Missouri River Recovery Management Plan and Environmental Impact Statement

Commercial Sand and Gravel Dredging Environmental Consequences Analysis

Technical Report

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Acronyms and Abbreviations

BiOp	2003 Amended Biological Opinion
EQ	environmental quality
ER	Engineering Regulation
ESH	emergent sandbar habitat
HC	human considerations
HEC-RAS	Hydrologic Engineering Center - River Analysis System
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
MRRP	Missouri River Recovery Program
NED	national economic development
OSE	other social effects
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
RED	regional economic development
ResSim	Reservoir System Simulation
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 Introduction

The Kansas City and Omaha Districts of the U.S. Army Corps of Engineers (USACE), in cooperation with the U.S. Fish and Wildlife Service (USFWS), have developed the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS). The purpose of the MRRMP-EIS is to develop a suite of actions that meets Endangered Species Act (ESA) responsibilities for the piping plover, the interior least tern, and the pallid sturgeon.

The purpose of the Commercial Sand and Gravel Dredging Environmental Consequences Analysis Technical Report is to provide supplemental information on the Commercial Sand and Gravel Dredging analysis and results, specifically the methodology and results of the sediment accumulation rate evaluation. Please note that the Final MRRMP-EIS, Section 3.15, Navigation, presents an evaluation of the impacts of changes in river flows and stages on the ability of dredgers to extract and transport material; this document is focused on the sediment accumulation rate.

1.1 Summary of Alternatives

The MRRMP-EIS evaluates the following alternatives. A detailed description of the alternatives is provided in Chapter 2 of the MRRMP-EIS.

- **Alternative 1 – No Action.** This is the No Action alternative, in which the Missouri River Recovery Program (MRRP) would continue to be implemented as it is currently, including a number of management actions associated with the MRRP and 2003 Amended Biological Opinion (BiOp) compliance. Management actions under Alternative 1 include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring pulse for pallid sturgeon. The construction of habitat would be focused in the Garrison and Gavins reaches for ESH (an average rate of 164 acres per year) and between Ponca to the mouth near St. Louis for pallid sturgeon early life stage habitat (3,999 additional acres constructed).
- **Alternative 2 – USFWS 2003 Biological Opinion Projected Actions.** This alternative represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (RPA) (USFWS 2003). Whereas Alternative 1 only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that the USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. Considerably more early life stage habitat (10,758 additional acres constructed) and ESH (an average rate of 1,331 acres per year) would be constructed under Alternative 2 than under Alternative 1. In addition, a spring pallid sturgeon flow release would be implemented every year if specific conditions were met. Alternative 2 would also modify System operations to allow for summer flows that are sufficiently low to provide for early life stage habitat as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon.
- **Alternative 3 – Mechanical Construction.** The USACE would mechanically construct ESH at an average rate of 332 acres per year distributed between the Garrison, Fort Randall, and Gavins Point Reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. The average annual construction amount includes replacing ESH lost to

erosion and vegetative growth, as well as constructing new ESH. An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 3. There would not be any reoccurring flow releases or pulses implemented under this alternative; should new information be learned through Level 1 and 2 studies over the next 9 years suggesting that spring discharges result in stronger aggregation of adult pallid sturgeon at spawning locations or increased reproductive success, a one-time spawning cue test could be implemented to provide additional information to support or refute this hypothesis. At the present time, it is assumed the test release would be similar to the timing, magnitude, duration, and pattern of the spawning cue included as a recurring release under Alternative 6.

- **Alternative 4 – Spring ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 195 acres per year distributed between the Garrison, Fort Randall, and Gavins Point Reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of an ESH-creating reservoir release in the spring. Alternative 4 would be similar to Alternative 1 (the No Action alternative), with the addition of a spring release designed to create ESH for the least tern and piping plover. An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 4.
- **Alternative 5 – Fall ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 253 acres per year distributed between the Garrison, Fort Randall, and Gavins Point Reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of an ESH-creating reservoir release in the fall. Alternative 5 is similar to Alternative 1 (the No Action alternative), with the addition of a release in the fall designed to create sandbar habitat for the least tern and piping plover. An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 5.
- **Alternative 6 – Pallid Sturgeon Spawning Cue.** The USACE would mechanically construct ESH annually at an average rate of 245 acres per year distributed between the Garrison, Fort Randall, and Gavins Point Reaches. In addition, the USACE would attempt a spawning cue pulse every three years in March and May. These spawning cue pulses would not be started and/or would be terminated whenever flood targets are exceeded. An estimated 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 6.

1.2 USACE Planning Accounts

Alternative means of achieving species objectives will be evaluated including consideration for the effects of each action or alternative on a wide range of human considerations (HC). Human considerations to be evaluated in the MRRMP-EIS alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the MRRMP-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR Parts 1500-1508). The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) also served as the central guiding regulation for the economic and environmental analysis included within the MRRMP-EIS. Further guidance that is specific to USACE is described in Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.
- The regional economic development (RED) account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The environmental quality (EQ) displays non-monetary effect of significant natural and cultural resources.
- The other social effects (OSE) account registers plan effects from perspective that are relevant to the planning process, but are not reflected in the other three accounts. In a general sense, OSE refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention.

The accounts framework enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders, while ensuring impacts are not double counted. Given the estimated minimal changes in the sediment accumulation rate under each of the MRRMP-EIS alternatives relative to Alternative 1, it was determined that no measurable impacts to NED, RED, OSE resulted and thus a detailed evaluation of these accounts was not undertaken for Commercial Sand and Gravel Dredging.

1.3 Approach for Evaluating Commercial Sand and Gravel Dredging Consequences of the MRRMP-EIS

The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain lead to changes to the benefits and costs associated with commercial sand and gravel dredging. This figure also shows the intermediate factors and criteria that were applied in assessing the impacts to commercial sand and gravel dredging.

Dredging operations are connected to the Missouri River and are affected by river flows, water surface elevation and sediment conditions. River flows can affect the movement of sediment on the river. A decrease in the overall amount of sediment in the river could lead to a decrease in the availability of materials to extract, conversely, an increase in the amount of sediment would mean there is additional material to extract. In addition, relatively high and low river flows and stages may restrict access to materials in the river, which could decrease the supply, increase operating costs, and possibly increase the cost of sand and gravel to end users. Changes in river conditions could lead to additional capital costs to modify equipment, dredges, or ports.

An analysis of the effects of the MRRMP-EIS alternatives on the average annual rate of sediment accumulation was conducted in selected reaches of the lower Missouri River, which provides an indication on the availability of sediment in the river.

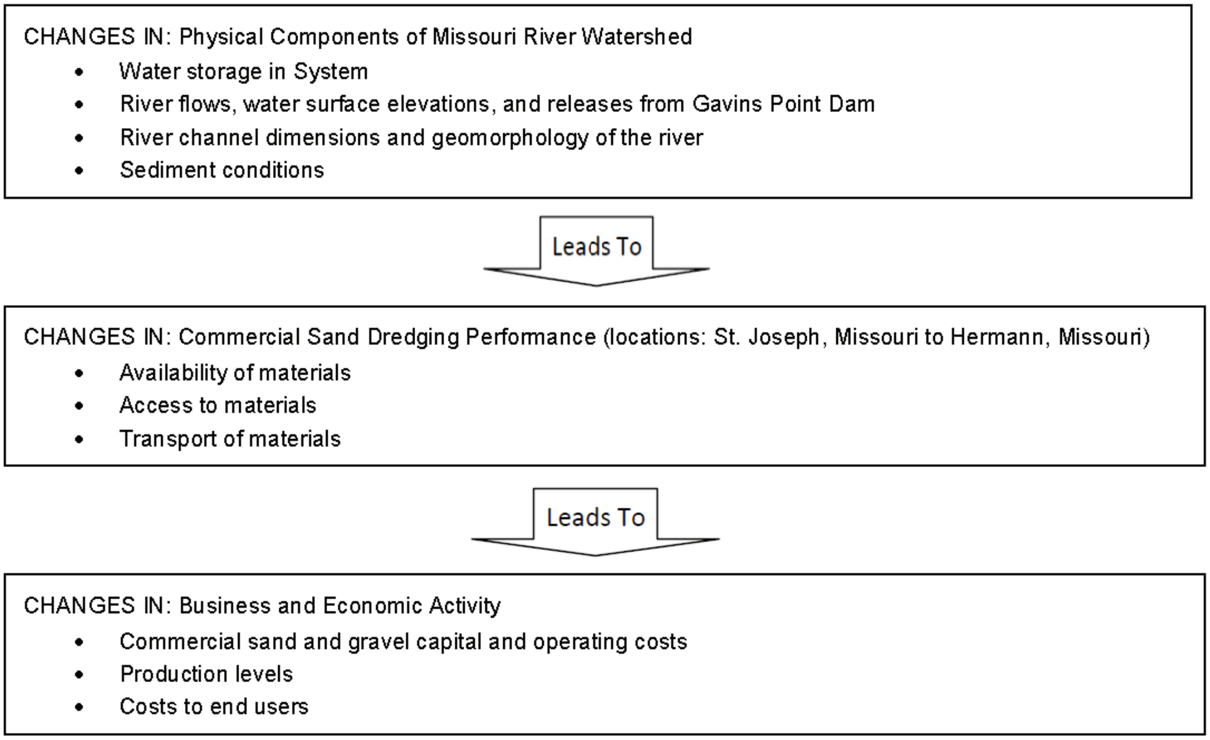

Figure 1. Flow Chart Showing How Physical Components of the River Affect the Analysis of Commercial Sand and Gravel Dredging

2.0 Methodology and Assumptions

This section includes a summary of the methodology to estimate the sediment accumulation rate, as well as the assumptions and limitations of the modeling, and risk and uncertainty considerations.

2.1 Sediment Accumulation Rate

Figure 2 shows the overall methodology used to evaluate the sediment accumulation rate under the MRRMP-EIS alternatives. Sediment accumulation equals the sum of all bed material load entering a reach minus the sum of all bed material load leaving a reach. A higher rate of sediment accumulation is generally considered a benefit for commercial sand and gravel dredging. The change in sediment accumulation rate was evaluated from St. Joseph, Missouri to Hermann, Missouri.

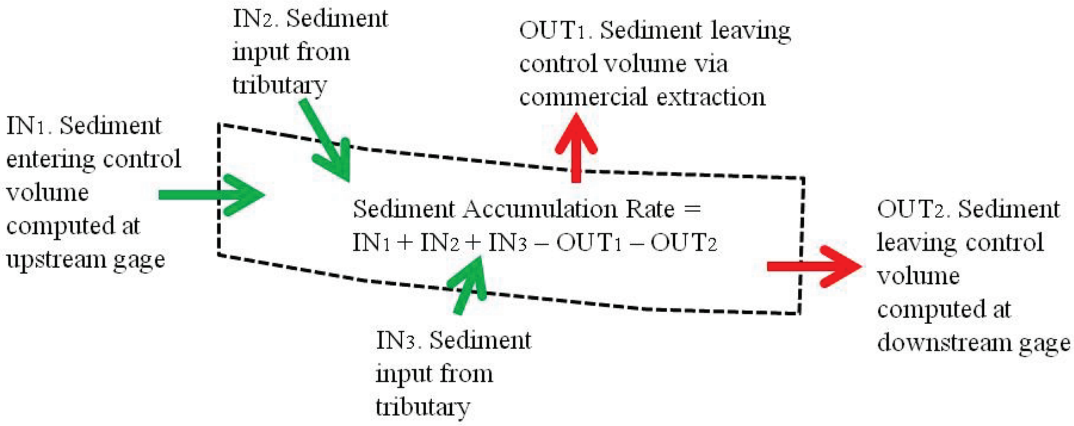

Figure 2. Sediment Accumulation Rate Methodology

The sediment accumulation rate approach is based on measured sediment loads and daily flows, not coupled geomorphic modeling (alteration of the geometry of the channel). The basic equation is that sediment accumulation equals the sum of all sediment entering a reach minus the sum of all sediment leaving a reach. These simplifications preclude the use of this analysis beyond a high-level understanding and ranking of flow-based alternatives

Table 1 identifies the definition of metrics for commercial sand and gravel dredging that has been calculated and presented in this technical report.

Table 1. Commercial Sand and Gravel Dredging Metric Definitions

Flow Scenario	St. Joseph Gage (tons/year)	Kansas City Gage (tons/year)	Kansas River and Platte River (tons/year)	Current allotted Dredging permits (2016 Permit) (tons/year)	Change in Accumulation Rate	Difference from Base (%)	
						St. Joseph to Kansas City	Kansas City to Hermann
Base	XX tons/year	XX tons/year	XX tons/year	XX tons/year	+/− XX tons/year	XX%	XX%
Alternative 1	XX tons/year	XX tons/year	XX tons/year	XX tons/year	+/− XX tons/year	XX%	XX%
Alternative 2	XX tons/year	XX tons/year	XX tons/year	XX tons/year	+/− XX tons/year	XX%	XX%

This analysis uses the USACE hydrology and hydraulic modeling. Flow release scenarios were produced in the Management Plan Reservoir System Simulation (ResSim) model, then routed downstream by the Management Plan Unsteady Hydrologic Engineering Center - River Analysis System (HEC-RAS) Model. Each alternative includes a permutation of historical data that spans from March 1, 1930 to December 31, 2012. This includes a static channel geometry for each alternative based on 2012 data; changes in channel geometry are not evaluated in the sedimentation accumulation rate model. However, the change in channel geometry associated with anticipated early life stage habitat for the pallid sturgeon were included in the channel geometry for the MRRMP-EIS alternatives. Based on engineering judgment and knowledge of the river, the creation of ESH would be a localized effect, not impacting the overall sediment accumulation rate.

The sediment data was derived from U.S. Geological Survey (USGS) unpublished work which was provided in support of MRRMP-EIS sediment modeling. USGS interpolated daily suspended sediment loads and sediment loads less than 0.0625 millimeters at each of the following gages from 1993 to 2013:

a. Missouri River at St. Joseph, Missouri
b. Platte River at Sharps Station, Missouri
c. Kansas River at Desoto, Kansas
d. Missouri River at Kansas City, Missouri
e. Grand River near Sumner, Missouri
f. Chariton River near Prairie Hill, Missouri
g. Missouri River at Hermann, Missouri

The sediment data provided by USGS in support of the MRRMP-EIS sediment modeling is not a stand-alone product and did not go through the standard USGS review process.

Commercial sand and gravel dredging occurs in the lower Missouri River in the following five segments (defined by the USACE Regulatory dredging EIS):

- St. Joseph (RM 391 to 498)
- Kansas City (RM 357 to 391)
- Waverly (RM 250 to 357)
- Jefferson City (RM 130 to 250)

St. Charles (RM 0 to 130)
The following analysis applies to two large reaches of the Missouri River bounded by sediment gages:

- St. Joseph, Missouri to Kansas City, Missouri
- Kansas City, Missouri to Hermann, Missouri

The gaged reaches do not line up precisely with the dredging segments, but are sufficient for this analysis.

The following steps were followed to assess the accumulation rate. Figure 3 depicts the rating curves river flow and sediment.

1. Subtract the sediment load that is less than 0.0625 millimeters from the total suspended load to compute a daily suspended bed material load in order to isolate the bed material load only.
2. Compute a flow/sediment load rating curve by plotting a best-fit curve function through coupled bed material load and daily flow values for each of the Mainstem gages. Due to the unique circumstances of the 2011 flood event, 2011 was excluded to avoid biasing the long-term flow/load rating curves. These rating curves are plotted in Figure 3.

3. Compute a series of daily sediment loads for each flow alternative using the rating curves and the daily flow values provided by the HEC-RAS modeling for the POR flow (1930 to 2012) adjusted for the various alternatives.

4. Divide by the number of days in the period of record flow record and multiply by 365 to produce an average annual sediment load at each Mainstem gage.

5. Compute reasonable averages for tributary inputs and dredging extraction rates. Tributary inputs were computed as the average daily load (1993 to 2013) multiplied by 365. Dredging extraction rates were included as specified in the 2016 permit renewal. Tributary sediment loads and dredging extraction rates remain constant among alternatives and are used to provide a reasonable transformation from the difference between incoming and outgoing sediment at the gages to the desired metric of sediment accumulation rate between the gages.

6. Compute the sediment accumulation rate for each flow alternative as the sum of all sediment entering the reach minus the sum of all sediment leaving the reach. Abbreviations are addressed in Table 2.

   a. St. Joseph to Kansas City: $SAR = SJ_{SED} + KR_{SED} + PR_{SED} – SJ_{DREDGE} – KC_{DREDGE} – KC_{SED}$

   b. Kansas City to Hermann: $SAR = KC_{SED} + GR_{SED} + CR_{SED} – WV_{DREDGE} – JC_{DREDGE} – HER_{SED}$

Table 2. Definition of Terms in Equations 6a, 6b, and 7a

Abbreviation	Definition
SAR	average annual sediment accumulation rate
DREDGE	annual dredging rate in the St. Joseph, Kansas City, Waverly, or Jefferson City segments
SED	average annual sediment load
SJ	Missouri River at Saint Joseph, Missouri
KR	Kansas River
PR	Platte River
KC	Missouri River at Kansas City, Missouri
GR	Grand River
CR	Chariton River
WAV	Waverly
JC	Jefferson City
HER	Missouri River at Hermann, Missouri

7. Compute the change in sediment accumulation compared to the base condition.

   a. $(SAR_{Alt\text{-}i} – SAR_{Alt\text{-}0})/ SAR_{Alt\text{-}0}$

2.2 Assumptions/Limitations for Analysis

Although the sediment accumulation rate evaluation is approached with a sediment budget format, the evaluation is more of a high-level ranking tool and not a detailed sediment budget. A sediment budget compares sediment sources, sinks, and fluxes for a concurrent period of time. This analysis compares the impact of varying the flow regime over the full POR. It includes non-concurrent tributary and dredging data to provide a reasonable transformation from a flux difference at gages to a sediment accumulation rate. The tonnages for tributary inputs are averages based on twenty years of sediment loads, and the dredging extraction is based on the 2016 permitted amounts. This analysis also assumes that the channel geometry does not alter the flow/sediment relationship, either through geomorphic feedbacks or through mechanical habitat creation. Although the estimates of the accumulation rate are approximate, the direction, order-of-magnitude, and relative ranking of alternatives are sufficient for high-level evaluation of flow-based alternatives. This type of analysis cannot be performed on geometric alternatives. Numerical modeling would be required for more detailed analysis.

2.3 Risk and Uncertainty

Risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall MRRMP-EIS is associated with the operation of the Missouri River System and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 82-year POR. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future and would not be captured by the HEC-RAS models or carried through to the modeling described is this document. The project team has attempted to address risk and uncertainty in the MRRMP-EIS by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River.

3.0 Sediment Accumulation Rate Results

Tables 3 and 4 present the results of this analysis from St. Joseph to Kansas City and Kansas City to Hermann, Missouri, respectively. Table 5 presents the composite result from St. Joseph to Hermann, Missouri. Please note that positive values represent higher sediment accumulation (beneficial to commercial sand and gravel dredging) and a negative value represents less sediment accumulation (adverse impact to commercial sand and gravel dredging). Tables 3, 4, and 5 indicate negligible changes that are well within the uncertainty of the input data and analysis methods. Within the limitations of this analysis, these alternatives result in functionally equivalent sediment accumulation rates.

All flow scenarios would have negligible effects (less than a 1.5 percent change) on the sediment accumulation. The different management alternatives would not have a significant impact on the sediment accumulation based on the analysis performed. Table 5 includes overall results (the sediment accumulation totals from Tables 3 and 4) from St. Joseph, Missouri to Hermann, Missouri.

Table 3. Average Annual Sediment Accumulation from St Joseph, Missouri to Kansas City, Missouri

Flow Alternative	St. Joseph Gage (tons/year)	Kansas City Gage (tons/year)	Kansas River and Platte River Gage (tons/year)	Dredging (2016 Permit) (tons/year)	Accumulation Rate (tons/year)	Change in Accumulation Rate from Alternative 1 (tons/year)	Difference from Alternative 1 (%)
Alternative 1	8,271,324	10,352,900	1,485,666	870,000	−1,465,910	NA	NA
Alternative 2	8,324,652	10,410,061	1,485,666	870,000	−1,469,743	-3,833	−0.3%
Alternative 3	8,267,783	10,350,174	1,485,666	870,000	−1,466,725	-815	−0.1%
Alternative 4	8,308,231	10,385,530	1,485,666	870,000	−1,461,634	4,276	0.3%
Alternative 5	8,273,912	10,347,608	1,485,666	870,000	−1,458,030	7,889	0.5%
Alternative 6	8,303,935	10,382,147	1,485,666	870,000	−1,462,547	3,363	0.2%

Table 4. Average Annual Sediment Accumulation from Kansas City, Missouri to Hermann, Missouri

Flow Alternative	Kansas City Gage (tons/year)	Hermann Gage (tons/year)	Grand River and Chariton River Gage (tons/year)	Dredging (2016 Permit) (tons/year)	Accumulation Rate (tons/year)	Change in Accumulation Rate from Alternative 1 (tons/year)	Difference from Alternative 1 (%)
Alternative 1	10,352,900	11,715,176	1,416,608	3,408,000	−3,353,668	NA	NA
Alternative 2	10,410,061	11,816,021	1,416,608	3,408,000	−3,397,351	-43,683	−1.3%
Alternative 3	10,350,174	11,711,669	1,416,608	3,408,000	−3,352,887	781	0.0%
Alternative 4	10,385,530	11,764,503	1,416,608	3,408,000	−3,370,365	-16,697	−0.5%
Alternative 5	10,347,608	11,692,678	1,416,608	3,408,000	−3,336,461	17,207	0.5%
Alternative 6	10,382,147	11,747,139	1,416,608	3,408,000	−3,356,384	-2,716	−0.1%

Table 5. Summary for St. Joseph to Hermann, Missouri

Flow Alternative	Accumulation Rate (tons/year)	Change in Accumulation Rate from Alternative 1 (tons/year)	Difference from Alternative 1 (%)
Alternative 1	−4,819,578	NA	NA
Alternative 2	−4,867,095	-47,517	−1.0%
Alternative 3	−4,819,612	-34	0.0%
Alternative 4	−4,831,998	-12,420	−0.3%
Alternative 5	−4,794,491	25,087	0.5%
Alternative 6	−4,818,931	647	0.0%

Because all flow scenarios have a negligible effect on the sediment accumulation (less than a 1.5 percent change) and are within the uncertainty of the input data and analysis methods, a detailed NED, RED, and OSE evaluation was not conducted. Please note that Section 3.15, Navigation, provides an evaluation of the impacts of changes in river flows and stages on the ability of dredgers to extract and transport material.

4.0 Literature Cited

USFWS 2003. Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Main Stem Reservoir System, Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project, and Operation of the Kansas River Reservoir System.

USACE 2011. United States Army Corps of Engineers Missouri River Bed Degradation Final Environmental Impact Statement (EIS), February 2011

USACE 2011a. United States Army Corps of Engineers Record of Decision for Authorization of Commercial Sand and Gravel Dredging on the Lower Missouri River, March 2011

USACE 2015. United States Army Corps of Engineers Memorandum for Record, Department of the Army Combined Decision Document for Permit Application NWK-2011-00361, NWK-2011-00362, NWK-2011-00363, NWK-2011-00364, MVS-2011-0177, MVS-2011-00178, December, 2015 (for the 2016 thru 2020 permit cycle).