerged sandbar already exists. The ESH program capitalizes on these areas of natural accumulation of sand by raising these shallowly submerged sandbars to exposed elevations. The programmatic implementation of ESH to date is based on a principle of systematic avoidance of potentially sensitive resources and the de-selection of less suitable project areas. This management concept was documented in the ESH PEIS and would continue to be associated with ESH construction under each of the alternatives. Sensitive resources are defined as known locations of protected plant and animal species, natural heritage and cultural resources, public and private infrastructure features, existing public and private recreational features, and other elements of the human environment. This is accomplished through site-specific NEPA analysis that includes identification of sensitive resources and coordination with the Tribes, public, stakeholders, and resource agencies prior to start of construction. USACE also would continue to conduct testing of material for contaminants prior to using those materials for in-river ESH construction.

ESH mechanical construction was retained for further alternatives development. Mechanical ESH creation could occur in the following river reaches:

- Garrison Reach: riverine segment between Garrison Dam and Lake Oahe; RM 1389.9-1304
- Fort Randall Reach: riverine segment between Fort Randall Dam and Lewis and Clark Lake; RM 880-845
- Gavins Point Reach: riverine segment below Gavins Point Dam and above the channelized river beginning at Ponca, Nebraska; RM 811.1-754

2.5.1.3 Mechanical Habitat Creation on Reservoir Shorelines or Islands

Mechanical habitat creation on reservoirs was proposed to provide higher- elevation nesting habitat for high-flow years when riverine habitat and lower-elevation reservoir shoreline habitat is unavailable. Reservoir habitat was included in “off-channel” habitat recommendations made by MRRIC. Created reservoir habitat would require intensive maintenance to keep vegetation from establishing. It would also likely require intensive predator control if birds use it for nesting for multiple years. In the event that reservoir levels dropped too much below the elevation of the constructed habitat, birds may not use the habitat.

USACE (2014a) recommended that the priority for mechanical habitat creation efforts should remain focused on the current riverine creation efforts, and not in the reservoirs. This conclusion was based on multiple identified uncertainties and risks, including inundation, increased incidental take, excessive cost compared to other proven habitat creation options, infrequent availability for use by the birds, and potential exacerbated predation and maintenance. Per acre project costs ranged from \$60,000 for a large project, which could benefit from economies of scale, to \$230,000 for smaller projects in the mainstem reservoirs (USACE 2014a). Average per acre cost for mainstem reservoir projects was \$172,000 (USACE 2014a) compared to \$50,000 per acre for in-river habitat construction (estimate developed for this draft EIS). USFWS also recommended not including this action as part of the plan citing the need for better understanding of reservoir habitat dynamics in relation to bird densities and reproductive output (USFWS, 2015a). USFWS (2015a) stated that since monitoring of least tern and piping plover populations within the Missouri River began in 1986, approximately 80 percent of the total incidental take of piping plover eggs and chicks and 58 percent of least tern eggs and chicks were due to rising pool levels in reservoirs. This management action was eliminated from further consideration because its effectiveness at meeting species objectives is not currently demonstrated relative to other available management actions. As described, it is also inefficient at meeting species objectives based on project costs relative to other available management actions.

2.5.1.4 “Off-Channel” Habitat Creation/Mechanical Creation of Hydrologically Connected non-ESH Habitat on River Segments

The MRRP Independent Science Advisory Panel’s (ISAP) evaluation of the Draft Bird Adaptive Management Cycle Example (ISAP 2015) contained recommendations to consider “off-channel” habitat for the birds as a management action in this MRRMP-EIS. Additionally on several occasions since 2010, MRRIC has recommended consideration of “off-channel” nesting habitat as a management action. These discussions have included habitat within reservoir pools, off-channel habitat similar to sandpits adjacent to the central Platte River and habitat creation in the

navigation channel below Ponca, Nebraska (USFWS 2015a). The reservoir habitat component was discussed in Section 2.5.1.3; however, the other two components are considered here.

USFWS defined “off-channel” habitat as areas that are not connected to the main channel hydrologically, energetically, and/or through sediment degradation/aggradation processes (USFWS 2015a). USACE completed an initial assessment of off-channel creation opportunities (USACE 2012a). The following sites were included in that assessment:

- Platte River Sandpits: Kearney, Nebraska, and vicinity
- Sandpits Adjacent to the Missouri River: North Dakota, South Dakota, and Nebraska
- Audubon Bend and North Alabama Bend: Wynot, Nebraska, and Vermillion, South Dakota
- Off Reservoir Within USACE Boundary Sites: Lake Sakakawea, North Dakota
- Audubon National Wildlife Refuge: Cole Harbor, North Dakota
- Lake Sharpe, South Dakota
- I-29 Borrow Pits: various sites in Iowa
- Kensler’s Bend: Nebraska and South Dakota
- DeSoto Bend National Wildlife Refuge: Missouri Valley, Iowa

The report identified some of these sites as having potential for consideration or further study as pilot projects. The report identified drawbacks associated with each site, which generally included land ownership considerations, extensive vegetation and predator management, and construction considerations (e.g., the need to haul sand to site and excavation requirements).

The USFWS definition would only apply to the sandpit or borrow pit sites listed; however, habitat creation in the navigation channel below Ponca, Nebraska is also considered in this section. USFWS recommended that USACE not include sandpit habitat management or habitat development in the navigation channel as management actions in this plan (USFWS 2015a). USFWS identified several issues that would need to be resolved to consider this a feasible management action including the reproductive potential of these areas, potential for high predation, habitat preferences and dispersal, forage availability, land acquisition, and feasibility of creation and maintenance (USFWS 2015a). This management action was eliminated from further consideration because it is not currently demonstrated to be as effective or efficient at meeting species objectives relative to other available management actions such as in-river construction of ESH and vegetation management on ESH (USACE 2012a). Although this action was eliminated from consideration in this EIS, USFWS has expressed a willingness to MRRIC to pursue funding for a pilot project. This funding would not be through the USACE MRRP; however, the results of any pilot project could be evaluated under the AM Plan.

2.5.1.5 Modification or Augmentation of Existing Sandbars

Sandbars can be augmented using dredges and earth-moving equipment to add sand to existing bars. Sandbars can also be reshaped to lessen the effects of erosion such as cut banks that limit the availability of foraging habitat. Many similarities exist between the mechanical creation of sandbars and the augmentation of existing sandbars, although costs and other logistics differ. Modification and augmentation of existing sandbars typically requires less time and budget than construction of new ESH. This action was retained for alternatives

development; however, the impacts of this action are considered to be included under the impacts of mechanical ESH construction because they affect resources similarly.

2.5.1.6 Vegetation Management

Vegetation growth on sandbars may limit the amount of suitable nesting habitat available to birds. USFWS lists vegetation encroachment as a major factor in limiting the amount of suitable nesting habitat for piping plovers in the Piping Plover 5-year Status Review (USFWS 2009). Sandbars are generally selected for vegetation control and removal due to historical use as nesting habitat by least terns or piping plovers. The primary and preferred method of vegetation control and removal is application of pre- and/or post emergent herbicides to selected sandbars. Herbicides may be applied by spraying from all-terrain vehicles or by hand in smaller, less vegetated areas. Less often, herbicides may be sprayed by air in large, densely vegetated areas. Additional vegetation control and removal methods include cutting, mulching, disking, mowing, raking, and removing vegetation from sandbars. Post-treatment removal using these additional methods may be necessary depending on the height and density of the vegetation on the selected sandbar. Vegetation that is woody with large stems may need post treatment breakdown and removal.

Duration and intensity of the initial treatment and removal depends upon the size and density of the vegetation on the sandbar. After the initial treatment and removal of vegetation on selected sandbars, maintenance would occur on an annual basis. Annual maintenance would include spraying herbicides in the spring or fall as needed usually in the same manner as the initial treatment. Due to the variability in duration and intensity of vegetation control and removal, costs are variable as well. Initial costs have the potential to be more expensive than the annual maintenance if sandbars require spraying and post treatment removal initially. Annual maintenance costs using herbicide amount to roughly \$100 per acre treated. To address water quality concerns, USACE collects samples analyzing for Glyphosate, AMPA, and Imazapyr which are the typical herbicides used for controlling vegetation on sandbars. Water quality monitoring is assumed to continue in association with the vegetation management action under all alternatives in this EIS.

Vegetation management was retained for alternatives development. This action would need to be implemented in combination with other habitat-creating management actions. It would not be effective on its own at meeting species objectives, but can enhance the effectiveness of other management actions and natural ESH creating flow events by extending the suitability of existing ESH.

2.5.1.7 Habitat Conditioning Flows

Habitat conditioning flows are reservoir releases of a specific magnitude and duration intended to maintain existing ESH. These flows overtop existing sandbars but are not high enough or of long enough duration to form new sandbars. These conditioning flows may scour existing vegetation, prevent establishment of woody vegetation, and deposit new sand on existing sandbars. These deposits enhance the quality of existing ESH and in turn increase the area of nesting/brood-rearing habitat. The improvement to total ESH area resulting from habitat conditioning flows remains uncertain because these flows may also erode existing sandbars. The characteristics of habitat condition flows (i.e., magnitude and duration) would be variable from year to year. Implementation of habitat conditioning flows was eliminated from further consideration within the scope of the MRRMP-EIS because there is not enough information at this time to indicate this action would be effective or efficient relative to other management

actions. Further research on the potential of this management action would be considered under the AM Plan.

2.5.1.8 Reservoir Water Level Management

Reservoir water level management involves the intentional manipulation of reservoir levels to increase the availability of nesting and brood-rearing habitat for the bird species. Reservoir releases expose potential shoreline habitat. Exposed shorelines that were previously inundated for more than 160 days in the past two years are expected to increase the unvegetated area available for nesting. Increases in reservoir elevation during the nesting season can inundate nests and lower fledgling production on reservoir shorelines. Such increases commonly occur as part of routine operations, particularly in Lake Sakakawea. In contrast, stable or declining reservoir levels during the nesting season can reduce or prevent nest inundation and provide additional foraging habitat. Only Lake Sakakawea and Lake Oahe have sufficient potential habitat (i.e., gradually sloping shorelines and areas free of bluffs) and water level variation to provide reservoir habitat. This management action was retained for alternatives development.

2.5.1.9 Lowered Nesting Season Flows

Lowered nesting season flows would consist of the intentional reduction of reservoir releases from standard releases during the May to August timeframe. Lowered nesting season flows may benefit least tern and piping plover in two ways: (1) the lower water surface elevation exposes more ESH for nesting, brood-rearing, and foraging and (2) the reduced flow can potentially decrease the rate of erosion of existing ESH. River stage during the nesting season helps determine how much habitat is available for nest site selection, brood rearing, and foraging. In nearly all cases, low flows expose more habitat that birds can use (eroded cut banks on sandbars may limit the extent to which more habitat becomes available, and whether piping plover chicks have access to foraging habitat). Generally any decrease in flow would increase habitat availability on river reaches; however, there is not a specific discharge that would have the same magnitude of effect in all cases. The resulting increase in habitat depends on how much ESH is in the river and at what elevations; if very few sandbars are present, less potential habitat is available to be exposed by low flows. Reducing reservoir releases to achieve a lowered nesting season flow would increase reservoir levels, which has potential to affect birds nesting on reservoir shoreline. This management action was retained for alternatives development.

2.5.1.10 Flow Management to Reduce Take

This action involves the adjustment of reservoir releases during the nesting season to reduce take of nests, eggs, and/or chicks by rising water levels. It is referred to as Steady Release – Flow to Target in the Master Manual. When conditions allow, this action is implemented below Garrison, Ft. Randall, and Gavins Point Dam. It includes initial steady releases high enough to inundate low-lying nesting habitat to encourage birds to nest at high elevations, so that increased releases later in the season do not inundate nests or strand chicks. As downstream tributary flows decline through the summer, releases can be increased or decreased as needed to meet downstream flow support needs while seeking to minimize impacts to nesting birds. Reducing flows during the nesting season meet a similar purpose, while also potentially providing more foraging habitat for plovers, but are more difficult to achieve given other System operating objectives. This management action can also result in increasing water levels during the nesting season in reservoirs. This management action was retained for alternatives development.

2.5.1.11 Predator Management (Predator Removal and Nest Caging)

USACE has been implementing this management action under a Predation Management Plan (USACE 2009a) developed in compliance with the 2003 Amended BiOp (USFWS 2003). The area subject to predator management activities includes all segments of the river where USACE currently monitors and manages for piping plover and least tern productivity. The primary objective of the plan is to increase the productivity of least terns and piping plovers by reducing the loss of eggs and chicks to predation and reducing the number of adults that are predated or driven away from nesting areas due to disturbance by predator species. The plan describes control methods to be employed to reduce predation, and provides a framework of guidelines for the implementation of predation control actions. The plan also provides a process for the evaluation of the effectiveness of predator management in achieving objectives.

The number of eggs and chicks lost to predation can be reduced or limited through either direct or indirect predator control and management actions. Predator control and management actions are implemented based on monitoring of least tern and piping plover breeding sites throughout the breeding season. Management actions are taken when there is observed predation activity impacting the success of least tern and piping plover breeding pairs. The level of action taken is a factor of habitat availability and severity of predation occurring. When habitat is abundant, the evidence of predation is less noticeable and fewer predator management actions are taken. When habitat is less abundant and signs of predation more evident, actions to manage predators are taken more often.

Direct management actions include the lethal or non-lethal removal of predators and are typically deployed when habitat is limited and the level of predation high. Targeted species such as raccoons, coyotes, mink, and great horned owls are either lethally or non-lethally removed depending on the species and situation. Typically state and federal wildlife control specialists are responsible for the non-lethal and lethal removal activities of targeted species.

Indirect management actions may include caging, fencing, or hazing which dissuades predators from breeding sites and are deployed when predation activities are present but not severe. Nests at risk of predation are primarily protected by placing exclosure cages around them. Exclosure cages can only be used to protect plover nests; terns frequently fly to and from their nests and are less likely to walk through the enclosure. Other indirect management actions such as fencing and hazing can be used in combination with other direct or indirect actions to maximize the effect of the management actions.

All predation control activities are conducted in compliance with all applicable state and federal regulations. Although cost estimates for predator management and control vary depending on level of effort required, past contracts with state and federal wildlife specialists ranged from \$10,000 to \$50,000 annually. These contracts involved intensive predation control efforts when habitat levels were low, and tern and plover nest densities and predation rates were high. All predation impacts observed and predation control activities undertaken in the field during the bird monitoring season are documented. This management action was retained for alternatives development.

2.5.1.12 Human Restriction Measures

Throughout the least tern and piping plover breeding season there is the possibility of interaction between birds and people. This can range from innocent curiosity to deliberate destruction of nests or eggs. Several measures can be taken to reduce disturbance to the birds.

Posting signs that restrict access to breeding areas, placing barricades to exclude human access, and outreach efforts are all frequently deployed and common actions that help to control and restrict human disturbance to breeding sites.

Restricting access through the placement of barricades and endangered species restriction signs are sometimes necessary to protect nesting and brood rearing sites from the public. When the birds have completed their nesting and chicks have fledged and left the site, the barricades and restriction signs may then be removed. Specifically, barricades are more often used to prevent vehicular access to nesting sites located along reservoir shorelines and are most commonly placed next to recreation areas to prevent off-road vehicle access to beaches. Barricades can be constructed using natural features such as rocks and logs, or a fence with a gate as a more permanent deterrent.

Endangered species restriction signs are placed at specific locations to make the public aware of least tern and piping plover nesting areas as well as the potential for prosecution of those individuals that enter a posted site under the ESA. Placement of restriction signs is evaluated on a case-by-case basis and depends on both the level of use as well as the level of bird activity. Sites that are remote with little opportunity for human disturbance may not be marked with restriction signs, as signs might attract attention and people to the site out of curiosity. Generally, under best practices, all river sites that contain five or more nests should be posted with restriction signs. All reservoir sites that have the potential for human visitation, especially those adjacent to recreation areas should also be signed. Restriction signs should be placed so that they are visible to the public at all entry points to the nesting area. On sandbar and beach shorelines, the signs are placed near the water to forestall boaters from landing. When the birds have completed both nesting and chick rearing, and have left a site, the restriction signs are removed.

Violation of the ESA can result in fines, imprisonment, or both. If a minor violation is observed by the monitoring crew, such as people inside a restricted area, the individuals are contacted, informed about the importance of not disturbing the birds, and asked to leave the restricted area with an explanation. If a major violation is observed, for example a person is pulling up the restriction signs, overturning predator exclosures, driving in the nesting area, or smashing eggs, action is taken and a law enforcement officer is notified. Law enforcement officers include the county sheriff's department, the state conservation officer, or USFWS special agent.

Human deterrence measures also include information sharing and education. These measures may be demonstrated by one-on-one conversations with individuals at boat ramps, handing out informational endangered species materials, giving campground talks, posting endangered species information signs, and public service broadcasts via television and radio stations. This management action was retained for alternatives development.

2.5.1.13 Channel Modifications to Increase Width

Buenau et al. (2016b) summarized the lines of evidence leading to consideration of this management action. Channel width has been associated with the formation and persistence of sandbars, in that sandbars are more likely to form and persist where the channel is wider. Although widening a channel would not inherently create more nesting habitat, it may improve conditions for sandbars to form under high flows and could reduce erosion on existing sandbars. This action was eliminated from further consideration because at this point there is a great deal of uncertainty about the scale of widening needed to increase persistence and/or formation of sandbars and there are other management actions available to achieve the objectives that are

not associated with the same level of uncertainty and risk. This management action will be further investigated through habitat monitoring and modeling through the AM Plan.

2.5.1.14 Sediment Redistribution

Sediment redistribution generally involves transporting sediment from reservoirs to the river reach downstream of the dam. The intent of redistribution would be to increase the sediment supply for sandbar formation in the river reach, thus increasing the amount of ESH created by higher flows. The Lewis and Clark Lake Sediment Management Study is investigating the engineering viability of this management action. Modeling completed to date has evaluated the hydraulic transport of Lewis and Clark Lake delta sediments through Gavins Point dam via sediment flushing (USACE 2013). Five flushing scenarios focused on very high river flows for short duration were developed as part of Phase I of this study. Modeled flow varied from 88,000 cfs to 176,000 cfs with up to 7 days at the peak flow. The largest event was also simulated with a section of the Gavins Point Dam spillway lowered by 10 feet to increase the energy available to move sediment. All flows in these simulations were released through the spillway at Gavins Point Dam to avoid sending sediment flow through the powerhouse. All the scenarios included draining Lewis and Clark Lake, increasing discharge at Fort Randall Dam upstream to the peak flow, maintaining the flow for the flush duration, and a reduction in flow that coincides with reservoir refilling.

USACE (2013) showed that all the flushing scenarios predicted transport of silt and clay size particles through the dam. In the cases of the high flow and modified spillway, the model predicted very high sediment concentrations and total mass of sediment transported. Each scenario also predicted the redistribution of sand size particles throughout the delta and bottom of Lewis and Clark Lake. However, due to the length of the reservoir and the location of the spillway gates 20 feet above the lake bottom, almost no sand was passed through the spillway for any scenario. Only the flushing scenario with 176,000 cfs and the modified spillway gates, when sediment concentrations were the highest, predicted 0.07 percent of the mass of sediment passing the spillway as sand; the remaining 99.93 percent was silt and clay. This result is important because the delivery of sand would be needed to support sandbar habitat development below the dam. The study concluded that additional scenarios exist that warranted additional examination. These additional scenarios along with an evaluation of cost considerations are included in Phase II of this study, which is ongoing. This action was eliminated from further consideration in this draft EIS because its effectiveness at contributing towards species objectives and implementation feasibility has not been demonstrated to date. Further research on the potential of this management action would be considered under the AM Plan.

2.5.2 Upper River Pallid Sturgeon

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the pallid sturgeon in the upper Missouri River from USACE actions on the Missouri River.

2.5.2.1 Fort Peck Actions/Lake Sakakawea Drawdown

The effectiveness and technical feasibility of management actions for achieving pallid sturgeon objectives in the upper Missouri River are highly dependent on several critical uncertainties related to pallid sturgeon behavior and environmental factors. The effects of available drift/dispersal distance and hypothesized inhospitable headwaters of Lake Sakakawea pose a

distinct constraint on pallid sturgeon recruitment. The ability to overcome these constraints has bearing on the efficacy of the following management actions:

- Altering the flow regime at Fort Peck,
- Temperature control at Fort Peck,
- Sediment bypass at Fort Peck, and
- Drawdown of Lake Sakakawea at Garrison Dam.

Drift: *Drift is the passive dispersal of the larvae carried by the flow of river water from the site of hatching to comparatively more stationary rearing habitats.*

Because the natural upstream migrations of spawning adult pallid sturgeon are blocked by Fort Peck Dam and severely limited by Intake Diversion Dam on the Yellowstone River, the maximum total available main channel drift distance for hatching larval pallid sturgeon is currently limited by Fort Peck and Intake Diversion Dams on the upstream end and the headwaters of Lake Sakakawea at the downstream end (Figure 2-3). Lake Sakakawea is currently considered to be an impediment to larval pallid sturgeon survival because emerging evidence suggests that anoxic (i.e., no oxygen) conditions exist in the transitional zone of Lake Sakakawea, and that free embryos that settle in that zone would therefore presumably not survive. Lethality of the headwaters of Lake Sakakawea is further inferred from recent studies (Guy et al. 2015) that demonstrated the transitional zone between the riverine (lotic) and reservoir (lentic) conditions in the upper reaches of Fort Peck are anoxic due to high concentrations of organic particulate material subject to microbial respiration. The anoxic condition at Lake Sakakawea truncates riverine habitat necessary for wild pallid sturgeon larvae to complete their drifting transition from free embryo to larvae.

Available data indicate that hatchery released free embryos, 5 days post-hatch or older, are able to survive to age-1 in the Missouri River between Fort Peck Dam and Lake Sakakawea, when released 170 miles upstream of the lake. Natural recruitment has not occurred in this reach, suggesting that mortality occurs days 0 to 5 post hatch. These observations support the hypothesis by Kynard et al. (2007) which implicates total drift distance as a limitation on natural recruitment. Thus within a given river reach, the distance required to complete the early life stage requirements is dependent on total reach length (based on available river length and spawning site selection), river discharge, velocity, habitat complexity, and temperature; all of which influence the Missouri and Yellowstone rivers differently.

The Missouri River between Fort Peck Dam, Montana, and the headwaters of Lake Sakakawea, North Dakota is regulated by releases from Fort Peck Dam, ultimately affecting water temperature, spawning cues, side-channel inundation, and habitat-forming processes. Overall, this reach is approximately 211 miles (340 kilometers [km]) in length. Considering the effects of the hypolimnetic discharge (i.e., cold water releases from the bottom of the reservoir) from Fort Peck Dam it is reasonable to conclude that the first 24–31 miles (40–50 km) downstream of the dam is unsuitable for pallid sturgeon spawning due in part, to cold water temperatures (Braaten et al. 2012), unless water temperature is mediated by inflows from the Milk River, releases over the Fort Peck Dam spillway, or through a temperature-control mechanism. Therefore riverine habitat available for the larval drift transition to occur in this river reach is limited to only 180–186 miles (290–300 km). The available drift distance within this reach is at the very lower end of what is believed necessary and so far no evidence of natural recruitment within this reach has been documented since the species was listed. Settlement of drifting free embryos generally occurs about 8 to 14 days post hatch depending on temperature (Braaten et al. 2012) although the actual amount of time spent drifting could be less than that if the fish reside in the interstices of the substrate (i.e., small spaces in between rocks) for some period following hatch.

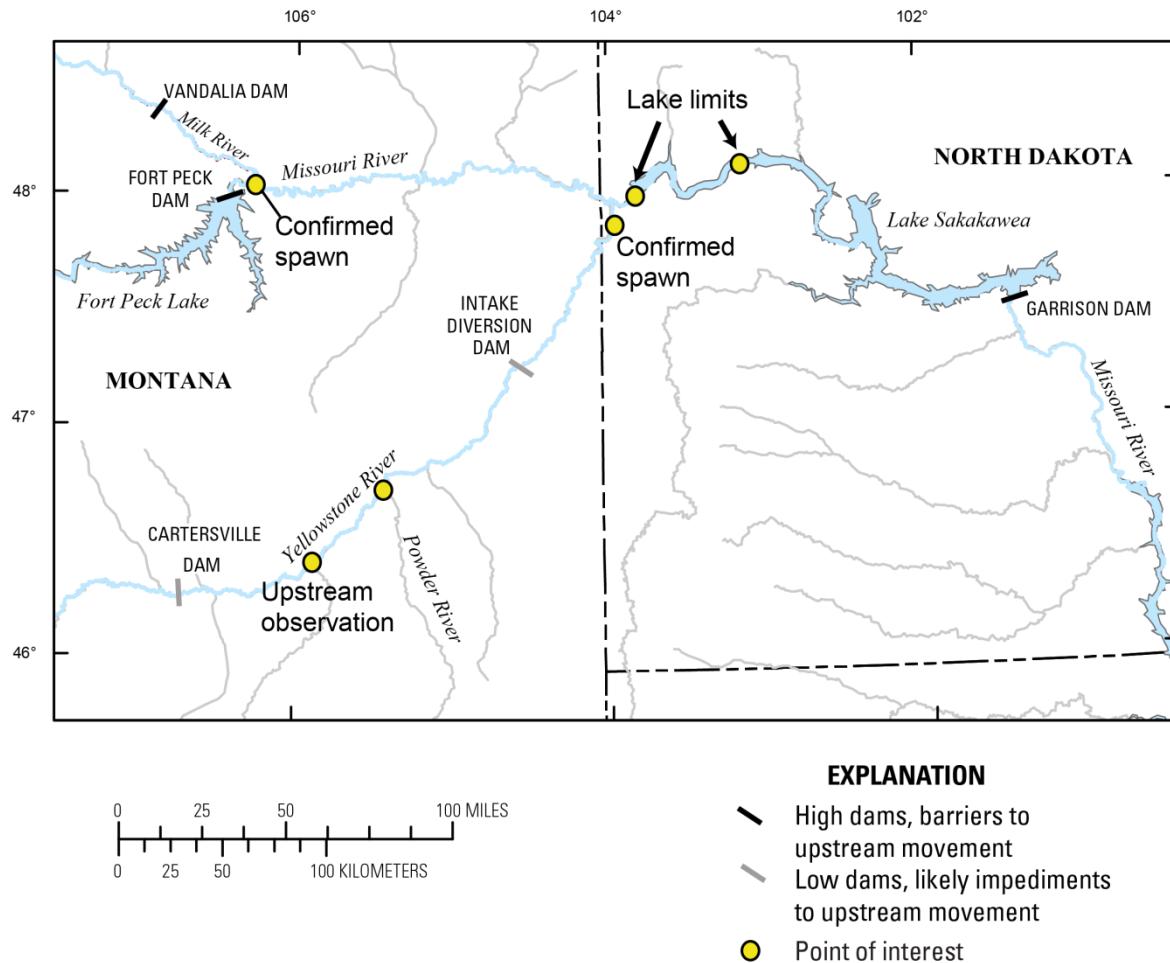


Figure 2-3. Upper Missouri River Locations Influencing Drift Distance Availability

Recent evidence from experimental streams supports a model of immediate drift for pallid sturgeon (DeLonay et al. 2015) although lack of residency has not been established for all potential combinations of field conditions (Jacobson et al. 2016b).

The effects analysis (Fischenich et al. 2014) used advection/dispersion modeling to assess drift in the Fort Peck to Lake Sakakawea reach. In one set of analyses they replicated flows and pool levels in a 10-year period from 2003 to 2012 to determine what percentage of free embryos remained within lotic reaches (i.e., upstream of the reservoir transition zone) for various drift durations. Spawning was assumed to occur at the Milk River confluence, about 9 miles downstream of the dam; spawning near this site was inferred in 2011 when extraordinary flows attracted an aggregation of reproductive fish relatively far upstream. The model predicted that 70 percent of the embryos remained in riverine segments on average after 6 days over the 10-year period. That figure dropped to 45 percent after 7 days, 16 percent after 8 days, and four and one-half percent at 9 and 10 days of drift respectively. In the absence of larvae being retained in the interstices of the substrate, or otherwise delayed in their dispersal, these analyses again suggest that long-term retention of sturgeon larvae in riverine segment below

Fort Peck Dam is likely less than five percent. Considered on an annual basis (rather than an average) retention after 8 days of drift was in excess of 20 percent for half the years (but zero or nearly zero in the remaining half).

The effects analysis also directly considered the effectiveness of decreased flows to reduce advection (i.e., alteration of the flow regime at Fort Peck) and lowered pool levels (i.e., drawdown) in Lake Sakakawea to extend the riverine segment. The Fort Peck temperature control action can be implied using drift duration as a surrogate for temperature. Simulations of drift were made using advection/dispersion models with an assumed spawning location at the Milk River confluence, as described previously. Flows were varied from 3,000 to 18,100 cfs (the historic minimum to the 5 percent exceedance level), and pool elevations in Lake Sakakawea were varied from 1,805 feet msl to 1,856 feet msl, approximately the range of observed values in the past 50 years, including the historic minimum, recent minimum, and maximum levels as well as the median and 10 and 90 percent exceedance values. In all, 48 combinations of flow and pool level were modeled and the percentage of free embryos retained in lotic reaches documented at 2-day intervals from 4 to 10 days. These analyses demonstrate that all three management actions affect retention. They also confirm the earlier analyses using historic flows. Retention is very low and approaching zero after about 8 days of drift. The analyses also reinforce the importance of interstitial hiding or other drift-delaying mechanisms as a critical unknown. If no interstitial hiding occurs, recruitment failure is likely except when both flows from Fort Peck and pool levels on Lake Sakakawea approach historic minimums.

The water in Fort Peck thermally stratifies resulting in a colder and denser water layer at depth. When this cold water is released, it substantially cools the riverine environments downstream. Average and maximum water temperatures immediately downstream of Fort Peck Dam can be reduced by as much as 10.8°F (6°C) and 18°F (10.4°C), respectively (Fuller and Braaten 2012). These effects decrease with increased distance from the dam, but are still measurable over 180 miles (290 km) downstream where average and maximum temperatures are still 1.8°F (1°C) cooler than Missouri River reaches above Fort Peck Reservoir (Fuller and Braaten 2012).

The water intakes for Fort Peck Dam are on the bottom of the reservoir making it challenging to develop and implement design options to discharge warm surface waters downstream. In 2009, USACE completed the Fort Peck Dam Temperature Control Device Reconnaissance Study. Ten alternatives to improve downstream water temperatures were evaluated for further consideration (USACE 2009b). The use of a flexible curtain to act as a submerged weir became the focus through subsequent investigations (USACE 2012b). This option uses a flexible curtain that is suspended a set distance from the water surface using a float system with the curtain bottom being anchored to the lake bottom with ballast and anchors. This option works by passing the warmer water from the upper portion of the water column over the weir crest into the intake area, rather than drawing cold water from the bottom of the reservoir (USACE 2012b). USACE does not consider this option feasible due to an estimated short life cycle (i.e., 10–20 years), uncertainties with meeting downstream temperature targets, emerging science on larval drift distances, high construction and operation and maintenance costs, and significant dam operation safety concerns.

Modeling predicts that if there is no delay in drift, then all combinations of aforementioned management actions on the Missouri River (alteration of Fort Peck flows, temperature modifications at Fort Peck, and drawdown of Lake Sakakawea) are likely to result in recruitment failure (Fischchenich et al. 2014). As stated previously, a reconnaissance study conducted in 2009 cited the challenges presented by management options at Fort Peck Dam (USACE 2009b). Prohibitively high costs and/or risk and uncertainty related to dam operations and dam safety

were associated with each option. Actively managing the hydrology below Fort Peck Dam to provide the appropriate volume and temperature at the correct time would be a significant challenge containing hydrological, physical, and biological uncertainty with a small probability for success (USFWS 2015b). Approximately 90 percent of the tagged adult pallid sturgeon in the upper Missouri River population use the Yellowstone River during the spawning period (May – July) (Braaten et al 2015). The only exception was during a historic flood when some fish chose the Missouri River, although most still chose the Yellowstone River. There is no evidence that pallid sturgeon could be attracted away from the Yellowstone River with reasonable manipulations in flow from Fort Peck Dam. Therefore, implementation of Fort Peck management actions or a drawdown of Lake Sakakawea were not retained for alternative development due to the high level of uncertainty regarding their feasibility to achieve desired biological results and documented issues regarding their technical feasibility. The AM Plan identifies a comprehensive framework for research and studies to address the uncertainty regarding the effectiveness of management actions for pallid sturgeon in the upper basin.

2.5.2.2 Evaluate Fish Passage at Intake on Yellowstone River

The Yellowstone River is the largest tributary to the Missouri River. While the Yellowstone River contains several low head diversion weirs that individually and cumulatively affect some fish migrations (Helfrich et al. 1999), these low weirs have insignificant effect on temperature and discharge when compared to the mainstem Missouri River dams and reservoirs. As a result, the Yellowstone River retains a near-natural hydrograph and temperature profile as well as near-natural habitat-forming processes.

Of the six diversion weirs on the river, the lowermost, Intake Diversion Dam, is approximately 71 miles (115 km) from the confluence with the Missouri River and limits most upstream movements of pallid sturgeon (Bramblett and White 2001; DeLonay et al. 2016). Although Intake Diversion Dam negatively affects upstream migrations of pallid sturgeon, passage over or around this structure has been occasionally documented (DeLonay et al. 2016). The total available drift distance from Intake Diversion Dam on the Yellowstone River to the headwaters of Lake Sakakawea is approximately 90 miles (144 km). The next diversion dam upstream from Intake Diversion Dam is Cartersville Dam which is located about 168 miles (270 km) upstream from Intake Diversion Dam or 258 miles (415 km) from the headwaters of Lake Sakakawea (Figure 2-3).

The U.S. Bureau of Reclamation operates Intake Diversion Dam on the Yellowstone River. This structure was built in 1905 as a 12-foot high wood and stone dam to divert water from the mainstem into an irrigation canal that runs parallel to the river and provides a dependable water supply for adjacent lands. Studies suggest that the Intake Diversion Dam impedes upstream migration of pallid sturgeon and their access to spawning and larval drift habitats (Bramblett 1996; Bramblett and White 2001; Fuller et al. 2008; Backes et al. 1994).

Improvements to fish passage are expected to be a substantial step forward in assisting the long-term survival and recovery of the pallid sturgeon in the upper basin by providing access to up to 165 miles in upstream reaches of the Yellowstone River. The hydrology, thermal conditions, and sediment regime are relatively undisturbed in the Yellowstone River, thereby potentially providing supporting habitat conditions for pallid sturgeon. Also, the additional drift distance is expected to better allow for adequacy of larval drift, which is currently hypothesized to be a requirement to support natural recruitment in the upper basin. According to the effects analysis, available drift/dispersal distance emerged as a fundamental limitation on pallid sturgeon recruitment in the upper river (Jacobson et al. 2016b).

Since 2010, the Bureau of Reclamation and USACE have collaborated on several studies that evaluated proposed alternatives for modification to Intake Diversion Dam that would reduce entrainment and improve fish passage. In October 2016, the Bureau of Reclamation and USACE released a final EIS that evaluated five action alternatives. The alternatives evaluated include a rock ramp, bypass channel, modified side channel, multiple pumps, and multiple pumps with conservation measures. The final EIS identified the bypass channel as the preferred alternative. A Record of Decision is expected in December 2016.

Impacts associated with the construction and operation of the Intake Diversion Dam Modification project are evaluated as part of the EIS the Bureau of Reclamation and USACE have jointly prepared for the Intake Diversion Dam Modification project. In light of the independent evaluation and implementation of this project the MRRMP-EIS primarily focuses on developing and analyzing management actions that may reduce the effects to the pallid sturgeon in the Upper Missouri River between Fort Peck and Lake Sakakawea. Additionally, expanded monitoring and assessment of migration, spawning, hatch, drift, and recruitment at Intake Diversion Dam is incorporated to all plan alternatives in this EIS and the proposed AM framework accounts for the use of this information in assessing future management needs of pallid sturgeon in the upper basin.

2.5.2.3 Propagation and Augmentation

The 2003 Amended BiOp (USFWS 2003) calls for USACE to assist in pallid sturgeon propagation and augmentation efforts. The Pallid Sturgeon Conservation Augmentation Program (PSCAP) uses stocking to supplement year class structure to the pallid sturgeon population due to the lack of natural recruitment in the Missouri River. The PSCAP also preserves the remaining population genetics and structure. Surplus individuals are also used for scientific studies to better understand uncertainties in the upper Missouri River.

Wild pallid sturgeon are collected each spring and brought into hatcheries for spawning and the eventual stocking of their progeny in cooperation with USFWS and state agencies and in accordance with USFWS guidance. Three federal hatcheries (Gavins Point National Fish Hatchery in Yankton, South Dakota, Garrison Dam National Fish Hatchery in Riverdale, North Dakota, and Neosho National Fish Hatchery in Neosho, Missouri) and three state hatcheries (Blind Pony State Fish Hatchery in Sweet Springs, Missouri, Miles City State Fish Hatchery in Miles City, Montana, and Bozeman Fish Technology Center in Bozeman, Montana) are involved with propagation of Missouri River pallid sturgeon. Pallid sturgeon are stocked into four Resource Priority Management Areas. In 2014, the hatcheries stocked a combined 24,309 fingerling and yearling-sized pallid sturgeon from the 2013 and 2014 year classes into the Resource Priority Management Areas (USACE 2015b). USACE supports pallid sturgeon propagation and augmentation efforts through the provision of annual funding. This management action was retained for alternatives development.

2.5.3 Lower River Pallid Sturgeon

The following management actions were considered in developing alternatives to avoid a finding of jeopardy to the pallid sturgeon in the lower Missouri River from USACE actions on the Missouri River.

2.5.3.1 Channel Reconfiguration

Channel reconfiguration consists of the physical manipulation of the river bed or bank to create or improve areas for provision of specific pallid sturgeon habitats thought to be limiting. Examples include adjustments to navigation training or bank stabilization structures, channel widening (i.e., top-width widening), floodplain modifications or other adjustments to channel geometry, placement of structures to encourage development of needed habitat or habitat complexity, chute development, or adjustments to existing chutes.

The intent of channel reconfigurations is to provide more or better functioning habitats that may be presently limiting to pallid sturgeon recruitment. The effects analysis identified four functional habitats that may be limiting (Jacobson et al. 2016b):

- Spawning habitat: Areas of coarse substrate, convergent flow with high turbulence and velocities; conducive to attraction of reproductive adults, spawning, fertilization, incubation and hatch of free embryos.
- Food-producing habitats: Stable, fine substrate conducive to hosting chironomid larvae populations for age-0 pallid sturgeon food. These are deposition areas with current velocities 0–0.08 m/s.
- Foraging habitats: Combinations of depth and velocity to provide for energy-efficient access to drifting food. Present data indicate age-0 catch per unit effort peaks at 1–3 m depth and 0.5–0.9 m/s current velocity (Ridenour et al. 2011).
- Free embryo interception, retention: Hydraulics that promote free-embryo transport from thalweg and retention in channel-marginal areas. Interception, food-producing habitats, and foraging habitats can be considered as interception rearing complexes (IRCs), discussed further in Section 2.6.3.

USACE has implemented channel reconfiguration projects in compliance with the BiOp for approximately the last 13 years. Projects would continue to be designed in a manner that would not adversely affect the current authorized purposes of the Missouri River, including flood control and navigation. Designs for early life stage pallid sturgeon habitat under each alternative will be developed to maintain sufficient flow in the navigation channel, and not result in deposition that would cause shoaling within the navigation channel or create other hazards to navigation. USACE routinely monitors the Missouri River navigation channel and coordinates these efforts with the U.S. Coast Guard and commercial navigators on the river. In areas where navigation impediments are identified USACE works with the U.S. Coast Guard and commercial navigators to develop and implement corrective action that will restore and maintain the authorized 9 foot deep by 300-foot-wide navigation channel.

Designs for pallid sturgeon early life stage habitat will be developed to ensure that the projects do not adversely affect existing flood risk management systems. As with the BSNP, USACE routinely monitors the performance of shallow water habitat (SWH) projects to determine if these projects are contributing to adverse impacts on adjacent flood risk management systems. If issues are identified, USACE works with the affected levee district to develop and implement a corrective plan. Projects will be designed in a manner that does not increase erosion on adjacent private lands or adversely impact public roads, bridges, levee and drainage systems, sewer lines drinking water intakes, etc. Elutriate sampling of material for contaminants would continue to take place for each project along with site-specific NEPA analysis. Each site-specific analysis seeks to identify and avoid impacts to sensitive resources that may be present

including biological, Tribal, cultural, and socioeconomic resources. For each site-specific project, USACE coordinates with the Tribes, the public, stakeholders, and resource agencies. These projects would continue to be implemented on existing public lands or on lands that are acquired from willing sellers.

Channel reconfiguration to create functional habitats using various potential measures was retained for alternatives development. The suite of actions to create functional habitats that could be implemented under this management action include:

- Structure modifications: These actions modify existing Missouri River control structures to restore processes that may create habitat.
 - Bank notches: A bank notch typically consists of excavating a 100- to 150-foot long, 75-foot-wide section of the high bank along with the underlying 75-foot-wide section of buried L-Head or straight out dike. The invert of a bank notch is excavated to 5 feet below the Construction Reference Plane using land-based equipment. Construction Reference Plane is defined as a sloping datum representing the water surface elevation met or exceeded 75 percent of the time during the April to November navigation season. Bank notches may be implemented in areas where USACE has a property interest. Long-term effects of a bank notch are erosion of the high bank and widening of the top-width of the river.
 - Dike notch: A dike notch consists of excavating a 50- to 100-foot wide section of a dike to an elevation either 4 or 5 feet below the Construction Reference Plane. Dike notches are placed entirely riverward of the high bank, but not further than the halfway point between the high-bank and riverward end of a dike. Dike notches are most often constructed using water-based equipment, but may also be constructed using land-based equipment. Physical changes expected from dike notch construction include the diversion of flow from the main channel through the notch, and then back to the main channel. Flow diversion creates a side channel formed by sandbars on each side.
 - Revetment notches and lowering: A revetment notch consists of excavating a 50- to 100-foot-wide section of a stone-fill revetment to an elevation 5 feet below the Construction Reference Plane using water- or land-based equipment. Physical changes expected from a revetment notch may include a scour hole on the land side or increased connectivity to areas disconnected from the main river channel during flows lower than the top of the river structures but above the elevation of the notch (e.g., a revetment notch at the downstream end of an open area would not necessarily develop a scour hole on the land side of the notch). Revetment lowering consists of excavating an entire section of revetment 50 to 100 feet into the bank in order to allow the river to widen its top-width. Revetment notches may be implemented in areas where USACE has a property interest.
- Placement of new structures: New structures may be placed in the river to encourage formation of habitat. Examples of potential new structures include chevrons, rootless dikes, and reverse sills. USACE would only place new structures in areas where there would not be an impact to other authorized purposes.
- Off-channel habitat: Restoration of off-channel habitat includes the creation of chutes and backwaters.
 - Flow-through chute construction: A chute is a side-channel of a river which diverts flow from the main channel through the chute, and back into the main channel, thus

creating an island. Construction involves excavation of side channels with possible multiple connections to the Missouri River in addition to the entrance and exit. The multiple connections are referred to as secondary connections or tie channels.

Construction can be accomplished through the use of hydraulic dredges or use of excavators to remove materials. Chutes provide a dynamic environment with active bank and bar building processes. A properly formulated chute will function in both normal and high flow events. Chutes typically include one or more grade control structures to limit degradation within the chute and maintain the proper flow split between the chute (typically less than 10 percent of total river volume flows in the chute) and the main channel.

- Backwaters: A backwater is a floodplain feature which is connected to the river on the downstream end but disconnected at the upstream end under normal flow conditions. Backwaters are constructed in a similar manner to chutes, but provide relatively still water. Excavation is typically performed by hydraulic dredge. Some of the excavated material would be distributed in the main channel adjacent to the excavation zone. The remaining material would be discharged into the thalweg of the Missouri River where it would become entrained into the bedload of the river.
- Channel widening or top-width widening: Channel widening projects involve the use of mechanical equipment to lower the adjacent floodplain and bank of the Missouri River to create habitat and widen the top-width of the river channel. Excavation is typically performed by hydraulic dredge. Some of the excavated material would be distributed in the main channel adjacent to the excavation zone. The remaining material would be discharged into the thalweg of the Missouri River where it would become entrained into the bedload of the river.

2.5.3.2 Propagation and Augmentation

The propagation and augmentation management action for lower river pallid sturgeon is the same as that described for upper river pallid sturgeon and was retained for alternatives development.

2.5.3.3 Alter Flow Regime at Gavins Point

Several management hypotheses are linked to alteration of the flow regime at Gavins Point as a management action. The nature of the flow alteration varies by hypothesis; however, all relate to System adjustments to achieve a more “naturalized” hydrograph downstream of Gavins Point Dam. Naturalization of the flow regime is considered incremental changes that move the flow regime towards the hydrological attributes (magnitude, duration, timing, or frequency) that would exist in the absence of dams and reservoirs, while recognizing social and economic constraints. More generally, naturalization refers to the process of using characteristics of the natural ecosystem to guide elements of river restoration, but constrained by social and economic values (Rhoads et al. 1999; Jacobson and Galat 2008).

Alteration of the flow regime for a pallid sturgeon spawning cue in the lower river would necessitate increased Gavins Point Dam releases during the spring relative to current operations. The exact characteristics of a spawning cue pulse that would elicit a spawning response are not known. The ISAP found no evidence that managed spring pulses are necessary to provide cues for pallid sturgeon spawning (Doyle et al. 2011). Increases in magnitude and duration of pulsed releases beyond those implemented in the spring rise technical criteria (USACE 2006a) would therefore be necessary under the hypothesis that

pulses are necessary to cue successful spawning. It is also hypothesized that alteration of the flow regime for enhanced primary and secondary production could be achieved through flow pulses that connect with low-lying lands and floodplains in the spring or by low flows that create shallow, warm water in the summer and fall. However, there is no evidence that nutrients, invertebrates, or forage fish in the lower Missouri River will increase in response to a managed spring pulse and shallow water (Doyle et al. 2011). Summer and fall low flows would result in decreased velocities and energetic demands, and decreased effective drift distances. These low flows would necessitate decreased Gavins Point Dam releases during the summer and fall seasons relative to current operations. Implementation of any of these Gavins Point Dam releases would require adjustments to System-wide reservoir operations. This management action was retained for alternatives development.

2.5.3.4 Temperature Management at Gavins Point Dam

This management action includes the operation of a temperature management system at Gavins Point Dam and/or Fort Randall Dam to increase the temperature of water released from Gavins Point Dam in May to serve as an aggregation and spawning cue for reproductive pallid sturgeon in the lower river. Current Fort Randall dam operations and configurations result in the release of colder water than would naturally occur; however, there is no clear evidence that this is also the case at Gavins Point Dam (Jacobson et al. 2016b). Quantitative data and models to support the hypothesis underlying this management action are lacking (Jacobson et al. 2016b). The effects analysis associated a high degree of uncertainty with this management action and stated that it had a considerable risk of failure if implemented with currently existing information (Jacobson et al. 2016b). As with temperature control options evaluated for Fort Peck Dam (USACE 2009b), options to implement this action would also have high life cycle costs. This management action was eliminated from further consideration because evidence is lacking to demonstrate it could be effective at contributing to the species objectives. It is also considered inefficient due to anticipated high costs associated with implementation.

2.5.4 Habitat Development and Land Management on MRRP Lands

The land requirements for implementation of habitat creation can occur (1) on existing public lands if the state or federal agency owning the property is willing to cooperate with USACE on the project; or (2) on land acquired in fee title from willing sellers. In the latter case, USACE must typically purchase enough land to accommodate the habitat project and provide a buffer between the project and adjacent lands. Based on an assessment of past pallid sturgeon SWH projects implemented by USACE, it was determined that an average of 7.7 acres of land are acquired for every 1 acre of pallid sturgeon habitat needed. USACE would develop habitat on lands consistent with its authorizations under the WRDA 1986, 1999, and 2007. Habitat development has included chutes and side channels, shallow water habitat, backwater areas, slack water habitats, wetlands, bottomland forest, and native prairie. The WRDA land acquisition authority is a result of USACE mitigation obligations under the Fish and Wildlife Coordination Act and therefore cannot be separated from the requirement that lands acquired for pallid sturgeon habitat construction also serve to mitigate for the BSNP impacts. The land acquisition authority for mitigation of the construction of the BSNP is not being reassessed through this Management Plan, and the total mitigation authority acres remain at 166,750 acres. USACE has acquired approximately 66,616 acres of the authorized 166,750 acres, nearly 40 percent. Land acquisition and habitat development under the BSNP mitigation authority is not limited to pallid sturgeon habitat and can include restoration of native vegetation, wetlands, bottomland forest, backwaters and other Missouri River habitats lost due to the BSNP. It is assumed real-estate purchases for the 15-year implementation timeframe would continue to

prioritize land that contributes to jeopardy avoidance, while still constituting appropriate acquisition and development under the aforementioned WRDA authorities. Land acquisition itself does not necessarily equate to Fish and Wildlife Coordination Act mitigation, rather, the determination of the appropriate land cover and habitat types for a parcel of land requires a site-specific analysis which would be conducted in tandem with planning for site-specific aquatic habitat related specifically to jeopardy avoidance.

USACE has worked with USFWS and the natural resource or conservation agencies of the four lower basin states (Iowa, Kansas, Missouri, and Nebraska) to develop and implement fish and wildlife habitat restoration plans for MRRP lands acquired under WRDA authorities. Historically, USACE has established native vegetation, created wetlands, restored riparian buffers, and performed other restoration activities. Acquired lands are managed by USACE, state fish and wildlife agencies, or USFWS. USACE performs operation and maintenance activities, maintains public access, and conducts best management practices on the lands in accordance with MRRIC's recommendation of a "Good Neighbor Policy." These activities generally include noxious weed control, controlled burns, maintenance of roads and signage, and temporary agricultural leasing for those areas which have not yet been restored.

2.6 Pallid Sturgeon Alternatives Development

Despite considerable effort during the effects analysis process, the identification of the specific factors causing recruitment failure for pallid sturgeon and a clear nexus between management actions and population response was not identified for the lower river (downstream of Gavins Point Dam) (Jacobson et al. 2016b). As a result, development of alternatives for pallid sturgeon was a collaborative process between USACE, USFWS, and the effects analysis team relying on the best available science. There were several key milestones during this process that shaped the concepts of the actions and alternatives formulated for the lower river pallid sturgeon. These milestone events are summarized here.

2.6.1 Identification of Lower Pallid Sturgeon Limiting Factors

In September 2014, USACE convened a group of pallid sturgeon experts to elicit their expertise in the alternatives development process. This workshop was not part of the effects analysis; however, it attempted to build on the results of the effects analysis in developing alternatives for the Management Plan. As part of preparation for this workshop and during the course of the workshop, a set of "limiting factors" that tied to the management hypotheses were identified and defined (Table 2-4). During the workshop, the experts were facilitated through an iterative process of ranking the "most likely" factor perceived to be limiting the lower river pallid sturgeon population (Long 2014). An outcome of the lower river pallid sturgeon expert elicitation process was the transition to structuring plan development around the limiting factors that were identified and defined (Table 2-5). The presentation of limiting factors in Tables 2-4 and 2-5 does not reflect any order or importance or prioritization.

Table 2-4. Lower River Pallid Sturgeon Limiting Factors Associated with the Management Hypotheses

Management Hypothesis	General Management Action(s)	Limiting Factor
Naturalization of the flow regime at Gavins Point will improve flow cues in spring for aggregation and spawning of reproductive adults, increasing reproductive success.	Alter flow regime at Gavins Point	Insufficient spawning cue signals
Naturalization of the flow regime at Gavins Point will improve connectivity with channel-margin habitats and low-lying floodplain lands, increase primary and secondary production, and increase growth, condition, and survival of exogenously feeding larvae and juveniles.		Insufficient food-producing habitat for age-0 pallid sturgeon
Naturalization of the flow regime at Gavins Point will decrease velocities and bioenergetic demands, resulting in increased growth, condition, and survival for exogenously feeding larvae and juveniles.		Insufficient foraging habitat for age-0 pallid sturgeon
Alteration of the flow regime at Gavins Point can be optimized to decrease mainstem velocities, decrease effective drift distance, and minimize mortality.		Inappropriate drift dynamics
Operation of a temperature management system at Fort Randall and/or Gavins Point will increase water temperature downstream of Gavins Point, providing improved spawning cues for reproductive adults.	Temperature management at Fort Randall and Gavins Point	Insufficient spawning cue signals
Re-engineering of channel morphology in selected reaches will create optimal spawning conditions—substrate, hydraulics, and geometry—to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.	Channel reconfiguration	Insufficient spawning habitat
Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.		Insufficient food-producing habitat for age-0 pallid sturgeon
Re-engineering of channel morphology will increase channel complexity and minimize bioenergetics requirements for resting and foraging of exogenously feeding larvae and juveniles.		Insufficient foraging habitat for age-0 pallid sturgeon
Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.		Insufficient interception habitat
Stocking at optimal size classes and in optimal numbers will increase growth rates and survival of exogenously feeding larvae and juveniles.	Lower basin propagation	Insufficient number/fitness of adults
Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.		Insufficient number/fitness of adults

Table 2-5. Lower River Pallid Sturgeon Limiting Factors

Limiting Factor	Definition of Limiting Factor
Insufficient number / fitness of adults	Insufficient numbers and/or fitness of reproductively mature adults in the lower Missouri River to allow for successful aggregation prior to spawning and to allow for successful spawning.
Insufficient spawning cue signals	The combination of peak flow intensity, timing, duration, shape, temperature and possibly other issues is not sending sufficient spawning cues.
Inappropriate drift dynamics	An inappropriate mainstem flow regime is resulting in problematic velocities, drift time, and geographic dispersal.
Insufficient spawning habitat	Insufficient spawning habitat (defined here as high quality, functioning spawning habitat, in contrast to the ubiquitous but (arguably) ineffective low quality habitat - outside, revetted bends).
Insufficient interception habitat	Insufficient habitat conditions to move free embryos from the thalweg into supportive channel-margin habitats.
Insufficient food producing habitat for age-0 pallid sturgeon	Insufficient habitat that supports populations of chironomids and other small invertebrate food items for first feeding.
Insufficient foraging habitat for age-0 pallid sturgeon	Insufficient habitat where hydraulic conditions and availability of food items combine to produce energetically favorable conditions for growth.

2.6.2 Drift Dynamics Limiting Factor

The concept of inappropriate drift dynamics is multi-faceted and includes three related hypotheses: (1) there is inadequate drift distance between spawning sites and lethal conditions for free embryos downstream; (2) free embryos are unable to exit the navigation channel before starving; and (3) free embryos die from direct damaging effects of flow turbulence. The first two of these were generated by the effects analysis process whereas the third arose during the workshop described in Section 2.6.1.

The first hypothesis regarding inadequate drift distance has strong support in the upper Missouri River, but evidence for lethal effects at long drift distances in the lower Missouri River or middle Mississippi River is lacking. The AM Plan includes studies on drift modeling, genetics, and microchemistry of pallid sturgeon fin rays to determine the origins and dispersal of pallid sturgeon. These studies are designed to determine where pallid sturgeon larvae complete their dispersal process and whether they survive.

The second hypothesis relates to the interception function of interception rearing complexes. Management actions related to interception of free embryos into appropriate foraging habitats so they do not starve in the main channel flow are addressed in Section 2.6.3.

The third hypothesis is speculative and based on the fragile nature of pallid sturgeon free embryos 0 to 5 days old. Presently there is no laboratory or field-based evidence to support the conjecture. Management actions to make measurable changes to decrease turbulent intensity over the entire lower river would require a considerable cost investment or perhaps very low flow releases from Gavins Point. Laboratory studies are currently planned under the AM Plan to quantify turbulent intensities needed to physically damage or kill free embryos.

2.6.3 Concept of the “Interception and Rearing Complex”

During the course of the effects analysis, a leading concept emerged regarding the formulation of management actions for three of the functional habitat types identified by the effects analysis team for lower river pallid sturgeon: interception, food-producing, and foraging habitat. This concept was termed interception and rearing complexes (IRCs) (Jacobson et al. 2016b).

Interception, food-producing, and foraging habitats for age-0 pallid sturgeon are inter-related, as it is the combination of habitats that would result in retention of young fish in supportive habitats. To represent this combination, the effects analysis team (Jacobson et al. 2016b) defined IRCs that are complex areas that include hydraulics to intercept drifting free embryos combined with food-producing habitats and foraging habitats. Any of these three habitat types could be limiting to growth and survival, and a limiting role could shift over time as proportions of the habitats shift or as population grows.

IRCs are areas that meet the functional definitions laid out in Jacobson et al (2016b). For the purpose of establishing targets and measuring progress, the physical definitions of IRCs are currently identified as follows: (1) food-producing habitat occurs where velocity is less than 0.08 meters per second (m/s); (2) foraging habitat is defined as areas with 0.5–0.7 m/s velocity and 1–3 m depth; and (3) interception habitat has been qualitatively described as zones of the river where hydraulic conditions allow free embryos to exit the channel thalweg. A functional IRC exists where the juxtaposition of the described habitats is such that all three functions are performed and collectively contribute to survival to age-1 (Figure 2-4). The specifications could be adjusted as warranted based on monitoring and evaluation, or new information regarding observed use of different habitats by age-0 pallid sturgeon. Research is continuing on conditions that create interception hydraulics. Effective interception hydraulics seem to occur where flow expands downstream from a wing dike followed by a relatively long section of river without wing dikes (Figure 2-4). Creating effective interception hydraulics on the Lower Missouri River may require only modest changes to wing-dike geometries.

The availability of food-producing and foraging habitats varies with flow, as does the local hydraulic field at any location (and hence the potential for interception and retention). Consequently, IRC habitat is flow-dependent and time-variant and can be affected by both mechanical manipulations of river geometry and flow management actions.

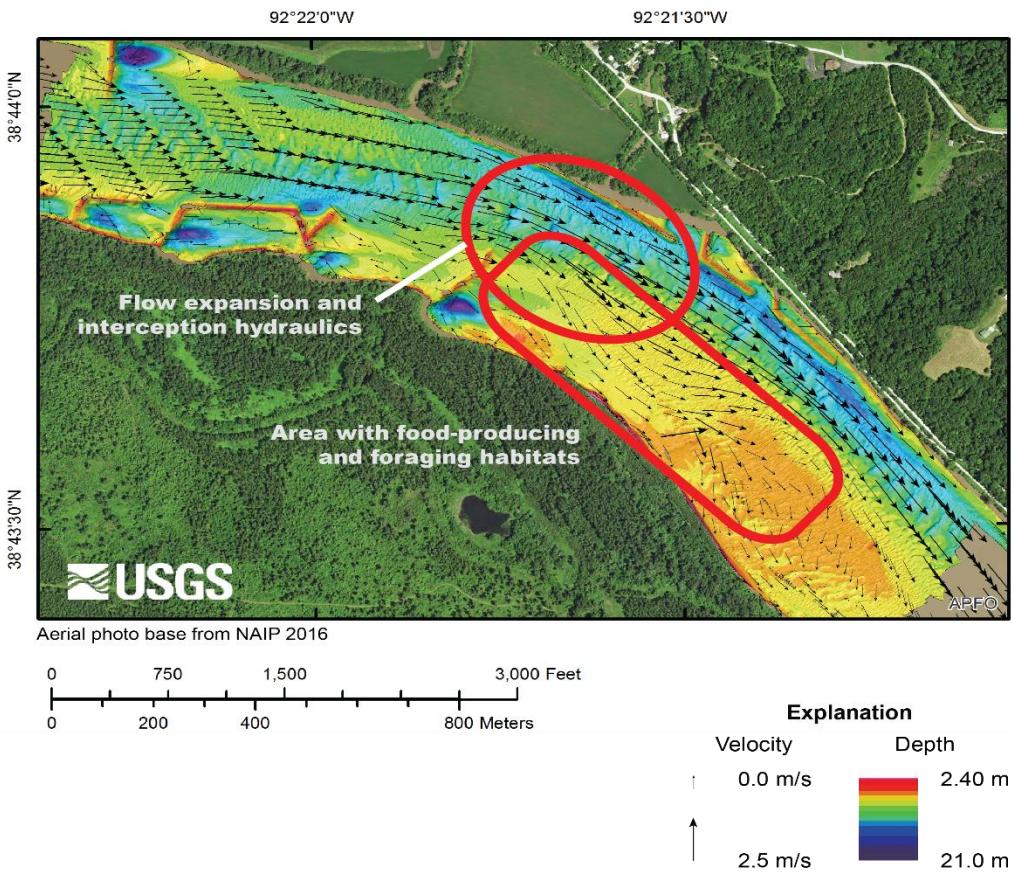


Figure 2-4. Interception and Rearing Complex Visualization

2.6.4 Lower Pallid Sturgeon Framework and U.S. Fish and Wildlife Service Jeopardy Avoidance Criteria

On November 2, 2015, USFWS provided USACE with a Planning Aid Letter (USFWS 2015c) confirming support for a document called “Lower Missouri River Pallid Sturgeon Framework, Targets and Decision Criteria” (USFWS and USACE 2015) (Appendix B: Fish and Wildlife Coordination Act Correspondence). This document provided guidance for actions to be included in this MRRMP-EIS, and its structure has been used to guide the formulation of Alternatives 3–6. Key principles underpinning the framework are as follows (extracted from USFWS and USACE 2015):

- Given the lingering uncertainties regarding the scope and scale of the management actions necessary for USACE to avoid a finding of jeopardy to pallid sturgeon, a strategy reliant upon a progressive AM program is the most effective way to manage risks to the pallid sturgeon.
- The framework is expected to accelerate the identification of recruitment bottlenecks, resulting in a more strategic and focused implementation of appropriate management actions. This approach has the added benefit of minimizing impacts to stakeholders and Tribes and avoiding unnecessary implementation costs.

- The artificial propagation program would be continued throughout the framework's implementation, and improvements to that program related to genetic concerns, disease, stocking size, etc., would be pursued consistent with USFWS propagation plan under development.
- Implementation of management actions at Level 3 (Table 2-6) for each hypothesis would be required within a specified timeframe, provided the hypotheses associated with the action are not rejected by that time.
- At any time during the framework's implementation, it may become apparent that: (1) a particular action is not needed; (2) a proposed action requires modification to be effective; or (3) that some new action not previously evaluated is required.

The framework for the lower river consists of four levels of activity as described in Table 2-6. As information is developed from Level 1 and 2 studies or through monitoring of effectiveness of management actions, the framework's decision criteria would be used to determine when and what action should follow. The framework includes the possibility that Level 1 and 2 science proceeds concurrently with Level 3 or 4 implementation to address continuing information needs. Chapter 4.0 describes implementation of actions within this framework in more detail for the preferred alternative.

Table 2-6. Pallid Sturgeon Framework for Lower River

Level 1: Research	Population-level biological response <u>IS NOT</u> expected	Studies without changes to the System (laboratory studies or field studies under ambient conditions).
Level 2: In-river testing		Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
Level 3: Scaled implementation	Population-level biological response <u>IS expected</u>	In terms of reproduction, numbers, or distribution, initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels which result in improvements in the population. The range of actions within this level is not expected to achieve full success (i.e., Level 4).
Level 4: Ultimate required scale of implementation		Implementation to the ultimate level required to remove as a limiting factor.

2.7 Bird Alternatives Development

The MRRMP-EIS PDT worked with the effects analysis team to formulate alternatives for the least tern and piping plover. This process focused on the formulation and modeling of alternatives that use Missouri River reservoir release changes to create ESH, increase the availability of existing ESH, or reduce loss of existing ESH to erosion. Through the PrOACT process, the PDT engaged with the MRRIC on the formulation and modeling of these bird alternatives.

The iterative development of management actions began with the bird "test alternatives." Model outputs and resulting HC proxy calculations were shared with MRRIC during a series of webinars in late March and early April 2015. The bird "test alternatives" provided a way to

examine the HC proxy metrics and model performance. Following MRRIC feedback on the performance of the HC proxy metrics for the “test alternatives,” some proxy calculation methods were revised or added. Round 1 bird alternatives were formulated to meet the bird habitat targets (described in Section 1.5.2) and resulting HC proxy calculations were discussed with MRRIC at the May 2015 meeting. For Round 2, bird alternatives were refined with consideration of MRRIC feedback received during Round 1. This section summarizes the rationale and processes that occurred in formulation of bird alternatives.

2.7.1 Development of the Bird “Test Alternatives”

The purposes of developing the Bird “Test Alternatives” were to:

- Allow calculation of the HC proxy metrics to determine if they adequately characterized the effects of a range of management actions and were sufficient for use in the first round of trade-off discussions or to identify any needed improvements.
- Introduce MRRIC members to the methodology that would be used in trade-off discussions.
- Continue to address MRRIC’s proposed action #7 (resulting from ISAP’s 2011 Final Report on Spring Pulses and Adaptive Management): “Aspects of how the entire hydrograph influences the three listed species should be evaluated when assessing the range of potential management actions.”
- Explore the range of management actions that would be necessary to meet the bird objectives.

The “test alternatives” focused on actions that create habitat structure and affect habitat availability in the Garrison, Fort Randall, and Gavins Point river reaches because:

- Habitat structure and availability are essential for bird survival.
- Habitat structure and availability are directly affected by USACE actions.
- Many of the other management actions are dependent on habitat structure and availability.
- Effects analysis bird population models are based on habitat structure and availability.

The bird “test alternatives” generally consisted of modeling just one management action to facilitate understanding of the separate effects of each action on the birds and HC. These management actions included:

1. Habitat-creating reservoir release:
 - Spring release
 - Fall release
2. Reservoir water level management:
 - Oahe unbalancing or drawdown

2.7.2 Initial Iterations of Habitat-Creating Flow Releases

The effects analysis team developed relationships between water volume required to create ESH and flow magnitude (Fischenich et al. in prep). Those relationships helped determine the magnitude and duration of reservoir releases initially used to develop and model habitat-forming flow releases. Higher releases are more efficient at creating habitat over a shorter period of time because a lesser volume of stored water is required. As releases increase to more than 60 kcfs, they begin to drop in efficiency and water savings. Therefore, 60 kcfs was initially selected as the Gavins Point release for modeling habitat-forming flow releases. The Gavins Point release was supported by upstream reservoir operations. Any time a release from Gavins Point was made, a corresponding release from Garrison dam was also implemented that was approximately 17.5 kcfs less than the Gavins Point release.

Downstream flow limits and criteria are defined in the Master Manual (USACE 2006a). For purposes of formulating habitat-forming flow releases, downstream flow limits are the flows at specific downstream locations, which if exceeded, would trigger a reduction in the magnitude of the release. Downstream flow limits were set to: Omaha – 71 kcfs; Nebraska City – 82 kcfs; Kansas City – 126 kcfs. The frequency and duration of the “test alternative” releases were specified based on information developed by the effects analysis. The effects analysis models indicate flow creation is most effective when ambient (i.e., existing) ESH amounts are low. Past monitoring indicates ESH is at low levels 5–7 years after a creation event due to erosion and vegetation encroachment. Therefore, the model initiated habitat-forming flow releases if no “natural” or planned habitat-forming flow release had occurred during the preceding 7 years. Based on information from the effects analysis, these “natural” or planned habitat-forming flow releases were defined by the duration of flow required to create 500 acres of sandbar habitat and assuming 250 acres of ESH was present (Table 2-7).

A primary consideration for the timing of a habitat-forming flow release is that the amount of water that could be used for the release becomes more certain as the year progresses. In light of this consideration, two seasonal habitat-forming flow releases were developed and modeled. The first was a spring release that began on April 1 and the second a fall release that started on September 1. To conserve water in System storage, habitat-forming flow releases were modeled to only occur if the System was in the flood control zone on April 1 for the spring release and at or above “full service” (35 kcfs) on September 1 for the fall release for the initial iteration of modeling.

Initially, the duration of the planned habitat-forming flow release for the spring was based on creating 500 acres at 60 kcfs (5.5 weeks) with the assumption that 250 ESH acres were existing. For the fall, the volume of water that is in excess of what is required for “full service” through the end of the navigation season was used to calculate the highest flow (up to 60 kcfs) and duration that could be provided based on the assumption that 250 ESH acres were existing (Table 2-7). If downstream flow limits were exceeded, Gavins Point releases were reduced by 5 kcfs until the constraints were no longer exceeded and the duration for the new release, based on Table 2-7, was attempted. If Gavins Point releases fell below 45 kcfs or System storage fell below the constraints described to initiate the planned release, the habitat-forming flow release was terminated.

The initial iteration of model runs resulted in very few implemented habitat-forming flow releases over the POR due to termination of the release because downstream flow limits were exceeded or System storage fell below the flood control zones or “full-service” levels as described

previously. Therefore, these initial iterations of habitat-forming flow releases were not effective at contributing towards meeting the bird habitat targets and therefore the species objectives.

2.7.3 Habitat-Forming Flow Releases Developed as Bird “Test Alternatives”

In order to assess potential for reservoir releases to create bird habitat, some of the constraints used during the initial iteration had to be relaxed. Instead of terminating the habitat-forming flow release if System storage fell below the annual flood control zones, water in the carryover-multiple use zone was used to complete the full 5.5 week duration for the spring and fall releases. This iteration of the spring release was referred to as “Spring Release A” in Table 2-8. The fall release was further revised by delaying the habitat-forming flow release until mid-October but allowing completion before the onset of ice conditions (December 1). This was referred to as “Fall Release A” in Table 2-8. These revisions to the spring and fall “test alternatives” also resulted in very few implemented habitat-forming flow releases over the POR and were not effective at contributing towards meeting the bird habitat targets.

Another iteration of the fall release was modeled that greatly relaxed the constraints by increasing the reservoir release to 70 kcfs for a duration of 8 weeks using water in the carryover multiple-use zone to complete the release. The frequency of implementing this release was also changed from as often as 7 years to 3 years if a natural or planned habitat-forming flow release had not occurred and System storage was above 31 MAF. The downstream flow limits were removed to allow the full duration of the release. This iteration was referred to as “Fall Release B” in Table 2-8. The primary purpose of this fall release iteration was to see if a release could be modeled that meets bird habitat targets. This iteration of the fall release resulted in a substantial increase in ESH creation and exceeded the bird habitat targets.

Table 2-7. Flow Duration Needed to Create 500 acres of Emergent Sandbar Habitat as a Function of Existing Emergent Sandbar Habitat

Existing ESH (acres)	Duration (weeks) to meet a 500-acre (new baseline ESH) target at various discharges (kcfs)												
	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75
50	22.7	14.5	10.7	8.5	7.0	6.0	5.2	4.6	4.1	3.8	3.4	3.2	2.9
100	23.1	14.8	10.9	8.6	7.1	6.0	5.3	4.7	4.2	3.8	3.5	3.2	3.0
150	23.6	15.1	11.0	8.7	7.2	6.1	5.3	4.7	4.2	3.9	3.5	3.2	3.0
200	24.2	15.3	11.2	8.9	7.3	6.2	5.4	4.8	4.3	3.9	3.6	3.3	3.1
250	24.7	15.6	11.4	9.0	7.4	6.3	5.5	4.9	4.4	4.0	3.6	3.3	3.1
300	25.3	15.9	11.6	9.1	7.5	6.4	5.6	4.9	4.4	4.0	3.7	3.4	3.1
350	25.8	16.2	11.8	9.3	7.7	6.5	5.7	5.0	4.5	4.1	3.7	3.4	3.2
400	26.5	16.5	12.0	9.4	7.8	6.6	5.7	5.1	4.6	4.1	3.8	3.5	3.2
450	27.1	16.9	12.2	9.6	7.9	6.7	5.8	5.2	4.6	4.2	3.8	3.5	3.3
500	27.8	17.2	12.5	9.8	8.0	6.8	5.9	5.2	4.7	4.3	3.9	3.6	3.3
550	28.5	17.6	12.7	9.9	8.2	6.9	6.0	5.3	4.8	4.3	3.9	3.6	3.4
600	29.2	17.9	12.9	10.1	8.3	7.0	6.1	5.4	4.8	4.4	4.0	3.7	3.4
650	30.0	18.3	13.2	10.3	8.4	7.2	6.2	5.5	4.9	4.5	4.1	3.7	3.5
700	30.9	18.7	13.4	10.5	8.6	7.3	6.3	5.6	5.0	4.5	4.1	3.8	3.5
750	31.7	19.2	13.7	10.7	8.8	7.4	6.4	5.7	5.1	4.6	4.2	3.9	3.6
800	32.7	19.6	14.0	10.9	8.9	7.5	6.5	5.8	5.2	4.7	4.3	3.9	3.6
850	33.7	20.1	14.3	11.1	9.1	7.7	6.7	5.9	5.2	4.7	4.3	4.0	3.7
900	34.7	20.6	14.6	11.3	9.3	7.8	6.8	6.0	5.3	4.8	4.4	4.1	3.7
950	35.8	21.1	14.9	11.6	9.4	8.0	6.9	6.1	5.4	4.9	4.5	4.1	3.8
1000	37.0	21.6	15.3	11.8	9.6	8.1	7.0	6.2	5.5	5.0	4.6	4.2	3.9
1050	38.3	22.2	15.6	12.1	9.8	8.3	7.1	6.3	5.6	5.1	4.6	4.3	3.9
1100	39.7	22.8	16.0	12.3	10.0	8.4	7.3	6.4	5.7	5.2	4.7	4.3	4.0
1150	41.2	23.4	16.4	12.6	10.2	8.6	7.4	6.5	5.8	5.3	4.8	4.4	4.1
1200	42.7	24.1	16.8	12.9	10.4	8.8	7.6	6.7	5.9	5.4	4.9	4.5	4.2
1250	44.4	24.8	17.2	13.2	10.7	9.0	7.7	6.8	6.1	5.5	5.0	4.6	4.2
1300	46.3	25.6	17.7	13.5	10.9	9.2	7.9	6.9	6.2	5.6	5.1	4.7	4.3
1350	48.3	26.4	18.1	13.8	11.2	9.4	8.1	7.1	6.3	5.7	5.2	4.8	4.4
1400	50.5	27.2	18.6	14.2	11.4	9.6	8.2	7.2	6.4	5.8	5.3	4.8	4.5

2.7.4 Reservoir Unbalancing “Test Alternative” (Oahe Unbalance)

An additional “test alternative” was developed to examine the potential of the reservoir water level management action. This “test alternative” exposed reservoir shoreline habitat by reducing Oahe reservoir levels 3 feet from what they would be under current operations every other year. This water would be stored in Fort Peck reservoir during years of reduced Oahe reservoir levels. This “test alternative” resulted in little additional available habitat over the POR. Table 2-8 summarizes each of the bird “test alternatives” for which HC proxy metrics were calculated and shared with MRRIC during webinars in March 2015.

Table 2-8. Bird “Test Alternatives”

	Reservoir System Operation*
Spring Release A	<ul style="list-style-type: none"> Release occurs if at full service or higher on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 7 years Habitat-forming flow release starting April 1 of 60 kcfs Attempt 5.5 week duration as often as every 7 years Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point
Fall Release A	<ul style="list-style-type: none"> Release occurs if at full service or higher on September 1 and if natural releases creating 250 acres of ESH have not occurred in previous 7 years Habitat-forming flow release starting October 21 of 60 kcfs, Attempt 5.5 week duration as often as every 7 years Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point
Oahe Unbalance	<ul style="list-style-type: none"> Reduce Oahe reservoir level by 3 feet every other year Water stored in Fort Peck during unbalancing, Garrison would float (no specific Garrison storage target as water is adjusted between Fort Peck and Oahe). Balance upper three reservoir storage the following year
Fall Release B	<ul style="list-style-type: none"> Habitat-forming flow release starting September 1 of 70 kcfs if System storage is equal to or greater than 31 million acre-feet (MAF) 8 week duration and occurs every 3 years Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point

*OMA = Omaha; Neb City = Nebraska City; KC = Kansas City; MAF = million acre-feet

2.7.5 Round 1 Alternatives

Following the initial HC proxy webinars, the PDT began formulation of bird alternatives for use in Round 1 trade-off discussions at the May 2015 MRRIC meeting. Round 1 bird alternatives were developed with the following considerations:

- Refine the criteria governing the implementation of habitat-forming flow releases to increase their effectiveness at meeting bird habitat targets, primarily by allowing them to occur more frequently, while staying within the current operational constraints to the greatest extent possible.
- Develop and model a summer low flow management action.
- Use a combination of management actions including mechanical ESH creation to achieve the bird habitat targets.

In addition to the refinements made based on these considerations, a reduced summer low flow action was formulated and incorporated into the bird alternatives presented for Round 1. Table 2-9 describes each of the Round 1 bird alternatives for which HC proxies were calculated and presented at the May 2015 MRRIC meeting. For each Round 1 bird alternative, mechanical ESH creation was used to make up the difference between the amount of ESH created by flow actions and the amount necessary to meet the bird habitat targets.

Table 2-9. Round 1 Bird Alternatives

Alternative	Reservoir System Operation*	Mechanical ESH
No Action	Current operation as defined in the Master Manual (USACE 2006a)	Approximately 107 acres/year
Mechanical ESH Creation Only	Current operation as defined in the Master Manual (USACE 2006a)	Build to meet bird targets
Spring Release B + Mechanical	<ul style="list-style-type: none"> Release occurs if at full service on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years Habitat-forming flow release starting April 1 of 60 kcfs Attempt 5.5 week duration as often as every 4 years Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations
Fall Release C + Mechanical	<ul style="list-style-type: none"> Release occurs if at full service on October 15 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years Habitat-forming flow release starting October 15 of 60 kcfs Attempt 5.5 week duration as often as every 4 years Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations

Alternative	Reservoir System Operation*	Mechanical ESH
Spring Release B + Low Summer Flow + Oahe Unbalance + Mechanical	<ul style="list-style-type: none"> Habitat-forming flow release as described for Spring Release B Low summer flow of 22 kcfs from Gavins Point between May 15 and August 3 every year, during this period ignore downstream flow limits, water supply requirements, and navigation targets Reduce Oahe reservoir level by 3 feet every other year, water stored in Fort Peck, Garrison will float, balance upper three reservoir storages the following year 	Build to meet bird targets after accounting for reservoir operations
Fall Release C + Low Summer Flow + Oahe Unbalanced + Mechanical	<ul style="list-style-type: none"> Habitat-forming flow release as described for Fall Release C Low summer flow of 22 kcfs from Gavins Point between May 15 and August 3 every year, during this period ignore downstream flow limits, water supply requirements, and navigation targets Reduce Oahe reservoir level by 3 feet every other year, water stored in Fort Peck, Garrison will float, balance upper three reservoir storages the following year 	Build to meet bird targets after accounting for reservoir operations

*OMA = Omaha; Neb City = Nebraska City; KC = Kansas City

2.7.6 Round 1 Bird Alternative Screening

Appendix A summarizes the HC proxy results for Round 1 bird alternatives. As mentioned previously, the reservoir water level management action was assessed by modeling an unbalancing of Lake Oahe. Modeling indicated that this action resulted in little additional available habitat over the POR. Bird population models showed that although this action contributed to bird populations on Lake Oahe, it resulted in a corresponding negative effect on the bird population at Lake Sakakawea due to higher reservoir levels. As a result, this management action was eliminated from further consideration because it was not effective at contributing to the bird habitat targets and in turn the species objectives. Spring and fall habitat-forming releases and low summer flows were retained for Round 2 bird alternative formulation.

2.7.7 Round 2 Alternatives

Following the May 2015 MRRIC meeting, the PDT began refining the bird alternatives for presentation at the Round 2 discussion with MRRIC. MRRIC feedback from Round 1 was considered in development of the Round 2 bird alternatives. Those MRRIC members who completed the ranking feedback forms or provided comments on the Round 1 alternatives expressed a wide range of opinions. Several MRRIC members expressed concern about the alternatives presented and their impacts on certain HCs. Others expressed support for the same alternatives. This feedback shaped the next round of model iterations in two main ways: (1) revisions to the summer low flow action were made to attempt to reduce HC impacts; and (2) continued refinement of the spring and fall ESH-creating reservoir releases to maximize effectiveness at meeting bird habitat targets and minimize HC impacts.

The PDT was unable to identify an iteration of a spring habitat-forming flow release, fall habitat-forming flow release, or a summer low flow that was effective at contributing towards meeting the bird habitat targets and could also be implemented within the operational constraints of the current Master Manual (USACE 2006a). As such, it was determined that some level of mechanical ESH construction would be required with all reservoir release and/or summer low flow actions.

The PDT refined and assessed 17 different bird alternatives for Round 2. The alternatives consisted of the No Action condition, four different spring habitat-forming flow releases, four different fall habitat-forming flow releases, and eight combinations of spring or fall habitat-forming flow releases with low summer flows. All of the fall and spring habitat-forming flow releases were modeled in combination with a low summer flow; however, only one version of a low summer flow was included for Round 2 discussion. Table 2-10 summarizes the eight Round 2 bird alternatives that were presented at the August MRRIC technical webinars.

Table 2-10. Round 2 Bird Alternatives

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
No Action	Current operation as defined in the Master Manual (USACE 2006a)	Approximately 107 acres/year	Yes
Mechanical ESH Creation Only	Current operation as defined in the Master Manual (USACE 2006a)	Build to meet bird targets	Yes
SPR_35SL + Mechanical (A32)	<ul style="list-style-type: none"> • Release occurs if service level is at 35 kcfs on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	No
SPR_42MAF + Mechanical (A30)	<ul style="list-style-type: none"> • Release occurs if System storage is at 42 MAF on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	Yes

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
SPR_31MAF + Mechanical (A29)	<ul style="list-style-type: none"> • Release occurs if System storage is at 31 MAF on April 1 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting April 1 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	No
FALL_35SL + Mechanical (A28)	<ul style="list-style-type: none"> • Release occurs if service level is at 35 kcfs on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	Yes
FALL_42MAF + Mechanical (A22)	<ul style="list-style-type: none"> • Release occurs if System storage is at 42 MAF on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	No
FALL_31MAF + Mechanical (A21)	<ul style="list-style-type: none"> • Release occurs if System storage is at 31 MAF on October 17 and if natural releases creating 250 acres of ESH have not occurred in previous 4 years • Release starting October 17 of 60 kcfs • Attempt 5.5 week duration as often as every 4 years • Checks downstream flow limits (71 kcfs at OMA, 82 kcfs at Neb City, 126 kcfs at KC), if exceeded reduce Gavins Point releases by 5 kcfs until no longer exceeded • Increased releases from Fort Randall similar to Gavins Point and releases from Garrison were approximately 17.5 kcfs less than those from Gavins Point 	Build to meet bird targets after accounting for reservoir operations	No

Alternative	Reservoir System Operation	Mechanical ESH	Retained for Plan Alternatives?
FALL_42MAF + Low Summer Flow + Mechanical (A26)	<ul style="list-style-type: none"> Release same as that in Fall–42 MAF Low summer flow of 25 kcfs from Gavins Point between May 15 and August 3 for 2 years following habitat-creating flow events. During this period, navigation requirements are ignored. 	Build to meet bird targets after accounting for reservoir operations	No

OMA = Omaha; Neb City = Nebraska City; KC = Kansas City; MAF = million acre-feet

2.7.8 Round 2 Bird Alternative Screening

Numerous iterations of habitat-forming flow releases were formulated and modeled using tools developed in the effects analysis. The intent was to identify characteristics of a flow release that were most effective at contributing towards bird habitat targets while minimizing the potential for HC impacts. The iterations varied in the magnitude of the target flow, frequency of implementation, and the criteria for initiating the flow release as well as terminating it. Appendix A includes the HC proxy results for Round 2 alternatives. Model runs indicated that flow releases of less than 45 kcfs were not effective at forming ESH and a 60 kcfs flow release was the most efficient at forming ESH. Flow releases with a planned frequency of greater than 4 years were not effective at creating ESH. As a result, iterations of habitat-forming flow releases that were less than 45 kcfs or did not occur at a frequency of at least 4 years were eliminated from further consideration because they were not effective at meeting the bird habitat targets. Habitat-forming flow releases that removed downstream flow limits as a termination trigger were also eliminated from further consideration due to the adverse HC impacts that would be expected from this operational change. Likewise, habitat-forming flow releases that did not adjust the downstream flow limits to correspond with Gavins Point releases were eliminated from further consideration as they were not effective at creating ESH.

Of those bird alternatives evaluated as part of Round 2, the Spring 42 MAF plus mechanical and the Fall 35 Service Level plus mechanical alternatives were retained for development of plan alternatives. Of the fall release alternatives evaluated, Fall 35SL and Fall 42 MAF had similar mechanical habitat construction costs; whereas Fall 31 MAF saved about \$2–2.5 million. However, Fall 31 MAF presented serious concerns relative to the other fall release alternatives. Fall 31 MAF resulted in greater impacts to the reservoirs. As an example, under Fall 31MAF a release would have been implemented in 1939 that would have lowered the elevation of Lake Sakakawea by 20 feet when the reservoir would have already been 30 feet below low pool elevation under current operations. This would lead to substantial downstream impacts in the year following the release (i.e., 1940) including a loss of 57 days of water supply at the Kansas City KCMO plant and 3 to 10 weeks of water intake losses at several major thermal power stations. Fall 31MAF also resulted in greater negative impacts to hydropower, wastewater, and water supply intakes in the upper river relative to the other fall alternatives. As a result, USACE determined that the potential HC impacts associated with Fall 31 MAF did not offset the mechanical construction cost savings and eliminated this bird alternative from further detailed evaluation. Fall 35 SL and Fall 42 MAF had very similar construction costs; however, Fall 42 MAF resulted in greater negative impacts as determined by the HC proxies. As a result, USACE eliminated Fall 42 MAF from further evaluation because it was inferior to Fall 35 SL.

Spring 42 MAF and Spring 31 MAF resulted in similar mechanical habitat construction costs; whereas, Spring 35 SL cost about \$4 to 5 million more annually. As with the fall alternatives, Spring 31 MAF resulted in substantial HC impacts in some years relative to the other spring alternatives. As a result, USACE determined that the relatively small cost savings associated with Spring 31 MAF did not outweigh the larger negative impacts to HC and eliminated it from further evaluation. Spring 42 MAF resulted in greater benefits to bird populations; however, it had greater negative impacts to certain HC. Spring 35 SL had inferior performance compared to Fall 35 SL. Therefore, USACE eliminated Spring 35 SL from further evaluation.

Modeling indicated that reduced or low summer flows improved riverine habitat in the southern region, but impacted reservoir breeding piping plover populations. While the low summer flow actions were beneficial for meeting bird habitat targets, additional habitat in the Garrison reach would be needed (above the target acreage), to compensate for impacts on reservoir habitat and to meet piping plover population objectives. Therefore cost savings associated with implementation of a low summer flow were relatively small (about \$1.2 million annually) when compared to the same alternative without a low summer flow action. The low summer flow alternative also resulted in an increased frequency of split navigation seasons, acceleration of problems at thermal power intakes, and negative impacts to other HCs including cultural resources and recreation. Relative to the same bird alternative that did not include a low summer flow action, USACE determined that there were insufficient benefits to the birds relative to negative impacts indicated by the HC proxies associated with the lower summer flow. As a result, implementation of this action as part of a Management Plan alternative evaluated in this EIS was eliminated from further consideration. However, the effects analysis indicated that there may be specific, less frequent occasions in which a low summer flow operation may be implementable within the operational constraints of the existing Master Manual. Therefore, continued research and study of this management action remains within the scope of the AM Plan.

2.8 Plan Alternatives Carried Forward for Detailed Evaluation

Table 2-11 summarizes the features of each plan alternative carried forward for detailed evaluation in this draft MRRMP-EIS. Six plan alternatives were carried forward (the No Action alternative and five action alternatives). The names of each alternative correspond to the concept or feature that distinguishes them from all other alternatives. Some of the alternatives share management actions and these are discussed in the sections describing common actions.

2.8.1 Actions Common to All Plan Alternatives

The following management actions would be implemented as part of all plan alternatives carried forward for detailed evaluation in this draft MRRMP-EIS including the No Action alternative.

2.8.1.1 Least Tern and Piping Plover

The geographic scope of management actions for least tern and piping plover would include the Missouri River from Fort Peck Dam downstream to Ponca, Nebraska.

Mechanical ESH Creation

All alternatives include mechanical ESH creation as a management action; however, the amounts of ESH that would be created mechanically vary by alternative (Table 2-12). Methods

to implement this action under all alternatives would occur as described in Section 2.5.1.5. Under the No Action alternative, USACE would mechanically construct ESH annually at a rate of up to 107 acres per year across the entire System. This amount is based on past average annual ESH construction in the Gavins Point Dam and upper Lewis and Clark Lake segments from 2004 through 2010. It represents continued implementation of this management action at the current level of intensity but in the Garrison and Gavins Point reaches.

Under Alternative 2, USACE would mechanically construct ESH annually at an average rate of 3,546 acres per year to meet the 2003 Amended BiOp acreage goal after accounting for ESH creation resulting from flow releases under this alternative. The USFWS Planning Aid Letter submitted to USACE on November 5, 2015, reiterated the ESH goals included in the BiOp, which state that USACE should achieve a goal of 11,886 acres of ESH on the System subdivided as follows:

- Below Garrison Dam – 50 acres of ESH per river mile
- Below Fort Randall Dam – 20 acres of ESH per river mile
- Lewis and Clark Lake – 80 acres per river mile
- Below Gavins Point Dam – 80 acres of ESH per river mile

USACE would have management discretion as to how those acreage goals are achieved (i.e., mechanical construction vs. flows). USACE would approach the acreage goals under Alternative 2 incrementally, beginning with lower acreages, monitoring the bird response, and moving to higher acreages if birds are not achieving the desired biological metrics. The level of ESH construction required by Alternative 2 could not be implemented while also avoiding all potentially sensitive resources as described in Section 2.5.1.2.

Under Alternative 3–6, mechanical construction amounts vary because this management action would be used to create enough ESH to meet bird habitat targets (described in Section 1.5.2.) after accounting for the amount of ESH created by System operations under each alternative. Under Alternative 3, USACE would only create ESH habitat through mechanical means. Alternatives 4 and 5 include a flow release specifically intended to create ESH. Alternative 6 includes a flow release for the intended benefit of pallid sturgeon but of a magnitude that creates ESH. Therefore, because the amount of ESH created by a flow release varies by alternative, so does the amount of mechanical ESH construction needed to achieve bird habitat targets.

It is important to note that under Alternatives 3–6, ESH would not need to be constructed every year – the amount constructed in any given year is dependent on the in-river ESH trends. Table 2-12 presents the average annual ESH construction amount for years in which the bird habitat model predicted construction would be required (i.e., average ESH construction in build years). The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as well as constructing new ESH. The percent of years ESH construction is anticipated under each alternative represents the modeling results relative to how often construction would be anticipated (e.g., if the model indicated construction is required in 75 percent of years that generally equals constructing in three of every four years). The range of ESH amounts that were forecasted are represented by the 2.5 percent (low end), median (middle), and 97.5 percent (high end) values (Table 2-12). The median amount can be interpreted as the construction amount that would be exceeded in half of the years construction is required and below that amount in half of the years. Table 2-12 also presents the average annual construction rate for

all years, which is the average over the modeled timeframe that includes years in which no construction occurs. This value was used to develop cost estimates presented later in this chapter.

Vegetation Management, Predator Management, and Human Restriction Measures

Vegetation management (Section 2.5.1.6), predator management (Section 2.5.1.11), and human restriction measures (Section 2.5.1.12) would be implemented as part of all the plan alternatives including the No Action alternative.

Flow Management to Reduce Take

Flow management to reduce take as described in Section 2.5.1.10 would be implemented as part of all plan alternatives including the No Action alternative.

Table 2-11. Summary of Features Comprising the MRRMP-EIS Alternatives Carried Forward for Detailed Consideration

Management Actions	Alternative 1 No Action	Alternative 2 USFWS 2003 BiOp Projected Actions	Alternative 3 Mechanical Construction Only	Alternative 4 Spring ESH Creating Release	Alternative 5 Fall ESH Creating Release	Alternative 6 Pallid Sturgeon Spawning Cue
Least Tern and Piping Plover						
Mechanical ESH Creation	X	X	X	X	X	X
Vegetation Management	X	X	X	X	X	X
Predator Management	X	X	X	X	X	X
Human Restriction Measures	X	X	X	X	X	X
Flow Management to Reduce Take	X	X	X	X	X	X
Spring Habitat-Creating Flow Release				X		
Fall Habitat-Creating Flow Release					X	
Monitoring and Research	X	X	X	X	X	X
Pallid Sturgeon (both Upper and Lower River)						
Propagation and Augmentation	X	X	X	X	X	X
Pallid Sturgeon Population Assessment Project	X	X	X	X	X	X
Level 1 and 2* Studies			X	X	X	X
Pallid Sturgeon: Upper River						
Monitoring and evaluation related to recruitment	X	X	X	X	X	X

Management Actions	Alternative 1 No Action	Alternative 2 USFWS 2003 BiOp Projected Actions	Alternative 3 Mechanical Construction Only	Alternative 4 Spring ESH Creating Release	Alternative 5 Fall ESH Creating Release	Alternative 6 Pallid Sturgeon Spawning Cue
Pallid Sturgeon: Lower River						
Spawning Habitat Construction			X	X	X	X
Early Life Stage Habitat Construction	X (SWH)	X (SWH)	X (IRC)	X (IRC)	X (IRC)	X (IRC)
Spawning Cue Release	X	X				X
Low Summer Flow		X				
Floodplain Connectivity		X				
Habitat Development and Land Management on MRRP Lands	X	X	X	X	X	X

2003 BiOp (USFWS 2003)

* Note that some Level 2 studies would require additional NEPA compliance beyond the scope of this EIS.

Table 2-12. Summary of Emergent Sandbar Habitat Construction by Alternative

Emergent Sandbar Habitat Construction	Alternative 1 No Action	Alternative 2 USFWS 2003 BiOp Projected Actions	Alternative 3 Mechanical Construction	Alternative 4 Spring ESH Creating Release	Alternative 5 Fall ESH Creating Release	Alternative 6 Pallid Sturgeon Spawning Cue
Average ESH construction in Build Years (acres)	107	3,546	391	240	309	304
Average ESH construction in All Years (acres)	89	3,545	294	117	194	216
Percent of Years Construction Anticipated	83	100	75	49	63	71
2.5% Construction Amount (acres)	107	594	21	8	15	14
Median ESH Construction Amount (acres)	107	3,056	315	213	264	237
97.5% ESH Construction Amount (acres)	107	9,266	1,169	669	805	935

Monitoring and Research

USACE conducts annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River mainstem. The monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take. USACE also performs ESH habitat monitoring. Monitoring results are used to determine the effectiveness of management actions for least terns and piping plovers. In addition, USACE funds focused research projects on various aspects of least tern and piping plover demographics and habitat use.

2.8.1.2 Pallid Sturgeon (Both Upper and Lower River)

Propagation and Augmentation

The PSCAP as described in Section 2.5.2.3 would be implemented as part of all the plan alternatives including the No Action alternative. The Pallid Sturgeon Recovery Team and Basin Workgroups undertake annual reviews of data to ensure timely updates to stocking plans in the upper and lower river (e.g., USFWS 2007). A new Pallid Sturgeon Propagation Plan is being developed by the Pallid Sturgeon Recovery Team because of important concerns related to fish health/disease, genetics, stocking size, stocking practices, etc. This propagation plan will

examine hatchery practices and recommend changes to rearing practices to minimize disease occurrences and ensure appropriate levels of production. The plan will also address issues related to obtaining appropriate genetic representation in the stocked population. The USFWS plan will focus on hatchery practices, rather than the fate of fish after release from the hatchery. The authority and responsibility for hatchery management lie with USFWS for those facilities operated by USFWS; states are responsible for the operation of their hatcheries. USACE support of pallid sturgeon propagation and augmentation efforts would continue at current levels under all plan alternatives. The USACE primary method of support is through the provision of annual funding, which is anticipated to continue at approximately \$455,000 annually, but is subject to change based on yearly budget appropriations.

Pallid Sturgeon Population Assessment Project

The Pallid Sturgeon Population Assessment Project (PSPAP) has been the primary fish monitoring element for the BiOp and the MRRP and would continue in some form under all plan alternatives including the No Action alternative. Data collected through the PSPAP are used to evaluate the PSCAP and provide long-term assessment of fish metrics. USACE is responsible for ensuring that these long-term assessment activities occur to meet BiOp required monitoring and evaluation. USACE has developed partnerships with state and federal agencies already active on the Missouri and Kansas Rivers and has provided the funding, standardized protocols, and quality control oversight necessary to implement the monitoring strategy of the PSPAP. Some level of redesign of the PSPAP is anticipated in the future in order to achieve efficiencies and align the PSPAP to help evaluate management hypotheses.

2.8.1.3 Pallid Sturgeon: Upper River

Monitoring and Evaluation of Recruitment

Under all plan alternatives, USACE would conduct the monitoring and assessment complimentary of that for which the Bureau of Reclamation has responsibility to determine if modifications for fish passage at Intake Diversion Dam are meeting pallid sturgeon objectives. The Bureau of Reclamation is responsible for monitoring the success of fish passage at Intake following implementation of fish passage measures. USACE would be responsible for ensuring that MRRP monitoring and assessment can determine if successful fish passage at Intake is contributing to the upper river pallid sturgeon population.

2.8.1.4 Pallid Sturgeon: Lower River

Unless stated otherwise, the geographic scope of management actions to benefit pallid sturgeon in the lower Missouri River is downstream of Gavins Point Dam to the confluence of the Missouri and Mississippi Rivers near St. Louis.

Early Life Stage Habitat Construction

All plan alternatives include channel reconfiguration for the creation of early life stage pallid sturgeon habitat; however, the amounts and types of habitat that would be created vary by alternative and those differences are described in the respective section for each alternative. Methods to implement this action may include any of those described in Section 2.5.3.1.

Habitat Development and Land Management on MRRP Lands

All plan alternatives include habitat development on MRRP lands; however, the amount of land acquisition varies by alternative and so would the magnitude of the action. Those differences are described in the respective section for each alternative. Methods to implement this action are described in Section 2.5.4.

2.8.2 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under the No Action alternative, the MRRP would continue to be implemented as it is currently. The current program does not implement all RPAs included in the 2003 Amended BiOp (USFWS 2003). The following sections describe the actions that would be taken towards BiOp compliance in addition to those common actions identified in Section 2.8.1 and their projected level of intensity as part of the No Action alternative.

2.8.2.1 Least Tern and Piping Plover

Under the No Action alternative, no additional management actions other than those described in Section 2.8.1 would be implemented in compliance with the BiOp for least tern and piping plover on the Missouri River.

2.8.2.2 Pallid Sturgeon – Lower River

Under the No Action alternative, the following management actions would be implemented in compliance with the BiOp for pallid sturgeon in the lower Missouri River in addition to those described Section 2.8.1.

Early Life Stage Habitat Construction

Under the No Action alternative, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the SWH program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under the No Action alternative, USACE would achieve the low end of this acreage target (i.e., 20 acres per river mile between Ponca, Nebraska, and the mouth). This equates to a total of 15,060 acres of SWH. Existing habitat on the System combined with SWH projects have created a total of 11,832 acres, leaving 3,999 acres to be created (Table 2-13). For purposes of evaluating potential impacts to the human environment, modeling assumed that the additional SWH acreage would be created as follows (Table 2-14):

- Approximately 3,519 acres of in-channel SWH created through channel or top-width widening. A conceptual width of 250 feet was assumed for projects between Ponca and Rulo (20 projects encompassing 48 river miles) and 300 feet for projects downstream of Rulo (24 projects encompassing 57 river miles). Actual project width and size will vary by site.
- Approximately 480 acres of off-channel backwaters, assuming 8 new backwaters with each creating 60 acres of SWH.

Table 2-13. Summary of Projected Shallow Water Habitat Creation Under Alternative 1

River Reach	River Mile Start	River Mile End	Miles in Reach	20 acres per mile of SWH	Existing acres of SWH	Target Acres of SWH
Ponca to Sioux City	753	735	18	360	120	240
Sioux City to Platte River	735	595	140	2,800	1,779	1,021
Platte River to Rulo	595	498	97	1,940	1,268	672
Rulo to Kansas River	498	367	131	2,620	1,491	1,129
Kansas River to Osage River	367	130	237	4,740	3,803	937
Osage River to Mouth	130	0	130	2,600	3,371	0
Total	753		15,060		11,832	3,999

Table 2-14. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 1

River Reach	Target Acres of SWH	Channel Widening ^a			Backwaters ^b	
		Acres	Miles	# of Projects	Acres	# of Projects
Ponca to Sioux City	240	180	5.9	2	60	1
Sioux City to Platte River	1,021	601	19.8	9	420	7
Platte River to Rulo	672	672	22.2	9	0	0
Rulo to Kansas River	1,129	1,129	31.1	14	0	0
Kansas River to Osage River	937	937	25.8	10	0	0
Osage River to Mouth	0	0	0	0	0	0
Total	3,999	3,519	105	44	480	8

a Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo.

b Assumes 60 acres of SWH are created by each project.

Assumptions associated with SWH acreages are documented in the HEC-RAS modeling reports (www.moriverrecovery.org). Table 2-15 summarizes the amount of land acquisition that was assumed to be required to implement the identified amount of SWH.

Table 2-15. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 1

River Reach	Target Acres of SWH	Additional Land Required – Habitat Only (acres) ^a	Additional Land Required – Total (acres) ^b
Ponca to Sioux City	240	240	1,848
Sioux City to Platte River	1,021	0	0
Platte River to Rulo	672	0	0
Rulo to Kansas River	1,129	675	5,198
Kansas River to Osage River	937	0	0
Osage River to Mouth	0	0	0
Total	3,999	915	7,046

- a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.
- b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

Spawning Cue Release

For purposes of modeling the No Action alternative, USACE assumed continued implementation of the plenary spring pulse as described in the Master Manual (USACE 2006a). It was also assumed that reservoir unbalancing as described in the Master Manual would not be implemented. The bimodal Gavins Point spring pulse plan was developed based on the following: the provisions of the 2003 Amended BiOp (USFWS 2003) including the Integrated Science Program (ISP), input from the 2005 spring pulse Plenary Group and its technical working groups, and Tribal consultations/meetings and public comments received on the draft spring pulse plan presented in the fall of 2005. A description of the detailed features of the plan follows.

Gavins Point Spring Pulse Downstream Flows Limits: The magnitude of both the March and May Gavins Point spring pulses would be constrained by the Gavins Point spring pulse downstream flow limits. These downstream flow limits are established at the same locations as the current downstream flow limits discussed in the Master Manual (USACE 2006a) and shown in Table 2-16. The downstream flow limits shown in Table 2-16 are the same values as the most conservative downstream flow limits and therefore, would provide similar downstream flood control during the spring pulse periods. As an additional precaution, radar detected precipitation and National Weather Service quantitative precipitation forecasted would continue to be used in forecasting the resultant downstream flows. Gavins Point releases would be adjusted as required during the spring pulse periods based on this forecast.

Table 2-16. Downstream Flow Limits During the Spring Pulse Under the No Action Alternative

Location	Flow Limit (cfs)
Omaha	41,000
Nebraska City	47,000
Kansas City	71,000

cfs = cubic feet per second

March Spring Pulse from Gavins Point: The March spring pulse below Gavins Point includes a preclude based on System storage. If the actual System storage as computed on March 1 is at or below 40.0 MAF, a March pulse would not be implemented. The magnitude of the March pulse is defined as the combination of the Gavins Point release increase and the contribution of the James River. Assuming that System storage is above the March pulse preclude, the magnitude of the March pulse would be 5,000 cfs and would be implemented the day after System releases reach the level necessary to provide downstream flow support for the beginning of the navigation season. More specifically, the magnitude of the Gavins Point release at the peak of the March pulse would be 5,000 cfs minus the contribution of the James River measured at the Scotland, South Dakota, stream gage. Actual releases from Gavins Point Dam would be set to the nearest 500 cfs increment. Also, the total Gavins Point release during the March pulse would not be set any higher than the Gavins Point power plant capacity (35,000 cfs). The duration of the peak of the March pulse would be 2 days. Following the 2-day peak, the March pulse flows would be reduced each day over the next 5 days until non-spring pulse downstream flow support rates are achieved.

May Spring Pulse from Gavins Point: The May spring pulse from Gavins Point would also have a preclude based on actual System storage as computed on May 1. If the actual System storage as computed on May 1 is at or below 40.0 MAF, a May pulse would not be implemented. The magnitude of the May pulse, as is the case for the March pulse, is defined as the combination of Gavins Point release increase and the contribution of the James River. Therefore, the magnitude of the Gavins Point release at the peak of the May pulse would be the result of the two-step proration computation described below minus the contribution of the James River measured at the Scotland, South Dakota, stream gage. The total Gavins Point release during the May pulse would not be constrained to the Gavins Point powerplant capacity, as is the case for the March pulse. The two-step proration computation to determine the magnitude of the May pulse is as follows:

1. First Step: The May pulse magnitude is first computed based on May 1 System storage. The May pulse magnitude is prorated in a straight-line interpolation between 16,000 cfs and 12,000 cfs based on a System storage range between 54.5 and 40 MAF. The May pulse magnitude in this step is limited to 16,000 cfs if System storage is greater than 54.5 MAF. For the initial occurrence of the May pulse, if System storage is between 36.5 and 40 MAF, the resultant magnitude from this step is 12,000 cfs.
2. Second Step: The resultant May pulse magnitude from the first step is then further prorated based on the USACE May 1, Mainstem Calendar Year Runoff Forecast for the Missouri River basin above Sioux City, Iowa. The May pulse magnitude computed in the first step could be decreased or increased by as much as 25 percent in this step. The May pulse magnitude resulting from the first step is

increased in a straight line interpolation from 0 to 25 percent for a calendar year runoff forecast that ranges from median to upper quartile. The May pulse magnitude from the first step is decreased in a straight line interpolation from 0 to 25 percent for a May 1 calendar year runoff forecast that ranges from median to lower quartile runoff. Use of both steps in this computational process produces a potential range of May pulse magnitudes from 9,000 cfs to 20,000 cfs. Actual releases from Gavins Point Dam would be set to the nearest 500 cfs increment.

The initiation of the May pulse would be between May 1 and May 19, depending on Missouri River water temperature measured immediately below Gavins Point Dam. The May pulse would be initiated after the second daily occurrence of a 16°C or higher Missouri River water temperature. However, the final decision on the date of the initiation of the May pulse would take into account the potential for "take" of threatened and endangered bird species during the pulse period and downstream flow conditions.

Gavins Point releases would be increased at a rate of approximately 6,000 cfs per day from normal downstream flow support releases until the full May pulse magnitude, as calculated previously, is achieved. The May pulse magnitude would be maintained for 2 days, after which releases would be decreased by 30 percent over the following 2 days. The remaining release reductions would be prorated over an additional 8 days until non-spring pulse downstream flow support rates are achieved. This would result in a recession length of 10 days from the peak of the May pulse. The length and magnitude of the recession may also be constrained by the downstream flow limits shown on Table 2-16.

Monitoring and Research

Pallid sturgeon science efforts require a comprehensive approach to provide information to decision-makers. USACE management actions require riverine monitoring to determine the species response, or effectiveness of the action, and any unintended effects. These assessments are further developed through research activities to clarify critical uncertainties. Research activities focus on factors limiting recruitment. These elements, in combination with propagation and augmentation, seek to identify and remove bottlenecks to pallid sturgeon recruitment. Under the No Action alternative, the following monitoring and research activities would continue in addition to the PSPAP, which is common to all plan alternatives.

- **Habitat Assessment and Monitoring Program:** The Habitat Assessment and Monitoring Program began in 2004 and was developed by representatives of state and federal agencies and academia that collectively possess knowledge and expertise on the Missouri River, pallid sturgeon and other native Missouri River fishes, research, experimental design, and statistical analysis. The Habitat Assessment and Monitoring Program focuses on the endangered pallid sturgeon, other big river native fishes, and their habitats as recommended by the BiOp. The goal of the Habitat Assessment and Monitoring Program is to assess the physical and biological responses to habitat creation actions that are expected to benefit pallid sturgeon and related fish communities.
- **Focused Pallid Sturgeon Research:** USACE annually funds focused research to address remaining critical pallid sturgeon information gaps including the identification and better understanding of key pallid sturgeon life stage transitions and development of explicit pallid sturgeon objectives and prioritized hypotheses.

2.8.2.3 Adaptive Management

Under Alternative 1, USACE would continue to implement the AM approach that has been in place since 2009. It consists of two primary components: the AM Plan for ESH (USACE 2011) and the AM strategy developed for SWH creation (USACE 2012c). The AM approach developed for the SWH and ESH sub-programs was developed in accordance with the 2000 BiOp and the 2003 amended BiOp, which called for establishing an AM process to evaluate species and habitat responses to management actions within the river and to continually provide knowledge for the decision-making process (USFWS 2000, 2003). In addition, USACE released a technical memorandum describing implementation guidance for Section 2039 of the WRDA 2007 which called for monitoring and AM of ecosystem restoration projects and provided some specific direction on what should be addressed within AM plans. Finally, the National Research Council (NRC) called for AM efforts in their 2002 report *The Missouri River Ecosystem: Exploring the Prospects for Recovery* (NRC 2002). In 2008, a multi-agency team consisting of representatives from USACE, USFWS, National Park Service (NPS), and experts in structured decision-making and model development initiated strategy development. In 2009, the strategy was updated by the MRRP Adaptive Management Work Group and the ESH Programmatic Environmental Impact Statement PDT in coordination with cooperating agencies on the Programmatic Environmental Impact Statement (i.e., USFWS and NPS) before finalization and implementation in 2010.

Monitoring data would be compiled and analyzed on an annual basis to assess progress towards stated objectives for both ESH and SWH and to report results. These annual reports would include recommendations related to all or some of the following program decisions: (1) level of construction effort, (2) pilot projects, (3) site adjustments, (4) incorporation of new methodologies, and (5) investigations. Every five years, additional analyses would be conducted in order to assess whether the elements of the ESH AM Plan and SWH AM strategy are being met. If a decision is made to update the ESH AM Plan or SWH AM strategy document, a scope, schedule, and plan of action would be developed.

MRRIC and other groups may choose to provide comments or recommend adjustments to AM strategies at any time during the implementation process. This could include changes to AM objectives, incorporation of additional management actions, input on anticipated benefits and tradeoffs, and other pertinent elements of the AM Plans. For additional detail regarding the AM framework that would be followed under Alternative 1, see the MRRP Adaptive Management Framework, ESH AM Plan, and SWH AM Strategy which are public documents available on the MRRP website at www.moriverrecovery.org.

2.8.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp RPA (USFWS 2003). Whereas the No Action alternative only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that USFWS anticipates would ultimately be implemented through AM and as impediments to implementation were removed. The following sections describe the actions that would be taken towards BiOp compliance and their projected level of intensity as part of the USFWS 2003 BiOp Projected Actions alternative. USFWS input on this alternative was formalized in a Planning Aid Letter submitted to USACE on November 5, 2015.

2.8.3.1 Least Tern and Piping Plover

Under Alternative 2, the following management actions would be implemented in compliance with the 2003 Amended BiOp (USFWS 2003) for least tern and piping plover on the Missouri River. These actions would be in addition to those described in Section 2.8.1.1.

Spring Habitat-Forming Flow Release

A spring reservoir release for the purposes of ESH creation is not included in Alternative 2. However, the timing and magnitude of the pallid sturgeon spawning cue release would provide ESH creating benefits. These benefits are accounted for in the habitat availability modeling that determined the amount of ESH that would be mechanically created (Table 2-12).

Lowered Nesting Season Flow

The low summer flow described for pallid sturgeon would also serve as a lowered nesting season flow for the benefit of least terns and piping plovers under Alternative 2. The criteria for the flow implementation would be the same as described in Section 2.8.3.2.

2.8.3.2 Pallid Sturgeon – Lower River

Under Alternative 2, the following management actions would be implemented in compliance with the BiOp for pallid sturgeon in the lower Missouri River. These actions would be in addition to those described in Section 2.8.1.2.

Early Life Stage Habitat Construction

Under Alternative 2, construction of habitat to support early life stage requirements of pallid sturgeon would occur as part of the SWH program. The SWH restoration goal as outlined in the 2003 Amended BiOp (USFWS 2003) is to achieve an average of 20–30 acres of SWH per river mile. Under Alternative 2, USACE would achieve the upper end of this acreage target (i.e., 30 acres per river mile between Ponca, Nebraska, and the mouth). This equates to a total of 22,590 acres of SWH. Existing SWH projects have created a total of 11,832 acres, leaving 10,758 acres to be created (Table 2-17). For the purposes of evaluating potential impacts to the human environment, modeling assumed that the additional SWH acreage would be created as follows (Table 2-18):

- Approximately 9,858 acres of in-channel SWH would be created through channel widening. A conceptual width of 250 feet was assumed for projects between Ponca and Rulo (60 projects encompassing 118.2 river miles) and 450 feet for projects downstream of Rulo (48 projects encompassing 115 river miles). Actual project width and size will vary by site.
- Approximately 900 acres of off-channel backwaters, assuming 15 new backwaters with each creating 60 acres of SWH.

Land acquisition to implement the SWH requirements described is summarized in Table 2-19.

Table 2-17. Summary of Projected Shallow Water Habitat Creation Under Alternative 2

River Reach	River Mile Start	River Mile End	Miles in Reach	30 acres per mile of SWH	Existing acres of SWH	Target Acres of SWH
Ponca to Sioux City	753	735	18	540	120	420
Sioux City to Platte River	735	595	140	4,200	1,779	2,421
Platte River to Rulo	595	498	97	2,910	1,268	1,642
Rulo to Kansas River	498	367	131	3,930	1,491	2,439
Kansas River to Osage River	367	130	237	7,110	3,803	3,307
Osage River to Mouth	130	0	130	3,900	3,371	529
Total	753		22,590		11,832	10,758

Table 2-18. Projected Composition of Shallow Water Habitat Creation Type Under Alternative 2

River Reach	Target Acres of SWH	Channel Widening ^a			Backwaters ^b	
		Acres	Miles	# of Projects	Acres	# of Projects
Ponca to Sioux City	420	240	7.9	4	180	3
Sioux City to Platte River	2,421	1,761	58.1	32	660	11
Platte River to Rulo	1,642	1,582	52.2	24	60	1
Rulo to Kansas River	2,439	2,439	44.7	19	0	0
Kansas River to Osage River	3,307	3,307	60.6	25	0	0
Osage River to Mouth	529	529	9.7	4	0	0
Total	10,758	9,858	233	108	900	15

a Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 450 feet for projects downstream of Rulo.

b Assumes 60 acres of SWH are created by each project.

Table 2-19. Land Acquisition Requirements to Implement Early Life Stage Pallid Sturgeon Habitat Under Alternative 2

River Reach	Target Acres of SWH	Additional Land Required: Habitat Only (acres) ^a	Additional Land Required: Total (acres) ^b
Ponca to Sioux City	420	420	3,234
Sioux City to Platte River	2,421	925	7,123
Platte River to Rulo	1,642	675	5,198
Rulo to Kansas River	2,439	1,985	15,285
Kansas River to Osage River	3,307	1,932	14,876
Osage River to Mouth	529	0	0
Total	10,758	5,937	45,716

- a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.
- b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

Spring Pallid Sturgeon Flow Release

USFWS determined in the 2003 Amended BiOp (USFWS 2003) that restoration of a normalized river hydrograph below Gavins Point Dam was necessary to avoid a finding of jeopardy to the pallid sturgeon. Several biologically relevant features were identified for a flow action below Gavins Point Dam including (1) flows to cue spawning that are sufficiently high for an adequate duration; and (2) flows that provide for connection of low-lying lands adjacent to the channel.

The spring pallid sturgeon flow release from Gavins Point Dam would be bimodal (i.e., consisting of two separate flow pulses) and would be implemented in every year if conditions are met. If System storage on March 15 is 31.0 MAF or less, equating to a “no service” navigation year, the spawning cue release would not be implemented. In addition, if downstream flood control targets are exceeded the spawning cue release would not be initiated or it would be terminated if these targets are exceeded during implementation. The results of preliminary reservoir simulation modeling based on an 82-year POR, indicate that in practice the bimodal spring pallid sturgeon flow releases would likely only meet the conditions for implementation once in every eight years. The conditions and characteristics of the two pulses would include:

- In advance of the first pulse, the maximum winter Gavins Point release would be maintained at 16 kcfs.
- First pulse from Gavins Point Dam.
 - Implementation would occur if the conditions described previously are met, System storage on March 1 is at least 40.0 MAF, and the System is not at storage evacuation service level on March 15.

- Implementation would begin with the typical increase in flow to provide for navigation around March 15.
- The rate of flow increase (i.e., the ascending limb of the pulse) would last 7 days until a peak of 31 kcfs is reached.
- Once reached, the peak flow would be maintained for 7 days. After that, the rate of decrease (i.e., the descending limb of the pulse) would last 7 days and then return to flow-to-target operations based on service level from March 15 storage check. Flow-to-target means that reservoir operations are adjusted daily to meet downstream navigation targets.
- Second pulse from Gavins Point Dam.
 - Implementation would occur if the conditions described previously are met and System storage on May 1 is at least 40.0 MAF. Downstream flow limits would be determined by adding the pulse magnitude to the existing downstream flow limits as shown in Table VII-7 and VII-8 in Master Manual (USACE 2006a). For example, if the pulse magnitude is 16 kcfs and the flood targets are 41 kcfs, 47 kcfs, and 71 kcfs at Omaha, Nebraska City, and Kansas City, respectively, the downstream flow limits would be 57 kcfs at Omaha (16 kcfs + 41 kcfs), 62 kcfs at Nebraska City (16 kcfs + 47 kcfs), and 87 kcfs at Kansas City (16 kcfs + 71 kcfs). The pulse would be terminated any time downstream flow limits are exceeded.
 - Implementation would begin on May 1.
 - The rate of flow increase (i.e., the ascending limb of the pulse) would last 7–10 days.
 - The pulse peak would be based on the March 1 forecast as follows but would never exceed a total Gavins Point Dam release of 60 kcfs:
 - Lower quartile or lower runoff = 12 kcfs rise over May 1 release and maintained for 14 days
 - Median = 16 kcfs rise over May 1 release and maintained for 25 days
 - Upper quartile or higher runoff = 20 kcfs rise over May 1 release and maintained for 35 days
 - The rate of decrease (i.e., the descending limb of the pulse) would last not less than 7 days until a return to “steady release” scenario is reached.

Low Summer Flow

The USFWS 2003 Amended BiOp (USFWS 2003) also called for modification to System operations to allow for flows that are sufficiently low to provide for SWH as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon. Alternative 2 includes a low summer flow that would be implemented as follows:

- Summer low flow would only be implemented in the two years following implementation of a complete bimodal spring pallid sturgeon flow release, meaning that both the first and second pulses as described in Section 1.1.6 are implemented completely.
- From June 23 to July 1, Gavins Point Dam release would be set to 25 kcfs
- On July 1, USACE would assess the navigation season length and operate as follows:

- If there is a shortened navigation season as determined by the existing Master Manual (USACE 2006a):
 - Gavins Point Dam releases would be determined based on meeting water supply targets (open channel non-navigation season).
 - The duration of those releases would be equivalent to that of the number of days the season is shortened less the 8 days in June (e.g., if season is shortened 30 days).
 - Following that duration, flows would be set to 25 kcfs until July 15 at which time release would be dropped to 21 kcfs until August 15. As of August 15, releases would return to 25 kcfs until September 1.
 - Flow-to-target operations would resume from September 1 until December 1.
- If there is not a shortened navigation season:
 - Releases of 25 kcfs would continue from July 1 to July 15 then drop to 21 kcfs until August 15. After August 15, releases would return to 25 kcfs until September 1.
 - Flow-to-target operations would resume from September 1 until December 1 or December 10 if a 10-day navigation season extension is determined.

Floodplain Connectivity

The USFWS 2003 Amended BiOp (USFWS 2003) stated the following in regard to floodplain connectivity:

Floodplain inundation and connectivity is essential in order to maximize the production of the forage base for pallid sturgeon. The forage base production must occur at a time that coincides with larval sturgeon becoming active, free-swimming feeders. Floodplains are highly productive habitat in the late spring and early summer when warm, shallow water floods over the area and produces a bloom of forage that is of appropriate size for larval fish to eat. Additionally, low-lying lands are an extremely important source for floodplain spawning fish which subsequently support the forage base for adult pallid sturgeon. Highly productive floodplains are necessary on a frequent annual basis to provide necessary life requisites for pallid sturgeon survival.

USACE coordinated with USFWS during alternatives development to identify criteria for clarification of the floodplain connectivity management action for Alternative 2. These criteria were included in a Planning Aid Letter submitted to USACE on November 5, 2015. The criteria stated that this management action should maximize floodplain habitat by ensuring that 77,410 acres of connected floodplain are inundated at a 20 percent annual chance exceedance. USACE conducted HEC-GeoRAS mapping to determine the acres of existing floodplain connectivity in the lower Missouri River. The mapping results indicated that 156,480 acres of floodplain connectivity are currently present, not including the area of the main channel. Under Alternative 2, it is assumed that operations would result in floodplain connectivity of at least 77,410 acres as indicated by the mapping results described previously.

Monitoring and Research

Monitoring and research efforts under Alternative 2 would be the same as described for Alternative 1.

2.8.3.3 Adaptive Management

The AM approach for Alternative 2, is similar to the AM approach that USACE has been implementing since 2009 and described for Alternative 1. The AM approach for Alternative 2 would be the same as for Alternative 1 but would be modified to address specific alterations in proposed management actions as described in the November 5, 2015, Planning Aid Letter from USFWS. Management actions implemented by USACE as part of Alternative 2 would be modified and continually improved upon through AM and in cooperation with USFWS. Due to changing river conditions, methods of implementing management actions may vary over time, and modifications to management actions would be based on an evaluation of habitat, flow, climate, species response, and any other new information available each year. Under Alternative 2, monitoring would be a key component to the AM approach to document how management actions were implemented and their effects within the river and on the listed species. USACE and USFWS would jointly define what is considered to be sufficient progress for each management action within specified timeframes to avoid a finding of jeopardy.

2.8.4 Alternative 3 Mechanical Construction Only

Under Alternative 3, current System operations as described in the Master Manual would continue except the spring plenary pulse and reservoir unbalancing would not be implemented. The following management actions are included under Alternative 3 in addition to those common actions identified in Section 2.8.1. Anticipated levels of mechanical ESH construction are shown in Table 2-12.

2.8.4.1 Adaptive Management

Under Alternative 3, the USACE would follow the AM Plan that was developed based on the results of the Effects Analysis. The AM Plan is a companion document to the MRRMP-EIS. The AM Plan identifies the process and criteria to implement the initial management actions, assess hypotheses, and introduce new management actions should they become necessary. The AM plan provides a management framework for pallid sturgeon in the upper and lower river segments that includes a hierarchical design of scientific studies and management actions aimed at addressing uncertainties about factors limiting pallid sturgeon natural recruitment. The AM Plan also includes a management framework for piping plovers and least terns consisting of a program of habitat construction, monitoring, and research activities. The AM Plan was designed to address uncertainty related to management for the species and meet updated species objectives that were developed based on results of the effects analysis.

The role of AM in MRRP least tern and piping plover management is to improve decision-making in light of uncertain future trends in habitat availability and improved understanding of various management actions. As the AM program is implemented, what is learned about the actions included within its scope will be applied to increase their effectiveness, and may also result in the addition or removal of management actions from consideration. For pallid sturgeon, lingering uncertainties regarding the scope and scale of the management actions necessary to address recruitment failure has led to an AM framework reliant upon a progressive AM approach to manage risks to the pallid sturgeon. Under Alternative 3, the AM strategy is driven

by the hypotheses generated by the effects analysis effort. For additional detail about the AM Framework, see Chapter 4.0 and the full AM Plan that accompanies the MRRMP-EIS (www.moriverrecovery.org).

2.8.4.2 Level 1 and 2 Studies

As part of the AM program described previously, USACE would implement Level 1 and 2 studies under Alternative 3 for better understanding of limiting factors associated with pallid sturgeon. Level 1 studies are research focused and do not change the System (laboratory studies or field studies under ambient conditions). Level 2 studies would focus on in-river testing of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response. For example, Level 2 studies would include a one-time spawning cue test release from Gavins Point if Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important. At the present time, it is assumed the test release would be similar to the timing, magnitude, duration, and pattern of the spawning cue included as a recurring release under Alternative 6. If determined to be necessary following 9–10 years of Level 1 studies, the test release would be implemented in accordance with the rules described for Alternative 6. For additional information on the types of studies that could be implemented under Alternative 3 see Chapter 4.0 and the AM Plan (www.moriverrecovery.org).

2.8.4.3 Spawning Habitat Construction

Under Alternative 3, USACE would construct up to three high-quality spawning habitat sites, and monitor the effectiveness of this action in terms of the relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos, and other indicators. Sufficient understanding to characterize the necessary features of high quality pallid sturgeon spawning habitat does not exist. These sites would be constructed following initial studies to further clarify habitat specifications. An early emphasis would use information from the Yellowstone River as the best natural reference condition to inform the design of these pilot projects on the lower Missouri River, while also continuing to examine the habitat characteristics of spawning sites on the lower Missouri River.

2.8.4.4 Early Life Stage Habitat Construction

Under Alternative 3, construction of habitat to support early life stage requirements of pallid sturgeon would occur following the IRC (interception and rearing complexes) concept. During the first 6–7 years of implementation, 12 site pairs (experimental IRC site and control site) would be implemented in an experimental “staircase” design to evaluate whether young fish are intercepted and retained. This would be complemented with other research and assessment to determine whether and why IRCs contribute to increased growth and survival. In the event that results are positive or equivocal, additional IRC sites would be constructed in the following years to accelerate determinations regarding these uncertainties. In addition to the IRC “staircase” experiment, existing SWH sites would be evaluated to determine if they are presently functioning as IRC habitat. Those that can be most efficiently modified to provide IRC habitat would be refurbished.

For the purpose of evaluating potential impacts to the human environment from IRC habitat development, it was assumed that approximately 260 acres per year of channel widening would be realistically constructed based on past experience. It was also assumed that construction would occur in 13 years of the 15-year implementation timeframe considered for this planning

process. Therefore, the HEC-RAS models, used as the basis for impact assessment, reflect about 3,380 acres (260 acres x 13 years) of accommodation space for new IRC habitat under Alternatives 3–6 (Table 2-20). Additional IRC habitat would be created by modifying structures to develop hydraulics to intercept free embryos into existing in-channel areas that contain the appropriate parameters of food and foraging habitat.

Table 2-20. Summary of Projected Channel Widening Under Alternatives 3–6

River Reach	River Mile Start	River Mile End	Miles in Reach	Target Acres of Channel Widening*
Ponca to Sioux City	753	735	18	0
Sioux City to Platte River	735	595	140	276
Platte River to Rulo	595	498	97	585
Rulo to Kansas River	498	367	131	670
Kansas River to Osage River	367	130	237	1,389
Osage River to Mouth	130	0	130	460
Total				3,380

* All acreage achieved through channel widening. Acreage amounts assume a top width of 250 feet for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo.

A conceptual channel widening of 250 feet was assumed for projects between Ponca and Rulo and 300 feet for projects downstream of Rulo for the required length of channel to simulate 3380 acres in the HEC-RAS models. The HEC-RAS models are not capable of simulating modifications to structures and existing SWH sites, however it is not anticipated that these measures would have any substantive effect to water surface elevations beyond the immediate modification area. When specific modification sites are identified, site-specific modeling and assessment would occur during detailed project design to ensure no substantive effects are realized. Land acquisition to implement the requirements described is summarized in Table 2-21.

Table 2-21. Land Acquisition Requirements to Implement Channel Widening Under Alternatives 3–6

River Reach	Target Acres of SWH	Additional Land Required – Habitat Only (acres) ^a	Additional Land Required – Total (acres) ^b
Ponca to Sioux City	0	0	0
Sioux City to Platte River	276	0	0
Platte River to Rulo	585	0	0
Rulo to Kansas River	670	216	1,664
Kansas River to Osage River	1,389	14	108
Osage River to Mouth	460	0	0
Total	3,380	230	1,772

- a Additional land requirements was determined by assessing if there were existing public lands (i.e., USACE, USFWS, or state conservation lands) within each river reach that may be appropriate for habitat development. If this value is zero it means that either there were no habitat targets within this reach for the alternative or the assessment determined that there was potential to achieve the habitat targets on existing public lands. These areas do not necessarily represent actual locations of future habitat development.
- b For estimating purposes, it was assumed that 7.7 acres of land acquisition are required for every 1 acre of habitat needed. This is based on historic implementation data and accounts for factors such as parcel size and other real estate acquisition considerations.

2.8.5 Alternative 4 – Spring ESH Creating Release

Alternative 4 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-12. Alternative 4 also includes adaptive management, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. The rest of this section describes the management action that is unique to Alternative 4, a spring habitat-creating flow release.

Alternative 4 reservoir operations would include a high spring release designed to create ESH for the least tern and piping plover. The spring plenary pulse and reservoir unbalancing including in the Master Manual would not be implemented. The following description of the spring-habitat creating flow release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time. In any year, the implementation of this habitat-creating flow release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous four years, and downstream flow limits are not exceeded (Table 2-22). If those conditions are met, the habitat-creating flow release would be implemented on April 1 with a release of up to 60 kcfs out of Gavins Point Dam, and as often as every 4 years. To achieve the Gavins Point Dam release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release.

Table 2-22. Downstream Flow Limits During Habitat-Creating Release

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	71
Nebraska City	82
Kansas City	126

The duration of the release would increase as release magnitude is decreased. Table 2-23 shows the duration (number of days) required for the habitat-creating flow release at various discharges.

Table 2-23. Estimated Durations of Habitat-Creating Flow Release

Gavins Point Release (kcfs)	Required Number of Days
60.0	35
55.0	49
50.0	77
45.0	175

If downstream flow limits are exceeded, the Gavins Point release would be reduced by 5 kcfs until the flow limits are no longer exceeded. In instances where the Gavins Point release falls below 45 kcfs, the release would be terminated. Modeling indicates that over the 82-year POR, the spring habitat-creating flow release as defined here would have been implemented 10 times and would have been partially implemented 7 times. Partial implementation means that the criteria were met in that year to initiate the flow release but it was terminated before completion.

Under current operations, navigation releases are computed based on the current service level prior to flood targets being assessed. Flow support for navigation and other downstream purposes is defined based on service level. A “full-service” level of 35.0 kcfs results in target flows of 31.0 kcfs at Sioux City and Omaha, 37.0 kcfs at Nebraska City, and 41.0 kcfs at Kansas City. Similarly, a “minimum-service” level of 29.0 kcfs results in target flow values of 6.0 kcfs less than the full-service levels. If System storage is high enough to warrant evacuation of flood storage, the service level will be greater than 35.0 kcfs.

The following example assumes a service level of 40.0 kcfs is the operations target. Navigation discharges for each of the target locations are computed based on Table 2-24 (Table VII-1 in the Master Manual (USACE 2006a)). These navigation discharges are the required discharges at the four target locations to support navigation. For a 40.0 kcfs service level, the required navigation discharges at Sioux City, Omaha, Nebraska City, and Kansas City are 36.0 kcfs ($40.0 - 4.0$); 36.0 kcfs ($40.0 - 4.0$); 42.0 kcfs ($40.0 + 2.0$); and 46.0 kcfs ($40.0 + 6.0$), respectively.

Table 2-24. Relation of Target Discharges to Service Level

Navigation Target Location	Navigation Target Flow Deviation from Service Level
Sioux City	-4.0 kcfs

Omaha	-4.0 kcfs
Nebraska City	+2.0 kcfs
Kansas City	+6.0 kcfs

Source: Master Manual, Table VII-1 (USACE 2006a)

cfs = cubic feet per second

Once navigation discharges are calculated, two tiers of flood target discharges are calculated and forecasted discharges are checked against the flood discharges. The first tier reduces navigation target flows to those consistent with full-service level of 35.0 kcfs when one or more of the forecasted downstream flows exceed the values in Table 2-25 (Table VII-7 in the Master Manual (USACE 2006a)). The second tier reduces navigation target flows to those consistent with minimum-service level of 29.0 kcfs when one or more of the forecasted downstream flows exceed the values in Table 2-26 (Table VII-8 in the Master Manual (USACE 2006a)).

Table 2-25. Full-Service Flood Target Flows

Flood Target Location	Flood Target Flow
Omaha	(navigation target flow + 10.0 kcfs)
Nebraska City	(navigation target flow + 10.0 kcfs)
Kansas City	(navigation target flow + 30.0 kcfs)

Source: Master Manual, Table VII-7 (USACE 2006a)

kcfs = 1000 cubic feet per second

Table 2-26. Minimum-Service Flood Target Flows

Flood Target Location	Flood Target Flow
Omaha	(navigation target flow + 15.0 kcfs)
Nebraska City	(navigation target flow + 20.0 kcfs)
Kansas City	(navigation target flow + 60.0 kcfs)

Source: Master Manual, Table VII-8 (USACE 2006a)

kcfs = 1000 cubic feet per second

Using Table 2-25 for a 40.0 kcfs service level, full-service flood target discharges at Omaha, Nebraska City, and Kansas City are 46.0 cfs ($36.0 + 10.0$); 52.0 kcfs ($42.0 + 10.0$); and 76.0 kcfs ($46.0 + 30.0$), respectively. If discharges at Omaha, Nebraska City, or Kansas City are forecasted to exceed their full-service flood targets, Gavins Point releases are then decreased until the full-service flood targets of 46.0 kcfs, 52.0 kcfs, and 76.0 kcfs are no longer forecasted to be exceeded while still maintaining at least full-service discharges at each of the target locations.

Using Table 2-26 for a 40.0 kcfs service level, minimum-service flood target discharges at Omaha, Nebraska City, and Kansas City are 51.0 kcfs ($36.0 + 15.0$); 62.0 kcfs ($42.0 + 20.0$); and 106.0 kcfs ($46.0 + 60.0$), respectively. If discharges at Omaha, Nebraska City, or Kansas

Cities are forecasted to exceed their minimum-service flood targets, Gavins Point releases are then decreased until the minimum-service flood targets of 51.0 kcfs, 62.0 kcfs, and 106.0 kcfs are no longer forecasted to be exceeded while still maintaining at least minimum-service discharges at each of the target locations. These calculations are summarized in Table 2-27.

The habitat-creating flow release of 60 kcfs from Gavins Point could not occur under current operations because of how the flood target criteria are operationally applied. If 60.0 kcfs were released from Gavins Point and it was assumed that all tributaries between Gavins Point and Omaha were dry, there would still be 60.0 kcfs at Omaha due to releases from Gavins Point. A 60.0 kcfs discharge at Omaha exceeds both the full-service flood target of 46.0 kcfs and the minimum-service flood target of 51.0 kcfs for a 40.0 service level. If the current flood target operations were used, the habitat-creating flow release would never have a chance to occur until the service level exceeded 49.0 kcfs; therefore, in order to allow this high release from Gavins Point, it was necessary to modify how the flood target criteria is applied during times when a habitat-creating flow release is attempted. This revision results in the downstream flow limits presented in Table 2-22.

Table 2-27. Example Navigation and Flood Target Discharges for a 40.0 kcfs Service Level Under Current Operations

Location	Navigation Discharge for 35.0 Service Level (Full-Service) (kcfs)	Navigation Discharge for 29.0 Service Level (Minimum-service) (kcfs)	Navigation Discharge for Example 40.0 Service Level (kcfs)	Full-Service Flood Target (kcfs)	Minimum-Service Flood Target (kcfs)
Sioux City	31.0	25.0	36.0	—	—
Omaha	31.0	25.0	36.0	46.0	51.0
Nebraska City	37.0	31.0	42.0	52.0	62.0
Kansas City	41.0	35.0	46.0	76.0	106.0

kcfs = 1000 cubic feet per second

2.8.6 Alternative 5 – Fall ESH Creating Release

Alternative 5 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-12. Alternative 5 also includes adaptive management, Level 1 and 2 studies, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. The rest of this section describes the management action that is unique to Alternative 5, a fall habitat-creating flow release.

Alternative 5 reservoir operations would include a high fall release designed to create ESH for the least tern and piping plover. The spring plenary pulse and reservoir unbalancing including in the Master Manual would not be implemented. The following description of the fall-habitat creating flow release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time. In any year, the implementation of this habitat-creating flow release would occur if System storage is 54.5 MAF or greater, natural flows creating 250 acres of ESH have not occurred in the previous four years, and downstream flow limits are not exceeded. Downstream flow limits for Alternative 5 would be the same as that for Alternative 4 (Table 2-22). If those conditions are met, the habitat-creating

flow release would be implemented on October 17 with a release of up to 60 kcfs out of Gavins Point Dam, and as often as every four years. To achieve the Gavins Point Dam release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release. As with Alternative 4, the duration of the release would increase as release magnitude is decreased (Table 2-23).

If downstream flow limits are exceeded, the Gavins Point release would be reduced by 5 kcfs until flood targets are no longer exceeded. In instances where the Gavins Point release falls below 45 kcfs, the release would be terminated. Modeling indicates that over the 82-year POR, the fall habitat-creating flow release as defined here would have been implemented 7 times and would have been partially implemented 2 times.

2.8.7 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes those common actions identified in Section 2.8.1 including mechanical ESH construction at anticipated levels shown in Table 2-12. The spring plenary pulse and reservoir unbalancing including in the Master Manual would not be implemented. Alternative 6 also includes adaptive management, spawning habitat construction, and early life stage pallid sturgeon habitat construction as specified under Alternative 3. Alternative 6 includes Level 1 and 2 studies as described under Alternative 3, except for the one-time spawning cue release. This test release is not applicable to Alternative 6, because the management action unique to Alternative 6 is a recurring pallid sturgeon spawning cue release. The rest of this section describes that spawning cue release. The following description of the spawning cue release indicates how this action was modeled; however, actual implementation would be adjusted to respond to hydrologic conditions at the time.

Under Alternative 6, USACE would attempt a spawning cue release every 3 years consisting of a bimodal pulse in March and May. These spawning cue releases would not be started or would be terminated whenever downstream flow limits are exceeded. HEC-ResSim modeling indicates that over the 82-year POR, the spawning cue release as defined here would have been implemented 11 times and would have been partially implemented 33 times.

March Pulse: USACE would initiate a March pulse once navigation releases were met at downstream target locations. The peak Gavins Point release would be two times the navigation release on the pulse initiation day. Flows would increase 2,200 cfs per day until the pulse peak is achieved, held for two days, and then reduced daily by 1,700 cfs per day until flow-to-target navigation releases are reached. Table 2-28 provides downstream flow limits associated with a March pulse. After the first occurrence of a March pulse, the prelude for System storage would change to 40.0 MAF. Based on HEC-ResSim POR simulations, Gavins Point releases during the March spawning cue would be 39–61 kcfs.

Table 2-28. Alternative 6 March Pulse Downstream Flow Limits

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	41 + Pulse Magnitude
Nebraska City	47 + Pulse Magnitude
Kansas City	71 + Pulse Magnitude

May Pulse: USACE would initiate a second pulse annually during May when water temperatures reach 16–18 °C (for modeling purposes, May 18 was the target date). The peak Gavins Point release would be two times the base release on the pulse initiation day. Flows would increase 2,200 cfs per day until the pulse peak is achieved, held for two days, and then reduced daily by 1,900 cfs per day until base flow is reached. Table 2-29 provides downstream flow limits associated with a May pulse. Based on HEC-ResSim POR simulations, Gavins Point releases during the May spawning cue would range from 50–67 kcfs.

Table 2-29. Alternative 6 May Pulse Downstream Flow Limits

Location	Thousand Cubic Feet Per Second (kcfs)
Omaha	41 + Pulse Magnitude
Nebraska City	47 + Pulse Magnitude
Kansas City	71 + Pulse Magnitude

2.9 Comparison of Alternatives

The potential impacts associated with each of the alternatives have been assessed and the findings are discussed in detail in Chapter 3.0 and further described in a series of technical reports available at www.moriverrecovery.org.

This section provides an overview of the analysis. Table 2-29 and Table 2-30 present the consequences of the alternatives on objectives and performance measures. This section then summarizes the differences between alternatives; discusses how the alternatives are different hydrologically; discusses some of the implications of these differences for endangered species and HC in terms of relative benefits and adverse impacts compared with Alternative 1; and provides a brief summary of the USACE evaluation using the four criteria specified in the Principles and Guidelines (Acceptability, Completeness, Effectiveness, Efficiency). Collectively, these evaluations provide the rationale for the identification of a preferred alternative for the MRRP, which is further described in Section 2.10.

2.9.1 Average Annual Consequence Tables

Table 2-30 and Table 2-31 summarize the average annual consequences of implementing each of the alternatives. Table 2-30 shows consequences in absolute values where quantitative estimates exist. All National Economic Development (NED) and most Regional Economic Development (RED) impacts were estimated using methods that could be applied to Alternative 1 as well as to the other alternatives. Not all items in Table 2-30 were estimated in absolute terms; however, any row with no entry for Alternative 1 was estimated only as a relative change compared to Alternative 1.

In each table, the “Dir” column clarifies the directionality of the numbers for each performance measure. “H” indicates that the higher the numerical value, the better for that interest; “L” indicates the lower the value, the better.

For example, some NED values (hydropower, recreation, irrigation, and navigation) are quantified in terms of benefits that the river provides. In these cases, the higher the number, the better. Other NED values (flood risk management, thermal power, water supply, and program

implementation costs) are calculated in terms of costs from a hypothetical condition where no costs are incurred to that resource. For these interests, the lower the number, the better.

Although absolute values provide important context, it is more relevant to decision-makers to consider the estimated differences between each of the action alternatives and Alternative 1. Table 2-31 shows the differences in the performance of Alternatives 2 to 6 in relation to Alternative 1. To make reading the table easier, a color-coding scheme has been introduced.

- Differences that are improvements from Alternative 1 are shaded **green**. The deeper the green, the higher the benefit of the alternative over Alternative 1 *relative to the other five alternatives in the same row (resource/use) only*.
- Differences that are adverse impacts relative to Alternative 1 are shaded **red**. The deeper the red, the higher the adverse impact for the alternative over Alternative 1 *relative to the other five alternatives in the same row (resource/use) only*.
- No differences are indicated by white cells.

Average annual average numbers provide an important but incomplete perspective on the impacts of the alternatives. In some cases they can give a misleading impression of the relative impacts. For example, for any given resource area, 20 individual years may have a small negative impact, and 1 year may have a very large positive impact relative to Alternative 1. In an average annual calculation, this might amount to crediting an alternative with a positive impact, which may be misleading. For this reason, it is important to understand the year-by-year impacts each alternative, and these are discussed in detail in Chapter 3.0 and further described in a series of technical reports available at www.moriverrecovery.org. In this summary discussion, only the most sensitive of cases of this effect are noted.

Various resource areas that were analyzed are not represented in these tables, usually because there was no meaningful difference in impacts to that resource area across the alternatives. See Chapter 3.0 for a full analysis of the resources evaluated in this MRRMP-EIS.

Table 2-30. Absolute Values of the Alternatives

			Dir	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
SPECIES OBJECTIVES				NO	YES	YES	YES	YES	YES
SPP OBJ	Pallid Sturgeon	Addresses Critical EA Pallid Hypotheses		NO	EXCEEDS	MEETS	MEETS	MEETS	MEETS
SPP OBJ	Piping Plover and Least Tern	Expected to Meet Revised Bird Targets		NO					
IMPACTS									
<u>Resources where NED is evaluated in terms of benefits</u>									
NED	Hydropower	Ave \$ 000 NED / yr	H	\$ 525,707	\$ 520,281	\$ 525,451	\$ 521,663	\$ 523,923	\$ 523,615
NED	Recreation	Ave \$ 000 NED / yr	H	\$ 38,271	\$ 38,434	\$ 38,294	\$ 37,864	\$ 38,243	\$ 38,006
NED	Irrigation	Ave \$ 000 NED / yr	H	\$ 5,921	\$ 5,785	\$ 5,946	\$ 5,711	\$ 5,917	\$ 5,786
NED	Navigation	Ave \$ 000 NED / yr	H	\$ 715	\$ 687	\$ 718	\$ 670	\$ 709	\$ 674
NED	Wastewater	-2 to +2 rating	H	REF. COND.	-1	0	0	0	0
<u>Resources where NED is evaluated in terms of damages / costs</u>									
NED	Flood Risk Management	Ave \$ 000 NED / yr	L	\$ 60,958	\$ 60,267	\$ 60,475	\$ 61,922	\$ 60,671	\$ 61,463
NED	Thermal Power	Ave \$ 000 NED / yr	L	\$ 52,933	\$ 81,096	\$ 51,566	\$ 53,355	\$ 51,870	\$ 51,631
NED	Water Supply	Ave \$ 000 NED / yr	L	\$ 376	\$ 381	\$ 372	\$ 389	\$ 375	\$ 384
NED	Program Expenditures	Ave \$ 000 NED / yr	L	\$ 73,825	\$ 337,525	\$ 69,207	\$ 60,408	\$ 64,260	\$ 65,342
NED	SUM Ave \$ 000 NED / yr		H						
RED	Flood Risk Management	Regional Employment (Ave)	H	-140	-138	-139	-140	-140	-140
RED	Irrigation	Regional Employment (Ave)	H	343	342	344	341	343	342
RED	Navigation	Regional Employment (Ave)	H	284	277	285	280	285	281
RED	Recreation	Regional Employment (Ave)	H	1,235	1,221	1,236	1,214	1,232	1,220
RED	Land Use and Ownership	Regional Employment (At End of Impl'n (15 years))	H	-26	-160	-8	-8	-8	-8
RED	Program Expenditures	Regional Employment Ave	H	1,278	5,307	1,149	1,023	1,078	1,094
RED	Flood Risk Management	Ave \$ 000 RED / yr Income	H	\$ -6,795	\$ -6,731	\$ -6,788	\$ -6,814	\$ -6,822	\$ -6,853
RED	Irrigation	Ave \$ 000 RED / yr Income	H	\$ 10,489	\$ 10,265	\$ 10,339	\$ 10,245	\$ 10,324	\$ 10,265
RED	Navigation	Ave \$ 000 RED / yr Income	H	\$ 19,254	\$ 18,719	\$ 19,287	\$ 18,928	\$ 19,287	\$ 19,035
RED	Recreation	Ave \$ 000 RED / yr Income	H	\$ 29,184	\$ 28,850	\$ 29,201	\$ 28,670	\$ 29,116	\$ 28,830
RED	Land Use and Ownership	Regional Income (\$000, At End of Impl'n (15 years))	H	\$ -1,153	\$ -7,397	\$ -301	\$ -301	\$ -301	\$ -301
RED	Program Expenditures	Ave \$ 000 RED / yr Income	H	\$ 66,552	\$ 264,054	\$ 59,265	\$ 53,295	\$ 55,908	\$ 56,642
RED	Land Use and Ownership	Tax Revenues (\$000, At End of Impl'n (15 years))	H	\$ -75	\$ -555	\$ -10	\$ -10	\$ -10	\$ -10
RED	Hydropower	Benefits to WAPA (Typ gen yr \$ 000 / yr)	H	\$ 27,832	\$ 24,049	\$ 27,142	\$ 26,995	\$ 24,478	\$ 33,293
RED	Thermal Power	-2 to +2 rating	H	REF. COND.	-2	0	0	0	0
EQ	Cultural Resources	Site-days at Risk	L	65,464	66,628	65,382	67,281	65,748	67,095
EQ	Fish and Wildlife	-2 to +2 rating	H	REF. COND.	2	1	1	1	1
EQ	Other Special Status Species	-2 to +2 rating	H	REF. COND.	2	1	1	1	0
EQ	Water Quality	-2 to +2 rating	H	REF. COND.	-2	0	-1	-1	-1
EQ	Air Quality	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
EQ	Ecosystem services	-2 to +2 rating	H	REF. COND.	+1	+1	+1	+1	+1
OSE	Tribal Interests (Other)	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
OSE	Flood Risk Management	Population at Risk	L	709	703	700	734	701	709
OSE	FRM - Channel Exceedances	Sum of Ft Randall and Garr Exceeds in POR	L	5,402	6,109	5,421	6,007	5,824	5,622
OSE	Hydropower	Ave Change in CO2 (kg/yr)	L	REF. COND.	55,292	-3,656	52,186	17,693	20,473
OSE	Irrigation	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
OSE	Navigation	Particulates (1000 g / mile)	L	.5	1.0	.4	.9	.4	.8
OSE	Recreation	-2 to +2 rating	H	REF. COND.	-1	0	-1	0	-1
OSE	Thermal Power	-2 to +2 rating	H	REF. COND.	-2	0	0	0	0
OSE	Water Supply	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
OSE	Health & Safety	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
OSE	Environmental Justice	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
Missipp R	Biological Resources	-2 to +2 rating	H	REF. COND.	0	0	0	0	0
Missipp R	Flood Risk Management	-2 to +2 rating	H	REF. COND.	+1	+1	-1	+1	+1
Missipp R	Navigation	-2 to +2 rating	H	REF. COND.	-1	+1	-1	+1	-1
Missipp R	Water Intakes	-2 to +2 rating	H	REF. COND.	0	+1	-1	+1	-1

Note: Commercial sand dredging, wastewater discharges and interior drainage are treated differently for NED/RED. See Chapter 3.

Note: All NED impacts were calculated at FY2016 price levels.

Note: MRRP Expenditures were calculated using a 50-year period of analysis and the FY2016 federal discount rate of 3.125%.

Note: For -2 to +2 scales, relative to No Action (Alt 1): -2 = "Large adverse change", -1 = "Small adverse change"

0 = "No or negligible change", +1 = "Small beneficial change", +2 = "Large beneficial change"

Dir = Numerical direction of preferred difference: H = Higher is Better, L = Lower is Better

Tribal Interests are addressed within multiple resource areas; 'Tribal Interests (Other)' reflects additional connections to the Missouri River that are unique to Tribal members.

**Table 2-31. Summary of the Alternatives Impacts
(Alternative Absolute Value Minus Alternative 1 Absolute Value)**

SPECIES OBJECTIVES				Dir	Alt 1	Difference from Alt 1				
						Alt 2		Alt 3		Alt 4
						YES	YES	YES	YES	YES
SPP OBJ	Pallid Sturgeon	Addresses Critical EA Pallid Hypotheses		NO	NO	EXCEEDS	MEETS	MEETS	MEETS	MEETS
SPP OBJ	Piping Plover and Least Tern	Expected to Meet Revised Bird Targets								
IMPACTS										
<i>Resources where NED is evaluated in terms of benefits</i>										
NED	Hydropower	Ave \$ 000 NED / yr	H	\$ 525,707	\$ -5,426	\$ -256	\$ -4,044	\$ -1,784	\$ -2,092	
NED	Recreation	Ave \$ 000 NED / yr	H	\$ 38,271	\$ 163	\$ 23	\$ -407	\$ -28	\$ -265	
NED	Irrigation	Ave \$ 000 NED / yr	H	\$ 5,921	\$ -136	\$ 25	\$ -210	\$ -4	\$ -135	
NED	Navigation	Ave \$ 000 NED / yr	H	\$ 715	\$ -28	\$ 3	\$ -45	\$ -6	\$ -41	
NED	Wastewater	-2 to +2 rating	H	REF. COND.	-1	0	0	0	0	0
<i>Resources where NED is evaluated in terms of damages / costs</i>										
NED	Flood Risk Management	Ave \$ 000 NED / yr	L	\$ 60,958	\$ -691	\$ -483	\$ 964	\$ -287	\$ 505	
NED	Thermal Power	Ave \$ 000 NED / yr	L	\$ 52,933	\$ 28,163	\$ -1,367	\$ 422	\$ -1,063	\$ -1,301	
NED	Water Supply	Ave \$ 000 NED / yr	L	\$ 376	\$ 5	\$ -4	\$ 13	\$ -1	\$ 8	
NED	Program Expenditures	Ave \$ 000 NED / yr	L	\$ 73,825	\$ 263,700	\$ -4,618	\$ -13,417	\$ -9,565	\$ -8,483	
NED	SUM Ave \$ 000 NED / yr		H		\$ -296,604	\$ 6,267	\$ 7,313	\$ 9,095	\$ 6,738	
RED	Flood Risk Management	Regional Employment (Ave)	H	-140	2	1	0	0	0	0
RED	Irrigation	Regional Employment (Ave)	H	343	-1	1	-2	0	0	-1
RED	Navigation	Regional Employment (Ave)	H	284	-7	1	-4	1	0	-3
RED	Recreation	Regional Employment (Ave)	H	1,235	-14	1	-21	-3	-3	-15
RED	Land Use and Ownership	Regional Employment (At End of Impl'n (15 years))	H	-26	-134	18	18	18	18	
RED	Program Expenditures	Regional Employment Ave	H	1,278	4,029	-129	-255	-200	-184	
RED	Flood Risk Management	Ave \$ 000 RED / yr Income	H	\$ -6,795	\$ 64	\$ 7	\$ -19	\$ -27	\$ -58	
RED	Irrigation	Ave \$ 000 RED / yr Income	H	\$ 10,489	\$ -224	\$ -150	\$ -244	\$ -165	\$ -224	
RED	Navigation	Ave \$ 000 RED / yr Income	H	\$ 19,254	\$ -535	\$ 33	\$ -326	\$ 33	\$ -219	
RED	Recreation	Ave \$ 000 RED / yr Income	H	\$ 29,184	\$ -334	\$ 17	\$ -514	\$ -68	\$ -354	
RED	Land Use and Ownership	Regional Income (\$000, At End of Impl'n (15 years))	H	\$ -1,153	\$ -6,243	\$ 852	\$ 852	\$ 852	\$ 852	
RED	Program Expenditures	Ave \$ 000 RED / yr Income	H	\$ 66,552	\$ 197,502	\$ -7,287	\$ -13,258	\$ -10,644	\$ -9,910	
RED	Land Use and Ownership	Tax Revenues (\$000, At End of Impl'n (15 years))	H	\$ -75	\$ -480	\$ 65	\$ 65	\$ 65	\$ 65	
RED	Hydropower	Benefits to WAPA (Typ gen yr \$ 000 / yr)	H	\$ 27,832	\$ -3,784	\$ 691	\$ -837	\$ -3,354	\$ 5,461	
RED	Thermal Power	-2 to +2 rating	H	REF. COND.	-2	0	0	0	0	0
EQ	Cultural Resources	Site-days at Risk	L	65,464	1,164	-82	1,817	284	1,631	
EQ	Fish and Wildlife	-2 to +2 rating	H	REF. COND.	+2	+1	+1	+1	+1	
EQ	Other Special Status Species	-2 to +2 rating	H	REF. COND.	+2	+1	+1	+1	0	
EQ	Water Quality	-2 to +2 rating	H	REF. COND.	-2	0	-1	-1	-1	
EQ	Air Quality	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
EQ	Ecosystem services	-2 to +2 rating	H	REF. COND.	+1	+1	+1	+1	+1	
OSE	Tribal Interests (Other)	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
OSE	Flood Risk Management	Population at Risk	L	709	-6	-9	25	-8	0	
OSE	FRM - Channel Exceedances	Sum of Ft Randall and Garr Exceeds in POR	L	5,402	708	19	605	422	221	
OSE	Hydropower	Ave Change in CO2 (kg/yr)	L	REF. COND.	55,292	-3,656	52,186	17,693	20,473	
OSE	Irrigation	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
OSE	Navigation	Particulates (1000 g / mile)	L	.5	.5	-.1	.4	-.1	.3	
OSE	Recreation	-2 to +2 rating	H	REF. COND.	-1	0	-1	0	-1	
OSE	Thermal Power	-2 to +2 rating	H	REF. COND.	-2	0	0	0	0	
OSE	Water Supply	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
OSE	Health & Safety	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
OSE	Environmental Justice	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
Missipp R	Biological Resources	-2 to +2 rating	H	REF. COND.	0	0	0	0	0	
Missipp R	Flood Risk Management	-2 to +2 rating	H	REF. COND.	+1	+1	-1	+1	+1	
Missipp R	Navigation	-2 to +2 rating	H	REF. COND.	-1	+1	-1	+1	-1	
Missipp R	Water Intakes	-2 to +2 rating	H	REF. COND.	0	+1	-1	+1	-1	

Note: Commercial sand dredging, wastewater discharges and interior drainage are treated differently for NED/RED. See Chapter 3.

Note: All NED impacts were calculated at FY2016 price levels.

Note: MRRP Expenditures were calculated using a 50-year period of analysis and the FY2016 federal discount rate of 3.125%.

Note: For -2 to +2 scales, relative to No Action (Alt 1): -2 = "Large adverse change", -1 = "Small adverse change"

0 = "No or negligible change", +1 = "Small beneficial change", +2 = "Large beneficial change")

Dir = Numerical direction of preferred difference: H = Higher is Better, L = Lower is Better

Tribal Interests are addressed within multiple resource areas; 'Tribal Interests (Other)' reflects additional connections to the Missouri River that are unique to Tribal members.

2.9.2 Discussion of Consequences

2.9.2.1 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Summary of Characteristics and Features

Alternative 1 is a continuation of the current operation of the System and management actions currently being used to comply with the BiOp (USFWS 2003). Although referred to as “No Action” because it is the default reference case under NEPA, the No Action alternative could be referred to as no change from existing operation and implementation of the MRRP. For pallid sturgeon, the range of actions includes a propagation program, shallow water habitat (SWH) construction and the spawning cue flow release included in the current Master Manual. For endangered birds, the range of actions includes the mechanical construction of approximately 107 acres per year of emergent sandbar habitat (ESH) and the use of other management actions to increase survival.

Alternative 1 does not meet the species objective of providing a 95 percent chance of persistence for piping plover over the 50-year modeled period. For pallid sturgeon, although there are potentially long-term benefits from SWH construction, it is uncertain how SWH addresses hypotheses developed through the effects analysis. No beneficial impacts to the pallid sturgeon are thought to be attributable to the spawning cue release as defined by the technical criteria in the Master Manual and described under Alternative 1. AM associated with Alternative 1 would be largely passive and is not designed to systematically improve learning.

Evaluation Discussion

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. It appears that Alternative 1 is insufficient in meeting the piping plover population persistence targets and therefore is not a complete plan and would not be effective in meeting all the species objectives. In addition, other alternatives are less costly than Alternative 1. The primary purpose of this alternative is to serve as a reference case to compare the relative benefits and adverse impacts of the other alternatives in order to identify a preferred alternative to avoid a finding of jeopardy to the species.

2.9.2.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Summary of Characteristics and Features

Alternative 2 represents the USFWS interpretation of the management actions that could ultimately be implemented as part of the 2003 BiOp RPA. Alternative 2 includes expected actions that USFWS anticipates would ultimately be implemented through AM and as impediments to implementation were removed.

The main features of this alternative for endangered birds are an ESH mechanical construction rate of 3,545 acres per year and lowered nesting season (otherwise referred to as low summer) flows. For pallid sturgeon, Alternative 2 calls for the continuation of the propagation and augmentation program; the construction of up 30 acres of SWH per river mile between Ponca, Nebraska and the mouth; an annual spring pallid sturgeon flow release comprising two pulses, one each in March and May, when these are possible within certain System condition

constraints; and the achievement of 77,000 acres of connected floodplain (i.e., periodically inundated land) with a long-term expected frequency of one year in five.

Over the POR, the main hydrological differences of Alternative 2 relative to Alternative 1 include

- Higher flows in approximately 65 percent of years during March and/or May as the spring pallid sturgeon flow releases are attempted (System conditions preclude noticeable higher flows in the remaining years);
- Lower summer flows in approximately 12 percent of years (the nesting flow operation is only invoked on the fully successful implementation of both pulses of the spring pallid sturgeon flow release); and
- Lower winter flows (from the second week in December to mid-March) in approximately 50 percent of years).

Balance of Beneficial and Adverse Effects

The net benefits of Alternative 2 compared to Alternative 1 mainly relate to listed species, improvements in net overall flood risk management performance, and regional income and job creation provided by program expenditures associated with habitat construction.

There would be possible beneficial impacts to pallid sturgeon from the spring pallid sturgeon flow release and low summer flow operations, but evidence is lacking to confirm or quantify the level of benefit. Over the long term, it is uncertain how beneficial SWH would be to age-0 pallid sturgeon but parameters defining SWH are not as well linked to specific pallid hypotheses resulting from the effects analysis as the IRC parameters. There may be benefits from floodplain connectivity. Limited beneficial impacts from passive AM should be anticipated. For piping plover and least tern, modeling indicates that updated population persistence targets would be exceeded under Alternative 2.

Alternative 2 would have net benefits to flood risk management on an average basis, reducing flood risk management impacts by \$691,000 per year. In 60 percent of years in the POR, there would be a net improvement in flood risk management outcomes relative to Alternative 1, including some large improvements in the lower river in the high flood risk years of 1993 and 2011. Modeled discharges from Gavins Point were identical for Alternatives 1 and 2 in 1993 and 2011; however, channel changes associated with early life stage pallid habitat construction under Alternative 2 reduce the stage associated with these high flows by a number of inches. Flood risk modeling indicates this would avoid substantial flood damage (approximately 8 percent reduction in damages relative to Alternative 1 using 1993 flow data and 5 percent reduction in damages using 2011 data). The net flood benefits in these years would extend into the Mississippi River. However, in 40 percent of years in the POR, Alternative 2 would have large, negative impact years relative to Alternative 1 associated with full and partial spring pallid sturgeon flow releases which increase the risk of flooding and is considered significant.

Alternative 2 would have regional benefits that follow from program expenditures associated with habitat construction. Relative to Alternative 1, Alternative 2 would support an annual average of 4,029 additional jobs in the first 15 years of the project, and would result in \$198 million in additional regional labor income annually during the project. Alternative 2 would result in an overall increase in recreation value due to habitat construction in the lower river but a decrease in recreation in the reservoirs due to, on average, lower summer reservoir levels. Alternative 2 may result in small but unquantified benefits to ecosystem services.

The net adverse effects of Alternative 2 relative to Alternative 1 concern a broad range of human considerations (HC), including program costs, species impacts during construction, cultural resources, thermal power, navigation, hydropower, recreation, irrigation, and land use and ownership.

Alternative 2 modeling sometimes indicates some net improvements in some resources in one geographical region of the river that would be offset by negative impacts in another (and therefore are not discernible in the tables above). For example, the Alternative 2 would result in some net annual benefits for thermal power in the upper river; however, there would be negative impacts below Gavins Point.

Alternative 2 would require an approximate 300 percent increase in federal funding for program expenditures (from a base of \$74 million per year to \$338 million per year), driven primarily by increased ESH construction and land acquisition requirements under this alternative. This is considered a significant increase in MRRP implementation costs. Alternative 2 would result in an increase in total cultural site days at risk in the reservoirs as compared to Alternative 1, and riverine reaches would have an increase in severity of impacts. Therefore, Alternative 2 has the potential to significantly impact cultural resources located within the System.

Modeling suggests that average annual costs under Alternative 2 for thermal power could be \$28 million which includes net benefits to thermal power in the upper river. In years with a low summer flow event, costs could rise up to \$80 million, although substantial capacity costs would be incurred every year by the industry. These impacts are considered significant. Substantial uncertainty is associated with this estimate for thermal power; however, these estimates come from industry input as well as economic and regulatory sources.

The average annual value of net hydropower generation would decline by \$5.4 million per year (a 1 percent *reduction*) however large declines (up to \$38 M) would occur in some years. This is considered a significant impact due to the potential large adverse impacts on NED and RED within specific years and the large increase in OSE impacts associated with increased emission of carbon dioxide, methane, and nitrous oxide from replacement thermal power sources.

Reservoir recreation losses (resulting mainly from lower reservoir levels during the summer in some periods following the spawning cue release) almost balance out lower river gains from an NED perspective, but annual average reductions in regional labor income in the reservoirs would be approximately \$334,000 relative to Alternative 1. On average, the irrigation sector would lose \$136,000 per year from a national economic perspective and \$224,000 per year in labor income regionally. Although negative navigation impacts from a national economic level are estimated to be small, regionally they could amount to \$535,000 per year on average relative to Alternative 1 in the Missouri River, and further negative impacts could be experienced by the navigation sector on the Mississippi River.

Land use and ownership may result in a decline in regional labor income of \$6.2 million at the end of the implementation period (15 years) as land would be acquired for endangered species and not available for crop production. This could additionally reduce local government tax revenues by \$480,000 at the end of the implementation period along the river from Sioux City to the mouth.

Relative to Alternative 1, the lowered winter flows of Alternative 2 would sometimes negatively impact water supply intakes, although the economic implications of this from the perspective of the MRRP are considered to be low (past and future river bed changes due to aggradation and

degradation are thought to be dominant factors driving cost impacts to water supply). There could be substantial negative water quality impacts associated primarily with large-scale habitat construction.

Evaluation Discussion

Alternative 2 was designed to address listed species concerns and, while not necessarily completely aligned with the latest scientific priorities (it was designed more than 15 years ago and before the large-scale effects analysis was undertaken for this plan), it is sufficiently effective for endangered species to be a viable alternative in the MRRMP.

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. The high level of mechanical ESH construction in the Garrison reach would be a concern to Tribes due to potential impacts to cultural resources. In addition, releases exceeding channel capacity in the Garrison and Fort Randall reaches are of particular concern due to impacts to adjacent property. As modeled over the POR, Alternative 2 could cause an approximated increase of 708 additional days of channel capacity exceedances in the Garrison and Fort Randall reaches relative to Alternative 1. Alternative 2 would result in significant adverse impacts to flood risk management, cultural resources, thermal power, and hydropower.

Although Alternative 2 would appear to meet the species objectives, there is much uncertainty surrounding the benefits of the management actions included in this alternative. Without a systematic scientific AM program to learn which management actions might be effective and why, it would be an inefficient use of public resources and could actually impede learning and progress toward meeting the species objectives. In addition, Alternative 2 would be the most expensive alternative and is estimated to cost approximately 3 times the cost of Alternative 1. This would not be an efficient use of resources even if it was effective in meeting the species objectives.

Therefore, Alternative 2 was not identified as the preferred alternative in this MRRMP-EIS.

2.9.2.3 Alternative 3 – Mechanical Construction Only

Summary of Characteristics and Features

In addition to the actions common to Alternatives 3–6 (including active AM; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs), under Alternative 3, USACE would create ESH through mechanical means at an average rate of 391 acres per year in the Garrison, Fort Randall, and Gavins Point river reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. Alternative 3 would also include the provision for a one-time spawning cue test release from Gavins Point if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important.

Hydrologically, the effects of this alternative would be very close to those for Alternative 1 but without the specification for spawning cue releases in March and May. Hydrological differences would be reduced flows relative to Alternative 1 in approximately 30 to 50 percent of years in late March and late April/early May, and corresponding increased flows relative to Alternative 1 during one or two weeks in October or November. The differences in magnitude of these flows

would be small compared to those associated with the other alternatives. Alternative 3 would have less channel reconfiguration for pallid sturgeon early life stage habitat relative to Alternative 1, and this would have implications on flow routing and assumed stage-discharge relationships at certain locations.

Balance of Beneficial and Adverse Effects

Alternative 3 has a wide range of benefits relative to Alternative 1, including certain benefits to endangered species, reduced program expenditures, and increased performance for most HCs.

Modeling indicates that updated piping plover and least tern population persistence targets would be met under Alternative 3 and there would be significant beneficial impacts to these species. Negligible adverse impacts from ESH and IRC construction activities are expected for pallid sturgeon. There could be long-term beneficial impacts from the creation of spawning sites and from IRC development although there is still much uncertainty regarding what is limiting pallid recruitment. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework.

The reduction in the scale of early life stage pallid habitat construction relative to Alternative 1 would help reduce overall program expenditures by \$5 million per year on average. In common with Alternatives 3, 5, and 6, Alternative 4 has a smaller scale of early life stage pallid habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in \$852,000 more in labor income and \$65,000 more in local tax revenue to local governments at the end of the implementation period.

The lack of a pallid spawning cue release in Alternative 3 relative to Alternative 1 would result in benefits to a range of HCs. Comparatively small average annual net increases relative to Alternative 1 may be expected for recreation (reservoir and river), irrigation, navigation, thermal power, flood risk management, water supply, and most of these have national, regional, and other social beneficial effects. A small increase in ecological services, fish and wildlife, and other special-status species and a small decrease in cultural resource site days at risk is indicated but these impacts are not considered significant.

Unquantified small benefits to the Mississippi River could be expected for flood risk management, navigation, and water intake-related sectors.

The main adverse effects of Alternative 3 are related to a reduction in more than 129 habitat construction related jobs (which would result in a relative reduction in regional income of \$7.3 million per year for this item). There would be comparatively small negative net impacts for hydropower and irrigation.

Evaluation Discussion

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. Alternative 3 would have beneficial impacts to most resources compared to Alternative 1. Some of the Tribes have expressed that the level of mechanical ESH construction in the Garrison reach is not acceptable and extensive coordination on site-specific construction activities to avoid sensitive areas in this reach would be an essential component of this alternative. As modeled over the POR, Alternative 3 would cause the least increase in channel capacity exceedances in the Garrison and Fort Randall reaches relative to Alternative 1

(an increase of only 19 additional days over the POR). Alternative 3 is not expected to result in any significant adverse impacts.

Alternative 3 is a complete plan in that it meets the USFWS probability of persistence targets for piping plover and least terns. Alternative 3 would continue ongoing pallid propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid (in common with Alternatives 4, 5, and 6).

Although Alternative 3 would not be the most efficient alternative from an overall NED standpoint, its lack of adverse NED impacts compared to Alternative 1 is a good balance between overall efficiency and level of impacts to NED resources. Although there are uncertainties associated with its effectiveness in meeting the species objectives (in common with Alternative 4, 5, and 6), Alternative 3 clearly demonstrates it would be the least impactive means of potentially meeting species objectives across the full range of interests.

Therefore, Alternative 3 has been identified as the **preferred alternative** in this MRRMP-EIS.

2.9.2.4 Alternative 4 – Spring ESH Creating Release

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6 (including active AM; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs), under Alternative 4, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 240 acres per year in the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a spring ESH-creating reservoir release. Alternative 4 would also include the provision for a one-time spawning cue test release from Gavins Point if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important.

Alternative 4 reservoir operations would be similar to Alternative 1 with the addition of the spring ESH-creating release. In any year, the implementation of this release would occur if System storage is at 42 MAF or greater on April 1, natural flows creating 250 acres of ESH have not occurred in the previous four years, and downstream flow is below downstream flow limits specific to this alternative. If those conditions are met, the release would be implemented on April 1 with a release of up to 60 kcfs out of Gavins Point, and as often as every four years. To achieve the Gavins Point release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5 kcfs less than the Gavins Point release. The duration of the release could vary, but there would typically be 40 days when releases from Gavins Point are 60 kcfs.

Over the POR, modeling shows that a full release occurs in 10 out of 82 years, with a partial (i.e., attempted but abandoned) release every 5 years. After the higher release period is completed, the upper three reservoirs have less water than they otherwise would have, and they must recover. During this phase, releases are lower than they otherwise would have been, allowing more water to accumulate in the reservoirs. This refill period can last from a few

months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

The net benefits of Alternative 4 relative to Alternative 1 are limited to the listed species, regional land use and ownership, and reduced program expenditures from a national perspective. Modeling indicates that updated piping plover and least tern population persistence targets would be met under this alternative and there would be significant beneficial impacts to the species. For pallid sturgeon, long-term beneficial impacts may be expected from the creation of spawning sites and from IRC development although there is still much uncertainty regarding what is limiting pallid recruitment. No negative impacts on pallid sturgeon are anticipated from the spring ESH-creating release. Long-term beneficial impacts to the species are anticipated from implementation and adjustment of management actions under an active AM framework.

Program expenditures under Alternative 4 would be the lowest of all alternatives, on average \$14 million per year less than Alternative 1. In common with Alternatives 3, 5, and 6, Alternative 4 has a smaller scale of early life stage pallid habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in \$852,000 more in labor income and \$65,000 more in local tax revenue to local governments at the end of the implementation period. There may be small benefits to ecosystem services, fish and wildlife, and other special-status species

The majority of the net impacts of Alternative 4 would be negative. Hydropower revenues would fall by an annual average of \$4 million per year as the result of lower flow years during System refill phases, a small percentage decrease of the overall value although reductions in some years following releases would be in the tens of millions which is considered significant.

Recreation as a sector would lose \$407,000 on average per year from the national perspective and \$514,000 per year in labor income regionally relative to Alternative 1. Most of these impacts would be from the upper three reservoirs (where summer elevations would more frequently be at lower than preferred levels), although lower river recreation may experience benefits from more preferable flow conditions and recreational opportunities offered by habitat creation.

Compared to Alternative 1, irrigation and thermal power would be negatively affected on average by \$210,000 and \$422,000 per year for NED impacts, respectively. Nationally, navigation losses would be \$45,000 per year, and regional losses in labor income would be over \$326,000 per year relative to Alternative 1. Alternative 4 would adversely impact cultural resources by increasing site days at risk by approximately 3 percent from Alternative 1, which is considered a significant impact.

Flood risk management issues would be made worse by Alternative 4. At a national level, close to \$1 million per year in losses would be expected on an average annual basis relative to Alternative 1, but some years would experience negative impacts in the tens of millions of dollars which is considered significant. Regionally, these negative impacts relative to Alternative 1 would result in a reduction of \$19,000 in average annual labor income. Other adverse effects of Alternative 4 are related to a reduction in more than 255 habitat construction related jobs (which would result in a relative reduction in regional income of \$13.3 million per year for this item).

Alternative 4 would additionally have small but presently unquantified negative impacts to flood risk management, navigation, and water intakes on the Mississippi.

Evaluation Discussion

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. Increased flood risk management issues associated with releasing water in the spring are inherent to the alternative's design. Although there may be some opportunities to reduce flood risk under real-time operation (refer to Chapter 5 in the AM Plan), there will always be additional risk associated with increasing river flows during the spring period when tributary inflows are flashy and difficult to respond to in a timely way. As modeled over the POR, Alternative 4 would cause an increase of over 600 additional days of channel capacity exceedances in the Garrison and Fort Randall reaches relative to Alternative 1. Alternative 4 would result in significant impacts to flood risk management, cultural resources, and hydropower.

Similar to Alternative 3, Alternative 4 is considered a complete plan in that it would meet USFWS probability of persistence targets for piping plover and least terns and would continue ongoing pallid propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both these birds and pallid sturgeon (in common with Alternatives 3, 5, and 6).

Alternative 4 is the second most efficient alternative from a combined NED standpoint but has a net average annual NED value only \$1 million greater than Alternative 3. The relative benefits to NED associated with this alternative are clearly not worth the broad range of often severe negative impacts to basin interests and local governments. Alternative 4 is potentially as effective in meeting the species objectives as Alternative 3, but the risk of severe negative impacts are compelling reasons for not identifying Alternative 4 as the preferred alternative in the MRRMP-EIS.

2.9.2.5 Alternative 5 – Fall ESH Creating Release

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6 (including active AM; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs) under Alternative 5, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 309 acres per year in the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a fall ESH-creating reservoir release. Alternative 5 would also include the provision for a one-time spawning cue test release from Gavins Point if the results of Level 1 studies during the first 9–10 years do not provide a clear answer on whether a spawning cue is important.

Alternative 5 reservoir operations would be similar to Alternative 1 with the addition of the fall ESH-creating release. In any year, the implementation of this release would occur if the service level is at 35 kcfs or greater (54.5 MAF System storage) on October 17, natural flows creating 250 acres of ESH have not occurred in the previous 4 years, and downstream flow is below identified downstream flow limits. If those conditions are met, the release would be implemented on October 17 with a release of up to 60 kcfs out of Gavins Point Dam, and as often as every four years. To achieve the Gavins Point release, Fort Randall Dam releases would be increased a similar amount as Gavins Point and releases from Garrison Dam would be approximately 17.5

kcfs less than the Gavins Point release. The duration of the release could vary, but there would typically be about 40 days when discharges from Gavins Point Dam are 60 kcfs.

Over the POR, modeling shows that a full release occurs in 7 out of 82 years, with a partial (i.e., attempted but abandoned) release in every 2 years. After the higher release period is completed, the upper three reservoirs have less water than they otherwise would have, and they must recover. During this phase, releases are lower than they otherwise would have been, allowing more water to accumulate in the reservoirs. This refill period can last from a few months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

Relative to Alternative 1, Alternative 5 has a range of net benefits for listed species, flood risk management, thermal power, program expenditures, regional land use and ownership, ecosystem services, and the Mississippi River.

Alternative 5 modeling indicates that updated piping plover and least tern population persistence targets would be met under this alternative and there would be significant beneficial impacts to these species. For pallid sturgeon, negligible adverse impacts from ESH and IRC construction activities are expected. Long-term beneficial impacts for pallid sturgeon could occur from the creation of spawning sites and IRC development although there is still much uncertainty regarding what is limiting pallid recruitment. No negative impacts on pallid sturgeon are anticipated from the fall ESH-creating release. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework. There may be small but unquantified benefits to ecosystem services, fish and wildlife, and other special-status species.

Alternative 5 has program expenditures that would be \$9 million less than Alternative 1 and in common with Alternatives 3, 4, and 6, Alternative 5 would have a smaller scale of early life stage pallid habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in \$852,000 more in labor income and \$65,000 more in local tax revenue to local governments at the end of the implementation period.

Although commercial navigation would have a net average annual NED that is \$6,000 lower than Alternative 1, it would benefit from an increase in regional income by an average annual \$33,000. Flood risk benefits from the national perspective are attributable to reduced damages relative to Alternative 1 in 44 out of the 82 years. Net thermal power benefits of over \$1 million on average would occur on the upper and lower river relative to Alternative 1 as a result of higher river flows under Alternative 5 and fewer acres of early life stage pallid habitat in the lower river compared to Alternative 1 which increase peak river temperatures in some years.

Relative to Alternative 1, Alternative 5 would have net adverse impacts to hydropower and recreation, and the reduced scale of habitat construction relative to Alternative 1 would result in a reduction in approximately 200 habitat construction related jobs (which would result in a relative reduction in regional income of \$10.6 million per year for this item). The adverse average annual hydropower impacts resulting from Alternative 5 would be a fraction of 1 percent of the overall value of electricity generated although reductions in some years following releases would be in the tens of millions which is considered significant. Alternative 5 would have little net change for recreation, although impacts to upper reservoir recreation would be offset somewhat

by gains to lower river recreation. There would be relatively small regional negative impacts associated with flood risk management and irrigation in the average year relative to Alternative 1.

Unquantified small benefits to the Mississippi River could be expected for flood risk management, navigation, and water intake-related sectors.

Evaluation Discussion

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. Alternative 5 results in net average annual benefits to flood risk management, thermal power, program expenditures, land use ownership and tax revenues, ecosystem services, and to the Mississippi River compared to Alternative 1. However, impacts of the ESH releases on flood risk management are a concern and net average annual benefits often mask more acute adverse impacts in release years or during System recharge periods. Likewise, although adverse impacts to hydropower on an average annual basis are a fraction of the total value of electricity generated, relatively severe adverse impacts occur in some years and this is considered significant. In addition, over the POR used for modeling, Alternative 5 would cause an increase of 422 additional days of channel capacity exceedances in the Garrison and Fort Randall reaches relative to Alternative 1.

Similar to Alternative 3, Alternative 5 is considered a complete plan in that it would meet the USFWS probability of persistence targets for piping plover and least terns and would continue ongoing pallid propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid (in common with Alternatives 3, 4, and 6).

Alternative 5 would be the most efficient alternative from a combined NED standpoint and would have an average annual NED value of \$2.8 million greater than Alternative 3. However, it would also have a larger negative regional impact compared to Alternative 3 of a roughly similar amount. Alternative 5 would potentially be as effective in meeting the species objectives as Alternative 3 but the additional channel capacity exceedances and potential for adverse impacts to flood risk management and hydropower in some years are reasons Alternative 5 was not identified as the preferred alternative for this MRRMP-EIS.

2.9.2.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Summary of Characteristics and Features

In addition to a range of actions common to Alternatives 3–6 (including active AM; vegetation management, predator management, and human restriction measures on ESH; Level 1 and 2 studies; propagation and augmentation; spawning habitat and channel reconfiguration for IRCs) under Alternative 6, USACE would create ESH for the least tern and piping plover through mechanical means at an average rate of 303 acres per year in the Garrison, Fort Randall, and Gavins Point reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of a Fall ESH-creating release.

Alternative 6 reservoir operations would be similar to Alternative 1 with the addition of an attempt, every 3 years, to perform a spawning cue release of a greater intensity than is currently

defined in the Alternative 1 (subject to System storage and flood control precludes). The release would be bimodal, with a release in March that increases by 2,200 cfs per day until a target flow magnitude (double the navigation flow target that was set on day one of the release) is reached. The peak would be maintained 2 days, and afterwards flows would be reduced at a rate of 1,700 cfs per day until flow-to-target navigation release rates are met. The second release would begin in mid-May with the precise date determined by water temperature. Flows would be increased at a rate of 2,200 cfs per day until a peak magnitude equaling twice that of the first day of the release is reached; after holding this for 2 days, flows would be allowed to return to normal at a declining daily flow rate of 1,900 cfs per day. Based on HEC-ResSim POR simulations, Gavins Point releases during the May spawning cue would range from 50 to 67 kcfs. In the case of a failed completion of this sequence, an attempt would be made in the following year, subject to preclusions.

Over the POR, modeling shows that a full release sequence of the type described here occurs in 11 out of 82 years, with a partial (i.e., attempted but abandoned due to constraints) release in 33 years. As with all other flow-release alternatives, after the higher flow period in the river is completed, a refill period begins in which the upper three reservoirs have less water than otherwise would have been the case, and must be refilled. During this phase, releases are lower than they otherwise would have been, allowing more water to accumulate in the reservoirs. This refill period can last from a few months to several years. In some cases, a second flow release might begin before the System has fully refilled from the first.

Balance of Beneficial and Adverse Effects

Relative to Alternative 1, Alternative 6 has a range of net benefits for listed species, regional land use and ownership, regional hydropower, ecosystem services, and fish and wildlife.

Modeling indicates that updated population persistence targets for piping plover and least tern would be met under Alternative 6. For pallid sturgeon, negligible adverse impacts from ESH and IRC construction activities are expected. Long-term beneficial impacts for pallid sturgeon could occur from the creation of spawning sites and IRC development although there is still much uncertainty regarding what is limiting pallid recruitment. There would be possible beneficial impacts from the spawning cue release, although evidence is currently lacking to confirm or quantify any level of benefit. Long-term beneficial impacts to the species are anticipated from the implementation and adjustment of management actions within an active AM framework. There may be small ecosystem services and fish and wildlife benefits.

Alternative 6 has program expenditures that would be \$8.5 million less than Alternative 1 and in common with Alternatives 3, 4, and 5, Alternative 6 would have a smaller scale of early life stage pallid habitat development relative to Alternative 1. This would reduce the need to purchase as much private land and increase crop production resulting in \$852,000 more in labor income and \$65,000 more in local tax revenue to local governments at the end of the implementation period. Although there would be an average annual decrease in hydropower value of \$2.1 million, there would be an annual financial gain of \$5.5 million in a typical generation year for the Western Area Power Administration (WAPA).

The majority of the net impacts of Alternative 6 would be negative. Recreation as a whole would lose \$265,000 per year from the national perspective and \$354,000 per year on average in regional labor income. Most of these impacts would be from the upper three reservoirs (where summer elevations are more frequently at lower than ideal levels), although lower river recreation may experience benefits from more preferable flow conditions and recreational

opportunities offered by habitat creation. Irrigation and navigation would be negatively affected on average by \$135,000 and \$41,000 per year, respectively, from a national perspective, and by \$224,000 and \$219,000 in decreased regional income. Alternative 6 would adversely impact cultural resources by increasing site days at risk in the reservoirs by approximately 2.5 percent from Alternative 1 which is considered a significant impact. The adverse average annual hydropower impacts resulting from Alternative 6 would be a fraction of 1 percent of the overall value of electricity generated although reductions in some years following releases would be in the tens of millions which is considered significant.

Impacts to flood risk management would increase under Alternative 6. Modeling suggests an average annual increased flood damage of over \$500,000 nationally and a decrease in average annual labor income of \$58,000 regionally.

On the Mississippi River small beneficial impacts may occur for flood risk management but small negative impacts may occur to navigation, water supply, and thermal power facilities.

Evaluation Discussion

A determination of the acceptability of this alternative will be informed by the public and agency review of this draft MRRMP-EIS. Alternative 6 results in negative impacts to a wide range of interests in the basin. Increased flood risk management issues associated with releasing water in the spring are inherent to this alternative's design. Although there may be some opportunities to reduce flood risk under real-time operation (refer to Chapter 5 in the AM Plan), there will always be additional risk associated with increasing river flows during the spring period when tributary inflows are flashy and difficult to respond to in a timely way. As modeled over the POR, Alternative 6 caused an increase of 221 additional channel capacity exceedances in the Garrison and Fort Randall reaches relative to Alternative 1.

Similar to Alternative 3, Alternative 6 is considered a complete plan because it would meet the USFWS probability of persistence targets for piping plover and least terns and would continue ongoing pallid propagation activities, build spawning habitat as in-river test projects to learn if this action is effective, and build IRC habitat through structure modification and channel widening. It would also be implemented under an active AM framework for both the birds and pallid (in common with Alternatives 3, 4, and 5).

Alternative 6 is a fairly efficient alternative from a combined NED standpoint but has a net average annual value only \$0.5 million greater than Alternative 3. The relative benefits to NED associated with this alternative are clearly not worth the broad range of often severe negative impacts to basin interests. Alternative 6 incorporates a spawning cue flow for pallid sturgeon and there is currently no scientific evidence that pallid sturgeon would benefit from such a flow and therefore Alternative 6 is not considered more effective in meeting the species objectives than Alternative 3.

Because of the risk of severe negative impacts and the effectiveness and efficiency of Alternative 6 is not substantially different from Alternative 3, Alternative 6 was not identified as the preferred alternative for this MRRMP-EIS.

2.10 Summary of Preferred Alternative

This section summarizes the description of the preferred alternative and explains components that were further refined during coordination with USFWS. Chapter 4.0 provides a more detailed

description of how the preferred alternative would be implemented under the AM Plan. The preferred alternative includes the initial set of actions that USACE would implement over the 15-year implementation period and monitoring and evaluation as described in the AM Plan. The AM Plan includes a suite of in-river management actions (Level 3), in-river test projects (Level 2), and research and monitoring (Level 1) aimed at achieving the objectives for the interior least tern, piping plover, and pallid sturgeon. As described in Section 2.9, the initial set of actions were chosen after careful consideration of species needs, critical management uncertainties, and anticipated impacts to authorized purposes and other socioeconomic impacts.

2.10.1 Pallid Sturgeon

- **Propagation and Augmentation:** Continue with Level 3 propagation and stocking actions in both the upper and lower river based on the PSCAP. Level 1 studies will include: engineering feasibility of hatchery needs, facilities, operations; retrospective analysis of survival linked to hatchery operations; and simulation models of population sensitivity to size, health, and genetics. Level 2 studies will consist of field experimentation with varying size and location of stocking based on agreed upon needs with USFWS and following the guidance in the USFWS Propagation Plan.
- **Population and Assessment Project:** The Pallid Sturgeon Population Assessment Project (PSPAP) would continue in some form in both the upper and lower river. Some level of redesign of the PSPAP is anticipated in order to achieve efficiencies and align the PSPAP with the AM Plan. Data collected through the PSPAP are used to evaluate propagation and augmentation and provide long-term assessment of fish habitat and population metrics. USACE has developed partnerships with state and federal agencies already active on the Missouri and Kansas Rivers and has provided the funding, standardized protocols, and quality control oversight necessary to implement the monitoring strategy of the PSPAP.

2.10.1.1 Upper River

The following actions in the upper river will be immediately implemented and monitoring of whether fish passage at Intake is successful will be undertaken by the Bureau of Reclamation in coordination with USACE.

- **Level 1 Research and Monitoring:** In addition to research and monitoring regarding propagation and augmentation which were previously described, research and monitoring will be implemented to address the following uncertainties:
 - **Spawning Cues:** Design complementary passive or active telemetry approach which can monitor reproductive behaviors opportunistically (no intentional spawning cue releases). Conduct opportunistic tracking of reproductive behaviors.
 - **Temperature Manipulation:** Field study of Lake Sakakawea conditions limiting age-0 survival; study of development rates of embryos, free embryos, and larvae; larval drift study.
 - **Drift Dynamics:** Model integration for drift and development; modeling location and rate of change of Lake Sakakawea headwaters; increase understanding of patchiness of anoxic zone in Lake Sakakawea; spawning habitat distribution on the Yellowstone River; field experiment drift/dispersal, advection/dispersion validation to refine drift model; mesocosm studies to quantify transport.

A description of these research and monitoring activities is included in Chapter 4.0 and Appendix C of the AM Plan (Detailed Description of Level 1 and Level 2 Science Components). After this research and monitoring the intent is to follow the decision criteria and governance process described in Chapter 4 of the AM Plan to guide implementation of subsequent activities.

2.10.1.2 Lower River

- **Spawning Habitat:** Level 1 studies would consist of investigation of functional spawning habitat in the Yellowstone River for potential replication, field gradient studies of habitat conditions, and mesocosm studies on spawning conditions and behaviors.

Level 2 actions would include engineering studies for sustainable design and implementation and manipulative field experiments for spawning habitat. Up to three spawning habitat sites would be created and monitored for effectiveness in terms of relative use of these sites compared to other control areas, and the relative spawning success, as determined by hatch rate, catch per unit effort of free embryos and other indicators.

- **Channel Reconfiguration for IRC Habitat:** Level 1 studies would consist of screening regarding limitations of food or forage habitats and technology development for IRC sampling, modeling, and measurement.

Level 2 in-river test projects would consist of manipulative field experiments with IRCS; Appendix E of the AM Plan presents a hierarchical staircase study design to evaluate the response of age-0 sturgeon catch to IRC habitat development activities. Twelve pairs, consisting of experimental and control sites, would be used in the experiment over a period of 6–7 years. It is estimated that the twelve experimental sites would meet the habitat targets for this time period (stage 1 and 2) as described in the USFWS Planning Aid Letter dated September 14, 2016. If results remain equivocal following this experiment, additional field experiments would be implemented at a level designed to resolve uncertainties regarding the importance of IRC habitat to the survival of age-0 sturgeon in an expedited manner. This would contribute in meeting the Level 3 habitat targets described in the Planning Aid Letter for the following 4 years (stage 3).

In addition to the experimental studies described previously and to the extent possible and where appropriate, the remaining Level 3 habitat recommendations outlined in the Planning Aid Letter for stage 3 would be met through Level 2 or 3 projects to modify existing SWH project sites which are not meeting IRC habitat criteria. If the designs are successful in increasing interception, interception continues to be hypothesized as limiting, and food and foraging habitat also continue to be hypothesized or proven to be limiting, then sites would be constructed at a rate to meet the Level 3 habitat targets.

- **Spawning Cue Release:** The spawning cue release currently included in the Master Manual would no longer occur under the preferred alternative because that particular frequency, magnitude, and duration of release has not been effective in causing upstream movements, aggregation of spawning adults, and spawning. Level 1 studies would consist of designing a complementary passive telemetry network or relying on continuation of active telemetry depending on feasibility and relative cost effectiveness. The opportunistic tracking of reproductive behaviors associated with monitored hydrologic characteristics would be implemented to answer uncertainties regarding the importance of a spawning cue to pallid recruitment. Obtaining a clear answer to this question depends on there being a wide enough variation (or contrast) in flow patterns across years, and a large enough number of tracked fish, to make meaningful comparisons.

If it is still unclear whether a spawning cue is important after 8–9 years of the aforementioned Level 1 studies, a Level 2 one-time spawning cue test release would be implemented to facilitate this determination. At this time it is assumed the test release would be similar in magnitude and duration to the flow release which was included as a recurring release under Alternative 6. Following a review of these releases which were modeled under Alternative 6 over the POR, actions necessary to avoid or minimize potential impacts were identified. Most notable are potential out of bank occurrences downstream of Fort Randall and Gavins Point Dams because releases from Oahe, Fort Randall, and Gavins Point Dams would be used to generate the spawning cue. Under real-time careful consideration of precipitation forecasts and resulting downstream tributary flow would be necessary in order to plan releases to avoid flooding potential downstream of Gavins Point Dam. However, since this release is above current channel capacity in the Fort Randall reach some impacts to private lands may occur. USACE has sought to minimize this impact as much as possible in the very selection of this alternative. USACE will continue to analyze how the release may impact private landowners and if these impacts are covered by any existing easements. Where an easement does not already exist, USACE will continue to effectively strategize how to minimize the impacts over the next nine years. Minimization through acquisition of easements and property will be investigated, although current authorities and funding for such efforts are extremely limited. Additionally, USACE will investigate other practical means to lessen these impacts such as dredging and sediment transport methods.

It would also be advisable to avoid this release when System storage levels are close to navigation preclusions to avoid impacts to navigation.

- **Level 1 Research and Monitoring:** In addition to research and monitoring regarding propagation and augmentation which were previously described, research and monitoring will be implemented to address the following uncertainties:
 - Temperature Control: Model water temperature management options, Fort Randall.
 - Drift Dynamics: Technology development: surrogate particles, particle tracking, learning from results of upper river drift tests; Field studies: Resilience, stamina in turbulent flows (lab or mesocosm study); Field studies on free embryo exit paths; Field gradient study, age-0 survival and complexity; Free embryo transport to Mississippi River (contingent on ongoing microchemistry work); Field experiments with particle tracking, embryos, and models

A description of these research and monitoring activities is included in Chapter 4.0 and Appendix C of the AM Plan (Detailed Description of Level 1 and Level 2 Science Components). After this research and monitoring, the intent is to follow the decision criteria and governance process described in Chapter 4 of the AM Plan to guide implementation of subsequent activities.

2.10.2 Least Tern and Piping Plover

The following is a summary of the initial set of actions to be implemented for the piping plover and least tern under the preferred alternative.

- **Mechanical ESH Construction:** This would include implementation of mechanical ESH creation in the Garrison, Fort Randall, and Gavins Point reaches to meet the standardized and available ESH targets specified by USFWS and described in Section 1.6.2. Based on hydrology and hydraulics modeling coupled with tern and plover population models this would result in constructing an average of 391 acres of ESH per

year. In real-time, the existing population and ESH status would be assessed, as described in the AM Plan, to determine actual annual construction needs based on trends in the population and ESH. This action would require extensive coordination with the Tribes in developing site-specific plans for construction in the Garrison reach in order to avoid sensitive areas.

- **Reduced Nesting-Season Flow Releases within Capability Provided in Current Master Manual:** Flexibility under the existing Master Manual to allow reduction in releases when no navigation traffic is scheduled can be used to extend the life of ESH for nesting terns and plovers.
- **Flow Management to Reduce Take:** The steady release operation under the existing Master Manual during the nesting season would continue. This involves releasing less water when possible to avoid flooding tern and plover nests below the dams. Regular communication between USFWS and reservoir control staff currently occur for this purpose and would continue.
- **Predator Management and Human Restrictions Measures:** Predator management and human restriction measures would continue on constructed and naturally created sandbars. Predator management would follow the existing plan for predator management developed by USACE in 2009. Proposed management actions in the plan include the use of exclusion cages and exclusion fencing to protect nests and hazing of predators in combination with audio or visual frightening devices to deter predators away from nesting sites. There would be lethal and non-lethal removal of individual target predators that have the greatest impact on least tern and piping plover nests and chicks, particularly raccoons, coyotes, mink, and great horned owls. Human restriction measures include fencing of nesting areas or signage to alert people of the presence of nesting birds.
- **Vegetation Management:** Vegetation management would continue to follow the existing vegetation management strategies as explained in the 2013 Environmental Assessments for vegetation management in Nebraska-South Dakota, and North Dakota. The primary method of vegetation removal from selected sandbars would be spraying from an all-terrain vehicle or hand spraying for smaller areas with less vegetation. In areas that are large or densely vegetated, aerial spraying from a helicopter would be conducted. USACE would continue to use an imazapyr-based (e.g., Habitat) and/or a glyphosate-based (e.g., Rodeo) herbicide approved by the EPA for aquatic use. Additional vegetation removal activities may include cutting, mulching, disking, mowing, raking, and removing vegetation from sandbars. The ESH interagency team will continue to meet annually to discuss locations on the river where vegetation treatment should be conducting in an effort to maintain as much ESH as possible while considering other competing needs such as the regeneration of cottonwoods.
- **Monitoring:** Annual productivity monitoring of least tern and piping plover populations on the reservoir and river reaches of the Missouri River mainstem would continue. The current monitoring focuses on an adult census, measurement of fledge ratios, and documentation of incidental take if applicable. ESH habitat quality monitoring and assessment of management actions to determine their effectiveness would also occur. In addition, focused research projects on various aspects of piping plover demographics and habitat use would be implemented based on the prioritization process developed for the AM Plan.
- **Research and Modeling:** Modeling and research would also occur related to ESH construction, habitat-creating flow releases, lowered nesting season flow releases, flow

releases to reduce take, sandbar augmentation and modification, vegetation management, predation control, human restriction measures, and reservoir water-level management. A detailed listing of the associated management questions and study summaries can be found in Chapter 3 of the AM Plan.