UNITED STATES ARMY CORPS OF ENGINEERS

Record of Decision
for
Authorization of
Commercial Sand and Gravel Dredging
on the
Lower Missouri River

MARCH 2011

Appendix B
Biological Assessment

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UNITED STATES ARMY CORPS OF ENGINEERS

Biological Assessment for Commercial Sand and Gravel Dredging on the Lower Missouri River

Great Lakes – Big Rivers Region
Mountain – Prairie Region

MARCH 2011

Prepared by
U.S. Army Corps of Engineers
Kansas City and St. Louis Districts

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SECTION 1

Introduction

This Biological Assessment (BA) has been prepared in compliance with Section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 United States Code §1531-1543). The BA evaluates the anticipated effects on federally listed threatened or endangered species of the issuance of permits by the U.S. Army Corps of Engineers (USACE) for commercial dredging of sand and gravel from designated reaches of the Lower Missouri River (LOMR), between river mile (RM) 0.0 and 500.0. The USACE has determined that their action potentially may affect federally listed species and therefore warrants consultation with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7(a)(2) of the ESA. The specifics of the USACE-proposed federal action are described in more detail in Section 3.

In a letter to the USFWS, dated January 22, 2010, the USACE requested a list of federally listed threatened or endangered species, along with designated critical habitat, that might be affected by the proposed commercial dredging activities. The USFWS responded to the USACE request in an email, dated February 10, 2010, and provided a list of species that are likely to occur within the proposed project area (see Appendix A for USACE letter and USFWS email response). Subsequent to the initial response by the USFWS, it was determined that one plant species should also be included in the BA (Ledwin pers. comm. 2010). Therefore, the species identified by the USFWS and evaluated in this BA are:

- Pallid sturgeon, *Scaphirhynchus albus*, Endangered;
- Least tern, *Sterna antillarum*, Endangered;
- Piping plover, C*haradrius melodus*, Threatened;
- Indiana bat, *Myotis sodalis*, Threatened; and
- Decurrent false aster, *Boltonia decurrens,* Threatened.

On September 1, 2010, the USFWS issued a final rule determining that shovelnose sturgeon (*Scaphirhynchus platorynchus*) should be treated as threatened due to similarity of appearance to the endangered pallid sturgeon in areas where they commonly coexist, such as the Missouri River (75 Federal Register [FR] 53598). However, the ruling extends take prohibitions only to activities associated with commercial fishing. All other activities in areas where the two species overlap and that are conducted in accordance with applicable laws and regulations will not be considered take under the regulations designating shovelnose sturgeon as threatened (75 FR 53598). Therefore, shovelnose sturgeon is not considered further in this BA, as take is not currently prohibited for activities associated with commercial sand and gravel dredging in the LOMR.

SECTION 2

Consultation to Date

Consultation with the USFWS has been ongoing since the beginning of the ESA. Table 2-1 summarizes consultation since the last BA for Missouri River commercial dredging was completed in 1994.

Table 2-1 Summary of Consultation with U.S. Fish and Wildlife Service

Date	Description
March 18, 1994	USACE Kansas City District submitted a BA of potential impacts of Missouri River commercial dredging submitted to USFWS.
October 9, 2002	USACE St. Louis District sent a letter to USFWS proposing additional restrictions for proposed Missouri River commercial dredging permits and finding that the activity was not likely to adversely affect the pallid sturgeon or other endangered or threatened species or their critical habitat.
January 17, 2003	USFWS sent a letter to the USACE St. Louis District concurring with the previous USACE finding conditioned on several permit conditions in addition to those proposed by the USACE.
June 27, 2003	USACE issued a Public Notice for re-authorization of Missouri River commercial dredging permits.
July 28, 2003	USFWS responded to the Public Notice for re-authorization of Missouri River commercial dredging permits.
January 12, 2004	USACE issued a Public Notice for authorization of proposed Muenks Brothers dredging permit.
March 8, 2004	USFWS responded to Public Notice for authorization of proposed Muenks Brothers dredging permit.
March 31, 2004	USACE Kansas City District sent the dredgers a letter transmitting comments received in response to the Public Notice referred to above for their Response and Rebuttal. USFWS had recommended several additional permit conditions including a dredge exclusion zone for some tributaries, river chutes, side channels, and areas adjacent to conservation lands (Missouri River Mitigation Project lands; FWS refuge lands; and Missouri Department of Conservation wildlife areas).
February 18, 2005	USFWS sent a letter to the USACE Kansas City District in response to objections and recommendations from the dredgers regarding proposed dredge exclusion zones. The letter makes some concessions and some requests.
March 27, 2007	USFWS sent a letter to the USACE Kansas City District expressing concerns about the delay by the USACE in making the permit decision but agreeing with the need for an EIS.
August 20, 2007	USACE Kansas City District completed the Environmental Assessment and sent the initial proffered dredging permits to the dredgers for permits good through 2009 when an EIS was expected to be completed.
October 30, 2009	USACE sent a letter requesting concurrence by the U.S. Fish and Wildlife Service (USFWS) with the determination that a 1-year extension of the Missouri River commercial dredging permits to allow for completion of the EIS would not adversely affect federally listed species. In that letter, concurrence was sought for the species and habitats to be covered in the assessment.

Date	Description
November 17, 2009	USACE sent a memorandum suggesting that the area of potential effect is the Lower Missouri River, its tributaries, and adjacent river banks within the Missouri River floodplain.
December 3, 2009	USFWS sent a letter to USACE with comments in response to the USACE letter requesting concurrence and agreed with the determination that the proposed permit extension would not adversely affect the pallid sturgeon (Scott pers. comm. 2009).
Late 2009	Correspondence between USACE and USFWS in which USFWS stated that new research and discoveries had been carried out on the pallid sturgeon since publication of the previous BA and that a new BA needs to be developed incorporating this recent research to support a conclusion of project effects.
January 22, 2010	USACE sent a letter to USFWS to verify the appropriate species list to evaluate in a BA.
February 10, 2010	USACE received a response from USFWS with species concurrence.
March 23, 2010	Telephone log documenting call (L. Dominguez, ENTRIX) to USFWS biologist Jane Ledwin regarding assessment of threatened and endangered plants.
December 16, 2010	Because the FEIS could not be finished before mid February USACE sent a letter to USFWS that determined that a three-month extension of the Missouri river commercial dredging permits would not adversely affect federally listed species.
December 27, 2010	USFWS sent a letter concurring that extending the Missouri River commercial dredging permits for three more months (through March 31, 2011) was not likely to adversely affect federally listed species, primarily because little dredging would be done during those cold months.
January 14, 2011	USACE submitted a Draft BA to USFWS for review.
February 24, 2011	USACE met with USFWS biologist Jane Ledwin to discuss her questions and concerns about the Draft BA and identify needed revisions.

SECTION 3

Description of the Proposed Action

3.1 INTRODUCTION

The USACE proposes to issue permits for extraction of commercial sand and gravel within specifically identified reaches of the LOMR between St. Luis, Missouri and Rulo, Nebraska (RM 0.0 to RM 500.0). The USACE prepared a Final Environmental Impact Statement for commercial sand and gravel dredging on the LOMR (USACE 2011); this document is referred to herein as “the FEIS.” The FEIS describes the current social, environmental, and economic resources associated with the LOMR and the potential effects associated with the Proposed Action (the action proposed by the applicants) and several sand and gravel extraction alternatives, including a No Action Alternative, and identifies the “Environmentally Preferred Alternative.” The 404(b)(1) Guidelines prohibit the USACE from authorizing a proposed activity unless it demonstrates that it is the least environmentally damaging practicable alternative (LEDPA). The alternative the USACE intends to authorize and that is considered in this BA is the LEDPA that is identified in Section 3.6along with the planned impact avoidance, minimization, and mitigation measures described in the following sections. The LEDPA contains conditions and limitations which include tonnage limits on annual extraction within general river segments and within specific degrading reaches, resource protection zones, and dredging and river monitoring requirements. Dredging operations and each of these classes of conditions and limitations are described in the following sections.

3.2 DREDGING OPERATIONS

Dredging for sand and gravel on the LOMR will be conducted using hydraulic suction-head or cutter-head dredges mounted on movable barges. The dredge consists of mechanical equipment mounted on a barge that can be moved into position and anchored during dredging operations. The dredge barge is held in a fixed position during dredging by deploying large, fortress-style anchors from the forward corners of the barge on the end of 1,000- to 2,000-foot-long cables. By selectively manipulating the length of each anchor cable, the dredge can be moved forward, backward, and from side to side during the dredging operation. From a single anchoring position, a dredge can operate in an area approximately 1,000–2,000 feet in length and approximately 400–500 feet in width before moving the anchors. Some dredges include piles (called "spuds") that can be raised and lowered to the river bottom, to assist with maintaining the dredge position.

All dredging operations will use one of two types of hydraulic suction dredges. In the upper and middle segments, the currently authorized operations use dredges with cutter heads and onboard processing equipment. Dredges with suction heads and simple onboard screens are used in the lower segments of the LOMR. During dredging, the dredging head (with or without a cutter head) and a suction line are mounted on a boom (called a ladder) that is lowered to the river bed. Sediment is removed from the river bottom until the suction head comes into contact with hard materials (such as bedrock, large rock substrates, or consolidated sediment layers)—at which time the suction head does not advance further into the river bottom, and the amount of bottom sediments sucked into the suction head is greatly reduced. The dredge boom is then raised, the dredge is relocated, and excavation recommences.

The characteristics of bottom sediments in the LOMR vary with location. Dredging in the LOMR produces material of highly variable grain size, including small stones, coarse and fine gravels, sands of various sizes, fine material, and some lignite particles. Sand and gravel suitable for commercial use in building materials must meet material specifications defined by grain size distribution and proportion of each grain size that may be included in the product. The dredged material is passed though screens and settling-sorting equipment to achieve a desired grain size distribution that meets material specifications for various commercial uses. The material ranging from 0.1 to 4.0 millimeters (mm) is typically retained, and the unwanted material is discharged into the river. Marketable material is loaded onto barges that are tied alongside the dredge barge. The barges, typically ranging from 120 to 200 feet long and from 30 to 45 feet wide, are pushed upstream and downstream by towboats. During loading and transport, river water drains from the loaded sand and is discharged back to the river via scuppers on the barge. For dredging operations in the lower segments of the LOMR, where discharge screens are used to sort the dredged material, this runoff is a considerable volume. No specific testing of overboard discharge of dredge slurry water or undesirable size fractions of sediment is conducted, as the discharged material is not exposed to any processing other than sorting.

Once loaded, barges are moved downstream to a sand plant, where they are tied next to an unloading barge with conveyor transfer equipment. Earth-moving equipment is used to transfer the sand and gravel to a conveyor system that moves it ashore; following offloading at the sand plant, empty barges are returned to the dredge site for reloading. Offloaded material may be washed to remove lignite, resorted into various classifications, and stored for sale and transport. The terminal where the unloading barge is located (the sand plant) typically includes a system of overhead conveyors, stackers, and earth-moving equipment for moving and stacking bulk materials; truck loading facilities; scales; and equipment maintenance facilities.

Sand plant facilities typically have direct access to local, state, and interstate highway systems for product transport. The onshore terminal may also include moorage for dredge barges, transport barges, and towboats. To the extent practicable, vessel maintenance is performed at the onshore facility.

Table 3-1 identifies the dredging equipment, barges, and towboats that will be used by the applicants. The location, approximate size and storage capacity, length of water frontage, and adjacent land use of each sand plant facility currently operated or proposed by the dredging applicants is shown in Table 3-2.

Table 3-1 Dredging Production Equipment to Be Used by the Applicants

Permit Applicant	Dredge Barges	Towboats	Barges
J.T.R., Inc.	3	3	7
Limited Leasing Company	3	3	29
Capital Sand Company, Inc.	3	3	12
Hermann Sand & Gravel, Inc.	1	3	4
Con-Agg of MO, L.L.C.	0	0	0
Holliday Sand & Gravel Company, L.L.C.	3	5	13

Dredging typically occurs from March through December. During the coldest periods, when ice formation may hinder operations and demand for aggregate and sand is lowest, dredgers typically perform annual maintenance on their equipment. Dredging operations are typically performed only during daylight hours but are capable of operating around the clock.

Seasonal flows, the configuration of river training structures and bends, and sediment transport in the river generate a pattern of sediment deposition that dredge operators can reasonably predict in some locations. Based on previous experience, dredge operators frequently return to known locations of sediment deposits that meet sand and gravel market criteria. Being able to return to specific locations minimizes the time for dredge movement, produces more consistent dredge material, maximizes yield for a given period of dredging, and reduces the cost of operation. Experience gained over time helps the dredge operators identify these prime locations. Moving to a new reach requires the dredger to search for new or other prime locations, increasing costs and reducing the certainty of supply.

Table 3-2 Sand Plants in the Lower Missouri River

Company	Plant Name	Location (river mile)	Size (acres)	Storage Capacity	Adjacent Land Use
Holliday Sand & Gravel Company, L.L.C.	St. Joseph	447.7	11	100,000	Industrial
	Riverside	371.8	28	200,000	Industrial
	Randolph	359.9	17	100,000	Industrial
Total			56	400,000	
Capital Sand Company, Inc.	Lexington	317.2	30	135,000	Agricultural
	Carrollton	287.0	12	10,000	Agricultural
	Glasgow	226.2	3.5	38,000	Industrial
	Boonville	196.6	4	50,000	Agricultural
	Rocheport	186.3	10	68,000	Agricultural
	Washington	65.4	21	150,000	Agricultural
	Jefferson City	143.5	9	202,000	Agricultural/ Industrial
Total			89.5	653,000	
Hermann Sand & Gravel, Inc.	Jefferson City	146.6	12 [a]	150,000	Agricultural
	Hermann	96.9	17 [a]	150,000	Agricultural/ Industrial
Total			29[a]	400,000	
J.T.R., Inc.	St. Charles	16.7	2[a]	60,000	Industrial
	Riverview	31.2	2	40,000	Industrial
Total			4	100,000	
Limited Leasing	Bridgeton[b]	44.0	30	90,000	Industrial
	Chesterfield[b]	28.0	86	190,000	Industrial
	F. Belle[c]	8.2	10	50,000	Industrial
	Alton[d]	203.9	3	N/A	Industrial/ Commercial
Total			N/A	230,000	

Notes:
N/A = Not applicable.

[a] Numbers are approximate.
[b] Owned by LaFarge.
[c] Owned by Central Stone.
[d] The Alton facility is located on the Mississippi River and is served by Lower Missouri River river miles 0–12 in the St. Charles segment.

Since 2008, each permitted dredge operator has been required to continuously report its dredge location using global positioning system (GPS) coordinates and its operating status. This reporting is required to monitor compliance with permit conditions and to better understand where dredging is occurring.

3.3 INTERRELATED AND INTERDEPENDENT ACTIONS

An interrelated action is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent action is an activity that has no independent utility apart from the action under consultation. The following paragraph addresses actions or programs that have been determined to be interrelated to, or interdependent with commercial dredging on the LOMR.

In addition to the proposed commercial dredging operations, a number of facilities or sand plants located onshore at various locations along the LOMR are required for unloading, processing, sorting, temporarily storing, and distributing commercial sand and gravel produced by the dredging operations.

3.4 ALTERNATIVES ANALYZED

In accordance with 33 CFR 325, Appendix B and 40 CFR 1500–1508, the FEIS (USACE 2011) evaluated the applicants' Proposed Action and a range of practicable alternatives to meet the basic and overall purpose of the Proposed Action. These alternative actions are:

- Proposed Action – Eight companies have requested approval of 11 Department of the Army (DA) Permits (DA permits) for dredging of specified quantities of sand and gravel from designated reaches of the LOMR, generally with the existing permit conditions (e.g., exclusion zones and operating protocols). Table 2.2-1 contains the names of each of the applicants, the annual tonnage amount requested, and the locations by river segment and general reaches for proposed dredging activities.
- No Action Alternative – The proposed dredging operations would not be authorized, current dredging permits would be allowed to expire, and all commercial sand and gravel dredging on the LOMR would cease.
- Alternative A – Allowable commercial dredging tonnages would be set at levels at the lower end of the range that are reasonably expected to reduce the contribution of sand and gravel dredging to continued river bed degradation in the LOMR under recent dredging practices (2,190,000 tons per year).

- Alternative B – Allowable commercial dredging tonnages would be set at levels at the upper end of the range that are reasonably expected to reduce the contribution of sand and gravel dredging to river bed degradation under recent dredging practices (5,050,000 tons per year).
- Alternative C – Allowable commercial dredging tonnages would be set at levels that approximate recent dredging amounts (6,900,000 tons per year).

Table 3-3 Summary of Permit Applications for Commercial Dredging in the Lower Missouri River

Permit Applicant	Amount Requested (tons/yr)	Segment of Operation [a]	General Reaches Requested [b] (river mile)	Activity [c]
J.T.R., Inc. (three permits for three operations)	1,550,000	St. Charles	0–35	Dredging / distribution
Limited Leasing Company	1,200,000	St. Charles	0–47	Dredging
Capital Sand Company, Inc. (St. Louis District permit)	500,000	St. Charles	40–50	Dredging/ distribution
Edward N. Rau Contractor Company	100,000	St. Charles	62–75	Distribution
Capital Sand Company, Inc. (Kansas City District permit)	2,255,000	St. Charles, Jefferson City, and Waverly.	62–354	Dredging / distribution
Hermann Sand & Gravel, Inc.	1,000,000	St. Charles, Jefferson City	56–164	Dredging / distribution
Con-Agg of MO, L.L.C.	250,000	Jefferson City	177–202	Distribution
Holliday Sand & Gravel Company, L.L.C.	3,760,000	Waverly, Kansas City, and St. Joseph	320–448	Dredging / distribution
The Master's Dredging Company, Inc.	1,000,000	Waverly	383–390	Dredging / distribution
Total	11,615,000		0–390	

[a] For analysis, the lower Missouri River has been divided into five segments: St. Charles (river mile [RM] 0 – RM 130; Mississippi River to Osage River); Jefferson City (RM 130 – RM 250; Osage River to Grand River); Waverly (RM 250 – RM 357; Grand River to Blue River); Kansas City (RM 357 – RM 391; Blue River to Platte River); and St. Joseph (RM 391 – RM 498; Platte River to Rulo, Nebraska). See Section 3.3 for further discussion.

[b] Indicates total range of the river within which individual reaches have been requested. See Table 2.2-2 for a list of specific reaches included in the permit applications.

[c] Distribution indicates operation of an onshore sand plant for offloading, processing, storage, and distribution of sand and gravel.

The lower Missouri River has been divided into five segments: St. Charles (river mile [RM] 0 – RM 130; Mississippi River to Osage River); Jefferson City (RM 130 – RM 250; Osage River to Grand River); Waverly (RM 250 – RM 357; Grand River to Blue River); Kansas City (RM 357 – RM 391; Blue River to Platte River); and St. Joseph (RM 391 – RM 498; Platte River to Rulo, Nebraska). The basis for defining the river segments is given in Section 3.3 of the FEIS (USACE 2011). Table 3-3 identifies the amount of sand and gravel that could be extracted from each segment and the amount currently supplied by the LOMR that would have to come from sources other than the LOMR under each alternative.

Table 3-4 Dredging Amounts for the Proposed Action and Alternatives by River Segment (tons/year)

Segment	Annual Average (2004–2008)	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph (RM 391 – RM 498)	326,928	1,150,000	0	350,000	860,000	330,000
Kansas City (RM 357 – RM 391)	2,520,107[c]	4,060,000	0	540,000	1,230,000	2,660,000
Waverly (RM 250 – RM 357)	815,505[c]	1,005,600	0	500,000	1,140,000	680,000
Jefferson City (RM 130 – RM 250)	1,633,852[c]	2,750,000	0	430,000	980,000	1,630,000[c]
St. Charles (RM 0 – RM 130)	1,706,895[c]	4,384,400	0	370,000	840,000	1,710,000[c]
Total dredging[a]	7,003,287	13,350,000	0	2,190,000	5,050,000	7,010,000[c]
Alternate sources[b]		*N/A*	*7,003,287*[c]	*4,813,287*[c]	*1,953,287*[c]	*0*

Note: N/A = Not applicable.

[a] Sum of Dredgers request by segment – the total amount authorized would be limited to approximately 11.6 million tons per year.

[b] Calculation of alternate sources was based on 2004–2008 average annual total dredging.

[c] Following completion of the Draft EIS, corrections to the dredging records initially submitted by the individual dredgers occurred. These corrections increased the average annual dredging amounts in the Waverly, Jefferson City, and St. Charles segments, and reduced the annual average dredging amounts in the St. Joseph and Kansas City segments. Comparison of the average annual amounts given in Tables 2.4-1 and 2.7-1 of the FEIS (USACE 2011) show the differences. Review of the results of the geomorphic analysis determined that the changes were not substantial and would not affect the findings of the impact assessment reported in Chapter 4 or Appendix A. Therefore, the updated dredging amounts have been given in Table 2.7-1 and used by the U.S. Army Corps of Engineers (USACE) in identification of the Environmentally Preferred Alternative in Section 2.7 of the FEIS (USACE 2011) and here in this table of the Biological Assessment but have not been revised in any other sections of the FEIS (USACE 2011).

3.5 ENVIRONMENTALLY PREFERRED ALTERNATIVE

3.5.1 Segment Limits

In the FEIS, the USACE identified the Environmentally Preferred Alternative based on its review of the impact analyses found in Chapters 4 and 5 and the potential mitigation measures found in Chapter 6 of the FEIS (USACE 2011). The Environmentally Preferred Alternative (Table 3-4) is a composite alternative. As previously noted, for most resource areas except economics, impacts either did not vary substantially or they varied in direct relationship to the impacts on river geomorphology. The alternative selected for each segment would reduce or hold to a nominal level the negative environmental effects of dredging particularly on bed degradation, infrastructure, and environmental resources while seeking to minimize the negative socioeconomic impacts on the local and regional economy and the sand and gravel industry. It was determined that the Environmentally Preferred Alternative should be the highest annual dredging amount that would result in no more than slight degradation, or less than approximately 2 feet in the short term and long term in each segment. Table 3-4 shows the total annual allowable amount of dredging per segment as part of the Environmentally Preferred Alternative. Table 3-4 also shows the percent increase or decrease in the proposed annual tonnage limitation by segment from the average annual amount of sand and gravel extracted from that segment for the 5-year period from 2004 to 2008.

Table 3-5 Selected Alternatives by River Segment for the Environmentally Preferred Alternative

Segment	Alternative	Total Annual Allowable Dredging (tons/year)	Average Annual Dredging 2004–2008 (tons/year)	Percent Change
St. Joseph	B	860,000	326,928	+163
Kansas City	A	540,000	2,520,107[a]	-79
Waverly	B	1,140,000	815,505[a]	+40
Jefferson City	C	1,630,000[a]	1,633,852[a]	-
St. Charles	C	1,710,000[a]	1,706,895[a]	-
Total		5,880,000[a]	7,003,287[a]	-16

[a] Following completion of the Draft EIS, corrections to the dredging records initially submitted by the individual dredgers occurred. These corrections increased the average annual dredging amounts in the Waverly, Jefferson City, and St. Charles segments, and reduced the annual average dredging amounts in the St. Joseph and Kansas City segments. Comparison of the average annual amounts given in Tables 2.4-1 and 2.7-1 of the FEIS (USACE 2011) show the differences. Review of the results of the geomorphic analysis determined that the changes were not substantial and would not affect the findings of the impact assessment reported in Chapter 4 or Appendix A. Therefore, the updated dredging amounts have been given in Table 2.7-1 and used by the U.S. Army Corps of Engineers (USACE) in identification of the Environmentally Preferred Alternative in Section 2.7 of the FEIS (USACE 2011) and here in this table of the Biological Assessment but have not been revised in any other sections of the FEIS (USACE 2011).

3.5.2 Limits on Localized Dredging Intensity

Alternatives selected for each segment to form the Environmentally Preferred Alternative are based on the condition that dredging would be distributed more broadly throughout the segment than has occurred under past dredging practices (except the Kansas City segment, where the total dredging amount would be significantly reduced). If dredging were not distributed more broadly and were allowed to remain concentrated around the existing sand plants, the level of future river bed degradation and associated direct and indirect impacts under these alternatives would be expected to be locally moderate to substantial. The level of expected future bed degradation and associated direct and indirect impacts can be reduced by (1) reducing the approved annual dredging volumes, especially in the areas with the highest levels of bed degradation as presented above; and (2) distributing dredging more broadly along the length of the river to reduce localized dredging intensity. Thus, in addition to designation of a total dredging amount for each segment, target levels for dredging intensity and how those limitations could be applied were also reviewed. The analytical basis for these target levels is discussed in Section 3.4.6.3 and Appendix A of the FEIS (USACE 2011).

To estimate potential dredging intensity effects on river bed degradation, historical dredging data were used to determine where dredging occurred (dredging reach) and at what intensity (annual average dredging amount in tons/mile). This information was then compared with observed patterns of local bed degradation by analyzing changes in local bed elevations in relation to dredging intensities using linear regression. The results suggest that dredging up to approximately 60,000 tons/mile/year is a level of local dredging intensity that is reasonably unlikely to result in local bed degradation.

3.5.3 Monitoring and Adaptive Management Framework

Integral to the Environmentally Preferred Alternative, which seeks effective protection against further river bed degradation and eventual recovery of degraded reaches of the river, is a monitoring and reevaluation process. The purpose of this process would be to identify degradation trends and evaluate their relationship to dredging activity. This information would be used to determine whether dredging levels or restrictions need to be modified.

As discussed in Section 6.3.1 of the FEIS (USACE 2011), low-flow water surface elevation and hydroacoustic bed elevation data (HBED) are two types of data that could be gathered to show river bed aggradation or degradation. Both have their advantages and disadvantages.

Advantages of low-flow water surface elevation data are the period of record that is available, the ability to collect data on the water surface and use it to estimate gross changes in bed elevation, the consistency of the data collected over a short period of time, and the low cost and effort for data collection. Its main disadvantage is the level of error and uncertainty resulting from the low number of physical measurements, the level of accuracy of the USGS stage and flow estimates, the interpolation of surface elevations and flow estimates between USGS gage stations, and normalization of the flows at the time of the survey to the CRP flow.

The advantages of using HBED for monitoring purposes are that it measures river bed elevations directly rather than using estimates from water surface elevations or models, surface water elevations are collected simultaneously, data exist for the whole Project area, and high-resolution data exist for 1998 (using a different protocol), 2007, 2008 (partial), and 2009. Disadvantages include high collection and data processing costs, the fact that water surface elevation data collected during HBED surveys would need to be normalized to a standard flow, the fact that the surface of the river bed varies with the flow, and the fact that a rigorous statistical analysis has not yet been done to determine what spatial density of sampling points and number of transects is sufficient to accurately show actual degradation or aggradation.

Based on the issues previously stated, the USACE has determined that, as part of the Environmentally Preferred Alternative, low-flow water surface elevation data should be collected every year and HBED surveys should be conducted every 5 years for the lower 498 miles of the LOMR. These data would be used to identify reaches that degraded or aggraded over the previous 5 years, to guide the adjustment of dredging in those reaches for the next 5-year permit cycle.

3.6 LEAST ENVIRONMENTALLY DAMAGING PRACTICABLE ALTERNATIVE (LEDPA)

3.6.1 Segment Limits

Table 3-6 shows the companies, amounts, and locations, that the USACE intends to authorize. The USACE has determined that the Environmentally Preferred Alternative for the St. Joseph, Waverly, Jefferson City, and St. Charles segments is practicable and therefore the LEDPA. However, the Environmentally Preferred Alternative for the Kansas City segment would reduce annual extraction by 1,980,000 tons from the average amount extracted annually between 2004 and 2008. Holiday Sand and Gravel Company has demonstrated that they cannot practicably increase extraction levels in the St. Joseph segment or develop alternate sources on the floodplain of the LOMR in less than three years and they need at least 850,000 tons in the Kansas City segment to remain viable during this three-year period. The USACE has determined that the LEDPA is to allow a three year transition period to the 540,000 Environmentally Preferred Alternative. Annual extraction will be limited to 1,200,000 tons in 2011; 900,000 tons in 2012; and 850,000 tons in 2013. This will to allow Holliday Sand to prepare to implement the Environmentally Preferred Alternative A (540K tons per year) in the Kansas City segment in 2014 and 2015.

In the St. Charles and Jefferson City segments, the previously authorized dredgers will be authorized to annually extract the average annual amount each company dredged from that segment from 2004 to 2008. In the Waverly segment Capital Sand will also be authorized to annually extract the average amount that company dredged annually from 2004 to 2008. Because Holliday Sand and Gravel Company will be authorized to dredge approximately 78% less material from the Kansas City segment than their average from 2004 to 2008, they will be authorized to annually extract the remaining 770,000 tons of the annual extraction limit for the Waverly segment and the entire 860,000 tons in the St. Joseph segment.

Table 3-6 Proposed March 2011 Dredging Permit Action

Application Number	Applicant Name and Address	River Miles Authorized for Dredging by This Permit	Annual Tons of Material Authorized by This Permit
NWK 2001-01429	**Capital Sand Company, Inc. (Capital Sand)** Post Office Box 104990 Jefferson City, MO 65110-4990	**(St. Charles Segment)** 62.00-75.00, 109.00-115.20, 115.95-118.40, 119.15-119.35, 119.85-124.35, 124.95-126.05, 126.90-127.50,	140,000
		(Jefferson City Segment) 130.20-157.00, 158.45-164.00, 172.00-176.40, 178.35-180.15, 180.65-184.75, 185.65-186.90, 188.20-192.00, 193.00-193.40, 195.75-202.10, 202.75-210.00, 220.00-226.95, 227.55-230.00, 245.00-249.65	1,350,000
		(Waverly Segment) 250.30-265.00, 283.00-297.90, 301.05-303.00, 314.00-328.00.	370,000
NWK 2001-01430	**Hermann Sand and Gravel, Inc. (Hermann Sand)** Route 3, Box 261 Hermann, Missouri 65041	**(St. Charles Segment)** 56.00-56.85, 61.25-66.00, 70.00-80.00, 80.50-89.75, 93.55-101.70, 109.00-115.20, 115.95-118.40	120,000
		(Jefferson City Segment) 146.00-157.00, 158.45-164.00	120,000
NWK 2001-01431	**Holliday Sand and Gravel Company (Holliday Sand)** 6811 West 63rd Street Overland Park, Kansas 66202	**(Waverly Segment)** 320.00-330.90, 331.65-336.00, 338.00-339.15, 350.00-356.30, 356.50-356.90	770,000
		(Kansas City Segment) 356.90-358.16, 358.36-359.24, 359.44-360.17, 360.37-361.20, 361.44-362.15, 362.35-364.25, 364.45-364.64, 364.84-365.43, 365.79-366.02, 366.30-367.00, 367.90-373.30, 374.20-375.10, 375.30-377.81, 378.90-379.70, 380.70-386.00	2011 - 1,200,000 2012 - 900,000 2013 – 850,000 2014 - 540,000 2015 – 540,000
		(St. Joseph Segment) 445.00-447.75, 448.25-456.75, 457.25-458.75	860,000
NWK 2001-01434	**Con-Agg of MO, L.L.C. (Con-Agg)** 2604 North Stadium Blvd. Columbia, Missouri 65202	**(Jefferson City Segment)** 178.35-184.75, 185.65-186.90, 188.20-192.00, 193.00-193.40, 195.75-196.50, 196.70-197.00, 198.50-199.15, 199.40-201.95	160,000
MVS P-2339	**J.T.R. Inc. (Jotori Dredging)** 2320 Creve Coeur Mill Road Maryland Heights, MO 63043	**(St. Charles Segment)** 1.00-4.00, 6.00 -12.00, 14.00-24.00, 30.00-35.00	460,000
MVS P-2342	**Limited Leasing Company** 1777 Highway 79 South Old Monroe, MO 63369	**(St. Charles Segment)** 0.00-12.00, 20.00-35.00, 40.00-47.00	990,000
TOTAL	2011 2012 2013		6,540,000 6,240,000 6,190,000

Application Number	Applicant Name and Address	River Miles Authorized for Dredging by This Permit	Annual Tons of Material Authorized by This Permit
	2014, 2015		5,880,000

3.6.2 Limits on Localized Dredging Intensity

Applying the 60,000-tons/mile/year dredging target to each individual river mile throughout the entire river presents difficulties to both the USACE and the dredgers. Applying a 60,000-tons/mile/year dredging target to the most heavily dredged and degraded five-mile reaches of the river would allow better management by the USACE and would provide more flexibility to the dredgers. The USACE has identified 14 specific five-mile reaches with water surface profiles more than two feet lower in 2005 than in 1990 and with a five-mile moving average bed elevation averaged over 2007, 2008, and 2009 that was more than a foot lower than in 1998. These degraded reaches occur between river miles 15 to 20, 25 to 35, 90 to 100, 140 to 150, 355 to 395, and 445 to 455. The USACE has determined that limiting dredging to no more than 300,000 tons/year in each of these 14 five-mile reaches is a practicable and necessary part of the LEDPA.

3.6.3 Monitoring and Adaptive Management Framework

The USACE has determined that a practicable and necessary part of the LEDPA is that water surface profiles are prepared annually by the USACE and a hydroacoustic bed elevation survey is provided by the dredgers in the fourth year of each permit cycle, if the USACE does not provide one through another study or river program. The USACE will evaluate the data and meet with the dredgers and state and federal agencies in October of each year to discuss the condition and trend of the river as shown by the most recent water surface profiles or surveys. Permits would be issued for five-year periods. During the five-year permit cycle, if the USACE determines from new data or analysis that additional measures should be taken to protect critical resources, it may modify, suspend, or revoke the permit at any time. Renewal of the dredging permits after five years would be a new Federal action requiring assessment of the prior NEPA document and assessment of any new information. In 2015, the data from the previous four years will be compared with the 2009 water surface profile and bed elevation baselines to evaluate if the permit limits and special conditions adequately limited the impact of dredging to no more than slight degradation across the river as projected by the EIS. Moderate to severe degradation instead of the slight degradation anticipated by the EIS for the Environmentally

Preferred Alternatives for the St. Joseph, Waverly, Jefferson City, and St. Charles segments or any additional degradation in the Kansas City segment would require a thorough review of the permit provisions and could result in reductions in authorized dredging reaches or quantities, or implementation of other mitigation measures in the new permit decision. Likewise, aggradation could allow for consideration of increased quantities.

3.7 SPECIAL PERMIT CONDITIONS

The proposed dredging permits will include special permit conditions to ensure avoidance or minimization of impacts on environmental resources. Those special permit conditions are categorized as operational measures, resource protection zones, and compliance and monitoring measures.

3.7.1 Operational Measures

- If future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee will be required, upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.
- Up to 10% of the permittee's authorized annual tonnage may be carried over each year to be extracted the following year. Annual tonnage with carryover may never exceed 110% of annual authorized tonnage. At the end of each year the permittee must notify the Corps in his annual tonnage report of any undredged tonnage that he intends to carryover.
- The permittee must discharge only suitable material that is free from toxic pollutants in other than trace quantities.
- The permittee must investigate for water supply intakes or other activities which may be affected by suspended solids and turbidity increases caused by work in the watercourse and give sufficient notice to the owners of affected activities to allow preparation for any changes in water quality.
- The permittee must employ measures to prevent dredged materials stored or disposed of on shore from running off or eroding into wetlands or tributaries to the Missouri River.
- The permittee must employ measures to prevent or control spilled fuels or lubricants from entering the waters of the United States.

- The permittee must store all construction materials, equipment, and/or petroleum products that are part of the on-shore operation, when not in use, above anticipated high water levels.
- The permittee may return unwanted dredged material and river water extracted from the Missouri River back to the Missouri River. The permittee must not dispose of waste materials, water, or garbage below the ordinary high water mark of any other water body, in a wetland area, or at any location where the materials could be introduced into the water body or an adjacent wetland as a result of runoff, flooding, wind, or other natural forces.
- The permittee must comply with all U.S. Coast Guard, State of Missouri, State of Kansas (RM 367 to 490), and USACE regulations concerning the prevention of navigation obstructions in navigable waters of the United States.
- The permittee must conduct operations in the Missouri River such that there will be no unreasonable interference with navigation.

3.7.2 Resource Protection Zones

Dredging can have a direct and immediate negative effect on various natural and manmade resources in the immediate area. To prevent or minimize these negative effects, dredging would generally be excluded in certain environmentally sensitive areas, in areas adjacent to certain infrastructure facilities, and in or near pallid sturgeon habitat. The specific resource protection zones within which dredging is prohibited are listed below. The USACE will provide the Dredgers with these exclusion zones in an electronic format that the dredge operator can use in the electronic dredge navigation system. The dredge operator is responsible for determining that the dredge does not operate within these exclusion areas. The dredge location is documented with GPS, and compliance with permit location exclusions is documented in reports submitted to the USACE.

- In permit conditions that specify a linear distance exclusion zone adjacent to a river feature, “dredging” refers to the operation of hydraulic cutter-head suction dredging. The exclusion zone distances will apply to and be measured from the end of the cutter head, rather than from a general point on the dredge.
- The permittee must confine dredging to between the Rectified Channel Lines (RCL) with the following restrictions. Dredging must be conducted in such a manner to preserve the structural integrity of the landmass landward of the RCL. This must be accomplished by maintaining an adequate "no dredging or discharging" zone riverward of the RCL so that material will stabilize into the dredging area at its natural angle of repose. This slope will vary depending upon river location

and the type of material being dredged, but it is your responsibility to ensure that this shallow water interface landward of the RCL be maintained.

3.7.2.1 Levees, Pipeline Crossings, Dikes, and Bridges

Dredging too close to levees, pipelines, submerged utility crossings, bridge piers or abutments, dikes, revetments, water intakes, boat ramps, and natural river banks or islands, even at sustainable levels, can harm these structures either through direct physical contact or by undermining, exposing, destabilizing, or weakening these structures. The following condition is necessary to ensure that adverse impacts of the authorized dredging on navigation, flood control, and water intake structures and endangered species and their habitat are minimized

- The permittee must not dredge within 500 feet of any levee centerline, pipeline or submerged utility crossing, bridge pier or abutment; nor within 200 feet of any dike, revetment, or other structure built or authorized by the U.S. Government; nor within 100 feet of any normal bank line or island, without special authorization. When dredging is performed adjacent to river stabilization structures, the dredging may be conducted only in the present streambed of the river at the authorized locations. This condition represents only the minimum distances needed between dredging and structures and natural features and does not relieve the permittee from liability for damage arising from dredging. The permittee must be satisfied that dredging to these limits will not cause damage to public and private property.

3.7.2.2 Water supply

Dredging too close to water intake structures, even at sustainable levels, can harm these structures through direct physical contact; by undermining, exposing, destabilizing, or weakening these structures; and by negatively affecting water quality at the water intake. Dredging over horizontal collector wells can harm these wells by direct physical contact and by modifying the depth and physical characteristics of the river bed over the wells and negatively affecting the volume and quality of water pumped by the wells. The following conditions are necessary to avoid adverse impacts to municipal drinking water intake structures and provide a mixing zone sufficient to reestablish water quality to background conditions on the Missouri River; to preserve the existing permeable aquifer material and avoid adverse impacts to the horizontal collector wells; and to avoid adverse impacts to water intake structures and water quality of water users other than municipal drinking water providers.

- The permittee must not conduct dredging operations in a zone extending 4,000 feet upstream and 500 feet downstream from any municipal drinking water intake structures located along either bank of the river unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, Corps of Engineers.

- The permittee must not conduct dredging operations in a zone extending 1,000 feet upstream and 1,000 feet downstream from any municipal drinking water horizontal collector wells located along either bank of the river unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, USACE.

- The permittee must not conduct dredging operations in a zone extending 500 feet upstream and 500 feet downstream from any other water intake structures other than those used for municipal drinking water unless he obtains an exemption to this condition in writing from the Chief of the Regulatory Branch, Kansas City District, USACE.

3.7.2.3 Pallid Sturgeon Habitat and Cultural Resources

Previous dredging permit evaluations have determined that dredging in the specific locations authorized by those permits would not have any direct adverse effect on any cultural resources or endangered species. The FEIS (USACE 2011) looked at a larger area of potential effect and identified various potential impacts that dredging could have on the endangered pallid sturgeon and on known and unknown but potential cultural resources throughout the Action Area if dredging caused more than slight bed degradation in the short- and long-term or if dredging expanded into areas not previously dredged. The first condition is a practicable measure that is necessary to ensure that adverse impacts of the authorized activity on cultural resources and the pallid sturgeon and its habitat are evaluated and minimized when dredging expands outside currently dredged reaches. The pallid sturgeon habitat protection areas listed on Table 3-7 include specific areas where monitoring has most frequently found pallid sturgeon that could be directly impacted by dredging. The protection areas also include USACE shallow water habitat project sites that could be negatively impacted by dredging through physical disturbance and by removing coarse sediment from the bed load at locations where it is needed to form the sand and gravel bars in chutes that are a vital part of shallow water habitat. Table 3-7 will be reevaluated by the USACE and discussed with the dredgers and the state and federal agencies each October along with degradation condition and trend indicated by the water surface profiles. The USACE and USFWS will also reevaluate the list when dredgers request new or expanded dredging areas. At these times, habitat protection zones may be added for newly completed shallow water habitat projects or newly identified pallid sturgeon habitat areas; habitat protection zones may also be deleted if shallow water habitat areas have matured and/or no longer need protection from adjacent dredging.

- To avoid impacting endangered species and cultural resources, the permittee must confine dredging to the specified reaches listed in Table 3-5. If the permittee desires to expand or relocate his dredging operation outside the specified reaches, he must submit a request to this office identifying the proposed new limits, in river miles, and the location of the unloading facility to be employed. Approval of the requests, if granted, will be provided in writing with modified reaches identified on the Missouri River Hydrographic Survey. Copies of the relocation requests must be furnished to the following agencies:

    1. U.S. Fish and Wildlife Service, Columbia Field Office
    2. Missouri Department of Natural Resources, Water Pollution Control Program
    3. Missouri Department of Natural Resources, State Historic Preservation Office
    4. Kansas Department of Health and Environment, Bureau of Water (for operations extending upstream of river mile 367)
    5. Kansas State Historical Society, State Historic Preservation Office (for operations extending upstream of river mile 367)
    6. Corps of Engineers, Kansas City District, Hydrologic Engineering Branch

- dredging is prohibited within the reaches identified in Table 3-7 as pallid sturgeon habitat features

Table 3-7 Pallid Sturgeon Habitat Areas Protected from Dredging on the Lower Missouri River

Missouri River Miles (including 0.25-mile buffer)		
Downstream Limit	Upstream Limit	Habitat Feature
44.25	44.85	RDB Centaur Chute
49.15	50.05	RDB Centaur Chute
56.85	59.05	LDB Chute/Island
58.55	61.25	RDB Chute/Island
89.75	91.10	RDB Island
89.90	91.45	LDB Loutre Slough
91.20	93.55	LDB Lunch Island
103.00	104.95	Both Gasconade Confluence and Dike Field
105.20	106.25	RDB Dike Field
115.20	115.95	RDB Island
118.40	119.15	RDB Dike Field
119.35	119.85	RDB St. Albert Chute

Missouri River Miles (including 0.25-mile buffer)		
Downstream Limit	Upstream Limit	Habitat Feature
124.35	124.95	RDB St. Albert Chute
126.05	126.90	LDB Dike Field
127.50	130.20	Both Osage River Confluence and Dike Field
157.00	158.45	LDB Island
176.40	178.35	LDB Island/RDB Tadpole Island Chute
180.15	180.65	RDB Tadpole Island Chute
184.75	185.65	RDB Chute
186.90	188.20	RDB Chute and Dike Field
193.40	195.75	RDB Dike Field/Island
202.10	202.75	RDB Lamine River Confluence
210.00	219.65	Lisbon/Jameson Complex
226.95	227.55	LDB Little Chariton Confluence
238.40	239.10	LDB Chariton River Confluence
249.65	250.30	LDB Grand River Confluence
269.85	271.35	RDB Shallow/Island
280.40	282.05	RDB Island
297.90	299.05	RDB Island
300.00	301.05	LDB Island
367.00	367.75	RDB Kansas River Confluence
390.85	391.45	LDB Platte River Confluence
456.75	457.25	LDB Worthwine Chute
458.75	459.25	LDB Worthwine Chute
462.65	463.25	LDB Nodaway River Confluence
478.55	479.15	RDB Wolf Creek Confluence
494.55	495.20	RDB Big Nemaha River Confluence

Source: USACE 2010a

Notes:

LDB = Left downstream bank.

RDB = Right downstream bank.

3.7.2.4 Degraded Reaches

As discussed in Section 3.5, if dredging were not distributed more broadly and were allowed to remain concentrated around the existing sand plants, the level of future river bed degradation and associated direct and indirect impacts under these alternatives would be expected to be locally moderate to substantial. There would also likely be some loss of shallow water habitat in these areas of moderate to substantial bed degradation. The following condition is necessary to ensure that dredging results in no more than slight degradation throughout each river segment but particularly in the most severely degraded reaches near some existing sand plants.

- No more than 300,000 tons of material shall be extracted within one year from each five-mile reach of the Missouri River between river miles 15 to 20, 25 to 35, 90 to 100, 140 to 150, 355 to 395, and 445 to 455. When the Corps' dredge report database indicates that extraction in a five-mile reach has reached 300,000 tons, all dredgers authorized to operate within that reach will be notified that it is closed to further dredging for the remainder of the calendar year unless the permittee requests and receives a waiver in writing from the Chief of the Regulatory Branch, Kansas City District, U.S. Army Corps of Engineers.

3.7.3 Compliance and Monitoring Measures

The FEIS (USACE 2011) identified the Environmentally Preferred Alternative which is that alternative that causes the least damage to the biological and physical environment and that best protects, preserves, and enhances historic, cultural, and natural resources. The USACE has concluded that the LEDPA, which is the Environmentally Preferred Alternative with some adaptation to make it practicable, should result in no more than slight degradation throughout the LOMR in the short- and long-term. These conclusions were based on the use interpretation of sediment transport equations and underlying data, the results of which include some level of uncertainty. While the results and the interpretation of the effects of bed degradation are based on the best currently available scientific data, sediment transport and estimates of previous bed degradation are indicators rather than accurate predictors of future degradation. The following permit conditions are part of a process to monitor key variables in the LOMR system throughout the 5-year permit cycle and provide information needed to determine whether dredging levels or permit restrictions should be adjusted. Such a monitoring and reevaluation process will allow the uncertainty inherent in the modeling and analysis of bed degradation to be addressed. It also will reduce the risk of potentially significant impacts, increasing the confidence that adjustments could be made to address impacts while they are relatively small. The permit conditions are also necessary to ensure that the dredgers comply with the conditions restricting where and how much material may be dredged.

- Within 30 days of execution of the permit, the permittee must provide a Dredge Monitoring Plan (DMP) for each individual dredge plant to the Regulatory Branch of the USACE, Kansas City District for approval. The DMP must show how the permittee will monitor, record, and report the cutter-head position, cutter-head operating status, extraction tonnage, and the presence of any hard substrates, mussel shells, or unusual concentration of gravel in an impartial, unbiased, reliable, and accurate manner. The DMP must include the specifications of the process and the Dredge Monitoring System (DMS) including sensors, hardware, software, communications devices that will: gather data; perform quality control on those data; calibrate, test, and repair sensors/data reporting equipment when they fail; and transfer the data to the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District. The DMS must include automated differential Global Positioning System (DGPS) equipment (or other comparable system) operating with a minimum accuracy level of 1-3 meters horizontal Circular Error Probable with horizontal positions tied into the UTM Zone 15 NAD 83 (feet) coordinate system recorded to the nearest foot. The DMS must always be on, recording cutter-head position and operating status every 5 minutes, 24-hours a day, 365 days a year, even when the dredge is not operating. The DMS must measure the amount of material removed from the river for each day the dredge is operational. The extraction material shall be measured by one of the methods described in the attached Standard Operating Procedure for Hydrographic Surveying and Dredge Monitoring. Faulty sensors or other components of the DMP system must be repaired within 96 hours. The DMS must not be inoperable more than 5% of the time. The permittee must install an approved DMS and have it inspected by the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District within 120 days of execution of the permit or the permittee must cease dredging operations until it is installed and inspected or the permittee submit a justification of the delay and an installation schedule and get an extension of this deadline in writing from the Chief of the Regulatory Branch, Kansas City District, USACE. **C/M**

- The Corps of Engineers periodically surveys the river as part of the management and operation of the Bank Stabilization and Navigation Project. If the Corps of Engineers for any reason has not surveyed the river in the fourth year (2014) of the five-year permit cycle, the authorized dredging companies must have the lower 498 miles of the LOMR surveyed during the summer months in accordance with the Standard Operating Procedures for Hydrographic Surveying and Dredge Monitoring. The survey shall be completed between June and September of 2014 and submitted to the USACE by January 1, 2015.
- If any part of the authorized work is performed by a contractor, before starting work the permittee must discuss the terms and conditions of this permit with the contractor and must give a copy of this entire permit to the contractor. After the initial 120 days of this permit, any contracted dredges or barges must also be equipped with and operate in accordance with an approved DMP as required

in Special Condition “b”. The DMP and system must be approved by the Regulatory Branch of the U.S. Army Corps of Engineers, Kansas City District prior to starting work.

- Until the dredges and barges are equipped with the DMS required by Special Condition “b”, the permittee must, for each dredge operated, record Global Positioning System (GPS) coordinates, tons of material removed, and the presence of any hard substrates or unusual concentration of gravel daily. If the dredge moves more than 100 feet in any one day then the amount of material removed from each location must be recorded separately. The operators may use hand-held GPS devices or automatically recording devices, but with which ever system used, must identify the device make/model and recording location. This information must be recorded on the attached Missouri River Commercial Dredging Location/Volume Report in an electronic spreadsheet. The permittee must furnish a copy of the completed monthly report by email to cody.s.wheeler@usace.army.mil at the Kansas City District Regulatory Branch by the 7th day of the following month. If the permittee does not receive an email confirmation that the report was received, he must contact the Regulatory Branch at 816-389-3990 for revised instructions for filing the monthly report.

3.8 ACTION AREA

The Action Area considered in this BA is defined as the geographic area within which the direct or indirect effects (physical, chemical, and/or biotic) of the proposed federal action will occur, and conforms closely to the geographic scope of the FEIS (USACE 2011). It includes the main channel and floodplain of the LOMR from the confluence of the Missouri and Mississippi Rivers in St. Louis, Missouri (RM 0) to Rulo, Nebraska at RM 500 (see Figure 3-1). The Action Area also includes perennial tributaries joining the LOMR for a distance of 0.25 mile upstream or to the first upstream control point. A “control point” includes any natural streambed feature or human-made structure that provides grade control and controls or impedes the upstream progress of a headcut.

Six Recovery Priority Management Areas (RPMA) were defined and identified in the Pallid Sturgeon Recovery Plan (USFWS 1993) for implementation of recovery tasks. These were based on population and geographic considerations, and based on the potential of these areas for recovery of the species. The Action Area of this biological assessment corresponds closely with the Lower Missouri River portion of RPMA 4, which is defined as the Missouri River downstream of Gavins Point Dam, South Dakota to the Missouri River/Mississippi River confluence, including major tributaries such as the Platte River.

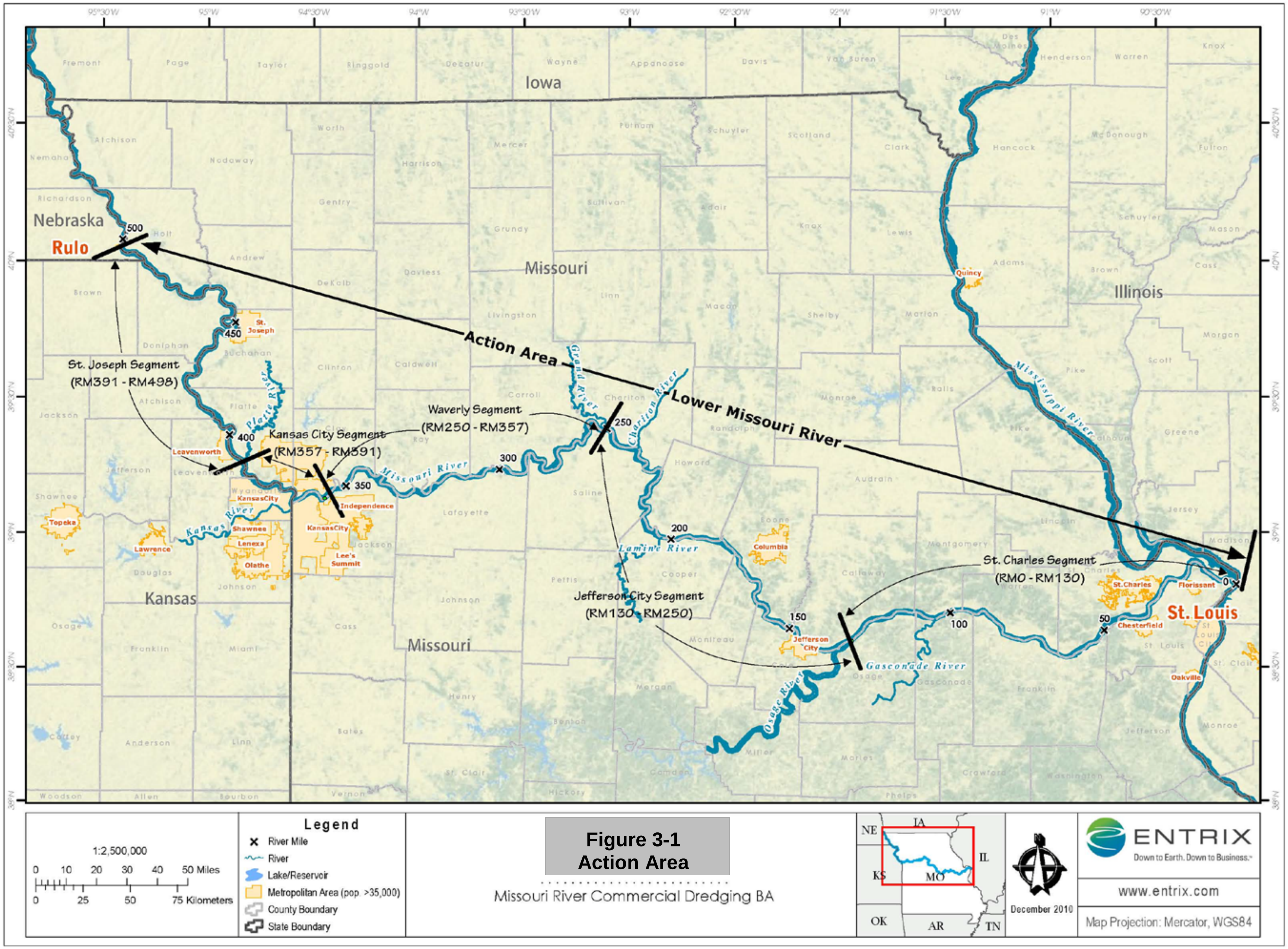

Figure 3-1
Action Area

SECTION 4

Status of the Species and Critical Habitat

4.1 PALLID STURGEON

4.1.1 Status Designation

The pallid sturgeon was federally listed as endangered under the ESA on September 6, 1990 (55 FR 36641).

Pallid sturgeon coexist with shovelnose sturgeon throughout the Missouri River system, including portions of the Yellowstone, Platte, and Kansas Rivers; the Mississippi River downstream of the mouth of the Missouri River; and the Atchafalaya River in Louisiana.

Critical habitat for pallid sturgeon has not been designated.

4.1.2 Species Description

The pallid sturgeon (*Scaphirhynchus albus*) is one of eight North American species of sturgeon, and one of three in North America in the genus *Scaphirhynchus*. The other two species within this genus are the shovelnose sturgeon (*Scaphirhynchus platorynchus*) and the Alabama sturgeon (*Scaphirhynchus suttkus*). The shovelnose sturgeon co-occurs with pallid sturgeon in the LOMR, and the Alabama sturgeon occurs only in the Mobile River Basin of Alabama and Mississippi (Williams and Clemmer 1991, USFWS 1993). The pallid sturgeon was first described by S. A. Forbes and R. E. Richardson in 1905, from nine specimens collected from the Mississippi River near Grafton, Illinois, in June 1904 (Forbes and Richardson 1905). Pallid sturgeon have a flattened, shovel-shaped snout; have a long, slender, and completely armored caudal peduncle; and lack a spiracle (Smith 1979). As with other sturgeon, the mouth is toothless, protractible, and ventrally positioned under the snout (USFWS 1993). The skeletal structure is primarily cartilaginous (Gilbraith, Schwalbach, and Berry 1988). Pallid sturgeon are one of the largest fish species in the

Missouri/Mississippi River drainage; they can weigh up to 80 pounds and reach lengths of 6 feet. Adult pallid sturgeon from the Upper Missouri River are generally larger than adults collected from the LOMR and the Lower Mississippi River (USFWS 1993). They are similar in appearance to the closely related and more common shovelnose sturgeon; however, shovelnose sturgeon rarely weigh more than 8 pounds, and their back and sides are brown compared to grayish-white of pallid sturgeon (USFWS 1993).

Because of the pallid sturgeon's similar appearance to the more common shovelnose sturgeon, the issue of their status as separate species has been debated since the pallid sturgeon was listed as an endangered species in 1990. However, studies conducted by genetics and fishery researchers—from as early as 1905 but primarily since their listing in 1990—have provided genetic evidence that, when coupled with morphological and biogeographic data, indicate that pallid sturgeon should be considered a separate species under the ESA (USFWS 2000).

4.1.3 Distribution and Abundance

In the late 1900s, the pallid sturgeon was described as one of the rarest, although widely distributed, fish of the Missouri River and lower Mississippi River (downstream from the mouth of the Missouri River) (USFWS 1993). The historical (pre-impoundment) range of the pallid sturgeon extended from the Missouri and Yellowstone Rivers in Montana downstream to the Missouri-Mississippi confluence and the Mississippi River possibly from near Keokuk, Iowa, downstream to the Gulf of Mexico (Coker 1929, Bailey and Cross 1954, Brown 1955, Kallemeyn 1983) (Figure 4-1).

The Missouri Department of Conservation's Blind Pony Hatchery was the first to successfully spawn pallid sturgeon in 1992. Since1994, over 436,000 fingerling-size or larger pallid sturgeon have been stocked into the Missouri River, of which nearly 94,000 have been stocked in the LOMR between Gavins Point Dam and the mouth (Figure 4-2).

As part of implementation of the USFWS 2000 Biological Opinion (2000 BiOp) as amended in USFWS (2003), the USACE has developed a pallid sturgeon population assessment program to document current and long-term trends in pallid sturgeon population abundance, distribution, and habitat usage throughout the Missouri River system. Standardized sampling has been conducted annually since 2003. Starting in 2008, baited trotlines were added as a "non-standard" sampling gear. The number of pallid sturgeon sampled has substantially increased since the USACE started sampling (Figure 4-3). This increase in the number of fish sampled is likely due to effective baited trotline sampling and pallid sturgeon stocking programs.

Figure 4-1 Pre-Impoundment Range of Pallid Sturgeon in Missouri and Mississippi Rivers

Source: Bailey and Cross 1954
Notes: Bold red line approximates historical range of pallid sturgeon.
Map not to scale.

4.1.4 Life History and Ecology

Prior to 2000, little was known about this species in the wild (USFWS 2003). However, substantial new information about the status and life history of the pallid sturgeon has been gained in the last decade as a result of the USACE compliance activities for the 2000 BiOp. Although numerous studies since 2000 have documented pallid sturgeon behavior, life history, genetics, habitat use, and distribution, the general life history of pallid sturgeon is still considered complex.

Generally, pallid sturgeon migrate upstream to spawn (Wildhaber et al. 2007) (Figure 4-4). Eggs incubate in these upstream locations, and the embryos and post-hatch larvae are free drifting downstream. The post-hatch larvae drift downstream and grow for approximately 10 days while they develop for exogenous feeding. The transition to the exogenous feeding larval stage approximately coincides with the transition to the utilization of benthic habitats. The early life history stages of pallid sturgeon are exceptionally vulnerable to predation and competition for food resources. The majority of adult fish species present in the LOMR feed on the zooplankton, which partially consists of pallid sturgeon and other fish in early life stages.

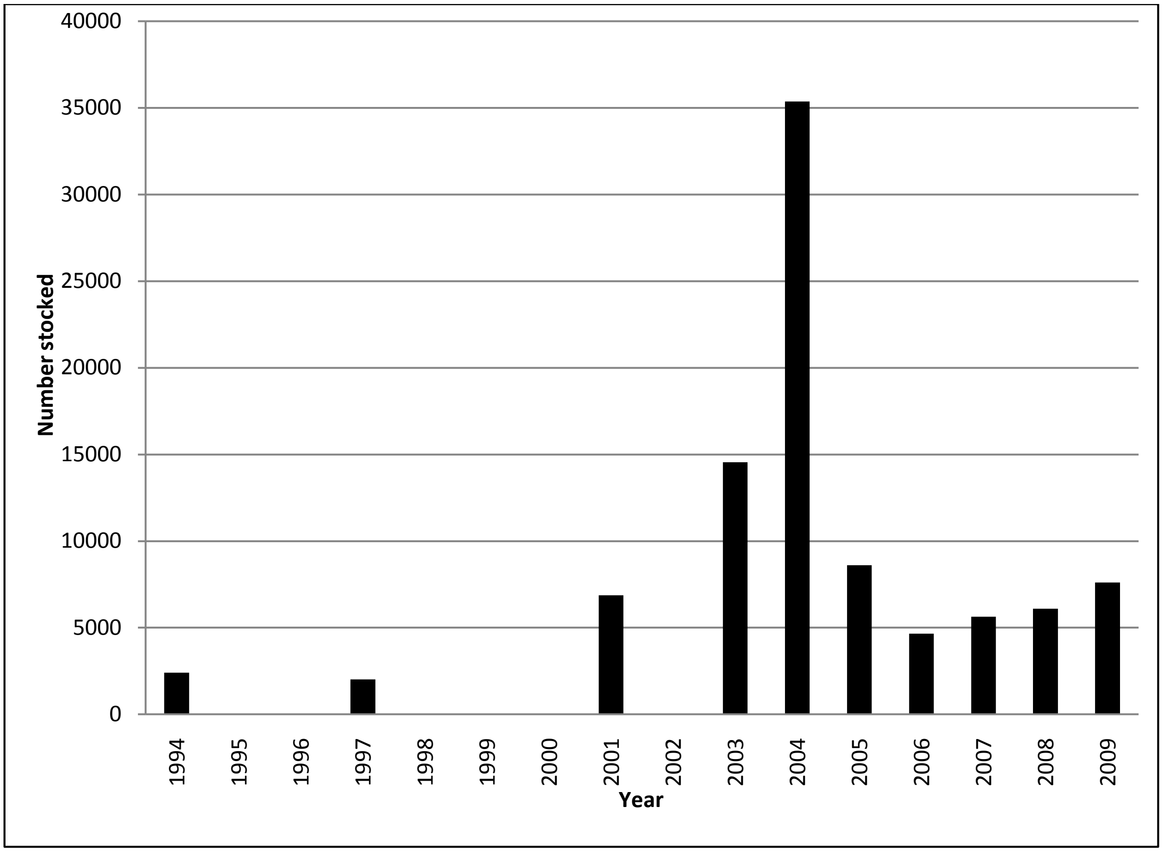

Figure 4-2 Numbers of Pallid Sturgeon Stocked in the Lower Missouri River from Gavins Point Dam and the Mouth (1994–2009)

Note: Data compiled by USACE based on sturgeon sampling data for the lower Missouri River from Gavins Point Dam to the mouth from individual Population Assessment annual reports.

Many other environmental factors influence the survival and productivity of the pallid sturgeon at each of the various life stages. Scientists study the impacts of environmental factors such as temperature, various habitat uses, and predator-prey interactions on pallid sturgeon survival and population. Because pallid sturgeon habitat is so highly modified, it may be difficult for researchers to fully understand habitat requirements.

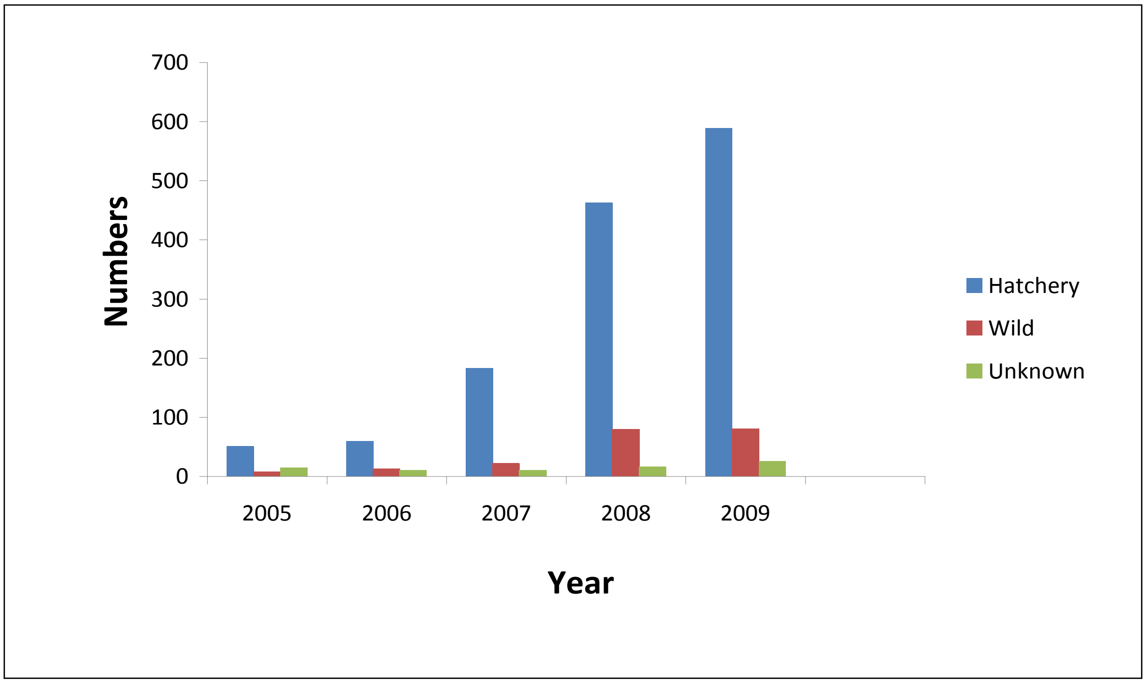

Figure 4-3 Numbers and Origin of Pallid Sturgeon Sampled on the Lower Missouri River from Gavins Point Dam to the Mouth (2005–2008)

Note: Stocking data is for fingerling-size, or larger, pallid sturgeon that have been stocked into the lower Missouri River between Gavins Point Dam and the mouth near St. Louis, Missouri. Data compiled by USACE based on sturgeon sampling data for the lower Missouri River from Gavins Point Dam to the mouth from individual Population Assessment annual reports.

4.1.4.1 Habitat

The pallid sturgeon is a bottom-oriented, large river obligate species that inhabits the Missouri and Mississippi Rivers and some tributaries, from Montana to Louisiana (Kallemeyn 1983) and the Atchafalaya River (Reed and Ewing 1993).

Pallid sturgeon evolved in the diverse environments of the Missouri and Mississippi Rivers. Floodplains, backwaters, chutes, sloughs, islands, sandbars, and main channel waters formed the large-river ecosystem that provided macrohabitat requirements for pallid sturgeon and other native large-river fishes, such as paddlefish and other sturgeon species. It should be noted, however, that much of these data are based on habitat characterizations conducted in altered environments, some of which have experienced substantial anthropogenic influences, including altered hydrograph, stabilized banks, loss of natural meanders and side channels, fragmented habitats, and increased water velocities. Thus, the current understanding of microhabitat usage may not indicate preferred habitats for the species but may better define suitable habitats within an altered ecosystem.

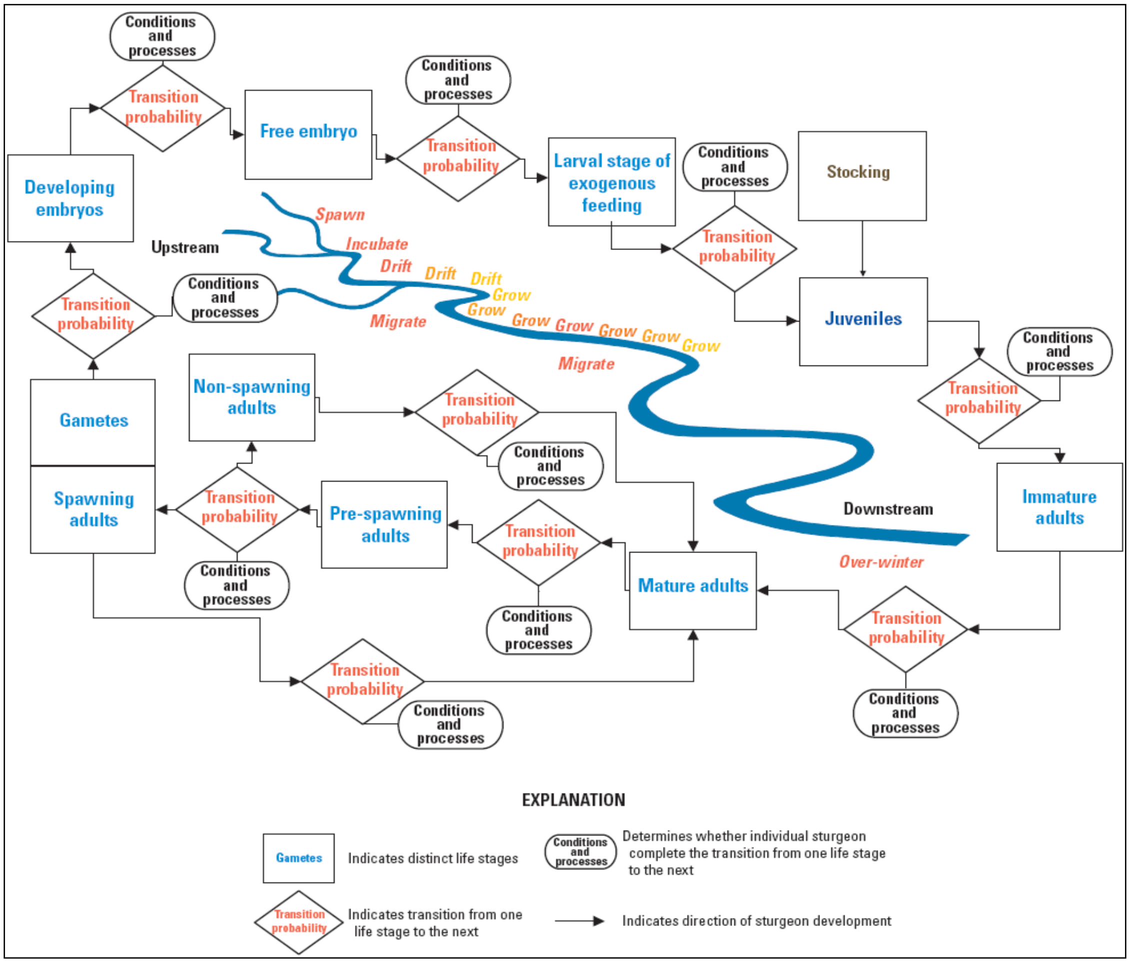

Figure 4-4 Conceptual Model of *Scaphirhynchus* Life History

Source: Wildhaber et al. 2007 with permission

Substrate

Pallid sturgeon have been documented over a variety of available substrates but are often associated with sandy and fine bottom materials in the Upper Missouri and Lower Yellowstone Rivers (Bramblett and White 2001; Gerrity, Guy, and Gardner 2005). Similarly, pallid sturgeon studied in the lower Platte River (Snook, Peters, and Young 2002; Swigle 2003; Peters and Parham 2008) and Middle Missouri River (Elliott, Jacobson, and DeLonay 2004; Spindler 2008) have also been associated with sandy substrates, which is the predominant substrate available. In these systems and others, pallid sturgeon appear to prefer underwater sand dunes (Bramblett 1996; Snook, Peters, and Young 2002; Elliott, Jacobson, and DeLonay 2004; Jordan et al. 2006).

Depth and Velocity

An assessment of the environmental characteristics at pallid sturgeon relocations compared to surrounding reaches suggests that they are found in nearly the full range of habitats available to them. Although the literature supports the idea that adult pallid sturgeon do not select strongly for depth, there seems to be a stronger selection for velocity (Reuter et al. 2009). In the Upper Missouri River Gerrity, Guy, and Gardner (2008) observed hatchery-reared pallid sturgeon in areas with mean depths ranging from 2.31 to 2.48 m; water column velocities associated with these observations were between 0.65 and 0.78 meter per second (m/s) and bottom velocities were between 0.67 m/s and 0.87 m/s. Bramblett and White (2001) report wild pallid sturgeon using depths between 0.6 and 14.5 m in the Lower Yellowstone River, with average bottom velocities of 0.65 m/s. In the Missouri portion of the Missouri River, wild pallid sturgeon were collected from areas with bottom velocities between 0.3 and 0.73 m/s at depths ranging from 1.2 to 13.8 m (Carlson and Pflieger 1981).

Hatchery-reared pallid sturgeon studied between Fort Randall and Gavins Point Dams were most frequently observed at depths exceeding 3 m and where bottom water velocities ranged from 0.1 to 0.9 m/s (Jordan et al. 2006). Elliott, Jacobson, and DeLonay (2004), using more sophisticated equipment and location data from the same fish study, reported that pallid sturgeon used areas with velocities from 0.69 to 1.01 m/s and suggest that they were using velocity in proportion to availability within the reach.

That sturgeon show a tendency to select some habitats while avoiding others is apparent in the literature. For example, patterns of depth availability and selection by sturgeon vary considerably by river sections while pattern selection for other variables, such as velocity, may be more consistent among river sections (Reuter et al. 2009).

Turbidity and Sediment

Pallid sturgeon evolved in the Missouri and Mississippi River systems. The association of pallid sturgeon with these large river systems has led to the conclusion that high sediment loads, and the associated elevated turbidity levels, are important for some of the pallid sturgeon life history components. Despite this conclusion, pallid sturgeon appear to be able to survive and utilize areas with consistently low turbidities (such as the impounded reaches of the Missouri River). Jordan et al. (2006) report study fish surviving below Fort Randall Dam, South Dakota where reported turbidities were between 5 and 12 nephelometric turbidity units (NTU). In Lake Sharpe, South Dakota, pallid sturgeon were found most frequently in water with measured turbidity values of 80–100 NTU. Conversely, in a more natural system like the Yellowstone River, wild and hatchery origin pallid sturgeon have been found in areas with turbidity levels seasonally exceeding 1,000 NTU. These data suggest that individual juvenile and adult pallid sturgeon can survive over a wide range of turbidity levels. Peters and Parham (2008) provide a variety of data that indicate the Lower Platte River experiences both annual and seasonal changes in turbidity, and the levels reported for the Lower Platte River encompass levels associated with pallid sturgeon found elsewhere.

Sediment is an important variable in environmental restoration of a river system like the Missouri River. Currently, it is not fully understood if high sediment loads are fundamentally important to individual juvenile and adult fish given the variability of turbidity previously reported. The general consensus is that sediment concentrations and transport are as important as the quantity and flow of water, are the basic building material for river landforms that support habitat for native fauna, and have been important to the evolution and adaptation of native fishes such as pallid sturgeon (NAS 2010). Thus, areas defined by high sediment levels and subsequently high turbidity levels, and that fluctuate seasonally and annually, may better mimic natural pre-alteration variability within the LOMR.

4.1.4.2 Reproductive Biology

Pallid sturgeon are long lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). Spawning is reported to occur between June and August, and females may not spawn every year (Kallemeyn 1983). Larval fish drift downstream from the hatching site for approximately 11 to 13 days before settling in the lower portion of the water column (Kynard, Henyey, and Morgan 2002; Kynard et al. 2007; Braaten et al. 2008)

Knowledge of pallid sturgeon reproduction or spawning behavior, such as microhabitat characteristics of spawning locations, substrate preference, water temperature, and spawning timing, has been rapidly increasing. Because most of the current research has been conducted in the context of a highly altered river, results indicate which habitats that are currently available are used by the pallid sturgeon for spawning.

The USFWS summarized available literature regarding pallid sturgeon in their 2000 BiOp. Pallid sturgeon are most frequently caught over a sand bottom, which is the predominant bottom substrate within the species' range on the Missouri and Mississippi Rivers. Constant et al. (1997) noted that pallid sturgeon spent considerable time associated with sand substrates. They noted that preference for sand substrates in low-slope areas suggests that pallid sturgeon use such areas as current refugia (e.g., use sand-wave troughs created as bed material moves along the river bottom. The pallid sturgeon collected on the Yellowstone River in July 1991 by Watson and Stewart (1991) was over a bottom of mainly gravel and rock, which is the predominant substrate at that capture site. Reed and Ewing (1993) found sturgeon occurring in the man-made, rip-rap lined outfall channels of the Old River Control Complex in Louisiana. Bramblett (1996) found that pallid sturgeon preferred sandy substrates, particularly sand dunes, and avoided substrates of gravel and cobble. Pallid sturgeon have adhesive eggs. Thus, spawning is thought to occur over hard substrates of gravel or cobble with moderate flow. However, information regarding pallid sturgeon reproduction and spawning remains scarce. Much of what has been learned is based on sampling of larval sturgeon, most of which are shovelnose sturgeon. From repeated collections of larval sturgeon in the Middle Mississippi River, Hrabik (2002) surmised that sturgeon (shovelnose and pallid) are spawning at the head of islands or other locations upstream and being transported as larvae to eddy pools along island shores and to the downstream tips of islands that may provide refugia for the developing fish. Doyle and Starostka (2003, reported in USFWS 2003) found juvenile sturgeon to be strongly associated with main channel sand bars over sand substrate and were caught throughout the range of velocities sampled. They collected young of the year (YOY) juvenile sturgeon and pallid sturgeon with trawls on sand bars, island tips, and notched L dikes. The YOY sturgeon were found along channel sand bars, as well as behind notched dikes with moderate flows. The authors suggest that there appears to be a preference for habitat created by dike modifications or islands that is used by pallid sturgeon, lake sturgeon, and shovelnose sturgeon during early life stages (Doyle and Starostka 2003, reported in USFWS 2003).

DeLonay and Little (2002) reported that radio-tagged sturgeon were almost exclusively found over a sand substrate (>95 percent) in the Lower Missouri River. Sand is the predominate substrate in this area. Pallid sturgeon were found in locations with current during all seasons, characterized by velocities ranging from 0.25 to 1.8 m/sec with the mean slightly greater than 1 m/sec (DeLonay and Little 2002). The depths at relocation points ranged from <1 to 10.5 m and averaged 3 m. The authors note that the usefulness of descriptive measurements of habitat such as depth and velocity is suspect due to the dynamic nature of river habitats. They reported that sturgeon were often found in locations of turbulence or complex current patterns, such as wing dike tips, off sand bars, or near steep drop offs—where current could vary by as much as 1.5 m/s between each side of the tracking vessel (DeLonay and Little 2002). They also found that sharp changes in bottom relief (drop offs, shelves, and scours), the spacing of engineered flow training structures, and the position of the thalweg appear to have greater influence over sturgeon location than depth, substrate, or velocity. Sturgeon were most often located in areas with moderate velocities at the channel margin or border, on outside bends, near sand islands, and off the tips of wing dikes. Areas with slack water were not used, and sturgeon were relocated with less frequency in narrow straight reaches with closely spaced wing dikes (DeLonay and Little 2002).

Intensive tracking of reproductive adult pallid sturgeon has been conducted recently through the Comprehensive Sturgeon Research Project (CSRP). Two wild pallid females were tracked to apices of their migration in 2007; when subsequently recaptured, they were determined to have spawned completely. This study was the first to document spawning of pallid sturgeon in the Lower Missouri River. In 2008, three separate pallid sturgeon spawning patches were resolved to areas of several hundreds of square meters by intensive tracking of three gravid female pallid sturgeon of hatchery origin. Each of the three geographically separated patches was on the outside of a revetted bend, with deep, relatively fast, and turbulent flow (DeLonay et al. 2010). Similar results to those observed in 2008 were observed in 2009 where it was documented that spawning occurred in deep (>3 m), swift water (>1 m/s) over or adjacent to course substrate along the base of a revetted outside bend (DeLonay et al. 2010). Hatchery-propagated pallid sturgeon were also documented spawning in the LOMR, indicating that hatchery progeny are surviving, growing, reaching reproductive maturity, and now potentially contributing a new generation of fish.

The results from the CSRP support the hypothesis that spawning location, water velocities, growth rates, and drift dynamics determine the spatial and temporal distribution of pallid sturgeon larvae and juveniles in the Missouri River (DeLonay et al. 2010). Calculations based on mean reach velocities indicate that drifting larvae that hatch along much of the LOMR have the potential to drift into the Mississippi River. The authors emphasize that habitat restoration that facilitates spawning further upstream, increases river length (by restoring cut-off channels), or decreases larval drift distance may assist in recruiting *Scaphirhynchus* sturgeon in the Missouri River. Improved understanding of typical drift distances of larval *Scaphirhynchus* sturgeon may provide useful guidance for placement of channel-restoration projects intended to provide rearing habitat. Whether larval sturgeon habitat is limiting for survival of larval sturgeon has not yet been determined. However, DeLonay et al. (2010) consider their results to indicate that spawning habitat availability is not a limiting factor in pallid sturgeon reproduction in the LOMR.

4.1.4.3 Diet

Food items consumed by pallid sturgeon range from aquatic insects to fish depending on life stage (Gerrity, Guy, and Gardner 2006, 2005; Wanner 2006). A number of studies have examined the food intake of pallid sturgeon; however, little information exists on their food habits. It is believed that pallid sturgeon are opportunistic suctorial feeders on benthic organisms (Held 1969, Carlson et al. 1985, Keenlyne 1997). Much of the dietary research on pallid sturgeon has been completed in conjunction with research on the food consumption of the closely related shovelnose sturgeon. These studies show that the majority of both these species' diets are comprised of aquatic insects, although pallid sturgeon generally consume more fish than the shovelnose sturgeon (Carlson et al. 1985). These findings suggest that the pallid sturgeon occupy a higher trophic level than the shovelnose, which may help explain the greater decline in their population (Gerrity, Guy, and Gardner 2006).

Pallid sturgeon diet is generally composed of fish and aquatic insect larvae, suggesting that pallid sturgeon may be omnivorous with a preference for piscivory as the fish reach larger sizes. Food habits of age-0 to age-1 pallid sturgeon are poorly understood. In a hatchery environment, exogenously feeding fry will consume brine shrimp, suggesting that zooplankton and small invertebrates are likely the food base for this age group. Carlson and Pflieger (1981) report the stomach contents (ml/fish) collected from pallid sturgeon (N=9, average length 67 centimeters [cm]) were composed of 38 percent fish, 38 percent *Trichoptera* (caddisflies), 9 percent *Odonata* (dragonflies and damselflies), 6 percent *Ehpemeroptera* (mayflies), and 3 percent *Diptera* (true flies), with the remaining 6 percent being plant and other material. Similarly, Wanner (2006) analyzed collected gut content from hatchery-reared pallid sturgeon released in South Dakota and found insects and fish as the primary food items. In his study, Wanner (2006) found that, by number, *Chironomidae* (non-biting midges) was the most abundant food item observed in 2003 and 2004, but fishes dominated percent composition (dry weight) in 2003 and *Ephemeroptera* was the dominant food item (percent dry weight) in 2004. Study fish in this effort ranged between 38.5 and 70.6 cm fork length (FL) (mean FL in 2003 was 53.1 cm and 58.1 cm in 2004). Gerrity, Guy, and Gardner (2006) found that fish comprised a majority of the diet (90 percent by wet weight) of their study fish (age-6 and age-7 hatchery0reared pallid sturgeon, average FL = 53.8 cm) in the Missouri River, Montana. These authors also report the presence of *Trichoptera*, *Chironomidae*, *Ephemeroptera*, and detritus in at least 10 percent of the fish. In the Middle and Lower Mississippi River, Hoover, George, and Killgore (2007) found wild and hatchery-reared pallid sturgeon adult food items to be primarily fish, based on volume. These authors also note both seasonal and locational variability in food items. Percent of total food volume collected from wild pallid sturgeon in the Lower Mississippi River is reported as follows: Spring diets were primarily composed of fish (77 percent), with invertebrates totaling 22.6 percent; winter diets were also primarily composed of fish (52.5 percent), with invertebrates comprising 47 percent of the collected volume. In the Middle Mississippi River, hatchery-reared and wild adult pallid sturgeon diets also were dominated by fish (68.9 percent of total volume), with invertebrates totaling 30.5 percent of total volume during spring sampling; and fish composed 95.6 percent of total diet volume collected during winter while invertebrates totaled only 4.4 percent during winter (Hoover, George, and Killgore 2007).

4.1.5 Threats

4.1.5.1 Habitat Alteration

Pallid sturgeon habitat has been dramatically altered over the past 60 years. Approximately 51 percent of the pallid sturgeon's historical range has been affected to some degree by channelization. Approximately 28 percent of historical habitat has been impounded; and 21 percent is affected by upstream impoundments that alter flow regimes, depress turbidity and water temperatures, and have continuing bank stabilization activities that limit channel meandering (Keenlyne 1989, USFWS 2000). These modifications to the river may restrict the life cycle requirements of pallid sturgeon by blocking movements to spawning and feeding areas, decreasing turbidity levels, altering larval drift distances, destroying spawning areas, altering conditions and flows of potential remaining spawning areas, and reducing food sources by lowering productivity (Keenlyne 1989, USFWS 2000).

4.1.5.2 Overharvest

Overharvest for commercial, recreational, scientific, or educational purposes is one of the threats to pallid sturgeon identified in the species' listing determination. Following listing, Montana, North Dakota, South Dakota, Nebraska, and Iowa closed all commercial sturgeon fishing on the Missouri River.

Today, four states—Tennessee, Missouri (except on the Missouri River upstream of the Kansas River to the Iowa border), Kentucky, and Illinois—allow commercial harvest of shovelnose sturgeon in waters occupied by pallid sturgeon. Allowing commercial fishing for shovelnose sturgeon in areas with overlapping pallid sturgeon ranges has resulted in the documented take of pallid sturgeon (Sheehan et al. 1997, USFWS 2007a, Bettoli et al. 2009). Mortality rates for pallid and shovelnose sturgeon suggest that incidental or illegal harvest of pallid sturgeon may be occurring in reaches where commercial shovelnose sturgeon harvest occurs.

As stated previously (Section 4.1.1), the shovelnose and pallid sturgeon and their roe (eggs sold as caviar) are similar in appearance. Currently, there is no reliable and completely accurate way to visually or genetically discern among roe of the two species, making enforcement of existing closed fishery regulations difficult.

4.1.5.3 Disease

Regulated pathogens of nationwide concern include viral, bacterial, and parasitic agents. These pathogens are those with the potential to produce severe epizootics of clinical disease but are also known to exist in a carrier state. Two pathogens of notable importance for pallid sturgeon recovery are a rhabdovirus (Viral Hemorrhagic Septicemia Virus [VHSv]) and an iridovirus (pallid sturgeon Iridovirus [PSIV]).

VHSv is a viral fish disease that has caused large-scale mortalities in numerous fish species. This virus has a number of identified isolates grouped in four types; three are from Europe and one is from North America. Each appears to have unique effects with specific pathogenicity on certain species. While the virus has not been documented to affect pallid sturgeon, it also has not been found in the range of the species. Since this pathogen can cause large scale mortalities in fish populations and it has a wide range of potential carriers, it is critical to make every attempt to monitor pallid sturgeon for VHSv.

PSIV is a concern in the context of pallid sturgeon recovery because it is known to cause mortalities in hatchery-reared pallid sturgeon; its effect on free-ranging sturgeon populations is unknown. The PSIV was first detected in shovelnose at the Gavins Point National Fish Hatchery in 1999. This iridovirus is known to infect pallid and shovelnose sturgeon. The disease originally surfaced during artificial propagation efforts and is known to cause substantial mortality in a hatchery rearing environment (USFWS 2006a). The iridovirus was first identified by histology from a female pallid sturgeon held at Garrison Dam National Fish Hatchery (USFWS 2006a). Subsequent testing has documented that this virus is found in the wild. Of 179 *Scaphirhynchus* tested from the Atchafalaya River between November 2003 and May 2004, eight (4 percent) were identified as virus positive and five (2.8 percent) were considered virus suspect. Both pallid and shovelnose sturgeon tested either positive or suspect. When manifested, this disease is known to cause substantial mortality in a hatchery rearing environment, but the effect of the virus on wild populations is poorly understood (USFWS 2006a).

4.1.5.4 Predation

Little information is available documenting piscivory as a threat limiting the recovery of the pallid sturgeon. Predation on larval fishes of all species occurs naturally. However, habitat modifications and increased water clarity and elevated non-native and native predatory fish populations could result in increased rates of predation on pallid sturgeon.

Pallid sturgeon embryos, post-hatch larvae ("free embryos"), and larvae drift freely (Kynard et al. 2007, Braaten et al. 2008). The distance any naturally spawned pallid sturgeon embryos and larvae are likely transported suggests a high rate of exposure to predation and a high likelihood of larvae being transported into the headwaters of reservoirs like Fort Peck and Lake Sakakawea. In addition to these reservoirs creating a more lentic environment, the reservoirs are, or have been, artificially supplemented with predatory species like walleye (*Sander vitreus*). Maintaining elevated populations of certain species in these reservoirs has been hypothesized as a contributing factor in poor survival of larval and juvenile pallid sturgeon. Parken and Scarnecchia (2002) reported that walleye and sauger (*Sander canadensis*) in Lake Sakakawea, North Dakota were capable of eating wild paddlefish (*Polyodon spathula*) up to 6.6 inches (167 mm) body length (12 inches [305 mm] total length) and thus likely could consume naturally produced pallid sturgeon larvae and smaller hatchery-produced pallid sturgeon released as part of supplementation efforts. When looking at these data for their sample location closest to the headwaters area, it appears that no age-0 paddlefish were found in walleye but were present in sauger, a native species closely related to walleye. Braaten and Fuller (2003, 2002) examined 759 stomachs from seven piscivorous species in Montana and found no evidence of predation on sturgeon. However, in all species sampled, unidentified fish or fish fragments were present. More data are needed to adequately assess predation effects on pallid sturgeon recruitment success.

In the LOMR, decreased turbidity may be a factor in predation on early life stages of pallid sturgeon. The significantly decreased suspended sediment levels in the water due to reservoir and water management may not be providing the level of turbidity cover that could be a critical, if not limiting, factor for the success of early life history stages. However, no studies have evaluated this hypothesis.

4.1.5.5 Pollution

Environmental contaminants have been documented in pallid sturgeon (Ruelle and Keenlyne 1992). Shovelnose sturgeon collected from the Lower Missouri River have been noted to exhibit both male and female gonad tissue (intersexual characteristics) (Wildhaber et al. 2005). Intersexual shovelnose sturgeon from the Middle Mississippi River were found to have higher concentrations of organochlorine compounds when compared to male shovelnose sturgeon (Koch et al. 2006).

Contaminant levels in pallid sturgeon also have been documented, but data are minimal. Elevated levels of polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium have been detected in tissue samples from three pallid sturgeon collected from the Missouri River in North Dakota and

Nebraska (Ruelle and Keenlyne 1992). Ruelle and Keenlyne (1992) also noted detectable concentrations of chlordane, DDT, DDE, and dieldrin. Research involving white sturgeon (*Acipenser transmontanus*) in the Columbia River found lower condition factors, gonadal abnormalities, and hermaphrodism in fishes with elevated levels of metabolites of DDT (DDE and DDD) as well as total PCBs and mercury (Feist et al. 2005). While the effects of contaminants on pallid sturgeon reproduction are poorly understood, observations of pallid sturgeon that exhibited both male and female reproductive organs have been documented (USEPA 2010).

4.1.5.6 Entrainment

Entrainment is the direct removal of aquatic organisms from the water column by the suction field or flow field generated at intakes of facilities or hydraulic dredges (Reine and Clarke 1998) or inflow zone of boat propellers. In areas of operation, suction-based dredging has posed an entrainment risk to pallid sturgeon and other aquatic organisms. Quantification of pallid sturgeon loss associated from this action and water diversion structures has not been accurately described, although some modeling estimates have been developed by USACE based on flow field predications of cutter-head dredges (McNair and Banks 1986). Preliminary data from non-dredging actions on the Missouri River suggest that entrainment may be a threat that warrants more investigation; most concerns are focused on early life stages, egg, and larvae, which are subject to drift and incapable of avoidance. Initial results from work conducted by Mid-America at their Neal Smith power facilities found that hatchery-reared pallid sturgeon were being entrained (Burns & McDonnell Engineering Company 2007a, 2007b). Over a 5-month period, four known hatchery-reared pallid sturgeon were entrained, of which two were released alive and two were found dead.

The USACE, St. Louis District, and the Dredging Operations and Environmental Research (DOER) Program have initiated research to assess the entrainment of larval and juvenile pallid sturgeon during dredging (Hoover et al. 2005). Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges. Larval and juvenile pallid sturgeon entrainment is known to occur in the few instances it has been studied. Uncertainty remains as to how extensive the encounters are and what the variation is during various times of the year. More details on entrainment are provided in Section 6.

4.1.6 Management and Protection

In addition to the dredging exclusion areas (Table 3-4), the amended BiOp (USFWS 2003) provides suggestions for extensive pallid sturgeon protective and recovery measures. The amended BiOp calls for restoration of a portion of the shallow water aquatic habitat lost from river engineering. Shallow-water habitat (SWH) on the LMOR is defined by the USFWS as water less than 5 feet (1.524 m) deep with a current velocity less than 2.5 feet per second (0.762 m/s), and is thought to be important for rearing of larval and juvenile pallid sturgeon (USACE 2004a). The BiOp also requires restoration of nearly 20,000 acres of SWH by 2020 and allows this habitat to substitute for achievement of SWH by variety of mechanisms, including excavation of side-channel chutes, dike notching, bank notching, and construction of chevrons.

Shallow water habitat projects in the main channel, such as dike notching, bank notching or chevrons, have been monitored under the Habitat Assessment and Monitoring Program (HAMP) since 2004. HAMP monitoring includes both biological response (fish species composition and richness) and habitat response (water depth, velocity and substrate) to SWH creation, with sampling designed to relate these two components. The main findings to date are that fish use of SWH is highly variable in project and control reaches (Sampson and Hall 2009 as cited in NAS 2010).

Reasonable and Prudent Alternatives are also described in the amended BiOp, with direct intent of pallid sturgeon species and habitat recovery. Achieving naturalization of the flow regime is a main goal of these efforts, with the intent to address (1) connection of the main channel to the flood plain seasonally for nutrient and energy exchange and fish access to floodplain habitats; (2) maintenance of nursery habitat for larval and juvenile pallid sturgeon (meeting essential late summer flows);
(3) providing environmental spawning cues for the pallid sturgeon through some combination of discharge and discharge-related variables like temperature, turbidity, and velocity; and (4) providing access to spawning habitat or "conditioning" of pallid sturgeon spawning habitat by flushing fine sediment from coarse substrate.

4.1.7 Status of Pallid Sturgeon in the Action Area

The Pallid Sturgeon Recovery Plan (USFWS 1993) identified six Recovery Priority Management Areas (RPMAs) for implementation of recovery tasks based on the most recent pallid sturgeon records of occurrence and the potential of these areas to contribute to the recovery of the species. The Action Area falls within the RPMA 4, which consists of the portion of the LOMR downstream of Gavins Point Dam to the confluence of the Missouri and Mississippi Rivers (USFWS 1993).

The distribution of the pallid sturgeon in Missouri, Kansas, and Nebraska is restricted to the LOMR mainstem, with some limited use of the downstream portions of some large tributaries. Since 1994, pallid sturgeon populations have been augmented with hatchery-reared fish (USFWS 2007a). Pallid sturgeon stocking data between 1994 and 2009 are presented in Table 3.10-2 and illustrated in Figure 3.10-1 of the FEIS (USACE 2011). The collection of individuals from all stocked cohorts indicates that hatchery supplementation is contributing to the pallid sturgeon population in RPMA 4. Between 1999 and 2005, 156 pallid sturgeon were captured in RPMA 4. Wild fish comprised 51 of the captured fish, while 82 captured fish were of hatchery origin and 24 fish were of unknown origin (USFWS 2007a). Unpublished 2009 sampling data provided by the USACE showed the capture of 589 hatchery-reared pallid sturgeon, 81 wild fish, and 26 fish of unknown origin; a total of 696 pallid sturgeon were captured in RPMA 4 in 2009 (Covington pers. comm.).

4.2 PIPING PLOVER

4.2.1 Description

The piping plover (*Charadrius melodus*) is a small migratory shorebird. Throughout the year, adults have a sand-colored upper body, white undersides, and orange legs. During the breeding season, adults develop orange bills and single black bands on the forehead and breast (USFWS 2001, 2000). Males and females are similar in appearance, but the male is slightly larger and the base of its bill is a brighter orange during breeding season. Juvenile plumage is similar to adult nonbreeding plumage, and this species acquires adult plumage the spring after it fledges (Prater, Marchant, and Vuorinen 1977).

The piping plover is a migratory species that is recognized to have distinct interior and coastal populations. The interior populations include the Great Lake–Big Rivers population and those that occur in the Great Plains region.

4.2.2 Status

The piping plover (*Charadrius melodus*) was federally listed on December 11, 1985 (50 FR, 50726-50734) (USFWS 1994). The populations in the Great Lakes–Big Rivers region, which does not include the Action Area, are listed as endangered. Piping plover populations outside of this region are listed as threatened. The state of Missouri considers the piping plover a transient species in Missouri.

The USFWS has designated critical habitat for this species in the Northern Great Plains region, which includes portions of Nebraska (50 FR 67 57638–57717). Critical habitat in Nebraska is outside of the Action Area. Kansas has designated critical habitat for piping plover on the Kansas River, from the confluence of the Smoky Hill River and Republican River downstream to the confluence of the Kansas and Missouri Rivers in Kansas City, Missouri (KDWP 2009).

4.2.3 Threats

The creation of reservoirs, channelization of rivers, and modifications of river flows have eliminated hundreds of miles of piping plover sandbar nesting habitat (USFWS 1994). Eggs and young are vulnerable to predation and human disturbance, including recreational activities and off-road vehicle use. Recreational effects include vehicular and pedestrian traffic on suitable nesting sites where eggs are well camouflaged within the sand.

Human-caused disturbance to wintering habitats is also a threat to the continued existence of this species. Motorized and pedestrian recreational activities, shoreline stabilization projects, navigation projects, and development can degrade and eliminate suitable wintering habitat for the species.

4.2.4 Reproduction and Development

The piping plover returns to its breeding grounds in mid-April, and most birds have arrived in the Northern Great Plains and initiate breeding behavior by mid-May (USFWS 1994). Populations that nest on the Missouri, Platte, Niobrara, and other rivers use beaches and dry barren sandbars with less than 25 percent vegetation cover in wide, open channel beds (USFWS 1994). Nesting piping plovers have been found in least tern nesting colonies at a number of sites on river sandbars and sand pits in the Great Plains (USFWS 1994).

The nest is typically far from cover and consists of shallow scrapes in the sand lined with small pebbles or shell fragments. Egg laying commences by the second or third week in May. The female generally chooses from several nest sites the male has constructed. Complete clutches contain three to four cryptically colored eggs (USFWS 1994), and incubation is shared by the male and female for an average of 26 days. Brooding duties also are shared by the male and female. Broods remain in nesting territories until they mature unless they are disturbed. Fledging takes approximately 21 to 35 days (USFWS 1994). If a nest fails or is destroyed, adults may re-nest up to four times (USFWS 1987). Breeding adults begin leaving nesting grounds as early as mid-July, with the majority gone by the end of August (Wiens 1986).

4.2.5 Diet

The piping plover feeds by alternating running and pausing to probe the sand and mud for prey items in or near shallow water (Bent 1929). Prey consists of marine worms, fly larvae, beetles, insects, crustaceans, mollusks, and other small invertebrates. In North and South Dakota reaches of the Missouri River, Le Fer, Frasera, and Krusec (2008) found that foraging adult plovers selected protected shoreline (inter-sandbar channels, inlets, and backwater areas) more often than expected based on availability. They suggest that these saturated and moist habitats typically supported higher numbers of macroinvertebrates, providing good food sources for chicks. The implication for these findings in the LOMR is that ongoing efforts to restore backwater and diverse habitats for fishery resources could eventually establish a habitat that provides a prey base for the piping plover.

4.2.6 Range

Historically, the piping plover bred in three geographic regions: the U.S. and Canadian Northern Great Plains from Alberta to Manitoba south to Nebraska, the Great Lakes beaches, and the Atlantic coastal beaches from Newfoundland to North Carolina (USFWS 1988a). The species current breeding range is similar except that breeding populations in the Great Lakes have almost disappeared (Haig and Plissner 1993).

Wintering areas are not well known, although wintering birds have been most often seen along the Gulf of Mexico, southern U.S. Atlantic coastal beaches from North Carolina to Florida, eastern Mexico, and scattered Caribbean Islands (Haig 1986, USFWS 1988a).

The distribution of piping plover in the Great Plains region includes several of the major river systems, reservoirs, and other suitable shoreline and wetland habitat. In Missouri, they are considered a transient species that rarely occur during migration (The Audubon Society of Missouri 2009). The Missouri River contains up to 70 percent of the Northern Great Plains population (USFWS 2009c), but the piping plover does not breed within the confined channels of the Action Area. In the LOMR, aquatic restoration techniques to create emergent sandbar habitat (ESH) and techniques that promote deposition areas could eventually provide suitable breeding habitat.

4.2.7 Population Level

The number of adult plovers on the Missouri River system has fluctuated from a low of 86 in 1997 to a high of 1,764 in 2005 and appears to be roughly correlated with the amount of suitable habitat available on the Missouri River system (USFWS 2009c). Since 2005, the number of breeding pairs has fluctuated below the 1988 recovery plan goal for the Great Lakes and Great Plains of 465 pairs (USFWS 1988a).

The main reason given for the population fluctuations is the availability of suitable habitat. The LOMR experienced high flows between 1996 and 1997, after which the Missouri River basin underwent a drought. During the drought period, the amount of water storage declined from 71.7 million acre feet (MAF) in 1997 to 33.9 MAF in 2007 (USFWS 2009c); the exposed reservoir shoreline habitat led to large numbers of plovers successfully nesting on the shores of the reservoirs. For example, on Lake Oahe from 1994 through 1997, there was an average of 42 adult piping plovers, whereas from 1998 through 2008, there was an average of 235 adults (USFWS 2000).

The current estimated population size of the Northern Great Plains piping plover has increased in this decade but remains below the recovery goals set out in the 1988 recovery plan.

4.2.8 Habitat

Piping plovers use wide, flat, open, unvegetated sand or pebble beaches on shorelines, islands in freshwater and saline wetlands, or mid-channel or channel margin sandbars laid down by high river flows. Vegetation, if present at all, consists of sparse, scattered clumps (Montana Field Guide 2010). In the Northern Great Plains, most piping plovers nest on the unvegetated shorelines of alkali lakes, reservoirs, or river sandbars (USFWS 1988a); and nesting territories often include small creeks or wetlands (USFWS 2001). On occasion, however, these birds will select non-typical sites for nesting, such as on the Missouri River where piping plovers have been documented to nest among cottonwood seedlings in habitat previously thought too densely vegetated for plovers (McGowan et al. 2007).

Critical habitat has been designated for the Northern Great Plains population of piping plover, which is outside of the Action Area.

4.2.9 Management and Protection

Recovery plans are available for the Atlantic Coast and Great Lakes populations of piping plovers but not for the Great Plains region. Recovery efforts in these areas include conserving breeding and wintering habitat; and protecting breeding birds, eggs, and chicks from predators and from disturbance and death caused by human activities.

In 2000, the USFWS issued a BiOp for the USACE's management of the Missouri River that included Reasonable and Prudent Alternatives to avoid jeopardy to the piping plover (USFWS 2000). The BiOp required flow changes to provide plover habitat over time but was not implemented. In 2003, the USFWS amended the BiOp to allow the USACE to provide sandbar habitat for plover nesting by mechanically building sandbars (through dredging in the river to pile up sand material), clearing existing sandbars of vegetation, and flow modifications (USFWS 2003).

The 2003 BiOp requires a total amount of acreage that must be available for habitat and allows multiple means of meeting these targets. However, only minimal sandbar habitat is available under current river management operations and, in 2005, far fewer acres were available than required by the 2003 BiOp (USFWS 2009c). To address this shortcoming, since 2004, the USACE has constructed approximately 605 acres of sandbar habitat at seven different river locations. Five of these habitat areas were created in the reach below Gavins Point Dam, with two additional islands created above the dam in the headwaters of Lewis and Clark Lake.

Currently, the USACE manages both flood control and piping plover habitat on the Missouri River system, meaning that piping plover habitat is frequently flooded during the nesting season to provide for other authorized system purposes (e.g., navigation and flood control). The USACE must often choose between inundating shoreline nests in a rising reservoir or releasing water from the dam and inundating habitat downstream (USFWS 2009c). Whenever possible, the USACE regulates the system to reduce potential flooding of tern and plover nests on the Missouri River. River stages downstream of four of the mainstem dams are closely monitored, and releases are adjusted during the nesting season to prevent nest inundation when possible (USFWS 2000). Releases from Gavins Point Dam may be increased in early May, in time for the arrival of nesting plovers, to force the birds to nest on higher sandbars so that navigation target flows can be met later in the nesting season when downstream tributary flows begin their normal decline in July and August (USFWS 2000). However, even with some system modifications, competing multipurpose demands (e.g., navigation and flood control) may conflict with uniform or constrained peaking summer releases for plovers in downstream areas; and habitat along the Missouri River is often flooded during the breeding season (USFWS 2009c).

To reduce operational conflicts between protecting piping plover habitat and other system purposes, the USACE has tried to develop suitable plover nesting habitat at higher elevations; this has been successful in attracting nesting birds, but initial productivity was limited because of predation and lack of forage (USFWS 2009c).

The USACE has also developed an extensive monitoring and management program for piping plovers on the Missouri River system since 1986, predator aversion techniques, public outreach, habitat enhancements, and a captive rearing program. Monitoring work includes annually locating and mapping colony and nest site locations, conducting systematic breeding pair surveys, determining nest fates and fledge ratios, and evaluating annual habitat trends. Predator aversion has included the use of nest enclosure cages, strobe lights, electric barrier fences, and removal of local problem predators. Additionally, nesting sites with historical propensities for human disturbance are posted with restricted access signs and roped off to prevent nest and chick losses. Public outreach serves to educate people about piping plovers and the efforts being made to protect them. Outreach includes local interpretive programs, school presentations, brochures, radio and television spots, boat ramp interpretive signs, and video documentaries. Habitat enhancement projects include removal of vegetation through hand-pulling, herbicide applications, mowing, burning, tilling, disking, capping with gravel, blasting, and scouring with heavy equipment to prolong the suitability of existing sandbars. In 1995, the USACE began a piping plover captive rearing program, which resulted in the construction of state-of-the-art facilities.

4.3 INTERIOR LEAST TERN

4.3.1 Description

The interior least tern (*Sternula antillarum,* formerly *Sterna antillarum*) is the smallest North American tern (Thompson et al. 1997). It has a black crown on the head, a snowy whiter underside and forehead, grayish back and wings, orange legs, and a yellow bill with a black tip (USFWS 2009b). Males and females are similar in appearance.

Three subspecies of least tern are recognized in the United States: the eastern or coastal least tern (*Sterna antillarum antillarum*), the California least tern (*Sterna antillarum browni*), and the interior least tern (*Sterna antillarum athalassos*). The subspecies are identical in appearance and are segregated on the basis of separate breeding ranges. The interior population occurs along major rivers in the interior United States, including the Missouri, Mississippi Arkansas, Red, and Rio Grande River systems.

The interior least tern is primarily piscivorous, feeding mostly on small-bodied fish found in shallow freshwater and saltwater, but its diet is varied and it may occasionally take aquatic invertebrates (Thompson et al. 1997). These birds are opportunistic and tend to select any small fish within a certain size range. Least terns feed in shallow waters of rivers, reservoirs, and lakes and forage by hovering and diving into water to catch small fish and aquatic crustaceans (USFWS 2009b, 1990b) and occasionally skimming the water surface for insects.

4.3.2 Status

The interior population of least tern was federally listed as endangered on June 27, 1985 (50 FR 21,784-21,792) (USFWS 1990b). The least tern is also listed as a state endangered species by Missouri, Kansas, and Nebraska. The USFWS has not designated critical habitat for this species. The State of Kansas has designated critical habitat for the interior least tern on the Kansas River, from the confluence with the Missouri River to the limit of the Action Area 5 miles upstream. No critical habitat is designated within the Action Area.

4.3.3 Threats

Alteration and destruction of riverine habitats due to channelization; irrigation; and construction of reservoirs, pools, and dams since the 1940s have contributed to the decline of the species through the elimination of much of the tern's sandbar nesting habitat in the Missouri, Arkansas, and Red River systems (USFWS 1990b, Audubon n.d.). These types of disturbances can eliminate nesting sites, can disrupt nesting birds, or may result in sandbars that are unsuitable for nesting due to vegetation encroachment or frequent inundation. The wide channels with sandbars that are preferred by the terns have been replaced by narrow, forested river corridors (USFWS 2009b).

Further population declines in the 1950s to 1970s have been attributed to pesticide use and human disturbance of nesting habitats (Audubon n.d.). Recreational activities on rivers and sandbars can disturb nesting terns and cause the birds to abandon nests (USFWS 2009b).

Historically, fairly predictable summer flow periods consisted of a high flow in May and June and a decline in flow for the remainder of the summer. The decline in flow levels allowed interior least terns to nest as water levels dropped and sandbars became available (Texas Parks and Wildlife 2009). The current regulation of river flow regimes using dams can result in high flow periods extending into the normal nesting period or occurring after nesting has begun, thus flooding active nest sites (USFWS 1990b).

Recreational, industrial, and residential development in coastal breeding areas continues to diminish many populations (Audubon n.d.).

4.3.4 Reproduction and Development

Interior least terns arrive at breeding areas from late April to early June and spend from 4 to 5 months at the breeding sites. Least terns are considered colonial nesters; colonies typically consist of up to 20 nests although colonies with up to 75 nests have been recorded on the Mississippi River (USFWS 1990b). Upon arrival, adult terns usually spend from 2 to 3 weeks in noisy courtship, including finding a mate, selecting a nest site, and strengthening the pair bond.

Interior least terns arrive at breeding areas from late April to early June. Nesting areas of interior least terns include sparsely vegetated sand and gravel bars within a wide, unobstructed river channel or salt flats along lake shorelines (Nelson 1998, USFWS 1990b). Nesting locations are usually well above the water's edge because nesting is typically initiated during high river flows, when much of the bars and shorelines are flooded. The extent of available nesting area depends on water levels and the resulting amount of exposed bar and shoreline habitat. The interior least tern also nests on artificial habitats such as sand and gravel pits next to large river systems and dredge islands (Campbell 2003, USFWS 1990b).

Least terns nest on the ground in a shallow depression in an open sandy area, gravelly patch, or exposed flat. Small twigs, pieces of wood, small stones, or other debris usually occur near the nest. Usually two to three eggs are laid by late May, and both parents incubate the eggs for approximately 20–22 days (USFWS 1990b). The chicks leave the nest only a few days after hatching, but the adults continue to provide care by leading the chicks to shelter in nearby grasses and bringing food (USFWS 2009b). Fledging occurs within 3 weeks after hatching.

4.3.5 Range

The interior population of least tern is migratory, breeding along inland river systems in the United States and wintering along the Gulf Coast, the coast of Caribbean Islands, the eastern coast of Central America, and northern South America (USFWS 1990b).

Historically, the breeding range of the interior least tern population extended from Texas to Montana and included the Rio Grande, Red, Missouri, Arkansas, Mississippi, and Ohio River systems. The birds continue to breed in most of the historical river systems, although current distribution is restricted to less altered river segments (USFWS 1990b).

A 2005 breeding bird survey (Lott 2006) did not identify any least tern nest sites in Missouri, and no nest sites were observed on the Missouri River south of the confluence of the Lower Platte River in Nebraska. In Kansas, the distribution of least terns include the Kansas River, the Arkansas River system, the Platte River and its tributaries, the Missouri River and reservoirs upstream of Gavin's Point Dam, and several other locations in northern Nebraska.

4.3.6 Population Level

The least tern is a difficult species to census accurately because the species frequently shifts nesting sites and the timing of nesting varies locally because of weather, habitat availability, and latitude (Thompson et al. 1997). The 1990 recovery plan for the interior population of least tern estimated the population to be approximately 5,000 individuals (USFWS 1990b).

The overall recovery objective of 7,000 birds identified in the 1990 recovery plan has been met, but the mean number of least terns in all drainage basins identified in the plan has not reached corresponding objectives related to geographic distribution of those birds, nor has each area remained stable for 10 years, as called for in the recovery plan (USFWS 2003).

A 2005 breeding distribution survey identified that, although least tern populations occurred over much of the species' historical range, populations were limited to river reaches with suitable habitat. Least tern nests were primarily observed on suitable nest sites along rivers and reservoir shorelines. Colonies were also identified at sand pits, at industrial sites, on alkali flats, and on rooftops. The 2005 breeding bird survey identified a total of 17,591 individuals (Lott 2006).

4.3.7 Habitat

Interior least terns prefer open habitat and tend to avoid thick vegetation and narrow beaches. Nesting habitat for these birds includes barren to sparsely vegetated sand, shell, and gravel beaches, sandbars, islands, and salt flats associated with rivers and reservoirs (USFWS 2009b). Nesting locations are often in higher elevations away from the water's edge because nesting typically begins when river levels are high and relatively small amounts of sand are exposed (Texas Parks and Wildlife 2009). Least terns are highly adapted to nesting in disturbed sites and may move colony sites annually, depending on landscape disturbance and vegetation growth at established colonies. As natural nesting sites have become scarce, terns have used sand and gravel pits, ash disposal areas of power plants, reservoir shorelines, and other man-made sites (Texas Parks and Wildlife 2009).

4.3.8 Management and Protection

In 1990, the USFWS published a recovery plan for the interior population of least tern (USFWS 1990b). That plan includes recovery goals for the least tern along major river systems throughout the species' range. Major recovery steps outlined in the plan include: (1) determine population trend and habitat requirements; (2) protect, enhance, and increase populations during breeding; (3) manage reservoir and river water levels to the benefit of the species; (4) develop public awareness and implement educational programs about the least tern; and (5) implement law enforcement actions at nesting areas where there are conflicts with high public use.

Protection of interior populations of least terns requires rivers to be maintained at levels that avoid flooding natural nesting areas wherever possible. Currently, the USACE manages both flood control and least tern habitat on the Missouri River system, meaning that least tern habitat is frequently flooded during the nesting season to provide for other authorized system purposes (e.g., navigation and flood control). The USACE must often choose between inundating shoreline nests in a rising reservoir or releasing water from the dam and inundating habitat downstream (USACE 2009a). Whenever possible, the USACE regulates the system to reduce potential flooding of tern and plover nests on the Missouri River. River stages downstream of four of the mainstem dams are closely monitored, and releases are adjusted during the nesting season to prevent nest inundation when possible (USFWS 2000). Releases from Gavins Point Dam may be increased in early May, in time for the arrival of nesting terns, to force the birds to nest on higher sandbars so that navigation target flows can be met later in the nesting season when downstream tributary flows begin their normal decline in July and August (USFWS 2000). However, even with some system modifications, competing multipurpose demands (e.g., navigation and flood control) may conflict with uniform or constrained peaking summer releases for terns in downstream areas; and habitat along the Missouri River is often flooded during the breeding season (USACE 2009a).

State, federal, and private organizations throughout the United States are collaborating to provide protection to the interior least tern though bird census, research, curtailment of human disturbance, and provision suitable habitat. Continued monitoring of confirmed and potential colony sites is underway to assess population status and reproductive success. Protective measures such as signs and fences are being implemented to restrict access to sites most threatened by human disturbance. Other management strategies include vegetation control at occupied sites, chick shelter enhancement, predator control, pollution abatement, and habitat creation/restoration at unoccupied sites.

4.4 INDIANA BAT

4.4.1 Description

The Indiana bat (*Myotis sodalis*) weighs a quarter of an ounce and has a wingspan from 9 to 11 inches (USFWS 2006b). The fur is dark-brown to black and is similar in appearance to many other related species. The Indiana bat is a very social species, and large numbers of individuals cluster together during hibernation (USFWS 2006b). Common prey includes a variety of flying insects found along rivers or lakes and in uplands.

4.4.2 Status

The Indiana bat was listed as endangered on March 11, 1967 (USFWS 2006b). Critical habitat for the species was designated on September 24, 1976 (41 FR 41914) but does not include any caves within the Action Area.

4.4.3 Threats

The Indiana bat is extremely vulnerable to disturbance because it hibernates in large numbers in only a few caves (USFWS 2006b). During hibernation, the bats cluster in groups of up to 500 individuals per square foot, and the largest hibernation caves can support from 20,000 to 50,000 bats. Large numbers of Indiana bat deaths have occurred due to human disturbance, such as cave exploration during hibernation. Between early spring and autumn, Indiana bats migrate to and use summer roosting and foraging areas located in riparian, floodplain, and upland forests (MDC 2010b, USFWS 2007). Between 2007 and 2009, the Missouri population of Indiana bat declined by 14 percent (USFWS 2010a). Current threats to the species include changes in summer habitats from alterations to land cover, the reduction in roosting and foraging forested habitat, and white-nose syndrome (MDC 2010b, USFWS 2010b). Population declines may also be attributed, in part, to the use of pesticides and other environmental contaminants. Bats may be affected by eating contaminated insects, drinking contaminated water, or absorbing the chemicals while feeding in areas that have been recently treated (USFWS 2006b).

4.4.4 Reproduction and Development

The Indiana bat mates during fall before they enter caves to hibernate. Females store the sperm through winter and become pregnant in spring soon after emerging from the caves (USFWS 2006b).

After migrating to summer areas, females roost under the peeling bark of dead and dying trees in maternity colonies of 100 or more bats. Each female in the colony gives birth to only one pup per year. Young bats are nursed by the mother, who leaves the roost tree only to forage for food. The young stay with the maternity colony throughout their first summer (USFWS 2006b).

4.4.5 Range

The Indiana bat is found over most of the eastern half of the United States. Almost half of all Indiana bats hibernate in caves in southern Indiana, and states with bat populations over 40,000 (in 2005) included Missouri, Kentucky, Illinois, and New York. Other states within the current range of the Indiana bat include Alabama, Arkansas, Connecticut, Iowa, Maryland, Michigan, New Jersey, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia (USFWS 2006b).

The Indiana bat occurs seasonally during summer along streams and rivers in northern Missouri. The species hibernate through winter in caves and abandoned mines in the Ozarks.

4.4.6 Population Level

The USFWS 2005 population estimate is about 457,000 Indiana bats, half as many as when the species was listed as endangered in 1967 (USFWS 2006b). In 2005, almost half of all Indiana bats (207,000) hibernated in caves in southern Indiana, followed by populations amounting to 65,000 in Missouri, 62,000 in Kentucky, 43,000 in Illinois, and 42,000 in New York (USFWS 2006b).

As of October 2006, the USFWS had records of extant winter populations at approximately 281 hibernacula in 19 states and 269 maternity colonies in 16 states (USFWS 2007b). Within Missouri, populations of Indiana bats are found in St. Louis County (winter population), Charlton County (summer populations), and Franklin and Boone Counties (summer and winter populations).

4.4.7 Habitat

The Indiana bat hibernates during winter in caves or abandoned mines. For hibernation, they require cool, humid caves with stable temperatures between 32° and 50° Fahrenheit (F). Very few caves within the bat's range have these conditions (USFWS 2006b).

After hibernation, the Indiana bat migrates to its summer habitat in wooded areas, where it usually roosts under loose tree bark on dead or dying trees. During summer, males roost alone or in small groups while females roost in larger groups of up to 100 bats (USFWS 2006b). Maternal colonies may occur in riparian or upland trees on river banks. Indiana bats also forage in or along the edges of forested areas.

4.4.8 Management and Protection

The USFWS developed a recovery plan in 1976, followed by a revision in 1983 (USFWS 2006b). A newly revised recovery plan for the Indiana bat was completed in 2007 (USFWS 2007b).

Some public lands like national wildlife refuges, military areas, and U.S. Forest Service lands are managed for Indiana bats by protecting forests. Management actions include ensuring that there are adequate species and sizes of trees needed by Indiana bats for roosting, and providing a supply of dead and dying trees that can be used as roost sites. In addition, caves used for hibernation are managed to maintain suitable conditions for hibernation and eliminate disturbance (USFWS 2006b). Collaboration continues with federal, state, and private organizations to improve bat habitat throughout their range.

4.5 DECURRENT FALSE ASTER

4.5.1 Description

The decurrent false aster (*Boltonia decurrens)* is a perennial plant that grows from 1 to 5 feet tall and occasionally reaches heights of over 6 feet. This plant is called "decurrent" because the leaf tissue extends down the stem from the point of leaf attachment (MDC 2010a). It is endemic to Illinois and central eastern Missouri, and is one of the rarest native species in this region (Center for Plant Conservation 2010).

Decurrent false aster is closely related to *Boltonia asteroides* var. *recognita*, a common weedy species of false aster that is sometimes found in the same habitat (MDC 2010a).

4.5.2 Status

The decurrent false aster was federally listed as threatened on November 14, 1988 (53 FR 45858). No critical habitat rules have been published for the decurrent false aster.

4.5.3 Threats

A major cause of the decurrent false aster's decline is intensive agricultural practices that increase topsoil runoff, smothering seeds and seedlings (USFWS 2009a). Further, agriculture has eliminated wet prairies and marshes within the species' range, and natural lakes have been drained and converted to croplands. Building levees along rivers and draining wetlands for cultivation has changed patterns of flooding and eliminated habitat, resulting in degradation of the species. Other current threats to the species include the use of herbicides (USFWS 2009a).

4.5.4 Reproduction and Development

Decurrent false aster blooms from July to October and bears seeds from August to October. They occur in branched groups of composite heads with yellow disk flowers and white to purplish ray flowers.

4.5.5 Range

Historically, this species was found on the shores of lakes and the banks of streams; today, it is most common in disturbed lowland areas (USFWS 1988b). The range of decurrent false aster is along the Illinois River in west central Illinois and along the Mississippi River near St. Louis, primarily within Illinois (Center for Plant Conservation 2010).

In Missouri, the distribution of decurrent false aster is restricted to the Mississippi River floodplain from the Illinois River southward. Current populations are more isolated than their former distribution and the plant is presently known to occur only in St. Charles County, Missouri.

The species is known to occur in the Big Muddy National Wildlife Refuge (USFWS 2010a). A few populations occur on private land, often in association with agricultural crop production. Levees and roadsides may support small populations. It seems likely that additional populations occur on private land that are yet to be recorded (MDC 2010a).

4.5.6 Population Level

The number of identified sites with above-ground plants varies from year to year. The majority of sites are in Illinois, with only one or two extant populations in Missouri (USFWS 1990a). In some years, some sites have been reported to have hundreds of thousands of individuals (USFWS 1990a).

4.5.7 Habitat

Habitat for this species is moist, sandy soil. It grows in wetlands, on the borders of marshes and lakes, and on the margins of bottomland oxbows and sloughs (MDC 2010a). Decurrent false aster favors recently disturbed areas, and it relies on periodic flooding to scour away other plants that compete for the same habitat (USFWS 2009a).

4.5.8 Management and Protection

A recovery plan was established for decurrent false aster on September 28, 1990 (USFWS 1990a). Many populations of the decurrent false aster are on public land, particularly on wetlands managed by the USACE. These populations are being managed by participating state and federal agencies through periodic flooding and mowing (MDC 2010a).

SECTION 5

Environmental Baseline and Cumulative Effects

This section identifies and describes past and ongoing human and natural factors leading to the current status of the species, its habitat, and ecosystem within the Action Area, except those caused by the LEDPA. This information is used, along with information describing the status of the species and critical habitat within the Action Area, to describe the expected condition of the species and their habitat without exposure to the proposed federal action. .

5.1 DESCRIPTION OF ENVIRONMENTAL BASELINE

The environmental baseline is defined as the effects of past and ongoing human induced and natural factors leading to the status of the species, its habitat, and ecosystem, within the Action Area. The environmental baseline is a snapshot of the pallid sturgeon's status at this time, and provides the context for the analysis of effects of the proposed federal action on listed species. In this biological assessment, the environmental baseline is described in Sections 4 and 6, as well as by information provided in this section. Details of the pallid sturgeon's habitat description, life history, population status, and known locations are included in Section 4. Given the large amount of information, extent of the Action Area, and complexities of the LOMR, discussion of environmental baseline is also provided in the context of the effects analysis in Section 6.

The Missouri River has been heavily modified from pre-settlement conditions. Since the 1930s, two major man-made modifications to the Missouri River have been constructed, resulting in dramatic long-term changes to the character of the LOMR. A series of dams and reservoirs at the upper end of the river (known as the Missouri River Mainstem Reservoir System) were built between 1936 and 1963, and substantially altered the character of flows and sediment supply in the LOMR. In addition to reservoirs, the Missouri River navigation channel is maintained by a complex series of dikes and revetments constructed by the Missouri River Bank Stabilization and Navigation Project (BSNP). These structures concentrate the flow of the river to maintain a channel depth sufficient for commercial barge traffic. Refer to Section 3 in the FEIS (USACE 2011) for detailed information on the LOMR basin's geographic water resources, aquatic ecology, wetlands, and terrestrial resources.

5.1.1 River Hydrology

Flows in the LOMR, or the hydrology, drive the geomorphic processes that shape the river. The amount and velocity of water flowing are the main factors in determining how much sediment is moving through the system. Dams built over 50 years ago upriver from the Action Area have affected the magnitude and timing of flows, and levees and dikes have constrained flows and altered flood peaks. For further discussions on geology and geomorphology, including existing bed degradation due to past human modification, see Sections 2.4 and 3.4 in the FEIS (USACE 2011).

5.1.2 Current Practices

This section summarizes the existing regional and unrelated federal actions within the Action Area that may affect listed species and their habitat. Major uses of the LOMR include current navigation, water operations and management, recreational uses, and commercial sand and gravel production. Sand and gravel have been dredged or excavated from the river since the 1930s. The USACE recently completed a description of river and land use management and a history of the river management era for the LOMR in association with its proposal to permit commercial sand and gravel dredging (USACE 2011). Dredging has been identified as one of main causes of stream bed degradation; however, the effects of commercial dredging have not been monitored extensively.

The USACE has implemented numerous projects along the Missouri River in response to the BiOp by the USFWS (USFWS 2000, 2003). These projects are basically designed to improve habitat for endangered native bird and fish species that occur along the LOMR; they can be grouped into emergent sandbar habitat (ESH) projects designed to benefit bird species and SWH projects mainly for the benefit of pallid sturgeon (NAS 2010). Current activities that influence the geomorphic character of the river include:

- Ongoing maintenance of BSNP structures, including changing dike heights and lengths;
- Activities to change the channel configuration or sediment loads such as dike notching;
- Activities associated with the Missouri River Recovery Program (creation of SWH such as side channels and chutes); and
- Dredging for levee construction and channel maintenance dredging.

The Missouri River Recovery Program Project is the only activity with a likelihood of changing the channel configuration or sediment loads of the river. Ongoing studies that are gaining knowledge about where there are deficits and surpluses of sediments could be factored into the placement of SWH projects that will likely reintroduce sediment. The ongoing degradation studies may inform river management about where other actions may occur during the permit period. The most likely reach where changes could occur in management action is the Kansas City reach. The actions likely would focus on widening of the river in this reach to reduce flood heights and scour. Likely strategies would include excavation of side channel chutes or backwaters and dike and revetment notching that would release large quantities of stored sediment from overbank areas (those areas of the floodplain between the river bank and levees where floodwaters have deposited fine-grained sediment from suspension). After initial effects of sediment pulses, such as higher turbidity and bed load movement, positive habitat benefits could be habitat diversification, areas of lower flow for refuge, and aggradation of habitat patches to help stabilize some areas of the benthic environment. These areas are most likely to occur on the channel margins because the navigation channel would be maintained by the controlled erosion dike-directed flows.

Maintenance dredging typically results in no net gain or loss of sediments because most of the material is moved to within the high banks of the river and eventually rerouted within the channel. Displacement of the material may alter patches of shoreline area vegetation if placed above the ordinary high water mark. Vegetation will recover, and placement of the dredged material simulates a sediment deposition event that would have occurred more frequently from overbank flows prior to river management.

The USACE receives miscellaneous requests for authorization of dredge fill material removal. The USACE typically requires extensive sediment studies for such requests, and a demonstration of surplus sediment would be required for the USACE to allocate removal beyond current authorizations.

5.2 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the Action Area, and are considered in the biological assessment. Future federal actions that are unrelated to the LEDPA are not considered in this section because they are subject to separate consultation(s) under Section 7 of the Act. The USACE is unaware of any additional significant state, tribal, local or private actions that are reasonably certain to occur in the action area producing cumulative effects beyond those ongoing effects already considered in the herein.

5.2.1 Past Actions

The Missouri River ecosystem was historically a highly dynamic, highly variable river system; but it experienced a marked ecological transformation during the 20th century. At the beginning of the century, the Missouri River was notorious for large floods, for a sinuous and meandering river channel that moved freely across its floodplain, and for massive sediment transport. Prior to channelization and flow regulation, the LOMR was braided to highly sinuous, a form naturally found in rivers with broad floodplains and heavy sediment loads. The river was characterized by log jams, snags, whirlpools, chutes, bars, cut-off channels, and secondary channels around bars. The main channel typically had a deep thalweg (the deepest part of the river) that contained the faster-moving flow and a shallower section(s) on one or both sides of the channel.

By the end of the 20th century, the Missouri River was channelized, with its flow highly regulated; it bore little resemblance to the previously wild, free-flowing river (NRC 2002). Unlike the historical river system, the current system is highly altered—both hydrologically and physically. With construction of the BSNP, the river bank top width has been reduced; side channels, islands, and ephemeral sand bars have been lost; and the physical process of channel meandering has been arrested. Sediment transport and availability for habitat development have been significantly impaired. The dams and BSNP structures have reduced the sediment availability to the lower river by almost six-fold (from 229 million metric tons to 40 million metric tons [NRC 2002]). These changes have resulted in significant cascading ecological effects on the health of the river and its biota.

The development of dams, water diversion structures, and structures to provide for flood control and navigation has substantially altered the natural processes that influenced the evolution of species in the Missouri River. Dam operations have considerably altered the timing and magnitude of river flows; and the low flows that ordinarily occurred throughout summer, fall, and winter are largely nonexistent under many water-year types.

Today, the Missouri River is one of the most highly modified and managed rivers in the world. The history of the development of the Missouri River, the reservoir systems, and the BSNP—and the associated impacts on the Missouri River ecosystem—are described in the FEIS (USACE 2011) and in many other accounts (NRC 2002, Galat et al. 2004; USACE 2009a, USFWS 2003). Therefore, they are not discussed further here.

From 1984 to 2006, more than $133 million was expended on habitat restoration activities on the LOMR (Jacobson, Blevins, and Bitner 2009). Initially, efforts focused on mitigating effects of the BSNP by restoring a variety of aquatic and terrestrial habitats. To comply with findings in the 2003 BiOp that USACE management of the Missouri River put the survival of the pallid sturgeon in jeopardy (USFWS 2003), restoration activities began in 2004 to emphasize creation of shallow water aquatic habitat. SWH is thought to be important for rearing of larval and juvenile pallid sturgeon, as well as essential habitat to support native aquatic species and biodiversity (USFWS 2003).

5.2.2 Present and Future Non-Federal Actions

Potential non-federal projects that could cumulatively affect listed species in the LOMR include future transportation improvements and energy development projects associated with nuclear power plants or placement of hydrokinetic turbines in the river channel.

5.2.2.1 Transportation Improvement Projects

Transportation improvement can significantly influence demand for gravel and sand from the LOMR. The significant decrease in highway and bridge construction in the 2010–2014 Missouri Statewide Transportation Improvement Program (STIP) reflects lower state revenues, uncertain federal funding, and limited proceeds from existing bond programs. Many of the larger-scale projects included in the previous year's STIP, such as the Mississippi River Bridge project in St. Louis, many of the Safe and Sound Bridge Improvement projects, and the federal American Recovery and Reinvestment Act of 2009 projects, are under construction. Although the 2010–2014 STIP contains many remaining bonded projects and the remaining Safe and Sound Bridge Improvement projects, the 5-year construction program is less than one-half the size of the previous 5 years. By 2011, transportation funding will drop by more than one-half and will continue falling to only one-third of the 2010 amount in subsequent years (MoDOT 2010).

5.2.2.2 Energy Development Projects

In July 2008, AmerenUE submitted an application to the U.S. Nuclear Regulatory Commission for a combined construction and operating license for a new nuclear power plant alongside its existing single unit at Callaway, Missouri. In April 2009, AmerenUE suspended efforts saying that state policies were making it too difficult to finance the project (World Nuclear News 2009). Although the project has not been cancelled, it is not considered a reasonably foreseeable action and therefore is not included in the cumulative effects analysis.

In April 2008, Free Flow Power Company submitted preliminary permit applications to the Federal Energy Regulatory Commission (FERC) to study 25 regions of the mainstem of the Missouri River for the feasibility of placing hydrokinetic turbines to produce electricity. FERC granted the permits in October 2008 and February 2009. In September 2009, Free Flow Power withdrew the preliminary permit applications, stating that—based on consultation and analysis of bathymetry and velocity—depth, river bed degradation, and the uncertainty surrounding the renewal of dredging permits were significant obstacles to hydrokinetic development at that time (Free Flow Power Company 2009). Consequently, the proposed placement of hydrokinetic turbines within the mainstem of the Missouri River is not considered a reasonably foreseeable action and is not included in the cumulative effects analysis.

SECTION 6

Effects of the Action

This section includes an analysis of the direct and indirect effects on listed species and their critical habitat that are associated with the LEDPA and its interrelated and interdependent actions. Potential direct effects on listed species would include entrainment into the dredges, direct physical disturbance of the river bottom and associated changes in substrate composition, changes in water quality, noise and physical disturbance-induced changes in behavior, and loss of some terrestrial habitat. These potential direct impacts would occur in the vicinity of dredge barges, towboats, and land-based sand plants. The impacts would be limited to the period during or shortly after dredging and towboat operation, sorting and loading at plant locations, and new sand plant construction. Individual organisms could be affected through injury, mortality, or behavioral modifications arising mostly from direct disturbance or habitat modification.

Potential indirect effects may result from changes in channel morphology and related effects on instream and floodplain habitats used by pallid sturgeon. These may occur due to changes in river sediment regime changes and associated changes in geomorphic processes as a result of sand and gravel removal. Indirect effects could occur in the short term or in the long term.

Special conditions and dredging exclusion zones would be in effect under the LEDPA, such as excluding dredging in potential sturgeon spawning areas and other important habitats and in areas adjacent to certain infrastructure facilities (see Section 3.7). In addition, limits on dredging intensity would be implemented at the reach scale to reduce the effects of locally intense dredging. Finally, monitoring of channel bottom elevations as a measure of bed degradation would be implemented under the LEDPA, allowing actual levels of bed change to be measured and addressed.

Below is a discussion of potential impacts to each of the listed species identified by the USFWS as potentially occurring in the Action Area. The documented occurrence and geographic distribution of listed species in the Action Area; their life history, movements, and migrations; and their habitat needs are considered in this assessment, in relation to the amounts and locations of commercial sand and gravel dredging that would occur under the LEDPA. The potential direct and indirect effects of dredging and related activities on the reproduction, growth, maturation, movements, and migrations of each species are considered in this section and are integrated with the most up-to-date literature, research results, and data available.

6.1 PALLID STURGEON

Potential direct and indirect effects on pallid sturgeon include impacts to individuals that may or may not affect the population level in the LOMR and impacts to habitat important to pallid sturgeon. This section is divided into two subsections: potential effects on pallid sturgeon and potential effects on pallid sturgeon habitat.

6.1.1 Potential Effects on Pallid Sturgeon

Individual and population-level impacts may include mortality or harm due to propeller damage by dredge barges and towboats or entrainment into the dredge, physical alteration of important habitat features within the dredging areas and the associated forage base, behavioral changes due to increased noise around the dredges or tugs or increased turbidity downstream of the dredges, and potential blockage of spawning migration corridors during dredging.

6.1.1.1 Navigation Propeller Entrainment

The effect of tugboat propellers on fish populations is a concern associated with potential increases in commercial navigation traffic (Killgore et al. 2001; Killgore et al. 2005). Towboats are used to move and position barges on the LOMR, resulting in the potential for injury or mortality to pallid sturgeon eggs, larvae, or juveniles that pass through the propeller field. The USFWS (2004) concluded that entrainment due to dredging operations and commercial navigation traffic represents an unknown, but perhaps significant, threat to the species through direct mortality.

To date, the baseline effects of navigation traffic related to propeller entrainment and mortality rates have not been evaluated in the LOMR, or more specifically, for pallid sturgeon, and only limited field assessments have been completed elsewhere. Rates of entrainment of pallid sturgeon on the LOMR are unknown and are expected to vary based on site-specific and species-specific conditions, including river hydrology, seasonal distribution of pallid sturgeon, the density of pallid sturgeon within a river segment during dredging operations, and the life history stage encountered during the period of barge or towboat traffic. Because useful propeller entrainment evaluations have been conducted on the Mississippi and other large rivers, this information is used as the best available. However, on the LOMR, barge sizes, load configuration, towboat and propeller size, as well as populations densities of sturgeon, are considerably smaller than many of the studies cited below, and so care must be used when considering this information.

Studies on the Upper Mississippi River and Illinois River (found that towboats entrain large volumes of water through their propellers (Gutreuter et al. 2003; Killgore et al. 2005). Towboat propellers often exceed 8 feet (approximately 2.5 m) in diameter and span between 20 and 100 percent of the depth of a confined navigation channel in the Upper Mississippi River (Gutreuter et al. 2003). Dettmers (pers. comm.) confirmed that the majority of the towboats evaluated in Gutreuter et al. (2003) were 9-foot propellers. The areas within which water is disturbed by propellers (referred to as the "inflow zone") for towboats on the Mississippi River were found to extend approximately 20 percent wider than the beam of the tugboat from centerline (Maynord 2000).

Ship propellers cause abrupt changes in hydraulic patterns due to increased turbulence and water velocities, pressure changes, and shear forces (Maynord 1990, Hyun and Patel 1991). Ship propellers also can injure or kill fish if the fish come in contact with the blades (Gutreuter 2003). Cada (1990) reported that fish eggs and larvae that pass through water currents induced by a propeller may come in contact with the blade and can experience stresses from pressure changes and shear forces as a result of abrupt changes in hydraulic patterns caused by the propellers. Killgore et al. (2001) evaluated mortality of icthyoplankton entrained through a scale model of a tugboat propeller. They found mortality to be a linear function of shear stress for all species and life stages. Larger larvae (e.g., shovelnose sturgeon) experienced lower mortality, while smaller larvae (e.g., lake sturgeon and blue suckers) experienced higher mortality. All larval species experienced delayed mortality, particularly at higher stress levels. Killgore et al. (2001) concluded that shear stress caused by tugboat traffic is probably a primary force contributing to the mortality of icthyoplankton entrained during vessel passage, but the magnitude of mortality is dependent on the individual size of icthyoplankton.

Gutreuter et al. (2003) developed a method to estimate mortality rates of adult fish caused by entrainment through the propellers of commercial towboats operating in river channels. They estimated entrainment mortality rates of adult fishes in Pool 26 of the Upper Mississippi River and Alton Pool of the Illinois River, where fish kills attributed to entrainment were observed. Their estimates of entrainment mortality rates were 0.53 fish/kilometer (km) of tugboat travel for shovelnose sturgeon (80 percent confidence interval, 0.00 – 1.33 fish/km). They concluded that their approach applies more broadly to commercial vessels operating in confined channels, including other large rivers and intra-coastal waterways. In its consideration of this information, it was the EPA's opinion that it is likely that tugboat traffic is a source of incidental mortality to adult pallid sturgeon (USEPA 2007). But in a report not cited by the USEPA (2007), Kilgore et al. (2005) reported on the results of an evaluation of towboat propeller-induced mortality of juvenile and adult fish in the same study area – Pool 26 of the Upper Mississippi River and Illinois River. The study used a specifically-designed net deployed from a twin-screw towboat to filter the propeller wash of towboats. Kilgore et al. (2005) reported that in a total of 139 10-minute trawls over a two-year period, benthic species were rarely collected, and only one sturgeon was collected with no evidence of propeller-type injuries. The disparity in the numbers of shovelnose sturgeon collected in the two studies discussed above adds uncertainty to calculating sturgeon entrainment due to towboats.

Firm conclusions cannot be made about the rate or significance of propeller entrainment and mortality in the LOMR. For larval and young juvenile, based on the literature findings, the extent of mortality would likely be a function of the amount of towboat traffic in a given river segment, towboat speed, and traffic volumes during the period when pallid sturgeon are most susceptible to shear stress (i.e., the larval or early juvenile life stages). The amount of vessel traffic, with the associated risk of injuring or killing fish, therefore is an important consideration. We used the findings of existing studies as the best available information to address this issue.

As part of the Restructured Mississippi and Illinois River Navigation Feasibility Study, the USACE conducted several studies on the Middle Mississippi River (USACE 2004b) to determine the impacts of navigation traffic on fisheries resources. Entrainment of fish larvae had been of particular concern; however, the USACE also conducted studies to evaluate entrainment of juvenile and adult fish, including pallid sturgeon (USACE 2004b), Bartell and Nair 2003).

In order to estimate the impacts of commercial navigation traffic on fish populations due to larval fish entrainment, the USACE conducted complex modeling studies using a model called NavLEM (USACE 2004b), Bartell and Nair 2003). Much of the following discussion is summarized from the *Final Biological Opinion of the Upper Mississippi River – Illinois Waterway System Navigation Study* (USFWS 2004). The results indicated that approximately 4.8 million sturgeon larvae were estimated to be entrained and killed per year by baseline commercial navigation totaling approximately 2.0 million miles (Bartell and Nair 2003). These estimated numbers of entrained and killed larvae are difficult to evaluate directly given that natural rates of larval fish mortality are high (Bartell and Nair 2003) and fish typically produce large numbers of eggs and larvae (USACE 2004b). To put this in perspective, the 4.8 million sturgeon larvae were estimated to represent approximately 0.81 percent of the sturgeon larvae produced in the open river during the year 2000 spawning season (Bartell and Nair 2003).

The model was then used to translate the estimates of baseline larval entrainment into equivalent adult fish lost due to commercial navigation traffic (USACE 2004b, Bartell and Nair 2003). Using this information and the ratio of pallid sturgeon to shovelnose sturgeon of 1:84, this equated to approximately 35 pallid sturgeon being lost in the Middle Mississippi River in the baseline condition. Further, the model estimated that 59 sturgeon recruits were lost due to commercial navigation in the Middle Mississippi River (Bartell and Nair 2003). This equates to approximately two pallid sturgeon recruits being lost every 3 years.

The other method of estimating entrainment mortality for pallid sturgeon used by the USACE (2004a) and the USFWS (2004) was a combination of two sources of information: (1) mortality rates (fish/km) determined by Guetreter et al. (2003) and USFWS (2004) and adjusted to sturgeon; (2) the number of miles of commercial navigation/barge traffic; and (3) the ratio of pallid sturgeon to shovelnose sturgeon. The mortality rate estimate for shovelnose sturgeon was determined to be 0.000002 shovelnose sturgeon/km of towboat travel, and there was approximately one pallid sturgeon for every 84 shovelnose sturgeon (ratio 1:84). Overall, for 3.2 million km (approximately 2.0 million miles) of commercial navigation traffic per year, annual pallid sturgeon entrainment was estimated at one pallid sturgeon killed every 10 years.

It should be noted that a great deal of uncertainty is associated with modeling and estimating propeller-induced adult and larval fish mortality with these types of estimates, which are further explained in detail in USACE 2004a. The estimates describe above from the Upper Mississippi and Illinois Rivers cannot be applied directly to the LOMR, as many of the important contributing factors are very different. The actual numbers of pallid sturgeon lost in any given year would be a function of many factors, including overall sturgeon larvae abundance, distribution of larvae in the navigation channel (vertically and horizontally), navigation traffic levels during the larval drift period, and navigation channel depth.

In the LOMR, pallid sturgeon populations are generally lower than the Upper Mississippi-Illinois River; the ratio of pallid sturgeon to shovelnose sturgeon are much lower; and the size of towboats, their propellers, and entrained volume of water are much smaller on the LOMR than on the Upper Mississippi and Illinois Rivers. Propeller sizes for the studies of Gutreuter et al. (2003) and Kilgore et al. (2005) were generally 2.5 m in diameter (9 feet); propeller sizes on the LOMR typically range from 0.8 m to 1.5 m (2.5 to 5 feet). As a result, the volumes of water that LOMR towboats entrain is considerably less in total volume and per mile of vessel movement that that for the Upper Mississippi and Illinois Rivers. Pallid sturgeon to shovelnose sturgeon ratios are much lower on the LOMR (roughly one pallid sturgeon for every 350 shovelnose sturgeon; Grady et al. 2001; Doyle and

Starostka 2003) than on the Upper Mississippi (roughly one pallid sturgeon for every 84 shovelnose sturgeon). The level of towboat traffic on the LOMR is also less than that of the estimates of propeller mortality estimated for Pool 26 of the Mississippi River. The total commercial navigation miles traveled to deliver the dredged sand and gravel on the LOMR would be roughly 510,000 miles/year (a number based on the number of trips reported in the FEIS and an approximate average trip distance of 10 miles), as compared to a total of approximately 2.0 million miles/year for Pool 26. These factors would all lead to a lower probability of entrainment and lower estimates of entrainment mortality in the LOMR as compared to those reported above for the Mississippi and Illinois Rivers. Based on the entrainment mortality estimates described above as reported in USFWS (2004) and factors on the LOMR, the probability of propeller mortality on the LOMR would be extremely low and much less probable than that on the Mississippi River, and thus minor and discountable.

Under the LEDPA, the level of commercial sand and gravel dredging in the LOMR would change very little from recent years (2004–2008 levels); therefore, the LEDPA is expected to result in little overall change in the current low potential for navigation propeller entrainment. Under the LEDPA, similar levels of commercial dredging would require greater towboat travel distances because dredging would be spread out to avoid localized effects of dredging intensity. Consequently, the potential for navigation propeller entrainment would increase slightly. The difference in which segment the individual fish mortality might occur would be related to the change in distribution of dredging amounts among the river segments (Table 3-3), as well as the seasonal distribution of the pallid sturgeon population. Because pallid sturgeon are highly migratory, and population and distribution data are limited, these differences cannot be accurately characterized.

6.1.1.2 Dredging Entrainment

Under the LEDPA, some injury and mortality to pallid sturgeon eggs, larvae, or juveniles could result from eggs or fish being drawn into the suction field of the dredge pump. Accurate information is lacking for the rate of pallid sturgeon entrainment into water intakes in the Action Area. Entrainment has been documented at power plant intakes (USFWS 2005) and in the irrigation canal supplied by Intake Dam on the Yellowstone River (Jaeger, Jordan, and Camp et al. 2004), but little data are available regarding the effects of dredge operations. The USACE St. Louis District and the DOER Program have completed work to assess dredge entrainment of fish species and the potential effects of these operations on larval and juvenile *Scaphirhynchus*. Reports include those of Reine and Clark (1998), Hoover et al. (2005), and USACE (2010c). The USACE conducted dredging entrainment susceptibility studies of sturgeon and paddlefish species (Hoover et al. 2005). Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields were used to develop a risk assessment model for entrainment of sturgeon by dredges. Intake water velocity and susceptibility to entrainment in the intake water flow were found to be the primary determinants for entrainment of individual organisms, presumably including pallid sturgeon. However, other secondary variables affecting swimming behavior and performance could also influence and determine entrainment rates (Boyson and Hoover 2009).

Susceptibility (risk of entrainment) depends on swimming behavior and performance (Boyson and Hoover 2009); some sturgeon life stages may also swim toward the dredge head for various reasons including visual, electro-receptive, or audible stimulation (Boyson and Hoover 2009). Researchers found that the rate of sturgeon entrainment at dredge heads would be determined, in part, by their location relative to the dredge, their swimming ability, and if they readily swim against the current (Hoover et al. 2005). While these factors are important in determining entrainment levels, other factors—such as the species' response to noise and turbidity, and its localized abundance and distribution—also would affect entrainment rates (Hoover et al. 2005).

Dredges create suction fields of various sizes, depending on their intake rate, head and pipeline diameter, and other factors. For example, a dredge can create an effect of approximately 1.6 feet per second (50 cm per second) up to a distance of 4.9 feet (1.5 m) from the dredge intake (Hoover et al. 2005). The entrainment studies conducted by Hoover et al. (2005) found that many pelagic, free-swimming fish with an escape speed equal to or greater than the intake velocity and those that are able to orient themselves with the flow would have a higher likelihood of escape, compared to slow-moving fish that cannot orient themselves toward the dredge flow field. A study that evaluated entrainment of white sturgeon found that similar variables dictated the rate of escape for different life history stages of that species (Boyson and Hoover 2009). Boyson and Hoover (2009) also found that smaller fish as a group, compared to larger juveniles and adults, had less endurance and slower swimming speeds, which increased their risk of entrainment.

Few answers and much uncertainty are present about the entrainment rate of pallid sturgeon (USFWS 2005) and the potential population-level effects of entrainment. In regard to the entrainment rate, most studies and the life history of pallid sturgeon suggest that larval and early juvenile would be the life stages most susceptible to entrainment (Peters and Parham 2008). This is because they have less swimming ability and swimming endurance, and because they drift somewhat passively over long distances as they develop and increase their swimming ability (Hoover et al. 2005). Once the eggs hatch, the larval pallid sturgeon drift downstream over long distances in the lower part of the water column, typically within 0.5 to 1 meter of the bottom. Larval drift is greatest adjacent to the bottom in the high-velocity thalweg (Braaten et al. 2010), where most dredging also occurs. In addition, some proportion of young larvae do not orient into the current, thus increasing the chance of coming into contact with a dredge intake field. As a combined result of all of these factors, larval pallid sturgeon in the LOMR may be susceptible to entrainment.

A recent report by the USACE (2010d) concluded that there is a slight possibility that some incidental take of pallid sturgeon could occur as a result of dredging during habitat creation projects. As reported in USACE (2010d), in April 2008, the USFWS initiated discussions with the USACE and other fishery experts regarding the impacts of ESH construction on pallid sturgeon and other fish, specifically with regard to the timing of dredging and construction activities. During those and subsequent discussions, experts from the USACE, USFWS, National Park Service, and South Dakota Game Fish and Parks concluded that no significant impact to pallid sturgeon was anticipated from these activities (USACE 2010d).

During 2008, a field study was conducted by the Engineer Research and Development Center (ERDC) and the Missouri Department of Conservation (MDC) to evaluate the presence or absence of the federally endangered pallid sturgeon in the discharge of operating sand dredges in the Mississippi River near St. Louis (RM 149.8). From September 30 to October 2, 2008, three methods were used to assess potential entrainment. Entrainment was directly assessed by sampling the dredged material and discharge materials with specially designed nets and seines. Discharge was filtered while the dredge was engaged in normal operations (dredge head mostly buried in the sand) and while the dredge head was positioned approximately 1–3 feet above the river bottom, to increase the probability of entrainment. Entrainment probability was assumed to be higher when the head was in the water column and not buried in the substrate. The ERDC and MDC study found no entrainment of fish as a result of the dredging operations performed (ERDC 2008).

In another study, for the entire period of 1990–2005, fewer than 25 cases of sturgeon entrainment by dredges operating in Gulf and Atlantic waters were confirmed (Hoover et. al. 2005). Finally, a study of entrainment of sturgeon by dredging operations was completed by the Hoover et al. (2008) near Duck Island, near the confluence of the Missouri and Mississippi Rivers. Over a 3-month dredging period, entrainment of four individual juvenile sturgeon was documented; all had incurred physical damage that resulted in mortality or delayed mortality.

While larvae and young juvenile pallid sturgeon in the LOMR may be susceptible to entrainment, and that entrainment may occur at some level, the entrainment rate and total number entrained in the LOMR cannot be estimated with accuracy due to lack of data. Some of the information needed to provide estimates of entrainment includes spawning locations, density of drifting larvae at various points within the water column, drift distance, diurnal drift patterns, and efficiency of dredge pumps in entraining water from various locations in the water column. Reine and Clark (1998) concluded that studies to date illustrate the difficulties in determining precise estimates of absolute entrainment rates and have seldom been able to determine population-level consequences with any degree of confidence.

Given the scant information available about actual levels of pallid sturgeon entrainment, reliable estimates of entrainment of pallid sturgeon into dredges in the LOMR are not possible. Based on the size of the inflow zone and the velocity of travel of propellers, the volume of water affected by propellers is much greater than the volume of water passing through the hydraulic dredge pumps. Because the level of navigation propeller-induced mortality of pallid sturgeon was estimated to be extremely low and much less probable than that on the Mississippi River, the potential for pallid sturgeon entrainment and mortality in the LOMR due to dredging entrainment is also determined to be extremely low and improbable and thus, minor and discountable.

Under the LEDPA, the level of commercial sand and gravel dredging in the LOMR would change very little from recent years (2004–2008 levels); consequently, the LEDPA is expected to result in little overall change in the potential for dredge pump entrainment. The difference in which segment the individual fish mortality might occur would likely be related to the change in distribution of dredging amounts among the river segments (Table 3-5), as well as the seasonal distribution of the pallid sturgeon population.

6.1.1.3 Sound and Noise

Fish are capable of producing and detecting sounds, and these sounds affect and are used in a wide variety of fish behaviors (Zelick et al. 1999). Fish detect and respond to sound, using its cues to hunt for prey, to avoid predators, and for social interaction. Sound production has been recently discovered in several species of sturgeon (Johnston and Phillips 2003). Pallid and shovelnose sturgeon produce sounds during the breeding season. In a naturally turbid environment such as the Missouri River, sound cues may play a significant role in communication.

Underwater human-caused noise has also been documented to influence fish behavior in general (Nightingale and Simenstad 2001). Exposure to sound includes a measure of both the received level and the duration of the signal. For example, the received noise level can be expressed in terms of acoustic pressure, particle velocity, or intensity (energy flux), which all vary with time over the duration of the signal. Most noise effects on fishes have been observed in situations of intense energy flux, such as construction-related pile driving or explosions, or propeller and engine noise from high-speed boats.

Dredging operations generally produce lower levels of sound energy over prolonged periods (Nightingale and Simenstad 2001). Nightingale and Simenstad (2001) conducted a literature review of potential dredging-related noise effects on several fish species. The authors concluded that further research into the effects of noises specific to dredging are required to determine the potential effects of dredging noise on fishes. However, noise from the operation of dredges is expected to result in avoidance of the dredging area by fish species sensitive to noise over the duration of the activity. DeLonay et al. (2010) document spring migrations of reproductive pallid sturgeon to be 10's to 100's of kilometers, and migrations have been documented through some dredging reaches (such as Jefferson City, Waverly, and Kansas City). The effect of sound and noise associated with dredging, specifically on migrating reproductive sturgeon, has not been documented (Jacobson pers. comm.).

Sturgeon have been reported to hear sound frequencies in the range of sounds produced by dredging operations (J. J. Hoover, unpublished data as cited in Boyson and Hoover 2009); and it has been reported that dredging sounds could attract, disperse, or cause sturgeon to rise in the water column (Boyson and Hoover 2009). However, using radio telemetry, adult pallid sturgeon have been observed near dredging boats, which suggests that this species may not be particularly sensitive to dredging noise (DeLonay pers. comm.).

Based on the existing information, there appears to be no basis for concluding that noise from commercial sand and gravel dredging would affect pallid sturgeon.

6.1.1.4 Migration and Spawning

Spawning Migration

Over the past 10 years, research led by scientists at the USGS Columbia Environmental Research Center (CERC) and under the Comprehensive Sturgeon Research Project (CSRP) has considerably increased the understanding of pallid sturgeon migration, spawning, and spawning habitats. The research consists of several interdependent and complementary research tasks engaging multiple disciplines that primarily address spawning as a probable limiting factor in reproduction and survival of the pallid sturgeon. Data synthesized and reported from 2005–2008 (DeLonay et al. 2010) and new information from 2009 show consistent patterns of upstream spawning migrations in which sturgeon appear to be spawning at many locations and over a period of 1–2 months. Radio-tracking of pallid sturgeon has shown that females in the LOMR exhibit spawning behavior characterized by rapid upstream movement, stopping and then spawning within hours, followed by a variable intermittent downstream movement (DeLonay et al. 2010).

During these studies, spawning was verified by the recapture of females that had released their eggs after spawning and by observation of spawning aggregations with high-resolution sonar imagery. The CERC studies showed that wild and hatchery–origin pallid sturgeon are spawning at multiple locations in the LOMR; however, it is as yet unknown how many adults are spawning and whether any young are surviving to contribute to the population.

McElroy et al. (2010a) combined location data from pallid sturgeon implanted with telemetric tags and pressure-sensitive data storage tags with depth and velocity data collected with an acoustic Doppler profiler to document the conditions used by migrating sturgeon as they migrated up the LOMR to spawn in spring 2010. The results showed that, within a small margin, pallid sturgeon in the LOMR select least-cost paths as they swim upstream (typical velocities near 1.0–1.2 m/s); velocities in the main thalweg of the LOMR are generally more than twice these values. Within the range of collected data, it is also seen that many alternative paths not selected for migration are two orders of magnitude more energetically expensive (typical velocities near 2.0–2.5 m/s). In general, sturgeon migrated along the inner banks of bends, avoiding high velocities in the thalweg and crossing the channel where the thalweg crosses in the opposite direction in order to proceed up the inner bank of subsequent bends.

Thus, the research to date does not suggest that upstream migration and movement of adult sturgeon in the LOMR are limited. In addition, no comments are found within the related literature and reports regarding blockages or inhibition of movements during the spawning period. In general, upstream-migrating sturgeon appear to migrate upstream in the slower velocities of the inside bend, where commercial dredging is less frequently performed. These data support the hypothesis that migrating sturgeon utilize lower-velocity habitats on inside bends, presumably to minimize energy expenditure (Reuter et al. 2009). In addition to little evidence of avoidance of dredging operations by pallid sturgeon (e.g., due to disturbance, noise, or turbidity), there is little indication of effects of commercial dredging operations on spawning movements and migrations.

Spawning

Spawning habitats documented during 2009 support results from 2005 to 2008 and serve to narrow and quantify spawning conditions – pallid sturgeon appear to spawn on the outside of revetted bends, in areas with deep (greater than 3 m), relatively fast (greater than 1 m/s), and turbulent flow near the toe of the revetted bank. Mapping of upstream probable spawning patches, however, indicated that fish aggregations may also occur at diverging flow over mid-channel bars. DeLonay et al. (2010) consider their results to indicate that spawning habitat availability is not a limiting factor in pallid sturgeon reproduction in the LOMR.

Based on the current understanding of pallid sturgeon spawning habitats, commercial dredging is very unlikely to result in direct disturbance of these spawning habitats. Commercial dredging occurs predominantly in the deep, faster thalweg areas—in areas with sandy bottoms—and not in the revetted areas along outside bends. This is related to the locations of sand deposits and the permit requirements to avoid dredging outside of the RCL and to avoid the toe of revetted banks. In addition, the other suspected location of pallid sturgeon spawning, at the flow divergence immediately above shallower mid-channel bars are not typically used by dredgers.

6.1.1.5 Suspended Sediment and Turbidity

Native aquatic species, such as pallid sturgeon, evolved in the LOMR under historically turbid conditions; turbid conditions that mimic the historical environment have largely been eliminated in the LOMR. At present, suspended sediment loads of the LOMR are from 0.2 to 17 percent of historical pre-dam values (Jacobson, Blevins, and Bittner 2009). Fish species that have become more abundant as turbidity has decreased include site-feeding species; some native fishes, such as pallid sturgeon, with morphological adaptations to use high-turbidity and high-velocity main-channel habitats have declined (Galat et al. 2005). The reduction in overall turbidity of the LOMR has affected the capability of pallid sturgeon and other native fish to forage successfully, which has increased competition with other non-native species (USFWS 2003).

The USACE and others have conducted various studies to examine the magnitude of suspended sediment (measured as total suspended solids), as well as dissipation rates and plume lengths, under a variety of conditions to estimate maximum anticipated effects from dredging (USACE 1986, 1988; Herbich and Brahme 1991; Collins 1995; Clarke and Wilber 2000; Anchor Environmental 2003).

Historical dredging operations within the LOMR have resulted in suspended sediment at the dredging sites and for some distance downstream within the sediment plume. USACE sampling below a cutter-head dredge in the LOMR near the confluence of the Kansas and Missouri Rivers demonstrated that suspended solid concentrations typically returned to background concentrations within approximately 1,300 feet (USACE 1990). The size of the elevated suspended sediment plume downstream of the dredge depends on a variety of factors, including the hydrodynamic conditions at the dredging site, the type of dredge used, operational methods, and sediment type. Dredging will result in localized elevation of suspended sediment at and downstream of the dredges under the LEDPA. However, the change in turbidity is anticipated to be short term and not substantially different from normally occurring levels under current conditions in the LOMR. Studies conducted by the USACE found that most organisms studied were relatively insensitive to the effects of sediment suspensions in the water and that, in general, dredging-induced turbidity is probably not of major environmental concern in most cases (USACE 1978).

Increased suspended sediment plumes downstream of the dredges would be expected under the LEDPA, although they are expected to be localized as described above. Pallid sturgeon are adapted to highly turbid waters and use turbidity as a cover habitat element. Decreased turbidity overall within the LOMR may have increased predation risk to small sturgeons that have historically used elevated turbidity as cover from predatory fish (DeLonay et al. 2010).

Localized areas with a slight increase in potential cover habitat due to increased turbidity would occur as a result of dredging under the LEDPA. Because elevated suspended sediment plumes would extend only a short distance downstream of dredging activities (approximately 1,300 feet), dredging may result in a slight temporary beneficial increase in cover habitat to pallid sturgeon that are located downstream of dredging activities. However, little is known of the relative use of more turbid areas within the dredge plumes versus other areas, and the potential benefit is unclear and probably small and temporary. Although the geographic distribution of dredging would change among the various segments of the LOMR, the amount of dredging would change little from baseline levels. Little or no effect on pallid sturgeon is expected from changes in suspended sediment or turbidity under the LEDPA.

6.1.2 Potential Effects on Pallid Sturgeon Habitat

The physical and biological features of aquatic habitat important to pallid sturgeon can be generally defined by the following constituent elements: (1) physical habitat with structural components known to be important for spawning, rearing, and feeding; (2) water conditions, such as water temperature, turbidity, and food availability; (3) river flow regime, which facilitates spawning migrations and larval and juvenile transport to rearing habitats; and (4) water quality suitable to support the various life stages of sturgeon in good condition. The following discussion focuses on the anticipated effects of the LEDPA on pallid sturgeon in the context of these constituent elements.

6.1.2.1 Physical Habitat

Various habitats thought to be important to pallid sturgeon are currently excluded from dredging in the LOMR (Table 3-7) and will continue to be excluded from dredging under the LEDPA. In addition, the LEDPA includes annual tonnage and dredging density limits within each of the five individually described segments of the LOMR (Table 3-5). Consequently, the total annual level of dredging throughout the Action Area will be reduced slightly under the LEDPA compared to the baseline, although dredging activity is expected to be distributed more broadly within each river segment relative to recent years. Spreading the dredging over a larger area is expected to reduce indirect habitat effects caused by locally intense dredging.

The overall magnitude and duration of direct effects on pallid sturgeon habitat would be determined by the area eventually dredged within each river segment, along with the time required for recovery and repopulation of the benthic habitat directly disturbed by dredging. Potentially, dredging may result in changes to pallid sturgeon habitat at and downstream of dredging sites throughout the Action Area, and these are discussed further below.

Potential Spawning Habitat

Laustrup, Jacobson, and Simpkins (2007) surveyed and mapped coarse substrate deposits and bedrock exposures within the LOMR. This survey provided an initial inventory of areas that may serve as sturgeon spawning habitat; approximately 219 acres of coarse substrate patches and bedrock were identified within the Action Area (Laustrup, Jacobson, and Simpkins 2007). The vast majority of the coarse substrate patches occur within the previously-established exclusion areas; most of the over 100 bedrock features are not within currently dredged areas. Only 0.4 percent, or approximately 0.8 acre of potential coarse patches habitat may be found outside of exclusion zones and would possibly be subject to dredging. This represents a small quantity of the mapped potential coarse substrate spawning habitat available in the Action Area.

As previously described, the most up-to-date information suggests that pallid sturgeon typically spawn on the outside of a revetted bend with deep (greater than 3 m), relatively fast (greater than 1 m/s), and turbulent flow near the toe of the revetted bank, and may also occur at diverging flow over mid-channel bars (DeLonay et al. 2010). DeLonay et al. (2010) consider their results to indicate that spawning habitat availability is not a limiting factor in pallid sturgeon reproduction in the LOMR.

Based on the current understanding of pallid sturgeon spawning habitats, commercial dredging is very unlikely to result in direct disturbance of known or suspected spawning habitats.

Benthic and Foraging Habitats

Dredging also can result in changes to benthic substrate composition and associated pallid sturgeon habitat downstream of dredging sites. As dredging removes sand and gravel, coarser and finer-grained materials are returned to the river bed. Depending on the type of dredge, coarse material is deposited on the river bed below the dredge or to the side of the dredge. As a result, rows of coarse material can form on the river bottom as the dredge moves up and down the river. Bed sediment can also become coarser below dredging operations as finer material is picked up by the river to replenish what was deposited in the dredging depression (Kondolf 1997). These effects are relatively local and tend to accumulate in the areas with the most dredging (Simons, Li, and Associates 1985).

The result may be localized alteration of benthic habitat used by pallid sturgeon. Data have not been collected to definitively characterize the dispersal patterns of coarse-grained sediment after dredging to determine how areas with altered sediment concentrations are used by pallid sturgeon or how long it may take for the river bed disturbed by dredging to regain important pallid sturgeon habitat characteristics. Large, stable substrates such as boulders and cobbles often support larger macroinvertebrates or more productive invertebrate populations than do unstable gravel and sand substrates (Gore 1985, Singhal and Mehrotra 2000). Harvey and Lisle (1998) reported that piles of cobbles produced by suction dredging probably have only minor, local effects on the abundance of aquatic organisms, and taxa that strongly select large, unembedded substrate might become more abundant where cobbles are piled.

Removal of substrate and benthic organisms at the dredging sites by entrainment would result in immediate localized effects on the benthic community (USACE 1998a, Harvey and Lisle 1998), but recovery of macroinvertebrates after such disturbances are typically rapid. This potential direct and indirect effect on pallid sturgeon would be confined primarily to the mid-channel areas where dredging would be allowed and to the area within the dredge suction field. The effects on pallid sturgeon foraging would likely be limited and temporary, given the fact that the proportion of the total foraging area of the river bottom dredged would be low, and the probability that alterations of the bottom substrates may produce equally productive fish and invertebrate habitats and greater substrate diversity.

Shallow-Water Habitat

Riverine habitat loss or alteration in the LOMR, especially loss of structurally complex shallow-water areas along stream margins and near sand bars, islands, backwaters, sloughs, chutes, and side channels, have been implicated as a strong contributing cause in the loss of several native Missouri River fishes (Johnson, Jacobson, and DeLonay 2006). Many of the research, resource management, and restoration plans and programs currently in place in the LOMR are designed to understand the role of SWH and to create more SWH through modifications of flow regime and channel geomorphology. The critical role of such SWH condition, given their presumed importance to young pallid sturgeon, as one of the key limiting factors in the successful reproduction and recruitment of pallid sturgeon, is one of the leading hypotheses now being pursued by multiple researchers (Braaten at al. 2008; DeLonay et al. 2010).

SWH is an important riverine habitat in the LOMR that provides for primary and secondary productivity, forage fish production, and early life stage development for native Missouri River fishes (Hesse et al. 1993, 1989; Galat et al. 2005; Johnson, Jacobson, and DeLonay 2006; Johnson, and Dietsch 2009). SWH is recognized as a now highly-underrepresented aquatic habitat type that was characteristic of the historical Missouri River. Historical changes, such as flow alterations and channelization of the LOMR, likely have substantially decreased the availability of shallow, slow-moving water (Johnson et al. 2006). Further, the LOMR has been and still is affected by reduced sediment inputs; these are important to creating and maintaining the diversity of habitats used by native fish such as the pallid sturgeon for reproduction and survival (USFWS 2003). While the use of SWH by young fish is supported by general river ecology theory, LOMR-specific data documenting the use of this habitat type by certain fish, such as pallid sturgeon, are only now starting to become available (Sterner et al. 2009; USACE 2009c).

The 2003 BiOp (USFWS 2003) indicated that the portion of the LOMR between the Platte River, Nebraska and the LOMR confluence with the Mississippi River is lacking sediment transport and sediment availability, which is adversely affecting pallid sturgeon habitat development and maintenance (USFWS 2003). Further, the USFWS has stated that larval and juvenile pallid sturgeon are limited by the quantity of SWH that provides rearing and refugia habitat (USFWS 2003). While the 2003 BiOp concluded that pallid sturgeon are limited by the lack of SWH, others have indicated that additional studies and modeling are needed to clearly establish which aquatic habitats are limiting to the survival of sturgeon and other native fish populations (Johnson, Jacobson, and DeLonay 2006; DeLonay et al. 2009).

SWH was originally defined as aquatic habitat that is less than 5 feet deep with velocities of less than 2 feet per second, as measured during the August median discharge (USFWS 2003). Recent clarifications further refine the definition of SWH as habitat with a high degree of diversity in depth and velocity that contains dynamic alluvial processes.

River flows and the corresponding river stage fluctuate daily, seasonally, and annually within the highly modified LOMR, and the presence of SWH is highly sensitive to flow regime (Johnson, Jacobson, and DeLonay 2006). Availability of SWH is generally high at the lowest discharges when water is shallow and slow over marginal sand bars and when river discharges are just over bankfull stage (Johnson, Jacobson, and DeLonay 2006). As river flow and stage change, the quantity of aquatic habitat with shallow water and slow velocities changes. Additional studies are underway in the LOMR to better understand the role and importance of SWH and its locations, relationship to channel morphology, and flows (DeLonay et al. 2010).

Programs to Address Shallow-Water Habitat

The Missouri River Restoration Program (MRRP) seeks to mitigate near-term losses of Missouri River habitats and to recover threatened and endangered species. One of these important habitats is SWH that is particularly important to the pallid sturgeon. The program further seeks to restore the Missouri River ecosystem through habitat creation, flow modifications, and monitoring and research to prevent further declines of other native species. Programs are in place through the MRRP to create SWH through mechanical techniques and LOMR flow modifications (MRRP 2007). The USACE's Shallow Water Habitat Program aims to create habitat considered necessary for the recovery of endangered pallid sturgeon. Under the 1986 BSNP Wildlife Mitigation Project, the USACE began constructing chutes and backwaters in 1991 along the main channel, in an effort to restore SWH. As of 2001, these projects have been incorporated into the Shallow Water Habitat Program under BiOp compliance (NAS 2010).

The Reasonable and Prudent Alternatives in the 2000 and Revised 2003 BiOps required reconstruction or rehabilitation of 20 percent of the SWH that existed prior to construction of the BSNP. The project area for the Shallow Water Habitat Program extends from near Ponca, Nebraska downstream to the mouth of the Missouri River at St. Louis. Plans are to ensure that 20–30 acres of shallow/slow-water habitat per river mile exist below Ponca, Nebraska by 2020 to meet this requirement; the program is generally on target as of 2010 (NAS 2010).

Natural SWH in the Missouri River includes side channels, backwaters, submerged sandbar and bank line margins, and low-lying depressions in the floodplain adjacent to the channel. Using natural SWH as a model, constructed SWHs under the revised definition are expected to have a predominance of shallow depths intermixed with deeper holes and secondary side channels, lower velocities, and higher water temperatures than main-channel habitats (NAS 2010). The criteria for depth (<5 feet depth) and for velocity (<2 feet per second) may be modified as understanding of large-river ecology improves. The SWH structures in the main channel aim to enhance habitat diversity by creating zones of higher and lower flow through dike fields and in chute-like areas behind dikes and revetments.

Two types of SWH projects are being constructed: (1) habitat creation at the margins of the navigable portion of the main river channel; and (2) construction or modification of chutes and backwaters on floodplains (NAS 2010). Constructed chutes are intended to have a hydrologic connection to the main channel at both high and low flows, have active bed sediment transport, and provide habitats that mimic historical depth and velocity conditions. Chutes provide shallower, more complex habitat than is found within the navigation channel; and they are designed to evolve over time, developing sinuosity and sandbars (NAS 2010). Constructed backwaters are connected to the main channel at only one end and therefore provide habitat with lower flow velocities.

The use of chutes to enhance habitat diversity and promote river and ecosystem restoration is a relatively new practice, and there is only a small body of existing projects or research findings that could be used to guide Missouri River chute construction and adjustments (NAS 2010). Studies in the Missouri River are being led by USGS scientists within their larger body of research on river corridor habitat dynamics (see Jacobson et al. 2004). However, there are few other examples from within the United States or internationally of restoring floodplains of large rivers (NAS 2010); for example, see Buisje et al. (2002). The limited amount of past projects and substantive research results lends support for the adaptive approach to these projects that is being promoted by the USGS, the USACE, and others.

The effectiveness of SWH projects in the main channel, such as dike notching, bank notching, or chevrons, have been monitored under the Habitat Assessment and Monitoring Program (HAMP) since 2004. HAMP monitoring includes both biological response (fish species composition and richness) and habitat response (water depth, velocity, and substrate) to SWH creation, with sampling designed to relate these two components. The main findings to date are that fish use of SWH is highly variable in project and control reaches (Sampson and Hall 2009). It is not yet possible to draw clear conclusions about the biological effectiveness of the monitoring or the projects. Despite the ongoing monitoring, the NAS (2010) concluded that the SWH restoration program was slow to start, spotty, and incomplete, making it difficult to draw conclusions about successes and progress.

Earlier studies of geomorphology, physical habitat, hydrology, and ecological evolution of natural and created chutes have been conducted by scientists from outside the USACE (Jacobson et al. 2004, Jacobson 2006). Monitoring results of this project for 2006–2008 are summarized and analyzed in a 2009 report (Sterner et al. 2009), which includes monitoring of both fish response and geomorphic/habitat response (NAS 2010). SWH created through construction of chutes off the main channel, originally as part of the Missouri River Fish and Wildlife Mitigation Project, were evaluated. Jacobson et al. (2004) reported that natural and engineered chutes (Cranberry Bend, Lisbon Bottom, Hamburg Bend, and North Overton Bottoms) were providing substantial amounts of SWH, proportionately considerable amounts of SWH in the context of the overall river reach, and providing SWH over a wider range of flows. For example, the 2.2-mile-long Lisbon Bottom chute provides as much as 50 percent of all of the SWH that exists within the accompanying 9.6-mile reach of the river.

Dredging Effects on Shallow-Water Habitat

Sediment loads and sediment transport are important in the development of SWH in the LOMR, and sediment in transient storage during its passage along the river channels and floodplains of the Missouri River valley has value for habitat formation (NAS 2010). Creation and maintenance of SWH are brought about by sediment transport and deposition, which has been reduced from historical levels (USFWS 2003). River bed degradation has resulted from reduced sediment loading and an increased capacity of the LOMR to transport sediment. The ESH and SWH programs are reintroducing some sediment into the Missouri River, and are gradually reintroducing channel mobility and hydraulic connections between the main channel and its floodplain that support new habitat formation (NAS 2010).

Continued river bed degradation could affect the long-term stability and functioning of SWH restored by the MRRP (USACE 2009), but the relationship between bed degradation and sediment transport rates and SWH formation is only poorly understood. Examples of emerging scientific understanding of the performance of SWH projects are only now being published (e.g., Papanicolaou et al. 2010, McElroy et al. 2010b). The research of Papanicolaou et al. (2010), designed to quantify the additional SWH gained from notching these dikes and to evaluate their performance under different flow conditions, demonstrates the complexities involved. Their numerical simulations showed that the SWH criterion for depth was more difficult to satisfy in the study reach than the SWH criterion for velocity, and results from the study suggested that notching the dikes had limited impact on the SWH because the area gained from the bank line shift was offset by the area lost from the scour holes formation. Their research also showed that the performance of the SWH projects was highly discharge dependent; the dike projects could provide the minimum required SWH for some mean annual discharges but not for others.

Despite ongoing research and studies, there are no data or studies that address the relationship between the performance of SWH project and reach-scale changes in bed elevation, or to general or bed elevation changes (either aggradation or degradation). This paucity of information makes it difficult to assess the potential impacts of degradation or channel change on SWH projects. For the purposes of the effects analysis, it was assumed that river bed degradation, in conjunction with the local (reach-scale) removal of sand and gravel, could affect the quantity and distribution of natural or created SWH in the LOMR. Potential effects on naturally occurring SWH could result from changes in elevation, configuration, or connectivity of the SWH to the main river channel, or could affect the performance of SWH projects relative to design specifications.

Because the linkage between river bed degradation, sediment availability, and the quantity of SWH has not been quantified, levels of potential river bed degradation were used in the FEIS (USACE 2011) as a proxy for the potential for changes in the quantities of SWH. The geomorphology analysis in the FEIS described the estimated changes in average river bed elevations and low-flow and high-flow water surface elevations using the following three categories: slight change (less than approximately 2 feet); moderate change (approximately 2–4 feet); and substantial change (greater than approximately 4 feet). Under the Environmentally Preferred Alternative and the LEDPA, dredging would be kept to levels that would result in bed degradation and associated changes in low-flow and high-flow water surface elevations that would be expected to be only slight in the short term and long term. (Note: Without concentration limits, moderate to substantial long-term bed degradation may occur in the long term in the Jefferson City and St. Charles segments, possibly resulting in alteration of SWH; but the proposed monitoring program would detect these changes should they occur, allowing them to be addressed in the next permitting cycle.) In the Kansas City and Waverly segments, slight degradation or aggradation may occur. In the Kansas City segment, the LEDPA would include a three year transition period to the Environmentally Preferred Alternative (see Section 3-10). Annual extraction in the segment would be limited to 1,200,000 tons in 2011; 900,000 tons in 2012; 850,000 tons in 2013; and 540,000 tons per year thereafter. These levels of extraction during this transition period are still expected to result in no more than slight degradation or aggradation for several reasons. First, the tonnage will be at or below the level extracted annually from 2007 to 2009 when comparison of the bed elevation surveys of the Kansas City segment in those years actually showed some recovery. The tonnage extracted annually from 2007 to 2009 was already slightly less than several years earlier when dredging had peaked in the segment. Second, the Missouri River basin experienced an extended drought from 2000 through 2007 and reservoirs and flow in the LOMR were extremely low until runoff, reservoir levels and releases returned to normal in 2009 and 2010. During the period of lower than average flows the LOMR had a corresponding lower than average bed load. Based on the current snowpack throughout the Missouri River basin, the 2010-2011 Annual Operating Plan for the Missouri River Mainstem System (USACE 2010f) projects river flows to be at or above normal in 2011 so the bed material load should be at or above normal and able to accommodate the higher transition dredging level. Third, the transition period is only three years. The final but important reason is that that the water surface profile will be monitored during the transition period and permits for dredging in the segment could be suspended, modified, or revoked if warranted.

The level of degradation anticipated throughout the LOMR is not expected to result in any substantial impacts on the abundance of SWH over and above natural year-to-year variations in the abundance of SWH; changes on the order of moderate to substantial would likely be required for this to occur. This conclusion is made for several reasons.

The first reason is that SWH amounts and dynamics are considerably dependent on flow regime (Jacobson and Galat 2006). Shallow-water, channel margin areas are spatially and temporally dynamic, changing elevation and location as water levels vary with diel and seasonal changes in river discharge. Reeves (2006) concluded that larval rheophilic fish habitat use within the upper 30 cm of the water column within the sandbar shore zone (between the water's edge and a depth of 1 m) is most strongly influenced by the local-environmental factor *current velocity*, followed by the hydrologic factor *change in flow from the 4-day mean*, and finally the geomorphic factor *macrohabitat*. Based on these findings, flow regime exerts such a strong influence on SWH that slight changes in channel form would not be expected to result in a substantial change in SWH.

The second reason is that the bed of the LOMR is in a regular state of flux, and local minor changes in bed elevation and low-flow water surface elevations are a regular feature of the river from year to year and in response to high-flow events. The monitoring results in the LOMR upstream of St. Joseph demonstrated the dynamic nature of the river bed from year to year, even in the absence of commercial dredging.

Finally, many SWH projects are not designed to be static habitat alterations but rather are designed to change and evolve over time in response to flow and sediment regime, in addition to design specifications (McElroy et al. 2010b, NAS 2010). Examples of research showing the evolving nature of SWH projects are provided by Jacobson (2006) and Jacobson et al. (2004). This means that some SWH projects could adjust to minor local changes in bed elevations as they evolve. Many of the SWH projects in the LOMR also have some existing protection from the localized effects of commercial sand and gravel dredging because they are within, partially within, or adjacent to dredging exclusion areas. Dredging is already excluded within 200 feet of dikes and revetments and 100 feet of natural bank lines and islands so SWH created by notching dikes should not be directly impacted by dredging. The inlets and outlets of recently created and still evolving chutes are also protected from dredging so that the sediment supply needed for sandbar formation in the chutes is not disrupted. The lower 50 miles of the LOMR has the greatest amount of SWH including many naturally occurring and mature chutes. Because these natural and mature chutes are in a state of equilibrium, are not actively evolving, and are not likely to be affected by nearby dredging, dredging has not been excluded near those chute inlets and outlets. Examples of protected SWH projects include the Overton Bottoms site (RM 178 to RM 188), which is partially protected by the exclusion areas described in Table 3-7 as RBD Chute at RM 184.75 to RM 185.65 and RBD Chute and Island at RM 186.90 to RM 188.20; and the Heckman Island site (RM 104 to RM 108), which is partially protected by the RBD Dike Field at RM 105.20 to RM 106.25. Protection zones have been added to Table 3-7 for still evolving SWH projects completed since 2005 including the Jameson Island chute (RM 210 to RM 214), and Worthwine Island chute (RM 456 to RM 459). As future SHW projects are completed, habitat protection zones may be added as discussed in Section 3-16.

6.1.2.2 Flow Regime

Stream flow is strongly related to many critical physiochemical components of rivers, such as dissolved oxygen, channel geomorphology, and water temperature, and can be considered a “master variable” that place bounds on the disturbance, abundance, and diversity of many aquatic plant and animal species (Power et al. 1995, Poff and Zimmerman 2010, Poff et al. 2010). The flow regime of the Missouri River and seasonal patterns of flows are essential ecological components of the life history of pallid sturgeon (DeLonay et al. 2009). Flow magnitudes and their timing are important for migration and spawning cues, flow regime strongly influences sediment transport and the development of riverine habitats, and flows strongly influence the amount of SWH (Johnson, Jacobson, and DeLonay 2006; Jacobson and Galat 2006).

The LEDPA would not affect the flow regime of the LOMR, which is largely controlled by flow releases from upstream reservoirs. The LEDPA would only indirectly interact with flow regime via related effects on sediment budget and rates of sediment transport. These effects are more thoroughly discussed in the FEIS (USACE 2011) and in the previous section on SWH.

6.1.2.3 Alteration of Water Quality

Under the LEDPA, dredging would increase or decrease depending on the river segment. Increased dredging would increase the potential for local resuspension of contaminants embedded within the substrate. Background sediment contamination in the LOMR is likely, but the degree of contamination has not been extensively documented (Jacobson et al. 2008). Some studies have indicated various levels of pesticides and metal concentrations in sediments at various locations in the LOMR (Jacobson et al. 2008, Poulton et al. 2010, Echols et al. 2008). Dredging under the LEDPA would increase the number of localized areas where sediment at and downstream of the dredging site would be temporarily suspended.

Under the LEDPA, the level of resuspension of contaminants is expected to decrease in the Kansas City segment due to reduced dredging and the subsequent disturbance of potentially contaminated sediments. The reduction is anticipated to result in a minor improvement in water quality at a local level. In addition, the amount of dredging activity would decrease in this segment, resulting in a reduced risk of spills and leaks and the introduction of oil, fuel, or other contaminants into the LOMR.

The number of areas within the St. Joseph and Waverly segments with possible contaminants temporarily resuspended is anticipated to increase under the LEDPA. Dredging vessel trips are expected to increase, accompanied by a small increase in the risk of vessel incidents (i.e. spills, leaks, and collisions).

Within the Jefferson City and St. Charles segments of the LOMR, dredging would continue as it has recently. Dredging in these segments is expected to result in temporarily re-suspending possibly contaminated sediment into the water column at a rate similar to the baseline condition. Dredging vessel numbers are expected to remain the same; therefore, the risk of dredging vessel incidents would not change.

6.2 PIPING PLOVER

Due to impoundment and channelization, virtually no piping plover nesting habitat is located in the Action Area (USFWS 2003). No portion of the LOMR in the Action Area has been designated as critical piping plover habitat (USFWS 2002). Piping plovers are a transient species that rarely occur in Missouri during migration between wintering grounds and breeding areas (The Audubon Society of Missouri 2009). Migration habitat use is poorly understood, but plovers likely use inland and coastal stopover sites when completing this migration (USFWS 2008). The importance of the Missouri River as migration habitat is unknown (USFWS 2003). Typically, piping plover migration between wintering and nesting habitats peak in spring and fall (USFWS 2008).

Due to the lack of suitable nesting habitat, the rare occurrence of this species during migration, and the lack of critical habitat in the Action Area, dredging under the LEDPA is not likely to affect piping plover populations or their nesting habitat.

6.3 INTERIOR LEAST TERN

Small flocks of interior least terns migrate between wintering and nesting habitat through Missouri from late-April to mid-May and from August through September (MDC 2010a). Although interior least tern breeding habitat historically was located along the Missouri River (USFWS 1992), a 2005 range-wide interior least tern survey (Lott 2006) did not identify any least tern nest sites along that river in Missouri; and no nest sites were observed on the Missouri River south of its confluence with the Lower Platte River in Nebraska. Suitable sand bar nesting habitat has been eliminated in the Action Area because of river channelization and operations (Smith and Renken 1991, USFWS 2003); past channelization projects along the LOMR have resulted in a 97-percent reduction in sand bar areas (Galat et al. 2005).

While interior least tern individuals may occur along the LOMR during migration, nesting has generally not been found to occur within the Action Area. However, by comment on the Draft EIS (USACE 2010a) from the USFWS, some nesting occurs in Council Bluffs at the energy facility adjacent to the river, located in Iowa approximately 80 to 100 miles north of Rulo. Nesting has been documented near Council Bluffs, Iowa, (IDA 2010) which is more than 80 miles north of the Action Area. Historically, the interior least tern nested along the LOMR to St. Louis, Missouri (USACE 2004a);

therefore, this species may use the LOMR for breeding if suitable nesting habitat was present. Due to the general lack of suitable sandbar nesting habitat currently in the Action Area and the lack of breeding birds in the Action Area, dredging under the LEDPA is not likely to affect interior least tern populations or their nesting habitat.

6.4 INDIANA BAT

Indiana bats are permanent residents throughout the Action Area (Natureserve 2009). Between early spring and autumn, Indiana bats migrate to and use summer roosting and foraging areas located in riparian, floodplain, and upland forests (MDC 2010b, USFWS 2007b). Because Indiana bats are located in terrestrial areas, this species and their habitat are unlikely to be affected by the quantity of LOMR dredging under the LEDPA or any of the alternatives.

Between 2007 and 2009, the Missouri population of Indiana bat declined by 14 percent (USFWS 2010b). Current threats to the species include changes in summer habitats from alterations to land cover, the reduction in roosting and foraging forested habitat, and white-nose syndrome (MDC 2010b, USFWS 2010b). Critical habitat for the Indiana bat has been designated only in caves that contain winter roosting habitat (USFWS 1976); therefore, dredging under the LEDPA would not affect designated critical habitat for the Indiana bat.

6.5 DECURRENT FALSE ASTER

The distribution of decurrent false aster is restricted to the portion of the Mississippi River floodplain south of the confluence of the Illinois River with the Mississippi River (MDC 2010c, Natureserve 2009). Decurrent false aster has the potential to occur along Missouri River floodplains in St. Charles County, Missouri (in the St. Charles segment) (MDC 2010c). The primary threat to the decurrent false aster is the loss of suitable wetland habitat (MDC 2010c).

No direct effects on the decurrent false aster from dredging would occur under the LEDPA. Because the decurrent false aster colonizes margins around previously inundated open water wetlands (MDC 2010c), lowering of the water elevation in open water wetlands within this small area could allow this species to establish in newly exposed areas. Therefore, indirect effects on decurrent false aster located in St. Charles County, Missouri could potentially include alteration of wetland habitat due to LOMR river bed degradation and the associated changes in surface water and alluvial aquifer elevations. However, this potential is remote because the water surface elevation and alluvial aquifer elevations are not likely to change near the confluence because of the backwater effect of the

Mississippi River. The LEDPA includes no additional land clearing and the level of dredging proposed to be authorized combined with the backwater effect of the Mississippi River should result in no effect on the false aster.

SECTION 7

Determination of Effect

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this biological assessment represents the best data currently available to assess the potential effects of commercial sand and gravel dredging on five federally listed species in the LOMR, including: pallid sturgeon, *Scaphirhynchus albus*; least tern, *Sterna antillarum*, piping plover, *Charadrius melodus*; Indiana bat, *Myotis sodalis*; and decurrent false aster, *Boltonia decurrens*.

After reviewing the current status of the listed species, the environmental baseline for the Action Area, the effects of the LEDPA, and the cumulative effects, the USACE concludes that the LEDPA would have the following effects on federally listed species within the Action Area.

Species	Federal Status	Effect Determination
Pallid sturgeon, *Scaphirhynchus albus*	Endangered	May Affect, Not Likely to Adversely Affect
Least tern, *Sterna antillarum*	Endangered	May Affect, Not Likely to Adversely Affect
Piping plover, *Charadrius melodus*	Threatened	May Affect, Not Likely to Adversely Affect
Indiana bat, *Myotis sodalis*	Threatened	No Effect
Decurrent false aster, *Boltonia decurrens*	Threatened	No Effect

7.1 PALLID STURGEON

Throughout their range, pallid sturgeon are affected by numerous environmental factors. For example, pallid sturgeon survival and reproduction are affected by water temperature, predation, illegal harvest, contaminants, invasive species, sediment reductions, habitat availability, and magnitude of seasonal floods, among other factors (Wildhaber et al. 2007). The relative importance of each factor and how their importance rankings may change over time are not adequately understood. Intensive management of the Missouri and Mississippi Rivers has resulted in dramatic physical changes to these rivers. Changes in flow, channel morphology, water quality, and biota have been implicated as causative agents in the dramatic declines in native river fishes and their resource base in general, and with the decline of pallid sturgeon in particular. Commercial sand and gravel dredging occurs within this broader context of drastic changes throughout the LOMR; commercial dredging has occurred throughout the last century, but has increased in recent years to its current higher levels, though its effects are poorly understood.

When combined with the past and present effects, along with those anticipated as a result of future non-federal actions within the Action Area, the LEDPA may affect, but is not likely to adversely affect pallid sturgeon. Based on the best available information reported in the literature and the specific factors on the LOMR, the potential for entrainment of pallid sturgeon due to dredging and towboat propellers and related mortality would be extremely low and improbable and thus judged to be minor and discountable. These conclusions are supported by studies where sturgeon entrainment was found to be low, as well as by other studies that found no entrainment of pallid sturgeon.

The other potential adverse effect of dredging on pallid sturgeon is through indirect effects on natural or created SWH, which is thought to be an important habitat to larval and young juvenile pallid sturgeon. However, the effects on SWH are estimated to be minor. This is because under the LEDPA, dredging levels for the entire LOMR, for each segment, and for specific most degraded reaches would be kept to levels expected to result in no more than slight bed degradation and associated changes in low-flow and high-flow water surface elevations in the short term (5 years) and long term. Changes of this magnitude are not expected to result in any substantial impacts on the abundance of SWH over and above natural year-to-year variations in the abundance of SWH, and several lines of reasoning are provided to support this conclusion. Many of the SWH projects in the LOMR also have some existing protection from the localized effects of commercial sand and gravel dredging because they are within, partially within, or adjacent to dredging exclusion areas. Annual water surface profiles and a bed elevation survey in the fourth year of each five-year permit cycle will be used to monitor and to ensure that bed degradation is not more than expected and that SWH is not lost.

Of the other potential effects of the LEDPA, all were judged to be minor and discountable. These include:

- Based on the existing information, there appears to be no basis for concluding that noise from commercial sand and gravel dredging would adversely affect pallid sturgeon.
- There is little evidence of avoidance of dredging operations by pallid sturgeon (e.g., due to disturbance, noise, or turbidity), and there is little indication of effects of commercial dredging operations on spawning movements and migrations.

- Based on the current understanding of pallid sturgeon spawning habitats, commercial dredging is very unlikely to result in direct disturbance of known and suspected pallid sturgeon spawning habitats.

- Increased elevated suspended sediment would have little effect on pallid sturgeon, a species adapted to high levels of turbidity; and plumes downstream of dredging activities may result in a slight temporary beneficial increase to no change in cover habitat to pallid sturgeon that are located downstream of dredging activities.

- The effects of dredging on pallid sturgeon foraging would likely be limited and temporary, given that the proportion of the total foraging area of the river bottom dredged would be low, and the probability that alteration of the bottom substrates may produce equally productive fish and invertebrate habitats and greater substrate diversity.

- The LEDPA would not affect the flow regime of the LOMR, which is largely controlled by flow releases from upstream reservoirs.

- The effects on dredging on water quality would be minor, and although there may be an increase in some contaminants liberated from bottom sediment, these levels would be very low and rapidly diluted in the river.

Overall, commercial dredging in the LOMR is Not Likely to Adversely Affect the Pallid sturgeon and their habitat.

7.2 INTERIOR LEAST TERN

Commercial dredging on the LOMR is not likely to adversely affect interior least tern due to the lack of suitable nesting habitat within the Action Area, the rare occurrence and lack of breeding interior least terns within the Action Area, and the absence of critical habitat in the Action Area.

7.3 PIPING PLOVER

Due to impoundment and channelization, virtually no piping plover nesting habitat is located in the Action Area (USFWS 2003). No portion of the LOMR in the Action Area has been designated as critical piping plover habitat (USFWS 2002). Piping plovers are a transient species that rarely occur in Missouri during migration between wintering grounds and breeding areas (The Audubon Society of Missouri 2009). Due to the lack of suitable nesting habitat, the rare occurrence of this species during migration, and the lack of critical habitat in the Action Area, dredging under the LEDPA is not likely to affect piping plover populations or their nesting habitat.

7.4 INDIANA BAT

Indiana bats are permanent residents throughout the Action Area (Natureserve 2009). Because Indiana bats are located in terrestrial areas, this species and their habitat would not be affected by commercial dredging under the LEDPA. Critical habitat for the Indiana bat has been designated only in caves that contain winter roosting habitat (USFWS 1976); therefore, the LEDPA will not affect designated critical habitat for the Indiana bat.

7.5 DECURRENT FALSE ASTER

No direct effects on the decurrent false aster from dredging would occur under the LEDPA. Because this species has not been identified in the Jefferson City, Waverly, Kansas City, or St. Joseph segments, no direct or indirect effect on the species would be associated with sand plant construction in these segments. Indirect effects in St. Charles County, Missouri are unlikely or nonexistent because water surface elevations and groundwater levels are not expected to change due to the backwater effect of the Mississippi River.

SECTION 8

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8.1 PERSONAL COMMUNICATIONS

DeLonay, Aaron. Research Ecologist, U.S. Geological Survey Columbia Research Station. Telephone conversation with Larry Dominguez (ENTRIX, Inc.) regarding behavior of adult sturgeon, April 4, 2010.

Covington, Glen [a]. U.S. Army Corps of Engineers, Kansas City District. Email communication to Larry Dominguez (ENTRIX, Inc.) regarding 2009 pallid sturgeon sampling results. May 24, 2010.

Covington, Glenn [b]. U.S. Army Corps of Engineers, Kansas City District. Email to Cody Wheeler, Project Manager, U.S. Army Corps of Engineers, Regulatory Branch, Kansas City District. July 1, 2010. Data for 2005–2008 available at: http://www.moriverrecovery.org/mrrp/f?p=136:153:2780039969139178::NO::P153_PROJECTID,P153_STURG_DOC_ID:90%2C0. 2009 data not yet posted.

Dettmers, John, M., Fisheries Ecologist, Great Lakes Fishery Commission and Affiliate of the Illinois Natural History Survey. Telephone conversation between John Dettmers and Paul (CardnoENTRIX, Inc.) regarding entrainment studies. January 6, 2011.

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Scott, C. M., U.S. Fish and Wildlife Service. Letter to Cody Wheeler, Project Manager, U.S. Army Corps of Engineers, Regulatory Branch, Kansas City District. December 3, 2009.

SECTION 9

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- Alison Uno, Staff Scientist, Cardno ENTRIX

From:	Jane_Ledwin@fws.gov
To:	Wheeler, Cody S NWK
Cc:	Hibbs, David R NWK; Jeppson, Matthew P NWK; Charlie_Scott@fws.gov
Subject:	Fw: Missouri River Commercial Dredging Final Biological Assessement
Date:	Wednesday, March 30, 2011 5:20:01 PM

Cody -

Please refer to the March 2011 Biological Assessment for Commercial Sand and Gravel Dredging on the Lower Missouri River, that covers proposed dredging permits in the Kansas City District reach of the Missouri River in Kansas and Missouri. The U.S. Fish and Wildlife Service has reviewed that document and the Final EIS and submits the following comments pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. 1533 et seq.).

As we understand the Corps preferred alternative, dredging amounts in Kansas City would be lowered and permitted levels in the St. Joseph reached would be increased. The reduction in dredging in the Kansas City reach would be phased over multiple years to allow the operator to adjust infrastructure and operations. We assume that the increase in the St. Joseph reach would be similarly phased in to ensure the total permitted levels are consistent with the information presented in the preferred alternative.

Adherence to the monitoring protocols and annual meetings with the dredgers and resource agencies are critical in ensuring river conditions are accurately assessed and addressed accordingly. We look forward to reviewing the initial year of monitoring results.

Based on the information in the BA, including the permit conditions, the monitoring plan, and the annual coordination, the Service concurs with the Corps' determination that the preferred alternative is not likely to adversely affected federally listed species. If the nature or scope of the activities change, please contact this office.

Thank you for your coordination on the permit renewals. If you have any questions regarding these comments, please contact me.

Best Regards -

Jane Ledwin
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