CHAPTER 4

Environmental Consequences

4.1 INTRODUCTION

4.1.1 Summary of Proposed Action and Alternatives Evaluated in Detail

This Chapter presents the environmental and socioeconomic consequences of implementing the Proposed Action and alternatives described in Chapter 2 and summarized below.

- Proposed Action – Permit applications for commercial sand and gravel dredging would be approved at the levels requested by the eight companies within the reaches of the river specified in the applications. Permitted dredging from the LOMR would equal or exceed recent demand levels; therefore, no increased utilization of alternate supplies would likely be necessary.
- No Action Alternative – Permit applications for commercial sand and gravel dredging would not be approved; commercial dredging of sand and gravel in the LOMR would cease on December 31, 2010. Alternate sources of commercial sand and gravel would be relied on to fulfill demand.
- Alternative A – Allowable commercial dredging tonnages would be set at levels at the lower end of the range that is reasonably expected to reduce the contribution of sand and gravel dredging to continued river bed degradation. Alternate sources of commercial sand and gravel would fulfill the remaining demand.
- Alternative B – Allowable commercial dredging tonnages would be set at levels at the upper end of the range that is reasonably expected to reduce the contribution of sand and gravel dredging to river bed degradation. Alternate sources of commercial sand and gravel would fulfill the remaining demand.
- Alternative C – Allowable commercial dredging tonnages would be set at levels that approximate recent dredging. Permitted dredging from the LOMR would equal or exceed recent demand levels; therefore, no increased utilization of alternate supplies would likely be necessary.

Each alternative is defined in terms of annual tonnage, dredging location, restrictions to dredging, operational conditions, and monitoring requirements, as described in Section 2.4.

4.1.2 Environmental Resources Evaluated

This environmental consequences chapter addresses the following resource areas and topics:

- Geology and Geomorphology
- Infrastructure
- Navigation and Transportation
- Water Resources
- Aquatic Resources
- Wetlands, Floodplains, and Terrestrial Resources
- Federally Listed Species
- Land Use and Recreation
- Economics and Demographics
- Noise
- Visual and Aesthetic Resources
- Cultural Resources
- Air Quality and Climate Change
- Cumulative Impacts

The following sections include a description of the approach and methods used in the analysis and a discussion of potential impacts by alternative, impact issue, and river segment.

4.1.3 Key Assumptions

Commercial dredging of sand and gravel was previously authorized to continue in the LOMR through December 31, 2010. Commercial dredging is conducted under a specific set of permit conditions previously developed to reduce the impacts of dredging on the river and related environmental resources. Defined below are assumptions used in the analysis of environmental consequences that reflect these important points.

4.1.3.1 Baseline Conditions

The environmental and socioeconomic impacts associated with implementation of the Proposed Action and each alternative were evaluated relative to baseline conditions. Baseline conditions, described in Chapter 3 (Affected Environment) reflect the existing environment of the LOMR, which includes the

direct and indirect impacts of dredging and other Missouri River projects to date. The direct and indirect impacts of the Proposed Action and each alternative were estimated or characterized as a change from baseline conditions. Adverse and beneficial impacts to a particular environmental resource (e.g., aquatic resources) were identified based on the direct impacts of dredging and indirect effects that are generally manifested through changes in the river channel geometry and water elevations, as compared to the baseline. Indirect impacts were based largely on the projected changes in the river channel based on the results of the geomorphic analysis.

Under the No Action Alternative, commercial dredging of sand and gravel in the LOMR would cease, as would the direct impacts associated with dredging operations (e.g., dredge and barge trips, removal of sand and gravel, noise, and air pollutant emissions). The indirect impacts of the No Action Alternative would be determined by the geomorphic response of the river to the change in sediment regime (e.g., greater sediment load and supply) within each river segment, and the corresponding effects on each of the environmental and socioeconomic resources. The Proposed Action represents a considerable increase in dredging, and Alternatives A and B represent a decrease in dredging compared to recent levels. Direct impacts associated with dredging were assessed based on the magnitude of dredging operations under the Proposed Action and the action alternatives; indirect impacts were assessed based on the projected changes in the river channel indicated by the geomorphic analysis.

Under Alternative C, dredging would approximate recent levels. The response of the river would generally follow its current trajectory, and ongoing impacts to resources would generally continue.

With respect to socioeconomics, it was assumed that baseline conditions include the socioeconomic effects of recent dredging activity on the regional economy, tax revenues, royalties, and the cost of sand and gravel. Potential socioeconomic impacts may include complex responses that are not immediately intuitive. For example, changes in economic activity caused by changes in the amount of river dredging can be offset by other changes in response, such as increases in the trucking industry.

4.1.3.2 Implementation of Current Permit Conditions

It is important to note that commercial dredging of sand and gravel authorized to continue through December 31, 2010, was previously permitted with a specific set of conditions that were imposed to reduce the environmental consequences associated with dredging activities. These conditions are presented in Section 2.4. The environmental consequences discussion assumes that these permit conditions would apply to the Proposed Action and action alternatives. Any potential new permit

conditions are discussed in Chapter 6, “Avoidance, Minimization, and Mitigation Actions,” with other potential mitigation actions. Furthermore, it was assumed that permitting agencies would continue to exercise their regulatory authority to develop and enforce site-specific permit conditions in order to ensure that federal, state, and local regulations are not violated and significant concerns of local residents are addressed. Examples include CWA Section 401 water quality certifications, NPDES discharge permits, MDNR sand and gravel mining permits, other mining permits, and local land use and zoning regulations. See Chapter 7 (Environmental Statutes, Executive Orders, and Governing Agencies) for more information.

4.1.3.3 Alternate Sources

As discussed in Chapter 2, it was assumed that reductions in river dredging below recent levels of demand for commercial sand and gravel would require the use of alternate sources—land- and river-based sources of aggregate and sand, and dredging in other rivers—to meet regional demand. This increase in land-based production and shifting production to other rivers would generate induced secondary environmental and socioeconomic impacts. However, the specific location, timing, and magnitude of these impacts are not reasonably foreseeable because they would result from land use, environmental, business, and regulatory factors that cannot be predicted. Therefore, the impact analysis for alternate sources is general and based on existing information about the most probable types and locations of sand and gravel sources (e.g., open-pit mines, instream mining, and dredging in other rivers).

4.2 GEOLOGY AND GEOMORPHOLOGY

4.2.1 Introduction

Potential direct and indirect impacts to the geology and geomorphology of the LOMR system are associated with dredging under each alternative. Direct impacts include changes in local sediment loads and river bed composition, and changes in river bed elevations. Indirect impacts include changes in channel geometry, which result in changes in low-flow and high-flow water surface elevations and tributary degradation. For purposes of the impact analysis, the proposed level of dredging under each alternative was compared to existing conditions, which include dredging and are described in Section 3.4.

The impact assessment is organized into the following sections:

- Potential impacts from dredging on the geomorphology of the LOMR system;
- Analysis methods, metrics, and assumptions;
- Potential impacts of the Proposed Action;
- Potential impacts of the No Action Alternative; and
- Potential impacts of Alternatives A, B, and C.

4.2.2 Potential Geomorphic Impacts from Dredging in the Lower Missouri River

Four potential impacts on the LOMR system that may arise from dredging were evaluated in the analysis. These include:

- Changes in sediment loads and river bed composition;
- Changes in river bed elevation;
- Changes in channel geometry and water surface elevation; and
- Tributary degradation.

4.2.2.1 Changes in Sediment Loads and River Bed Composition

Dredging affects the sediment load by removing sand and gravel-sized sediment from the river bed. Two potential impacts of dredging on the sediment load and river bed composition were considered:

(1) the effect of removing sand and gravel by commercial dredging on sediment loads in a reach; and (2) the change in size of the particles that compose the river bed (Kondolf 1997).

As described in Section 3.4.5.4, most of the sediment transported by the LOMR consists of "wash load," which is fine sand-, silt-, and clay-sized particles that typically remain in suspension and do not interact with the river bed. The "bed material load" consists of medium to coarse sand and gravel-sized particles moving along the river bed and some of the coarser sand transported in the water column. The amount and size of material transported by the river depend primarily on the volume and velocity of the water moving through a reach of the river; as flows increase, the amount and size of sediment that the river can transport increase (see Section 3.4.5 for more detail on sediment loads). Material extracted by commercial dredging consists primarily of bed material load. Wash load-sized material is generally a smaller particle size, and is either not found in the river bed or is discharged back into the river during dredging (see Section 3.4.5.4 for additional detail).

A depression forms in places where sediment is dredged from the river bed. When dredging at that location has finished, the depression refills over time with material moving along the river bed (bed load) or with material from the water column (suspended sediment) (Simons, Li, and Associates 1985). Erosion of the river bed occurs both upriver as a headcut and downriver from the dredging depression, as the river entrains sediment to replenish its transport capacity (Kondolf 1997; Simons, Li, and Associates 1985; Rinaldi, Wyzga, and Surian 2005).

Because most of the commercially dredged material must meet detailed specifications, dredging operations return the material that is too fine or too coarse to the river. This results in an increase in fine sediment transported downriver as this fine material is discharged into the river from the dredging operation (Kondolf et al. 2002). Depending on the type of dredge, coarse material is deposited on the river bed below the dredge or to the side of the dredge (see Section 2.2.2 for pictures and details of the different types of dredging operations). Consequently, rows of coarse material can form on the river bottom as the dredge moves up and down the river. Bed sediment also can 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; Rinaldi, Wyzga, and Surian 2005).

These effects are relatively local and tend to accumulate in areas with the most dredging (Simons, Li, and Associates 1985). Therefore, changes in sediment loads and river bed composition are considered dredging-related impacts that occur in the vicinity of the dredging operation.

4.2.2.2 Changes in River Bed Elevation

Degradation (lowering of the river bed elevation) on the LOMR can result in the failure of in-river structures, such as dikes and revetments, and exposure of buried pipes. These effects are described in Section 3.5. Factors contributing to degradation are described in Section 3.4.6 and include changes in sediment supply, flow modification by dams, major flood events, BSNP structures, and commercial dredging. The relative contribution of each factor varies at different locations on the river, as does the extent of degradation.

Dredging contributes to river bed degradation in two ways: (1) by directly removing sediment from the river bed; and (2) by reducing the amount of sediment transported through a reach (Kondolf 1997; Simons, Li, and Associates 1985; Rinaldi, Wyzga, and Surian 2005). Degradation has been most pronounced on the LOMR in areas with the most dredging (Figure 3.4-20 in Section 3.4.6.2).

A "headcut," or sudden change in the river bed elevation, can occur if enough sediment is removed from a reach of the river by dredging (Kondolf et al. 2002; Simon, Li, and Associates 1985). In the case of headcuts caused by dredging, erosion occurs on the upriver side, as well as on the downriver side. A headcut will migrate up the river until the average channel slope returns to the pre-headcut level or the headcut encounters substrate that is resistant to erosion (Papanicolaou et al. 2008). The rate at which a headcut advances is determined by bed substrate properties such as particle size, density, and erodibility—as well as factors affecting the flow hydraulics such as flow rate, overfall height, and tailwater conditions. If the bed material is sandy alluvium, such as in the LOMR system, bed erosion and headcut movement can occur relatively quickly (Papanicolauo et al. 2008). Headcuts in the mainstem LOMR have been observed in association with channel cutoffs during construction of the BSNP and in association with dredging in the Kansas City segment (see Sections 3.4.3.2 and 3.4.6.3 for details regarding the effects of cutoffs and dredging).

Aggradation (raising of the river bed elevation) could occur in areas degraded by past dredging when proposed dredging would be less than past dredging. However, because it was designed to maintain a self-scouring navigation channel that reduces deposition, the BSNP may prevent a degraded reach from recovering even if commercial dredging is reduced.

4.2.2.3 Changes in Channel Geometry and Water Surface Elevations

Changes to both low-flow and high-flow water surface elevations may result from changes in channel geometry (USACE 2007; Rinaldi, Wyzga, and Surian 2005). "Channel geometry" refers to the shape of

a channel, which is altered when the river bed degrades or aggrades in a reach, or when bank erosion or deposition occurs in the active channel.

At low flows, water depths are shallow and more closely track changes in the river bed. Therefore, river bed degradation is likely to cause water surface elevations to decrease during periods of low flows. For the purpose of this analysis, low flows were considered to be 40,000 cfs or less. Changes in low-flow water surface elevations can affect municipal water intakes, boat ramps, and BSNP structures; can affect shallow-water habitat, wetlands, and groundwater water surfaces; and can result in tributary degradation (USACE 2007).

Reduced low-flow water surface elevations also allow vegetation to become established along the river banks and on sand bars, especially if periods of low flows become prolonged. The increased amount of vegetation traps sediment, building up land in the channel and reducing the amount of area in the channel to convey high flows. The smaller area in the channel cross section reduces conveyance capacity, resulting in increased water surface elevations at high flows. Figures 3.4-3 and 3.4-4 illustrate how the river channel has narrowed over time and how the high-flow water surface elevations increase as a result. High-flow water surface elevations have increased at most gage locations in the Project area over the past 20 years (USACE 2007).

Floods are instances of rare high-flow events that are of particular concern. Increases in high-flow water surface elevations can increase flood stages and the likelihood of breaching levees that would result in flood-related damage. Higher flood stages also increase the potential for bed scour and degradation from a flood event, which would reduce the river bed elevation and the low-flow water surface elevation. For this analysis, high flows were considered to be 200,000 cfs or greater. Floods were not considered because they cannot be predicted.

Conversely, high-flow water surface elevations may be reduced in the short term in areas where rapid channel degradation occurs. If the channel bed degrades more quickly than vegetation can become established and trap sediment in the channel, a deeper channel cross section is created and the high-flow water surface elevation may decline temporarily.

Due to the complex relationship between channel geometry and water surface elevations, the uncertainty related to estimating changes in water surface elevation is greater than that for other parameters.

Historical water surface elevations at USGS gages on the LOMR are displayed in Figures 3.4-21, 3.4-22, 3.4-28, and 3.4-31; the change in low-flow water surface elevation for the whole length of the LOMR between 1990 and 2005 is displayed in Figure 3.4-20.

4.2.2.4 Tributary Degradation

Degradation on tributaries to the LOMR occurs when the mainstem LOMR channel bed at the confluence of a tributary degrades or when the low-flow water surface elevation on the mainstem drops below typical levels. Tributary degradation has been observed in the Kansas City segment in areas with substantial mainstem degradation (USACE 2009). A tributary will adjust to a new base level in the mainstem by eroding its bed to match the new elevation at the confluence with the LOMR. This often occurs in the form of a headcut, or sudden drop in channel elevation, that erodes and moves upstream until it reaches a geomorphic control point such as a bedrock exposure, dam, or other structure (e.g., culverts, bridge crossings, and rip-rap) that is resistant to erosion. Geomorphic controls usually occur within a few thousand feet of the mainstem LOMR due to the extensive development and dikes constructed in the LOMR floodplain. Consequently, tributary degradation is likely to occur between the confluence with the LOMR and the first geomorphic control point.

Tributary degradation is most likely to occur in areas of concentrated dredging, where river bed degradation and reductions in low-flow water surface elevations are expected to occur as a result of dredging. Table 4.2-1 lists the tributaries by river segment in the areas where existing dredging has been concentrated.[1] These tributaries are at greatest risk of degradation under alternatives where low-flow water surface elevations are expected to decline as a result of dredging in those areas.

Tributary headcutting and degradation can affect infrastructure (including the geomorphic control) by eroding material from around and underneath the structure. For example, if a headcut eroding upstream reaches a bridge crossing, the headcut can erode the material around the bridge foundation and weaken the foundation (Kondolf 1997). These effects are addressed in Section 4.3.

Aggradation on the mainstem LOMR increases in the mainstem low-flow water surface elevations, and changes in high-flow water surface elevations are unlikely to cause tributary bed degradation and are not considered in this analysis.

[1] The Waverly segment is not included in Table 4.2-1 because dredging is not concentrated in any one portion of the segment.

Table 4.2-1 Perennial Tributary Streams in Areas with the Most Dredging under Existing Conditions

River Mile	Tributary Name
St. Joseph Segment	
453.8	Mace Creek
450.1	*
Kansas City Segment	
382.9	Brush Creek
382.2	*
377.4	White Branch
377.4	*
375.9	Burlington Creek
372.1	Line Creek
367.8	Jersey Creek
358.0	*
356.9	Blue River
351.6	*
350.6	Mill Creek
Jefferson City Segment	
148.2	Cedar Creek
145.6	Grays Creek
144.3	Turkey Creek
143.4	Wears Creek
141.3	*
141.0	*
St. Charles Segment	
49.0	Femme Osage Creek
48.2	*
41.8	*
41.7	*
38.8	*
38.4	Bonhomme Creek
37.7	*
34.0	*

Table 4.2-1 Perennial Tributary Streams in Areas with the Most Dredging under Existing Conditions

River Mile	Tributary Name
St. Charles Segment (continued)	
33.4	Duckett Creek
30.7	Creve Coeur Creek
29.1	*
28.3	*
21.3	*
17.8	*
11.9	*
7.3	*
6.9	Mill Creek
2.7	*
1.9	*

Note: The Waverly segment is not included because dredging is not concentrated in any one portion of the segment.

* Tributary was not named in the U.S. Army Corps of Engineers geographic information systems database.

4.2.3 Assessment Methods

The LOMR system described in the affected environment (Section 3.4) was used as a baseline for the impact analysis. Long-term records from the USGS gage stations were reviewed in the context of systemic changes, including changes in flow and sediment resulting from construction of the mainstem dams and the BSNP, and historical dredging levels. Emphasis was placed on recent trends because changes associated with the BSNP have mostly stabilized since it was completed in the 1980s (USACE 2009). Changes in CRP-adjusted low-water surface elevations between 1990 and 2005 were reviewed, as were changes in channel bed cross sections between 1998, 2007, 2008, and 2009 (see Appendix A and Section 3.4.6.1 for details on these analyses). In addition to the trends indicated by these analyses, proposed dredging for each alternative and segment was compared to the bed material load estimates for each segment to determine what percent of the sediment load would be removed by dredging. The results of the bed material load calculations provided one piece of the geomorphic assessment, which was considered in conjunction with all the other available data.

Bed material load estimates were developed for three USGS gage locations (St. Joseph, Kansas City, and Hermann) in the Project area using the best data available at the time the Draft EIS was prepared (Section 3.4.5). Because the bed material load is similar in size to the material being extracted by commercial dredging, it is an approximate indicator of the amount of dredging-sized sediment currently moving through the system (see Figure 3.4-15). The amount of material to be removed by dredging was compared to the estimated bed material loads in areas where river bed degradation has occurred, and in areas without much river bed change, to determine the proportion of the bed material load removed by dredging in those areas. Bed material load estimates were extrapolated between stations for the Waverly and Jefferson City segments as a gage with sediment data was not available in these segments. The average annual bed material load estimates used in the impacts analysis were based on below-average flow conditions from 2000 to 2009, which represent a worst-case scenario for estimating impacts.

4.2.3.1 Changes in Sediment Loads and River Bed Composition

To provide a basis for estimating potential changes to the sediment loads from dredging proposed under each alternative, the percent of the average annual bed material load transported by dredging was calculated for each segment. This gives a relative comparison between the amount dredged and the sediment load for the segment. Dredging generally removes the bed material load-sized sediment and returns the finer sediment and the coarser gravel and cobbles to the river. The analysis also estimated whether sediment availability, fine sediment, and coarse material were likely to increase or decrease in relation to the increase or decrease in the amount of dredging that occurs at a location.

4.2.3.2 Changes in River Bed Elevation

The analysis methods described above were used to estimate potential changes in river bed elevations associated with the Proposed Action and the alternatives. They include:

- Review of past river bed elevation and water surface elevation trends, including river bed elevation changes, stage changes, and slopes;
- Comparison of dredging levels with bed material load estimates to determine the proportion removed by dredging; and
- Comparison of calculated equilibrium slopes with measured river bed slopes at three gage locations to determine whether the existing slope is in equilibrium with flows and sediment loads.

Trends in river bed elevation and water surface elevations, stage changes, slopes, and bed material load estimates are described above and in detail in Section 3.4.

Equilibrium Slope Analysis

In addition to the above analyses, the channel equilibrium slope was calculated at each gage location with adequate sediment data. The calculation was based on the channel geometry, flows, and estimated bed material load (see Appendix A for details regarding bed material load calculations and the equilibrium slope calculation). The calculated channel equilibrium slope was then compared to actual slope measurements based on water surface elevations or channel bed slopes. Where the measured slopes are similar to the calculated results at a gage location, the channel is likely to be close to equilibrium with respect to flows and sediment loads. If the results of the calculation differ from the measured slope, the channel may be out of equilibrium and may respond by aggrading or degrading.

The calculated channel equilibrium slope for cross sections of the river at the St. Joseph and Hermann gages are similar to the measured slopes for those gages, indicating that they are close to equilibrium. The measured slope for the cross section at the Kansas City gage, however, is lower than the calculated slope, indicating that the channel may be out of equilibrium. In this case, the channel would be expected to adjust if the factor that is causing the disequilibrium is removed.

Categories of Bed Elevation Change

Changes in average river bed elevation were classified into three categories: slight change (less than approximately 2 feet), moderate change (approximately 2–4 feet), and substantial change (greater than approximately 4 feet). The categories were selected based on average river bed elevation and low-flow water surface elevation changes observed over the past 20 years. Slight changes in average river bed elevations and water surface elevations occur naturally and may be within measurement error for the methods used to estimate change. Slight aggradation or degradation can occur in a segment independent of dredging and can result from variations in flow conditions and sediment supply. In the absence of dredging and in areas where dredging is not concentrated, these variations may outweigh dredging effects at the segment scale. For example, aggradation occurred in the St. Joseph segment between 2007 and 2009 (see Figure 3.4-21 for details). A moderate change is less likely to be caused by natural variation but is also less likely to cause significant impacts to infrastructure and resources. Substantial change, as has occurred in the Kansas City segment and near the urban areas of Jefferson City and St. Charles (as recorded from the CRP-adjusted low-flow water surface elevations), is more likely to affect infrastructure and other resources.

The amount of change also was linked to the period of analysis. Average river bed elevation changes were determined for the short term (approximately 5 years) and the long term (approximately 5–20 years).

Moderate change in river bed elevations can occur due to migration of sand dunes and inter-annual variability in flows and sediment loads (Abraham pers. comm.). Aggradation and degradation in this analysis refer to longer-term trends in *average* river bed elevation rather than temporary fluctuations in local river bed elevations.

4.2.3.3 Changes in Channel Geometry and Water Surface Elevations

Changes in low-flow water surface elevations were estimated based on the data and trends analyses described above. Changes in low-flow water surface elevations were estimated using three categories: slight change (less than approximately 2 feet), moderate change (approximately 2–4 feet), and substantial change (greater than approximately 4 feet). Changes in high-flow water surface elevations were estimated based on past trends and the change in low-flow water surface elevations in the short term and the long term. Due to the complexity regarding changes in high-flow water surfaces, the impact assessment assesses only whether high-flow water surfaces elevations are likely to increase or decrease as a result of each alternative.

4.2.3.4 Tributary Degradation

Because tributary degradation has not been well quantified on the LOMR, and each tributary is different with regard to size, degree of modification, length between the main channel and control points, degradation, and other factors, each tributary was not analyzed individually. Instead, the impact assessment characterizes the likelihood that tributary degradation would increase under an alternative based on the change in low-flow water surface elevations on the mainstem LOMR occurring near the tributary. The analysis focused on tributaries in areas with concentrated dredging and degradation under existing conditions, such as the areas around St. Joseph, Kansas City, Jefferson City, and St. Charles (Table 4.2-1). In general, low-flow water surface elevations would need to decrease a moderate or substantial amount before tributaries are likely to be affected. Tributary degradation has been documented in the Kansas City segment, which experienced a decrease in low-flow water surface elevations of approximately 2–7 feet between 1990 and 2005 (USACE 2009). Slight changes in low-flow water surface elevation were considered unlikely to affect tributary degradation because slight changes range from 0 to 2 feet and are likely too small to cause tributary degradation with any certainty.

4.2.3.5 Assumptions

Key assumptions used in the impact analysis include the following:

- Period of analysis – The period of analysis is 20 years. Change that would occur from approximately 0 to 5 years is considered short term, while change between approximately 5 and 20 years is considered long term. It should be noted that the impacts described in this analysis follow trends that may not coincide with the transition from short term to long term. For example, a segment or reach projected to experience a moderate amount of degradation in the long term may transition from a slight to moderate amount of degradation at any time between approximately 5 and 20 years.
- Flow conditions – The impact analysis assumed that flow conditions were below average and similar to the flows from 2000 to 2009. This is consistent with the bed material load analysis in Section 3.4.5 and provides an estimate of worst-case impacts because potential degradation under normal-flow conditions would be less. Although they can measurably affect river bed elevations, extreme flood or drought scenarios were not considered in the analysis because they cannot be accurately predicted.
- Dredging locations – To estimate impacts from dredging, the analysis assumed that most dredging would occur near existing dredging locations, which are typically within 10 miles upriver and 5 miles downriver of a sand plant. Dredging and sand plant locations are shown in Figure 2.2-1 (Sheets 1 through 5) in Section 2.2.
- Other actions affecting geomorphology – Other activities that could affect the geomorphology of the LOMR in the short term and the long term include implementation of the MRRP by the USACE in compliance with the 2003 Biological Opinion for the project (USFWS 2003). These activities are not addressed in the impacts analysis but are addressed in the cumulative effects analysis (Chapter 5).

4.2.4 Proposed Action

The Proposed Action would permit approximately 11,615,000[2] tons of commercial dredging from the five segments of the LOMR. This would increase the amount of material dredged in each segment, with the greatest increases occurring in the St. Joseph and St. Charles segments. Table 4.2-2 shows the amount dredged under existing conditions (2004–2008), the amount of dredging proposed under the Proposed Action, the amount dredged as a percent of the bed material load for both existing

[2] The total permitted under the Proposed Action would be limited to 11,615,000 tons even though the total amount analyzed is 13,350,000 tons due to permit requests that overlap segment boundaries.

conditions and the Proposed Action, and the portion of the segment where dredging is concentrated under existing conditions.

Table 4.2-2 Dredging under Existing Conditions and the Proposed Action

Segment	Dredging – Existing Conditions (tons/year)	Dredging Percent of Bed Material Load – Existing Conditions	Dredging – Proposed Action (tons/year)	Dredging Percent of Bed Material Load – Proposed Action	Percent Increase in Dredging from Existing Conditions	Primary Dredging Location – Existing Conditions
St. Joseph	326,928	9%	1,150,000	33%	252%	RM 445 – RM 455
Kansas City	2,658,831	50%	4,060,000	76%	53%	Throughout segment
Waverly	677,987	14%	1,005,600	20%	48%	Throughout segment
Jefferson City	1,578,858	37%	2,750,000	65%	74%	RM 140 – RM 150
St. Charles	1,649,326	45%	4,384,400	119%	166%	Below RM 50

Note: RM = River mile.

4.2.4.1 Changes in Sediment Loads and River Bed Composition

All Segments

Localized changes in sediment loads and river bed composition occur in the vicinity of the dredging operation and are proportional to the amount of dredging occurring. Table 4.2-2 lists the amount of dredging proposed for each segment under the Proposed Action, compares the proposed level to existing conditions, and describes where dredging is concentrated in the segment. Increased dredging to the levels described in the Proposed Action would result in the following effects in all segments:

- Short-term impacts in all segments under the Proposed Action would include a local decrease in sediment availability as the dredged area captures sediment transported by the river, and erosion occurs downriver as the river replaces the captured sediment. The amount of fine sediment in the water column would increase below the active dredge location as the dredging operation discharges unusable material back into the river.
- Long-term impacts in all segments under the Proposed Action would include an increase in the concentration of coarse gravel and cobbles on or near the surface of the river bed as material is dredged from the river bed and the material that is too coarse to retain is deposited back onto the surface of the river bed.

St. Joseph, Kansas City, and Waverly Segments

Because of the additional amount of dredging required to obtain material that meets specifications, the effects of dredging on sediment availability and coarse sediment would be greater for the St. Joseph, Kansas City, and Waverly segments than for the Jefferson City and St. Charles segments. In general, the bed material in the St. Joseph, Kansas City, and Waverly segments tends to be finer than the specifications for concrete sand, requiring that additional material be dredged from the river bed (see Figures 3.4-14 and 3.4-15 for the size distribution of bed material relative to the specifications). For example, up to two-thirds of the material dredged in some areas of the Kansas City segment is too fine to meet specifications for making concrete and is discharged back into the river. As a result, the actual volume of material extracted from the river bed may be three times greater than the dredging records indicate, increasing local impacts on sediment availability and coarse sediment.

4.2.4.2 Changes in River Bed Elevation

St. Joseph Segment

The Proposed Action would permit 1,150,000 tons of dredging per year in the St. Joseph segment. From 2004 to 2008 (existing conditions), dredging occurred mainly in the St. Joseph area between RM 445 and RM 455, and averaged 326,928 tons per year.

The Proposed Action would increase the amount dredged in the St. Joseph segment by approximately 2.5 times the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from approximately 9 percent (existing conditions) to 33 percent. By comparison, this level of dredging as a percent of the bed material load is similar to the level that occurred in the Jefferson City segment from 2004 to 2008, where dredging-related degradation has occurred. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 20 percent.

If the proposed level of dredging in the St. Joseph segment occurs in the same area that past dredging occurred (in the St. Joseph area between RM 445 and RM 455), slight dredging-related degradation in that area would be expected in the short term, and moderate to substantial dredging-related degradation would be expected in the long term.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the

reach. The result would be a slight aggradation or degradation throughout the reach in the short term and slight degradation in the long term.

Kansas City Segment

The Proposed Action is to permit 4,060,000 tons of dredging per year in the Kansas City segment. From 2004 to 2008 (existing conditions), dredging averaged 2,658,831 tons per year in the Kansas City segment. The segment is relatively short compared to the other segments, and past dredging has occurred throughout the segment.

The Proposed Action would increase the amount dredged in the Kansas City segment by 53 percent above the annual average dredged from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from 50 percent to approximately 76 percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 49 percent. The Kansas City segment has experienced the most river bed degradation of any of the segments based on both the low-flow analysis and the 1998–2009 HBED cross section analysis.

Dredging under the Proposed Action would result in continued river bed degradation in the Kansas City segment, in both the short term and the long term. Projecting the past degradation trend into the future, moderate additional river bed degradation likely would occur in the short term, and substantial river bed degradation would occur in the long term (see Section 3.4.6 for details on past trends).

Other factors likely to contribute to the effects of dredging on the channel bed elevation include the BSNP structures in the Kansas City segment that effectively scour the navigation channel and reduce deposition of new sediment; flow modification from upstream dams that increase moderate flows and eliminate the lowest pre-dam flows from the annual hydrograph; and the Kansas River, which contributes flows but likely has reduced sediment delivery due to dredging and dams. These factors reduce deposition of sediment in this segment and, along with dredging, contribute to the ongoing degradation of the river bed in the segment (see Section 3.4.6.3 for details).

Waverly Segment

The Proposed Action is to permit 1,005,600 tons of dredging per year in the Waverly segment. From 2004 to 2008 (existing conditions), dredging averaged 677,987 tons per year in this segment. Past dredging has been limited and not concentrated in any portion of the segment.

The Proposed Action would increase the amount of dredging in the Waverly segment by 48 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from 14 percent to approximately 20 percent. The amount dredged under the Proposed Action as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 13 percent.

The USGS gage at Waverly indicates that the river bed elevation has been stable since approximately the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation in the middle portion of the segment (RM 255 to RM 325). Increasing the dredging from 14 to 20 percent of the bed material load in the Waverly segment, particularly if it is spread throughout the reach as is currently done, could cause slight degradation or aggradation in the short term and slight degradation in the long term. Changes in river bed elevations would be subject to normal variability on the river, which would result in some areas with aggradation and some areas with degradation.

Jefferson City Segment

The Proposed Action is to permit 2,750,000 tons of dredging per year in the Jefferson City segment. From 2004 to 2008 (existing conditions), dredging averaged 1,578,858 tons per year in this segment. More dredging occurred in the Jefferson City area between RM 140 and RM 150 than in other portions of the segment. Moderate degradation occurs in the Jefferson City portion of the segment, with upriver portions experiencing less degradation (as indicated at the Boonville gage) or aggradation (above RM 225).

The Proposed Action would increase the amount of dredging in the Jefferson City segment by 74 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from 37 percent to approximately 65 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 42 percent.

The USGS gage at Boonville indicates that the river bed elevation has declined slightly in the Jefferson City segment since the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation throughout most of the segment, except for the Jefferson City area. Increasing the dredging from 37 to 65 percent of the bed material load, particularly if it is concentrated in the Jefferson City area as is currently done, would cause moderate river bed degradation in the short term and

substantial river bed degradation in the long term in the Jefferson City area. An additional potential impact from this level of dredging is development of a headcut that could migrate upriver and cause degradation above the area of active dredging and erosion of the river bed downriver. The rest of the segment outside the area of concentrated dredging near Jefferson City would experience slight degradation or aggradation in the short term and the long term.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of bed degradation or aggradation throughout the reach in the short term and slight to moderate degradation in the long term.

St. Charles Segment

The Proposed Action is to permit 4,384,400 tons of dredging per year in the St. Charles segment. From 2004 to 2008 (existing conditions), dredging averaged 1,649,326 tons per year in the segment. Most of the dredging in this segment occurs near St. Charles, below RM 50.

The Proposed Action would increase the amount of dredging in the St. Charles segment by approximately 166 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from 45 percent to approximately 119 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 78 percent.

Average river bed elevation trends at the USGS gage at Hermann (RM 98) indicate that the river bed elevation has been declining steadily in the St. Charles segment since approximately 1959. The 1998–2009 HBED cross section analysis shows some areas of aggradation, with degradation occurring in the area with the most dredging. Increasing the dredging from 45 to 119 percent of the bed material load, particularly if it is concentrated in the St. Charles area, would cause moderate degradation in the short term and substantial degradation in the long term in the St. Charles area. An additional potential impact from this level of dredging is development of a headcut that could migrate upriver and cause degradation above the area of active dredging and erosion of the river bed downriver. Areas outside the St. Charles area would experience slight degradation in the short term and the long term.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach.

The result would be a slight to moderate amount of dredging-related river bed degradation throughout the St. Charles segment in the short term and moderate river bed degradation in the long term.

4.2.4.3 Changes in Channel Geometry and Water Surface Elevations

St. Joseph Segment

If the proposed level of dredging in the St. Joseph segment occurs in the same area that past dredging occurred (in the St. Joseph area between RM 445 and RM 455), slight dredging-related river bed degradation in that area would be expected in the short term, and moderate to substantial dredging-related river bed degradation would be anticipated in the long term.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in the long term in the St. Joseph area.

High-flow water surface elevations likely would increase in the long term in the St. Joseph area, as vegetation becomes established and deposition occurs in the river channel.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the segment. The result would be a slight amount of dredging-related low-flow water surface reductions throughout the segment in the long term.

If dredging was evenly distributed throughout the St. Joseph segment, changes in high-flow water surface elevations are unlikely to change from existing trends, which have been stable over the past 30 years.

Kansas City Segment

Dredging under the Proposed Action likely would result in continued river bed degradation in the Kansas City segment in both the short term and long term, and at a similar or slightly faster rate than has occurred over the past 10 years. Moderate degradation likely would occur in the short term, while substantial degradation likely would occur in the long term.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels in the Kansas City segment likely would result in a moderate reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in the long term.

High-flow water surface elevations in the Kansas City segment could increase or decrease in the short term, and likely would increase in the long term as vegetation becomes established and deposition occurs in the river channel.

Waverly Segment

Increasing dredging from 14 to 20 percent of the bed material load in the Waverly segment, particularly if it is spread throughout the reach as is currently done, likely would cause slight degradation or aggradation in the short term and slight degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevation in the Waverly segment likely would increase or decrease slightly in the short term and decrease slightly in the long term.

Changes in high-flow water surface elevations in the Waverly segment are unlikely to change from existing trends, which have increased slightly in the past 30 years.

Jefferson City Segment

Increasing the dredging from 37 to 65 percent of the bed material load, particularly if it is concentrated in the Jefferson City area as is currently done, would cause moderate river bed degradation in the short term and substantial degradation in the long term in the Jefferson City area.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight reduction in low-flow water surface elevations in the short term and moderate reductions in the long term in the Jefferson City area.

High-flow surface elevations likely would increase in the long term in the vicinity of Jefferson City.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight decrease or increase in the low-flow water surface throughout the Jefferson City segment in the short term and a slight decrease in the long term. Changes in high-flow water surface elevations are unlikely to change from existing trends, which have increased slightly in the past 30 years.

St. Charles Segment

Increasing the dredging from 45 to 119 percent of the bed material load under the Proposed Action, particularly if it is concentrated in the St. Charles area, would cause moderate degradation in the short term and substantial degradation in the long term in the St. Charles area.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a moderate reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in the long term in the St. Charles area.

High-flow water surface elevations in the St. Charles area could decrease in the short term and likely would increase in the long term as vegetation becomes established and deposition occurs in the floodplain channel.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight to moderate reduction in the low-flow water surface elevation throughout the reach in the short term and a moderate reduction in the long term. High-flow water surface elevations could slightly increase in the long term in the St. Charles area as the channel degrades, vegetation becomes established, and deposition occurs in the floodplain channel.

4.2.4.4 Tributary Degradation

Tributary degradation is linked to low-flow water surface elevations in the main channel. In general, a moderate to substantial decrease in LOMR low-flow water surface elevations would need to occur before tributaries are likely to be affected (see Section 4.2.3.4 for details).

St. Joseph Segment

Dredging at the proposed levels likely would result in a slight reduction in low-flow water surface elevations in the short term, and moderate to substantial reductions in the long term in the St. Joseph area.

Tributary degradation is likely to increase in the long term in the St. Joseph area under the Proposed Action.

Kansas City Segment

Dredging under the Proposed Action likely would result in a moderate reduction in low-flow water surface elevations in the Kansas City segment in the short term, and moderate to substantial reductions in the long term.

Tributary degradation is likely to increase in the short term and the long term in the Kansas City segment under the Proposed Action.

Waverly Segment

Dredging under the Proposed Action likely would result in a slight reduction in low-flow water surface elevations in the Waverly segment in the long term.

Because dredging under the Proposed Action would not result in moderate or substantial decreases in low-flow water surface elevations in the Waverly segment, dredging-related tributary degradation would be unlikely to increase.

Jefferson City Segment

Dredging under the Proposed Action likely would result in a slight reduction in low-flow water surface elevations in the Jefferson City segment in the short term, and moderate reductions in the long term. If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight reduction or increase in the low-flow water surface throughout the Jefferson City segment in the short term and a slight decrease in the long term.

Tributary degradation is likely to increase in the long term in the Jefferson City portion of the segment under the Proposed Action. If dredging was spread throughout the reach, tributary degradation would be unlikely in the short term or the long term.

St. Charles Segment

Dredging under the Proposed Action likely would result in a moderate reduction in low-flow water surface elevations in the St. Charles segment in the short term, and moderate to substantial reductions in the long term. If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight to moderate reduction in the low-flow water surface elevation throughout the reach in the short term and a moderate reduction in the long term.

Tributary degradation is likely to increase in the short term and the long term in the St. Charles area under the Proposed Action. Degradation also is likely to occur in the short term and the long term if dredging was spread throughout the reach. The St. Charles segment has more side channels than other segments, and degradation would occur in those areas as well as in the tributaries.

4.2.5 No Action Alternative

Under the No Action Alternative, no commercial dredging would occur in any segment. Table 4.2-3 shows the amount dredged under existing conditions (2004–2008), the dredging proposed under the No Action Alternative, the amount dredged as a percent of the bed material load for existing conditions and the No Action Alternative, and the portion of the segment where dredging is concentrated under existing conditions.

Table 4.2-3 Dredging under Existing Conditions and the No Action Alternative

Segment	Dredging – Existing Conditions (tons/year)	Dredging Percent of Bed Material Load – Existing Conditions	Dredging – No Action Alternative (tons/year)	Dredging Percent of Bed Material Load – No Action Alternative	Primary Dredging Location – Existing Conditions
St. Joseph	326,928	9%	0	0%	RM 445 – RM 455
Kansas City	2,658,831	50%	0	0%	Throughout segment
Waverly	677,987	14%	0	0%	Throughout segment
Jefferson City	1,578,858	37%	0	0%	RM 140 – RM 150
St. Charles	1,649,326	45%	0	0%	Below RM 50

Note: RM = River mile.

4.2.5.1 Changes in Sediment Loads and River Bed Composition

All Segments

Changes in sediment loads and river bed composition occur in the vicinity of the dredging operation and are proportional to the amount of dredging occurring. Because no commercial dredging would take place under the No Action Alternative, no impacts related to dredging would occur in any segment. Dredging would not remove any portion of the bed material load from areas in any segment that experienced concentrated dredging under existing conditions. Coarse material deposited on the river bed from past dredging would be mixed into the river bed over time and would be transported downriver during higher flow events.

4.2.5.2 Changes in River Bed Elevation

All Segments

Under the No Action Alternative, no dredging-related river bed degradation would occur in any segment. Aggradation likely would occur in areas where concentrated dredging occurred recently as the river bed responded to influxes of bed material load in the absence of dredging.

St. Joseph Segment

Under the No Action Alternative, the St. Joseph area (RM 445 to RM 455, where past dredging has been concentrated) would experience slight to moderate aggradation in the short term and the long term. Changes in river bed elevations in the rest of the St. Joseph segment would be subject to normal variability in flows and sediment delivery, which would result in some areas with aggradation and some with degradation.

Kansas City Segment

Under the No Action Alternative, the Kansas City segment likely would experience slight to moderate aggradation in the short term and moderate to substantial aggradation in the long term. Other factors likely to influence the amount of aggradation in this segment include the BSNP structures in the segment that effectively scour the navigation channel and reduce deposition of new sediment; flow modification from upstream dams that increase moderate flows and eliminate the lowest pre-dam flows from the annual hydrograph; and the Kansas River, which contributes flows but likely has reduced sediment delivery due to dredging and dams. These factors reduce deposition of sediment in this segment and may limit aggradation or recovery of the river bed in this segment.

Waverly Segment

Because dredging has not been concentrated in any one portion of the segment in the past, and past dredging has not exceeded 10 percent of the bed material load, impacts from past dredging have been minimal in the Waverly segment. Under the No Action Alternative, the Waverly segment likely would experience slight aggradation or degradation in the short term and the long term in different portions of the segment, in response to inter-annual changes in flows and sediment supply.

Jefferson City Segment

The Jefferson City segment has experienced moderate degradation in the Jefferson City portion of the segment near RM 140 and RM 150. Under the No Action Alternative, the Jefferson City area would

experience slight to moderate aggradation in the short term and slight aggradation or degradation in the long term once that portion of the river bed had recovered from past dredging. The rest of the segment likely would experience slight aggradation or degradation in the short term and the long term in different portions of the segment, in response to inter-annual changes in flows and sediment supply.

St. Charles Segment

Average river bed elevation trends at the USGS gage at Hermann indicate that the river bed elevation has been declining steadily since approximately 1959. The 1998–2009 HBED cross section analysis shows some areas of aggradation, with degradation occurring in the area with the most dredging below RM 50. Under the No Action Alternative, the St. Charles area likely would experience slight to moderate aggradation in the short term and slight aggradation or degradation in the long term once that portion of the river bed had recovered from past dredging. The rest of the segment likely would experience slight aggradation or degradation in the short term and the long term in different portions of the segment, in response to inter-annual changes in flows and sediment supply.

4.2.5.3 Changes in Channel Geometry and Water Surface Elevations

St. Joseph Segment

Under the No Action Alternative, the St. Joseph segment would experience slight to moderate aggradation in the short term and the long term in the St. Joseph area (in the vicinity of RM 445 to RM 455, where past dredging has been concentrated).

Water surface elevations for 20,000-cfs flows have been slightly declining for the last 10 years at the USGS gage at St. Joseph. Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations in the St. Joseph segment likely would increase slightly in the short term and the long term in the vicinity of past concentrated dredging.

High-flow water surface elevations in the vicinity of St. Joseph also would follow existing trends and likely would increase in the long term as the river bed aggrades.

Kansas City Segment

Under the No Action Alternative, the Kansas City segment likely would experience slight to moderate aggradation in the short term and moderate to substantial aggradation in the long term.

Low-flow water surface elevations have been declining at the USGS gage in Kansas City for over 50 years, and the rate of decline has increased over the past 15 years. In addition to dredging, other factors likely have affected degradation in the Kansas City segment under existing conditions. Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations likely would experience a slight to moderate increase in the short term and moderate to substantial increases in the long term, in the areas with the greatest past degradation.

High-flow water surface elevations in the Kansas City segment likely would increase in the short term and the long term as the river bed aggrades.

Waverly Segment

Under the No Action Alternative, the Waverly segment likely would experience aggradation or degradation in the short term and the long term in different portions of the segment, in response to changes in flows and sediment supply.

Low-flow water surface elevations at the USGS gage at Waverly have been comparatively stable for the past 30 years. This trend likely would continue under the No Action Alternative.

High-flow water surface elevations have increased slightly in the Waverly segment over the past 30 years. This trend would not be affected by the No Action Alternative and likely would continue.

Jefferson City Segment

Under the No Action Alternative, the Jefferson City area would experience slight to moderate aggradation in the short term and slight aggradation or degradation in the long term once that portion of the river bed has recovered from past dredging. The rest of the segment likely would experience slight aggradation or degradation in the short term and the long term in different portions of the segment, in response to changes in flows and sediment supply.

Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations likely would experience a slight increase in the short term and the long term in the Jefferson City area. Other portions of the segment would be subject to normal variability on the river, resulting in slight increases or decreases in low-flow water surface elevations in the long term.

Under the No Action Alternative, high-flow water surface elevations likely would continue to follow existing long-term trends and likely would increase in the long term in the vicinity of Jefferson City.

St. Charles Segment

Under the No Action Alternative, the St. Charles portion of the segment likely would experience slight to moderate aggradation in the short term and slight aggradation or degradation in the long term once that portion of the river bed has recovered from past dredging. The rest of the segment likely would experience slight aggradation or degradation in the short term and the long term in different portions of the segment, in response to changes in flows and sediment supply.

Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations likely would experience a slight increase in the short term and the long term in the vicinity of past concentrated dredging. Other portions of the St. Charles segment would be subject to normal variability on the river resulting in slight increases or decreases in low-flow water surface elevations in the long term.

High-flow water surface elevations have not changed much over the past 30 years at the USGS gage at Hermann. This trend is likely to continue for most of the segment. In the St. Charles area, an increase in high-flow water surface elevations may occur under the No Action Alternative as the river bed aggrades in the short term after the cessation of dredging.

4.2.5.4 Tributary Degradation

All Segments

No further degradation or reduction of low-flow water surface elevations would be expected under the No Action Alternative. Tributary headcutting and degradation that had already initiated in all segments as a result of dredging under existing conditions likely would continue in the short term and the long term under the No Action Alternative, but new tributary headcuts or degradation would be unlikely to occur under this alternative.

4.2.6 Alternative A

Alternative A would permit approximately 2,190,000 tons of commercial dredging from the five segments of the LOMR. This would decrease the amount dredged in the Kansas City, Jefferson City, and St. Charles segments and would increase the amount dredged in the St. Joseph and Waverly segments. Table 4.2-4 shows the amount dredged under existing conditions (2004–2008), the dredging proposed under Alternative A, the amount dredged as a percent of the bed material load for

existing conditions and Alternative A, the percent change in dredging between existing conditions and Alternative A, and the portion of the segment where dredging is concentrated under existing conditions.

Table 4.2-4 Dredging under Existing Conditions and Alternative A

Segment	Dredging – Existing Conditions (tons/year)	Dredging Percent of Bed Material Load – Existing Conditions	Dredging – Alternative A (tons/year)	Dredging Percent of Bed Material Load – Alternative A	Percent Change in Dredging from Existing Conditions	Primary Dredging Location – Existing Conditions
St. Joseph	326,928	9%	350,000	10%	7%	RM 445 – RM 455
Kansas City	2,658,831	50%	540,000	10%	-80%	Throughout segment
Waverly	677,987	14%	500,000	10%	-26%	Throughout segment
Jefferson City	1,578,858	37%	430,000	10%	-73%	RM 140 – RM 150
St. Charles	1,649,326	45%	370,000	10%	-78%	Below RM 50

Note: RM = River mile.

4.2.6.1 Changes in Sediment Loads and River Bed Composition

All Segments

Localized changes in sediment loads and river bed composition occur in the vicinity of the dredging operation and are proportional to the amount of dredging occurring. Dredging proposed under Alternative A would result in the following effects in all segments:

- Short-term impacts in all segments would include a local decrease in sediment availability as the dredged area captures sediment transported by the river, and erosion occurs downriver as the river replaces the captured sediment. The amount of fine sediment in the water column would increase below the active dredge location as the dredging operation discharges unusable material back into the river.
- Long-term impacts in all segments under Alternative A would include an increase in the concentration of coarse gravel and cobbles on or near the surface of the river bed as material is dredged from the river bed and the material that is too coarse to retain is deposited back onto the surface of the river bed.

St. Joseph, Kansas City, and Waverly Segments

Because of the additional amount of dredging required to obtain material that meets specifications, the effects of dredging on sediment availability and coarse sediment would be greater for the St. Joseph, Kansas City, and Waverly segments under Alternative A than for the Jefferson City and St. Charles segments. In general, the bed material in the St. Joseph, Kansas City, and Waverly segments tends to be finer than the specifications for concrete sand, requiring additional material to be dredged from the river bed (see Figures 3.4-14 and 3.4-15 for the size distribution of bed material relative to the specifications). For example, up to two-thirds of the material dredged in some areas of the Kansas City segment is too fine to meet specifications for making concrete and is discharged back into the river. As a result, the actual volume of material extracted from the river bed may be three times greater than the retained dredging volumes indicate, increasing local impacts on sediment availability and coarse sediment.

4.2.6.2 Changes in River Bed Elevation

St. Joseph Segment

Alternative A would permit 350,000 tons of dredging per year in the St. Joseph segment. From 2004 to 2008 (existing conditions), dredging has occurred mainly in the St. Joseph area between RM 445 and RM 455, and has averaged 326,928 tons per year.

Alternative A would increase the amount dredged in the St. Joseph segment by 7 percent over the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from approximately 9 percent (existing conditions) to 10 percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 6 percent.

If the proposed level of dredging occurs in the same area that past dredging took place (in the St. Joseph area between RM 445 and RM 455), no change in existing degradation trends would be likely. Slight degradation or aggradation would be likely in the short term, with a potential for slight degradation in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from the removal of sediment from the river bed would be spread throughout

the reach. The result would be a slight amount of degradation or aggradation in the short term and the long term.

Kansas City Segment

Alternative A would permit 540,000 tons of dredging per year in the Kansas City segment. From 2004 to 2008 (existing conditions), dredging averaged 2,658,831 tons per year in this segment. The segment is relatively short compared to the other analysis segments, and past dredging has occurred throughout the segment. The Kansas City segment has experienced the most river bed degradation of any of the analysis segments based on both the low-flow analysis and the 1998–2009 HBED cross section analysis.

Alternative A would decrease the amount dredged in the Kansas City segment by approximately 80 percent below the annual average dredged from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 50 to 10 percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 7 percent.

Dredging at the proposed level would reduce dredging-related degradation in the Kansas City segment in the short term and the long term. Slight degradation or aggradation of the river bed would be possible in the short term, and slight aggradation would be possible in the long term.

Other factors likely to influence the potential for aggradation include the BSNP structures in the Kansas City segment that effectively scour the navigation channel and reduce deposition of new sediment; flow modification from upstream dams that increase moderate flows and eliminate the lowest pre-dam flows from the annual hydrograph; and the Kansas River, which contributes flows but likely has reduced sediment delivery due to dredging and dams (see Section 3.4.6.3 for details). These factors reduce deposition of sediment in this segment and may limit aggradation or recovery of the river bed in this segment.

Waverly Segment

Alternative A would permit 500,000 tons of dredging per year in the Waverly segment. Past dredging has been limited and has not been concentrated in any portion of the segment.

Alternative A would decrease the amount of dredging in the Waverly segment by 26 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of

the bed material load at below-average flows would decrease from 14 to 10 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 7 percent.

The USGS gage at Waverly indicates that the river bed elevation has been stable since approximately the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation in the middle portion of the segment (RM 255 to RM 325). Decreasing dredging from 14 to 10 percent of the bed material load, particularly if it is spread throughout the reach as is currently done, could cause slight degradation or aggradation in the short term and the long term. Changes in river bed elevations would be subject to normal variability on the river, which would result in some areas with aggradation and some with degradation.

Jefferson City Segment

Alternative A would permit 430,000 tons of dredging per year in the Jefferson City segment. From 2004 to 2008, dredging averaged 1,578,858 tons per year in the Jefferson City segment. More dredging occurred in the Jefferson City area between RM 140 and RM 150 than in other portions of the segment. Moderate river bed degradation in this segment is concentrated in the Jefferson City area, with upriver portions experiencing less degradation (as indicated at the Boonville gage) or aggradation (above RM 225).

Alternative A would decrease the amount of dredging in the Jefferson City segment by 73 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 37 to 10 percent. The amount dredged as a percent of the bed material load under average flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 7 percent.

The USGS gage at Boonville indicates that the river bed elevation in the Jefferson City segment has declined slightly since the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation throughout most of the segment except for the Jefferson City area, which showed slight to moderate degradation. Decreasing the amount dredged from 37 to 10 percent of the bed material load would cause slight degradation or aggradation in the short term and the potential for slight degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of river bed degradation or aggradation throughout the reach in the short term and the long term.

St. Charles Segment

Alternative A would permit 370,000 tons of dredging per year in the St. Charles segment. From 2004 to 2008, dredging averaged 1,649,326 tons per year in the St. Charles segment. Most of the dredging in this segment occurred near St. Charles, below RM 50.

Alternative A would decrease the amount of dredging in the segment by 78 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 45 to 10 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 7 percent.

Average river bed elevation trends at the USGS gage at Hermann indicate that the river bed elevation has been declining steadily since approximately 1959. The 1990–2005 low-flow analysis shows degradation occurring in the area with the most dredging near St. Charles. Decreasing the dredging from 45 to 10 percent of the bed material load, particularly if it is concentrated in the St. Charles area, would cause slight degradation or aggradation in the short term and the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be slight degradation or aggradation in the segment in the short term and the long term.

4.2.6.3 Changes in Channel Geometry and Water Surface Elevations

St. Joseph Segment

Dredging proposed under Alternative A, particularly if concentrated in the St. Joseph area, likely would result in slight degradation or aggradation in the short term and a potential for slight degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevations likely would be slightly reduced in the long term in the St. Joseph area. Water surface elevations for 20,000-cfs flows have been slightly declining for the last 10 years.

High-flow water surface elevations could increase or decrease in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

Kansas City Segment

Dredging proposed under Alternative A likely would result in slight degradation or aggradation in the Kansas City segment in the short term and slight aggradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevation in the Kansas City segment could increase or decrease slightly in the short term and likely would increase slightly in the long term.

High-flow water surface elevations in the Kansas City segment could increase or decrease slightly in the short term and might increase slightly in the long term as the river bed aggrades.

Waverly Segment

Dredging proposed in the Waverly segment under Alternative A likely would result in slight degradation or aggradation in the short term and the long term.

Low-flow and high-flow water surface elevations are unlikely to change from existing trends. Low-flow water surface elevations have not changed much in the past 20 years in the Waverly segment, and high-flow water surface elevations have increased a slight to moderate amount in the past 20 years.

Jefferson City Segment

Dredging proposed under Alternative A would cause slight degradation or aggradation in the short term and the potential for slight degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight reduction or increase in low-flow water surface elevations in the short term and a slight decrease in the long term in the Jefferson City area.

Under Alternative A, high-flow water surface elevations likely would continue to follow long-term trends and likely would increase in the long term in the vicinity of Jefferson City.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

St. Charles Segment

Dredging proposed under Alternative A could cause slight degradation or aggradation in the short term and the long term in the St. Charles area.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels could result in slight decreases or increases in low-flow water surface elevations in the short term and the long term in the St. Charles area.

The effects of dredging on high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations in the short term or the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

4.2.6.4 Tributary Degradation

All Segments

Because dredging under Alternative A would not result in moderate or substantial decreases in low-flow water surface elevations for any of the segments, dredging-related tributary degradation would be unlikely to increase in any segment under this alternative.

4.2.7 Alternative B

Alternative B would permit 5,050,000 tons of commercial dredging from the five segments of the LOMR. This would decrease the amount dredged in the Kansas City, Jefferson City, and St. Charles segments and increase the amount dredged in the St. Joseph and Waverly segments. Table 4.2-5 shows the amount dredged under existing conditions (2004–2008), the dredging proposed under Alternative B, the amount dredged as a percent of the bed material load for existing conditions and Alternative B, the percent change in dredging between existing conditions and Alternative B, and the portion of the segment where dredging is concentrated under existing conditions.

Table 4.2-5 Dredging under Existing Conditions and Alternative B

Segment	Dredging – Existing Conditions (tons/year)	Dredging Percent of Bed Material Load – Existing Conditions	Dredging – Alternative B (tons/year)	Dredging Percent of Bed Material Load – Alternative B	Percent Change in Dredging from Existing Conditions	Primary Dredging Location – Existing Conditions
St. Joseph	326,928	9%	860,000	25%	163%	RM 445 – RM 455
Kansas City	2,658,831	50%	1,230,000	23%	-54%	Throughout segment
Waverly	677,987	14%	1,140,000	23%	68%	Throughout segment
Jefferson City	1,578,858	37%	980,000	23%	-38%	RM 140 – RM 150
St. Charles	1,649,326	45%	840,000	23%	-49%	Below RM 50

Note: RM = River mile.

4.2.7.1 Changes in Sediment Loads and River Bed Composition

All Segments

Localized changes in sediment loads and river bed composition occur in the vicinity of the dredging operation and are proportional to the amount of dredging occurring. Dredging under Alternative B would result in the following effects in all segments:

- Short-term impacts in all segments would include a local decrease in sediment availability as the dredged area captures sediment transported by the river, and erosion occurs downriver as the river replaces the captured sediment. The amount of fine sediment in the water column would increase below the active dredge location as the dredging operation discharges unusable material back into the river.

- Long-term impacts in all segments under the Alternative B would include an increase in the concentration of coarse gravel and cobbles on or near the surface of the river bed as material is dredged from the river bed and the material that is too coarse to retain is deposited back onto the surface of the river bed.

St. Joseph, Kansas City, and Waverly Segments

Because of the additional amount of dredging required to obtain material that meets specifications, the effects of dredging on sediment availability and coarse sediment would be greater for the St. Joseph, Kansas City, and Waverly segments under Alternative B than for the Jefferson City and St. Charles segments. In general, the bed material in the St. Joseph, Kansas City, and Waverly segments tends to be finer than the specifications for concrete sand, requiring additional material to be dredged from the river bed (see Figures 3.4-14 and 3.4-15 for the size distribution of bed material relative to the specifications). For example, up to two-thirds of the material dredged in some areas of the Kansas City segment is too fine to meet specifications for making concrete and is discharged back into the river. As a result, the actual volume of material extracted from the river bed may be three times greater than the retained dredging volumes indicate, increasing local impacts on sediment availability and coarse sediment.

4.2.7.2 Changes in River Bed Elevation

St. Joseph Segment

Alternative B would permit 860,000 tons of dredging per year in the St. Joseph segment. From 2004 to 2008 (existing conditions), dredging has occurred mainly in the St. Joseph area between RM 445 and RM 455, and averaged 326,928 tons per year.

Alternative B would increase the amount dredged by 163 percent over the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from approximately 9 percent (existing conditions) to 25 percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 15 percent.

If the proposed level of dredging occurs in the same area that past dredging occurred, in the St. Joseph area between RM 445 and RM 455, there likely would be slight degradation in the short term and slight to moderate degradation in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of degradation or aggradation in the short term and the potential for slight degradation in the long term.

Kansas City Segment

Alternative B would permit 1,230,000 tons of dredging per year in the Kansas City segment. From 2004 to 2008 (existing conditions), dredging averaged 2,658,831 tons per year in this segment. The segment is relatively short compared to the other analysis segments, and past dredging has occurred throughout the segment. The Kansas City segment has experienced the most river bed degradation of any of the analysis segments based on both the low-flow analysis and the 1998–2009 HBED cross section analysis.

Alternative B would decrease the amount dredged in the Kansas City segment by 54 percent below the annual average dredged from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 48 to 23 percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 15 percent.

Dredging at the proposed level would reduce dredging-related degradation in the Kansas City segment in both the short term and the long term, and would result in slight degradation in the short term and moderate degradation in the long term.

Other factors likely contribute to the effects of dredging on the channel bed elevation in this segment. These include the BSNP structures in the Kansas City segment that effectively scour the navigation channel and reduce deposition of new sediment; flow modification from upstream dams that increase moderate flows and eliminate the lowest pre-dam flows from the annual hydrograph; and the Kansas River, which contributes flows but likely has reduced sediment delivery due to dredging and dams. These factors reduce deposition of sediment in this segment and, along with dredging, contribute to the ongoing degradation of the river bed in this segment (see Section 3.4.6.3 for details).

Waverly Segment

Alternative B would permit 1,140,000 tons of dredging per year in the Waverly segment. From 2004 to 2008 (existing conditions), dredging averaged 677,987 tons per year in this segment. Past dredging has been limited and has not been concentrated in any portion of the segment.

Alternative B would increase the amount of dredging in the Waverly segment by 68 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would increase from 14 to 23 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 15 percent.

The USGS gage at Waverly indicates that the river bed elevation has been stable since approximately the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation in the middle portion of the segment (RM 255 to RM 325). Increasing the dredging from 14 to 23 percent of the bed material load, particularly if it is spread throughout the reach as is currently done, could cause slight degradation or aggradation in the short term and slight degradation in the long term. Changes in river bed elevations would also be subject to normal variability on the river, which would result in some areas with aggradation and some areas with degradation.

Jefferson City Segment

Alternative B would permit 980,000 tons of dredging per year in the Jefferson City segment. From 2004 to 2008, dredging averaged 1,578,858 tons per year in the Jefferson City segment. More dredging occurred in the Jefferson City area between RM 140 and RM 150 than in other portions of the segment. Moderate river bed degradation in this segment occurred in the Jefferson City portion of the segment, with upriver portions experiencing less degradation (as indicated at the Boonville gage) or aggradation (above RM 225).

Alternative B would decrease the amount of dredging in the Jefferson City segment by 38 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 37 to 23 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 15 percent.

The USGS gage at Boonville indicates that the river bed elevation has declined slightly since the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation throughout most of the segment except for the Jefferson City area, which showed slight to moderate degradation. Decreasing the amount dredged from 37 to 23 percent of the bed material load would cause slight degradation in the short term and slight to moderate degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of river bed degradation or aggradation throughout the reach in the short term and slight degradation in the long term.

St. Charles Segment

Alternative B would permit 840,000 tons of dredging per year in the St. Charles segment. From 2004 to 2008, dredging averaged 1,649,326 tons per year in the St. Charles segment. Most of the dredging in this segment occurred below RM 50 near St. Charles.

Alternative B would decrease the amount of dredging in the segment by approximately 49 percent compared to the annual average from 2004 to 2008. Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would decrease from 45 to 23 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 15 percent.

Average river bed elevation trends at the USGS gage at Hermann indicate that the bed elevation has been declining steadily since approximately 1959. The 1990–2005 low-flow analysis shows some areas of aggradation, with degradation occurring in the area with the most dredging in the St. Charles area. Decreasing the dredge amount from 45 to 23 percent of the bed material load, particularly if it is concentrated in the St. Charles area, would cause slight degradation in the short term and slight to moderate degradation in the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight degradation or aggradation in the short term and slight degradation in the long term.

4.2.7.3 Changes in Channel Geometry and Water Surface Elevations

St. Joseph Segment

Dredging proposed under Alternative B, particularly if it was concentrated in the St. Joseph area, likely would result in slight degradation or aggradation in the short term and a potential for slight to moderate degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations likely would be slightly reduced in the short term and slightly to moderately decreased in the long term in the St. Joseph area. Water surface elevations for 20,000-cfs flows have been slightly declining for the last 10 years.

High-flow water surface elevations would follow existing trends and likely would increase in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

Kansas City Segment

Dredging proposed under Alternative B likely would result in slight degradation in the Kansas City segment in the short term and moderate degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevation in the Kansas City segment likely would decrease slightly in the short term and decrease slightly to moderately in the long term.

High-flow water surface elevations in the Kansas City segment likely would increase in the long term.

Waverly Segment

Dredging proposed under Alternative B could cause slight degradation or aggradation in the short term and slight degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevation in the Waverly segment likely would increase or decrease slightly in the short term and decrease slightly in the long term.

Changes in high-flow water surface elevations in the Waverly segment are unlikely to change from existing trends, which have increased slightly in the past 30 years.

Jefferson City Segment

Dredging proposed under Alternative B would cause slight degradation in the short term and slight to moderate degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight reduction in low-flow water surface elevations in the long term in the Jefferson City area.

Under Alternative B, high-flow water surface elevations likely would continue to follow long-term trends and likely would increase in the long term in the vicinity of Jefferson City.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

St. Charles Segment

Dredging proposed under Alternative B would cause slight degradation in the short term and slight to moderate degradation in the long term in the St. Charles area.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight to moderate decrease in low-flow water surface elevations in the long term in the St. Charles area.

High-flow surface elevations likely would increase in the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

4.2.7.4 Tributary Degradation

Tributary degradation is linked to low-flow water surface elevations in the main channel. In general, a moderate to substantial decrease in LOMR low-flow water surface elevations would need to occur

before tributaries are likely to be affected. Therefore, degradation is unlikely to occur in the Waverly segment.

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

Under Alternative B, moderate decreases in low-flow water surface elevations would occur in the long term in areas with concentrated dredging in the St. Joseph, Kansas City, Jefferson City, and St. Charles segments. Tributary degradation is likely to increase in the vicinity of concentrated dredging in these segments as a result of dredging under Alternative B. Tributary degradation would be unlikely to increase if dredging was spread throughout the reach rather than concentrated in the urban areas.

4.2.8 Alternative C

Alternative C would permit approximately 6,900,000 tons of commercial dredging from the five segments of the LOMR. This would be the same as the average annual amount of dredging from 2004 to 2008. Table 4.2-6 shows the amount dredged under existing conditions (2004–2008), the dredging proposed under Alternative C, the amount dredged as a percent of the bed material load for existing conditions and Alternative C, the percent change in dredging between existing conditions and Alternative C, and the portion of the segment where dredging is concentrated under existing conditions.

Table 4.2-6 Dredging under Existing Conditions and Alternative C

Segment	Dredging – Existing Conditions (tons/year)	Dredging Percent of Bed Material Load – Existing Conditions	Dredging – Alternative C (tons/year)	Dredging Percent of Bed Material Load – Alternative C	Percent Change in Dredging from Existing Conditions	Primary Dredging Location – Existing Conditions
St. Joseph	326,928	9%	330,000	9%	1%	RM 445 – RM 455
Kansas City	2,658,831	50%	2,660,000	50%	0%	Throughout segment
Waverly	677,987	14%	680,000	14%	0%	Throughout segment
Jefferson City	1,578,858	37%	1,580,000	37%	0%	RM 140 – RM 150
St. Charles	1,649,326	45%	1,650,000	45%	0.0%	Below RM 50

Note: RM = River mile.

4.2.8.1 Changes in Sediment Loads and River Bed Composition

All Segments

Localized changes in sediment loads and river bed composition occur in the vicinity of the dredging operation and are proportional to the amount of dredging occurring. Dredging ***proposed under Alternative C would result in the following effects in all segments:

- Short-term impacts in all segments would include a local decrease in sediment availability as the dredged area captures sediment transported by the river, and erosion occurs downriver as the river replaces the captured sediment. The amount of fine sediment in the water column would increase below the active dredge location as the dredging operation discharges unusable material back into the river.
- Long-term impacts in all segments under Alternative C would include an increase in the concentration of coarse gravel and cobbles on or near the surface of the river bed as material is dredged from the river bed and the material that is too coarse to retain is deposited back onto the surface of the river bed.

St. Joseph, Kansas City, and Waverly Segments

Because of the additional amount of dredging required to obtain material that meets specifications, the effects of dredging on sediment availability and coarse sediment would be greater for the St. Joseph, Kansas City, and Waverly segments under Alternative A than for the Jefferson City and St. Charles segments. In general, the bed material in the St. Joseph, Kansas City, and Waverly segments tends to be finer than the specifications for concrete sand, requiring additional material to be dredged from the river bed (see Figures 3.4-14 and 3.4-15 for the size distribution of bed material relative to the specifications). For example, up to two-thirds of the material dredged in some areas of the Kansas City segment is too fine to meet specifications for making concrete, and is discharged back into the river. As a result, the actual volume of material extracted from the river bed may be three times greater than the retained dredging volumes indicate, increasing local impacts on sediment availability and coarse sediment.

4.2.8.2 Changes in River Bed Elevation

St. Joseph Segment

Alternative C would permit 330,000 tons of dredging per year in the St. Joseph segment. This approximates the level of dredging that occurred from 2004 to 2008 (existing conditions), which has occurred mainly in the St. Joseph area between RM 445 and RM 455.

Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would remain at approximately nine percent. The amount proposed to be dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would remain approximately 6 percent.

If the proposed level of dredging occurs in the same area that past dredging occurred (in the St. Joseph area between RM 445 and RM 455), existing degradation trends would not change. Slight degradation or aggradation would be expected in the short term, with a potential for slight degradation in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of degradation or aggradation in the short term and the long term.

Kansas City Segment

Alternative C would permit 2,660,000 tons of dredging per year in the Kansas City segment. This approximates the level of dredging that occurred from 2004 to 2008 (existing conditions). The segment is relatively short compared to the other analysis segments, and past dredging has occurred throughout the segment. The Kansas City segment has experienced the most river bed degradation of any of the analysis segments based on both the low-flow analysis and the 1998–2009 HBED cross section analysis.

Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would remain at approximately 50 percent. The amount dredged under this alternative as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would remain at approximately 32 percent.

Dredging at the proposed level would result in a continuation of current trends (see Section 3.4.6 for details on current trends) in the Kansas City segment, resulting in slight to moderate degradation in the short term and substantial degradation in the long term.

Other factors likely contribute to the effects of dredging on the channel bed elevation in this segment. These include the BSNP structures in the Kansas City segment that effectively scour the navigation channel and reduce deposition of new sediment; flow modification from upstream dams that increase moderate flows and eliminate the lowest pre-dam flows from the annual hydrograph; and the Kansas River, which contributes flows but likely has reduced sediment delivery due to dredging and dams. These factors reduce deposition of sediment in this segment and, along with dredging, contribute to the ongoing degradation of the river bed in the segment (see Section 3.4.6.3 for details).

Waverly Segment

Alternative C would permit 680,000 tons of dredging per year in the Waverly segment. This approximates the level of dredging that occurred from 2004 to 2008 (existing conditions). Past dredging has been limited and has not been concentrated in any portion of the segment.

Under this alternative, the amount dredged as a percent of the bed material load at below-average flows would remain at approximately 14 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would remain at approximately 9 percent.

The USGS gage at Waverly (RM 293) indicates that the river bed elevation has been stable since approximately the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation in the middle portion of the segment (RM 255 to RM 325). Maintaining dredging at 14 percent of the bed material load, particularly if it is spread throughout the reach as is currently done, would cause slight degradation or aggradation in the short term and the long term. Changes in river bed elevations would be subject to normal variability on the river, which would result in some areas with aggradation and other areas with degradation.

Jefferson City Segment

Alternative C would permit 1,580,000 tons of dredging per year in the Jefferson City segment. This approximates the level of dredging that occurred from 2004 to 2008 (existing conditions). More dredging occurred in the Jefferson City area between RM 140 and RM 150 than in other portions of the segment. River bed degradation in this segment occurs in the Jefferson City portion of the segment,

with upriver portions experiencing less degradation (as indicated at the Boonville gage) or aggradation (above RM 225).

Under Alternative C, the amount dredged at below-average flows would remain at 37 percent of the bed material load. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would remain at approximately 24 percent.

The USGS gage at Boonville indicates that the river bed elevation has declined slightly since the 1993 flood event. The 1998–2009 HBED cross section analysis shows areas of aggradation throughout most of the segment except for the Jefferson City area, which shows moderate degradation. Maintaining dredging at 37 percent of the bed material load would cause slight degradation in the short term and moderate to substantial degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight amount of bed degradation or aggradation throughout the reach in the short term and slight degradation in the long term.

St. Charles Segment

Alternative C would permit 1,650,000 tons of dredging per year in the St. Charles segment. This approximates the level of dredging that occurred from 2004 to 2008 (existing conditions). Most of the dredging in this segment occurred below RM 50 near St. Charles.

Under Alternative C, the amount dredged as a percent of the bed material load at below-average flows would remain at 45 percent. The amount dredged as a percent of the bed material load under average-flow conditions (as estimated from the 1994–2009 analysis period) would be approximately 29 percent.

Average river bed elevation trends at the USGS gage at Hermann indicate that the bed elevation has been declining steadily since approximately 1959. The 1990–2005 low-flow analysis shows areas of degradation occurring in the area with the most dredging. Maintaining dredging at 45 percent of the bed material load, particularly if it is concentrated in the St. Charles area, would cause slight degradation in the short term and moderate to substantial degradation in the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The result would be a slight degradation or aggradation in the short term and slight degradation in the long term.

4.2.8.3 Changes in Channel Geometry and Water Surface Elevations

St. Joseph Segment

Dredging proposed under Alternative C, particularly if it was concentrated in the St. Joseph area, likely would result in slight degradation or aggradation in the short term and a potential for slight degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, low-flow water surface elevations likely would be slightly reduced in the long term in the St. Joseph area. Water surface elevations for 20,000-cfs flows have been slightly declining for the last 10 years at the USGS gage at St. Joseph.

High-flow water surface elevations would follow existing trends and could increase or decrease slightly in the long term in the St. Joseph area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near St. Joseph, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

Kansas City Segment

Dredging proposed under Alternative C in the Kansas City segment likely would result in slight to moderate degradation in the short term and moderate to substantial degradation in the long term.

Because low-flow water surface elevations are linked to river bed elevation changes, the low-flow water surface elevation in the Kansas City segment likely would decrease a slight to moderate amount in the short term and a moderate to substantial amount in the long term.

High-flow water surface elevations in the Kansas City segment likely would increase in the long term.

Waverly Segment

Dredging proposed under Alternative C in the Waverly segment likely would result in slight degradation or aggradation in the short term and the long term.

Low-flow and high-flow water surface elevations in the Waverly segment are unlikely to change from existing trends. Low-flow water surface elevations have not changed much in the past 20 years, and high-flow water surface elevations have increased a slight to moderate amount in the past 20 years.

Jefferson City Segment

Dredging proposed under Alternative C would cause slight degradation in the short term and moderate to substantial degradation in the long term in the Jefferson City area. Areas outside of the Jefferson City area would experience slight degradation or aggradation in the short term and the long term.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight reduction in low-flow water surface elevations in the short term and a moderate to substantial reduction in the long term in the Jefferson City area.

In response to dredging proposed under Alternative C and long-term trends, high-flow water surface elevations likely would increase in the long term in the Jefferson City area.

If dredging was evenly distributed throughout the segment rather than within a 10-mile reach near Jefferson City, direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

St. Charles Segment

Dredging proposed under Alternative C would cause slight degradation in the short term and moderate to substantial degradation in the long term in the St. Charles area.

Because low-flow water surface elevations are linked to river bed elevations, dredging at the proposed levels likely would result in a slight decrease in low-flow water surface elevations in the short term and a slight to moderate decrease in the long term in the St. Charles area.

High-flow water surface elevations likely would increase in the long term in the St. Charles area.

If dredging was evenly distributed throughout the segment rather than concentrated near St. Charles, the direct impacts from removal of sediment from the river bed would be spread throughout the reach. The effects of dredging on low-flow and high-flow water surface elevations would not be distinguishable from other factors affecting water surface elevations.

4.2.8.4 Tributary Degradation

Tributary degradation is linked to low-flow water surface elevations in the main channel. In general, a moderate to substantial decrease in LOMR low-flow water surface elevations would need to occur before tributaries are likely to be affected. Therefore, tributary degradation is unlikely to occur in the St. Joseph and Waverly segments.

Kansas City, Jefferson City, and St. Charles Segments

Under Alternative C, moderate decreases in low-flow water surface elevations would occur in the short term in the Kansas City segment, and moderate to substantial decreases would occur in the long term in areas with concentrated dredging in the Kansas City, Jefferson City, and St. Charles segments. Tributary degradation is likely to increase in the vicinity of concentrated dredging in these segments under Alternative C in the short term and the long term in the Kansas City segment, and in the long term in the Jefferson City and St. Charles segments. Tributary degradation would be unlikely to increase if dredging was spread throughout the reach rather than concentrated in the urban areas.

4.2.9 Alternate Sources

The No Action Alternative and Alternatives A and B rely to varying degrees on alternate sources of commercial sand and gravel to meet regional demand, as discussed in Section 2.3.2. Alternate sources of supply include increased dredging on the Mississippi and Kansas Rivers to the extent that additional capacity is available under existing dredging permits, off-river open-pit mines and in-river mining operations on other rivers. The alternate sources would make up for supply lost from the LOMR in response to market factors; therefore, the specific locations that would provide supplies are not known and impacts related to the geomorphology of associated rivers and streams cannot be determined. In the short term, existing alternate sources are expected to provide needed sand and gravel, and impacts to the geomorphology of any stream or rivers associated with existing alternate sources are expected to be minimal. In the long term, expanding existing alternate sources and developing new sources may affect the geomorphology of adjacent rivers and streams.

4.2.10 Summary of Impacts

Table 4.2-7 contains a summary of potential impacts on geology and geomorphology for the Proposed Action and alternatives.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph Segment					
Changes in sediment loads and river bed composition[a]	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the St. Joseph segment due to increased amount of dredging required to obtain material that meets specifications.	• No impacts.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the St. Joseph segment due to increased amount of dredging required to obtain material that meets specifications.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the St. Joseph segment due to increased amount of dredging required to obtain material that meets specifications.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the St. Joseph segment due to increased amount of dredging required to obtain material that meets specifications.
Changes in river bed elevation[b]	• Slight degradation in the short term and moderate to substantial degradation in the long term in the St. Joseph area.	• Slight to moderate aggradation in the short term and the long term in the St. Joseph area.	• Slight degradation or aggradation likely in the short term, potential for slight degradation in the long term in the St. Joseph area.	• Slight degradation in the short term and slight to moderate degradation in the long term in the St. Joseph area.	• Slight degradation or aggradation likely in the short term, potential for slight degradation in the long term in the St. Joseph area.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph Segment (continued)					
Changes in channel geometry and water surface elevations[b]	• Moderate reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in the long term in the St. Joseph area. • High-flow water surface elevations likely would increase in the long term in the St. Joseph area.	• Low-flow water surface elevations likely would slightly increase in the short term and in the long term in the St. Joseph area. • High-flow water surface elevations in the vicinity of St. Joseph likely would increase in the long term as the river bed aggrades.	• Low-flow water surface elevations likely would be slightly reduced in the long term in the St. Joseph area. • High-flow water surface elevations could increase or decrease in the long term in the St. Joseph area.	• Low-flow water surface elevations likely would be slightly reduced in the short term and slightly to moderately decreased in the long term in the St. Joseph area. • High-flow water surface elevations likely would increase in the long term in the St. Joseph area.	• Low-flow water surface elevations likely would be slightly reduced in the long term in the St. Joseph area. • High-flow water surface elevations would increase or decrease slightly in the long term in the St. Joseph area.
Tributary degradation	• Tributary degradation is likely to increase in the long term in the St. Joseph area.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is likely to increase in the long term in the St. Joseph area.	• Tributary degradation is unlikely to increase.
Kansas City Segment					
Changes in sediment loads and river bed composition[a]	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas.	• No impacts.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Kansas City Segment (continued)					
Changes in sediment loads and river bed composition[a] (continued)	• Potential impacts are proportional to the amount of dredging and would be greater in the Kansas City segment due to increased amount of dredging required to obtain material that meets specifications.		• Potential impacts are proportional to the amount of dredging and would be greater in the Kansas City segment due to increased amount of dredging required to obtain material that meets specifications.	• Potential impacts are proportional to the amount of dredging and would be greater in the Kansas City segment due to increased amount of dredging required to obtain material that meets specifications.	• Potential impacts are proportional to the amount of dredging and would be greater in the Kansas City segment due to increased amount of dredging required to obtain material that meets specifications.
Changes in river bed elevation[b]	• Moderate additional degradation likely in the short term and substantial degradation likely in the long term.	• Slight to moderate aggradation likely in the short term and moderate to substantial aggradation likely in the long term.	• Slight degradation or aggradation likely in the short term and slight aggradation likely in the long term.	• Slight degradation likely in the short term and moderate degradation likely in the long term.	• Slight to moderate degradation likely in the short term and substantial degradation likely in the long term.
Changes in channel geometry and water surface elevations[b]	• Moderate reduction in low-flow water surface elevations in the short term and substantial reductions in the long term. • High-flow water surface elevations could increase or decrease in the short term and likely would increase in the long term.	• Low-flow water surface elevations likely would slightly to moderately increase in the short term and moderately to substantially increase in the long term • High-flow water surface elevations likely would increase in the short term and the long term as the river bed aggrades.	• Low-flow water surface elevations could increase or decrease slightly in the short term and likely would increase slightly in the long term. • High-flow water surface elevations could increase or decrease slightly in the short term and likely would increase in the long term as the river bed aggrades.	• Low-flow water surface elevations likely would decrease slightly in the short term and decrease slightly to moderately in the long term. • High-flow water surface elevations likely would increase in the long term.	• Low-flow water surface elevations likely would decrease slightly to moderately in the short term and moderately to substantially in the long term. • High-flow water surface elevations likely would increase in the long term.
Tributary degradation	• Tributary degradation is likely to increase in the short term and the long term.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is likely to increase in the long term.	• Tributary degradation is likely to increase in the short term and the long term.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Waverly Segment					
Changes in sediment loads and river bed composition[a]	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the Waverly segment due to increased amount of dredging required to obtain material that meets specifications.	• No impacts	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the Waverly segment due to increased amount of dredging required to obtain material that meets specifications.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the Waverly segment due to increased amount of dredging required to obtain material that meets specifications.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging and would be greater in the Waverly segment due to increased amount of dredging required to obtain material that meets specifications.
Changes in river bed elevation[b]	• Slight degradation or aggradation likely in the short term and slight degradation in the long term.	• Slight aggradation or degradation likely in the short term and the long term.	• Slight degradation or aggradation likely in the short term and the long term.	• Slight degradation or aggradation likely in the short term and slight degradation in the long term.	• Slight degradation or aggradation likely in the short term and the long term.
Changes in channel geometry and water surface elevations[b]	• Low-flow water surface elevation likely would increase or decrease slightly in the short term and decrease slightly in the long term. • No change from existing trends for high flows.	• No change from existing trends for low flows or high flows.	• No change from existing trends for low flows or high flows.	• Low-flow water surface elevation likely would increase or decrease slightly in the short term and decrease slightly in the long term. • No change from existing trends for high flows.	• No change from existing trends for low flows or high flows.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Waverly Segment (continued)					
Tributary degradation	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.
Jefferson City Segment					
Changes in sediment loads and river bed composition[a]	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas. • Potential impacts are proportional to the amount of dredging.	• No impacts	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas. • Potential impacts are proportional to the amount of dredging.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas. • Potential impacts are proportional to the amount of dredging.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in coarse gravel and cobbles in dredged areas. • Potential impacts are proportional to the amount of dredging.
Changes in river bed elevation[b]	• Moderate degradation likely in the short term and substantial degradation likely in the long term in the Jefferson City area.	• Slight to moderate aggradation in the short term and slight aggradation or degradation in the long term in the Jefferson City area.	• Slight degradation or aggradation likely in the short term and slight degradation likely in the long term in the Jefferson City area.	• Slight degradation likely in the short term and slight to moderate degradation likely in the long term in the Jefferson City area.	• Slight degradation likely in the short term and moderate to substantial degradation likely in the long term in the Jefferson City area.
Changes in channel geometry and water surface elevations[b]	• Slight reduction in low-flow water surface elevations in the short term and moderate reductions in the long term in the Jefferson City area.	• Low-flow water surface elevations likely would experience a slight increase in the short term and the long term in the Jefferson City area.	• Slight reduction or increase in low-flow water surface elevations in the short term and a slight decrease in the long term in the Jefferson City area.	• Slight reduction in low-flow water surface elevations in the long term in the Jefferson City area.	• Slight reduction in low-flow water surface elevations in the short term and a moderate to substantial reduction in the long term in the Jefferson City area.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Jefferson City Segment (continued)					
Changes in channel geometry and water surface elevations[b] (continued)	• High-flow surface elevations likely would increase in the long term in the vicinity of Jefferson City.	• High-flow water surface elevations likely would continue to follow existing long-term trends and likely would increase in the long term in the vicinity of Jefferson City.	• High-flow water surface elevations likely would continue to follow long-term trends and likely would increase in the long term in the vicinity of Jefferson City.	• High-flow water surface elevations likely would continue to follow long-term trends and likely would increase in the long term in the vicinity of Jefferson City.	• High-flow surface elevations likely would increase in the long term in the Jefferson City area.
Tributary degradation	• Tributary degradation is likely to increase in the long term in the Jefferson City area.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is likely to increase in the long term in the Jefferson City area.	• Tributary degradation is likely to increase in the long term in the Jefferson City area.
St. Charles Segment					
Changes in sediment loads and river bed composition[a]	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging.	• No impacts	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging.	• Local short-term decrease in sediment availability. • Fine sediment in the water column would increase below the active dredge location. • Long-term increase in concentration of coarse gravel and cobbles on or near the surface of the river bed in dredged areas. • Potential impacts are proportional to the amount of dredging.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Charles Segment (continued)					
Changes in river bed elevation[b]	• Moderate degradation likely in the short term and substantial degradation likely in the long term in the St. Charles area	• Slight to moderate aggradation likely in the short term and slight aggradation or degradation likely in the long term in the St. Charles area.	• Slight degradation or aggradation likely in the short term and the long term in the St. Charles area.	• Slight degradation likely in the short term and slight to moderate degradation likely in the long term in the St. Charles area	• Slight degradation likely in the short term and moderate to substantial degradation likely in the long term in the St. Charles area.
Changes in channel geometry and water surface elevations[b]	• Moderate reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in the long term in the St. Charles area. • High-flow water surface elevations could decrease in the short term and likely would increase in the long term in the St. Charles area.	• Low-flow water surface elevations likely would experience a slight increase in the short term and the long term in the St. Charles area. • High-flow water surface elevations are likely to increase as the river bed aggrades in the short term and the long term in the St. Charles area.	• Slight decreases or increases in low-flow water surface elevations in the short term and the long term in the St. Charles area. • No change from existing trends for high-flows in the short and long term.	• Slight to moderate decrease in low-flow water surface elevations in the long term, in the St. Charles area. • High-flow surface elevations likely would increase in the long term in the St. Charles area.	• Slight decrease in low-flow water surface elevations in the short term and a slight to moderate decrease in the long term in the St. Charles area. • High-flow water surface elevations likely would increase in the long term in the St. Charles area.
Tributary degradation	• Tributary degradation is likely to increase in the short term and the long term in the St. Charles area.	• Tributary degradation is unlikely to increase.	• Tributary degradation is unlikely to increase.	• Tributary degradation is likely to increase in the long term in the St. Charles area.	• Tributary degradation is likely to increase in the long term in the St. Charles area.

Table 4.2-7 Summary of Potential Impacts on Geology and Geomorphology

Notes:

Assumptions:

Elevation Changes. Changes in average river bed elevation and low-flow water surface elevations were estimated using three categories: slight change (less than approximately 2 feet), moderate change (approximately 2 to 4 feet), and substantial change (greater than approximately 4 feet).

Period of Analysis. The period of analysis is 20 years. Changes that would occur from approximately 0 to 5 years are considered short term and changes between approximately 5 and 20 years are considered long term.

Flow Conditions. The impact analysis assumed that flow conditions were below average and similar to the flows from 2000 to 2009 that were used in the bed material load analysis.

Dredging Locations. To estimate impacts from dredging, the analysis assumed that most dredging would occur near the same locations that dredging occurred under existing conditions, which are typically within 10 miles upriver and 5 miles downriver of a sand plant.

[a] Impacts are local and increase with increased amounts of dredging.

[b] Impacts are based on the assumption that most dredging would occur near existing dredging locations, typically near urban areas.

4.2.11 References

4.2.11.1 Printed Literature

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USACE (U.S. Army Corps of Engineers). 2007. Missouri River Stage Trends, Missouri River Mainstem Reservoirs. (Reservoir Control Center Technical Report). January.

4.2.11.2 Personal Communication

Abraham, David. U.S. Army Corps of Engineers, Engineer Research Development Center. Conference call on November 16, 2009, with the USACE and ENTRIX.

4.3 INFRASTRUCTURE

4.3.1 Introduction

As described in Section 4.2, commercial dredging activity on the LOMR can contribute to ongoing changes in the elevation of the river bed and changes in the water surface elevations during periods of low and high flows. River bed degradation and associated water level changes can undermine the foundations of infrastructure facilities, affect the operation of water intake structures, expose pipelines and other submerged infrastructure, and cause slumping or undermining of revetments that could threaten the integrity of nearby levees. Infrastructure also can be affected by aggradation.

During the scoping process for this EIS, the USACE received a number of comments related to the potential adverse effects on infrastructure caused by river bed degradation and changes in water surface elevations. Commentors stated that river bed lowering increases the potential for scour effects, poses a threat to the stability of existing bridge foundations, and requires expensive countermeasures to mitigate the potential threat to bridges. Water suppliers and electric utilities commented that declining low water levels from ongoing dredging has compromised the performance of water intakes that provide cooling and process water to several electric generating stations. This has required expensive modifications to intake structures, premature pump wear, and damage that threaten the reliability of electric generation at the affected plants. Finally, some water suppliers were concerned that dredging near public water supply collector wells located along and under the river could decrease the yield of wells by introducing fine material and reducing the permeability of the aquifer, and could increase the risk of microbial contamination by reducing the effectiveness of river bed filtration.

The potential impacts of river bed degradation also affects some tributary rivers and streams joining the LOMR, resulting in bed lowering in the tributaries, erosion, bank failures, and accompanying damages to infrastructure (USACE 2009). Tributary degradation occurs as low-flow water surface elevations on the mainstem drop because tributaries adjust to the new base level by eroding their beds to match the new base elevation (Kondolf 1994, NOAA 2003), a process referred to as headcutting.

As described in the Affected Environment Section 3.5, the following six categories of infrastructure may be affected by the direct or indirect effects of commercial dredging of sand and gravel. Impacts to these same six categories were evaluated in this section:

- Water intake facilties;
- Water supply wells;
- Levees;
- BSNP structures (i.e., dikes and revetments);
- Bridge, pipeline and cable crossings; and
- Wharf and dock facilities.

The following sections describe the approach used to assess potential impacts; summarize key comments received during the scoping period; and describe the potential effects on infrastructure from implementation of the Proposed Action and the alternatives. The description of impacts is presented by river segment where appropriate.

4.3.2 Assessment Methods

The results of the geomorphology analysis, together with information from infrastructure owner/operators and their websites, were used to assess how existing infrastructure facilities on the LOMR could be affected by commercial dredging operations. The potential impacts on infrastructure were determined by assessing whether the changes in river bed elevations and changes in low-flow and high-flow water surface elevations identified in the geomorphology analysis were likely to adversely affect existing infrastructure.

The geomorphology analysis 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).

Changes in high-flow water surface elevations were characterized as likely to increase or likely to decrease for the Proposed Action and the alternatives. Effects on infrastructure were considered adverse if estimated changes in river bed elevations and changes in low-flow and high-flow water surface elevations could:

- Damage infrastructure facilities or structures;
- Increase operation and maintenance costs;
- Undermine the foundations of dikes, revetments, or levees;
- Expose bridge piers, pile foundations, buried pipelines, or underwater cables; or
- Reduce the quantity or quality of water withdrawn from horizontal collector wells used for public water supply.

The severity or magnitude of these effects was assumed to be proportional to the number of people that could be affected, the value of property and investment potentially at risk, and the costs required to counter or prevent these effects from occurring. Potential adverse effects were assessed for both short-term (i.e., approximately 5 years) and long-term (approximately 5–20 years) periods consistent with the geomorphology analysis.

A number of restrictions on dredging operations from previous dredging permits have been assumed to apply to each alternative. These restrictions would help to protect existing infrastructure from the potential adverse effects of commercial dredging operations and include the following:

- Dredging will not occur 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.
- Dredging will not occur in a zone extending 4,000 feet upstream and 500 feet downstream from any municipal drinking water intake structure located along either bank of the river.
- Dredging will not occur in a zone extending 1,000 feet upstream and 1,000 feet downstream from any municipal drinking water horizontal collector well located along either bank of the river.
- Dredging will not occur in a zone extending 500 feet upstream and 500 feet downstream from any water intake structure other than those used for municipal drinking water.

The potential impacts on infrastructure that is located on tributaries to the LOMR also was considered, but the assessment was limited by the lack of data for tributaries. The likelihood that tributary degradation would increase under an alternative was based on the change in low-flow water surface elevations on the mainstem LOMR occurring near the tributary, as estimated in the geomorphology analysis. In general, low-flow water surface elevations would need to decrease a “moderate” or

"substantial" amount before tributary headcutting would occur and existing infrastructure would be affected.

The potential for impacts related to river bed degradation on infrastructure located in areas of alternate sources of supply that might be subject to increased dredging activity under some of the alternatives is not included in this impact analysis. Limits incorporated into existing dredging permits for the Kansas and Mississippi Rivers include conditions and restrictions that would reduce the likelihood of increased dredging in these rivers causing substantial impacts on infrastructure. In the Kansas River, there are limits on the amount of allowable river bed degradation. If degradation exceeds those limits, dredging must cease. According to the USACE, river bed degradation in the Mississippi River has not been reported to be an issue to date (USACE 2003).

Floodplain open-pit mines and instream mining could result in increased traffic on nearby roads and bridges and minor impacts on infrastructure in some areas, including the need for additional maintenance. These impacts are considered in Section 4.4.

4.3.3 Proposed Action

The Proposed Action would permit approximately 11,615,000 tons of commercial dredging from the five segments of the LOMR. This would increase the amount of material dredged in each segment, with the greatest increases occurring in the St. Joseph and St. Charles segments.

4.3.3.1 Changes in River Bed Elevations and Low-Flow and High-Flow Water Surface Elevations

Table 4.2-7 summarizes the changes in river bed elevations and low-flow and high-flow water surface elevations under the Proposed Action for each river segment.

Based on the estimated levels of river bed degradation and changes in low-flow and high-flow water surface elevations, the segments most likely to experience conditions that could adversely affect infrastructure under the Proposed Action include the St. Joseph segment between RM 445 and RM 455, the Kansas City segment over its entire length, the Jefferson City segment between RM 140 and RM 150, and the St. Charles segment between RM 0 and RM 50. Changes in the Waverly segment under the Proposed Action are not expected to adversely affect most categories of infrastructure. All of the segments are expected to experience increased high-flow water surface elevations in the long term.

4.3.3.2 Impacts to Water Intake Facilities

The existing water intake facilities primarily provide water for public water systems and cooling and process water for power generation facilities. According to the USACE, river bed degradation and a decline in low-flow river stages on the LOMR has caused increased pumping costs and pump requirements for water intakes along the degrading reaches. Considerable funds have been spent to modify existing intakes to continue operations under the current river conditions. On several occasions during winter low-flow periods, water levels at intakes have reached critical levels, nearly taking water supply intakes out of operation. Interruption of cooling and process water supplies to power plants could cause expensive shutdowns for electric utilities (USACE 2009).

At some facilities, short-term water losses from intake facilities can be made up by alternate well sources. In many cases, however, modifications of existing intakes have neared their practical limits. Future modifications would require major upgrades or new facilities to access low-flow water surface elevations. In the short term, the needs for dependable water supply likely would be accommodated with increased operational costs and short-term fixes (USACE 2009).

Major investments in new water intake facilities, or major modifications to existing facilities, can be expected in the long term if ongoing degradation trends persist. In some instances, these investment costs may be passed on to users in the form of higher rates. Electric utilities required to make major modifications to existing water intake facilities, or to construct new facilities, in order to obtain adequate cooling and process water during low-flow periods would incur costs that would be passed on to ratepayers (USACE 2009).

A more detailed description of potential impacts to water intake facilities under the Proposed Action for each segment is presented below.

St. Joseph Segment

The geomorphology analysis estimates that the area between RM 455 and RM 445 in the St. Joseph segment could experience nearly 2 feet of river bed degradation and a corresponding 2-foot decline in low-flow water levels over the next 5 years under the Proposed Action. These amounts increase to 4 feet or more over the next 20 years. High-flow surface water levels between RM 455 and RM 445 also are expected to increase in the long term; however, operation of water intake facilities is not usually adversely affected by temporary periods of high-flow water surface elevations.

Only one water intake facility is located between RM 455 and RM 445 in the St. Joseph segment – the intake for the 100-MW Aquila Lake Road Power Station operated by KCP&L at RM 445.9. KCP&L has expressed concerns about the effect of ongoing river bed degradation on cooling and process water intake infrastructure for several of their power plants on the Missouri River, including the Aquila Lake Road Power Station (Heidtbrink pers. comm.). Similar levels of river bed degradation and reductions in low-flow water elevations have required installation of new circulating water pumps and modifications of the intake facility at the company's Hawthorn Station (RM 358.8). KCP&L also has installed supplemental submersible pumps at the Aquila Lake Road Power Station over the past 5 years to address ongoing low-flow water conditions. It is not known whether the improvements made at the Aquila Lake Road Power Station are sufficient to counter the river bed degradation and declining low-flow water levels expected to occur over the next 20 years. Typical costs for new water pumps and modifications to existing intake structures can range between $1 and $2 million (Schrempp pers. comm.).

Other intake facilities in the St. Joseph segment outside of the reach between RM 455 and RM 445, including the Iatan Power Plant and several water supply intake facilities, are not expected to experience levels of river bed degradation or reductions in low-flow water levels (in the short term or the long term under the Proposed Action) that would cause a notable adverse effect on system performance or long-term operation and maintenance costs.

Kansas City Segment

The geomorphology analysis estimates that the entire Kansas City segment from RM 391 to RM 357 could experience between 2 and 4 feet of river bed degradation in the next 5 years, and as much as 4 or more feet of river bed degradation over the next 20 years under the Proposed Action. Low-flow water levels between RM 391 and RM 357 are expected to decline up to 4 feet in the next 5 years, and more than 4 feet over the next 20 years. High-flow surface water elevations between RM 391 and RM 357 also are expected to increase in the long term. The water intake facilities listed in Table 4.3-1 could be subject to the effects of river bed degradation and reductions in low-flow water elevations under the Proposed Action.

Four of these intake facilities provide cooling and process water to four major power plants, including the Nearman Bottoms, Quindaro, and Hawthorn power plants and the Trigen-Kansas City facility that provides heating and cooling to buildings in downtown Kansas City.

Table 4.3-1 Water Intake Facilities in the Kansas City Segment Potentially at Risk under the Proposed Action

Facility Name[a]	River Mile
Johnson Co. Water District No. 1 (WaterOne)	380.0
Nearman Bottoms Power Plant (KCBPU)	378.7
Mid-Continent Asphalt & Paving	378.4
Kansas City, KS Water Co. (KCBPU)	373.5
Kansas City, KS Power & Light (KCBPU)	373.4
Kansas City, Missouri Water Department	371.0
Kansas City Power and Light, Co. (KCP&L Co.)	365.8
KCP&L Co.	358.2

[a] Names of water intake facilities were obtained from the Missouri River Navigation Charts and may not correspond to the current facility name or operating utility.

Low river levels can contribute to premature pump wear, damage, and reliability issues (Heidtbrink pers. comm.). Kansas City, Kansas, has already spent $22.6 million on a cooling tower and emergency pumps to retrofit two power generating facilities in response to declining low-flow water levels. Additional river bed degradation in the long term possible under the Proposed Action likely would require additional pumps and further intake modifications, including possible replacement of existing intake facilities in their entirety (USACE 2009).

Three of the potentially affected intake facilities in the Kansas City segment provide drinking water to nearly 1 million residents in the Kansas City metropolitan area. Declining low-flow water levels already have required Kansas City, Missouri, to spend more than $4 million to extend water intakes and drinking water pumps to reach lower river levels (USACE 2009). In 2004, Water One completed installation of emergency low-level pumping units at their Missouri River intake (RM 380) at a cost of approximately $2 million (Schremmp pers. comm.). Continuing river bed degradation possible under the Proposed Action has the potential to require major modification and possibly total replacement of these intake facilities in the long term.

Waverly Segment

The geomorphology analysis estimates that the amount of river bed degradation and decline in low-flow water elevations in the Waverly segment (RM 357 to RM 250) would be relatively unchanged in the next 5 years, and less than 2 feet over the next 20 years under the Proposed Action. This amount of

change would be unlikely to affect existing water intake facilities; therefore, no adverse effects are expected in this segment under the Proposed Action. High-flow surface water elevations in the Waverly segment are expected to increase in the long term but without notable consequence to water intake facilities.

Jefferson City Segment

The geomorphology analysis estimates that the area between RM 150 and RM 140 in the Jefferson City segment could experience between 2 and 4 feet of river bed degradation over the next 5 years under the Proposed Action, and more than 4 feet of river bed degradation over the next 20 years. Low-flow water levels between RM 150 and RM 140 are not expected to change much over the next 5 years (less than 2 feet) under the Proposed Action; over the next 20 years, however, low-flow water levels could decline by as much as 4 feet under the Proposed Action. High-flow surface water elevations between RM 150 and RM 140 are expected to increase in the long term under the Proposed Action, but no adverse effects on water intake facilities are anticipated.

The only water intake facility in the Jefferson City segment potentially at risk for damage or decreased operational performance is the intake facility located at RM 144 operated by Missouri American Water Company. This intake has a capacity of 4,875 gpm and provides drinking water to the community of Jefferson City. Ongoing river bed degradation and reductions in low-flow water levels over the next 20 years under the Proposed Action could require the company to install additional pumps, modify intake structures, and possibly replace the existing intake facility to ensure adequate water supplies. These types of improvements can require investment in the range of $1 to $2 million, which likely would result in increased utility rates for current and future customers in this community of approximately 40,000 residents.

Other intake facilities in the Jefferson City segment located outside of the reach between RM 150 and RM 140, including the Glasgow Waterworks and the Boonville Water Company, are not expected to experience levels of river bed degradation or reductions in low-flow water levels (in the short term or the long term) that would result in a notable adverse effect on system performance or long-term operation and maintenance costs.

St. Charles Segment

The geomorphology analysis estimates that the area between RM 50 and RM 0 in the St. Charles segment could experience between 2 and 4 feet of river bed degradation over the next 5 years under the Proposed Action, and more than 4 feet of river bed degradation over the next 20 years. Low-flow

water levels between RM 50 and RM 0 are expected to decline between 2 and 4 feet over the next 5 years under the Proposed Action, and more than 4 feet over the next 20 years. High-flow surface water levels between RM 50 and RM 0 also are expected to decrease in the short term but increase in the long term under the Proposed Action; however, these types of facilities are not usually adversely affected by temporary periods of high-flow surface water elevations.

The water intake facilities listed in Table 4.3-2 could be subject to the effects of river bed degradation and reductions in low-flow water elevations under the Proposed Action.

Table 4.3-2 Water Intake Facilities in the St. Charles Segment Potentially at Risk under the Proposed Action

Facility Name[a]	River Mile
City of St. Louis Waterworks	37.0
St. Louis County Waterworks	36.3
St. Louis County Waterworks	36.2
St. Charles Waterworks	29.0
St. Louis County Waterworks	20.5
St. Louis County Water Dept.	20.2

[a] Names of water intake facilities were obtained from the Missouri River Navigation Charts and may not correspond to the current facility name or operating utility.

These six water intake facilities provide drinking water to more than 1 million people, including business and industry within the greater St. Lewis metropolitan area. Ongoing river bed degradation and reductions in low-flow water levels between RM 50 and RM 0 over the next 20 years could require the municipalities and water companies operating these facilities to install supplemental water pumps, modify existing intake structures, and possibly replace the entire intake facilities to ensure adequate water supplies. While these types of improvements would require investment in the range of $1 million to $2 million at each facility, these costs would be spread over a large customer base which would reduce the effect of increased utility rates on individual customers.

Three intake facilities located in the St. Charles segment upriver from RM 50 supply cooling and process water to three major power plants, including the Labadie Power Plant at RM 57.7, the Callaway Power Plant RM 115.4, and the Chamois Power Plant at RM 117.0. These power plants generate over 3,600 MW of electricity and supply customers across central and eastern Missouri. Because the levels of river bed degradation and reduction in low-flow water elevations near these intake facilities are

expected to be less than approximately 2 feet over the next 20 years, the available supply of cooling and process water to these major power plants is not expected to be adversely affected.

4.3.3.3 Impacts to Water Supply Wells

The primary concern related to the potential effect of river bed degradation on water supply wells is the possibility that dredging could affect the production capacity of the wells and diminish the levels of natural river filtration. According to engineers familiar with these processes, the depressions that are developed as the river bed materials are removed are filled by finer-grained deposits of silt and clay. These deposits reduce the permeability of the river and aquifer, and reduce the amount of water that can be pumped by the collector wells. Additionally, the deposited fine-grained materials can lead to oxygen reduction in the aquifer. These conditions can result in poorer quality water being pumped by the wells. Dredging operations also can accelerate degradation of the river bed. This leads to lower water levels in the river (and aquifer) and less available drawdown and therefore reduced yields (Stowe pers. comm.). In addition, river bank filtration relies on the river bed material to reduce turbidity, pathogens, bacteria, and viruses. Reduction of the river bed through dredging increases the possibility that these contaminants can pass through the river to the treatment plant and reduce the quality of water (Orth pers. comm.).

A more detailed description of potential impacts to water supply wells under the Proposed Action for each segment is presented below.

St. Joseph Segment

The Missouri American Water Company operates a collector well and seven vertical wells along the Missouri River near the City of St. Joseph. The primary source of water for the company's 30,000 customers is a lateral collector well located at RM 454.75. Increased dredging activity near this well under the Proposed Action could pose a short-term and long-term threat to its ongoing operation. The company has expressed concern that ongoing dredging in the area could reduce the permeability of the aquifer, and in turn, the output of the well. The company is also concerned that continued river bed degradation could reduce river bed filtration that the company relies on to reduce turbidity, pathogens, bacteria, and viruses in the withdrawn water. The company has recommended that a no-dredge zone be created 2,000 feet upstream and 2,000 feet downstream from the well at RM 454.75 to reduce the potential for adverse impacts on their existing system (Fuerman pers. comm.).

Kansas City Segment

The Kansas City Board of Public Utilities operates two horizontal collector wells at approximately RM 379 that are capable of producing more than 80 million gallons of source water per day. These wells are the only water source for the Nearman Water Treatment Plant, which serves over 145,000 residents in Kansas City, Kansas and Wyandotte County. The utility has concerns that ongoing dredging activity in this area could adversely affect the water quality and quantity of water available from these two high-yielding collector wells. Within the next 2 years, these two wells will become the utility's sole source for water for over 180,000 customers. The company has recommended that a no-dredge zone be established from a point approximately 2,000 feet upriver from the intake for the Nearman Power Plant at RM 378.7 and extending downriver for approximately 1 mile to a point 2,000 feet below the second collector well at approximately RM 379.1 (Uden pers. comm.).

Waverly, Jefferson City, and St. Charles Segments

No water supply wells were identified in the Waverly, Jefferson City, or St. Charles segment.

4.3.3.4 Impacts to Levees

River bed degradation can set in motion a chain of events that includes bank erosion, bank instability, bank failure, soil weakening, scour and erosion, levee foundation failure, and potentially, catastrophic levee failure. In addition, vegetation encroachment along river banks and sand bars can trap sediment, creating land in the stream channel. This reduces the channel area available to convey high flows which causes increased high-flow water surface elevations and increased flood stages (USACE 2009).

River bed degradation and increased high-flow water surface elevations can adversely affect levees that provide critical flood protection. In addition to the 20 miles of federal levees protecting the Kansas City metropolitan area, another 130 miles of federal levees along the mainstem of the Missouri River protect areas between Rulo, Nebraska and St. Louis, Missouri. These levees protect a good portion of the City of St. Joseph, a number of small towns, and large amounts of rural area (USACE 2009). Approximately 360 miles of smaller non-federal levees also line the mainstem of the Missouri River and its major tributaries, protecting thousands of acres of farmland and small towns (USACE 2010a). A widespread degradation pattern could threaten many of these areas.

River bed degradation is a growing concern at many locations along the Missouri River mainstem. Of particular concern are areas where levees are founded on existing revetments or very close to unprotected slopes. Many of the levees and floodwalls in the Kansas City area are founded on

revetment-protected slopes. Although the impacts have not been fully evaluated and inventoried, an investigation by the USACE in the Kansas City area indicates that the toes of some revetments supporting critical levee structures have eroded due to degraded channel conditions. The study noted that the condition of eroded revetments in this area poses a significant risk for failure of the levee system (USACE 2009).

During a major flood event, sloughing or a series of successive bank failures could cause partial, or sudden and total, failure of the affected levee segment (USACE 2009). Evidence that eroded areas can result from normal to moderate flows in these areas suggests that a major flood event could pose high risks of severe erosion and the potential for levee failure. During a large flood event, the erosion would not be visible or easily monitored; and response after levee failure would be difficult (USACE 2009). Even if a levee has not been weakened by river bed degradation, increased high-flow water surface elevations related to channel narrowing could decrease the level of flood protection provided by that levee.

A more detailed description of potential impacts to levees under the Proposed Action for each segment is presented below.

St. Joseph Segment

The geomorphology analysis estimates that the area between RM 455 and RM 445 in the St. Joseph segment could experience river bed degradation levels of approximately 2 feet over the next 5 years under the Proposed Action, and up to 4 feet or more over the next 20 years. As a result, high-flow water surface elevations between RM 455 and RM 445 also are expected to increase in the long term under the Proposed Action. Three federal levee units between RM 455 and RM 445 could potentially be at risk from adverse effects caused by river bed degradation and increased water surface elevations during high flows (Table 4.3-3). No non-federal levees or major tributaries were identified between RM 455 and RM 445.

Levee Unit L-476 extends 7 miles along the left descending bank of the Missouri River. Most of the levee is upstream from the City of St. Joseph, and only an approximately 1-mile segment of the levee (at the downstream end) could potentially be at risk to adverse effects from river bed degradation and increased water surface elevations during high flows. Levee Unit R-471-460 extends nearly 15 miles along the right descending bank of the river and Levee Unit L-455 extends approximately 8 miles along the left bank of the river, through the heart of the City of St. Joseph. These levees protect nearly

27,000 acres of urban and industrial land, over 5,600 residents, and approximately $2.3 billion in investment value on both the Kansas and Missouri sides of the river (USACE 2010a).

Table 4.3-3 Federal Levees in the St. Joseph Segment Potentially at Risk under the Proposed Action

Unit Name[a]	River Miles
Levee Unit L-476	461.0–454.0
Levee Unit R-471-460	456.5–441.8
Levee Unit L-455	445.6–437.6

[a] R and L refer to right and left descending banks, respectively. The number is the river mile at the center point of the levee at the time it was authorized. The river miles do not match up exactly now, because of river cutoffs constructed since the levee was authorized.

The Elwood-Gladden Drainage District in Kansas is currently sponsoring a $33-million project to raise the height of Levee Unit R-460-471 by an average of 3 feet, including some minor corresponding modifications to Levee Unit L-455. These improvements are proposed to restore the original reliability and performance of the system that was overtopped and failed in the 1993 flood, causing over $65 million in damages in the protected area in Kansas (Roberts 2010).

Levee Unit L-455, between RM 444 and RM 446.5, appears to be particularly vulnerable to future river bed degradation and increased high-flow water levels under the Proposed Action. In this area, the levee is constructed on top of revetment on the outside bend of the river. Over the next 20 years, this area could be subject to substantial river bed degradation that could cause material underlying the revetment to be removed, thereby potentially putting both the revetment and levee at risk of future failure, particularly during periods of high-flow water levels. This risk would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety. Typical costs for revetment repair are discussed in Section 4.3.4.5.

Other federal and non-federal levees in the St. Joseph segment located outside of the reach between RM 455 and RM 445 would not be expected to experience levels of river bed degradation or increases in high-flow water levels (in the short term or the long term under the Proposed Action) that would result in a notable adverse effect on existing levels of protection or long-term operation and maintenance costs. This includes the approximately 32 miles of non-federal levees protecting over 55,000 acres of primarily agricultural uses along the LOMR and major tributaries.

Kansas City Segment

The geomorphology analysis estimates that the entire Kansas City segment from RM 391 to RM 357 could experience river bed degradation levels between 2 and 4 feet over the next 5 years under the Proposed Action, and up to 4 feet or more over the next 20 years. Low-flow water surface elevations are expected to decline by as much as 4 feet over the next 5 years under the Proposed Action, and possibly more than 4 feet over the next 20 years. High-flow surface water elevations in the Kansas City segment are expected to increase in the long term under the Proposed Action, posing a continuing threat to flood protection infrastructure.

Table 4.3-4 lists the federal levee units in the Kansas City segment, including major tributaries, potentially at risk from adverse effects caused by river bed degradation and increased water surface elevations. The reliability of federally constructed levees, particularly those founded upon revetment-protected slopes, could potentially be at risk in the short-term and the long term under the Proposed Action. In some areas, the potential for catastrophic failure may be a possibility.

Table 4.3-4 Federal Levees in the Kansas City Segment Potentially at Risk under the Proposed Action

Unit Name	River Miles
Levee Unit L-385[a]	372.1-375.9
Levee Unit Fairfax-Jersey	374.0–367.5
Levee Unit North Kansas City	370.5–363.5
Levee Unit Central Industrial District	367.4–365.7
Levee Unit East Bottoms	365.7–357.5
Levee Unit Birmingham	360.3–354.0
Levee Unit Armourdale	Kansas River 2.1–6.5
Levee Unit Argentine	Kansas River 4.5–9.5

[a] L refers to left descending bank. The number is the river mile at the center point of the levee at the time it was authorized. The river miles do not match up exactly now, because of river cutoffs constructed since the levee was authorized.

Levees on major tributaries to the Missouri River could also be at risk of river bed degradation under the Proposed Action because of headcuts. In addition, the Armourdale and Argentine Levee Units along the Kansas River could be susceptible to river bed degradation and increasing high-flow water levels in areas where material has been or could be eroded from the toes of levee slopes.

Most of the non-federal levees in the Kansas City segment are located upriver or downriver from Kansas City along the mainstem of the LOMR and its major tributaries; they protect primarily agricultural areas. Approximately 10 miles of non-federal levee protect over 5,200 acres of primarily agriculture land north of Kansas City. These levees typically range between 6 and 16 feet in height and can vary with respect to maintenance standards and levels of protection.

While not all levees within the Kansas City segment have been surveyed, the USACE has identified several levees within the segment that appear vulnerable to the effects of continued river bed degradation (USACE 2009). These include the North Kansas City Levee Unit at approximately RM 370, the Fairfax-Jersey Creek Levee Unit at approximately RM 368, and the East Bottoms Levee Unit at approximately RM 366. All three of these levees are located immediately adjacent to, or integrated with, revetment sections of the BSNP. Altogether, more than 10 miles of federal levees in the Kansas City segment are located adjacent to, or integrated with, BSNP revetments.

At-risk revetments and levees are particularly vulnerable during flood events, which can result in rapid, short-term river bed degradation. This is particularly troublesome because inspection and repair of revetment failures are extremely hampered during flood events. Extreme events, such as the 1993 flood, present an increased risk to all of the levees and floodwalls located along revetments in the Kansas City reach. Levees could become increasingly at risk as river bed degradation exceeds the performance capabilities of the existing revetments. Without effective countermeasures, there would be an increased long-term risk of levee/floodwall failure (USACE 2009).

Flood events may lower the river bed by several feet in the short term. This can cause levee and floodwall instability in reaches where the structures are near river banks stabilized by revetments. In the Kansas City reach, some levees and floodwalls are placed in these locations, most notably along the right descending bank of the Missouri River near the confluence of the Kansas River. These systems were tested under extreme flow conditions in 1993 and performed successfully. Since 1993, the river bed has degraded approximately 5 feet, as measured at the Kansas City USGS gage, adding uncertainty to future performance. This amount of river bed degradation leaves no assurance that the floodwalls will perform successfully during an equivalent event in the future.

The USACE Kansas City District has responded to this concern by requesting $19 million from Congress to take corrective actions at the Fairfax-Jersey Creek Levee Unit and the North Kansas City Levee Unit. The funding request cited the findings of a 2006 USACE study (Kansas Citys [Seven Levees] Phase I Feasibility Study) 2006), which determined that original design and construction

deficiencies exist at sites on both levee units. The funding request also stated that, currently, both levee units pose a high probability of failure for the design flood event and that the USACE desires to be proactive by taking the necessary corrective actions before the next high-water event. Both units are in the Planning, Engineering & Design phase for their respective projects and hope to advance toward construction soon. The total cost to correct the deficiencies, as currently estimated by the USACE Kansas City District, is $9 million for the Fairfax-Jersey Creek Floodwall Improvements and $10 million for the North Kansas City Underseepage Improvements (Roberts 2010, USACE 2010b).

The severity or magnitude of these potential adverse effects can be put in perspective by identifying the number of people, number of jobs, and total investment potentially at risk from failure of levees in this segment. For example, the North Kansas City Levee Unit protects nearly 1,100 residential units, 4,900 residents, approximately 500 businesses, and 26,700 jobs. Major facilities protected by the levee unit include the Charles B. Wheeler Downtown Airport; BNSF and Norfolk Southern railroad yards; and numerous retail sector small businesses, warehouses, and industrial sites. The levee unit's estimated protected investment is almost $3.5 billion, based on October 2008 prices (USACE 2009).

The Fairfax-Jersey Levee Unit protects approximately 350 businesses and facilities, a total estimated investment of almost $3.5 billion, and a workforce of more than 11,100 people. Protected businesses include a General Motors assembly plant and other large commercial, industrial, and public facilities such as Owens-Corning, Weyerhauser, and Certainteed (USACE 2009).

The East Bottoms Levee Unit protects approximately 750 businesses and homes, with a total estimated value of approximately $5.4 billion. The industrial structure includes manufacturing, transportation, and major warehouse storage, as well as retail businesses. The area includes major facilities, including a KCP&L power plant; a water treatment plant; a Sears distribution center; the Isle of Capri Casino; and facilities operated by Cargill, General Mills, and Bayer Corporation. More than 3,200 residents live in the area, and more than 20,100 people are employed in East Bottoms businesses (USACE 2009).

Altogether, the Kansas Citys Levees (Fairfax-Jersey Creek, North Kansas City, Central Industrial District, East Bottoms, Birmingham, Armourdale, and Argentine Levee Units) and Levee Unit 385 protect 154,566 acres of commercial, industrial and residential land use; a population of over 23,000; and an investment value of over $19 billion.

Non-federal levees outside the Kansas City metropolitan area, depending on their location, could experience river bed degradation levels of 4 feet or more and reductions in low-flow water elevations by more than 4 feet over the next 20 years under the Proposed Action. These conditions could subject

non-federal levees to increased bank erosion, levee damage, and potentially, levee failure. Countering these effects likely would result in increased annual maintenance costs for the various levee associations, drainage districts, and conservation districts that sponsor the non-federal levees.

Waverly Segment

In the Waverly segment, there is one federal levee (Levee Unit R-351) that extends approximately 10 miles along the right bank of the river between the towns of Atherton and Sibley, Missouri (RM 350 to RM 339.7), protecting approximately 8,861 acres of rural agricultural land and approximately $15 million in investment (USACE 2010b). Non-federal levees are far more common in this segment, with approximately 130 miles of non-federal levees protect over 362,000 acres of primarily agricultural lands. Because the Waverly segment is not expected to experience notable amounts of river bed degradation or increases in high-flow water elevations over the next 20 years under the Proposed Action, no adverse effects to these levees are anticipated.

Jefferson City Segment

The geomorphology analysis estimates that the area between RM 150 and RM 140 in the Jefferson City segment could experience between 2 and 4 feet of river bed degradation over the next 5 years and more than 4 feet of river bed degradation over the next 20 years under the Proposed Action. As a result, high-flow water surface elevations in this area are expected to increase in the long term.

No federal levee units are located between RM 150 and RM 140. Five non-federal levee units extend approximately 13.7 miles along the river in this area, which includes several tributaries. These levees typically range between 6 and 16 feet in height and protect over 12,000 acres of primarily agricultural land.

In the long term under the Proposed Action, these non-federal levees could experience increased bank erosion, bank instability, bank failure, soil weakening, scour and erosion, levee foundation failure, and potentially, levee failure. Vegetation encroachment and reduction in channel area also could result in further increases in high-flow water surface elevations and increased flood stages (USACE 2009). During a major flood event, sloughing or a series of successive bank failures could cause partial, or sudden and total, failure of an affected levee segment (USACE 2009). These risks would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety of the levee systems.

Other federal and non-federal levees in the Jefferson City segment located outside of the reach between RM 150 and RM 140 (including federal Levee Units L-246 and L-234/Chariton between the towns of Brunswick and Glasgow, Missouri) would not be expected to experience levels of river bed degradation or increases in high-flow water levels (in the short term or the long term under the Proposed Action) that would cause a notable adverse effect on existing levels of protection or long-term operation and maintenance costs.

St. Charles Segment

The geomorphology analysis estimates that the area between RM 50 and RM 0 in the St. Charles segment could experience between 2 and 4 feet of river bed degradation over the next 5 years and more than 4 feet of river bed degradation over the next 20 years under the Proposed Action. High-flow water levels between RM 50 and RM 0 are expected to decrease in the short term but increase in the long term.

No federal levee units are located between RM 50 and RM 0. There are, however, an undetermined number of non-federal levees along portions of the river and along several tributaries. Although detailed information was not available for these levees, they appear to protect primarily agricultural areas. At least three non-federal levees protect urban areas below RM 45 (USACE 2004).

These levees could experience increased bank erosion, bank instability, bank failure, soil weakening, scour and erosion, levee foundation failure, and potentially, levee failure in the short term and the long term under the Proposed Action. During a major flood event, sloughing or a series of successive bank failures could cause partial, or sudden and total, failure of the affected levee segment (USACE 2009). These risks would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety of the levee systems.

Levees outside of the reach between RM 50 and RM 0 in the St. Charles segment would not be expected to experience levels of river bed degradation or increases in high-flow water levels (in either the short or the long term under the Proposed Action) to a degree that would cause a notable adverse effect on existing levels of protection or current operation and maintenance costs.

4.3.3.5 Impacts to Bank Stabilization and Navigation Project Structures

Continuing river bed degradation and individual flood events require ongoing maintenance of BSNP structures. The USACE maintenance program for dikes focuses on maintaining the dikes at their minimum design elevations measured against the CRP. If the channel degrades and navigation

season flows cannot be maintained, the dikes must be altered to maintain the design water surface elevations in a given river segment (USACE 2009).

In many cases, the dikes self-adjust to the appropriate design height by losing material from the top of the structure to erosion as the water surface elevation drops. If the rate of river bed degradation exceeds the rate of normal erosion of the tops of the structures, it becomes necessary to mechanically remove the top few feet of each structure. Additional maintenance includes reestablishing the riverward ends of structures, repairing portions of structures that have eroded more quickly than the natural erosion rate, and repairing segments of structures that have settled or sustained flood damage. Because dikes are not likely to fail completely in a short amount of time, regular maintenance and repair are usually sufficient to maintain their function (Chapman pers. comm.).

Unlike dikes, which are somewhat self-adjusting, revetments that are made from rocks placed on the river bank extending down to the river bed cannot adjust to river bed degradation. When the river bed elevation degrades, it leaves the revetment toe exposed and hanging. Eventually, the revetment will collapse and slide into the river, exposing the upper portion of the river bank. This requires backfilling the eroded bank behind the line of the original revetment and then replacing stone to protect the reestablished bank line. This situation can be extremely serious if a levee, floodwall, road, or other structure is immediately adjacent to the revetment (Chapman pers. comm.).

Revetments tend to fail in sudden discrete events. If failure occurs during or before a severe flood event, it could allow the river to migrate into a bank. If the revetment is close enough to a levee or floodwall, or if the bank is allowed to erode away in a severe flood event until it reaches a levee or floodwall, it could undermine the levee or floodwall and cause it to fail. Failure would allow whatever is protected by the levee or floodwall to be flooded, and the river could start flowing through that weakness and erode a new channel (Chapman pers. comm.).

The USACE maintenance program for revetments focuses on reinforcement of the toe of the revetments. The stability of a revetment depends on the toe that is supported on the bed of the river. As the river degrades, the bed of the river drops from underneath the revetment and can reduce the factor of safety of the revetment or cause outright failure. To bring the revetment back to the original factor of safety, it is necessary to add rock to the toe. It is estimated that 5,000 tons per mile of revetment per foot of river bed degradation are required to maintain the original factor of safety. Some of this tonnage reflects the difficulty of placing rock underwater in swift current. The normal contract price for placed rock is $30 per ton (Chapman pers. comm.).

The potential effects of river bed degradation and changes in low-flow and high-flow water surface elevations on BSNP structures within each segment under the Proposed Action are described below.

St. Joseph Segment

Estimated river bed degradation levels under the Proposed Action of approximately 2 feet over the next 5 years and 4 feet or more over the next 20 years could adversely affect approximately 60 dikes and approximately 8 miles of rock revetment in the area between RM 455 and RM 445. This includes a 2.5-mile segment of revetment between RM 444 and RM 446.5 that is integrated into the foundation of Levee Unit L-455.

Because the rate of river bed degradation between RM 455 and RM 445 under the Proposed Action likely would exceed the rate at which erosion can remove material from the top of the dikes, mechanical removal of as much as 4 feet or more material from the top of existing dikes within the segment may be required over the next 20 years under the Proposed Action.

Over the next 20 years under the Proposed Action, the segment of revetment between RM 444 and RM 446.5 could be subject to substantial river bed degradation that could cause material underlying the revetment to be removed, thereby putting both the revetment and levee at potential risk of future failure, particularly during periods of high-flow water levels. This risk would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety. Assuming 5,000 tons of rock per mile of revetment per foot of river bed degradation, the estimated cost to reinforce the toes of 8 miles of revetment in this segment would be approximately $4.8 million.

BSNP structures in the St. Joseph segment located outside of the reach between RM 455 and RM 445 would be unlikely to experience levels of river bed degradation (in the short term or the long term under the Proposed Action) that would result in a notable adverse effect on the overall performance or operation and maintenance costs of these facilities.

Kansas City Segment

Degradation levels between 2 and 4 feet over the next 5 years and up to 4 feet or more over the next 20 years throughout the Kansas City segment under the Proposed Action pose risks to nearly 150 dikes and approximately 42 miles of rock revetments. More than 10 miles of these revetments are integrated into the foundations of critical levee units, including the North Kansas City levee, the Fairfax-Jersey Creek levee and the East Bottoms levee. The USACE has identified these levees as particularly vulnerable to the effects of river bed degradation and revetment failure, especially during

periods of high-flow water levels (USACE 2009). As in other segments, this risk would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety.

The estimated cost to reinforce the toes of 42 miles of revetment in this segment would be approximately $6 million. Because of the high rates of river bed degradation in the Kansas City segment, mechanical removal of material from the top of existing dikes may be required in the long term. In 2004, the USACE spent approximately $400,000 to remove 30,000 cubic yards of rock from the tops of structures (an average of approximately 2 feet) in the Kansas City reach. In 2009, the USACE spent an additional $336,000 in the Kansas City reach to remove 24,000 cubic yards of rock from the top of structures (another approximately 2 feet). This occurred over approximately 20 river miles, from RM 360 to RM 380 (Chapman pers. comm.)

Waverly Segment

The USACE maintains approximately 558 wooden pile and rock rip-rap dikes and approximately 127 miles of rock revetments along the navigation channel in the Waverly segment as part of the BSNP. Because this segment is not expected to experience notable amounts of river bed degradation or changes in low-flow or high-flow water elevations in the short term or the long term under the Proposed Action, no adverse effects to these BSNP structures are anticipated.

Jefferson City Segment

Estimated river bed degradation levels under the Proposed Action of between 2 and 4 feet over the next 5 years and more than 4 feet of river bed degradation over the next 20 years could adversely affect approximately 70 dikes and approximately 3 miles of rock revetment in the area between RM 150 and RM 140 in the Jefferson City segment.

Over the next 20 years under the Proposed Action, the area between RM 150 and RM 140 could be subject to substantial river bed degradation that could cause material underlying the revetments to be removed. This could put the revetments at potential risk of future failure, particularly during periods of high-flow water levels. This risk would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety.

The estimated cost to reinforce the toes of 3 miles of revetment in the Jefferson City segment is approximately $1.8 million. Because the rate of erosion between RM 150 and RM 140 likely would exceed the rate of river bed degradation under the Proposed Action, mechanical removal of material from the top of the existing dike is not expected to be required in the long term.

BSNP structures in the Jefferson City segment located outside of the reach between RM 150 and RM 140 would be unlikely to experience levels of river bed degradation (in the short term or the long term under the Proposed Action) that would result in a notable adverse effect on the performance or operation and maintenance costs of these facilities.

St. Charles Segment

Estimated river bed degradation levels of between 2 and 4 feet over the next 5 years and more than 4 feet over the next 20 years in the area between RM 50 and RM 0 in the St. Charles segment could adversely affect more than 320 dikes and over 20 miles of rock revetment under the Proposed Action.

Over the next 20 years, the area between RM 50 and RM 0 could be subject to substantial river bed degradation under the Proposed Action that could potentially put revetments at risk, particularly during periods of high-flow water elevations, due to removal of material from underneath the revetments. This risk would need to be countered with regular inspections, maintenance, and repairs to maintain the required factor of safety.

The estimated cost to reinforce the toes of 20 miles of revetment in the St. Charles segment is approximately $12 million. Because the rate of erosion in the area between RM 50 and RM 0 likely would exceed the rate of river bed degradation under the Proposed Action, mechanical removal of material from the top of the existing dike is not expected to be required in the long term.

BSNP structures in the St. Charles segment located outside of the reach between RM 150 and RM 140 would be unlikely to experience levels of river bed degradation (in the short term or the long term under the Proposed Action) that would result in a notable adverse effect on the performance or operation and maintenance costs of these facilities.

4.3.3.6 Impacts to Bridge, Pipeline, and Cable Crossings

River bed degradation can increase the risk to bridge, pipeline and cable crossing infrastructure by removing material from around bridge pylons or piers and by reducing the amount of cover needed to protect subsurface pipelines and cable crossings. Also, because the river bottom throughout most of the LOMR is composed primarily of sand, it can change dramatically during and following high-flow events. During high-flow events, bridge pier footings, bridge abutments, and pipelines can become exposed by the scour potential associated with greater channel velocity.

The potential effects of river bed degradation and changes in low-flow and high-flow water surface elevations on bridge, pipeline, and cable crossings within each segment under the Proposed Action are described below.

St. Joseph Segment

The river bed between RM 455 and RM 445 in the St. Joseph segment is expected to experience nearly 2 feet of river bed degradation and a corresponding 2-foot decline in low-flow water levels over the next 5 years under the Proposed Action. These amounts are expected to increase to 4 feet or more over the next 20 years. High-flow surface water elevations between RM 455 and RM 445 also are expected to increase in the long term under the Proposed Action.

The St. Joseph Highway Bridge at RM 447.9 and the Union Pacific Railroad Bridge at RM 448.2 are the only two bridges located in this area of substantial future river bed degradation and potential scour. According to the MoDOT, scour has been observed at the western end of the St. Joseph Highway Bridge, and countermeasures (i.e., dumping rock around the footings) have been implemented on the Kansas side. In addition, the USACE has rebuilt a dike near the bridge to help manage flows near the bridge (Stotlemeyer pers. comm.). The typical costs to remediate scour and river bed degradation problems can range between $1 and $2 million per bridge (Heckman pers. comm.).

Because the highway bridges along this segment have been built with deep foundations, are regularly inspected, and are reinforced against scour as necessary, the moderate to substantial river bed degradation and reduction in low-flow water surface elevations expected near the St. Joseph Highway Bridge under the Proposed Action are not expected to noticeably increase the risk of structural damage to the bridge.

Two pipelines crossings were identified near or between RM 455 and RM 445. These include a natural gas pipeline crossing at RM 455.5 and a water supply pipeline crossing at RM 450.4. No issues related to river bed degradation at these crossing locations have been reported. Because most pipelines crossing the Missouri River are installed at depths that would avoid the possibility of exposure under a range of changing bed conditions, the levels of river bed degradation expected at these crossing locations under the Proposed Action (4 feet or more over the next 20 years) are not be expected to pose a substantial risk to these pipelines.

All other identified highway and railroad bridges and pipelines within the St. Joseph segment are located outside of the reach between RM 455 and RM 440. These facilities would be unlikely to

experience adverse effects from river bed degradation or scour (in the short term or the long term under the Proposed Action) to a degree that would threaten the soundness or security, or the long-term operation and maintenance costs, of these facilities.

Kansas City Segment

The entire Kansas City segment from RM 391 to RM 357 could experience river bed degradation levels between 2 and 4 feet over the next 5 years and up to 4 feet or more over the next 20 years under the Proposed Action. The expected trends in low-flow water surface elevations are similar, decreasing up to 4 feet over the next 5 years and more than 4 feet over the next 20 years. High-flow water surface elevations also are expected to increase in the Kansas City segment in the long term under the Proposed Action.

Table 4.3-5 lists the bridge crossings in the Kansas City segment that would be subject to the anticipated levels of river bed degradation and changes in water surface elevations under the Proposed Action. These bridges are critical links in the Kansas City transportation system. In 2009, the combined AADT on the Fairfax Highway Bridges (US 69), the Wolcott Highway Bridges (Interstate 435), the Kansas City Highway Bridge (Interstate 635), the Paseo Bridge (Interstate 29 and 35), and the Interstate 435 Bridge was over 242,000 vehicles (MoDOT 2009). This represents a substantial portion of the overall freeway traffic volume in the Kansas City area. The three railroad bridges provide important connections to major distribution centers and intermodal rail yards, as well as critical river crossings.

Most of these bridges are founded on either deep-drilled shafts that extend 60–85 feet below the river bed or on concrete spread footings up to 30 feet deep. These construction methods, combined with implementation of aggressive scour countermeasures by the MoDOT and the KDOT, greatly reduce the likelihood that ongoing river bed degradation would cause structural damage to these bridges in the short term or the long term under the Proposed Action.

Table 4.3-6 lists the pipeline and cable crossings in the Kansas City segment that could potentially be at risk from continued river bed degradation under the Proposed Action. Most of this infrastructure is concentrated in the urbanized areas approximately 10 miles upriver and downriver from the heart of Kansas City. Over 10 individual pipelines that transport natural gas, liquid petroleum, water, and wastewater are located in this area, as well as a telecommunication line.

Table 4.3-5 Bridge Crossings in the Kansas City Segment Potentially at Risk under the Proposed Action

Crossing Name (Route Number)	River Mile
Wolcott Highway Bridges (Interstate 435)	383.3
Kansas City Highway Bridge (Interstate 635)	374.1
Fairfax Highway Bridges (US 69)	372.6
Broadway Avenue Bridge	366.2
Hannibal Railroad Bridge	366.1
A.S.B. Railroad Bridge	365.6
Heart of America Bridge (Route 9)	365.5
Paseo Bridge (Interstate 29 and 35)	364.8
Chouteau Highway (Route 269)	362.3
Interstate 435 Bridge	360.3
Harry S. Truman Railroad Bridge	359.3

Table 4.3-6 Pipeline and Cable Crossings in the Kansas City Segment Potentially at Risk under the Proposed Action

Crossing Name	Utility Type	River Mile
Williams Natural Gas	Pipeline	375.2
AT&T	Cable	374.0
Williams Brothers	Pipeline	374.0
Skelley Pipeline	Pipeline	373.9
Williams Brothers	Pipeline(s)	372.5
Williams Brothers	Pipeline	369.5
Kansas City, MO Water	Tunnel	366.1
Kansas City, MO Sewer	Pipeline(s)	361.2
American Oil	Pipeline	356.5

According to an inspection report completed in February 1999, several pipelines in this area were exposed and sensitive to changes in river bed elevations (West Consultants 1999). The current status of these pipelines was not able to be verified. However, the fact that pipeline exposure has occurred in

the past 11 years within the Kansas City segment suggests that other pipelines installed at similar depths in this area may be subject to adverse effects from ongoing river bed degradation.

Waverly Segment

Four vehicle bridges and one railroad line cross the Missouri River in the Waverly segment. The vehicle bridges are operated and maintained by the MoDOT and provide cross-river connections for US 291, Route 224, US 65, and Route 41. The combined traffic volume of these four bridges is 32,768 AADT. The railroad bridge is owned and operated by the BNSF. Multiple pipelines also cross the Missouri River in the Waverly segment.

Because the Waverly segment is not expected to experience notable amounts of river bed degradation or changes in low-flow or high-flow water elevations over the next 20 years under the Proposed Action, no adverse effects to these bridges and pipelines are anticipated. Any observed problems related to river bed degradation or scour at the four highway bridges would be addressed through implementation of scour countermeasures by the MoDOT.

Jefferson City Segment

The river bed in the area between RM 150 and RM 140 in the Jefferson City segment is expected to experience between 2 and 4 feet of river bed degradation over the next 5 years and more than 4 feet of river bed degradation over the next 20 years under the Proposed Action. Low-flow water levels in the area between RM 150 and RM 140 are not expected to change much over the next 5 years (less than 2 feet) under the Proposed Action; over the next 20 years, however, low-flow water levels could decline by as much as 4 feet. High-flow water levels in the area between RM 150 and RM 140 also are expected to increase in the long term under the Proposed Action.

Only one bridge, the Jefferson City Highway Bridge (US 63 and US 54), located at RM 143.0 would be subject to substantial long-term river bed degradation under the Proposed Action. This bridge carries approximately 29,832 AADT between Jefferson City and the communities of Cedar City and North Jefferson, Missouri. One municipal sewer pipeline and one submerged cable crossing operated by Missouri River Light and Power also cross the Missouri River between RM 150 and RM 140 at RM 143.5 and RM 143.8, respectively. Although the MoDOT has reported that the Jefferson City Highway Bridge is currently being monitored for scour problems (Stotlemeyer pers. comm.), no problems at the pipelines or cable crossings have been reported.

Because the highway bridges along this segment have been built with deep foundations, are regularly inspected, and are reinforced against scour as necessary, the moderate to substantial river bed degradation and moderate decline in low-flow water surface elevations near the Jefferson City Highway Bridge are not expected to noticeably increase the risk of structural damage to the bridge under the Proposed Action.

All other identified highway and railroad bridge, pipeline, and cable crossings located in the Jefferson City segment are located outside of the reach between RM 150 and RM 140. These facilities would be unlikely to experience adverse effects from river bed degradation or scour (in the short term or the long term under the Proposed Action) to a degree that would threaten the soundness or security, or the long-term operation and maintenance costs, of these facilities.

St. Charles Segment

The river bed in the area between RM 50 and RM 0 in the St. Charles segment is expected to experience between 2 and 4 feet of river bed degradation over the next 5 years and more than 4 feet of river bed degradation over the next 20 years under the Proposed Action. Low-flow water levels in the area between RM 50 and RM 0 are expected to decline between 2 and 4 feet over the next 5 years and more than 4 feet over the next 20 years under the Proposed Action. High-flow water levels in this area are expected to decrease in the short term but increase in the long term.

Table 4.3-7 lists the bridge crossings in the St. Charles segment that would be subject to these anticipated levels of river bed degradation and changes in water surface elevations. These bridges provide critical connections for commutes and freight traveling between St. Louis and St. Charles and other parts of the metropolitan area. In 2009, the combined traffic volume on these bridges was nearly 315,000 AADT (MoDOT 2009). The two railroad bridges also provide important connections between St. Louis and St. Charles. No information was available on the condition of the railroad bridges.

Because the highway bridges in the St. Charles segment have deep foundations secured to competent material, are regularly inspected, and are reinforced against scour as necessary, the moderate to substantial river bed degradation and moderate decline in low-flow water surface elevations between RM 50 and RM 0 are not expected to noticeably increase the risk of structural damage to these bridges.

Table 4.3-8 lists the pipeline and cable crossings in the St. Charles segment that could potentially be at risk from continued river bed degradation under the Proposed Action. Five pipelines transporting water, natural gas, and liquid petroleum are located in this area, as well as two telecommunication lines. No

problems have been reported at these pipeline and cable crossings. Because most pipelines and submerged cables are likely installed at depths that would avoid the possibility of exposure under a range of changing river bed conditions, the levels of river bed degradation expected at these crossing locations (4 feet or more over the next 20 years under the Proposed Action) are not be expected to pose a substantial risk to these pipelines or cable crossings.

Table 4.3-7 Bridge Crossings in the St. Charles Segment Potentially at Risk under the Proposed Action

Crossing Name (Route Number)	River Mile
Bellefontaine Highway (US 67)	8.1
Burlington Northern Inc. Railroad	8.2
Proposed New Highway (MO 115)	27.0
Norfolk and Southern Railroad	27.1
St. Charles Highway (MO 115)	28.2
Interstate 70 and US 40	29.6
Weldon Springs Highway (US 40 and 61)	43.9

Table 4.3-9 Pipeline and Cable Crossings in the St. Charles Segment Potentially at Risk under the Proposed Action

Crossing Name	Utility Type	River Mile
Laclede Gas Co.	Pipeline	8.0
Union Electric Co.	Cable	19.6
AT&T	Cable	26.5
St. Peters Water	Pipeline	34.5
Shell	Pipeline	44.2
Shell	Pipeline	44.5
Explorer	Pipeline	54.4

All other identified highway and railroad bridge, pipeline, and cable crossings located in the St. Charles segment are located outside of the reach between RM 50 and RM 0. These facilities would be unlikely to experience adverse effects from river bed degradation or scour (in the short term or the long term

under the Proposed Action) to a degree that would threaten the soundness or security, or the long-term operation and maintenance costs, of these facilities.

4.3.3.7 Impacts to Wharf and Dock Facilities

All Segments

There are 155 wharves, docks, boat ramps, and other shoreline loading facilities along the LOMR in the Project area. These facilities can be adversely affected if changes in water surface elevation or channel characteristics damage or affect the manner in which the facilities typically are used.

Many old wharves and terminals are located along the river. Many of them were used to ship grain, petroleum, chemicals, and other products up and down the river. Most of these facilities are no longer in use (Chapman pers. comm.). Some loading facilities have been abandoned because of inaccessibility to loading and mooring capabilities that was caused by lowering of the water surface on the Missouri River (USACE 2009). Currently, only a handful of terminals are operating. Most commercial products that were shipped by barge in the past are now likely being shipped by truck or rail.

It is possible that some terminals have adapted to the river bed degradation without notifying the USACE. A likely adjustment would be using a mooring barge between the terminal and the barge being offloaded. It is likely that if an unused terminal in a degraded reach was reopened, it would be necessary to remove rock in front of the terminal to make it usable again. The USACE would work with terminal operators if there was an access problem by performing hydrographic surveys and perhaps removing rock in front of the terminal to provide barges with more draft (Chapman pers. comm.).

Most of the existing boat ramps in the Project area are new or have been completely renovated over the last 10 years. This trend was not due to river bed degradation but more to factors such as the Lewis and Clark Bicentennial, adequate State funds, and renewed interest in river recreation. The USACE has worked closely with the designers of the new/renovated boat ramps to ensure that they extend deep enough to allow for some amount of river bed degradation. Some ramps were extended over the last 10 years to make them more usable during the severe drought that occurred during the mid-2000s (Chapman pers. comm.).

Boat ramps with known problems that are likely due to river bed degradation include:

- City of Leavenworth ramp (extended in winter 2008/2009);
- City of Parkville ramp (usable only during high water elevations);
- Kansas City Missouri Riverfront Park ramp (extended when it was reopened in 2005); and
- City of Saint Charles ramp (usable only during high water elevations). (Chapman pers. comm.)

The potential effect of river bed degradation on boat ramps would be loss of access by recreational boaters and sportsmen to an affected reach of the river. Loss of access also could affect access by emergency personnel and work crews affiliated with the USACE, USGS, USFWS, and MDC work crews (Chapman pers. comm.).

4.3.4 No Action Alternative

Under the No Action Alternative, no commercial dredging would occur in any segment. Because no commercial dredging would occur, no impacts on infrastructure related to dredging would occur in any segment.

4.3.4.1 Projected Changes in River Bed Elevations and Low-Flow Water Levels

Once commercial dredging has been discontinued, the river bed would respond and change in response to influxes of bed material load in the absence of dredging. Aggradation likely would occur in areas where concentrated dredging occurred historically. Table 4.2-7 summarizes the changes in river bed elevations, and changes in low-flow and high-flow water surface elevations expected to occur in each segment under the No Action Alternative.

4.3.4.2 Impacts to Water Intake Facilities

All Segments

Under the No Action Alternative, the potential adverse effects from river bed degradation and declining low-flow water levels on water intake facilities on the LOMR that provide water for public water systems and cooling and process water for power generation plants would not occur. Water losses from intake facilities would not need to be replaced by other sources, such as wells. Major investments in new water intake facilities, or major modifications to existing facilities, would not be required. In some cases, depending on the location, maintenance costs could be affected by the need to remove

sediment buildup around intake structures. In most areas, however, existing or modified BSNP structures could effectively control sediment buildup.

4.3.4.3 Impacts to Water Supply Wells

St. Joseph and Kansas City Segments

Under the No Action Alternative, the potential adverse effects of river bed degradation on lateral (or horizontal) water supply wells in the St. Joseph and Kansas City segments would not occur. The permeability of the underlying aquifer would not be reduced, and existing river bed filtration would not be affected.

4.3.4.4 Impacts to Levees

All Segments

With the elimination of commercial dredging under the No Action Alternative, the processes of river bed degradation and aggradation would be controlled primarily by the USACE as part of the BSNP. The USACE would continue to maintain BSNP structures and implement countermeasures to control bank erosion, scour, and any other natural or human-related processes that could pose a threat to existing levees.

4.3.4.5 Impacts to Bank Stabilization and Navigation Project Structures

All Segments

As described above, under the No Action Alternative, the processes of river bed degradation and aggradation would be controlled to a large degree by the USACE as part of the BSNP. The USACE would continue to maintain the system of dikes by reestablishing the riverward ends of structures, repairing portions of structures that have eroded more quickly than the natural erosion rate, and repairing segments of structures that have settled or sustained flood damage. The USACE also would continue to reinforce the toes of revetments that may have been compromised by ongoing river bed degradation or severe flood events.

4.3.4.6 Impacts to Bridge, Pipeline, and Cable Crossings

All Segments

While the risk to bridge, pipeline, and cable crossing infrastructure from dredging-related river bed degradation would not be present under the No Action Alternative, ongoing river bed degradation and scour could continue to pose a threat to existing infrastructure. Threats to bridges likely would be addressed by implementation of countermeasures such as placing gabions (large rectangular wire baskets containing rock) or dumping rock around bridge footings. Pipeline or cable crossings that might become exposed likely would be reburied or protected by other means by owners and operators.

4.3.4.7 Impacts to Wharf and Dock Facilities

All Segments

Existing wharves, docks, boat ramps, and other shoreline loading facilities in the Project area likely would experience no noticeable effect under the No Action Alternative. In some areas, such as the Kansas City segment, moderate to substantial levels of aggradation may be noticeable.

4.3.5 Alternative A

Alternative A would permit approximately 2,190,000 tons of commercial dredging in the five segments of the LOMR. This alternative would decrease the amount dredged in the Kansas City, Waverly, Jefferson City, and St. Charles segments and would increase the amount dredged in the St. Joseph segment compared to 2004–2008 levels.

4.3.5.1 Projected Changes in River Bed Elevations and Low-Flow Water Levels

Table 4.2-7 summarizes the changes in river bed elevations and changes in low-flow and high-flow water surface elevations under Alternative A by river segment. Under Alternative A, all segments could experience nearly a 2-foot increase or a 2-foot decrease in river bed elevations over the next 5 years. Over the next 20 years, two segments would experience slight degradation (St. Joseph and Jefferson City) while others would experience either slight degradation or slight aggradation. Only slight changes in low-flow and high-flow water surface elevations are expected over the short term and the long term, except the Jefferson City segment, which is expected to experience an increase in high-flow water levels in the long term.

4.3.5.2 Impacts to Water Intake Facilities

All Segments

The slight change in river bed degradation and reduction in low-flow water surface elevations expected in all segments under Alternative A would result in little to no adverse impact on existing water intake facilities over the short term or the long term. The increase in high-flow water surface elevation expected in the Jefferson City segment over the next 20 years under Alternative A would not be expected to noticeably affect the Missouri American Water Company intake facility at RM 144. In some cases, depending on location, maintenance costs could be affected by the need to remove slight sediment buildup (less than approximately 2 feet) around intake structures. In most areas, however, existing or modified BSNP structures could effectively control sediment buildup.

4.3.5.3 Impacts to Water Supply Wells

St. Joseph and Kansas City Segments

Under Alternative A, the slight amount of river bed degradation expected in the St. Joseph and Kansas City segments, over both the short term and the long term, and the slight aggradation expected in the Kansas City segment over the long term, would have no noticeable adverse effect on the two lateral (horizontal) water supply wells located in the St. Joseph and Kansas City segments. The expected change in river bed elevation of less than 2 feet under Alternative A would not substantially reduce the permeability of the underlying aquifer or adversely affect river bed filtration. The companies that operate these two wells, the Missouri American Water Company and the Kansas City Board of Public Utilities, have recommended that a no-dredge zone be created 2,000 feet upstream and 2,000 feet downstream from their wells. Such an arrangement would further reduce the potential for adverse impacts on these water supply systems (Fuerman pers. comm., Uden pers. comm.).

Waverly, Jefferson City, and St. Charles Segments

No water supply wells were identified in the Waverly, Jefferson City, or St. Charles segment.

4.3.5.4 Impacts to Levees

All Segments

With the substantial reduction in commercial dredging in most segments under Alternative A, the potential risk to federal and non-federal levees from potential effects such as bank erosion, bank

instability, bank failure, soil weakening, scour and erosion, levee damage and potential levee failure would generally be less than under current conditions. The only area expected to experience an increase in high-flow water surface elevations in the long term under Alternative A is the area between RM 150 and RM 140 in the Jefferson City segment. Existing levees would continue to be subject to the periodic effects of high-flow water surface elevations and the potential undermining effects of those conditions. Continued inspections, maintenance, and damage repair would be required, particularly in areas such as the St. Joseph and Kansas City segments where some levees have been constructed on top of revetments.

4.3.5.5 Impacts to Bank Stabilization and Navigation Project Structures

All Segments

The potential effects on BSNP structures under Alternative A (such as exposure of the tops of dikes due to river bed degradation rates that are more rapid than erosion rates) would be less than under current conditions. Likewise, the potential for erosion at the toe of revetments would be less. The reduced potential for these types of effects would reduce the cost to maintain and repair these structures compared to existing conditions.

4.3.5.6 Impacts to Bridge, Pipeline, and Cable Crossings

All Segments

Because these segments are not expected to experience even moderate amounts of river bed degradation or changes in low-flow water elevations over the next 20 years, none of the bridges, pipelines or cable crossing in the Project area would be expected to experience adverse effects from river bed degradation or scour (in the short term or the long term under Alternative A) to a degree that would threaten the soundness or security, or the long-term operation and maintenance costs of those facilities. Any observed problems related to river bed degradation or scour at affected highway bridges would be addressed through implementation of scour countermeasures by the MoDOT and the KDOT. Any threats to pipelines or cable crossings would be addressed by the owners and operators.

4.3.5.7 Impacts to Wharf and Dock Facilities

All Segments

Existing wharves, docks, boat ramps, and other shoreline loading facilities in the Project area likely would experience no noticeable effect under Alternative A. In some areas, a slight increase in aggradation levels may be noticeable.

4.3.6 Alternative B

Alternative B would permit 5,050,000 tons of commercial dredging in the five segments of the LOMR. This would result in a decrease in the amount dredged in the Kansas City, Jefferson City, and St. Charles segments, and an increase in the amount dredged in the St. Joseph and Waverly segments compared to 2004–2008 levels.

4.3.6.1 Projected Changes in River Bed Elevations and Low-flow Water Levels

Table 4.2-7 summarizes the changes in river bed elevations and changes in low-flow and high-flow water surface elevations under Alternative B by river segment. Under Alternative B, river bed degradation levels and reductions in low-flow water levels in most segments would be less than 2 feet over the next 5 years and no more than 4 feet over the next 20 years. The Waverly segment could experience slight levels of degradation and declining low-flow water elevations or slight levels of aggradation and increasing low-flow water elevations over the short term under Alternative B.

4.3.6.2 Impacts to Water Intake Facilities

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

River bed degradation levels of as much as 4 feet over the next 20 years in portions of these segments under Alternative B could pose a moderate long-term risk to a number of existing water intake facilities within these segments compared to existing conditions. As described for the Proposed Action, these intake facilities provide critical water supplies to local communities and electric power plants throughout the Project area, including the Aquila Lake Road, Nearman Bottoms, Quindaro, and Hawthorn power plants, which together generate over 1,100 MW of electrical power. Potentially affected intake facilities include intakes operated by several water purveyors supplying water to nearly 2 million people in the Kansas City and St. Lewis metropolitan areas. Intake facilities located in all segments except the Waverly segment could require modifications or installation of additional pumps to ensure sufficient

water supplies. The cost of new pumps and modifications to existing intake structures can range between $1 and $2 million.

Waverly Segment

The potential for slight aggradation over the next 5 years in the Waverly segment under Alternative B could require additional maintenance at some intake facilities to remove up to 2 feet of sediment buildup. In most areas, however, existing or modified BSNP structures could effectively control the potential sediment buildup. The less than 2-foot change in river bed elevation in the Waverly segment over the long term under Alternative B would be unlikely to adversely affect existing water intake facilities.

4.3.6.3 Impacts to Water Supply Wells

St. Joseph and Kansas City Segments

Under Alternative B, the potential for up to 4 feet of river bed degradation in the next 5 years near two lateral (horizontal) water supply wells in these segments could present an increased risk to the permeability of the underlying aquifer and the effectiveness of river bed filtration near these wells. The companies that operate these wells, the Missouri American Water Company and the Kansas City Board of Public Utilities, have recommended that a no-dredge zone be created 2,000 feet upstream and 2,000 feet downstream from their wells to reduce the potential for adverse impacts on their existing systems (Fuerman pers. comm., Uden pers. comm.). Implementation of such restrictions could help reduce the potential for adverse impacts on these water supply systems (Fuerman pers. comm., Uden pers. comm.).

Waverly, Jefferson City, and St. Charles Segments

No water supply wells were identified in the Waverly, Jefferson City, or St. Charles segment.

4.3.6.4 Impacts to Levees

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

The estimated river bed degradation of up to 4 feet over the next 20 years in portions of these segments under Alternative B could pose a moderate risk to existing federal and non-federal levees in the St. Joseph, Kansas City, Jefferson City, and St. Charles segments. Potential effects such as bank erosion, bank instability, bank failure, soil weakening, scour and erosion, levee damage, and potential

levee failure, would generally be greater than under current conditions. Implementation of countermeasures likely would be required to ensure the required factor of safety, including regular inspections, maintenance, and repairs. This would be particularly likely in areas such as the Kansas City segment, where a number of levees have been constructed on top of revetments. Similar countermeasures may be required for levees located along major tributaries.

Waverly Segment

The estimated level or river bed degradation and decline in low-flow water surface elevations in the Waverly segment is less than 2 feet over the next 20 years under Alternative B. These low levels of change suggest that adverse affects on existing levees would not occur.

4.3.6.5 Impacts to Bank Stabilization and Navigation Project Structures

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

As described for Alternative A, the potential effects on BSNP structures (such as exposure of the tops of dikes caused by river bed degradation rates that are more rapid than erosion rates) would generally be greater under Alternative B than under current conditions, and likely would require implementation of countermeasures to ensure the required factor of safety, including regular inspections, maintenance, and repairs. Likewise, the potential for erosion at the toe of revetments would be greater under Alternative B than under current conditions. The potential costs to reinforce or repair BSNP structures in the St. Joseph, Kansas City, Jefferson City, and St. Charles segments could be substantial. For example, assuming 5,000 tons of rock per mile of revetment per foot of river bed degradation (between 2 and 4 feet), the estimated cost to reinforce the toes of 73 miles of revetment in the St. Joseph, Kansas City, Jefferson City, and St. Charles segments segment could range between $21.9 and $43.8 million.

Waverly Segment

The less than 2-foot change in the river bed in the Waverly segment due to river bed degradation in the long term under Alternative B would be unlikely to affect existing BSNP structures; therefore, no adverse effects are expected in this segment.

4.3.6.6 Impacts to Bridge, Pipeline, and Cable Crossings

All Segments

Because all segments are expected to experience no more than moderate levels of river bed degradation and declines in low-flow water elevations over the next 20 years, none of the bridge, pipeline, or cable crossings in the Project area would be expected to experience adverse effects from river bed degradation or scour (in the short term or the long term under Alternative B) to a degree that would threaten the soundness or security, or the long-term operation and maintenance costs, of those facilities. Any observed problems related to river bed degradation or scour at affected highway bridges would be addressed through implementation of scour countermeasures by the MoDOT and the KDOT. Any threats to pipelines or cable crossings would be addressed by the owners and operators.

4.3.6.7 Impacts to Wharf and Dock Facilities

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

The wharves, docks, boat ramps, and other shoreline loading facilities located within these segments could be adversely affected under Alternative B if the expected 2–4 feet of river bed degradation would affect the manner in which the facilities typically are used. Most of the wharves and terminal facilities in these segments are no longer in use, and the expected levels of river bed degradation under Alternative B would not substantially affect current users. River bed degradation levels are not expected to adversely affect most boat ramps because most ramps in the Project area have been constructed or renovated within the last 10 years and have been designed to accommodate changing water level conditions. A few boat ramps with existing low-water elevation problems could experience worsening conditions in the long term unless they are modified to accommodate declining water elevations. These include the City of Parkville ramp (usable only during high water) and the City of Saint Charles ramp (usable only during high water) (Chapman pers. comm.).

Waverly Segment

The less than 2-foot change in the river bed in the Waverly segment due to river bed degradation in the long term under Alternative B would be unlikely to affect existing wharves, docks, boat ramps, or other shoreline loading facilities. Therefore, no adverse effects are expected in this segment.

4.3.7 Alternative C

Alternative C would permit approximately 6,900,000 tons of commercial dredging in the five segments of the LOMR. This would be approximately the same as the average annual amount of dredging from 2004 to 2008 (existing conditions).

4.3.7.1 Projected Changes in River Bed Elevations and Low-Flow Water Levels

Table 4.2-7 summarizes the changes in river bed elevations and changes in low-flow and high-flow water surface elevations under Alternative C by river segment.

Under Alternative C, river bed degradation in all segments would be less than 2 feet in the short term. Over the next 20 years, however, river bed degradation could reach and exceed 4 feet. Changes in low-flow and high-flow water surface elevations would be similar, except in the St. Joseph and Waverly segments where changes would be slight to none.

4.3.7.2 Impacts to Water Intake Facilities

Kansas City, Jefferson City, and St. Charles Segments

River bed degradation levels of as much as 4 feet or more over the next 20 years in portions of these segments under Alternative C could pose a moderate to substantial long-term risk to a number of existing water intake facilities in the segments compared to existing conditons. As described for the Proposed Action, these intake facilities provide critical water supplies to local communities and electric power plants throughout the Project area, including the Nearman Bottoms, Quindaro, and Hawthorn power plants, which together generate over 1,000 MW of electrical power. Potentially affected intake facilities also include intakes operated by several water purveyors supplying water to nearly 2 million people in the Kansas City and St. Lewis metropolitan areas. Intake facilities located in all segments, except the St. Joseph and Waverly segments, could require modifications or additional pumps to ensure sufficient water supplies under Alternative C. The cost of new pumps and modifications to existing intake structures can range between $1 and $2 million.

St. Joseph and Waverly Segments

The less than 2-foot change in the river bed in the St. Joseph and Waverly segments due to river bed degradation under Alternative C would be unlikely to affect existing water intake facilities. Therefore, no adverse effects on water intake facilities are expected in the St. Joseph or Waverly segment.

4.3.7.3 Impacts to Water Supply Wells

St. Joseph and Kansas City Segments

Under Alternative C, the potential for 4 feet of more of river bed degradation near the lateral (horizontal) water supply well operated by the Kansas City Board of Public Utilities at RM 379 could present an increased risk to the permeability of the underlying aquifer and the effectiveness of river bed filtration near the well. The less than 2 feet of river bed degradation at the lateral (horizontal) water supply well operated by the Missouri American Water Company at RM 454.75 is not expected to notably affect the permeability of the underlying aquifer or the effectiveness of river bed filtration near that well. The companies that operate these wells have recommended that a no-dredge zone be created 2,000 feet upstream and 2,000 feet downstream from their wells to reduce the potential for adverse impacts on their existing system (Fuerman pers. comm., Uden pers. comm.). Such restrictions could help reduce the potential for adverse impacts on these water supply systems (Fuerman pers. comm., Uden pers. comm.).

Waverly, Jefferson City, and St. Charles Segments

No water supply wells were identified in the Waverly, Jefferson City, or St. Charles segment.

4.3.7.4 Impacts to Levees

Kansas City, Jefferson City, and St. Charles Segments

The estimated river bed degradation of up to 4 feet or more over the next 20 years in portions of the Kansas City, Jefferson City, and St. Charles segments under Alternative C could pose a substantial risk to existing federal and non-federal levees in these segments. Potential effects such as bank erosion, bank instability, bank failure, soil weakening, scour and erosion, levee damage, and potential levee failure would generally be greater under Alternative C than under current conditions. Implementation of countermeasures likely would be required to ensure the required factor of safety, including regular inspections, maintenance, and repairs. This would be particularly likely in areas such as the Kansas City segment where levees have been constructed on top of revetments. Similar countermeasures may be required for levees located along major tributaries.

St. Joseph and Waverly Segments

The less than 2-foot change in the river bed in the St. Joseph and Waverly segments due to river bed degradation under Alternative C would be unlikely to affect existing levees; therefore, no adverse effects are expected in these segments.

4.3.7.5 Impacts to Bank Stabilization and Navigation Project Structures

Kansas City, Jefferson City, and St. Charles Segments

The potential effects on BSNP structures (such as exposure of the tops of dikes due to river bed degradation rates that are more rapid than erosion rates) in the Kansas City, Jefferson City, and St. Charles segments under Alternative C would generally be greater than under existing conditions, and ould likely would require the implementation of countermeasures to ensure the required factor of safety, including regular inspections, maintenance, and repairs. Likewise, the potential for erosion at the toe of revetments in these segments would be greater under Alternative C than under existing conditions. Assuming 5,000 tons of rock per mile of revetment per foot of river bed degradation (4 feet or more), the estimated cost to reinforce the toes of 65 miles of revetment in the Kansas City, Jefferson City, and St. Charles segments could exceed $39 million.

St. Joseph and Waverly Segments

The less than 2-foot change in the river bed in the St. Joseph and Waverly segments due to river bed degradation under Alternative C would be unlikely to affect existing BSNP structures. Therefore, no adverse effects to BSNP structures are expected in these segments under Alternative C.

4.3.7.6 Impacts to Bridge, Pipeline, and Cable Crossings

Kansas City, Jefferson City, and St. Charles Segments

Degradation levels and changes in low-flow water elevations in the Kansas City, Jefferson City, and St. Charles segments under Alternative C would generally be greater than under existing conditions and be similar to those described for the Proposed Action. Potential adverse effects to the same bridges and pipelines as described for the Proposed Action would be likely to occur under Alternative C.

Because the highway bridges along this segment have been built with deep foundations, are regularly inspected, and are reinforced against scour as necessary, the moderate to substantial river bed

degradation and reduction in low-flow water surface elevations projected in these segments under Alternative C are not expected to noticeably increase the risk of structural damage to these bridges.

Because most pipelines crossing the Missouri River are installed at depths that would avoid the possibility of exposure under a range of changing bed conditions, the levels of river bed degradation expected at these crossing locations (4 feet or more over the next 20 years under Alternative C) are not expected to pose a substantial risk to these pipelines.

Any observed problems related to river bed degradation or scour at affected highway bridges would be addressed through implementation of scour countermeasures by the MoDOT and the KDOT. Any threats to pipelines or cable crossings would be addressed by the owners and operators.

4.3.7.7 Impacts to Wharf and Dock Facilities

Kansas City, Jefferson City, and St. Charles Segments

The wharves, docks, boat ramps, and other shoreline loading facilities located within the Kansas City, Jefferson City, and St. Charles segments could be adversely affected under Alternative C if the expected 2–4 feet or more of river bed degradation would affect the manner in which the facilities typically are used. Most of the wharves and terminal facilities in these segments are no longer in use, and the expected levels of river bed degradation under Alternative C are not likely to substantially affect current users. Expected river bed degradation levels are not likely to adversely affect most boat ramps because most ramps in the Project area have been constructed or renovated within the last 10 years and have been designed to accommodate changing water level conditions. A few boat ramps with existing low-water elevation problems could experience worsening conditions in the long term unless they are modified to accommodate declining water elevations. These include the City of Parkville ramp (usable only during high water) and the City of Saint Charles ramp (usable only during high water) (Chapman pers. comm.).

St. Joseph and Waverly Segments

The less than 2–foot change in the river bed in the St. Joseph and Waverly segments due to river bed degradation under Alternative C would be unlikely to affect existing wharves, docks, boat ramps, or other shoreline loading facilities. Therefore, no adverse effects are expected in these segments.

4.3.8 Summary Table

Table 4.3-9 contains a summary of potential impacts on infrastructure for the Proposed Action and alternatives.

4.3.9 References

4.3.9.1 Printed Literature

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USACE (U.S. Army Corps of Engineers). 2004. Upper Mississippi River System Flow Frequency Study. Final Report. January.

USACE (U.S. Army Corps of Engineers). 2003. Department of the Army Permit Evaluation and Decision Document. March 5.

Table 4.3-9 Summary of Potential Impacts on Infrastructure

Category of Effect	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Impacts to water intake facilities and water supply wells	• Increased costs of maintenance, potentially higher utility rates, and increased risk of shutdown of intake structures in the long term in St. Joseph, Kansas City, Jefferson City, and St. Charles segments. • Potential decreases in flow rate capacity and filtration effectiveness in St. Joseph and Kansas City segments.	• No impact.	• Little to no adverse impact on existing water intake facilities. • No noticeable adverse effect on water supply wells.	• Increased costs of maintenance, potentially higher utility rates, and increased risk of shutdown of intake structures in the long term in St. Joseph, Kansas City, Jefferson City, and St. Charles segments. • Potential decreases in flow rate capacity and filtration effectiveness in St. Joseph and Kansas City segments.	• Increased costs of maintenance, potentially higher utility rates, and increased risk of shutdown of intake structures in the long term in Kansas City, Jefferson City, and St. Charles segments. • Potential decreases in flow rate capacity and filtration effectiveness in St. Joseph and Kansas City segments.
Impacts to levees and Bank Stabilization and Navigation Project (BSNP) structures	• Increased risk of levee and BSNP structure failure in St. Joseph, Kansas City, Jefferson City, and St. Charles segments.	• Decreased risk of levee and BSNP structure failure in LOMR.	• Decreased risk of levee and BSNP structure failure in LOMR; except between RM 150 and RM 140 in Jefferson City segment, where the risk would remain the same.	• Increased risk of levee and BSNP structure failure in St. Joseph, Kansas City, Jefferson City, and St. Charles segments.	• Increased risk of levee and BSNP structure failure in Kansas City, Jefferson City, and St. Charles segments.
Impacts to bridge, pipeline, and cable crossings	• Increased risk of structural damage to bridges, pipeline, and cable crossings in Kansas City segment.	• Decreased risk of structural damage to bridges, pipeline and cable crossings from dredging; risks related to degradation would remain.	• Decreased risk of structural damage to bridges, pipelines, and cable crossings.	• No impact.	• No impact.
Impacts to wharf and dock facilities	• Increased risk of damage to four boat ramps.	• No impact.	• No impact, except in certain areas where aggradation would decrease risk of boat ramp damage.	• Potential increased risk of damage to two boat ramps; no impact in Waverly segment.	• Potential increased risk of damage to two boat ramps; no impact in St. Joseph or Waverly segment.

4.3.9.2 Personal Communications

Chapman, Michael. Chief, River Engineering and Restoration Section, U.S. Army Corps of Engineers. Email to Steve Seville, ICF International, April 20, 2010.

Fuerman, Robert. Director of Production, Missouri American Water. Letter to Cody Wheeler, U.S. Army Corps of Engineers, Kansas City, MO, February 10, 2009

Heckman, Dennis. State Bridge Engineer, Missouri Department of Transportation. Email to Heather Scotten, ENTRIX, Inc., June 16, 2010.

Heidtbrink, Scott. Senior Vice President, Supply, Kansas City Power & Light. Letter to Cody Wheeler, U.S. Army Corps of Engineers, Kansas City District, Kansas City, MO. January 28, 2009.

Orth, Michael. Black & Veatch. Letter to Lanny Uden, Board of Public Utilities, Kansas City, Kansas, February 7, 2005.

Schremmp, Tom. Director of Production, WaterOne (Water District No. 1 of Johnson County). Letter to Cody Wheeler, U.S. Army Corps of Engineers, Kansas City District, Kansas City, MO, February 10, 2010

Stotlemeyer, Scott. Bridge Engineer, Missouri Department of Transportation, River Bridge Maintenance. Telephone conservation with Heather Scotten, ENTRIX, Inc., June 15, 2010

Stowe, Samual. Collector Wells International. Letter to Lanny Uden, Board of Public Utilities, Kansas City, Kansas, February 18, 2005.

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4.4 NAVIGATION AND TRANSPORTATION

4.4.1 Introduction

This section describes the environmental consequences of the Proposed Action and the alternatives on navigation and surface transportation. As described in Section 3.6, the changes in dredging operations that would occur with implementation of the Proposed Action or the alternatives have the potential to affect navigation and riverborne commerce, as well as traffic and transportation patterns.

This section includes a summary of the assessment methods used to evaluate impacts on navigation and surface transportation, followed by a description of the potential project impacts.

4.4.2 Assessment Methods

This section describes the methods and assumptions used to determine potential impacts on navigation and transportation associated with the Proposed Action and the alternatives.

4.4.2.1 Navigation Traffic

Navigation traffic impacts were analyzed by comparing dredging-related tug/barge trips on the LOMR under existing conditions and under the Proposed Action or the alternatives. Annual tug/barge trips under existing conditions were quantified according to the method described in Appendix D, Air Quality and Climate Change Technical Information. Based on information provided by the Dredgers related to tugs and barges, this analysis assumed that these vessels operated 216 days per year. A “trip” is defined as a one-way vessel movement (e.g., a tug pushing a barge from the dredge to the onshore processing facility counts as two vessel trips).

Limited information is currently available on how implementation of the Proposed Action and alternatives would affect the operation and number of existing equipment (i.e., tugs and barges). For the purposes of this analysis, annual tug/barge trips for the Proposed Action and alternatives were assumed to be proportional to permitted sand and gravel volumes. To determine tug/barge trips for the Proposed Action and the alternatives, the estimated annual tug/barge trips under existing conditions were multiplied by the percent of change in sand and gravel volumes in each segment between the existing condition and the alternative. Calculated estimates of annual tug/barge trips under the Proposed Action and the alternatives were then compared to estimated annual tug/barge trips under existing conditions.

4.4.2.2 Surface Road Traffic

Surface road traffic impacts were analyzed by comparing haul truck trips made from existing sand plants on the LOMR to established market areas under existing conditions, and haul truck trips that would be made under the Proposed Action or alternatives. Daily haul truck trips for each of the five river segments were estimated based on the annual volume of sand and gravel dredged from each segment. This estimate assumes an average truck capacity of 20 tons and 216 delivery days per year. A "trip" is defined as a one-way truck movement (e.g., a haul truck delivering sand from the processing plant to the point of delivery and back would be considered two truck trips).

As discussed in Section 3.6, this analysis assumes that sand plants would have direct (i.e., within 10 miles) access to major arterials, such as state, interstate, and U.S. highways, and that these arterials would be used to haul sand and gravel to market areas within an approximately 25-mile radius. It is not known with certainty what routes are currently used by the haul trucks or what routes would be used from the new sand plants proposed in the St. Joseph and St. Charles segments. Representative low and high ADT values (the mean daily traffic volume on a roadway over a 24-hour period) under existing conditions for the highways within a 10-mile radius of the sand plants are given by river segment in Table 3.6-5. These ADT ranges provide a basis of comparison for the changes in the number of truck trips under the Proposed Action and alternatives.

4.4.3 Proposed Action

4.4.3.1 Changes in Navigation Traffic

St. Joseph Segment

Under the Proposed Action, tug and barge traffic in the St. Joseph segment would increase from increased volume of dredged material from the river (Table 4.4-1). Annual tug and barge trips would increase by approximately 3,335 trips over existing conditions (a 252-percent change). This increase in river traffic could potentially limit the river area available for other navigation traffic, including commerce-related tugs and barges and recreational boats, and could result in congestion on the river. As described in Section 3.6, the majority of traffic on the LOMR is associated with commercial dredgers (i.e., tugs and barges), and is generally limited to areas on the river within a few miles (and no more than 7 to 10 miles) upstream of the onshore sand plants. Thus, any increase in dredging-related traffic and potential limitation of navigation areas would be confined to areas relatively close to these facilities. It is expected that the potential limitation would be negligible because the navigation channel is

approximately 300 feet wide. This width is assumed sufficient to allow large vessels, such as tugs, tows, or barges, and smaller recreational vessels to maneuver around the commercial dredging vessels.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Under the Proposed Action, dredging-related tug and barge traffic would increase in the Kansas City, Waverly, Jefferson City, and St. Charles segments, as indicated in Table 4.4-1. Tug/barge trips in these four segments would not increase as substantially as in the St. Joseph segment. Relative to existing conditions, tug/barge trips in the Kansas City, Waverly, Jefferson City, and St. Charles segments would increase by 5,676 trips (a 53-percent change), 851 trips (a 48-percent change), 4,580 trips (a 74-percent change), and 25,557 trips (a 166-percent change), respectively. These increases in tug and barge traffic would not be considered adverse. As noted above, the 300-foot width of the river is assumed sufficient to allow large and small vessels ample room for navigation, even with substantial increases in tug and barge traffic.

Alternate Sources

Under the Proposed Action, additional demand would not be placed on alternate sources of sand and gravel. Therefore, navigation traffic at alternate sources would not change.

4.4.3.2 Changes in Navigation Hazards

St. Joseph Segment

Continuing river bed degradation could result in hazards to navigation by exposing previously submerged structures (e.g., sunken vessels, old bridge piers, pipelines, and rock/clay outcroppings) on the river bed (USACE 2009a), and by creating conditions conducive to the formation of shoals (i.e., sandbars) in the navigation channel.

As described in Section 3.5, there are 52 pipeline crossings in the Project area. Of these, 41 pipeline crossings are located in river segments that are experiencing river bed degradation and are currently being dredged. Some of these pipelines were installed many decades ago. Recently (within the past 20 years), the USACE has required that pipelines be installed a minimum of 28 feet below the river bed. Given the ongoing river bed degradation in the LOMR, especially in substantially degraded segments where individual locations have degraded from two to seven feet in the last 20 years (USACE 2009b), there is the potential for pipelines that were installed several years ago to become exposed and present a navigation hazard.

Table 4.4-1 Estimated Annual Dredging-Related Tug/Barge Trips on the Lower Missouri River [a, b]

	Existing Conditions[c]	Proposed Action[c]		No Action Alternative		Alternative A[c]		Alternative B[c]		Alternative C[c]	
Segment	Trips	Trips	% Change Relative to Existing Conditions	Trips	% Change Relative to Existing Conditions	Trips	% Change Relative to Existing Conditions	Trips	% Change Relative to Existing Conditions	Trips	% Change Relative to Existing Conditions
St Joseph	1,324	4,659	252	0	-100	1,418	7	3,484	163	1,337	1
Kansas City	10,772	16,448	53	0	-100	2,188	-80	4,983	-54	10,776	0
Waverly	1,761	2,612	48	0	-100	1,299	-26	2,961	68	1,766	0
Jefferson City	6,174	10,754	74	0	-100	1,681	-73	3,832	-38	6,178	0
St. Charles	15,412	40,969	166	0	-100	3,457	-78	7,849	-49	15,418	0

[a] Assumes 216 delivery days per year.

[b] A "trip" is defined as a one-way vessel movement ,and it was assumed that for every tug movement, there was a barge movement (e.g., a tug pushing a full barge from the dredge to the onshore processing facility counts as two vessel trips. Similarly, a tug pushing an empty barge from the onshore processing facility to the dredge would count as two vessel trips).

[c] For the purpose of this analysis, tug trips under the Proposed Action and alternatives were assumed to be proportional to permitted sand and gravel volumes for each segment, and were calculated accordingly. Tug and barge trips under existing conditions are based on information provided by permit applicants and represent the maximum number of tug and barge trips in a year.

There are numerous abandoned sunken barges and other vessels and large objects in the Missouri River (USACE 1991a, 1991b; Wheeler pers. comm. 2010). The locations of some, but not all, of these sunken vessels are known. River bed degradation may expose some of these vessels, which would result in a potential navigation hazard. In the past, rock/clay outcroppings have been exposed as a result of river bed degradation and became obstacles to navigation traffic during low water periods (Wheeler pers. comm. 2010). River bed degradation reduces the clearance over rocky outcrops and, over time, the shelves may become more exposed (Chapman pers. comm. 2010, USCG 2009).

As described in Section 4.2, under the Proposed Action, slight river bed degradation likely would occur over the short term in the St. Joseph segment, and moderate to substantial river bed degradation would take place over the long term. Thus, there is greater potential for exposure of previously submerged objects in the navigation channel in this segment. Exposure of these features could pose obstacles or hazards to navigation vessels, resulting in navigation accidents or vessel damage (USCG 2009).

Kansas City, Jefferson City, and St. Charles Segments

In the past 10 years, submerged objects have presented obstacles to navigation in the LOMR near Kansas City and in a few other locations. For example, in 2003, a submerged truck was removed at RM 378; and in 2004, bridge rubble was removed at RM 366. These objects are often found once a barge collides with them and are then subsequently removed or relocated (Chapman pers. comm. 2010). Similarly, rock/clay outcroppings in this segment have previously interfered with navigation traffic. Holliday Sand & Gravel Company has indicated that there is clay outcropping in the Kansas City segment, near the Charles B. Wheeler Downtown Airport (RM 368). This area becomes impassable during periods of low water (Wheeler pers. comm. 2010).

Under the Proposed Action, dredging in the Kansas City, Jefferson City, and St. Charles segments would increase. This increase would likely contribute to moderate additional degradation in the short term (up to 5 years) and substantial degradation in the long term (5 to 20 years). Thus, there is the potential for previously submerged objects and rock/clay outcroppings to become exposed in areas with the most dredging, which could result in navigation accidents or vessel damage.

Waverly Segment

Under the Proposed Action, slight river bed degradation or aggradation may occur in the Waverly segment in the short term. Continuing slight river bed degradation could result in hazards to navigation in the long term by exposing previously submerged structures. Submerged objects or rock/clay outcroppings are present in the Waverly segment. If river bed degradation was severe enough to

expose these objects or outcroppings, they could present a hazard to navigation. Aggradation of the river bed in the Waverly segment would improve navigation. Due to the potential for slight river bed degradation or aggradation in this segment, the Proposed Action is not likely to adversely impact navigation in the Waverly Segment.

Alternate Sources

Under the Proposed Action, additional demand would not be placed on alternate sources of sand and gravel. Therefore, navigation hazards at alternate sources would not change.

4.4.3.3 Changes in Truck Traffic

St. Joseph Segment

Under the Proposed Action, daily haul truck trips from the processing facilities to market areas would increase by 191 percent in the St. Joseph segment (Table 4.4-2). Representative low and high ADT values for the highways within a 10-mile radius of sand plants in the St. Joseph segment are provided in Table 3.6-5. Adding these truck trips to the ADT counts in Table 3.6-5 would result in a maximum increase in traffic in the St. Joseph segment along the state, interstate, and U.S. highways of approximately 65, 6, and 25 percent, respectively. However, these values assume that all trips are made on only one type of highway. In fact, it is likely that the haul trucks would use all three highway types and the increase in truck trips, therefore, would be divided among all highways with access from the sand plants to the various points of delivery within a 25-mile radius of the sand plants. The increase is substantial, especially on state highways. Furthermore, it is not known to what extent surface streets may be affected in the immediate vicinity of the sand plants or at points of delivery. As such, this increase in haul truck traffic is considered adverse because it could contribute to congestion and traffic delays.

Kansas City Segment

Under the Proposed Action, daily haul truck trips from the processing facilities to market areas would increase by 28 percent (Table 4.4-2). A new sand plant would be built and operated in the Kansas City segment (Master's-Waldron). Based on the volume of sand and gravel that The Master's Dredging Company has requested to dredge in this segment, approximately 26 percent of the daily truck trips anticipated under the Proposed Action in the Kansas City segment would originate from the Master's-Waldron sand plant.

Table 4.4-2 Estimated Annual Haul Truck Trips Under the Proposed Action and Alternatives

		Proposed Action			No Action Alternative			Alternative A			Alternative B			Alternative C		
Segment	Facility Name (Company)	Annual Tons	Estimated Tons Delivered Per Day[a]	Trips Per Day	Annual Tons	Estimated Tons Delivered Per Day[a]	Trips Per Day	Annual Tons	Estimated Tons Delivered Per Day[a]	Trips Per Day	Annual Tons	Estimated Tons Delivered Per Day[a]	Trips Per Day	Annual Tons	Estimated Tons Delivered Per Day[a]	Trips Per Day
St. Joseph	St. Joseph (Holliday)	950,330	4,400	440	0	0	0	350,000	1,620	162	860,000	3,981	398	330,000	1,528	153
	Total	*950,330*	*4,400*	*440*	*0*	*0*	*0*	*350,000*	*1,620*	*162*	*860,000*	*3,981*	*398*	*330,000*	*1,528*	*153*
Kansas City	Riverside (Holliday)	1,379,769	6,388	639	0	0	0	211,147	978	98	480,946	2,227	223	1,040,995	4,815	482
	Randolph[b] (Holliday)	1,429,901	6,620	662	0	0	0	354,253	1,640	164	807,306	3,737	373	1,108,753	5,133	513
	Waldron (Master's)[c]	1,000,000	4,630	463	0	0	0	153,031	708	71	348,570	1,614	161	753,818	3,492	349
	Total	*3,809,670*	*17,637*	*1,764*	*0*	*0*	*0*	*718,431*	*3,326*	*333*	*1,636,802*	*7,578*	*758*	*2,902,666*	*12,313,43815*	*1,344*
Waverly	Lexington (Capital SL)	474,923	2,199	220	0	0	0	301,604	1,396	140	687,657	3,184	318	410,182	1,889	190
	Carrollton (Capital SL)	31,439	146	15	0	0	0	19,965	92	9	45,521	211	21	27,153	126	13
	Total	*506,362*	*2,344*	*235*	*0*	*0*	*0*	*321,569*	*1,489*	*149*	*733,178*	*3,394*	*339*	*437,335*	*2,025*	*203*
Jefferson City	Glasgow (Capital SL)	154,068	713	71	0	0	0	29,954	139	14	68,267	316	32	110,063	510	51
	Boonville (Capital SL)	12,819	59	6	0	0	0	2,492	12	1	5,680	26	3	9,157	42	4
	Rocheport (Capital SL)	308,321	1,427	143	0	0	0	59,944	278	28	136,616	632	63	220,258	1,020	102
	Jefferson City (Herman)	500,000	2,315	231	0	0	0	97,210	450	45	221,548	1,026	103	357,190	1,654	165
	Jefferson City (Capital SL)	1,236,501	5,725	572	0	0	0	240,400	1,113	111	547,889	2,537	254	883,331	4,089	409
	Total	*2,211,709*	*10,239*	*1,024*	*0*	*0*	*0*	*430,000*	*1,991*	*199*	*980,000*	*4,537*	*454*	*1,579,999*	*7,315*	*731*
St. Charles	Hermann (Hermann)	500,000	2,315	231	0	0	0	44,719	207	21	101,525	470	47	199,423	923	92
	Washington (Rau)[c]	100,000	463	46	0	0	0	8,944	41	4	20,305	94	9	39,885	185	18
	Washington (Capital SL)	786,930	3,643	364	0	0	0	70,382	326	33	159,785	740	74	313,864	1,453	145
	Bridgeton (Limited)	350,000	1,620	162	0	0	0	31,303	145	14	71,067	329	33	139,596	646	65
	St. Charles (J.T.R.)	1,348,775	6,244	624	0	0	0	120,632	558	56	273,868	1,268	127	537,954	2,491	249
	Chesterfield (Limited)	650,000	3,009	301	0	0	0	58,135	269	27	131,982	611	61	259,250	1,200	120
	Riverview (J.T.R.)	201,225	932	93	0	0	0	17,997	83	8	40,859	189	19	80,258	372	37
	Fort Belle (Limited)	100,000	463	46	0	0	0	8,944	41	4	20,305	94	9	39,868	185	18
	Total[d]	*4,036,930*	*18,689*	*1,869*	*0*	*0*	*0*		*1,670*	*167*	*819,696*	*3,795*	*379*	*1,610,098*	*7,455*	*744*

[a] Assumes average truck capacity of 20 tons and 216 delivery days per year.

[b] For the purposes of determining truck trips per segment, values "annual tons delivered" for Randolph (Holliday) represent the combined total of 361,956 dredging from the Kansas City and Waverly segments. A total of 308,867 tons/year are dredged by Holliday in the Waverly segment and distributed from the sand plant at Randolph.

[c] New proposed facility.

[d] Totals for the St. Charles segment do not include the Alton facility, which is located on the Mississippi River.

Waverly and Jefferson City Segments

Under the Proposed Action, daily haul truck trips from the processing facilities to market areas would increase by 37 percent in the Waverly segment, and by 40 percent in the Jefferson City segment (Table 4.4-2).

St. Charles Segment

Under the Proposed Action, daily haul truck trips from the processing facilities to market areas would increase by 145 percent in the St. Charles segment (Table 4.4-2). A new sand plant would be built and operated (Rau-Washington). Based on the volume of sand and gravel the Edward N. Rau Contractor Company has requested to dredge in this segment, approximately 2.5 percent of the total dredging in the St. Charles segment would originate from the Rau-Washington sand plant.

Representative low and high ADT values for the highways within a 10-mile radius of sand plants in the St. Charles segment are provided in Table 3.6-5. Adding these truck trips to the ADT counts in Table 3.6-5 would result in a maximum increase in traffic in the St. Charles segment along the state, interstate, and U.S. highways of approximately 182, 4, and 7 percent, respectively. However, these values assume that all trips are made on only one type of highway. In fact, it is likely that the haul trucks would use all three highway types, and the increase in truck trips, therefore, would be divided among all highways with access from the sand plants to the various points of delivery within a 25-mile radius of the sand plants.

The increase is substantial, especially on state highways. Furthermore, it is not known to what extent surface streets may be affected in the immediate vicinity of the sand plants or at points of delivery. As such, this increase in haul truck traffic is considered adverse because it could contribute to congestion and traffic delays.

Alternate Sources

Under the Proposed Action, additional demand would not be placed on alternate sources of sand and gravel. Therefore, truck traffic at alternate sources would not change.

4.4.4 No Action Alternative

4.4.4.1 Changes in Navigation Traffic

All Segments

Under the No Action Alternative, beneficial impacts to navigation would occur because commercial sand and gravel dredging would cease in the LOMR. Commercial dredging-related navigation traffic would be eliminated in all five river segments, and the potential for interference of dredge-related vessels with other vessels on the LOMR would be eliminated.

Alternate Sources

Any increase in dredging of alternate river sources (i.e., the Mississippi River) would result in an increase in tug/barge traffic on that river.[1] The potential for an adverse impact on navigation would depend on existing navigation traffic in the river and the navigable river area. No change in navigation traffic is associated with the other alternate sources.

4.4.4.2 Changes in Navigation Hazards

St. Joseph and Kansas City Segments

Due to the expected aggradation of the river bed that would occur in these segments under the No Action Alternative, the potential for previously submerged objects to become exposed would decrease. This impact could be beneficial to navigation.

Waverly Segment

Slight aggradation or degradation is expected in the short term and the long term. Aggradation would decrease the potential for previously submerged objects to become exposed, which would be beneficial to navigation. Continuing river bed degradation could result in hazards to navigation in the long term by exposing previously submerged structures. However, degradation is expected to be slight and, therefore, not severe enough to expose the objects or outcroppings present in the Waverly segment. The No Action Alternative is not likely to adversely impact navigation in the Waverly segment.

[1] Kansas River dredging would not involve the use of barges (USACE pers. comm.)

Jefferson City and St. Charles Segments

In these segments, slight to moderate aggradation is expected in the short term, and slight aggradation or degradation is anticipated in the long term. Aggradation would decrease the potential for previously submerged objects to become exposed, which would be beneficial to navigation. Degradation in the long term would increase the potential for previously submerged objects and rock/clay outcroppings to become exposed in areas with the most dredging, which could result in navigation accidents or vessel damage. If degradation occurs, it is expected to be slight. Therefore, the increase in navigation accidents or vessel damage due to exposed areas would be small.

Alternate Sources

The potential for an increased risk of navigation hazards in the Mississippi River would depend on the amount of sand and gravel dredged, the existing river bed degradation, and whether large submerged objects in the area could be exposed and pose a hazard to navigation vessels. No navigational hazards are associated with the other alternate sources.

4.4.4.3 Changes in Truck Traffic

All Segments

Under the No Action Alternative, trucks would no longer haul dredging material to the market areas via existing routes (Figure 3.6-1). This would result in elimination of all truck trips currently made on an annual basis in each of the five segments (Table 3.6-4), and an overall decrease in traffic along trucking routes. This impact would benefit transportation in the Project area.

Alternate Sources

Annual haul truck trips would be expected to increase on the major transportation corridors between the alternate source facilities and the market areas. Because it is not known which of the existing alternate sources would be used to replace sand and gravel otherwise dredged from the LOMR, the roadways that may be affected cannot be identified, and the extent to which traffic on these roadways would change cannot be estimated. However, these mining operations currently provide sand and gravel to urban market areas via haul trucks, and it is assumed that the trucks have direct access to the state and interstate highway system from these sites and use major transportation corridors. In general, major transportation corridors (i.e., interstate and state routes and U.S. highways) have relatively large traffic capacities; therefore, it is unlikely that any increase in haul truck traffic from these alternate source locations would adversely impact traffic circulation. As such, there would be no adverse impact.

4.4.5 Alternative A

4.4.5.1 Changes in Navigation Traffic

St. Joseph Segment

Under Alternative A, tug and barge traffic in the St. Joseph segment would increase (Table 4.4-1) in proportion to the increased volume of dredged material extracted from the river (seven percent). This increase in river traffic could limit the portion of the river available for other navigation traffic, including commerce-related tugs and barges and recreational boats, and may result in congestion on the river.

As described in Section 3.6, the majority of traffic on the LOMR is associated with commercial dredgers (i.e., tugs and barges), and is generally limited to areas on the river within a few miles (and no more than 7 to 10 miles) upstream of onshore sand plants. Thus, any increase in dredging-related traffic and the resultant potential limitation in navigation area would be confined to areas in proximity to these facilities. It is expected that the potential limitation in navigation area would be negligible because there would be only a seven percent increase in tug/barge trips per year (94 barge/tug trips). Furthermore, it is assumed that the 300-foot wide navigation channel would be sufficiently wide to allow large vessels, such as tugs, tows, or barges, as well as smaller recreational vessels to maneuver around the commercial dredging vessels, if necessary. As such, this impact is not considered adverse.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Because of a reduction in dredging in the Kansas City, Waverly, Jefferson City, and St. Charles segments under Alternative A, dredging-related navigation traffic would be reduced in these segments (Table 4.4-1) by 26 to 80 percent. This impact could be beneficial because it would decrease the potential for interference of dredging-related vessels with other vessels on the LOMR.

Alternate Sources

Changes in navigation traffic related to alternate sources of sand and gravel would apply only to dredging in other river locations (i.e., the Mississippi River). Any increase in dredging would result in an increase in tug/barge traffic on the river. The potential for an adverse impact would depend on existing navigation traffic and the area available for vessels to maneuver around one another in these rivers. No change in navigation traffic would be associated with the other alternate sources.

4.4.5.2 Changes in Navigation Hazards

St. Joseph and Jefferson City

These segments would experience slight aggradation or degradation in the short term under Alternative A. In the long term, slight degradation could result in hazards to navigation by exposing previously submerged structures (e.g., sunken vessels, old bridge piers, pipelines, and rock/clay outcroppings) on the river bed (USACE 2009a), and by creating conditions conducive to the formation of shoals (i.e., sandbars) in the navigation channel. Due to the small potential for degradation in the long term, a substantial increase in the exposure of previously submerged objects and/or clay/rock outcroppings is unlikely.

Kansas City Segment

The Kansas City Segment would experience slight aggradation or degradation in the short term under Alternative A. In the long term, slight aggradation would decrease the potential for navigational hazards due to exposed (previously submerged) structures (e.g., sunken vessels, old bridge piers, pipelines, and rock/clay outcroppings) on the river bed (USACE 2009a).

Waverly and St. Charles Segments

The Waverly and St. Charles segments would experience slight aggradation or degradation in the short term and long term under Alternative A. Due to the small potential for degradation in the long term, a substantial increase in the exposure of previously submerged objects and/or clay/rock outcroppings is unlikely. If slight aggradation occurred, the likelihood of previously submerged structures becoming exposed and resulting in navigation hazards would decrease.

Alternate Sources

The potential for any adverse impact in the Mississippi River[2] related to navigation hazards would depend on the amount of sand and gravel dredged, the existing river bed degradation, and whether large submerged objects in the area could be exposed and pose a hazard to navigation vessels. Increased dredging in this river may contribute to river bed degradation, which may expose navigational hazards that are currently submerged. Changes in navigation hazards are not associated with other alternate sources.

[2] The Kansas River does not have commercial barge traffic.

4.4.5.3 Changes in Truck Traffic

St. Joseph Segment

Under Alternative A, there would be approximately 11 additional daily truck trips in the St. Joseph segment relative to existing conditions (Tables 3.6-4 and 4.4-2). This represents an approximately seven-percent increase in truck traffic. Representative low and high ADT values for the highways within a 10-mile radius of sand plants in the St. Joseph segment are given in Table 3.6-5. With the addition of these truck trips to the ADT counts presented in Table 3.6-5, the maximum increase in traffic in the St. Joseph segment along the state, interstate, and U.S. highways would be nominal at approximately 2 percent, 0.2 percent, and 0.9 percent, respectively. Because this increase is not substantial, it is not likely that these truck trips would contribute to congestion or traffic delays. As such, this impact would not be adverse.

Kansas City, Jefferson City, and St. Charles Segments

Net daily haul truck trips in the Kansas City, Jefferson City, and St. Charles segments would be reduced by 76 percent, 73 percent, and 78 percent, respectively, under Alternative A. The overall reduction of truck traffic in these segments would be beneficial because it would lower the likelihood of traffic delays or congestion due to haul truck traffic.

Under Alternative A, new sand plants would be built in the Kansas City and St. Charles segments, which would increase haul truck trips on surface roads and major arterials near the new facility. Construction of the Master's and Rau sand plants would result in an increase in truck traffic of approximately 71 and four daily haul truck trips, respectively. The increase in truck trips from construction of the Rau sand plant is considered nominal. The increase in truck traffic from construction of the Master's sand plant is not considered substantial because this sand plant would be near a major metropolitan area (Kansas City) and, thus, close to major transportation corridors with relatively large traffic capacities. It is unlikely that any increase in haul truck traffic from the Kansas City segment location would adversely impact traffic circulation. As such, there would be no adverse impact.

Waverly Segment

Daily haul truck trips would decrease by approximately 13 percent in the Waverly segment under Alternative A. This increase could result in a slight decrease in traffic delay or congestion.

Alternate Sources

Annual haul truck trips would be expected to increase on the major transportation corridors near the alternate source facilities. Because it is not yet known which of the existing alternate sources would be used to replace sand and gravel otherwise dredged from the LOMR, the roadways that may be affected cannot be identified, and the extent to which traffic on these roadways would change cannot be estimated. In general, major transportation corridors (i.e., interstate and state routes, and U.S. highways) have relatively large traffic capacities; therefore, it is unlikely that any increase in haul truck traffic from these alternate source locations due to increased operations would adversely impact traffic circulation.

4.4.6 Alternative B

4.4.6.1 Changes in Navigation Traffic

St. Joseph and Waverly Segments

Under Alternative B, tug and barge trips in the St. Joseph and Waverly segments would increase by approximately 2,160 trips and 1,200 trips (Table 4.4-1), respectively, relative to existing conditions. These represent percentage increases of 163 percent and 68 percent, respectively. As previously described, this increase in river traffic could limit a portion of the river area available for other navigation traffic, including commerce-related tugs and barges and recreational boats, and could result in congestion on the river.

As described in Section 3.6, the majority of traffic on the LOMR is associated with commercial dredgers (i.e., tugs and barges), and is generally limited to areas on the river within a few miles (and no more than 7 to 10 miles) upstream of the onshore sand plants. Thus, any increase in dredger-associated traffic, and resultant limitation of navigation area, would be confined to areas close to these facilities. The 300-foot width of LOMR navigation channel is assumed sufficient to allow large vessels, such as tugs, tows, or barges, as well as smaller recreational vessels to maneuver around the commercial dredging vessels if necessary. As such, this would not be an adverse impact.

Kansas City, Jefferson City, and St. Charles Segments

Because of reduced dredging in the Kansas City, Jefferson City, and St. Charles segments under Alternative B, the dredging-related navigation traffic in these segments would be reduced (Table 4.4-1)

by 38 to 54 percent. This would decrease the potential for interference from dredging-related vessels with other vessels on the LOMR. As such, this would result in a beneficial impact to navigation.

Alternate Sources

Changes in navigation traffic would apply only to dredging in other river locations (i.e., the Mississippi River). Any increase in dredging would result in an increase in tug/barge traffic in this river. The potential for an adverse impact would depend on existing navigation traffic and the area available for vessels to maneuver around one another in the river. No change in navigation traffic would be associated with the other alternate sources.

4.4.6.2 Changes in Navigation Hazards

St. Joseph, Jefferson City and St. Charles Segments

Geomorphic estimates indicate that, overall, there would be slight additional river bed degradation in the short term and slight to moderate river bed degradation in the long term in these segments. Continuing river bed degradation could result in hazards to navigation by exposing previously submerged structures (e.g., sunken vessels, old bridge piers, pipelines, and rock/clay outcroppings) on the river bed (USACE 2009a), and by creating conditions conducive to the formation of shoals (i.e., sandbars) in the navigation channel. Because of slight degradation in the short term, the potential to increase navigation hazards is minimal in the short term in these segments. The slight to moderate river bed degradation in the long term would be accompanied by a slight to moderate potential to increase the frequency of navigational hazards in the long term. Alternative B would result in a potential negative impact to navigation.

Kansas City Segment

Slight degradation would occur in the short term and moderate degradation would occur in the long term in this segment. Continuing river bed degradation could result in hazards to navigation by exposing previously submerged structures (e.g., sunken vessels, old bridge piers, pipelines, and rock/clay outcroppings) on the river bed (USACE 2009a), and by creating conditions conducive to the formation of shoals (i.e., sandbars) in the navigation channel. Because of slight degradation in the short term, the potential to increase navigation hazards is minimal in the short term. The slight to moderate river bed degradation in the long term would be accompanied by a slight to moderate potential to increase the frequency of navigational hazards in the long term. Alternative B would result in a potential negative impact on navigation.

Waverly Segment

Geomorphic estimates indicate the likelihood of slight degradation or slight aggradation in the short term, and slight degradation in the long term in the Waverly segment under Alternative B. Consequently, there would be a negligible increased risk of navigational hazards in the Waverly segment.

Alternate Sources

The potential for any adverse impact in the Mississippi River related to navigation hazards would depend on the amount of sand and gravel dredged, existing river bed degradation, and whether large submerged objects are present in the area that could be exposed and pose a hazard to navigation vessels. Increased dredging in the Mississippi River may contribute to river bed degradation, which may expose navigational hazards.

4.4.6.3 Changes in Truck Traffic

St. Joseph and Waverly Segments

Alternative B would result in 398 and 339 daily haul truck trips in the St. Joseph and Waverly segments, respectively (Table 4.4-2). This represents an increase in haul truck trips in these segments by 164 percent and 98 percent, respectively. With the addition of the these truck trips to the ADT counts in Table 3.6-5, the maximum increase in traffic in the St. Joseph segment along the state, interstate, and U.S. highways would be approximately 55 percent, 5 percent, and 21 percent, respectively. Similarly, the maximum increase in traffic in the Waverly segment would be approximately 74 percent, 0.9 percent, and 9 percent along the state, interstate, and U.S. highways, respectively.

This increase in truck traffic would be relatively substantial, especially on state highways. Furthermore, it is not known to what extent surface streets in the immediate vicinity of the sand plants or points of delivery may be affected. This increase in haul truck traffic could contribute to congestion and traffic delays.

Kansas City, Jefferson City, and St. Charles Segments

Under Alternative B, the reduction in dredging in the Kansas City, Jefferson City, and St. Charles segments would result in an overall reduction of daily haul truck trips for each segment between 38 and 50 percent (Table 4.4-2), and traffic flow would be improved in these segments.

Haul truck trips would increase on surface roads and major arterials near the new sand plant facilities in the Kansas City and St. Charles segments. Traffic associated with the new Rau sand plant facility would represent a nominal increase of approximately nine daily haul truck trips. However, there would be approximately 161 daily haul truck trips out of the Master's facility in the Kansas City segment. This increase in truck traffic from construction of the Master's sand plant is not considered substantial because this sand plant would be close to a major metropolitan area (Kansas City) and, thus, near major transportation corridors with relatively large traffic volume capacities. Therefore, it is unlikely that this increase in haul truck traffic from the new Kansas City segment location would adversely impact traffic circulation. As such, this impact would not be adverse.

Alternate Sources

Annual haul truck trips would be expected to increase on the major transportation corridors near the alternate source facilities. Because it is not yet known which of the existing alternate sources would be used to replace sand and gravel otherwise dredged from the LOMR, the roadways that may be affected cannot be identified, and the extent to which traffic on these roadways would change cannot be estimated. However, these mining operations currently provide sand and gravel to urban market areas via haul trucks, and it is assumed that the trucks have direct access to the state and interstate highway system from these sites and use major transportation corridors. In general, major transportation corridors (i.e., interstate and state routes, and U.S. highways) have relatively large traffic capacities; therefore, it is unlikely that any increase in haul truck traffic from these alternative source locations due to increased operations would adversely impact traffic circulation. As such, there would be no adverse impact.

4.4.7 Alternative C

Under Alternative C, the current limits on dredging would be maintained, and current dredging operations would not increase or decrease in any segment of the river, except in association with the two new sand plants in the Kansas City and St. Charles segments. Increased reliance on alternate sources for sand and gravel production would not be necessary.

4.4.7.1 Changes in Navigation Traffic

All Segments

Because the overall volume of dredging in the LOMR would not increase under Alternative C, the number of tug/barge trips wouldnot increase and the there would be no impact to navigation traffic.

Total tug/barge trip numbers in each segment would not increase because the total dredging in each segment would be essentially the same as existing conditions; however, tug/barge trips would shift within the Kansas City and St. Charles segments because of construction and operation of the new sand plants.

Alternate Sources

Alternative C would not result in increased demand for sand and gravel from alternate sources. Therefore, no changes in navigation traffic would occur at alternate sources.

4.4.7.2 Changes in Navigation Hazards

St. Joseph Segment

Geomorphic estimates indicate that under Alternative C, there is the potential for slight degradation or slight aggradation in the short term. In the long term, slight degradation is expected. Therefore, the potential for exposure of navigational hazards would be negligible in the short term. Due to the small potential for degradation in the long term, a substantial increase in the exposure of previously submerged objects and/or clay/rock outcroppings is unlikely.

Kansas City Segment

Under Alternative C, geomorphic estimates indicate the likelihood of slight to moderate degradation in the short term, and substantial degradation in the long term. As such, there would be some increases in navigational hazards in the short-term, increasing over time. The long-term potential for collisions with submerged objects poses an increased navigation hazard that could be adverse.

Waverly Segment

Geomorphic estimates indicate that under Alternative C, there is the potential for slight degradation or slight aggradation in the short term and long term. The potential for exposure of navigational hazards would be negligible.

Jefferson City and St. Charles Segments

Under Alternative C, geomorphic estimates indicate the likelihood of slight degradation in the short term, and moderate to substantial degradation in the long term in these segments. Minimal increases in navigational hazards would occur in the short term, and moderate to substantial potential for

increased exposure of hazards would take place in the long term. The long term potential for collisions with submerged objects poses an increased navigation hazard that could be adverse.

Alternate Sources

Alternative C would not result in increased demand for sand and gravel from alternate sources. Therefore, no changes in navigation hazards would occur at alternate sources.

4.4.7.3 Changes in Truck Traffic

St. Joseph, Waverly, and Jefferson City Segments

Because sand and gravel extraction would not increase under Alternative C, truck traffic near the existing sand plant facilities would not change. Therefore, there would be no impact to truck traffic in the St. Joseph, Waverly, and Jefferson City segments under Alternative C.

Kansas City and St. Charles Segments

Haul truck trips would increase on surface roads and major arterials near the new sand plant facilities in the Kansas City and St. Charles segments. Traffic associated with the new Rau sand plant facility would represent a nominal increase of approximately 18 daily haul truck trips; however, approximately 349 daily haul truck trips would originate from the Master's facility in the Kansas City segment. This increase in truck traffic from construction of the Master's sand plant is not considered substantial because this sand plant would be near a major metropolitan area (Kansas City) and, thus, near major transportation corridors with relatively large traffic volume capacities. Consequently, it is unlikely that the increase in haul truck traffic from the new Kansas City segment location would adversely affect traffic circulation. No impact to truck traffic in the Kansas City or St. Charles segment would occur under Alternative C.

Alternate Sources

Alternative C would not result in increased demand for sand and gravel from alternate sources. Therefore, no changes in truck traffic would occur at alternate sources.

4.4.8 Summary of Impacts

A summary of the potential impacts on navigation and transportation under the Proposed Action and the alternatives is provided in Table 4.4-3.

Table 4.4-3 Summary of Potential Impacts on Navigation and Transportation

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Changes in navigation traffic	• Increase in dredging vessels and navigation traffic in all segments.	• Benefit to navigation due to elimination of dredging vessels in all segments. • Potential increase in navigation traffic on the Mississippi River.	• Slight increase in dredging vessels and navigation traffic in St. Joseph segment; decrease in traffic in all other segments. • Potential increase in navigation traffic on the Mississippi River	• Increase in dredging vessels and navigation traffic in St. Joseph and Waverly segments; decrease in traffic in all other segments. • Potential increase in navigation traffic on the Mississippi River	• No change in dredging vessels and navigation traffic in all segments.
Changes in navigation hazards	• Increased potential for previously submerged objects to become exposed and become a navigation hazard in all segments.	• Decreased potential for previously submerged objects to become exposed and become a navigation hazard in St. Joseph and Kansas City segments; slight change in hazard potential in Waverly segment; slight increase in hazard potential in Jefferson City and St. Charles segments. • Potential increase in navigation hazards on the Mississippi River.	• Slight degradation in the long term in St. Joseph, Waverly, Jefferson City, and St. Charles segments, resulting in exposure of previously submerged objects or clay/rock outcroppings; no increase in the potential for previously submerged objects to become exposed and become a navigation hazard in Kansas City segment. • Potential increase in navigation hazards on the Mississippi River.	• Moderate increased potential for previously submerged objects to become exposed and become a navigation hazard in the long term in St. Joseph, Kansas City, Jefferson City, and St. Charles segments; negligible increased potential for hazards in Waverly segment. • Potential increase in navigation hazards on the Mississippi River.	• Increased potential for previously submerged objects to become exposed and become a navigation hazard in most segments.
Changes in truck traffic	• Substantial increase in haul truck traffic; most pronounced in St. Joseph and St. Charles segments, potentially resulting in congestion and traffic delays.	• Elimination of haul truck traffic in all segments. • Potential increase in truck traffic at alternate sources.	• Decrease in haul truck traffic; additional truck traffic near new sand plants. • Potential increase in truck traffic at alternate sources.	• Decrease in haul truck traffic in all segments except St. Joseph and Waverly segments; additional truck traffic near new sand plants. • Potential increase in truck traffic at alternate sources.	• No change in haul truck traffic near existing sand plants; additional truck traffic near new sand plants.

4.4.9 References

4.4.9.1 Printed Literature

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4.4.9.2 Personal Communications

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4.5 WATER RESOURCES

4.5.1 Introduction

Section 3.7 describes LOMR surface water quality and groundwater resources in the context of current dredging operations. This section compares the consequences of the Proposed Action and the alternatives to the existing conditions in the LOMR. For surface water, potential dredging-related impacts are associated with suspended sediments and contaminants in the water column. For groundwater, direct impacts would be associated with the temporary alteration of river bed hydraulic conductivity and indirect impacts would be associated with changes in river stage.

Potential impacts on surface water and groundwater quality from the Proposed Action and the alternatives are described in Sections 4.5.3 through 4.5.7. Section 4.5.8 contains a summary of potential dredging-related impacts on surface water and groundwater resources in and near the LOMR.

The potential water resources impacts under the Proposed Action and the alternatives could result in indirect impacts on wetland hydrology (Section 4.7), water withdrawal infrastructure (Section 4.3), and biological aquatic resources (Section 4.6).

4.5.2 Methodology and Approach

Because of the large size of the Project area, the high variability in geologic conditions, and a lack of site-specific data throughout the Project area, water resources were evaluated in a qualitative fashion that includes a narrative discussion of potential impacts under each alternative scenario. Water resource impacts are discussed at both the local and reach scale, depending on the effect type. Direct impacts would be limited to the period during or shortly after dredging, while indirect impacts could extend through a prolonged period after dredging.

Surface water quality is primarily affected by dredging through local, direct impacts. The quantity of dredging proposed under each alternative was compared to existing dredging to determine the relative increase and the corresponding change in magnitude of localized impacts. The groundwater impacts are indirectly driven by changes to the LOMR stage due to river bed degradation. The consequences to groundwater levels in the alluvial aquifer were based on the geomorphology impact assessment.

4.5.3 Proposed Action

Under the Proposed Action, the negative impacts to water quality discussed in Section 3.7 would increase proportionally with dredging. Direct impacts under the Proposed Action would include an increase in the suspension of sediment at the dredge head and at the dredge discharges. Direct impacts to groundwater would include local short-term alterations to river bed hydraulic conductivity (by altering the streambed deposits that influence the interactions of groundwater and the LOMR). Changes in alluvial aquifer levels could occur as a secondary impact of river bed degradation. As described in Section 4.4, increased dredging would result in an elevated potential for vessel collisions or leakage of fuels, oils, and chemicals.

4.5.3.1 Suspended Sediment

Existing dredging operations result in suspended sediment at and downstream of the dredge site. For the purpose of this analysis, the term “suspended sediment” refers to both the introduction and resuspension of sediments in the form of TSS from the river bed, glacial deposits, or upland sources in the water column. The size of the elevated suspended sediment plume downstream of the dredge depends on a variety of factors, including the hydrodynamic conditions of the dredging site, the type of dredge used, operational methods, and sediment type. Because coarser-grained sediment particles have a greater fall velocity, they settle out more quickly than silt and fine-grained sand particles, which typically comprise the suspended sediment plume downstream of the dredge. The USACE and others have conducted various studies to examine the magnitude of suspended sediment and TSS, as well as dissipation rates and plume lengths under a variety of conditions to estimate maximum anticipated impacts from dredging (Anchor Environmental 2003; Clarke et al. 2000; Collins 1995; Herbich et al. 1991; USACE 1988, 1986).

Table 4.5-1 contains a summary of the plume length from dredging in the LOMR and suspended solid concentrations downstream of the dredge head. USACE sampling of in situ suspended solids below a cutter-head dredge in the LOMR near the confluence of the Kansas and Missouri Rivers indicated that suspended solid concentrations returned to background concentrations within approximately 1,300 feet (Table 4.5-1) (USACE 1990). Sediment resuspension and the associated increase in suspended solids for cutter-head dredges is primarily limited to the lower portion of the water column (USACE 1988). Overflow discharges, similar to hopper dredge overflow, is typically distributed throughout the water column. The maximum suspended solid concentrations at and downstream of the hydraulic dredge head have been evaluated in multiple studies and, as discussed above, the suspended solid plume at the hydraulic dredge head can be determined by multiple operational and hydrological factors.

As discussed in Section 3.7, the USACE reported that, based on studies conducted in the James River in Virginia and the Savannah River in Georgia, the cutter-head dredge removed bed sediment with a relatively small amount of suspended sediment extending beyond the immediate vicinity of the dredge (USACE 1986). The study showed that a cutter-head dredge produced between 25 and 250 mg/l of suspended solids above background levels within 100 feet of the dredge and that the quantity of suspended solids decreased to between 10 and 150 mg/l within 400 feet of the dredge (USACE 1986). Note that suction-head dredges produce substantially lower levels of suspended sediment compared to cutter-head dredges because cutter-head dredges extract glacial deposits that are not part of the base load. Therefore, suspended sediment plumes in areas dredged with suction-head dredges that remove only sediment base load would be lower than the values reported in Table 4.5-1. The potential to suspend contaminants contained in the sediment or elutriate water is discussed under "Contaminants."

Table 4.5-1 Summary of Reported Suspended Solid Levels in the Lower Missouri River and Typical Suspended Solids Plume Concentration and Extent

Segment	Maximum Total Suspended Solids Measured (mg/l)[a]	Minimum Total Suspended Solids Measured (mg/l)[a]	Suspended Solids Concentration above Background at 100 Feet from Dredge Head[b] (mg/l)	Suspended Solids Concentration above Background at 400 Feet from Dredge Head[b] (mg/l)	Average Elevated Suspended Solids Plume Length in the LOMR[c] (feet)
St. Joseph	1,161.7	76.7	25 – 250	10 – 150	1,300
Kansas City	434.7	94.8	25 – 250	10 – 150	1,300
Waverly	232.5	91.9	25 – 250	10 – 150	1,300
Jefferson City	362.1	79.8	25 – 250	10 – 150	1,300
St. Charles	655.8	61.4	25 – 250	10 – 150	1,300

Note: mg/l = Milligrams per liter.

[a] Obtained from grab samples during summer 2004, 2005, and 2006 at various locations along the river segments (USEPA 2009).

[b] Suspended solid concentrations above background levels at the lower portion of the water column (USACE 1986).

[c] Average extent of elevated suspended solids concentration downstream of hydraulic dredging in the LOMR (USACE 1990).

Table 4.5-1 also contains the maximum and minimum total suspended solids levels found in grab samples collected during summer months between 2004 and 2006 from various sampling sites located along each river segment (USEPA 2009). Maximum suspended sediment levels would likely occur during high runoff periods, such as during the spring snowmelt. Variation between the maximum and

minimum suspended solids concentrations recorded at the USEPA grab sample sites exceeded the upper limit of the predicted suspended sediment levels in the plume downstream of dredging. Because natural suspended sediment variations in the LOMR have been documented as exceeding the average predicted suspended sediment levels at 100 and 400 feet from the dredge head, it is likely that dredging operations would not likely result in a significant change in suspended sediment concentrations, compared to natural variation. While dredging would result in elevated suspended sediment concentrations along the suspended sediment plume during periods of low background suspended sediment levels, the levels of suspended sediments from dredging would not likely exceed levels that occur naturally during high runoff events, such as during snowmelts.

As discussed in Section 3.7, state water quality standards for turbidity and suspended sediment in the LOMR are largely qualitative, and it is important to note that sediment levels in the LOMR have decreased substantially from historical levels due to the installation of dams and the associated flow modifications, bank stabilization, and the design of the navigation channel. Any suspended sediment from the hydraulic dredge head would be limited to the bottom of the water column. Large-particle sediments from the dredge discharges would quickly settle to the bottom of the LOMR; and the fine sediments discharged, depending upon background levels at the time of discharge, may contrast with receiving waters. But fine sediment discharge would likely not be of sufficient quantity to differ substantially from the maximum natural suspended sediment levels in receiving waters.

All Segments

Under the Proposed Action, the number of areas subject to localized, short-term increases in suspended sediment would substantially increase (an approximately 93-percent increase) relative to existing levels produced during dredging. Depending on the duration, location, and timing of dredging activities—in conjunction with conditions that determine plume length, elevated suspended sediment plumes downstream of the dredging sites could spatially and temporally overlap. This would likely occur only in those river segments where different companies would be simultaneously dredging (the Waverly, Jefferson City, and St. Charles segments). The Dredgers have indicated that, typically, dredges would maintain a distance of approximately 3,000 feet from other dredges. Because the typical sediment plume would extend approximately 1,300 feet downstream of the dredge, overlap of sediment plumes would be unlikely under typical conditions.

The Proposed Action would increase the number of areas with short-term elevated suspended sediment plumes at and downstream of dredging sites in the St. Joseph, Kansas City, Waverly, Jefferson City, and St. Charles segments. Suction dredges that extract only bed load, opposed to

cutter-head dredges that cut into glacial deposits, typically produce less sediment suspension at the dredge head (Herbich et al. 1991). Therefore, increased dredging in segments where cutter-head dredges extend into the glacial deposits would experience larger suspended sediment plumes at the dredge head under the Proposed Action. Because of the background suspended sediment levels in the LOMR and the localized nature of the suspended sediment from dredging, any increase in suspended sediment levels from dredging would not result in a long-term change in overall water quality in the segment or the LOMR.

As discussed in Section 4.2, the portions of the LOMR subject to river bed degradation would contribute to continued or increased tributary headcutting, which would add sediment to the LOMR. This indirect effect largely would not occur in those portions of the LOMR where the river bed was stable, aggrading, or only slightly degrading. Under the Proposed Action, tributary degradation and associated headcutting would likely increase or remain at current levels in all river segments, which would result in long-term continued or increased rates of sediment delivery.

Kansas City and St. Charles Segments

An additional indirect impact under the Proposed Action would be land disturbance from construction of the Edward N. Rau Contractor Company and The Master's Dredging Company, Inc. sand plants. Clearing and grading associated with construction of these facilities could result in soil erosion, which could be delivered to adjacent water resources via storm water. Construction of these sand plants would likely require NPDES permitting, which would minimize the potential impacts of these plants on surface water resources.

Alternate Sources

No alternate sources would be required under the Proposed Action; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily suspend sediment. Further, no increased upland, floodplain, or instream mining would result in increased sediment runoff via storm water.

4.5.3.2 Contaminants

Under the Proposed Action, dredging would increase, which would increase the potential for local suspended sediment and contaminants in pore water (water contained in the spaces between sediment grains). Background sediment contamination in the LOMR is likely, but the degree of contamination has not been extensively documented (Jacobson, Blevins, and Bitner 2008). Some studies have indicated various levels of pesticides and metal concentrations in sediments at various locations in the

LOMR (Jacobson, Blevins, and Bitner 2008; Poulton et al. 2005; Echols et al. 2008). As noted under "Suspended Sediment," dredging under the Proposed Action would increase the number of localized areas where sediment at and downstream of the dredging site would be temporarily suspended. Contaminants may be released into the water column in particulate or dissolved form from suspended sediment (USEPA 1996). The degree of potential desorption and dispersal of interstitial pore water would depend on the concentration and properties of the suspended contaminant and site-specific conditions. Many strongly adsorbed contaminants, including hydrophobic organics (such as PCBs) and some inorganic species, tend to remain strongly adsorbed to sediments even after mechanical resuspension into the water column from dredging (USACE 1988). Metal releases are more complex than hydrophobic organic species because of the presence of acid-volatile sulfides in the sediment (USEPA 1996). Acid-volatile sulfides typically interact with metals to render the metal biologically immobile by reacting with the metal to form a highly insoluble and stable sulfide. In general, metals concentrations sampled along the LOMR were not remarkably elevated, and the acid-volatile sulfide values suggest a low potential for toxicity from suspended sediments containing these metals (Poulton et al. 2005).

In support of the L-385 Levee project, the USACE conducted testing to determine the area required for dilution of dissolved contaminants released from sediment disturbance and the distance required for the settling of suspended materials (USACE 1990). The study found that some contaminant sample concentrations exceeded receiving water concentrations, but none exceeded the water quality standards in place at the time. Although elevated concentrations of contaminants were detected, the researchers concluded that the mixing would quickly reduce any elevated contaminant concentration to background levels, and dredging in sand bed sediments would not release significant levels of contaminants (USACE 1990).

The Missouri Clean Water Commission raised concerns about the water quality impacts associated with the addition of sediment (through shallow-water habitat creation projects) into the LOMR (MRRP 2007, Gossenauer 2009). Dredging will not introduce nutrients to the LOMR; however, like contaminants, this activity may suspend nutrients contained in benthic sediments. In response to the Missouri Clean Water Commission concerns, the USACE has commissioned the National Academy of Science to complete an independent assessment of the impacts of adding sediment, and associated nutrients, to the LOMR (MRRP 2007, Gossenauer 2009). The National Academy of Science report will be available in summer 2010.

As discussed in Section 3.7, the temporary resuspension of sediment during dredging is not likely to release nutrients into the LOMR water column. USACE testing of sediment, elutriate water, and river water in the LOMR in support of their shallow-water habitat creation program found that introduction of sediment into the LOMR did not result in exceedances of water quality standards for phosphorous or nitrogen (USACE 2007). Phosphorous typically adsorbs to fine sediment (Soballe 2009); therefore, phosphorous is not likely released in significant quantities during disturbance of sediments. Nitrogen is typically in a dissolved state and is only indirectly linked to sediment (Soballe 2009). Further, USACE testing has found that the total phosphorous concentration of elutriate water (measuring the potential release of water-soluble constituents from sediment to the water column) at five shallow-water habitat creation sites was approximately 66 percent lower than concentrations present in the river water (USACE 2007). The USACE indicated that this was most likely due to adsorption of phosphorous to the sediment. Likewise, it is likely that remobilized sediment adsorbs total phosphorous from the river water (Soballe 2009). The disturbance of sediment during dredging operations under the Proposed Action or any of the alternatives is not likely to greatly increase the nutrient load of the LOMR; therefore, dredging is not likely to substantially lower DO levels.

Jacobs et al. (2008) suggest that individual restoration projects that discharge sediment into the river would result in a minor localized effect, but these actions may contribute to a cumulative effect depending on the location and sequence of the projects. Potential cumulative impacts on water quality are discussed in Chapter 5. As discussed above, the Dredgers have indicated that dredges typically maintain a distance of approximately 3,000 feet from other dredges. Because the typical sediment plume and any associated contaminants would extend less than 1,300 feet downstream of the dredge, minimal—if any—overlap would be expected in sediment plumes that contain adsorbed contaminants under typical conditions. Further, due to the flow rates in the LOMR, any concentration of contaminants released to the water columns would be diluted to near background levels prior to reaching downstream dredging sites.

The current PCB and chlordane TMDL in the Missouri segments of the LOMR applies to the presence of PCBs and chlordane in fish tissues. The bioaccumulation of PCBs and chlordane in aquatic organisms (mainly bottom-feeding fish) is primarily driven by consumption or exposure to sediments containing these chemical constituents. The MDNR TMDL indicates that the presence of these compounds is “mainly a sediment issue and amounts in the water column are virtually non-detectable” (MDNR 2006a). Because the solubility of both of these contaminants is low, they would generally be prevented from reaching high concentrations in LOMR water. The Proposed Action could increase the number of areas where sediments with PCBs or chlordane adsorbed would be redistributed through the

water column, but the Proposed Action would not serve as a new source of these contaminants. In support of their shallow-water habitat creation program, the USACE tested sediment, elutriate water, and river water at five sites to determine the potential addition of multiple parameters (including PCBs and chlordane) from the addition of sediment from the program (USACE 2007). The USACE found that shallow-water habitat construction that resulted in the addition of sediment to the LOMR would not result in exceedances of Missouri State water quality standards. These results indicate that any increase in contaminant quantities released into the water column would be quickly diluted and would not likely be of sufficient quantity to exceed water quality standards.

All Segments

The Proposed Action would substantially increase (approximately by 93 percent) the number of localized areas with the potential for suspended sediment plumes. This would increase the chance of temporary resuspension of contaminants at and downstream of the dredging sites in all segments.

As discussed in Section 4.4, the number of vessels on the LOMR under the Proposed Action would increase, which would represent an approximate two-fold increase in the risk of a vessel incident that could result in an inadvertent spill or leak. According to USCG data, one reported incident on the LOMR in a dredged reach occurred during 2009 (USCG 2009). As a condition of the permits, Dredgers would be required to implement measures to prevent or control spilled fuels or lubricants from entering waters of the United States.

Alternate Sources

No alternate sources would be required under the Proposed Action; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily suspend sediment or increase the risk of vessel collision. Further, no increased upland, floodplain, or instream mining would result in contaminated storm water runoff.

4.5.3.3 Alluvial Aquifer Levels and Interactions

The hydraulic conductivity of the river bed material influences the interactions between the LOMR and groundwater (Kelly 1996), and the alluvial aquifer thickness is an important component of providing filtration for municipal collector wells. Alluvial aquifer materials near the river may function as filters for river-born particulate material and other contaminants from the river water, particularly for municipal groundwater collector wells (Christiansen 2004). In general, the relationship between the quality of groundwater that is extracted from collector wells and thickness of the alluvial material between surface

waters and collector wells is not well understood (Christiansen 2004). As discussed in Section 4.4, existing dredging may extend into glacial deposits that tend to consist of coarser and more densely packed sand compared to modern bed load deposits. Depending on the angle in which the dredge is lowered, sediment can be removed to about 30 feet below the surface of the river bed (see Section 4.4). Reintroduction of silt and fine-grained sand and cobble into these areas that previously contained a wider variety of substrate sizes would alter the hydraulic conductivity of the river bed and the subsequent groundwater recharge and filtration rates on a local, segment, or river-wide scale.

Because cobble is less readily mobilized, it would tend to accumulate over time in those locations that are subject to increased dredging as sand within the desired size range is removed from the river bed by dredging. 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 also can 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). While changes to sediment concentrations may result from dredging in the LOMR, data have not been collected in the LOMR to definitively characterize the dispersal patterns of fine-grained sand and silt or cobble after dredging.

Under the Proposed Action, the number of locations and the frequency of changing sediment composition at and downstream of the dredging sites could increase as dredging increased. The introduction of clay and fine sand in areas could serve to lower hydraulic conductivity, while the coarsening of substrate with cobble could serve to locally increase hydraulic conductivity.

The storage capacity of the alluvial aquifer is approximately 60 years, regardless of the LOMR river stage, as long as the alluvial aquifer was still hydraulically connected to the LOMR (Kelly 2010). While overall storage capacity or hydraulic connectivity on a river- or segment-wide scale would not be drastically affected by the variability in LOMR stage, alluvial aquifer elevations would change during prolonged drought periods when river stage is low.

Figure 4.5-1 depicts the LOMR stage at the USGS gage located near St. Joseph (gage number 06818000) and the MDNR groundwater observation well at St. Joseph (gage number 374254094524501) (USGS 2010a, 2010b). As shown in the figure, over prolonged drought periods (1987–1992 and 2000–2007), when river stage was lowered for extended periods, there was a corresponding decrease in groundwater levels during that time.

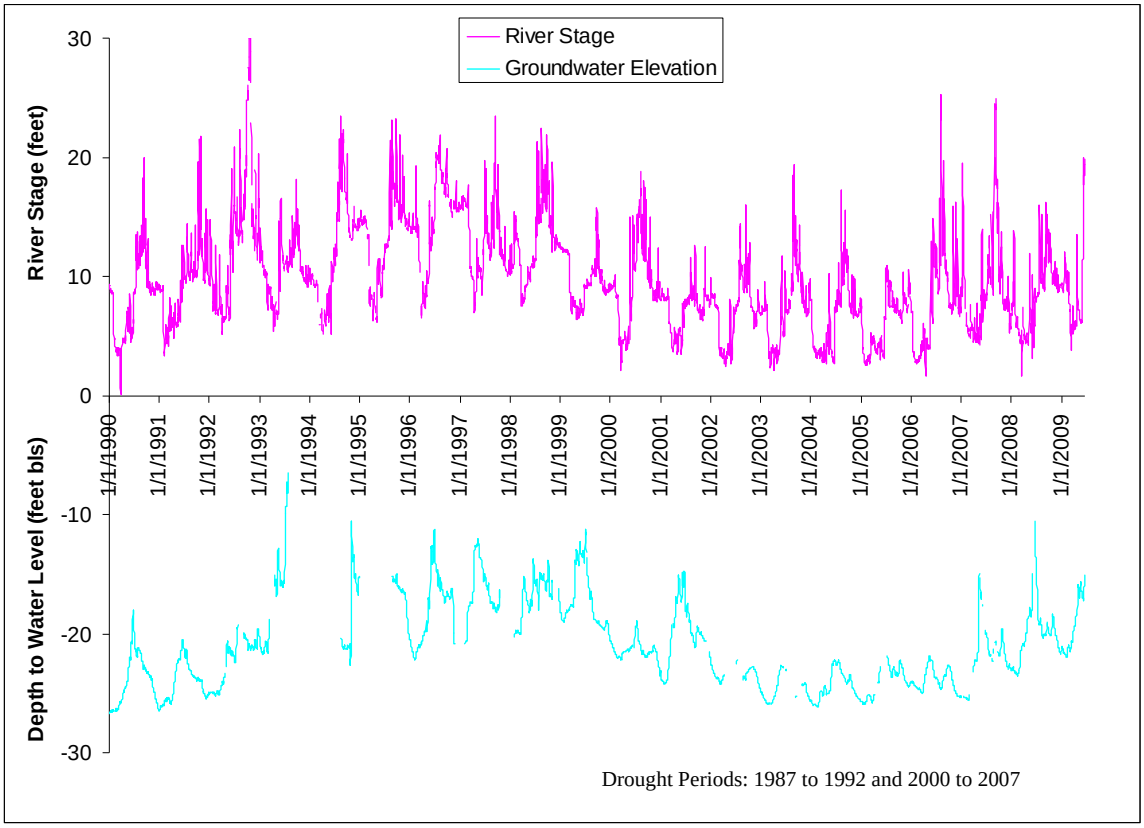

Figure 4.5-1. Groundwater Level and River Stage at St. Joseph

Sources: USGS 2010a, 2001b.

As discussed in Section 3.7, river channel elevation more acutely affects water levels at lower river flows. Therefore, the decreasing LOMR stage would track the rate of LOMR river bed degradation that, during low flows, would increase the depth to groundwater levels. The changes in aquifer levels at increasing distances from the LOMR are delayed after changes in stage of the LOMR, and the magnitude of the alluvial aquifer change is reduced with increasing distance from the LOMR (USACE 1998). Groundwater response to water pulse simulations indicated that small river stage changes over a short duration had a limited impact on groundwater levels; but larger, long-term river stage changes had a much greater impact on alluvial aquifer levels (Kelly 2000). Several conditions may alter groundwater interaction with river stage, including the hydraulic properties of the aquifer, well pumping rates, and the presence of drainage ditches and other water bodies.

Generally, groundwater levels mirror river stage, but at lesser magnitude (Lucey, Schapp, and Fischer 1999). For example, groundwater and LOMR stage monitoring near Nebraska City, Nebraska

(approximately 55 miles north of Rulo, Nebraska) found that an approximate 8-foot decrease in river stage during a 2-month-period in 1995 and 1996 resulted in an approximate 6.5-foot change in groundwater levels approximately 1,000 feet from the LOMR (in the floodplain) (Lucey, Schapp, and Fischer 1999). At a distance of approximately 5,000 feet from the LOMR, groundwater levels under the floodplain decreased approximately 3 feet; and at 10,000 feet from the LOMR, groundwater levels under the floodplain decreased approximately 1.5 feet during the same period. River stage changes between 1999 and 2000 at approximately RM 190 fluctuated approximately 21 feet, and groundwater levels at a floodplain well located approximately 2,200 feet from the LOMR fluctuated approximately 11 feet (USGS 2001).

Because groundwater levels generally mirror river stage (although in lesser magnitude), short-term river bed degradation would cause a slight change to groundwater levels at locations near the LOMR and little to no effect on groundwater levels at greater distances from the LOMR. A substantial long-term decrease in LOMR stage would likely result in a moderate to substantial impact on groundwater levels near the LOMR and moderate to slight impacts on groundwater levels farther from the LOMR, depending on the magnitude of changes in river stage.

Fluctuations in groundwater levels in the LOMR floodplain, particularly during prolonged reduced stage periods, may change the wetland hydroperiod and the related wetland vegetative community (Kelly 2000), especially in wetlands located near the LOMR channel. USGS studies conducted in Platte County, Missouri indicated that lowering the groundwater table by as little as 3 feet could make the study wetland drier and result in corresponding changes in vegetative and soil characteristics (Blevins 2004). Wetlands, including wetland hydrology, vegetation, and soils, are discussed further in Section 4.7.

All Segments

The Proposed Action could increase the deposit of silt, fine-grained sand, and cobble at and downstream of the dredging sites in all segments. This could locally change river bed hydraulic conductivity, which could result in a localized, minor impact on groundwater recharge rates in the short term.

Further, an increase in river bed degradation and the associated decrease in low-flow surface elevations would occur in all river segments under the Proposed Action. Depending on the magnitude of the river bed change, increased river bed degradation under the Proposed Action could result in a

short-term and long-term indirect effect on alluvial groundwater levels, particularly during prolonged dry periods.

Alternate Sources

No alternate sources would be required under the Proposed Action; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily change hydraulic connectivity. Further, any impacts to alluvial aquifers from any river bed degradation in these rivers may be alleviated. No increased upland, floodplain, or instream mining would result in contaminants entering near-surface groundwater resources.

4.5.4 No Action Alternative

Under the No Action Alternative, existing dredging would stop, and all of the direct consequences to water resources would not occur. Minor, localized improvements to surface water quality would be expected in the areas that had previously been dredged. River bed hydraulic conductivity would improve slightly, and groundwater levels in the alluvial aquifer would not be lowered during low-flow events.

4.5.4.1 Suspended Sediment and Contaminants

All Segments

The degree of the localized water quality improvements under the No Action Alternative would largely depend on the amount of dredging that had previously occurred. For example, local improvements in water quality in the Kansas City segment would be greater than those in the St. Joseph segment because of the greater amount of dredging historically in the Kansas City segment. No significant or river-wide improvements in water quality would occur under the No Action Alternative because of the localized effect of dredging on water quality.

Because the LOMR river bed could stabilize or aggrade under the No Action Alternative, tributary headcutting would halt. Indirect impacts from dredging-caused river bed degradation, such as added sediments from tributary headcuts, would be slowed or halted and would result in a minor improvement in the local water quality.

The No Action Alternative would result in no direct local impacts due to suspended sediment at or downstream of the dredge; therefore, no contaminated sediments or pore waters would be suspended. There would be a minor, localized improvement in water quality.

Alternate Sources

Dredging in the Kansas and Mississippi Rivers would result in similar water quality impacts as those occurring in the LOMR under existing conditions. Dredging in these rivers would result in localized suspended sediments and minor levels of contaminants at and downstream of the dredge site. Water quality impacts from dredging in these rivers would be considered and minimized through the USACE permitting process.

Indirect impacts from open-pit mines and instream mining would be caused by land disturbance, which could affect streams or other adjacent surface water resources. Land disturbance and discharge of process water could increase sediment runoff into adjacent water bodies. During mining operations, fuels, lubricants, or other hazardous materials could mobilize as runoff, leave the site, and affect adjacent streams. Storm water that may become contaminated with oil, grease, or other materials and process water used to wash sand or gravel also could be discharged to local waterways. Instream sand and gravel mining could result in alterations to the stream channel—including the possible formation of a wide, shallow channel with bank erosion, braided flows, and increased water temperatures—if the excavation is done improperly; and elimination of side channels, relocation of the thalweg, and increased mobilization of sediments could occur (Roell 1999).

4.5.4.2 Alluvial Aquifer Levels and Interactions

The response of the alluvial aquifer under the No Action Alternative would be closely related to the response of the LOMR river bed to the halt of dredging. In general, the No Action Alternative would result in no change in low-flow water surface water levels or a slight long-term increase in these levels. Because changes in river bed hydraulic conductivity are likely a relatively short-term impact under existing dredging, sediment composition would return to pre-dredging conditions under the No Action Alternative. No local changes to river bed hydraulic conductivity would occur in the long term.

All Segments

As discussed in Section 4.2, river bed degradation would likely stabilize and could potentially aggrade or increase in these segments under the No Action Alternative. Following this trend in river bed elevation, low-flow surface water elevations would not change or increase under the No Action Alternative. Groundwater levels closest to the LOMR would most likely respond to this stabilization or slight increase in river stage by remaining the same or slightly increasing during low-flow periods. This effect would be most likely in the portions of the alluvial aquifer closest to the LOMR.

Alternate Sources

Under the No Action Alternative, a variety of groundwater impacts could arise from extraction and mining of alternate sources to replace the quantity of sand and gravel currently dredged from the LOMR. The groundwater impacts from these alternate forms of extraction would depend on the type, land size, and quantity of material extracted for the operation.

Dredging in the Kansas and Mississippi Rivers would result in impacts similar to those in the Missouri River under the Proposed Action. Both rivers would experience minor, local changes in river bed hydraulic conductivity at dredging sites. The water levels in the Mississippi River Valley alluvial aquifer and alluvial aquifers from the Kansas River rise and fall in response to changes in stream water levels (Miller and Appel 1997, USACE 1990). The EIS for commercial dredging activities in the Kansas River indicated that degradation of the Kansas River channel had resulted in declining groundwater levels in the area (USACE 1990). No reports of current river bed degradation in the Mississippi River were identified during preparation of this document. Because both rivers are linked to alluvial aquifer systems, any river bed degradation as a result of dredging would result in corresponding long-term changes in the groundwater levels. The effects of dredging activities on groundwater resources would be evaluated, and conditions would be implemented to minimize effects (if necessary) during the USACE permitting process.

Water exposed during hydraulically excavated open-pit mining activities is essentially groundwater that becomes exposed to the surface during land-disturbing activities, removal of overburden, and dredging. The water contained in the lagoon formed by these operations is therefore connected to surficial groundwater resources. Any runoff of contaminated material, such as fuel, lubricants, or other chemicals, could contaminate groundwater resources. Excavation at instream sand and gravel mines typically occurs down to or near the top of the water table, which may approximate the water level in the adjacent stream. Potential impacts to groundwater from this mining method primarily include spills or leaks from the heavy equipment performing the excavation. Although risks of groundwater contamination would be less in upland open-pit mining areas, accidental spills and leaks of hazardous materials could enter groundwater resources at open-pit mines if spills occurred in highly permeable areas.

4.5.5 Alternative A

Alternative A would substantially decrease (approximately 68-percent from current levels) the localized sediment and contaminant effects on water quality from dredging compared to existing conditions. The

erosion and contamination effects related to alternate sand and gravel sources described for the No Action Alternative could occur, but at a lower rate. Indirect impacts to alluvial aquifer levels from decreased river stage during low-flow periods in currently degrading river segments could be reduced under Alternative A.

4.5.5.1 Suspended Sediment

Localized sediment suspension in the LOMR would decrease significantly under Alternative A. Suspended sediment levels at and downstream of the dredge sites would continue to be localized and would be elevated only in the short term (see Table 4.5-1). As described in Section 4.2, the rate of tributary headcutting would not increase in any of the river segments under this alternative, which would limit the addition of sediment from tributaries as a result of dredging.

St. Joseph Segment

Alternative A would result in an increase (approximately 7 percent from current levels) in the number of suspended sediment plumes at, and typically less than, 1,300 feet downstream of the dredging site in the St. Joseph segment. The number or frequency of areas with elevated suspended sediment would slightly increase. While the dredging effort would slightly increase, the relatively high natural background suspended sediment concentrations in the LOMR, combined with localized elevated suspended sediment plume length, would result in a minor, short-term increase in suspended sediment in this river segment under Alternative A.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Alternative A would decrease (between 26 and 79 percent of current dredging levels) the frequency or number of areas with suspended sediment plumes at and downstream of dredging sites in the Kansas City, Waverly, Jefferson City, and St. Charles segments. Overall, due to the local nature of dredging impacts on suspended sediment levels and the relatively high natural background sediment concentrations, Alternative A would result in a minor, short-term improvement in water quality in these segments.

Land disturbance from construction of the Edward N. Rau Contractor Company and The Master's Dredging Company sand plants could result in soil erosion, which could be delivered to adjacent water resources via storm water. Construction and operation of this plant would require adherence to relevant storm water permitting that would limit the potential addition of sediment to adjacent water bodies.

Alternate Sources

The water quality impacts from land disturbance at open-pit mine sites under Alternative A would be similar to those described for alternate sources under the No Action Alternative, but of less magnitude (an approximate 31-percent decrease compared to the No Action Alternative level). Extraction and mining of sand and gravel from alternate sources located in uplands, floodplains, or stream channels could discharge sediment into adjacent water resources via storm water during and after land disturbance. The magnitude of storm water runoff would depend on the location and amount of the land clearing. Dredging in the Mississippi and Kansas Rivers would result in local increases in suspended sediment at and downstream of the dredging sites.

4.5.5.2 Contaminants

Similar to the suspended sediment, an overall decrease in the potential for resuspension and redistribution of contaminated sediment in the LOMR would be expected under Alternative A. Because of the reduction in dredging, the number of vessels would decrease. Consequently, the risk of vessel incidents, including the potential for spills, leaks, and collisions, would decrease.

St. Joseph Segment

Alternative A would result in a slight, temporary increase in the amounts of contaminants that could be suspended. Any increase of contaminants in the water column would be quickly diluted and would not substantially affect overall water quality in the LOMR. The number of dredging vessels would increase slightly, with an accompanying slight increase in the risk of vessel incidents (including spills, leaks, and collisions) in the St. Joseph segment.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Alternative A would substantially decrease the local areas where contaminated sediments could be disturbed in these segments. This reduction could result in a minor, temporary improvement in water quality at a local level. The number of dredging vessels would decrease significantly; therefore, the risk of dredging vessel incidents (including spills, leaks, and collisions) in these segments would substantially decrease.

Alternate Sources

Water contamination from alternate sand and gravel sources would be delivered via mechanisms similar to those described for the No Action Alternative. Operation of upland, floodplain, and instream mines could result in dewatering, which could introduce contaminants to surface waters. Further,

contaminants remobilized in soils from land disturbance could be delivered to surface waters via erosion. Dredging in the Mississippi and Kansas Rivers could temporarily remobilize contaminants in the water column and redistribute contaminated sediments.

4.5.5.3 Alluvial Aquifer Levels and Interactions

Reduced dredging would occur under Alternative A, and the direct effects from dredging related to river bed hydraulic conductivity would generally be reduced in the river segments with less dredging.

Under Alternative A, the alluvial aquifer would continue to respond to river stage, regardless of the river bed elevation. Stabilization or aggradation of the river bed would result in a potential stabilization or increase in alluvial aquifer levels during dry periods.

St. Joseph Segment

In the St. Joseph segment, the deposit of silt, fine-grained sand, and cobble at and downstream of the dredging sites would slightly increase under Alternative A. This would result in a slight increase in the number or frequency of areas experiencing a local, short-term change in river bed hydraulic conductivity. Long-term low-flow surface water elevations would likely slightly decrease under Alternative A; therefore, groundwater levels closest to the LOMR would remain the same or slightly decrease during low flows. These effects on groundwater levels would decrease with increasing distance from the LOMR.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Alternative A would result in a significant decrease in dredging in the Kansas City, Waverly, Jefferson City, and St. Charles segments and in the number of locations or frequency in which silt, fine-grained sand, and cobble were deposited at the dredging sites. Sediment composition and the associated recharge rate could still be altered, as currently occurs, but the locations or frequency of alterations would be reduced.

River stages at low flows would likely stabilize or slightly decrease with the reduction of dredging under Alternative A. Groundwater levels closest to the LOMR would remain the same or would slightly decrease during low flows. The effects on groundwater levels would decrease with increasing distance from the LOMR.

Alternate Sources

Groundwater contamination associated with the use of alternate sources would be similar, but of lesser magnitude, to the description for the No Action Alternative. Dredging in the Mississippi and Kansas Rivers would have the potential to locally alter river bed hydraulic conductivity and could result in river bed degradation, with similar effects to connected groundwater levels as described for the LOMR. Operation of open-pit and floodplain mines could result in direct exposure of groundwater resources to the surface, which could serve as a pathway to introduce contaminants to aquifers.

4.5.6 Alternative B

Under Alternative B, the direct surface water and groundwater quality effects (suspended sediment, remobilization of contaminants, and alterations of hydraulic connectivity) of dredging would decrease. The alluvial aquifer would continue to respond to river stage, but the level of river bed degradation in each river segment would determine the magnitude of an increase in groundwater depth during dry periods. The potential water quality consequences from alternate sand and gravel sources would also occur, but with less potential impact than under the No Action Alternative or Alternative A.

4.5.6.1 Suspended Sediment

Temporary suspended sediment from the dredges would continue to occur in a localized area, but sediment plumes would be reduced. Tributary headcutting would continue in those areas with the most dredging, which would slightly increase tributary sediment added to most river segments under Alternative B.

St. Joseph Segment

The local areas with temporarily elevated suspended sediment plumes (typically up to 1,300 feet downstream of dredging sites) would increase (approximately 163 percent of existing dredging) under Alternative B. Because of the natural suspended sediment background concentrations in the LOMR, Alternative B would result in a minor, short-term increase in suspended sediment in these river segments. Tributary headcutting would continue in those areas with the most dredging, which would slightly increase tributary sediment added to the St. Joseph segment.

Waverly Segment

The local areas with temporarily elevated suspended sediment plumes (typically up to 1,300 feet downstream of dredging sites) would increase (approximately 68 percent from existing dredging) under

Alternative B. Because of the natural suspended sediment background concentrations in the LOMR, Alternative B would result in a minor, short-term increase in suspended sediment in the Waverly segment. The rate of tributary headcutting would not increase in the Waverly segment under this alternative, which would limit the addition of sediment from tributaries as a result of dredging.

Kansas City, Jefferson City, and St. Charles Segments

Alternative B would substantially decrease (between approximately 37 and 53 percent of current dredging) the number of local areas with suspended sediment plumes in the Kansas City, Jefferson City, and St. Charles segments. Overall, due to the local nature of dredging impacts on suspended sediment levels and the relatively high natural background sediment concentrations in the LOMR, Alternative B would result in a minor, short term improvement in water quality in these segments. Tributary headcutting would continue in those areas with the most dredging, which would slightly increase tributary sediment added to these river segments.

Land disturbance from construction of the Edward N. Rau Contractor Company and The Master's Dredging Company sand plants could result in soil erosion, which could be delivered to adjacent water resources via storm water. Construction and operation of this plant would require adherence to relevant storm water permitting that would limit the potential addition of sediment to adjacent water bodies.

Alternate Sources

The water quality impacts from land disturbance at open-pit and instream mine sites under Alternative B would be similar to those described for the No Action Alternative but of less magnitude (an approximate decrease of 73 percent compared to the No Action Alternative levels). Extraction and mining of sand and gravel from alternate sources in uplands, floodplains, or steam channels could result in sediment runoff to adjacent water resources via storm water during and after land disturbance. The magnitude of storm water runoff would depend on the location and amount of the land clearing. Dredging in the Mississippi and Kansas Rivers would result in local increases in suspended sediment at and downstream of the dredging sites.

4.5.6.2 Contaminants

The potential for resuspension and remobilization of contaminated sediment in the LOMR would decrease under Alternative B. The decrease in dredging-related vessels on the LOMR would reduce the risk of vessel incidents.

St. Joseph and Waverly Segments

Although the number of areas in the St. Joseph and Waverly segments with contaminants temporarily suspended would increase under Alternative B, any increase in contaminant resuspension in the water column would likely be quickly diluted and minor. Dredging vessels would increase slightly, accompanied by a slightly increased risk of vessel incidents. Overall, the increased dredging in these segments could result in added contaminants, but due to quick dilution, any elevated contaminant levels would return quickly to background levels.

Kansas City, Jefferson City, and St. Charles Segments

The frequency and number of local areas in the Kansas City, Jefferson City, and St. Charles segments where contaminated sediments could be disturbed and remobilized into the water column would substantially decrease under Alternative B. A minor, temporary improvement in water quality would occur at previous dredge sites. The number of dredging vessels would decrease; therefore, the risk of spills, leaks, and collisions from dredging vessel incidents would substantially decrease. Because of contaminant properties in the LOMR and the quick dilution rate, a minor, short-term improvement in the concentration of contaminants in the water column would occur under Alternative B in these segments.

Alternate Sources

Increased dredging in the Mississippi and Kansas Rivers could temporarily suspend contaminated sediments and pore water to the water column. Operation of upland, floodplain, and instream mines could result in pit dewatering, which could serve as a pathway for contaminants to be added to nearby surface waters.

4.5.6.3 Alluvial Aquifer Levels and Interactions

River bed hydraulic conductivity would continue to be slightly altered for a short period in those locations subject to dredging. Dredging under Alternative B would result in river segments undergoing at least a slight decline in river stage, which may affect groundwater levels during low-flow periods.

All Segments

Because groundwater levels generally mirror river stage (but of lesser magnitude), in the short term, river bed degradation would result in a slight to moderate change in groundwater levels at locations near the LOMR. The effects of river bed degradation on groundwater levels at greater distances from the LOMR could range from no effect to a moderate change in the depth to groundwater during low-

flow periods. Low-flow river stages likely would decrease in all segments under Alternative B, which would affect the depth to the alluvial aquifer during low-flow periods.

The St. Joseph, Kansas City, and St. Charles segments would experience a slight to moderate decrease in river stage over the long term, which would likely result in a slight change in the depth to groundwater during low-flow periods near the LOMR and little impact on groundwater levels farther from the LOMR. Slight long-term declines in low-flow surface water levels in the Waverly and Jefferson City segments would likely have a slight effect on alluvial aquifer levels near the LOMR and no effect on aquifer levels farther from the river channel.

St. Joseph and Waverly Segments

The deposit of coarse sediment at and downstream of the dredging sites in the St. Joseph and Waverly segments would increase under Alternative B. This impact would be more pronounced in the St. Joseph segment where the rate of dredging would likely increase more substantially. This would result in an increase in the number or frequency of areas experiencing a local, short-term change in river bed hydraulic conductivity.

Kansas City, Jefferson City, and St. Charles Segment

The number of locations and the frequency in which silt, fine-grained sand, and cobble sediment at the dredging sites would be deposited would substantially decrease in these segments under Alternative B. Sediment composition and the associated recharge rate would still be altered, but the locations and frequency of the alterations would be reduced.

Alternate Sources

Potential impacts on groundwater resources from extraction and mining of sand and gravel from alternate sources include the increased risk of contamination of groundwater from mining activities that penetrate aquifers. Further, instream dredging in the Kansas River could result in increased river bed degradation and an associated decrease in river stage that may impact the Kansas River alluvial aquifer.

4.5.7 Alternative C

The quantity of material dredged from the LOMR, compared to existing levels of dredging, would not change under Alternative C. Direct and indirect impacts to groundwater resources associated with dredging in the LOMR would continue at levels similar to those currently occurring. Because no

alternate sources of sand and gravel would be required, no impacts from extraction and mining of alternate sources would occur under this alternative.

4.5.7.1 Suspended Sediment

All Segments

Under Alternative C, the locations and frequency of elevated suspended sediment plumes downstream of dredging would be similar to those currently occurring in the LOMR. The quantity and degree of dredging activity would not change substantially under Alternative C; therefore, the rate of tributary headcutting that would deliver sediment to the LOMR would not change. Tributary degradation and associated headcutting would likely continue in those areas with the most dredging, which would slightly increase the quantities of sediment delivered to the LOMR via the tributaries.

Kansas City Segment

Land disturbance from construction of The Master's Dredging Company sand plant could result in soil erosion, which could be delivered to adjacent water resources via storm water. Construction and operation of this sand plant would require adherence to relevant storm water permitting that would limit the potential addition of sediment to adjacent water bodies.

St. Charles Segment

Land disturbance from construction of the Edward N. Rau Contractor Company sand plant could result in soil erosion, which could be delivered to adjacent water resources via storm water. Construction and operation of this sand plant would require adherence to relevant storm water permitting that would limit the potential addition of sediment to adjacent water bodies.

Alternate Sources

No alternate sources would be required under Alternative C; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily suspend sediment. Further, no increased upland, floodplain, or instream mining would result in increased sediment runoff via storm water.

4.5.7.2 Contaminants

All Segments

Under Alternative C, dredging would continue to temporarily suspend contaminated sediment and pore water in the water column at a rate similar to the baseline condition. Dredging vessel numbers would remain the same; therefore, the risk of dredging vessel incidents would not change.

Alternate Sources

No alternate sources would be required under Alternative C; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily suspend contaminants or increase the risk of vessel collisions. Further, no increased upland, floodplain, or instream mining would result in contaminated storm water runoff.

4.5.7.3 Alluvial Aquifer Levels and Interactions

The locations and frequency of areas subject to dredging may change slightly under Alternative C, but dredging would result in similar short-term disturbance to river bed hydraulic connectivity in all segments.

St. Joseph and St. Charles Segments

Slight to moderate long-term declines in low-flow surface water levels in the St. Joseph and St. Charles segments under Alternative C would likely have a slight effect on alluvial aquifer levels near the LOMR and no effect on aquifer levels farther from the river channel.

Kansas City and Jefferson City Segments

A slight to moderate decrease in river stage over the short term and a moderate to substantial decrease over the long term would likely affect alluvial aquifer levels near the Kansas City and Jefferson City segments under Alternative C. Alluvial aquifer levels near the LOMR most likely would substantially decrease during low-flow periods, and these effects would decrease as distance from the LOMR increases.

Waverly Segment

The Waverly segment would not experience a significant change in alluvial aquifer levels under Alternative C.

Alternate Sources

No alternate sources would be required under Alternative C; therefore, dredging in the Kansas or Mississippi Rivers would not temporarily change hydraulic connectivity. Further, any impacts to alluvial aquifers from any bed degradation in these rivers may be alleviated. No increased upland, floodplain, or instream mining would result in contaminants entering near surface groundwater resources.

4.5.8 Summary of Impacts

Table 4.5-2 contains a summary of potential impacts on water resources for the Proposed Action and alternatives.

4.5.9 References

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Table 4.5-2 Summary of Potential Impacts on Water Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Surface water – suspended sediment	• Substantial increase in localized, short-term suspended sediment plumes at and downstream of the dredging site. • Increased suspended sediment delivered to the LOMR via tributaries. • Temporarily increased erosion delivered to surface waters from sand plant construction. • No impacts from extraction and mining of sand and gravel from alternate sources.	• Reduction in localized, short-term suspended sediment plumes at and downstream of dredging sites in the LOMR. • Reduced suspended sediment delivered to the LOMR via tributaries. • Increase in localized, short-term suspended sediment plumes at and downstream of dredging sites in the Mississippi and Kansas Rivers. • Increased erosion delivered to adjacent surface waters via storm water runoff at mines.	• Reduction in localized, short-term suspended sediment plumes at and downstream of dredging sites in the LOMR. • Reduced suspended sediment delivered to the LOMR via tributaries. • Temporarily increased erosion delivered to surface waters from sand plant construction. • Increase in localized, short-term suspended sediment plumes at and downstream of the dredging site in the Mississippi and Kansas Rivers. • Increased erosion delivered to adjacent surface waters via storm water runoff at mines.	• Reduction in localized, short-term suspended sediment plumes at and downstream of dredging sites in the LOMR. • Reduced suspended sediment delivered to the LOMR via tributaries. • Temporarily increased erosion delivered to surface waters from sand plant construction. • Increase in localized, short-term suspended sediment plumes at and downstream of the dredging site in the Mississippi and Kansas Rivers. • Increased erosion delivered to adjacent surface waters via storm water runoff at mines.	• Similar direct impacts in localized, short-term suspended sediment plumes at and downstream of dredging sites in the LOMR. • Continued levels of suspended sediment delivered to the LOMR via tributaries. • No impacts from extraction and mining of sand and gravel from alternate sources.

Table 4.5-2 Summary of Potential Impacts on Water Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Surface water – contaminants	• Increase in disturbance of contaminated sediments in the LOMR. • Increase in risk of vessel collision or inadvertent release of contaminants in the LOMR.	• No disturbance of contaminated sediments in the LOMR. • No risk of vessel collision or inadvertent release of contaminants in the LOMR. • Increase in disturbance of contaminated sediments in the Mississippi and Kansas Rivers. • Increase in potential for contaminants added to surface water via open-pit dewatering.	• Considerable reduction in disturbance of contaminated sediments in the LOMR. • Decrease in risk of vessel collision or inadvertent release of contaminants in the LOMR. • Increase in disturbance of contaminated sediments in the Mississippi and Kansas Rivers. • Increase in potential for contaminants added to surface water via open-pit dewatering.	• Considerable reduction in disturbance of contaminated sediments in the LOMR. • Decrease in risk of vessel collision or inadvertent release of contaminants in the LOMR. • Increase in disturbance of contaminated sediments in the Mississippi and Kansas Rivers. • Increase in potential for contaminants added to surface water via open-pit dewatering.	• Similar disturbance of contaminated sediments in the LOMR. • Similar risk of vessel collision or inadvertent release of contaminants in the LOMR. • No impacts from extraction and mining of sand and gravel from alternate sources.

Table 4.5-2 Summary of Potential Impacts on Water Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Groundwater – alluvial aquifer levels and interactions	• Substantial increase in localized, short-term changes in LOMR river bed hydraulic conductivity at and downstream of the dredging site. • Decrease in LOMR alluvial groundwater levels where river bed degradation lowers LOMR stage over prolonged periods. • No impacts from extraction and mining of sand and gravel from alternate sources.	• No short-term changes in LOMR river bed hydraulic conductivity at or downstream of the dredging site. • Increase in or stabilization of LOMR groundwater levels during low-flow periods. • Potential decrease in Mississippi and Kansas River alluvial aquifers if river bed degradation occurs. • Potential increase in contaminants added to groundwater from extraction and mining of sand and gravel from alternate sources.	• Reduction in localized, short-term changes in LOMR river bed hydraulic conductivity at and downstream of the dredging site. • Increase in or stabilization of LOMR groundwater levels during low-flow periods. • Potential decrease in Mississippi and Kansas River alluvial aquifers if river bed degradation occurs. • Potential increase in contaminants added to groundwater from extraction and mining of sand and gravel from alternate sources.	• Reduction in localized, short-term changes in LOMR river bed hydraulic conductivity at and downstream of the dredging site. • Increase in or stabilization of LOMR groundwater levels during low-flow periods. • Potential decrease in Mississippi and Kansas River alluvial aquifers if river bed degradation occurs. • Potential increase in contaminants added to groundwater from extraction and mining of sand and gravel from alternate sources.	• Continuation of direct impacts of localized, short-term changes in LOMR river bed hydraulic conductivity at or downstream of the dredging site. • Decrease in alluvial groundwater levels where river bed degradation lowers LOMR stage over prolonged periods. • Potential decrease in Mississippi and Kansas River alluvial aquifers if river bed degradation occurs. • No impacts from extraction and mining of sand and gravel from alternate sources.

Notes:

LOMR = Lower Missouri River.
NPDES = National Pollutant Discharge Elimination System.
USACE = U.S. Army Corps of Engineers.

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4.6 AQUATIC RESOURCES

4.6.1 Introduction

The aquatic resources impact analysis addresses direct and indirect consequences to the quality and quantity of aquatic habitats and organisms resulting from dredging. The analysis provides the basis for understanding the extent, duration, and degree of impact from dredging under the Proposed Action and the alternatives.

Dredging directly affects fish and benthic invertebrates by capturing and removing aquatic organisms via the dredge head or dredging vessel propeller (entrainment), causing injury or mortality. Dredging also may cause behavioral changes of aquatic organisms because of dredging noise and physical habitat disturbance. Potential indirect effects include changes to aquatic habitats due to river bed degradation. Direct impacts would be limited to the period during or shortly after dredging and typically would be localized and temporary. Indirect impacts could occur in localized areas or river-wide and could extend in time from short term (approximately 5 years) to long term (approximately 20 years).

The potential effects of dredging on aquatic resources were evaluated for both aquatic habitat and species. For the purpose of this analysis, it is important to note that there still is uncertainty regarding aquatic species habitats, distribution, and their response to dredging in the LOMR. Aquatic resource impacts would be linked to changes in water quality (Section 4.5) and geomorphology (Section 4.2). Water quality impacts that could affect individuals include potential temporary elevated levels of suspended sediment. Geomorphic impacts that could affect aquatic habitat include changes in river bed elevation and the associated changes in water surface elevations.

4.6.2 Potential Impacts on Aquatic Habitat

In addition to direct habitat disturbance from dredging, potential indirect impacts to aquatic habitat—particularly shallow-water habitat—may be associated with river bed degradation (USACE 2009). These indirect impacts to aquatic habitat also could result from potential geomorphic changes that alter shallow-water connectivity due to changes in surface water levels. Data have not been collected documenting the quantity of shallow-water habitat present in the LOMR, or the potential quantity of shallow-water habitat that would be lost or gained due to river bed degradation (USACE 2009); therefore, the potential dredging-related effects of dredging and river bed degradation cannot be fully quantified at this time.

4.6.2.1 Direct Alteration of Habitat

As discussed in Section 3.4, the main channel benthic habitat of the LOMR is a dynamic system in which the bed load and associated benthic habitats often are changing. Benthic fish use habitats in and adjacent to main channels, where dredging is primarily concentrated, with environmental conditions that can include bed load sediment transport and high near-bed flow velocities (Hurley et al. 2004). Macroinvertebrate density and diversity increase with sediment stability, decreased water velocities, and increasing silt and organic matter (Galat et al. 2005); therefore, macroinvertebrate diversity and density are likely to be reduced in the channelized LOMR main channel, compared to unchannelized and shallow-water habitats. Further, these species are typically found on hard substrates, opposed to shifting sand substrates (such as in those areas where dredging occurs [Galat et al. 2005]).

The magnitude and duration of direct impacts on aquatic habitat at the dredge site would be determined by the time required for recovery and repopulation of the benthic areas (USACE 1978). Typically, the more naturally variable an aquatic habitat, the less the direct effect of dredging on that habitat (USACE 1978). Aquatic organisms common to these naturally variable areas are adapted to unstable sediment conditions and can better withstand the stresses imposed by dredging (USACE 1978). Thus, due to the high level of variability in the benthic habitats in the LOMR, aquatic species present in these habitats are likely be better able to withstand and recover from the localized alteration of benthic habitat due to dredging. Current dredging is largely restricted, and is likely to be restricted under the new permits, from shallow-water habitat (as discussed in Section 4.6.2.2), in side channel areas, at tributary junctions, and near dikes and revetments. The maintenance and establishment of these chutes and side channel areas that mimic historical depth and velocity patterns in the LOMR would assist in the restoration and maintenance of native fish communities (Latka, Nestler, and Hesse 1993).

Many areas of coarse aggregate sediments (e.g., cobble and bedrock) that substrate-spawning species (e.g., sturgeon and sauger) are known to use are found on outside bends that are constantly flushed free of fine sediment (DeLonay et al. 2009). As discussed in Chapter 2, multiple dredging exclusion areas have been established for recent dredging activities, and these exclusion areas are likely to be continued under future dredging actions (if approved), to protect course aggregate sediments. Laustrup, Jacobson, and Simpkins (2007) surveyed the LOMR during low water conditions to identify and map coarse substrate deposits and bedrock exposures. These particular areas likely would serve as coarse aggregate spawner habitat, although preferred spawning habitat for various species has not been definitively identified in the LOMR (Laustrup, Jacobson, and Simpkins 2007). A GIS coverage of the locations of aggregate areas was overlain with the dredge areas (assuming that future dredging

under all alternatives [except the No Action Alternative] would occur in the vicinity of historically dredged areas) to estimate the quantity of dredging that would occur in areas containing potential spawning habitat. Approximately 219 acres of aggregate were identified in the Project area between Rulo, Nebraska and St. Louis, Missouri. Of this quantity, a small amount (approximately 0.4 percent [0.8 acre]) of potential aggregate spawning habitat was found to be potentially subject to dredging. This would represent a small quantity of the mapped aggregate habitat in the Project area.

Dredging also can result in short-term and long-term changes to benthic substrate composition downstream of dredging sites. Alterations of benthic substrate can diversify local benthic habitats. As dredging removes sand and gravel, coarser-grained material is returned to the river bed (see Section 4.2). 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 also can 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); they can result in a localized alteration of benthic habitat used by aquatic species. Changes to benthic sediment and the associated aquatic habitats can result from dredging in the LOMR; however, data have not been collected in the LOMR to definitively characterize the dispersal patterns of coarse-grained sediment after dredging or determine how areas with altered sediment concentrations are used by aquatic species.

4.6.2.2 Indirect Alteration of Shallow-Water Habitat Abundance

Riverine habitat loss or alteration in the LOMR has been implicated in the loss of several native Missouri River fishes (Johnson, Jacobson, and DeLonay 2006). Many of the resource management and restoration plans currently in place identify and attempt to mediate processes that operate both at the coarse scale (e.g., land use and flow modification) and at finer scales (e.g., localized habitat restoration and connection to the floodplain) (Pegg and Taylor 2007).

As discussed in Section 3.8, shallow-water habitat 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 (Jacobson, Blevins, and Bitner 2008; Johnson, Jacobson, and DeLonay 2006; Hesse et al. 1993, 1989; Galat et al. 2005). Shallow-water habitat is recognized as a highly underrepresented aquatic habitat type that was characteristic of the historic Missouri River (USACE 2010). Historical changes, such as flow alterations and channelization of the LOMR, likely have substantially decreased the availability of shallow, slow-moving water (Johnson, Jacobson, and

DeLonay 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 shallow-water habitat 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, have not been developed (Johnson, Jacobson, and DeLonay 2006).

The *USFWS 2003 Amendment to the 2000 Biological Opinion on the Operation of the Missouri River Mainstem Reservoir System Operation and Maintenance of the Missouri River Bank Stabilization and Navigation Project and Operation of the Kansas River Reservoir System* (2003 Biological Opinion) (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 adversely affects pallid sturgeon habitat development and maintenance (USFWS 2003). Further, USFWS has stated that larval and juvenile pallid sturgeon are limited by the quantity of shallow-water habitat that provides rearing and refugia habitat (USFWS 2003). "Shallow-water habitat" is 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). A recent clarification to the definition further defines shallow-water habitat as habitat with a high degree of diversity in depths and velocity that contains dynamic alluvial processes. While the USFWS in the 2003 Biological Opinion concluded that pallid sturgeon are limited by the lack of shallow-water habitat, 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).

As discussed in Section 3.4, river flows and the corresponding river stage fluctuates daily, seasonally, and annually. Within the highly modified LOMR, the presence of shallow-water habitat is highly sensitive to flow regime (Johnson, Jacobson, and DeLonay 2006). Availability of shallow-water habitat is 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 flows and stages change, the quantity of aquatic habitat with shallow-water and slow velocities changes. Additional studies are required to identify the quantity and location of shallow-water habitat in the LOMR.

The LOMR is managed for shallow-water habitat, and several programs have been implemented (such as the MRRP) to create shallow-water habitat through mechanical techniques and LOMR flow

modification (MRRP 2007). The 2003 Biological Opinion (USFWS 2003) established a goal of 30 acres of shallow-water habitat per mile for the LOMR and estimated a shallow-water habitat acreage deficiency of approximately 20,000 acres. The 2003 Biological Opinion further requires the USACE to construct and have in place 20–30 acres of shallow-water habitat per mile in the LOMR by 2020. This additional shallow-water habitat is to be constructed in river reaches without 20–30 acres of shallow-water habitat (USFWS 2003). Shallow-water habitat is being created by a variety of mechanisms, including excavation of side channel chutes, dike notching, bank notching, and construction of chevrons (Jacobson, Johnson, and Dietsch 2009).

As discussed above, the 2003 Biological Opinion indicated that the LOMR is lacking sediment transport and sediment availability (USFWS 2003). Creation and maintenance of shallow-water habitat are brought about by sediment transport and deposition, which has been reduced (USFWS 2003). As sediment is removed from active transport, the river erodes material from the river bed downriver from the dredged area to replace the material removed from active transport (see Section 3.4). Hesse et al. (1989) suggest that restoration of sediment flow into the free-flowing portions of the Missouri River below dams may contribute organic matter to downstream habitats.

River bed degradation also can alter the quantity of shallow-water habitat in the LOMR (USACE 2009). River bed degradation can worsen the adverse biologic impacts of channelization by reducing the amount of shallow-water habitat available for primary production of plankton and invertebrates, and fish spawning and nursery areas (USACE 2009). Hesse et al. (1989) indicated that river bed degradation in the free-flowing portions of the Missouri River eliminated many backwater and subsidiary channels. Continued riverbed degradation could affect the long-term stability and functioning of shallow-water habitat restored by the MRRP (USACE 2009). As described above, for some of the river located outside of the navigation channel, depths are greater than 5 feet in August. Therefore, the low-flow water surface elevations caused by river bed degradation could expose some shallow-water habitat, while shallow-water habitat in other areas could be created. Although this response of shallow-water habitat to alterations of surface water flow may be occurring, it is important to note that these effects cannot be quantified at this time, and that additional studies are needed to fully determine and quantify the impacts of river bed degradation on shallow-water habitat (USACE 2009).

Potential river bed degradation, in conjunction with the removal of potential shallow-water habitat forming base load sediments, may change the quantity and distribution of natural or created shallow-water habitat in the LOMR. In those river segments with increased dredging-related river bed degradation, the quantity of natural or created shallow-water habitat could decrease because of river

bed modification. However, because the rate of erosion of natural and created shallow-water habitat from river bed degradation is not known at this time, the expected rate of erosion of these habitats due to the Proposed Action or Alternative A, B, or C cannot be determined.

4.6.2.3 Sand Plant Construction

Sand plant construction under the Proposed Action and Alternatives A, B, and C will require land-clearing activities that could result in overland runoff or erosion from uncontained storm water. In general, the potential introduction of contaminants to adjacent water bodies could result in changes in holding, feeding, or migratory behavior of fish (Kondolf 2006).

A bedrock patch on an outside meander bend is located approximately 1 mile downstream of The Master's Dredging Company proposed sand plant at Waldron. Fish using this potential spawning habitat may be exposed to elevated suspended sediment from storm water runoff during construction. However, elevated suspended sediment from sand plant construction is not anticipated to result in a substantial impact to this habitat due to its distance downstream from the proposed sand plant.

Overall, due to the best management practices and storm water permitting that would be required during construction of the proposed sand plants—in conjunction with the background flows and natural suspended sediment levels in the LOMR, sand plant construction is not anticipated to result in a significant impact to aquatic organisms or their habitats. Therefore, potential impacts associated with construction of sand plants are not evaluated further in this section.

4.6.3 Potential Impacts on Aquatic Species

Potential direct impacts on individual aquatic species include entrainment, alterations of habitat from increased turbidity, and behavioral changes due to increased noise. Benthic organisms (fish and macroinvertebrates) living near the river bottom or in the substrate in the main channel areas could be subject to entrainment during dredging. The individual's response to elevated suspended sediment would be determined by the size, shape, and duration of the elevated suspended sediment plume, the tolerance of the fish, and the location of the dredge areas.

4.6.3.1 Dredge Entrainment

Removal of substrate and benthic organisms at the dredging site by the dredge (entrainment) would result in immediate localized effects on the benthic community (USACE 1998a, Harvey and Lisle 1998).

This direct effect on benthic organisms would be confined primarily to the mid-channel areas where dredging would be allowed.

Intake water velocity, and the organisms susceptibility to entrainment in the intake water flow, are the primary determinants for entrainment; but secondary variables affecting swimming behavior and performance also could influence and determine entrainment rates (Boyson and Hoover 2009). Fish may swim toward the dredge head for various reasons including visual, electro-receptive, or audible stimulation (Boyson and Hoover 2009). Boyson and Hoover (2009) identified the need for future research to evaluate the effect of these variables on entrainment rates.

The USACE conducted dredging entrainment susceptibility studies of sturgeon and paddlefish species (Hoover et al. 2005). Researchers found that the rate of fish entrainment would be determined, in part, by the organism's location relative to the dredge in the water column, its swim speed, and whether the species readily swims against the current (rheotaxis) (Hoover et al. 2005). While these factors are important to 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). Although these results are likely to be applicable to other free-swimming aquatic organisms, it is important to note that swimming performance and behavior models are substantially different for each species; and recent studies have shown differences between populations of the same species (Boyson and Hoover 2009).

Cutter-head dredges can create a suction field effect of approximately 1.6 feet per second (50 centimeters per second) up to a distance of 4.9 feet (1.5 meters) from the dredge intake (Hoover et al. 2005). In the escapement studies conducted by Hoover et al. (2005), researchers found that many pelagic, free-swimming fish (such as paddlefish), 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 escapement, compared to slow-moving fish (such as pallid sturgeon) that cannot orient themselves toward the dredge flow field. In a study that evaluated entrainment of white sturgeon, researchers found that similar variables dictated escapement rate for different life history stages of that species (Boyson and Hoover 2009). Boyson and Hoover (2009) found that smaller fish as a group, compared to larger juveniles and adults, had less endurance and slower swim speeds, which increased their risk of entrainment.

The USACE (1998a) conducted a literature review of studies evaluating the effects of dredging entrainment on aquatic organisms. Entrainment ranges for various fish species have been reported to

range from less than 0.001 fish per cubic yard to 0.594 fish per cubic yard of dredge extraction (USACE 1998a). In general, the literature review concludes that the results of the limited studies have been inconclusive in determining the absolute entrainment rates or the population-level consequences for larval, juvenile, and adult fish and aquatic invertebrates (USACE 1998a). Studies by the USACE to determine precise estimates of absolute entrainment rates found that additional studies are required to quantify entrainment rates and to identify any potential dredging windows that would minimize entrainment rates (USACE 1998a).

No definitive mortality estimates are available for the potential quantity or rate of fishes or their larvae that could be subject to entrainment from dredging in the LOMR. The most conservative assumption is that 100 percent of all entrained animals die; however, depending on the taxon, size, and age, entrainment processes may generate non-uniform mortalities (USACE 1998b).

In general, the USACE (1998b) concluded that dredging would not likely be a substantial problem for many fish or shellfish species in water bodies experiencing periodic dredging; however, dredging may pose a more substantial risk to some sensitive aquatic resources. As discussed throughout this section, species-specific entrainment rates and the site-specific factors that dictate entrainment rates are poorly understood. Studies showing the effects of entrainment at an individual or population level are lacking for many aquatic species and for the LOMR. As suggested by research on entrainment susceptibility (Hoover et al. 2005), entrainment impacts in the LOMR would likely be concentrated among those species and life history stages with an escape speed less than the intake velocity.

4.6.3.2 Propeller Entrainment

Dredge barges and transport barges (barges used for transporting excavated material to sand plants or other terminal locations) are anticipated to be positioned or moved using tugboats (see Section 2.2.2). The effect of tugboat propellers on fishes and other aquatic resources between the dredging sites and various sand plants is a concern associated with the magnitude of tugboat traffic and the river channel geometry.

Studies on the upper Mississippi River found that towboats (and presumably tugboats) entrain large volumes of water through their propellers. Towboat propellers often exceed 8 feet (~2.5 meters) in diameter and were found to span between 20 and 100 percent of the depth of a confined navigation channel in the upper Mississippi (Gutreuter, Dettmers, and Wahl 2003). The area within which water is entrained by propellers (referred to as the “inflow zone”) for tow barges on the Mississippi was found to extend approximately 20 percent wider than the beam of the tow 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 fish come in contact with the blades (Gutreuter, Dettmers, and Wahl 2003). The volume of vessel traffic, with the associated risk of injuring or killing fish, therefore is an important consideration. If vessel traffic is high, the impacts to fish species could be considerable.

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. Killgore et al. (2001) evaluated mortality of icthyoplankton entrained through a scale model of a towboat 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 (>75 percent). All larval species experienced delayed mortality, particularly at higher stress levels. Killgore et al. (2001) concluded that shear stress caused by towboat 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. The extent of mortality would be a function of the amount of tow traffic on a given river system, towboat speed, and traffic volumes during the period when larvae are most susceptible to shear stress (i.e., the early developmental phase) (Killgore et al. 2001).

Gutreuter, Dettmers, and Wahl (2003) developed a method to estimate mortality rates of adult fish from entrainment through propellers of commercial towboats. The method combined trawling for fish while following the towboats and the use of a hydrodynamic diffusion model. Trawling recovered a fraction of the fish killed by vessel traffic and the hydrodynamic model was used to estimate the fraction of total mortality collected in the trawls. Examining observed propeller entrainment rates in study locations on the Mississippi and Illinois Rivers, Gutreuter, Dettmers, and Wahl (2003) estimated entrainment mortality rates between 0.2 fish/ mile (0.13 fish/km) of towboat travel for skipjack herring (*Alosa chrysochloris*), 0.84 fish/mile (0.53 fish/km) for shovelnose sturgeon (*Scaphirhynchus platorychus*), and 4.0 fish/mile (2.52 fish/km) for gizzard shad (*Dorosoma cepedianum*). The estimation approach may apply broadly to commercial vessels operating in confined channels, including large rivers (Gutreuter, Dettmers, and Wahl 2003). No comparable propeller entrainment studies have been identified for the LOMR. Rates of entrainment on the LOMR may vary from these estimates based on site-specific and species-specific conditions, including river hydrology, seasonal distribution of fish species, and the life history stage of particular fish species during the period of traffic.

4.6.3.3 Sound and Noise Impacts

Fishes produce and use sounds in a wide variety of behaviors (Zelick, Mann, and Popper 1999). Fish detect and respond to sound, utilizing 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 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 impacts to 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 impacts 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. It is expected that noise from the operation of dredges—while not as intense as pile driving or explosions—may result in avoidance of the dredging area by fish species sensitive to noise over the duration of the activity.

Hearing generalists are fish that lack adaptations or have not developed hearing specializations to enhance auditory sensitivity. Hearing generalists generally cannot hear sounds above 500–1,500 Hz (depending on the species). Dredging noise occupies the mid- to low-frequency range, is tonal and continuous, and is likely tolerable by the hearing generalists.

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

4.6.3.4 Elevated Suspended Sediment and Turbidity

Native organisms that evolved and are naturally associated with turbid environments typically are highly tolerant of elevated suspended sediment (USACE 1978). The highest suspended sediment loads in the downstream channelized section of the LOMR are only 17 percent of pre-dam values (Jacobson, Johnson, and Dietsch 2009). The combination of channelization and flow modifications in the LOMR has collectively resulted in a reduction of habitat and caused a substantial change in river species composition (Pegg and Taylor 2007). Species that have become more abundant as turbidity has decreased include site-feeding carnivores and pelagic planktivores, while some native big-river fishes with morphological adaptations to use high-turbidity and high-velocity main-channel habitats have declined (Galat et al. 2005). The reduction of turbidity in 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). Table 4.6-1 describes the various reproductive strategies for native and non-native fish found in the LOMR.

As described in Section 4.5, USACE sampling below a cutter-head dredge in the LOMR near the confluence of the Kansas and Missouri Rivers indicated that suspended solid concentrations typically returned to background concentrations within approximately 1,300 feet (USACE 1990). It was concluded that fine sediment discharge likely would not be of sufficient quantity to differ substantially from the maximum natural suspended sediment levels in receiving waters. While dredging may result in a temporary, localized elevation of suspended sediment, these changes in water quality are not anticipated to differ substantially from naturally occurring levels. 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).

Non-native fish species that are not as tolerant of elevated suspended sediment would be most affected by dredging if particular species are more sensitive to elevated suspended sediments (e.g., non-native bass may experience slowed egg development; non-native site feeders may experience reduced feeding success) (Blevins 2006). Depending on fish reproductive strategy (see Table 4.6-1), the physiological impacts associated with increased suspended sediments may include reduced fecundity and brood size in fish, and retarded development of eggs and larvae (Kerr 1995). Exposed fish eggs (broadcast strategy) are generally more sensitive (and vulnerable) than eggs buried in the substrate (nest or brood-hiding strategy) (Kerr 1995). Information is limited about the incubation success of fish spawning in the LOMR in aggregate habitat.

As discussed above, native aquatic species evolved in the LOMR under historically turbid conditions, and turbid conditions that mimic the historical environment have largely been eliminated in the LOMR (see Section 3.7). Because of the historical context and role of suspended sediment in the LOMR system and the general reduction in suspended sediment in recent history, the introduction of suspended sediment, while localized to a short distance downstream of the dredge (see Section 4.5), would likely result in a temporary improvement in habitat conditions for native aquatic species.

Table 4.6-1 Reproductive Strategies of Selected Common Fish in the Lower Missouri River

Open Substratum Spawners (Broadcast)	Open Substratum Spawners (Submerged Objects)	Brood Hiders (Redds)	Brood Hiders (Crevice Spawners)	Nest Spawners (Hole –Burrows)	Nest Spawners (Rock and Gravel)
• Blue sucker[a,b] • River carpsucker[b] • Brassy minnow • Sand shiner[b] • Pallid sturgeon[a,b] • Sauger[b] • Plains minnow[a,b] • Shorthead redhorse[b] • Shovelnose sturgeon[a,b] • Smallmouth buffalo[b] • W. Silvery minnow[a,b] • White sucker[b] • River shiner[a] • Emerald shiner • Silver chub[a] • Silverband shiner[a] • Goldeye • Bigmouth buffalo[b] • Freshwater drum[b] • Paddlefish	• Common carp • White bass	• Chestnut lamprey[a]	• Tadpole madtom[a] • Fathead minnow • Red shiner	• Blue catfish[b] • Channel catfish[b] • Flathead catfish[b] • Stonecat[b]	• Flathead chub[a,b] • Sicklefin chub[a,b] • Sturgeon chub[a,b] • Bluegill • Crappie

Note: "Reproductive strategy" is defined as a group with similar strategies to raise their young (i.e., parental care).

References: Common Missouri River species as identified in Section 3.8. Reproductive strategies determined from general species descriptions found at Montana Field Guide 2010, PFBC 2010, TSU 2010.

[a] Indicates that the fish is a state or federal special-status species.

[b] Indicates that the fish is also in the benthic fish guild.

4.6.4 Assessment Methods

Because aquatic resources and potential impacts to aquatic resources are specific to local conditions and shift according to season, migration, and flow conditions, potential consequences to these resources were evaluated in a qualitative fashion that includes a narrative discussion of potential impacts under each alternative scenario. Further, as discussed throughout Sections 4.6.2 and 4.6.3, most of the potential aquatic resource impacts from dredging cannot be quantified due to the lack of dredging-related impact data and LOMR-specific studies. Impacts to aquatic habitat are discussed at a general reach scale, while impacts to aquatic species are addressed at a local scale.

Individual organisms are primarily affected by the occurrences and magnitude of dredging activities, and primarily through localized direct and indirect impacts. The quantity of dredging under the Proposed Action and each alternative was compared to recent dredging (defined in Chapter 2 as the average annual dredging from 2004 to 2008) to determine the relative increase and the corresponding change in magnitude of these localized individual impacts. The habitat impacts are primarily driven by changes to the LOMR bed profile and low-flow surface water elevation due to river bed degradation. These potential impacts to aquatic habitat are evaluated in the context of potential river bed degradation and are tied to the geomorphology discussion presented in Section 4.2.

The geomorphology analysis 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).

Changes in high-flow water surface elevations were characterized as likely to increase or likely to decrease for the Proposed Action and the alternatives. Because the linkage between river bed degradation, sediment availability, and the quantity of shallow-water habitat has not been quantified (USACE 2009), levels of potential river bed degradation were used as a proxy for the potential for changes in the quantities of shallow-water habitats.

4.6.5 Proposed Action

4.6.5.1 Potential Impacts on Aquatic Habitat

All Segments

The Proposed Action would substantially increase the amount and location of dredging, by approximately 93 percent when compared to recent dredging in the LOMR. In general, it is anticipated that this increase in dredging effort would result in a corresponding increase in the locations, frequencies, and quantities of benthic habitats that would be subject to direct disruption. The disruption of habitat quality and availability would be temporary.

St. Joseph Segment

The Proposed Action would result in moderate to substantial long-term river bed degradation in the St. Joseph segment. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat and quantity have not yet been quantified (USACE 2009). If these geomorphic processes are linked to the erosion of shallow-water habitat, this level of river bed degradation would be more likely to affect the abundance of shallow-water habitat.

Kansas City, Jefferson City, and St. Charles Segments

The Proposed Action would result in substantial long-term river bed degradation in the Kansas City, Jefferson City, and St. Charles segments, which could alter the quantity and distribution of shallow-water habitat. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat and quantity have not yet been quantified (USACE 2009). Alteration of shallow-water habitat could occur through river bed degradation, resulting in decreased water surface elevations and less sediment that would expose shallow areas, or physical erosion of shallow-water habitats.

Waverly Segment

Potential short-term aggradation or slight river bed degradation could occur in the Waverly segment under the Proposed Action. Depending on the sediment deposition patterns, shallow-water habitat may be created in this segment under the Proposed Action. Low-flow water surface elevations are not anticipated to change significantly and may not have a potential to alter the abundance of shallow-water habitat in this segment.

Alternate Sources

No alternate sources of supply would be required under the Proposed Action; therefore, no aquatic habitat disturbance or modification would occur as a result of instream mining of sand and gravel or dredging in the Kansas or Mississippi River. Alternate sources of sand from floodplain or upland open-pit mines would not be needed under the Proposed Action; therefore, the potential for sediment and contaminant delivery from these operations to water bodies would not increase.

4.6.5.2 Potential Impacts on Aquatic Species

All Segments

The Proposed Action would substantially increase the amount of dredging, by approximately 93 percent when compared to recent dredging in the LOMR. In general, it is anticipated that this increase in dredging effort would result in a corresponding increase in the potential for entrainment of aquatic species along with direct and indirect effects associated with dredging-related noise and elevated turbidity levels. The Proposed Action may result in an increase in localized, although temporary, injury or mortality to fish by entrainment. Localized increases in suspended sediment downstream of the dredge may temporarily benefit native species that are associated with turbid environments and could potentially adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-native species).

Alternate Sources

No alternate sources of supply would be required under the Proposed Action; therefore, no instream gravel mining or dredging would take place in the Kansas or Mississippi River with associated behavioral changes, decreased reproductive success, mortality through entrainment, or modification of habitat. Alternate sources of sand from floodplain or upland open-pit mines would not be needed under the Proposed Action; therefore, no increased potential for sediment and contaminant delivery from these operations to the river and no increased potential for behavioral, reproductive, or mortality effects on aquatic species would be associated with alternate sources of supply.

4.6.6 No Action Alternative

4.6.6.1 Potential Impacts on Aquatic Habitat

All Segments

Under the No Action Alternative, all segments would experience long-term aggradation or potentially slight degradation that may stabilize shallow-water habitats. Depending on the sediment deposition and aggradation patterns, shallow-water habitat may be created in some segments under this alternative. Further, under the No Action Alternative, the direct benthic habitat disturbance from commercial sand dredging activities would halt.

Alternate Sources

Development or expansion of upland and floodplain open-pit mines under the No Action Alternative may not directly affect aquatic resources but could result in destruction of riparian or wetland habitat and introduction of contaminants and sediment via storm water runoff (see Section 4.5) (Roell 1999, Brown, Lyttle, and Brown 1998). These changes in water quality could result in decreased aquatic habitat quality or quantity. For example, the increased introduction of sediment in water bodies from floodplain open-pit mining runoff could result in habitat degradation through filling of interstitial spaces in stream substrates and decreased depths of pools that are habitat for larger fish species (Brown, Lyttle, and Brown 1998). Additional aquatic habitat alteration from floodplain open-pit mining would occur if the excavation pit was captured by the active stream channel during flooding, which would cause an abrupt relocation of the channel and extensive channel instability (Roell 1999, Kondolf 1997). Captured pits that are large relative to the stream channel create lake-like environments that can locally change aquatic habitat type and conditions and the associated biological community (Roell 1999).

Similar impacts would be associated with instream mining operations, such as potential spills of diesel fuel or other contaminants, as those discussed for upland mining (Kondolf 2006). Further, stream mining activities could destabilize the stream bed and banks, which causes simplification of aquatic habitats (Roell 1999, Kondolf 2006). Instream sand and gravel mining in streams and rivers could result in a variety of alterations to those stream channels—including the possible formation of wide, shallow channels with bank erosion, braided flows, and increased water temperatures—if the excavation is done improperly; and elimination of side channels, relocation of the thalweg, and increased mobilization of sediments could occur (Roell 1999). Channel widening could result in shallowing of the stream bed that could produce braided flow or subsurface inter-gravel flow in riffle

areas; these conditions could hinder fish movement between pools or increase stream temperatures (Brown, Lyttle, and Brown 1998). Further, instream mining could reduce habitat complexity through sedimentation of deep pools (Brown, Lyttle, and Brown 1998). These changes in physical habitat can affect species interactions and community composition (Brown, Lyttle, and Brown 1998), as discussed in Section 4.6.6.2. This potential degradation of aquatic habitat from instream sand and gravel mining could extend beyond the boundaries of the immediate gravel mining areas (Brown, Lyttle, and Brown 1998).

4.6.6.2 Potential Impacts on Aquatic Species

All Segments

Because the No Action Alternative does not involve dredging in the LOMR, no individuals in any segment would be entrained or experience temporary behavioral modifications due to noise from dredging activities. Entrainment would decrease compared to the rates of entrainment under recent levels of commercial dredging. Because dredging would cease, localized elevated suspended sediment plumes would not occur downstream of the dredges and native species would not benefit from turbidity associated with the temporary increase in suspended sediment.

Alternate Sources

Regardless of the location (the Mississippi and Kansas Rivers or other rivers), dredging under the No Action Alternative would result in similar general impacts on aquatic species related to entrainment, noise, and turbidity as described for the LOMR (USACE 1978).

As discussed above, development or expansion of upland or floodplain open-pit mines may not directly affect aquatic resources but may result in destruction of riparian or wetland habitat and introduction of contaminants and sediment via storm water (see Section 4.5). The potential introduction of contaminants in water bodies from upland mining may result in changes in holding, feeding, or migratory behavior of fish (Kondolf 2006). In addition to the habitat alterations discussed above, the introduction of sediment from these operations into aquatic habitat would result in suffocation of eggs, larvae, and benthic invertebrates and could decrease pool depths used by larger fish species (Brown et al. 1998). The downstream effects (up to several miles downstream of mining sites) of elevated turbidity could reduce species abundance and result in a change in species composition (Kondolf 2006). Brown et al. (1998) found higher total densities and diversity of fish families captured in reference streams compared to mined stream reaches for most fish species.

The most widespread effects of instream mineral extraction on aquatic habitats are channel alterations and sedimentation, which can cause substantial negative effects on aquatic life (Roell 1999, Kondolf 1997). Instream mining can result in impacts to aquatic species similar to those described for open-pit mines, which could result in reduction or elimination of populations of aquatic species (Roell 1999). Alterations of pool and riffle habitat characteristics and frequency, as discussed above, can change the aquatic biotic community composition through changes to food production or retention, distance between patches, refuge security, and refuge distribution (Brown, Lyttle, and Brown 1998). These environmental degradations to biotic communities are likely to extend far beyond the boundaries of the immediate gravel mining areas (Brown, Lyttle, and Brown 1998).

4.6.7 Alternative A

4.6.7.1 Potential Impacts on Aquatic Habitat

All Segments

Under Alternative A, the St. Joseph, Kansas City, Waverly, Jefferson City, and St. Charles segments are expected to experience long-term aggradation or slight long-term degradation. Depending on the sediment deposition patterns, shallow-water habitat may be created in segments under this alternative. Low-flow water surface elevations are not anticipated to change significantly and may not have a potential to alter the abundance of shallow-water habitat in these segments.

St. Joseph Segment

Under Alternative A, dredging is expected to slightly increase (by approximately 7 percent compared to recent dredging) in the St. Joseph segment, which would result in a corresponding slight increase in the locations and frequencies that benthic habitats would be subject to a temporary direct disruption of habitat quality and availability.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Although direct benthic habitat disturbance would occur under Alternative A, the frequency of disturbances would decrease compared to recent dredging.

Alternate Sources

Because fewer alternate sources would be required under Alternative A (a decrease of approximately 32 percent compared to the No Action Alternative level), the impacts of alternate sources would be

similar to those described for the No Action Alternative, but the impacts would occur at a reduced frequency. Open-pit upland and floodplain mining could result in destruction of riparian or wetland habitat and introduction of contaminants and sediment via storm water (see Section 4.5) (Roell 1999; Brown, Lyttle, and Brown 1998), which would decrease habitat quality. Further, additional aquatic habitat alteration from floodplain open-pit mining would occur if the excavation pit was captured by the active stream channel during flooding, which would cause an abrupt relocation of the channel and extensive channel instability (Roell 1999, Kondolf 1997).

The impacts of instream mining operations would be similar to those discussed for upland mining (e.g., potential spills of diesel fuel or other contaminants) (Kondolf 2006). Further, instream mining activities could destabilize the stream bed and banks, which causes simplification of aquatic habitats (Roell 1999, Kondolf 2006). Channel widening could result in shallowing of the stream bed, which could produce braided flow or subsurface intergravel flow in riffle areas; these conditions could hinder fish movement between pools or increase stream temperature (Brown, Lyttle, and Brown 1998).

4.6.7.2 Potential Impacts on Aquatic Species

St. Joseph Segment

Under Alternative A, dredging would slightly increase (by approximately 7 percent compared to recent dredging) in the St. Joseph segment. The rate of entrainment and noise disturbance also would slightly increase under Alternative A. Elevated suspended sediment plumes would result in a temporary, localized positive effect on native fish species by increasing, temporarily, local turbidity at and downstream of the dredging location.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Under Alternative A, dredging would decrease relative to recent dredging in the Kansas City, Waverly, Jefferson City, and St. Charles segments. Overall, dredging would decrease (between 26 and 79 percent of recent dredging) in these segments, with a corresponding decrease in the number of organisms that would be expected to be entrained. Because elevated underwater noise from dredge vessels would not occur as frequently, short-term localized avoidance behaviors in noise-sensitive fish species are expected to decrease. Given that dredging impacts on suspended sediment levels are localized and temporary, Alternative A is expected to decrease the frequency of elevated suspended sediment plumes compared to recent dredging, which would decrease the availability of temporary habitat cover (i.e., turbidity) for native fish species.

Alternate Sources

The impacts on aquatic species associated with alternate sources of sand and gravel under Alternative A would be similar to those described for the No Action Alternative but of less magnitude (a decrease of approximately 32 percent compared to the No Action Alternative level). Dredging in the Mississippi and Kansas Rivers and other rivers under Alternative A would result in similar impacts on aquatic species related to entrainment, noise, and turbidity as described for the LOMR.

The potential introduction of contaminants in water bodies from upland and floodplain open-pit mining may result in changes in holding, feeding, or migratory behavior of fish (Kondolf 2006) and reproductive success of fish and macroinvertebrates (Brown et al. 1998). These changes may result in reduced species abundance and changes in species composition (Kondolf 2006).

Instream mining may result in impacts to aquatic species similar to those described for open-pit mines, which could result in reduction or elimination of populations of aquatic species (Roell 1999). Alterations of pool and riffle habitat characteristics and frequency due to sedimentation and channel widening can change the aquatic biotic community composition through changes to food production or retention, distance between patches, refuge security, and refuge distribution (Brown, Lyttle, and Brown 1998).

4.6.8 Alternative B

4.6.8.1 Potential Impacts on Aquatic Habitat

St. Joseph Segment

Under Alternative B, dredging in the St. Joseph segment would result in slight to moderate long-term river bed degradation. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat distribution and availability have not yet been quantified (USACE 2009), but if these geomorphic processes are linked to the erosion of shallow-water habitat, this level of river bed degradation would be more likely to affect the abundance of shallow-water habitat in this segment.

Under Alternative B, the location and frequency of dredging in the St. Joseph segment would substantially increase (to approximately 163 percent compared to recent dredging). This increase in dredging would result in a corresponding increase in the locations and frequencies that benthic habitats would be subject to direct disruption, even though temporary, and would affect habitat quality and availability.

Kansas City and St. Charles Segments

Under Alternative B, dredging in the Kansas City and St. Charles segments would likely result in moderate long-term river bed degradation and the potential for alteration of shallow-water habitat abundance and connectivity. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat and quantity have not yet been quantified (USACE 2009), but if these geomorphic processes are linked to the erosion of shallow-water habitat, this level of river bed degradation would be more likely to affect the abundance of shallow-water habitat.

Under Alternative B, dredging would decrease in the Kansas City and St. Charles segments compared to recent dredging. Dredging would be between 49 and 53 percent of recent dredging, with a corresponding reduction in the frequency of direct benthic habitat disturbance.

Waverly Segment

Slight long-term river bed degradation or aggradation would occur in the Waverly segment under Alternative B. This may stabilize or slightly decrease the quantity of shallow-water habitat. Depending on the sediment deposition patterns, shallow-water habitat may be created in segments under this alternative. Low-flow water surface elevations are not anticipated to change significantly and may not have a potential to alter the abundance of shallow-water habitat in the Waverly segment.

Under Alternative B, dredging levels would substantially increase in the Waverly segment (approximately 68 percent of recent dredging). This increase in dredging would result in a corresponding increase in the locations and frequencies that benthic habitats would be subject to direct disruption, even though temporary, of habitat quality and availability.

Jefferson City Segment

Under Alternative B, dredging in the Jefferson City segment would result in slight to moderate long-term river bed degradation, resulting in the potential for alteration of shallow-water habitat abundance and connectivity. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat and quantity have not yet been quantified (USACE 2009), but if these geomorphic processes are linked to the erosion of shallow-water habitat, this level of river bed degradation would be more likely to affect the abundance of shallow-water habitat.

Under Alternative B, dredging would decrease in the Jefferson City segment. Dredging would be 37 percent of recent dredging, with a corresponding reduction in the frequency of direct, temporary benthic habitat disturbance.

Alternate Sources

Impacts on aquatic resources from alternate sources of sand and gravel under Alternative B would be similar to those described for the No Action Alternative and Alternative A but of substantially less magnitude (an approximately 73-percent decrease compared to the No Action Alternative). Open-pit upland and floodplain mining could result in destruction of riparian or wetland habitat and introduction of contaminants and sediment via storm water (see Section 4.5) (Roell 1999; Brown, Lyttle, and Brown 1998), which would decrease habitat quality. Further, additional aquatic habitat alteration from floodplain open-pit mining would occur if the excavation pit was captured by the active stream channel during flooding, which would cause an abrupt relocation of the channel and extensive channel instability (Roell 1999, Kondolf 1997).

Impacts related to instream mining operations would be similar to those discussed for upland mining impacts, such as potential spills of diesel fuel or other contaminants (Kondolf 2006). Further, instream mining activities could destabilize the stream bed and banks, which causes simplification of aquatic habitats (Roell 1999, Kondolf 2006). Channel widening could result in shallowing of the stream bed, which could produce braided flow or subsurface intergravel flow in riffle areas; these conditions could hinder fish movement between pools or increase stream water temperature (Brown, Lyttle, and Brown 1998).

4.6.8.2 Potential Impacts on Aquatic Species

St. Joseph and Waverly Segments

Under Alternative B, dredging in the St. Joseph and Waverly segments would increase (by approximately 163 percent and 68 percent, respectively, compared to recent dredging). Increased dredging would result in a corresponding increase in the potential for entrainment, noise, and elevated turbidity. Alternative B would result in an increase in temporary localized injury or mortality to fish by entrainment. Localized increases in suspended sediment downstream of the dredge would temporarily benefit native species that are associated with turbid environments and have the potential to adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-natives).

Kansas City, Jefferson City and St. Charles Segments

Under Alternative B, dredging would decrease in the Kansas City, Jefferson City, and St. Charles segments. Overall, dredging levels would be between 37 and 53 percent of recent dredging, with a

corresponding decrease in the number of organisms expected to be entrained. Because elevated underwater noise from dredge vessels would decrease, the short-term localized avoidance behaviors in noise-sensitive fish species are expected to decrease. Given that dredging impacts on suspended sediment levels are localized and temporary, Alternative B is expected to decrease the frequency of elevated suspended sediment plumes, which would decrease the availability of temporary habitat cover for native fish species.

Alternate Sources

Impacts on aquatic resources from alternate sources of sand and gravel under Alternative B would be similar to those described for the No Action Alternative and Alternative A but of substantially less magnitude (an approximately 73 percent decrease compared to the No Action Alternative). Similar impacts related to localized entrainment, noise, and turbidity would occur at dredging sites in the Mississippi and Kansas Rivers and other rivers, as described for the LOMR.

The potential introduction of contaminants in water bodies from upland and floodplain open-pit mining may result in changes in holding, feeding, or migratory behavior of fish (Kondolf 2006) and reproductive success of fish and macroinvertebrates (Brown et al. 1998). These changes may result in reduced species abundance and changes in species composition (Kondolf 2006).

Instream mining also may result in impacts to aquatic species similar to those described for open-pit mines, which could result in reduction or elimination of populations of aquatic species (Roell 1999). Alterations of pool and riffle habitat characteristics and frequency due to sedimentation and channel widening can change the aquatic biotic community composition through changes to food production or retention, distance between patches, refuge security, and refuge distribution (Brown, Lyttle, and Brown 1998).

4.6.9 Alternative C

4.6.9.1 Potential Impacts on Aquatic Habitat

All Segments

Under Alternative C, the frequency of dredging would be similar in magnitude, but not necessarily in location or distribution, to recent dredging (as described in Chapter 2). The quantity of dredging activity would not change substantially; therefore, the rate of temporary benthic habitat disruption would be similar to recent levels of benthic habitat disturbance.

St. Joseph and Waverly Segments

Long-term aggradation or slight long-term degradation may occur in the St. Joseph and Waverly segments under Alternative C, which would stabilize or slightly alter the quantity of shallow-water habitat. Depending on the sediment deposition patterns, shallow-water habitat may be created under this alternative. Low-flow water surface elevations are not anticipated to change significantly and may not have a potential to alter the abundance of shallow-water habitat in these segments.

Kansas City, Jefferson City, and St. Charles Segments

Alternative C would result in moderate to substantial long-term river bed degradation in the Kansas City, Jefferson City, and St. Charles segments, which may result in alteration of shallow-water habitat abundance or connectivity. The effects of river bed degradation and reduced sediment bed load on shallow-water habitat and quantity have not yet been quantified (USACE 2009), but if these geomorphic processes are linked to the erosion of shallow-water habitat, this level of river bed degradation would be more likely to affect the abundance of shallow-water habitat.

Alternate Sources

No alternate sources of supply would be required under Alternative C; therefore, no aquatic habitat disturbance or modification would occur as a result of instream mining of sand and gravel or dredging. Under Alternative C, alternate sources of sand from floodplain or upland open-pit mines would not be needed; therefore, the potential for sediment and contaminant delivery from these operations to water bodies would not increase.

4.6.9.2 Potential Impacts on Aquatic Species

All Segments

Under Alternative C, the frequency of elevated suspended sediment plumes downstream of dredging would be similar, but not necessarily in the location or distribution, to recent dredging (as described in Chapter 2). The quantity of dredging activity would not change substantially; therefore, the rate of entrainment and noise production would not change substantially. Potential effects associated with recent dredging are evaluated in the Affected Environment discussion for aquatic resources (Section 3.8).

Alternate Sources

No alternate sources of supply would be required under Alternative C; therefore, neither instream gravel mining nor dredging in the Kansas or Mississippi Rivers would take place with associated behavioral changes, decreased reproductive success, mortality through entrainment, or modification of habitat. Alternate sources of sand from floodplain or upland open-pit mines would not be needed under Alternative C, with no increased potential for sediment or contaminant delivery from these operations to the river and no increased potential for behavioral, reproductive, or mortality effects on aquatic species.

4.6.10 Summary of Impacts

Table 4.6-2 contains a summary of the potential impacts on aquatic resources associated with the Proposed Action and alternatives.

Table 4.6-2 Summary of Potential Impacts on Aquatic Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Potential impacts on aquatic habitat	• Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low-flow surface water elevation.	• Increase in or stabilization of shallow-water habitat in the mainstem. • Potential degradation of aquatic habitat from contaminated runoff and stream geomorphology changes from the use of open-pit and instream mining.	• Increase in or stabilization of shallow-water habitat in the mainstem in most areas. • Potential degradation of aquatic habitat from contaminated runoff and stream geomorphology changes from the use of open-pit and instream mining.	• Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low-flow surface water elevation. • Potential degradation of aquatic habitat from contaminated runoff and stream geomorphology changes from the use of open-pit and instream mining.	• Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low-flow water surface elevations.
Potential impacts on individual aquatic species	• Substantial increase in the rate of entrainment, noise disturbance, and elevated suspended sediment.	• No entrainment, noise disturbance, or elevated suspended sediment caused by dredging. • Potential reduction reproductive success, behavioral changes, or mortality through the introduction of contaminants and aquatic habitat alterations from alternate sources.	• Substantial decrease in entrainment, noise disturbance, and elevated suspended sediment caused by dredging. • Potential reduction reproductive success, behavioral changes, or mortality through the introduction of contaminants and aquatic habitat alterations from alternate sources.	• Decrease in entrainment, noise disturbance, and elevated suspended sediment caused by dredging. • Potential reduction reproductive success, behavioral changes, or mortality through the introduction of contaminants and aquatic habitat alterations from alternate sources.	• Entrainment, noise disturbance, or elevated suspended sediment rates similar to recent dredging.

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4.7 WETLANDS, FLOODPLAINS, AND TERRESTRIAL RESOURCES

4.7.1 Introduction

The LOMR has been subjected to a long history of alterations in support of navigation and flood control, resulting in the loss of most of the riparian forests, wetlands and associated wetland functions, and terrestrial wildlife. The forested area of the Missouri River floodplain dropped from 76 percent to 13 percent between 1826 and 1972, and the cultivated area increased from 18 percent to 83 percent (Munger et al. 1974, Bragg and Tatschl 1977). Wetlands in the Missouri River floodplain declined 39 percent between 1890 and 1980; during that same period, sandbar habitat declined 97 percent, and open water habitat declined 45 percent (Hesse et al. 1988). Flow regulation has altered the hydrograph; the annual flood pulse is lower and shorter, and low-flow pulses are fewer and occur earlier in the year, which contributes to the overall alteration of floodplain wetland ecosystem function and health (Galat and Lipkin 2000).

The physical environment along the Missouri River has been shaped by the channel form and flow regime, both of which have been altered substantially and are managed for purposes other than ecological functions (Jacobson and Galat 2006). Hesse et al. (1988) estimated that net carbon production in floodplain wetlands decreased 65 percent, primarily as a result of vegetation changes. The wetland wildlife habitat function also has declined substantially, although there is little documentation (Hesse et al. 1988).

Flood control has the indirect effect of allowing agriculture in the floodplain, which has largely replaced natural habitats. Until recently, the management focus for some of the remaining wetlands along the LOMR has been to manage them for duck habitat (for hunting) (Galat et al. 1998; Bodie, Semlitsch, and Renken 2000). Levees and drainage ditches have removed much of the connectivity between wetlands along the LOMR and also have reduced the flood attenuation wetland function (Ward and Sanford 1995, Blevins 2004). Under the USDA programs described in Section 3.9.2, some wetlands converted to agricultural lands have been enrolled in programs to enhance, protect, and restore previous wetlands functions.

Dredging in the LOMR would not directly affect wetlands or terrestrial wildlife habitat because dredging activities would be limited to the areas within the channel of the LOMR. Commercial dredging is likely to have contributed to the loss of LOMR wetlands indirectly through river bed degradation. River bed degradation in the LOMR has occurred as a combined result of several factors, including commercial

dredging (see Section 3.4.6). River bed degradation lowers the river stage level, particularly during low-flow periods; surface water modeling (USACE 1994) and groundwater studies (Kelly 2001) indicate that decreasing river stage levels lowers the frequency and duration of surface water flows and lowers groundwater levels, resulting in decreased wetland acreage and changes in wetland types.

The primary wetland impact associated with continued commercial dredging in the LOMR, therefore, is the continued potential indirect effect of commercial dredging on wetlands that are dependent on the alluvial aquifer. Continued dredging would contribute to further river bed degradation, leading to lower river stages and lowered groundwater levels, which could cause both a decrease in wetland acreage and a change in wetland type in groundwater-dependent wetlands. The effects of lowered groundwater levels on wetlands would vary depending on site-specific wetland characteristics such as soil type, topography, proximity to the LOMR, reliance of groundwater input, and surface water connections. Because conditions and responses of wetlands to lowered alluvial aquifer levels would vary considerably, the following discussion identifies general potential impacts to wetlands associated with changes in groundwater levels.

Depending on the severity of alterations to groundwater inflow to wetlands, obligate wetland vegetation species (species that are almost always [99 percent of the time] associated with natural wetlands) in groundwater-supported wetlands may be replaced with facultative vegetation species (species that occur in wetlands 67–99 percent of the time) or upland vegetation species (species that occur in wetlands 0–67 percent of the time). Some riparian trees also could be sensitive to decreasing groundwater levels caused by river bed degradation during prolonged dry periods (Scott, Shafroth, and Auble 1999; Shafroth, Stromberg, and Patten 2000; Rood, Braante, and Hughes 2003). Temporary and seasonal wetlands occurring in agricultural areas with sandy loam or sandy-clay loam soils could be greatly affected by surface water elevations and durations of flow at different elevations. This effect would be most pronounced during summer and drought periods, when river stages are lowest, and when wetlands are most dependent on groundwater. Impacts on alluvial aquifer levels related to river bed degradation, and the associated groundwater-dependent wetlands, would be more pronounced in those areas nearest to the LOMR, which are more sensitive to changes in river stage, and could be manifested in changes to obligate and other wetland vegetation species that require certain hydrologic conditions for maintenance (see Section 4.5.3.3). The effects on wetland functions would be variable and could range from loss of all wetland functions to reduced or altered functions.

In addition to affecting existing wetlands, lowered groundwater levels could affect wetland restoration and preservation efforts being conducted under the Missouri River Recovery Program and various USDA wetland and habitat programs.

The following sections identify potential effects on wetlands and floodplain resources as a result of dredging operations or production of sand and gravel from alternate sources.

4.7.1 Assessment Methods

A semi-quantitative approach was used to assess potential indirect impacts on wetland and floodplain resources. Under this approach, wetlands that could be affected by the Proposed Action and alternatives were identified and quantified, but the extent and magnitude of the effects were not used because they could not be determined. The acreage of potentially affected wetlands served as a relative measure by which to compare impacts associated with alternatives.

Wetlands within the LOMR floodplain with the potential to be affected by the Proposed Action and the alternatives were identified by GIS analysis. Geospatial data for LOMR floodplain wetlands were obtained from the USFWS NWI website (USFWS 2010a). NWI data are developed through the use of remotely sensed data; therefore, the accuracy of the image interpretation depends on the quality of the imagery, the image analyst, and the amount of ground truth verification work (USFWS 2010b). Further, the NWI GIS coverage excludes some types of "farmed wetlands" as may be defined by the Food Security Act or that do not coincide with the Cowardin et al. (1979) definitions (USFWS 2010b). Although the accuracy of NWI data may vary depending on multiple factors, this data set was developed for use at a regional scale and is the most comprehensive data set available for the LOMR floodplain region.

A wetlands coverage was created that included all wetland polygons in the LOMR floodplain from RM 0 to RM 489. From this coverage, a subset of wetlands that would be most likely to be affected was selected, based on three assumptions: (1) that, in general, deep wetlands and water bodies are supported by groundwater and could be affected by changing river stage levels; (2) that, in general, shallow wetlands and water bodies are not directly supported by groundwater and would be unaffected by lowered river stage levels; and (3) that wetlands closer to the river would be more likely to be affected than wetlands farther from the river. Although these assumptions are generally supported by existing data (Kelly 2000, 2001; Chapman et al. 2003; Blevins 2004), not all deep wetlands are influenced by groundwater (Chapman et al. 2003). Some shallow wetlands have surface connections

to deeper wetlands supported by groundwater (Kelly 2001), and these wetlands could be affected if a decrease in the groundwater depth affected the water surface levels in the deep wetlands.

Wetland polygons within the 100-year floodplain were sorted by river segment, wetland classification, and wetland type. The few studies of river stage effects on groundwater levels have focused on wetlands within a few thousand feet of the river (Kelly 2000, 2001; Chapman et al. 2003; Blevins 2004). Although all groundwater-supported wetlands in the LOMR floodplain potentially could be affected, the groundwater response to river stage level decreases with increasing distance from the river (Kelly 2000, 2001). Wetlands with a wetland regime of semi-permanently flooded, intermittently exposed, and permanently flooded—which are most likely to be deeper wetlands supported by groundwater—were quantified in order to provide comparisons between alternatives and river segments.

As discussed above, a large quantity of converted wetlands have been and are being used for agricultural purposes. Some of these areas are held in easements managed by the USDA, while others are not. The USDA maintains wetland data in paper or electronic format for parcels enrolled in their easement programs, but the USDA does not contain a comprehensive record or data of prior converted wetlands in the states through which the LOMR flows (Dacey pers. comm.). Consequently, use of this information would not provide an accurate estimate of the quantity of converted wetlands along the LOMR.

This assessment assumes that other terrestrial land cover types along the LOMR floodplain are not supported by groundwater but are dependent on rainfall, surface runoff, or other surface waters. These terrestrial land cover types (e.g., grassland and deciduous forest) would not be directly or indirectly affected by Project dredging because they are not dependent on groundwater. Consequently, the analysis of vegetation and wildlife impacts within the LOMR floodplain was restricted to wetlands, as described above, and sand plant construction areas. University of Missouri 2005 land cover data were used in conjunction with NWI mapping and aerial photo interpretation to determine the vegetation types that would be impacted through the construction of the proposed sand plants. These land cover types and the associated vegetation communities were used to assess the potential Project-related impacts to wildlife resources.

4.7.1.1 Indirect Effects on Groundwater-Dependent Wetlands

Much of the wetlands along the LOMR floodplain are not supported by groundwater but are dependent on rainfall, surface runoff, or other surface waters, including irrigation. These wetlands would not be affected by dredging activities. Wetlands that could be indirectly affected by lowered groundwater

levels resulting from river bed degradation caused by dredging are summarized in Table 4.7-1. It is important to note that these numbers are likely underestimate the number of wetlands present in the Project area because of the large numbers of temporary, seasonal, and semi-permanent wetlands that have been converted to agricultural production in the LOMR floodplain. Approximately 1,310 acres of wetlands with a wetland regime of semi-permanently flooded, intermittently exposed, or permanently flooded are present in the LOMR floodplain in the Project area. Most of these wetlands (94 percent) are freshwater emergent wetlands, and only small amounts of freshwater forested wetlands (4 percent), and freshwater scrub-shrub wetlands (2 percent) are present. The majority of these wetlands are in the Waverly segment (61 percent) and St. Joseph segment (22 percent). The following sections discuss the potential impacts of the Proposed Action and alternatives on wetland resources by river segment.

Table 4.7-1 Estimated Acres of Groundwater-Supported Wetlands in the Lower Missouri River Floodplain[a]

	Wetland Class			
Segment	Forested (acres)	Scrub-Shrub (acres)	Emergent (acres)	Total Acres
St. Joseph	0.0	0.0	295.53	295.53
Kansas City	0.0	1.34	52.37	53.71
Waverly	46.43	18.27	738.81	803.51
Jefferson City	0.0	1.93	55.4	57.33
St. Charles	6.66	2.36	91.34	100.36
Total	53.09	23.9	1,233.45	1,310.44

[a] Potential impact wetland areas include those wetlands in the floodplain of the lower Missouri River with a semi-permanently flooded, intermittently exposed, and permanently flooded wetland classification.

4.7.1.2 Indirect Effects on Wetland-Dependent Species

Dredging in the LOMR occurs under existing conditions and may result in indirect effects on riparian and emergent wetlands within and adjacent to dredged areas because lower water surface levels affect groundwater-dependent wetlands. Indirect effects of dredging on terrestrial resources would be limited to alteration of vegetation resources in riparian and emergent wetland habitats, as discussed above, and potential conversion of these habitats to upland habitat types. This effect would result in loss or degradation of wetland habitat and consequently would affect wetland-dependent wildlife, including dabbling ducks, songbirds, mammals, reptiles, and amphibians.

As discussed in Section 4.2 (Geology and Geomorphology), river bed degradation could result in localized erosion of sand bar habitat features that may be located near the dredge sites. Sand bar habitats are important to shore birds, including the piping plover and interior least tern (see Section 4.8 [Federally Listed Species]). Erosion of these habitats would result in a decrease in available sand bar habitat for species that use sand bars for one or more of their life stages.

4.7.1.3 Potential Impacts from Construction of Sand Plants

Wetlands

Under the Proposed Action and Alternatives A, B, and C, sand plants would be constructed on property owned or controlled by The Master's Dredging Company and Edward N. Rau Contractor Company. The Master's Dredging Company plans to develop a sand plant at one of two sites near Waldron, Missouri (Master's [Waldron]). The only land cover type, as determined through inspection of aerial photos, NWI GIS coverage, and University of Missouri land cover GIS data, on either site is cropland (Table 4.7-2). Due to the historical conversion of wetlands to agricultural cropland, this area may retain some wetland characteristics if the land was a wetland prior to cultivation. Based on available desktop data, no direct or indirect effects on wetland resources would be likely as a result of sand plant construction on either Master's site. The wetland characteristics of these sites cannot be definitively determined until wetland delineations are conducted.

Aerial photography, NWI coverages, and University of Missouri land cover GIS data were inspected to approximate the land cover classes present at the Edward N. Rau Contractor Company property on the shore of the Missouri River at Washington, Missouri (Rau [Washington]). The wetland characteristics of this site cannot be definitively determined until a wetland delineation is conducted. For the purpose of this assessment, it was assumed that all existing wetland resources identified through desktop analysis would need to be cleared and filled to construct the new facility. Land cover data indicate that the parcel contains a mosaic of land cover types, including forested wetlands, herbaceous wetlands, open water, upland, and agricultural lands (Table 4.7-2). Depending on the configuration and size of the Rau (Washington) sand plant, wetland resources could be impacted by construction and operation.

Table 4.7-2 Land Cover Types on the Proposed Sand Plant Properties

	Land Cover Type (acres)							
Location	Cropland	Grassland	Woody-Dominated Wetlands	Herbaceous-Dominated Wetlands	Open Water	Low-Density Urban	Impervious Surface	Total
The Master's Dredging Company (Waldron)	20–60[a]	--	--	--	-	--	--	20–60[a]
Edward N. Rau Contractor Company (Washington)	0.28	0.66	15.37	4.24	2.82	1.60	0.18	25.15

Note: -- = Not applicable.

[a] Actual sand plant size would vary depending on the volume of dredging under each alternative.

Source: University of Missouri GIS database.

Wildlife and Vegetation

The primary impact on vegetative cover types from sand plant construction would be clearing and removal of vegetation on the sand plant parcels. The severity of impact would depend on the type of vegetation impacted and the size of the area cleared. The Master's site contains cropland (Table 4.7-2); and the Rau property contains a mosaic of land cover types, including forested wetlands, herbaceous wetlands, open water, upland, and agricultural lands (Table 4.7-2). Existing vegetation and habitats at the sand plant sites would be converted to industrial land cover after construction of the facilities. Activities that may result in habitat loss include, but are not limited to, vegetation removal to create new sand and gravel extraction and processing facilities; excavation and grading; and temporary stockpiling of soils, construction materials, or construction wastes.

Forested wetland habitats would be more dramatically altered by construction of sand plants than any other habitat. Because trees would be cleared from the sand plant area, species that depend on trees for food, refuge, or nesting would be displaced to nearby forested habitat. Some nesting species and tree-cavity nesting species would suffer mortality during clearing. For adult birds that are able to disperse from the construction area, nesting success may be denied or diminished for one annual breeding cycle. During construction and operation of the sand plants, mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality.

4.7.2 Proposed Action

4.7.2.1 Indirect Effects on Wetlands and Wetland-Dependent Wildlife Species from Changes in Groundwater Levels

St. Joseph and St. Charles Segments

Under the Proposed Action, increased dredging in the St. Joseph and St. Charles segments would lead to moderate to substantial long-term decreases in low-flow water surface levels in this segment. This effect in turn could lead to localized indirect effects on floodplain wetland habitat as a result of changes in groundwater levels that support floodplain wetlands. Under the Proposed Action, up to 6.66 acres of forested wetlands, 2.36 acres of scrub-shrub wetlands, and 386.87 acres of emergent wetlands, as identified in NWI data, could be affected in these two segments through changes in groundwater levels. Note that these numbers are likely conservative due to the large quantity of wetlands that have been converted to agricultural lands in the LOMR floodplain that is not captured in the NWI data. These areas provide habitat for several state-listed species, migratory birds, and numerous common wildlife species. Loss or degradation of emergent wetland habitats would result in displacement of the wetland-dependent species but could provide additional upland habitat for other non-wetland-dependent species that are described in Section 3.10.

Kansas City and Jefferson City Segments

Under the Proposed Action, increased dredging in the Kansas City and Jefferson City segments would lead to a moderate short-term and a substantial long-term decrease in low-flow water surface levels. This effect in turn could lead to localized indirect effects on floodplain wetlands as a result of changes in groundwater levels that support floodplain wetlands. Under the Proposed Action, up to 3.27 acres of scrub-shrub wetlands and 107.77 acres of emergent wetlands, as identified by NWI data, could be affected by changes in groundwater levels. Note that these numbers are likely conservative due to the large quantity of wetlands that have been converted to agricultural lands in the LOMR floodplain that is not captured in the NWI data. These areas provide habitat for several state-listed species, migratory birds, and numerous common wildlife species. Loss or degradation of wetland habitats would result in displacement of wetland-dependent species but could provide additional upland habitat for other non-wetland-dependent species that are described in Section 3.10.

Waverly Segment

Under the Proposed Action, increased dredging in the Waverly segment would lead to slight degradation or aggradation of the river bed in the short term and the long term. Because low-flow water surface levels would change only slightly over the long term, it is not likely that changes in alluvial aquifer levels would affect wetland resources. Changes to wetland habitats and species composition in the Waverly segment also are not likely under the Proposed Action.

Alternate Sources

Under the Proposed Action, increased dredging would meet or exceed regional demands; therefore, no alternate sources of sand and gravel would be required. Potential indirect effects on wetland habitats associated with alternate sources of supply would not occur, such as wetland dredging or filling from upland and floodplain open-pit mines or alterations of groundwater levels and the associated floodplain wetland loss from dredging in the Mississippi or Kansas River. Further, direct or indirect mortality through clearing of upland and floodplain open-pit sites would not occur.

4.7.2.2 Potential Impacts on Wetland and Upland Vegetation and Habitats from Construction of Sand Plants

Kansas City Segment

Under the Proposed Action, The Master's Dredging Company plans to develop a sand plant at one of two sites near Waldron, Missouri in the Kansas City segment. According to land cover data and aerial photo interpretation, the only land cover type on either site is cropland (Table 4.7-2). Based on available desktop data, no direct or indirect effects on wetland resources would be likely as a result of sand plant construction on either Master's site. The wetland characteristics of these sites cannot be definitively determined until a wetland delineation of the site is conducted.

During construction and operation, mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality. As described in Section 3.10, cropland is the most common land cover type in the LOMR floodplain; it is anticipated that species displaced by construction of the Master's sand plant would quickly find suitable alternative habitat.

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under the Proposed Action; therefore, no direct or indirect effects on wetland, vegetation, or wildlife resources would result from construction of sand plants in these segments.

St. Charles Segment

Under the Proposed Action, construction of a new sand plant at the Edward N. Rau Contractor Company property in the St. Charles segment could result in direct effects on up to 15.37 acres of forested wetlands, 4.24 acres of herbaceous-dominated wetlands, and 2.82 acres of open water (Table 4.7-2). The wetland characteristics of this site cannot be definitively determined until a wetland delineation is conducted. For the purpose of this assessment, it was assumed that all existing wetland resources on the property would need to be cleared and filled to construct the new facility. Construction activities that involve dredge or fill of any delineated wetlands on the site would require that the facility operator obtain relevant CWA Section 404 and 401 certification and authorization, which would include required avoidance, minimization, and mitigation measures.

An additional 0.94 acre of cropland and grassland land covers could be directly affected by sand plant construction. Due to the historical conversion of wetlands to agricultural cropland, this area may retain some wetland characteristics if the land was a wetland prior to cultivation. Vegetative communities cannot be fully determined until a wetland delineation is conducted at the site. Vegetation and wildlife species would be displaced in both upland and wetland areas. Species that depend on wetland trees would be displaced to nearby forested habitat, and some nesting and tree-cavity nesting species could suffer mortality or a decrease in breeding success. Mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality.

4.7.3 No Action Alternative

4.7.3.1 Indirect Effects on Wetlands and Wetland-Dependent Wildlife Species from Changes in Groundwater Levels

All Segments

Under the No Action Alternative, dredging would result in slight aggradation or degradation of the river bed in the short term and slight aggradation of the river bed in the long term. River bed aggradation would result in slight increases in low-flow water surface levels in the short term and long term. This

effect in turn would lead to stabilized or improved groundwater levels that support floodplain wetlands. Floodplain wetlands would not be adversely affected from changes in groundwater levels under this alternative. No change to wetland habitats or species composition in any segment would be likely under the No Action Alternative.

Alternate Sources

Under the No Action Alternative, in-channel dredging on the Kansas River or Mississippi River would not result in direct effects on wetland habitat because dredging activities would be limited to the area within the river channels. The potential indirect effects of dredging alternate sources have not been quantified because the location of these actions is not known at this time. It was assumed, however, that any river bed degradation associated with alternate sources of dredging would lead to localized indirect effects on floodplain wetland habitats as a result of changes in surface water and groundwater surface levels on the Kansas and Mississippi Rivers. Potential indirect effects to wetland-dependent species, such as displacement and loss of habitat, would be similar to those described for the LOMR.

Any expansion of existing or new land-based mining that would directly impact wetland resources would be required to obtain a CWA Section 404 and 401 permit and certification. Appropriate wetland permitting of alternate sources would require the implementation of avoidance, minimization, and mitigation measures.

New or expansion of open-pit and floodplain mining under the No Action Alternative could result in conversion of wildlife habitat and vegetative land cover to industrial land covers. The degree of impacts to wildlife species, such as species displacement and habitat modification, would depend on the location of the alternate source, land covers, and the level of extraction.

4.7.3.2 Potential Impacts on Wetlands and Upland Vegetation and Habitats from Construction of Sand Plants

All Segments

No new facilities would be constructed in any segment under the No Action Alternative; therefore, no direct or indirect effects on wetland, vegetation, or terrestrial resources would result from construction of sand plants in any segment.

4.7.4 Alternative A

4.7.4.1 Indirect Effects on Wetlands and Wetland-Dependent Wildlife Species from Changes in Groundwater Levels

All Segments

Dredging in the LOMR would not result in direct effects on wetlands because dredging activities would be limited to the areas within the channel of the LOMR. The effects of dredging on river bed degradation, the indirect effects of declining groundwater surface levels during prolonged drought periods on wetlands, and the associated potential change in vegetation and wildlife habitat, would halt.

Under Alternative A, river bed degradation would lead to only a slight decrease or increase in low-flow water surface levels, which would lead to stabilized groundwater levels that support floodplain wetlands. Correspondingly, no changes to wetland habitats or species composition would be expected under Alternative A.

Alternate Sources

The wetland impacts from dredging in the Mississippi and Kansas Rivers and at open-pit mine sites under Alternative A would be similar to those described for the No Action Alternative, but of less magnitude. Under Alternative A, any river bed degradation associated with dredging of alternate sources could lead to localized indirect effects on floodplain wetlands as a result of changes in surface water and groundwater surface levels on the Kansas and Mississippi Rivers.

Further, any expanded or new open-pit mines could result in wetland impacts and would be subject to relevant wetland permitting. New or expansion of open-pit and floodplain mining could also result of the conversion of wildlife habitat and vegetative land cover to industrial land covers. Impacts to wildlife species, such as species displacement and habitat modification, would be similar to those described for the No Action Alternative but would occur in fewer locations.

4.7.4.2 Potential Impacts on Wetlands and Upland Vegetation and Habitats from Construction of Sand Plants

Kansas City Segment

Under Alternative A, The Master's Dredging Company plans to develop a sand plant at one of two sites near Waldron, Missouri in the Kansas City segment. According to land cover data and aerial photo

interpretation, the only land cover type on either site is cropland (Table 4.7-2). Based on available desktop data, no direct or indirect effects on wetland resources would be likely as a result of sand plant construction on either Master's site. The wetland characteristics of these sites cannot be definitively determined until a wetland delineation of the site is conducted.

During construction and operation, mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality. As described in Section 3.10, cropland is the most common land cover type in the LOMR floodplain; it is anticipated that species displaced by the construction of this sand plant would quickly find suitable alternative habitat.

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St Joseph, Waverly, or Jefferson City segment under Alternative A; therefore, no direct or indirect effects on wetland, vegetation, or wildlife resources would result from construction of sand plants in these segments.

St. Charles Segment

Under Alternative A, construction of a new sand plant at the Edward N. Rau Contractor Company property in the St. Charles segment could result in direct effects on up to 15.37 acres of forested wetlands, 4.24 acres of herbaceous-dominated wetlands, and 2.82 acres of open water (Table 4.7-2). The wetland characteristics of this site cannot be definitively determined until a wetland delineation is conducted. For the purpose of this assessment, it was assumed that all existing wetland resources on the property would need to be cleared and filled to construct the new facility. These activities would require that the facility operator obtain relevant CWA Section 404 and 401 certification and authorization, which would include required avoidance, minimization, and mitigation measures.

An additional 0.94 acre of cropland and grassland land covers could be directly affected by sand plant construction. Due to the historical conversion of wetlands to agricultural cropland, this area may retain some wetland characteristics if the land was a wetland prior to cultivation. Vegetative communities cannot be fully determined until a wetland delineation is conducted. Vegetation and wildlife species would be displaced in both upland and wetland areas. Species that depend on wetland trees would be displaced to nearby forested habitat, and some nesting and tree-cavity nesting species could suffer mortality or a decrease in breeding success. Mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality.

4.7.5 Alternative B

4.7.5.1 Indirect Effects on Wetlands and Wetland-Dependent Wildlife Species from Changes in Groundwater Levels

Dredging in the LOMR would not result in direct effects on wetland habitats because dredging activities would be limited to the areas within the channel of the LOMR. Dredging under Alternative B could affect alluvial aquifer levels and those wetlands that are groundwater dependent. Effects to wetlands associated with low-flow surface water elevations would be manifested during prolonged drought and dry periods.

Under Alternative B, the need for alternate sources of sand and gravel would be substantially less than under the No Action Alternative and Alternative A; therefore, fewer wetland-related impacts would be associated with alternate sources.

St. Joseph, Kansas City, and St. Charles Segments

Under Alternative B, river bed degradation would lead to slight to moderate long-term decreases in low-flow water surface levels. This effect in turn could lead to localized indirect effects on floodplain wetlands as a result of changes in groundwater levels that support floodplain wetlands. Under Alternative B, up to 6.66 acres of forested wetlands, 3.70 acres of scrub-shrub wetlands, and 439.24 acres of emergent wetlands, as identified in NWI data, could be affected by changes in groundwater levels. Note that these numbers are likely conservative due to the large quantity of wetlands that have been converted to agricultural lands in the LOMR floodplain that is not captured in the NWI data. Those wetlands closest to the LOMR would be most dramatically affected, particularly during prolonged dry periods. Emergent, scrub-shrub, and forested wetlands provide habitat for several state-listed species, migratory birds, and numerous common wildlife species. Loss or degradation of wetland habitats would result in displacement of the wetland-dependent species, but could provide additional upland habitat for other non-wetland-dependent species that are described in Section 3.10.

Waverly and Jefferson City Segments

Under Alternative B, dredging in the Waverly and Jefferson City segments would lead to slight long-term decreases in low-flow water surface levels. This effect in turn could lead to slight potential localized indirect effects on floodplain wetlands as a result of changes in groundwater levels that support floodplain wetlands. Because only a slight long-term decrease in low-flow water surface levels

is anticipated under this alternative, substantial impacts to groundwater resources and associated wetlands are not anticipated. Effects to groundwater-fed wetlands that are located nearest to the LOMR could occur during periods of prolonged drought. No changes to wetland habitats or species composition would be expected under Alternative B.

Alternate Sources

The wetland impacts from dredging in the Mississippi and Kansas Rivers and at open-pit mine sites under Alternative B would be similar to those described for alternate sources under the No Action Alternative and Alternative A, but of less magnitude. Under Alternative B, any river bed degradation associated with dredging alternate sources could lead to localized indirect effects on floodplain wetlands as a result of changes in surface water and groundwater surface levels on the Kansas and Mississippi Rivers.

Further, any expanded or new open-pit mines could result in wetland impacts and would be subject to relevant wetland permitting. New or expansion of open-pit and floodplain mining could result in conversion of wildlife habitat and vegetative land cover to industrial land covers. Impacts to wildlife species, such as species displacement and habitat modification, would be similar to those described for Alternative A but would occur in fewer locations.

4.7.5.2 Potential Impacts on Wetlands and Upland Vegetation and Habitats from Construction of Sand Plants

Kansas City Segment

Under Alternative B, The Master's Dredging Company plans to develop a sand plant at one of two sites near Waldron, Missouri in the Kansas City segment. The only land cover type on either site is cropland (Table 4.7-2). According to land cover data and aerial photo interpretation, the only land cover type on either site is cropland (Table 4.7-2). Based on available desktop data, no direct or indirect effects on wetland resources would be likely as a result of sand plant construction on either Master's site. The wetland characteristics of these sites cannot be definitively determined until a wetland delineation of the site is conducted.

During construction and operation, mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality. As described in Section 3.10, cropland is the most common land cover type in the LOMR floodplain; it is anticipated that species displaced by construction of this sand plant would quickly find suitable alternative habitat.

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under Alternative B; therefore, no direct or indirect effects on wetland, vegetation, or wildlife resources would result from construction of sand plants in these segments.

St. Charles Segment

Under Alternative B, construction of a new sand plant at the Edward N. Rau Contractor Company property in the St. Charles segment could result in direct effects on up to 15.37 acres of forested wetlands, 4.24 acres of herbaceous-dominated wetlands, and 2.82 acres of open water (Table 4.7-2). The wetland characteristics of this site cannot be definitively determined until a wetland delineation is conducted. For the purpose of this assessment, it was assumed that all existing wetland resources on the property would need to be cleared and filled to construct the new facility. These activities would require that the facility operator obtain relevant CWA Section 404 and 401 certification and authorization, which would include required avoidance, minimization, and mitigation measures.

An additional 0.94 acre of cropland and grassland land covers could be directly affected by sand plant construction. Due to the historical conversion of wetlands to agricultural cropland, this area may retain some wetland characteristics if the land was a wetland prior to cultivation. Vegetative communities cannot be fully determined until a wetland delineation is conducted. Vegetation and wildlife species would be displaced in both upland and wetland areas. Species that depend on wetland trees would be displaced to nearby forested habitat, and some nesting and tree-cavity nesting species could suffer mortality or a decrease in breeding success. Mobile species present in all habitats would disperse to adjacent habitats, while small non-mobile species could suffer mortality.

4.7.6 Alternative C

4.7.6.1 Indirect Effects on Wetlands and Wetland-Dependent Wildlife Species from Changes in Groundwater Levels

Dredging in the LOMR would not result in direct effects on wetland habitats because dredging activities would be limited to the areas within the channel of the LOMR. The volume of dredged sediment collected in all of the LOMR segments would be the same as current volumes; therefore, no new alternate sources would be required.

St. Joseph and Waverly Segments

Under Alternative C, the continued level of dredging effects on river bed degradation and the low-flow water surface levels would lead to a slight long-term reduction or no change in low-flow surface water elevations. This effect in turn could lead to slight, if any, potential localized indirect effects on floodplain wetlands as a result of changes in groundwater levels that support floodplain wetlands. Because only a slight long-term decrease in low-flow water surface levels is anticipated under this alternative, substantial changes in groundwater levels and associated wetlands are not anticipated. Effects to groundwater-fed wetlands that are located nearest to the LOMR could occur during periods of prolonged droughts. No changes to wetland habitats or species composition would be expected under Alternative C.

Kansas City, Jefferson City, and St. Charles Segments

Under Alternative C, river bed degradation could result in a moderate to substantial decreases in low-flow water surface levels, which could result in a long-term lowering of alluvial aquifer levels. Indirect effects on floodplain wetlands could occur under this alternative as a result of changes in groundwater levels that support floodplain wetlands. Under Alternative C, up to 6.66 acres of forested wetlands, 5.63 acres of scrub-shrub wetlands, and 199.11 acres of emergent wetlands, as identified in NWI data, could be affected by changes in groundwater levels. Note that these numbers are likely conservative due to the large quantity of wetlands that have been converted to agricultural lands in the LOMR floodplain. These wetlands provide habitat for several state-listed species, migratory birds, and numerous common wildlife species. Loss or degradation of wetland habitats would result in displacement of the wetland-dependent species but could provide additional upland habitat for other non-wetland-dependent species that are described in Section 3.10.

Alternate Sources

Dredging under Alternative C would remain at current levels; therefore, no alternate sources of sand and gravel would be required. Under Alternative C, the potential indirect effects on wetland habitats would not occur, such as wetland dredging or filling from upland and floodplain open-pit mines or alterations of groundwater levels and the associated floodplain wetland loss from dredging in the Mississippi or Kansas River. Further, direct or indirect mortality through the clearing of upland and floodplain open-pit sites would not occur.

4.7.6.2 Potential Impacts on Wetlands and Upland Vegetation and Habitats from Construction of Sand Plants

Kansas City Segment

The Master's Dredging Company plans to develop a sand plant at one of two sites near Waldron, Missouri in the Kansas City segment under Alternative C. According to land cover data and aerial photo interpretation, the only land cover type on either site is cropland (Table 4.7-2). Based on available desktop data, no direct or indirect effects on wetland resources would be likely as a result of sand plant construction on either Master's site. The wetland characteristics of these sites cannot be definitively determined until a wetland delineation of the site is conducted.

During construction and operation, mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality. As described in Section 3.10, cropland is the most common land cover type in the LOMR floodplain, and it is anticipated that species displaced by the construction of this sand plant would quickly find suitable alternative habitat.

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under Alternative C; therefore, no direct or indirect effects on wetland, vegetation, or wildlife resources would result from construction of sand plants in these segments.

St. Charles Segment

Under Alternative C, construction of a new sand plant at the Edward N. Rau Contractor Company property in the St. Charles segment could result in direct effects on up to 15.37 acres of forested wetlands, 4.24 acres of herbaceous-dominated wetlands, and 2.82 acres of open water (Table 4.7-2). The wetland characteristics of this site cannot be definitively determined until a wetland delineation is conducted. For the purpose of this assessment, it was assumed that all existing wetland resources on the property would need to be cleared and filled to construct the new facility. These activities would require that the facility operator obtain relevant CWA Section 404 and 401 certification and authorization, which would include required avoidance, minimization, and mitigation measures.

An additional 0.94 acre of cropland and grassland land covers could be directly affected by sand plant construction. Due to the historical conversion of wetlands to agricultural cropland, this area may retain some wetland characteristics if the land was a wetland prior to cultivation. Vegetative communities

cannot be fully determined until a wetland delineation is conducted. Vegetation and wildlife species would be displaced in both upland and wetland areas. Species that depend on wetland trees would be displaced to nearby forested habitat, and some nesting and tree-cavity nesting species could suffer mortality or a decrease in breeding success. Mobile species present in all habitats would disperse to adjacent habitats, while small, non-mobile species could suffer mortality.

4.7.7 Summary of Impacts

Table 4.7-3 presents a summary of potential impacts on wetlands, floodplains, and terrestrial resources associated with the Proposed Action and the alternatives.

4.7.8 References

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Table 4.7-3 Summary of Potential Impacts on Wetlands, Floodplains, and Terrestrial Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Indirect effects on wetlands and wetland-dependent wildlife species from changes in groundwater levels	• Short-term and long term loss of wetland acreage, altered composition of vegetation, and altered wetland habitat functions during periods of low flow in those segments most affected by river bed degradation.	• Increase in or stabilization of LOMR wetland habitats during low-flow periods in all segments. • Potential decrease in groundwater input into wetlands due to potential bed degradation in the Kansas and Mississippi Rivers.	• Increase in or stabilization of LOMR wetland habitats during low-flow periods in most segments. • Potential decrease in groundwater input into wetlands due to potential bed degradation in the Kansas and Mississippi Rivers.	• Short-term and long term loss of wetland acreage, altered composition of vegetation, and altered wetland habitat functions during periods of low flow in those segments most affected by river bed degradation. • Potential decrease in groundwater input into wetlands due to potential bed degradation in the Kansas and Mississippi Rivers.	• Short-term and long-term loss of wetland acreage, altered composition of vegetation, and altered wetland habitat functions during periods of low flow in those segments most affected by river bed degradation.
Potential impacts on wildlife and vegetation from construction of sand plants	• Displacement of mobile species and loss of non-mobile wildlife and vegetation species from clearing.	• Conversion of wildlife habitat and vegetative land cover to industrial land covers at alternate source sites.	• Displacement of mobile species and loss of non-mobile wildlife and vegetation species from clearing. • Conversion of wildlife habitat and vegetative land cover to industrial land covers at alternate source sites.	• Displacement of mobile species and loss of non-mobile wildlife and vegetation species from clearing. • Conversion of wildlife habitat and vegetative land cover to industrial land covers at alternate source sites.	• Displacement of mobile species and loss of non-mobile wildlife and vegetation species from clearing.

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4.8 FEDERALLY LISTED SPECIES

4.8.1 Introduction

This section describes the potential impacts of the Proposed Action and the alternatives on species federally listed as threatened or endangered, and their habitats in the Action Area. For the purposes of the Section 4.8 analysis, the term "Action Area" includes those portions of the LOMR that would be affected by dredging under the Proposed Action or alternatives. Therefore, the Action Area extends from Rulo, Nebraska to the mouth of the LOMR in St. Louis, Missouri. Federally listed species potentially present in the Action Area include pallid sturgeon, piping plover, interior least tern, Indiana bat, and decurrent false aster.

4.8.2 Assessment Methods

Documented species occurrence in the Action Area, their life history, and habitat needs were considered in relation to the amounts and locations of commercial sand and gravel dredging described for the Proposed Action and alternatives. Project-related impacts are evaluated in terms of the Action Area (opposed to the Project area, as discussed in the other EIS sections) because this section summarizes the biological assessment and assesses the potential Project-related impacts in the context of ESA consultation.

The potential direct and indirect impacts of dredging affecting the reproduction, growth, maturation, movements, and migrations of each species are considered in this section. Impacts that may affect federally listed species include those affecting riverine habitats, water quality, and physical disturbance from dredging. This section also considers impacts described in other resource sections, including water quality, aquatic ecology, and geology and geomorphology, as they relate to federally listed threatened and endangered species. This section does not evaluate the potential impacts of dredging within individual river segments because federally listed threatened and endangered species could occur throughout multiple segments of the Action Area, and the effects of dredging in one segment could affect individuals or populations in other locations within the Action Area.

4.8.3 Potential Impacts

Direct impacts would be limited to the time period during or shortly after dredging activity or sand plant construction. Individual organisms could be affected through injury, mortality, or behavioral modifications arising mostly from physical disturbance. Indirect impacts would include those that affect

habitat quality or quantity and could occur at the local or river-wide spatial scale as a result of geomorphic changes in the LOMR. Indirect impacts could occur in the short term and in the long term.

Impacts associated with some of the alternatives (the No Action Alternative and Alternatives A and B) may result from greater reliance on alternate sources of sand and gravel and could be short term (sand plant construction) or long term (dredging in other rivers). Because the locations of these alternate sources have not been definitively identified, the extent of these potential impacts cannot be quantified. Alternatives that would require greater use of alternate sources would have a greater potential to affect federally listed threatened and endangered species. The number of federally listed threatened or endangered species that would be potentially affected by alternate sources cannot be exhaustively listed because the exact location of alternate sources cannot be definitively determined. Some alternate sources would potentially affect species that also could be affected by dredging in the Action Area, while for other sources there would be little overlap of potential species affected. For example, in the *Final Regulatory Report and Environmental Impact Statement – Commercial Dredging Activities on the Kansas River, Kansas* (USACE 1990), the following species were identified within the dredging area at the time of EIS preparation: peregrine falcon (*Falco peregrinus*), least tern, piping plover, Eskimo curlew (*Numenius borealis*), Mead's milkweed (*Asclepias meadii*), and western prairie fringed orchid. Alternate sources would have the potential to affect these, and other, species with different listings depending on the alternate source type, location, habitats affected, and species abundance. Open-pit floodplain and upland mining would be more likely to affect terrestrial species, while alternate river dredging and instream mining would be more likely to affect waterbird, floodplain, and aquatic threatened or endangered species.

The potential for impacts to federally listed threatened or endangered species from alternate sources would be greatest under the No Action Alternative, followed by Alternative A and then Alternative B. No impacts to threatened or endangered species from the use of alternate sources would occur under the Proposed Action or Alternative C.

Special conditions and dredge exclusion zones would be in effect in permits, as described in Chapter 2, such as excluding dredging in some areas. Other restrictions and controls in dredging permits would prevent or minimize the potential for some negative impacts, for example to potential spawning habitat to protect pallid sturgeon.

As discussed in Section 3.10, in correspondence dated February 10, 2010, the USFWS indentified piping plover, interior least tern, pallid sturgeon, and Indiana bat as potentially occurring within or near

the LOMR (Ledwin pers. comm. [a]). Follow-up telephone correspondence with the USFWS indicated that the decurrent false aster could potentially occur in the LOMR floodplain in St. Charles County, Missouri (Ledwin pers. comm. [b]). Below is a discussion of the individual species that have been identified by the USFWS as potentially occurring within the Action Area and the potential impacts associated with the Proposed Action and the alternatives.

4.8.3.1 Pallid Sturgeon

The pallid sturgeon is found in the LOMR throughout the Action Area and uses various river segments for different life stages. Several entities (e.g., MDC and USFWS) stock hatchery-reared pallid sturgeon in the Action Area. These hatchery fish have been captured in several locations during population assessment sampling efforts. These fish have been documented spawning in the LOMR, indicating the survival and growth to reproductive maturity of hatchery fish (Delonay et al. 2009). Sampling of two segments of the LOMR was conducted in 2008 between the Platte River, Nebraska and Big Sioux River, Iowa; and Osage River, Missouri, upstream to the Grand River, Missouri (Delonay et al 2009). Of the 218 pallid sturgeon captured, 190 were hatchery-origin fish, and 28 were wild fish. Pallid sturgeon Population Assessment Project data from 2005 through 2009 are illustrated in Figure 4.8-1.

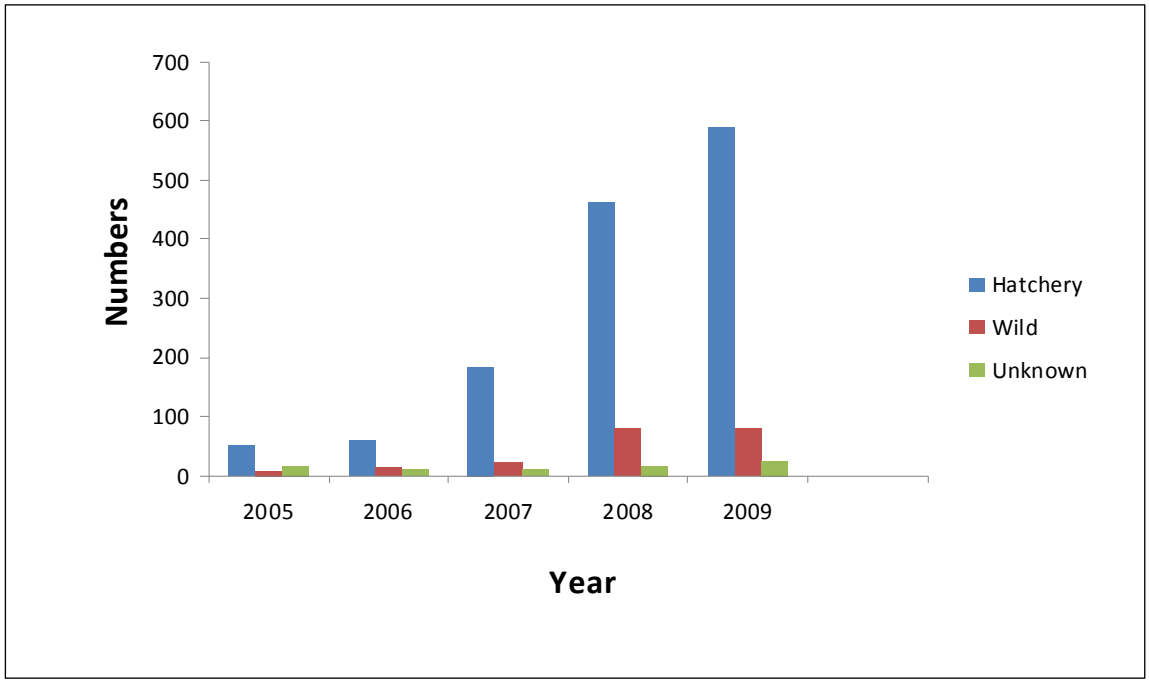

Figure 4.8-1 Pallid Sturgeon sampled by the Population Assessment Project (2005–2009)

Source: Covington pers. comm.

Direct and indirect effects on pallid sturgeon and their habitats would be similar to those described for aquatic resources (Section 4.6). Potential Project-related impacts to pallid sturgeon would include a negligible quantity of course substrate spawning habitat that may be subject to dredging, mortality through entrainment (incidental trapping of fish and other aquatic organisms in the dredge suction field or by the dredging vessel propeller), and alterations of shallow-water habitat.

Dredging may result in changes to benthic substrate at and downstream of dredging sites and potentially throughout the Action Area. Laustrup et al. (2007) surveyed the LOMR during low water conditions to identify and map coarse substrate deposits and bedrock exposures. These particular areas would likely serve as sturgeon and other coarse aggregate spawner habitat. A GIS coverage of the locations of aggregate areas was overlaid with the dredge areas (assuming that future dredging under all alternatives [except the No Action Alternative] would occur in similar locations) to estimate the quantity of dredging that would occur in areas containing potential spawning habitat. Approximately 219 acres of aggregate were identified within the Action Area. Of this quantity, a small amount (approximately 0.4 percent [0.8 acre]) of potential spawning habitat was found to be potentially subject to dredging. This would represent a small quantity of the mapped aggregate habitat in the Action Area.

Alterations of benthic substrate may diversify local benthic habitats. As discussed in Section 4.2, as dredging removes sand and gravel, coarser-grained material is returned to the LOMR 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 also can 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, tend to accumulate in areas with the most dredging (Simons, Li, and Associates 1985), and may result in a localized alteration of benthic habitat used by pallid sturgeon. While changes to benthic sediment and the associated pallid sturgeon habitat may result from dredging in the Action Area, data have not been collected in the Action Area to definitively characterize the dispersal patterns of coarse-grained sediment after dredging or how it may be used by pallid sturgeon.

For the portion of the LOMR between the Platte River, Nebraska and its confluence with the Mississippi River, the USFWS stated that larval and juvenile pallid sturgeon abundance is limited by the quantity of shallow-water habitat that provides rearing and refugia habitat for this life stage (USFWS 2003). Under the Proposed Action and some of the alternatives, portions of the Action Area would undergo river bed degradation in some to all river segments, which could lead to the alteration of shallow-water habitat

abundance and connectivity in both the short term and the long term. The effect of river bed degradation on shallow-water habitat abundance would vary depending on multiple site-specific conditions, such as the existing depth distribution and river flows. Under certain flow conditions, river bed degradation could increase the amount of shallow-water habitat by lowering the depth of water and velocity in dike fields. A more detailed assessment of the potential Project-related effects to shallow-water habitat is found in Section 4.6.

The importance of tributaries of the LOMR to pallid sturgeon is largely unknown. Tagged wild pallid sturgeon have been found to move short distances up some tributaries, which suggests that pallid sturgeon use tributaries opportunistically for feeding when conditions allow (DeLonay et al. 2009). As described in Section 4.2, river bed degradation under the Proposed Action and Alternatives B and C may contribute to increased tributary headcutting and altered surface water elevations. These geomorphic changes may result in decreased tributary habitat connectivity through tributary headcutting (as described in Section 4.2), which could slightly reduce tributary availability for pallid sturgeon feeding.

Increased injury or mortality to pallid sturgeon eggs, larvae, or juveniles through entrainment could occur at and near the dredge suction field and from dredging-related tugboat propellers. Section 4.6 contains a detailed analysis of potential dredging-related entrainment. Limited information is available regarding the rate of pallid sturgeon entrainment in the Action Area and throughout the species' range. The USACE has conducted dredging entrainment susceptibility studies of sturgeon and paddlefish species (Hoover et al. 2005). Intake water velocity, and the organism's susceptibility to entrainment in the intake water flow, is the primary determinant for entrainment, but there are other secondary variables affecting swimming behavior and performance that could influence and determine entrainment rates (Boyson and Hoover 2009). Researchers found that the rate of sturgeon entrainment at dredge heads would be determined, in part, by the organism's location relative to the dredge in the water column, their swim speed ability, and if the species readily swims against the current (rheotaxis) (Hoover et al. 2005). While these factors are important to determining entrainment levels, other factors such as the species' response to noise and turbidity, and it's localized abundance and distribution, also would affect entrainment rates (Hoover et al. 2005).

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 may also injure or kill pallid sturgeon eggs or larvae if they come in contact with the blades (Gutreuter et al 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. The extent of pallid sturgeon mortality would be a function of the amount of tow traffic in a given area and the distribution pallid sturgeon eggs and larvae within the Action Area.

There is uncertainty about the population-level effects of entrainment because of the uncertainty of egg, benthic juvenile, and drift larvae mortality that may occur naturally or due to entrainment. Under the alternatives that would include dredging (the Proposed Action and Alternatives A, B, and C), entrainment could occur if pallid sturgeon are present within the dredge suction field or eggs or larvae are present in the propeller inflow zone. The Action Area, depending on river stage, contains approximately 75,517 acres of total river area (as determined through GIS analysis). Approximately 17,506 acres of the Action Area currently undergoes dredging. Using the assumption that future dredging under all alternatives (except the No Action Alternative) would occur in similar locations, approximately 23 percent of the total Action Area could be subject to dredging.

A localized increased suspended sediment plume downstream of the dredge would be expected under the Proposed Action and the dredging alternatives, but the rate at which these local plumes occur would vary by alternative. As discussed in Section 3.7, the USGS estimates that suspended sediment levels in the LOMR have decreased approximately 70–80 percent compared to pre-impoundment conditions (Blevins 2006). Pallid sturgeon are tolerant of highly turbid environments and use turbidity as a cover habitat element. Decreased turbidity may have increased predation risk to small sturgeons that have historically used elevated turbidity as cover from sight-feeding piscivorous fishes (DeLonay et al. 2009). Because elevated suspended sediment plumes would extend only a short distance downstream of dredging activities, dredging could result in a slight temporary beneficial increase in cover habitat to pallid sturgeon that are located downstream of dredging activities. Localized areas with a slight increase in potential cover habitat would occur under all of the alternatives that contain dredging.

Sand plant construction under the Proposed Action and Alternatives A, B, and C would require land-clearing activities during construction, which could result in overland runoff or erosion from uncontained storm water. A bedrock patch located on an outside meander bend is located approximately one mile downstream of The Master's Dredging Company proposed sand plant at Waldron. Pallid sturgeon using potential spawning habitat there may be exposed to elevated suspended sediment from storm water runoff during construction. These facilities would likely require NPDES storm water permitting that would minimize the potential introduction of suspended sediment and contaminants to the LOMR. Further, due to the distance downstream of this habitat from the proposed sand plant facility,

suspended sediment levels are anticipated to return to background levels and not result in a significant impact to spawning habitat. Sensitive pallid sturgeon habitat was not identified downstream of the Edward N. Rau Contractor Company sand plant.

Alternate Sources

Upland and floodplain open-pit mining sources are not expected to substantially affect pallid sturgeon or their habitat. Uncontrolled storm water runoff could result in the introduction of contaminants to adjacent water bodies that may contain pallid sturgeon habitat, affecting pallid sturgeon or their habitat, although these impacts are expected to be minor.

Instream dredging in the Kansas and Mississippi Rivers has the potential to affect pallid sturgeon. Between 1952 and 2007, no captures of pallid sturgeon were recorded in the Kansas River (Niswonger et al. 2009). Since 2007, five hatchery-stocked pallid sturgeon have been captured near the mouth of the Kansas River between RM 5.8 and 14.3; therefore, dredging in the Kansas River could affect pallid sturgeon. The current Kansas River dredging permits limit the amount of sand that can be extracted from each reach of the river and limits river bed degradation in any 10-mile reach to no more than 2 feet from the baseline established when the EIS was completed (1990). Some reaches of the Kansas River already have been closed to dredging because degradation has surpassed 2 feet. Some of the tonnage authorized to be extracted from the remaining reaches of the river has not been extracted and could be extracted to make up for any decreased dredging in the Missouri River. However, increased dredging of sand and gravel from the Kansas River could result in river bed degradation beyond the 2-foot limit and would result in termination of dredging in those degraded reaches. Increasing the dredging or degradation limits in the Kansas River dredging permits would require a new EIS and consultation with the USFWS regarding potential impacts to federally listed threatened and endangered species, including the pallid sturgeon.

Potential impacts to pallid sturgeon from dredging in the Mississippi River could include entrainment and alteration of habitat. Dredging beyond the limits currently permitted by the USACE also would require separate consultation with the USFWS to minimize any impacts to pallid sturgeon. Based on consultation with the USFWS, the USACE permit conditions could include avoidance, minimization, and mitigation measures—such as restricted dredging locations or timing restrictions.

Instream mining in smaller rivers in Kansas or Missouri is not expected to affect the pallid sturgeon because this species occurs in large, turbid, free-flowing riverine habitats.

4.8.3.2 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 Proposed Action or any of the alternatives is not likely to affect piping plover populations or their nesting habitat.

Alternate Sources

The Kansas River floodplain provides nesting habitat for breeding pairs of piping plover, and the area has been state listed as critical habitat (KDWP 2004b). As discussed in Section 4.2, river bed degradation can reduce sand bar habitat. The EIS for commercial dredging activities in the Kansas River indicated the occurrence of river bed degradation in the Kansas River (USACE 1990). The current Kansas River dredging permits limit the amount of sand that can be extracted from each reach of the river and limits the degradation in any 10 mile reach to no more than 2 feet from the baseline established when the EIS was completed. Some reaches of the Kansas River have already been closed to dredging because degradation surpassed 2 feet. Some of the tonnage authorized to be extracted from the remaining reaches of the river is not currently extracted and could be extracted to make up for any decreased dredging in the Missouri River. However, increased sand and gravel dredging from the Kansas River could result in river bed degradation beyond the 2 feet limit and would result in the termination of dredging in those degraded reaches and could cause the erosion and elimination of sand bars and the associated piping plover habitat. Increasing the dredging or degradation limits in the Kansas River dredging permits would require a new EIS and consultation with the USFWS regarding potential impacts to federally listed threatened and endangered species, including the piping plover.

Floodplain open-pit mining and instream mining could eliminate sand bar habitat if these facilities were located on sand bars. More often, these activities increase nesting habitat in the floodplains of major

rivers through removal of vegetation to create sand flats that are similar to natural sand bars. Piping plover have been found to use sand pits created during floodplain mining along the Platte River in Nebraska for nesting (Sidle and Kirsch 1993). Typically, these human-made sand flats are used in the portions of the species historical range where natural sand bars are limited or have been eliminated. In areas where natural sand bars are limited, the increase in sand pit mines may alter the piping plover distribution (Sidle and Kirsch 1993). The Nebraska Game and Parks Department (NGPD) (NGPD 2010) reports a low success rate of interior least terns using open-pit mines due to frequent human disturbance and predation. It is anticipated that piping plover using floodplain open-pit mines would experience similar pressures. Due to increased disturbance at these sites, reproductive success is reduced compared to natural sand bars. Overall, the use of alternate floodplain and instream open-pit mines would provide additional nesting habitat, although the new habitat associated with floodplain mining would be of relatively low quality.

4.8.3.3 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 historical interior least tern breeding habitat was located along the Missouri River (USFWS 1992), 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 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 (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 not been found to occur within the Action Area. Historically, the interior least tern nested along the LOMR to St. Louis, Missouri (USACE 2004); therefore, this species may use the LOMR for breeding if suitable nesting habitat was present. Due to the general lack of suitable sand bar nesting habitat currently in the Action Area and the lack of breeding birds in the Action Area, dredging under any of the alternatives is not likely to affect interior least tern populations or their nesting habitat.

Alternate Sources

Impacts to interior least terns from alternate sources would be similar to those described for the piping plover. Least terns have been observed in the Mississippi River floodplain in Missouri (Smith and Renken 1991) and along the Kansas River. In-channel dredging in these rivers could contribute to river

bed degradation, which could lead to the erosion or elimination of sand bar habitat within the floodplains of these rivers. Thus, dredging in other rivers could negatively affect sand bar nesting habitat. Commercial dredging in the Kansas and Mississippi Rivers is already authorized by Department of the Army permits with restrictions limiting the amount of sand that can be dredged, Increasing dredging in these rivers beyond current limits would require separate consultation with the USFWS regarding potential impacts to federally listed threatened and endangered species, including the interior least tern.

Like the piping plover, least terns have been observed nesting at open-pit sand mines in Nebraska along the Platte River (Sidle and Kirsch 1993) and along the Mississippi River in Missouri (Renken and Smith 1991). It is likely that this species would use open-pit sand mines in the floodplains of other major rivers, particularly those rivers where natural floodplain sand bar habitat is limited. As discussed above, reproductive success at floodplain sand pit mines is diminished (NGPD 2010) compared to natural sand bars. Overall, the use of floodplain and instream open-pit mines along major rivers would result in the creation of low-quality interior least tern nesting habitat.

4.8.3.4 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 2007). 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 Proposed Action or any of the alternatives.

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 and the reduction in roosting and foraging forested habitat (MDC 2010b, USFWS 2010b). Construction of The Master's Dredging Company sand plant would affect only cropland, and examination of aerial photos indicate an absence of potential roosting trees at the proposed sand plant locations. Therefore, land-clearing activities for construction of The Master's Dredging Company sand plant is not expected to affect roosting trees. The Edward N. Rau Contractor Company sand plant would be constructed on lands with upland and wetland riparian forest vegetation, which may be appropriate roosting or foraging habitat for the Indiana bat. Because alteration and elimination of forested areas have been found to affect summer habitat for the Indiana bat, elimination of roosting trees could adversely affect Indiana bats. Critical habitat for the Indiana bat has been designated only

in caves that contain winter roosting habitat (USFWS 1976); therefore, neither the Proposed Action nor the alternatives would affect designated critical habitat for the Indiana bat.

Alternate Sources

Instream extraction from alternate sources would not directly affect Indiana bats or their habitat. Similar to the impacts described above, the disturbance of forested riparian, floodplain, or upland habitat through vegetation clearing in support of the expansion or creation of open-pit mines may result in elimination of summer roosting and foraging habitat. The use of alternate sources may result in impacts from vegetation clearing activities that could result in a decrease in summer roosting and foraging habitat.

4.8.3.5 Decurrent False Aster

The distribution of decurrent false aster in the Action Area 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 (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 to the decurrent false aster from dredging would occur under the Proposed Action or any of the alternatives. Indirect effects to decurrent false aster located in St. Charles County, Missouri could include alteration of wetland habitat due to LOMR river bed degradation and the associated changes in surface water and alluvial aquifer elevations. This could occur only under the Proposed Action and Alternatives B and C. This potential impact would be limited to the small area where the LOMR and Mississippi River floodplains overlap near the confluence of the two rivers. Because the decurrent false aster colonizes margins around previously inundated open water wetlands (MDC 2010c), the effect of lowering of the water elevation in open water wetlands within this small area could allow this species to establish in newly exposed areas. A minor change in groundwater input into wetlands in this area may result in increased establishment opportunities; however, a greater reduction of groundwater input that results in total elimination of wetland habitat (as discussed in Section 4.7) may result in elimination of potential decurrent false aster habitat.

Under the Proposed Action and Alternatives A, B, and C, construction of a new sand plant at the Edward N. Rau Contractor Company property in the St. Charles segment would result in direct effects on up to 15.37 acres of forested wetlands, 4.24 acres of herbaceous-dominated wetlands, and 2.82 acres of open water. Installation of sand plant facilities in these floodplain wetland areas could result in

elimination of decurrent false aster habitat if the species is present near the proposed sand plant facilities.

Because this species has not been identified in the Jefferson City, Waverly, Kansas City, or St. Joseph segments, there would be no direct or indirect impact on the species associated with sand plant construction in these segments.

Alternate Sources

Currently, the decurrent false aster is limited to Illinois and St. Charles County, Missouri (Natureserve 2009, MDC 1997). Use of alternate sources of sand and gravel outside of these areas would not affect this species. Instream dredging in the Mississippi River would not directly affect the decurrent false aster. If increased dredging in the Mississippi River contributed to river bed degradation and decreases in alluvial aquifer levels, wetland habitat for the decurrent false aster could be altered or eliminated. Commercial dredging in the Mississippi River is already authorized by Department of the Army permits with restrictions limiting the amount of sand that can be dredged. Increasing dredging in the Mississippi River beyond current limits would require consultation with the USFWS regarding potential impacts to federally listed threatened and endangered species, including the decurrent false aster.

Floodplain open-pit mining along the Mississippi and Illinois Rivers could result in physical disturbance to this species or its habitat, if the species is present in wetlands at the open-pit mining sites.

4.8.4 Summary of Impacts

Table 4.8-1 provides a summary of the potential impacts to federally listed threatened and endangered species in and near the Action Area.

Table 4.8-1. Summary of Potential Impacts on Federally Listed Species in and near the Action Area

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Pallid sturgeon	• Localized increase in cover habitat from suspended sediment. • Potential entrainment, if pallid sturgeon are present in the dredge suction field. • Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low flow surface water elevation	• No additional cover habitat from suspended sediment. • No potential for entrainment. • Increase in or stabilization of shallow-water habitat in the mainstem. • Potential entrainment and habitat alteration in the Kansas and Mississippi Rivers from alternate sources.	• Localized minor cover habitat from suspended sediment. • Potential entrainment, if pallid sturgeon are present in the dredge suction field. • Increase in or stabilization of shallow-water habitat in the mainstem in most areas. • Potential entrainment and habitat alteration in the Kansas and Mississippi Rivers from alternate sources.	• Localized minor cover habitat from suspended sediment. • Potential entrainment, if pallid sturgeon are present in the dredge suction field. • Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low flow surface water elevation. • Potential entrainment and habitat alteration in the Kansas and Mississippi Rivers from alternate sources.	• Localized minor cover habitat from suspended sediment. • Potential entrainment, if pallid sturgeon are present in the dredge suction field. • Potential alteration of shallow-water habitat and connectivity in those segments most affected by river bed degradation, removal of sediment load, and decreased low flow surface water elevations.
Piping plover	• No impact.	• Loss of sand bar habitat where associated with floodplains of alternate sources. • Increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• Increased loss of sand bar habitat in floodplains of alternate sources. • Minor increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• Increased loss of sandbar habitat in floodplains of alternate sources. • Minor increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• No impact.

Table 4.8-1. Summary of Potential Impacts on Federally Listed Species in and near the Action Area

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Interior least tern	• No impact.	• Loss of sand bar habitat where associated with floodplains of alternate sources. • Increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• Increased loss of sand bar habitat in floodplains of alternate sources. • Increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• Increased loss of sand bar habitat in floodplains of alternate sources. • Minor increase in human-made, low-quality nesting habitat at floodplain open-pit mines.	• No impact.
Indiana bat	• Potential roosting habitat cleared for sand plant construction.	• Increased loss of riparian habitat in floodplains of alternate sources.	• Potential roosting habitat cleared for sand plant construction. • Increased loss of riparian habitat in floodplains of alternate sources.	• Potential roosting habitat cleared for sand plant construction. • Increased loss of riparian habitat in floodplains of alternate sources.	• Potential roosting habitat cleared for sand plant construction.
Decurrent false aster	• Potential clearing of habitat and individuals as a result of sand plant construction.	• Potential loss of riparian and wetland habitat in floodplains of alternate sources.	• Potential clearing of habitat and individuals as a result of sand plant construction. • Increased potential for loss of riparian and wetland habitat in floodplains of alternate sources.	• Potential clearing of habitat and individuals as a result of sand plant construction. • Increased potential for loss of riparian and wetland habitat in floodplains of alternate sources.	• Potential clearing of habitat and individuals as a result of sand plant construction.

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4.9 LAND USE AND RECREATION

4.9.1 Introduction

This section describes impacts to land use and recreation related to the Proposed Action and alternatives. As discussed in Section 3.11, dredging under the Proposed Action and alternatives could affect land use and recreational resources adjacent to the river through changes in water levels, river bed degradation, and locations of dredging facilities and related activities.

Dredging along the LOMR is a historical and ongoing activity. Land use and recreation impacts would therefore occur only if implementation of the Proposed Action or alternatives would result in (1) a change in or conflict with an existing land use; or (2) a change in the availability or quantity of recreational opportunities as a result of changes in the rate of river bed degradation, processing amounts at existing facilities, or water surface elevations; construction of new facilities; or changes in the location of dredging activities.

4.9.2 Assessment Methods

4.9.2.1 Land Use

This section describes the methods used to analyze potential impacts on land use associated with the Proposed Action and the alternatives. As stated above, land use impacts would occur if implementation of an alternative would result in a change in or conflict with an existing land use. The analysis of land use impacts therefore primarily focuses on the new facilities that would be constructed under the Proposed Action, Alternative A, Alternative B, and Alternative C: Master's–Waldron in the Kansas City segment and Rau–Washington in the St. Charles segment. Consideration of land use impacts from construction of the new facilities is based on their potential to directly affect the land use on which the facilities would be built or to indirectly affect adjacent land use. Changes in the quantity of material processed at existing onshore facilities or alternate sources are also considered.

4.9.2.2 Recreation

This section describes the methods used to analyze potential impacts on recreation associated with the Proposed Action and the alternatives. The anticipated recreational opportunities, functions, and values under the Proposed Action and alternatives were compared with existing conditions to determine whether a decrease in recreational opportunities would occur, or whether dredging activities would

conflict with existing or planned recreational use. This analysis qualitatively addresses the severity and intensity of potential impacts within the context of existing conditions.

The analysis of recreation impacts considers (1) the direct impact of dredging on boaters because of the location of the dredges; and (2) the indirect impact of dredging on trail and boat ramp access from potential river bed degradation or changes in water surface elevation. Water surface elevations are critical for boat ramps, which rely on a predictable range of water levels in order to operate. Changes in river bed elevation and water surface elevation can alter sediment transport processes, and result in further changes in water surface elevation. Dredging affects river bed elevation (and therefore sediment transport and water surface elevation) and would be greatest in the segments with onshore facilities. Therefore, recreation impacts related to river bed degradation, such as lack of access to boat ramps, are likely to be greatest in segments with onshore facilities, as discussed in further detail below.

The discussion of recreation impacts related to the effects of the alternatives on wetlands is based on findings related to groundwater and terrestrial species in Section 4.7. These indirect impacts to wetland-related recreational use would result from a lowering of groundwater levels and would not necessarily occur in the same location as dredging activities. A loss of wetland area could reduce opportunities for wildlife viewing, bird watching, hiking, hunting, and educational opportunities. Any loss also would be contrary to the goals of the SCORP for Missouri and Kansas.

Impacts on recreation trails are discussed for land-based trails of statewide or national importance. Impacts on recreation trail access could be caused by varying water levels and their capacity to reduce or increase the occurrence of washouts, and could be indirectly linked to dredging activities. The Historic Trail follows the actual river with the exception of the 165-mile portion from St. Charles to Boonville, which is part of the Katy Trail. Recreationists on the river portion of the Historic Trail are considered boaters. Therefore, impacts on recreationists using the river portion of the Historic Trail are categorized with direct impacts to recreational boating from the presence of dredges and barges.

Dredging activities have the potential to affect fish and fish habitat in the LOMR—including those considered as sport fish, such as channel catfish, flathead catfish, sauger, crappie, white bass, largemouth bass, bluegill, and paddlefish. Changes in recreational fishing opportunities are based on expected effects on fish species, as discussed in Section 4.6.

4.9.3 Proposed Action

4.9.3.1 Changes in Existing or Planned Land Uses

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segments under the Proposed Action. Existing sand plants in these segments would process an increased amount of material, which would not affect the adjacent agricultural or industrial land uses. Therefore, no change in land use or adverse impact to adjacent land use would occur in these segments under the Proposed Action.

Kansas City Segment

Under the Proposed Action, The Master's Dredging Company would construct a new 20- to 60-acre onshore facility in the Kansas City segment near RM 388 on land designated by Platte County for agricultural use. The proposed facility would be constructed on land with a soil designation of prime farmland and a zoning designation of agricultural. Whether the land is in current agricultural production is unknown. The facility would convert up to 60 acres from an agricultural designation in Platte County, which would conflict with the designated land use. Industrial use is not allowed under the current agricultural zoning designation. Platte County would require a zoning change and a special use permit. The maximum 60 acres that would be converted represents 0.06 percent of the 93,138.7 acres of prime farmland in Platte County. This reduction in prime farmland would be minimal.

The land adjacent to the proposed facility is designated by Platte County as agricultural; however, the proposed industrial facilities would not conflict with adjacent land uses because the sand plant would not prevent or hinder agricultural use. All other Dredgers in the Kansas City segment would use existing facilities that are in compliance with local land use designations. Under the Proposed Action existing sand plants would continue to operate as they do now, except that processing amounts would increase.

St. Charles Segment

Under the Proposed Action, the Edward N. Rau Contractor Company would construct a new onshore facility (Rau–Washington) in the St. Charles segment near RM 67. The sand plant would be built on land designated by the City of Washington for heavy industrial use and therefore would not conflict with the zoning designation. The land appears undeveloped and is partially vegetated. The area adjacent

to the proposed facility site is also zoned for heavy industrial use; therefore, the proposed facility would not indirectly affect adjacent land use. Existing facilities in the St. Charles segment would continue to operate as they do now, except for processing an increased amount of material, which would not result in a land use conflict with adjacent agricultural or industrial land use.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes in existing or planned land uses would not occur at alternate source locations.

4.9.3.2 Changes in Recreational Boating

St. Joseph Segment

Under the Proposed Action, an increase in barge trips on the river related to the increase in material dredged could affect recreation boating, both in terms of the area available for boating and the quality of experience.[1] As stated in Section 4.4, the number of barge trips would increase by 252 percent compared to existing conditions. Interference with recreational boating related to additional barges would be lessened to the extent that (1) alternative boating areas are available in the LOMR; (2) barges are not concentrated in one area; and (3) Condition C of the dredging restrictions is enforced. Under Condition C, the Dredgers must not dredge within 200 feet of any dike, revetment, or other structure (e.g., boat ramp) built or authorized by the U.S. Government; nor within 100 feet of any normal bank line or island, without special authorization. Also, many recreational boating trips likely would occur outside of the main channel, where the dredges and barges would operate. The number of dredges on the river would not change.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Under the Proposed Action, barge trips would increase because of increased material extraction by 53 percent (Kansas City segment), 48 percent (Waverly segment), 74 percent (Jefferson City segment), and 166 percent (St. Charles segment). Views of barges and necessary rerouting of recreational boating trips due to additional barges on the river would be reduced to the extent that (1) alternative boating areas are available in the LOMR; (2) barges are not concentrated in one area; and (3) Condition C of the dredging restrictions is enforced. Many recreational boating trips likely would occur outside of the main channel, where the dredges and barges would operate. The number of dredges on the river would not change.

[1] Boat ramps are addressed in Section 4.9.4.4 for the Proposed Action.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes in recreational boating at alternate source locations would not occur.

4.9.3.3 Changes in Access to Boat Ramps

St. Joseph Segment

As discussed in Section 3.5, boat ramps are susceptible to local scour and deposition as channel flow characteristics change over time; this can damage the base of the ramps and limit access to the river during low-flow periods when the ramp base may be exposed. Based on the data provided in Section 4.2, the areas adjacent to the onshore facilities in the St. Joseph segment (where the most dredging would occur under the Proposed Action) would likely experience slight river bed degradation in the short term and moderate to substantial river bed degradation in the long term. The St. Joseph segment also would experience a slight reduction in low-flow water surface elevations in the short term and moderate to substantial reductions in low-flow water surface elevations in the long term. The increases in river bed degradation and low-flow water surface elevations in the long term would increase the likelihood of scour problems and damage to boat ramps. Between RM 445 and RM 455, up to 4 feet of river bed degradation could occur as a result of dredging activities. The likelihood of scour problems and damage to boat ramps would be reduced to the extent that boat ramps are maintained to address damages and fluctuations in water surface elevations.

In the St. Joseph segment, the Holliday–St. Joseph reach has seven boat ramps. If a boat ramp in the Holliday–St. Joseph reach does not receive routine maintenance, suffers substantial scour damage, or does not operate at low-flow water surface elevations caused by increased dredging, that boat ramp could be unusable for entire seasons or portions of seasons during low-flow periods. Nearby alternate ramps could be used; therefore, no substantial loss of recreation opportunity or access would occur. However, given the magnitude of potential river bed degradation between RM 445 and RM 455 under the Proposed Action, several ramps could be inoperable at the same time, resulting in decreased access to boat ramps.

Kansas City Segment

In the Kansas City segment, the Holliday–Riverside reach, the Holliday–Randolph reach, and the proposed Master's–Waldron reach each has two boat ramps, which would allow continued access during low-flow periods if a ramp was damaged by scour. Under the Proposed Action, moderate river

bed degradation in the short term and substantial river bed degradation in the long term is likely to occur in the Kansas City segment. Reductions in low-flow water surface elevations would be moderate in the short term and substantial in the long term. If multiple boat ramps were damaged and forced to close, boat ramp access would be lost. If only one ramp in a specific reach was forced to close, the decrease in accessibility would be less because the other boat ramp would remain available. The likelihood of disruptions to boat ramp access in the Kansas City segment would increase in the long term under the Proposed Action.

Waverly Segment

In the Waverly segment, the Capital–Lexington and Capital–Carrollton reaches each have two boat ramps, which would allow continued access during low-flow periods if a ramp was damaged by scour. Under the Proposed Action, the Waverly segment would experience slight river bed degradation or aggradation in the short term, and slight degradation in the long term. Under the Proposed Action, the Waverly segment is expected to experience a slight decrease or increase in low-flow water surface elevations in the short term, and a slight decrease in the long term compared to existing conditions. These slight geomorphic effects would not likely lead to substantial ramp damage, to the point of necessitating closure. The Proposed Action would not likely result in disrupted access to recreational boat ramps in the short term or the long term in the Waverly segment.

Jefferson City Segment

In the Jefferson City segment, reaches with sand plants each have at least two boat ramps—except for the Capital–Jefferson City reach and the Capital–Boonville reach, each of which has one boat ramp. Access to the LOMR in the reaches with multiple ramps would not likely be disrupted during low-flow periods under the Proposed Action, as long as only a portion of ramps (or no ramps) in a reach was closed. Under the Proposed Action, the Jefferson City segment would experience moderate river bed degradation in the short term and substantial river bed degradation in the long term. Decreases in low-flow surface water elevations would be slight in the short term and moderate in the long term. If the boat ramp in the Capital Sand–Jefferson City reach (Noren boat ramp) and the boat ramp in the Capital Sand–Boonville reach (Franklin Island boat ramp) required closure during low-flow periods because of scour damage, no other public access points would be available near the reach. Although this instance would reduce boat ramp access, proper maintenance of the ramps to address scour issues would lessen the likelihood of boat ramp closure. Under the Proposed Action, the likelihood of boat ramp access disruptions in the Jefferson City segment would increase in the long term.

St. Charles Segment

In the St. Charles segment, several sand plant reaches have only one nearby boat ramp. Under the Proposed Action, the St. Charles segment likely would experience moderate river bed degradation in the short term and substantial river bed degradation in the long term. Reductions in low-flow water surface elevations would be moderate in the short term and moderate to substantial in the long term under the Proposed Action. Where multiple boat ramps are present in a reach, a reduction in recreation access due to scour damage is unlikely because if one ramp is inaccessible, another ramp would be available nearby. However, if (1) proper maintenance to address scour issues was not completed on a single available ramp in a reach; and (2) river bed degradation damaged that ramp, boat ramp access would be disrupted and related recreational opportunities would decrease. The likelihood of disruptions to boat ramp access would increase in the long term in the St. Charles segment under the Proposed Action.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes in access to boat ramps at alternate source locations would not occur.

4.9.3.4 Changes in Wetlands-Related Recreational Opportunities

St. Joseph, Kansas City, Jefferson City, and St. Charles Segments

Under the Proposed Action, changes in groundwater levels could result in conversion of forested wetlands, scrub-shrub wetlands, and emergent wetlands suitable for several wetland-dependent state-listed species, migratory birds, and common wildlife species to upland forests, scrublands, and grasslands or seasonal wetlands more suitable to upland-dependent species. Conversion of wetlands to uplands also could remove these areas from federal regulation under Section 404 of the CWA and allow them to be cleared, filled, and used for agriculture, residential or commercial development. Conversion of wetland habitat to upland habitat could reduce recreational opportunities specifically related to wetlands, such as watching, hunting, trapping, and fishing wetland fish and wildlife species, particularly if the reduced opportunities occurred within designated recreation areas. However, within designated recreation areas, recreational opportunities such as hiking and camping, watching, hunting, and trapping upland wildlife would increase if wetlands were converted to uplands. The same impacts could occur on private lands unless the landowner chooses to clear or develop those new uplands that were previously regulated as wetlands. Table 4.9-1 shows the acreage of potential wetland conversion

for each segment by type of wetland habitat, as an indication of the potential disruptions to wetlands-related recreational opportunities.

Table 4.9-1 Potentially Converted Wetlands under the Proposed Action (acres)

Segment	Forested Wetlands	Scrub-Shrub Wetlands	Emergent Wetlands
St. Joseph	0	0	295.53
Kansas City	0	1.34	52.37
Waverly	0	0	0
Jefferson City	0	1.93	55.4
St. Charles	6.66	2.36	91.34

Waverly Segment

Under the Proposed Action, changes in groundwater levels potentially resulting in conversion or alteration of wetlands would not occur in the Waverly segment, or would be slight. Therefore, wetlands-related recreational opportunities in the Waverly segment are not expected to change.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes in wetland-related recreational opportunities at alternate source locations would not occur.

4.9.3.5 Changes in Access to Portions of Land-Based Recreation Trails

St. Joseph and Kansas City Segments

No land-based recreation trails of statewide or national importance are located in the St. Joseph or Kansas City segment. Therefore, no impacts on recreation trail access would occur in these segments under the Proposed Action.

Waverly Segment

Portions of the Katy Trail that are in the floodplain of the LOMR can be subject to washouts during flood events. These washouts can result in a temporary loss of access to portions of the trail and can damage the trail. An increase in high-flow water surface elevations could increase the likelihood, frequency, extent, and magnitude of washouts. Under the Proposed Action, high-flow water surface elevations would not change in the Waverly segment; therefore, no change in the likelihood, frequency,

extent, or magnitude of washouts would occur. Recreational trail closures related to washouts would not occur in the Waverly segment under the Proposed Action.

Jefferson City Segment

Portions of the Katy Trail and the paved portion of the Historic Trail in the Jefferson City segment are located in the floodplain and are prone to washouts during flood events. Under the Proposed Action, high-flow water surface elevations in the Jefferson City segment would increase in the long term, which could prolong or result in more frequent access limitations during flood events. Limits to trail access related to washouts under the Proposed Action would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR. The potential access limitations would be temporary and would occur during periods of low use (i.e., during or immediately following storms).

St. Charles Segment

Portions of the Katy Trail and the paved portion of the Historic Trail in the St. Charles segment are located in the floodplain and are prone to washouts during flood events. Under the Proposed Action, high-flow water surface elevations in the St. Charles segment would decrease in the short term and are likely to increase in the long term. Lower high-flow water surface elevations in the short term would result in reduced potential for washouts along the trail and increased recreational opportunities. In the long term, increased high-flow water surface elevations would lead to a greater likelihood, frequency, extent, and magnitude of washouts, resulting in more recreational trail closures related to washouts. Limits to trail access related to washouts under the Proposed Action would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR. The potential access limitations would be temporary and would occur during periods of low use (i.e., during or immediately following storms).

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, access to land-based recreational trails at alternate source locations would not change.

4.9.3.6 Changes in Recreational Fishing Opportunities

St. Joseph, Waverly, and Jefferson City Segments

The Proposed Action would increase the potential for fish entrainment, elevated noise, and elevated turbidity. Temporary localized noise avoidance behaviors in noise-sensitive fish species also would be

expected with an increase in dredging. Localized increases in suspended sediment downstream of the dredge would benefit species that are associated with turbid environments and would potentially adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-native species). No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under the Proposed Action. To the extent that sport fish populations decline because of the increased dredging that would occur under the Proposed Action, recreational fishing opportunities also would decline.

Kansas City Segment

The Proposed Action would increase the potential for fish entrainment, elevated noise, and elevated turbidity as well as temporary localized injury or mortality to fish eggs, larvae, and macroinvertebrates by entrainment. Temporary localized noise avoidance behaviors in noise-sensitive fish species would be expected with an increase in dredging. Localized increases in suspended sediment downstream of the dredge would benefit species that are associated with turbid environments and would potentially adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-native species). Sand plant construction under the Proposed Action would require land-clearing activities that could result in overland runoff or erosion from uncontained storm water. This would increase the chances of discharge of pollutants (e.g., gasoline, oil, and grease) into water bodies and aquatic habitats, which could affect fishes and other aquatic life through toxic or sub-lethal effects on reproduction, growth, and recruitment. To the extent that sport fish populations decline because of increased dredging and sand plant construction, recreational fishing opportunities also would decline.

St. Charles Segment

The Proposed Action would substantially increase the number of dredging areas in the St. Charles segment, with a corresponding increase in the potential for entrainment, elevated noise, and elevated turbidity. The Proposed Action would result in an increase in temporary localized injury or mortality to fish eggs, larvae, and macroinvertebrates by entrainment. Temporary localized noise avoidance behaviors in noise-sensitive fish species also would be expected related to an increase in dredging. Localized increases in suspended sediment downstream of the dredge would benefit species that are associated with turbid environments and would potentially adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-native species). Sand plant construction would require land-clearing activities that could result in overland runoff or erosion from uncontained storm water. This would increase the chances of discharge of pollutants (e.g., gasoline, oil, and grease) into water bodies and aquatic habitats that could affect fishes and other aquatic life

through toxic or sub-lethal effects on reproduction, growth, and recruitment. To the extent that sport fish populations decline because of increased dredging and sand plant construction, recreational fishing opportunities also would decline.

Alternate Sources

No alternate sources of supply would be required under the Proposed Action. Consequently, no changes would occur related to fish populations with no associated change to recreational fishing opportunities.

4.9.4 No Action Alternative

4.9.4.1 Changes in Existing or Planned Land Uses

All Segments

Under the No Action Alternative, no new facilities would be constructed that could conflict with zoning designations or affect adjacent land use. Abandonment of existing facilities could leave unused equipment and cleared and graded swaths of land near the river. Although this land would no longer be used for staging dredges or processing, the land could be used for other industrial uses requiring proximity to the river. The land would not necessarily be appropriate for conversion (at least in the short term) to recreational uses.

Alternate Sources

A substantial increase in reliance on alternate sources of sand and gravel would occur under the No Action Alternative. This analysis assumes that, in the short term, increased demand for sand and gravel would be met through supplies from currently permitted sources. An increase in production at the alternate source facilities has the potential to conflict with adjacent land uses. However, whether a land use conflict would occur cannot be determined without knowing the increase in production quantities, changes in operations, and specific facilities that would be used. In the long term, construction of new alternate source facilities has the potential to result in land use conflicts, depending on the location of the planned facility.

4.9.4.2 Changes in Recreational Boating

All Segments

Under the No Action Alternative, no Dredgers would operate in the LOMR. Barge traffic in the river would be substantially reduced, increasing the river area available for recreational boaters and increasing recreational opportunities.

Alternate Sources

Potential alternate sources of material include dredging from the Mississippi River and would result in an increase in barge traffic on the Mississippi River. The Kansas River is dredged with pipeline dredges, and barges are not used. Increased barge traffic would result in a greater likelihood of barges interfering with the recreational boating experience on the Mississippi River. The interference with the recreational experience resulting from the presence of additional barges would be reduced to the extent that (1) alternate boating areas are available in the river; (2) barges are not concentrated in one area; and (3) dredgers remain a certain distance from the shoreline and boat ramps. Many recreational boating trips likely would occur outside of the main river channel, where the dredges and barges would operate.

4.9.4.3 Changes in Access to Boat Ramps

All Segments

Under the No Action Alternative, changes in river bed elevations in the short term would range from slight river bed degradation to moderate aggradation. In the long term, changes in river bed elevations would range from slight river bed degradation to moderate aggradation—except for aggradation in the Kansas City reach, which could be substantial. Changes in low-flow surface water elevations in the short term would range from no change to a moderate increase. In the long term, changes in low-flow surface water elevations would range from no change in the Waverly segment; to a slight increase in the St. Joseph, Jefferson City, and St. Charles segments; to a potentially substantial increase in the Kansas City segment. Aggradation would reduce the potential for scour damage at boat ramps in the LOMR because of the lower likelihood of the sediment supporting the base of the ramps being eroded away. A reduction in the potential for scour damage would increase the likelihood that ramps could stay open during low-flow periods and maintain boat access. The Kansas City segment could experience the highest increase in consistency of access because of the greater potential for

substantial aggradation and increases in low-flow water surface elevation in the long term under the No Action Alternative.

Alternate Sources

Under the No Action Alternative, dredging activities likely would increase on the Kansas and Mississippi Rivers. Although the specific amount of increase in dredging is not known, some river bed degradation could occur on these rivers. If dredging increases on the Kansas River, accelerated degradation is likely to occur in the reaches where increased dredging occurs. Dredging may be halted when degradation reaches a certain threshold, dictated by dredging regulations on the Kansas River. Impacts on boat ramps would vary depending on the location of the dredging activities, extent and proximity of dredging, and associated changes in water surface elevation and river bed degradation rates. Any increase in river bed degradation could potentially increase scour at boat ramps on the Kansas and Mississippi Rivers. As a result, recreational access provided by boat ramps at alternate source locations could be disrupted.

4.9.4.4 Changes in Wetlands-Related Recreational Opportunities

All Segments

Under the No Action Alternative, no indirect impacts to wetlands related to dredging activities would occur in the LOMR. However, if open-pit mines are developed in the Missouri River floodplain in the long term, wetlands could be lost or converted to other habitat types, such as upland habitat. A loss in wetlands-related recreational opportunities would accompany the loss or conversion of wetlands.

Alternate Sources

The potential indirect effects of using alternate sources have not been quantified because the locations of alternate sources are not known at this time. However, river bed degradation associated with alternate sources of sand and gravel under the No Action Alternative could result in localized indirect effects on floodplain wetlands as a result of changes in surface water and groundwater surface elevations on the Kansas and Mississippi Rivers. This loss of wetlands could affect several state-listed species, migratory birds, and numerous common wildlife species by removal of suitable habitat. The loss of habitat could reduce recreational opportunities related to wetlands, particularly in designated recreation areas.

4.9.4.5 Changes in Access to Portions of Land-Based Recreation Trails

St. Joseph and Kansas City Segments

No land-based recreation trails of statewide or national importance exist in the St. Joseph or Kansas City segments. Therefore, recreation trail access would not change in these segments under the No Action Alternative.

Waverly Segment

Under the No Action Alternative, high-flow water surface elevations would not change in the Waverly segment. Therefore, the potential for washouts to occur and limit access along the Katy Trail and the Historic Trail would not change. Use of or access to the Katy Trail would not change under the No Action Alternative.

Jefferson City Segment

Under the No Action Alternative, high-flow water surface elevations likely would continue to follow existing long-term trends in the Jefferson City segment and likely would increase in the long term. The potential long-term increase in high-flow water surface elevations could increase the frequency or extent of washouts along the Katy Trail and the paved portion of the Historic Trail. Limits to trail access related to washouts would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR. The access limitations would be temporary and likely would occur during periods of low use (i.e., during or immediately following storms).

St. Charles Segment

High-flow water surface elevations are likely to increase in the St. Charles segment in the short term and long term under the No Action Alternative. The potential increase in high-flow water surface elevations could increase the frequency or extent of washouts along the Katy Trail and the paved portion of the Historic Trail. Limits to trail access related to washouts would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR. The access limitations would be temporary and likely would occur during periods of low use (i.e., during or immediately following storms).

Alternate Sources

It is not currently known how much dredging would increase along the Kansas and Mississippi Rivers; however, river bed degradation likely would occur in areas of increased dredging. If high-flow water

surface elevations decreased because of river bed degradation, the likelihood of washouts could decrease along any recreation trails located in the floodplain of either river, and access and recreational opportunities would increase. Recreation trail access could improve under the No Action Alternative.

4.9.4.6 Changes in Recreational Fishing Opportunities

All Segments

Because the No Action Alternative does not include dredging in the LOMR, fish populations would not experience entrainment or temporary behavioral modifications related to noise. No new facilities would be constructed in any segment under the No Action Alternative. Recreational fishing opportunities would not change in the long term.

Alternate Sources

Dredging in the Mississippi and Kansas Rivers under the No Action Alternative would result in similar impacts on aquatic species related to entrainment, noise, and turbidity as described for the LOMR. Development or expansion of upland, floodplain, or instream open-pit mines would not directly affect aquatic resources but could result in the removal of riparian habitat and introduction of contaminants via storm water (Section 4.5). These changes in water quality could result in behavioral changes, toxicity, and decreased reproductive success in fish. To the extent that these changes result in declining fish populations, recreational fishing opportunities would decrease.

4.9.5 Alternative A

4.9.5.1 Changes in Existing or Planned Land Uses

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under Alternative A. Existing facilities in these segments would experience an increase (St. Joseph segment) or decrease (Waverly and Jefferson City segments) in processing quantities, which would not affect adjacent agricultural or industrial land use. Therefore, no change in land use or adverse effects to adjacent land use would occur in these segments.

Kansas City Segment

Under Alternative A, The Master's Dredging Company would construct a new 20- to 60-acre onshore sand plant in the Kansas City segment near RM 388 on land designated by Platte County for

agricultural use. The proposed facility would be constructed on land with a soil designation of prime farmland and a zoning designation of agricultural. Whether the land is in current agricultural production is unknown. The sand plant would convert up to 60 acres from an agricultural designation in Platte County, which would conflict with the designated land use. Industrial use is not allowed under the current agricultural zoning designation. Platte County would require a zoning change and a special use permit. The maximum 60 acres that would be converted represents 0.06 percent of the 93,138.7 acres of prime farmland in Platte County. This reduction in prime farmland therefore would be minimal.

The land adjacent to the proposed facility is designated by Platte County as agricultural; however, the proposed industrial facilities would not conflict with adjacent land uses because the sand plant would not prevent or hinder agricultural use. All other Dredgers in the Kansas City segment would use existing facilities that are in compliance with local land use designations. Existing facilities would continue to operate as they do now, except that processing amounts would decrease under Alternative A.

St. Charles Segment

Under Alternative A, the Edward N. Rau Contractor Company would construct a new onshore facility (Rau–Washington) in the St. Charles segment near RM 67. The sand plant would be built on land designated by the City of Washington for heavy industrial use and therefore would not conflict with the zoning designation. The land appears undeveloped and is partially vegetated. The area adjacent to the proposed facility site is also zoned for heavy industrial use; therefore, the facility would not conflict with an adjacent land use designation. Existing facilities in the St. Charles segment would continue to operate as they do now, except that processing quantities would be lower under Alternative A. Reduced processing quantities would not disrupt adjacent land use.

Alternate Sources

Under Alternative A, reliance on alternate sources of sand and gravel would increase compared to existing conditions. This analysis assumes that increased demand for sand and gravel in the short term would be met through supplies from currently permitted sources. An increase in production at the alternate source facilities has the potential to conflict with adjacent land uses. However, whether a land use conflict would occur cannot be determined without knowing the increase in production quantities, changes in operations, and specific facilities that would be used. In the long term, construction of new alternate source facilities has the potential to result in land use conflicts, depending on the location of the planned facility.

4.9.5.2 Changes in Recreational Boating

St. Joseph Segment

Under Alternative A, increases in barge traffic would occur related to increased dredging. Barge trips would increase by 7 percent in the St. Joseph reach. Interference with recreational boating related to additional barges would be reduced to the extent that (1) alternative boating areas are available in the LOMR; (2) barges are not concentrated in one area; and (3) Condition C of the dredging restrictions is enforced. Also, many recreational boating trips likely would occur outside of the main channel, where the dredges and barges would operate. The number of dredges on the river would not change.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Under Alternative A, less dredging (26–80 percent) would occur in the Kansas City, Waverly, Jefferson City, and St. Charles segments compared to existing conditions. Less dredging would result in a reduction of barge traffic and less interference with recreational boaters.

Alternate Sources

Under Alternative A, increased amounts of material dredged from the Mississippi River would result in an increase in barge traffic on the Mississippi River. The Kansas River is dredged with pipeline dredges, and barges are not used. More barge traffic would result in a greater potential for conflicts with recreational boaters on the Mississippi River. To the extent that alternate areas for boating are available on the river and restrictions on dredging near boat ramps and other recreational facilities would be enforced (similar to those on the LOMR), potential conflicts with recreational boaters would be reduced.

4.9.5.3 Changes in Access to Boat Ramps

St. Joseph Segment

Under Alternative A, slight river bed degradation or aggradation likely would occur in the short term in the St. Joseph segment, with a potential for slight river bed degradation in the long term. Low-flow water surface elevations likely would be slightly reduced in the long term. These slight changes in low-flow water surface elevations would not likely result in substantial changes in the potential for scour to damage boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Kansas City Segment

Under Alternative A, slight river bed degradation or aggradation likely would occur in the short term in the Kansas City segment, and slight aggradation likely would occur in the long term. Low-flow water surface elevations could increase or decrease slightly in the short term and likely would increase slightly in the long term. Slight changes would not likely result in substantial changes in the potential for scour to damage boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Waverly Segment

Slight river bed degradation or aggradation likely would occur under Alternative A in the short term and the long term in the Waverly segment. Water surface elevations would remain similar to existing conditions. No changes or slight changes in river bed or water surface elevations would not substantially change the potential for scour to damage boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Jefferson City Segment

Slight river bed degradation or aggradation would like occur in the short term in the Jefferson City Segment under Alternative A, and slight river bed degradation likely would occur in the long term. A slight reduction or increase in low-flow water surface elevations would occur in the short term, and a slight decrease would occur in the long term. Slight changes in river bed or water surface elevations are not likely to substantially change the potential for scour to damage boat ramps.

St. Charles Segment

Slight river bed degradation or aggradation likely would occur in the short term and the long term in the St. Charles segment under Alternative A. Slight decreases or increases in low-flow water surface elevations likely would occur in the short term and the long term. Slight changes would not likely result in substantial changes in the potential for scour to damage boat ramps.

Alternate Sources

Under Alternative A, increased reliance on alternate sources of sand and gravel likely would increase dredging activities on the Kansas and Mississippi Rivers, which could result in some river bed degradation on these rivers. If dredging increases on the Kansas River, accelerated degradation is

likely to occur in the reaches where dredging increases occur. Dredging may be halted when degradation reaches a certain threshold, dictated by dredging regulations on the Kansas River. Impacts on boat ramps would vary depending on the location of boat ramps, the location of dredging activities, the extent and proximity of dredging, and associated changes in water surface elevation and river bed degradation rates. Any increase in river bed degradation could potentially increase scour at boat ramps on the Kansas and Mississippi Rivers, potentially resulting in more frequent ramp closures and decreased recreational access. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

4.9.5.4 Changes in Wetlands-Related Recreational Opportunities

All Segments

Under Alternative A, changes in groundwater levels that could result in conversion or alteration of wetlands would not take place or would be slight. Therefore, wetlands-related recreational opportunities are not expected to change in any of the segments because of changes in groundwater.

If open-pit mines are developed in the Missouri River floodplain in the long term, wetlands could be lost or converted to other habitat types, such as upland habitat, which could affect wetlands-related recreational opportunities.

Alternate Sources

The potential indirect effects on wetlands-related recreational opportunities related to increased reliance on alternate sources for production of sand and gravel have not been quantified because the locations of the alternative sources are not known at this time. However, river bed degradation associated with dredging at alternate sources could result in localized indirect effects on floodplain wetlands caused by changes in surface water and groundwater surface levels on the Kansas and Mississippi Rivers. This loss of wetlands could result in loss of suitable habitat for several state-listed species, migratory birds, and numerous common wildlife species. The loss of habitat would potentially reduce recreational opportunities related to wetlands, particularly in designated recreation areas.

4.9.5.5 Changes in Access to Portions of Land-Based Recreation Trails

St. Joseph and Kansas City Segments

No land-based recreation trails of statewide or national importance are located in the St. Joseph or Kansas City segment. Recreation trail access in these segments would not change under Alternative A.

Waverly and St. Charles Segments

Under Alternative A, high-flow water surface elevations would not change, nor would the frequency or severity of washouts along the Katy Trail or the paved portions of the Historic Trail. Recreation trail access would not be affected in these segments under Alternative A.

Jefferson City Segment

The potential long-term increase in high-flow water surface elevations in the Jefferson City segment that would occur under Alternative A could increase the frequency and extent of washouts along the Katy Trail and the paved portion of the Historic Trail. Limits to trail access related to washouts would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR.

Alternate Sources

It is not currently known how much dredging would increase along the Kansas and Mississippi Rivers because of reliance on alternate sources of sand and gravel under Alternative A; however, river bed degradation likely would occur in areas of increased dredging. If high-flow water surface elevations decreased because of river bed degradation, washouts could be less likely along recreation trails in the floodplain of either river, which would increase access and recreational opportunities.

4.9.5.6 Changes in Recreational Fishing Opportunities

St. Joseph Segment

Under Alternative A, entrainment, noise, and suspended sediment effects on individual aquatic species would be similar to those occurring under existing conditions. No change to recreational fishing would occur in the St. Joseph segment.

Kansas City and St. Charles Segments

Sand plant construction would require land-clearing activities that could result in overland runoff or erosion from uncontained storm water. This would increase the chances of discharge of pollutants (e.g., gasoline, oil, and grease) into water bodies and aquatic habitats that could affect fishes and other aquatic life through toxic or sub-lethal effects on reproduction, growth, and recruitment. To the extent that fish populations decline, recreational fishing opportunities would decrease.

Waverly and Jefferson City Segments

A decrease in the number of fish eggs, larvae, and macroinvertebrates that would be entrained would occur in the Waverly and Jefferson City segments under Alternative A. Because less noise would be produced under Alternative A, the short-term localized avoidance behaviors in noise-sensitive fish species would decrease. Given that dredging impacts on suspended sediment levels are localized and natural background sediment concentrations are relatively high in the LOMR, Alternative A would result in a minor, short-term improvement in water quality in these segments that would alleviate potential elevated suspended sediment effects on fish and macroinvertebrate communities. To the extent that these effects do not change fish populations, recreational fishing opportunities would not change.

Alternate Sources

Dredging in the Mississippi and Kansas Rivers would result in similar impacts on aquatic species related to entrainment, noise, and turbidity as described for the LOMR. Development or expansion of upland, floodplain, or instream open-pit mines would not directly affect aquatic resources but could result in the removal of riparian habitat and introduction of contaminants via storm water (Section 4.5). These changes in water quality could result in behavioral changes, toxicity, and decreased reproductive success in fish. To the extent that these changes result in declining fish populations, recreational fishing opportunities would decrease.

4.9.6 Alternative B

4.9.6.1 Changes in Existing or Planned Land Uses

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under Alternative B. Existing facilities in these segments would experience an increase (St. Joseph and Waverly segments) or decrease (Jefferson City segment) in processing quantities, which would not

affect adjacent agricultural or industrial land use. Therefore, no change in land use or adverse impact to adjacent land use would occur in these segments under Alternative B.

Kansas City Segment

Under Alternative B, The Master's Dredging Company would construct a new 20- to 60-acre onshore facility in the Kansas City segment near RM 388 on land designated by Platte County for agricultural use. The proposed facility would be constructed on land with a soil designation of prime farmland and a zoning designation of agricultural. Whether the land is in current agricultural production is unknown. The proposed sand plant would convert up to 60 acres from an agricultural designation in Platte County, which would conflict with the designated land use. Industrial use is not allowed under the current agricultural zoning designation. Platte County would require a zoning change and a special use permit. The maximum 60 acres that would be converted represents 0.06 percent of the 93,138.7 acres of prime farmland in Platte County. The adverse impact to prime farmland would therefore be minimal.

The land adjacent to the proposed sand plant is designated by Platte County as agricultural; however, the proposed industrial facilities would not conflict with adjacent land uses because the sand plant would not prevent or hinder agricultural use. All other Dredgers in the Kansas City segment would use existing facilities that are in compliance with local land use designations. Existing facilities in the Kansas City segment would continue to operate as they do now, except that processing amounts would decrease under Alternative B compared to existing conditions.

St. Charles Segment

Under Alternative B, the Edward N. Rau Contractor Company would construct a new onshore facility (Rau–Washington) in the St. Charles segment near RM 67. The facility would be built on land designated by the City of Washington for heavy industrial use and therefore would not conflict with the zoning designation. The land appears undeveloped and is partially vegetated. The area adjacent to the proposed facility site is also zoned for heavy industrial use; therefore, the facility would not conflict with the adjacent land use. Existing facilities in the St. Charles segment would continue to operate as they do now, except that processing quantities would be lower under Alternative B compared to existing conditions, which would not disrupt adjacent land use.

Alternate Sources

Under Alternative B, reliance on alternate sources of sand and gravel would increase. This analysis assumes that increased demand for sand and gravel would be met through supplies from currently

permitted sources in the short term. An increase in production at the alternate source facilities could potentially conflict with adjacent land uses. However, whether a land use conflict would occur cannot be determined without knowing the increase in production quantities, changes in operations, and specific facilities that would be used. In the long term, construction of new alternate source facilities has the potential to result in land use conflicts, depending on the location of the planned facility.

4.9.6.2 Changes in Recreational Boating

St. Joseph and Waverly Segments

Increases in barge traffic would accompany increased dredging in the St. Joseph and Waverly segments under Alternative B. Barge trips would increase by 163 percent in the St. Joseph reach and 68 percent in the Waverly reach. Interference with recreational boating because of additional barges would be reduced to the extent that (1) alternative boating areas are available in the LOMR; (2) barges are not concentrated in one area; and (3) Condition C of the dredging restrictions is enforced. In addition, many recreational boating trips likely would occur outside of the main channel, where the dredges and barges would operate. The number of dredges on the river would not change.

Kansas City, Jefferson City, and St. Charles Segments

Under Alternative B, less dredging (38–54 percent) would occur in the Kansas City, Jefferson City, and St. Charles segments compared to existing conditions. Less dredging would result in a reduction of barge traffic and less interference with recreational boaters.

Alternate Sources

Under Alternative B, increased amounts of material dredged from the Mississippi River would result in an increase in barge traffic on the Mississippi River. The Kansas River is dredged with pipeline dredges, and barges are not used. More barge traffic would result in a greater potential for conflicts with recreational boaters on the Mississippi River. To the extent that alternate areas for boating are available on the river and restrictions to dredging near boat ramps and other recreational facilities would be enforced (similar to those on the LOMR), conflicts with recreational boaters would be reduced.

4.9.6.3 Changes in Access to Boat Ramps

St. Joseph Segment

Under Alternative B, slight river bed degradation would occur in the short term in the St. Joseph segment, and slight to moderate river bed degradation would occur in the long term. Low-flow water surface elevations would decrease slightly in the short term and would decrease slightly to moderately in the long term. Potentially moderate levels of river-bed degradation and decreases in low-flow water surface elevations in the long term would increase the likelihood of scour problems and damage to boat ramps, also in the long term. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Kansas City Segment

Under Alternative B, river bed degradation and decreases in low-flow water surface elevations in the Kansas City segment would be slight in the short term. Moderate river bed degradation and slight to moderate decreases in low-flow water surface elevations, in the long term, could increase the likelihood of scour problems and damage to boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Waverly Segment

Under Alternative B, changes in river bed elevation and low-flow water surface elevations in the Waverly segment would be slight in the short term. Slight river bed degradation and decreases in low-flow water surface elevations that would occur in the long term would not likely result in substantial changes in the potential for scour to damage boat ramps.

Jefferson City Segment

Under Alternative B, slight river bed degradation would occur in the short term in the Jefferson City segment, and slight decreases in low-flow water surface elevations would occur in the long term. Slight to moderate river bed degradation that would occur in the long term could increase the likelihood of scour problems and damage to boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

St. Charles Segment

Under Alternative B, slight river bed degradation would occur in the short term in the St. Charles segment. Slight to moderate river bed degradation and decreases in low-flow water surface elevations that would occur in the long term could increase the likelihood of scour problems and damage to boat ramps. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Alternate Sources

Under Alternative B, dredging activities likely would increase on the Kansas and Mississippi Rivers. Although the amount of dredging that would occur is currently unknown, some river bed degradation on these rivers could occur. If dredging increases on the Kansas River, accelerated degradation is likely to occur in the reaches where increased dredging occurs. Dredging may be halted when degradation reaches a certain threshold, dictated by dredging regulations on the Kansas River. Impacts on boat ramps would vary depending on the location of boat ramps, the location of the dredging activities, the extent and proximity of dredging, and associated changes in water surface elevation and river bed degradation rates. Any increase in river bed degradation could increase scour at boat ramps on the Kansas and Mississippi Rivers and could result in closure of boat ramps and disrupted recreational access. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

4.9.6.4 Changes in Wetlands-Related Recreational Opportunities

St. Joseph, Kansas City, and St. Charles Segments

Under Alternative B, changes in groundwater levels could result in conversion of forested wetlands, scrub-shrub wetlands, and emergent wetlands suitable for several wetland-dependent state-listed species, migratory birds, and common wildlife species to upland forests, scrublands, and grasslands or seasonal wetlands more suitable to upland-dependent species. Also, this conversion of wetlands to uplands could remove these areas from federal regulation under Section 404 of the CWA and allow them to be cleared, filled, and used for agriculture or residential or commercial development. Conversion of wetland habitat to upland habitat could reduce recreational opportunities specifically related to wetlands, such as watching, hunting, trapping, and fishing wetland fish and wildlife species, particularly if the reduced opportunities occurred within designated recreation areas. However, within designated recreation areas, recreational opportunities such as hiking and camping, and watching, hunting, and trapping upland wildlife would increase if wetlands were converted to uplands. The same

impacts could occur on private lands unless the landowner chooses to clear or develop those new uplands that were previously regulated as wetlands. Table 4.9-2 shows the acreage of wetland loss for these segments by type of wetland habitat, as an indication of the potential disruptions to wetlands-related recreational opportunities.

Table 4.9-2 Potentially Converted Wetlands under Alternative B (acres)

Segment	Forested Wetlands	Scrub-Shrub Wetlands	Emergent Wetlands
St. Joseph	0	0	295.53
Kansas City	0	1.34	52.37
Waverly	0	0	0
Jefferson City	0	0	0
St. Charles	6.66	2.36	91.34

If open-pit mines are developed in the Missouri River floodplain in the long term, wetlands could be lost or converted to other habitat types, such as upland habitat. A loss in wetlands-related recreational opportunities would accompany the loss or conversion of wetlands.

Waverly and Jefferson City Segments

Under Alternative B, changes in groundwater levels potentially resulting in conversion or alteration of wetlands would not occur or would be slight in the Waverly and Jefferson City segments. Therefore, wetlands-related recreational opportunities are not expected to change in these segments because of changes in groundwater.

Alternate Sources

River bed degradation associated with dredging alternate sources under Alternative B could cause localized indirect effects on floodplain wetlands because of changes in surface water and groundwater surface levels on the Kansas and Mississippi Rivers. This loss of wetlands could result in loss of suitable habitat for several state-listed species, migratory birds, and numerous common wildlife species. The loss of habitat could reduce recreational opportunities related to wetlands, particularly if the loss occurred in designated recreation areas.

4.9.6.5 Changes in Access to Portions of Land-Based Recreation Trails

St. Joseph and Kansas City Segments

No land-based recreation trails of statewide or national importance are located in the St. Joseph or Kansas City segments; consequently, recreation trail access would not change under Alternative B in these segments.

Waverly Segment

Under Alternative B, high-flow water surface elevations would not change in the Waverly segment. The frequency or severity of washouts along the Katy Trail or the paved portion of the Historic Trail would not change.

Jefferson City and St. Charles Segments

Under Alternative B, the potential long-term increase in high-flow water surface elevations that would occur could increase the frequency or extent of washouts along the Katy Trail and the paved portion of the Historic Trail in the Jefferson City and St. Charles segments. Limits to trail access related to washouts would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR.

Alternate Sources

Under Alternative B, river bed degradation likely would occur in areas of increased dredging of alternate sources. If high-flow water surface elevations decreased because of river bed degradation, washouts could be less likely along recreation trails in the floodplain of either the Kansas or Mississippi River, which would increase access and recreational opportunities.

4.9.6.6 Changes in Recreational Fishing Opportunities

St. Joseph Segment

Under Alternative B, the potential for entrainment, elevated noise, and elevated turbidity would increase. Increased dredging would result in temporary localized increases in injury or mortality to fish eggs, larvae, and macroinvertebrates by entrainment. Temporary localized noise avoidance behaviors in noise-sensitive fish species would also be expected related to an increase in dredging. Localized increases in suspended sediment downstream of the dredge would benefit species that are associated with turbid environments and would potentially adversely affect those species with greater sensitivity to

increased levels of suspended sediment (such as non-natives). To the extent fish populations decline, recreational fishing opportunities would decrease.

Kansas City Segment

Under Alternative B, the number of fish eggs, larvae, and macroinvertebrates that would be entrained would decrease. This alternative would decrease the short-term localized avoidance behaviors in noise-sensitive fish species. The minor short-term improvement in water quality in these segments would alleviate potential effects of elevated suspended sediment on fish and macro-invertebrate communities. Sand plant construction under Alternative B would require land-clearing activities during construction that could result in overland runoff or erosion from uncontained storm water. These changes in water quality could result in acute or chronic toxicity and sub-lethal effects that could affect reproduction, growth, and recruitment in individuals downstream of the new sand plant facilities. Recreational fishing opportunities would decline to the extent that fish populations decline.

Waverly Segment

The potential for entrainment, elevated noise, and elevated turbidity would increase. Increased dredging would result in temporary localized increases in injury or mortality to fish eggs, larvae, and macroinvertebrates by entrainment. Temporary localized noise avoidance behaviors in noise-sensitive fish species also would be expected. Localized increases in suspended sediment downstream of the dredge would benefit species that are associated with turbid environments and would potentially adversely affect those species with greater sensitivity to increased levels of suspended sediment (such as non-natives). Recreational fishing opportunities would decline to the extent that fish populations decline.

Jefferson City Segment

Under Alternative B, the number of fish eggs, larvae, and macroinvertebrates that would be entrained would decrease. This alternative would decrease the short-term localized avoidance behaviors in noise-sensitive fish species. The minor short-term improvement in water quality in these segments would alleviate potential effects of elevated suspended sediment on fish and macroinvertebrate communities. Recreational fishing opportunities would decline to the extent that fish populations decline.

St. Charles Segment

The number of fish eggs, larvae, and macroinvertebrates that would be entrained would decrease. This alternative would decrease the short-term localized avoidance behaviors in noise-sensitive fish species. The minor short-term improvement in water quality in these segments would alleviate potential elevated suspended sediment effects on fish and macroinvertebrate communities. Sand plant construction under Alternative B would require land-clearing activities during construction that could result in overland runoff or erosion from uncontained storm water. This would increase the chances of discharge of pollutants (e.g., gasoline, oil, grease) into water bodies and aquatic habitats that could affect fishes and other aquatic life through toxic or sub-lethal effects on reproduction, growth, and recruitment. Recreational fishing opportunities would decline to the extent that fish populations decline.

Alternate Sources

Dredging in the Mississippi and Kansas Rivers would result in similar impacts on aquatic species related to entrainment, noise, and turbidity as described for the LOMR. Development or expansion of upland, floodplain, or instream open-pit mines would not directly affect aquatic resources but could result in the removal of riparian habitat and introduction of contaminants via storm water (Section 4.5). These changes in water quality could result in behavioral changes, toxicity, and decreased reproductive success in fish. To the extent that these changes result in declining fish populations, recreational fishing opportunities would decrease in alternate source locations.

4.9.7 Alternative C

4.9.7.1 Changes in Existing or Planned Land Uses

St. Joseph, Waverly, and Jefferson City Segments

No new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment under Alternative C. Existing facilities in these segments would experience an increase (St. Joseph and Waverly segments) or decrease (Jefferson City segment) in processing quantities, which would not affect adjacent agricultural or industrial land use. Therefore, no change in land use or adverse impact to adjacent land use would occur in these segments under Alternative C.

Kansas City Segment

Under Alternative C, The Master's Dredging Company would construct a new 20- to 60-acre onshore facility in the Kansas City segment near RM 388 on land designated by Platte County for agricultural

use. The proposed facility would be constructed on land with a soil designation of prime farmland and a zoning designation of agricultural. Whether the land is in current agricultural production is unknown. The proposed sand plant would convert up to 60 acres from an agricultural designation in Platte County, which would conflict with the designated land use. Industrial use is not allowed under the current agricultural zoning designation. Platte County would require a zoning change and a special use permit. The maximum 60 acres that would be converted represents 0.06 percent of the 93,138.7 acres of prime farmland in Platte County. The adverse impact to prime farmland therefore would be minimal.

The land adjacent to the proposed sand plant is designated by Platte County as agricultural; however, the proposed industrial facilities would not conflict with adjacent land uses because the sand plant would not prevent or hinder agricultural use. All other Dredgers in the Kansas City segment would use existing facilities that are in compliance with local land use designations. Existing facilities in the Kansas City segment would continue to operate as they do now, except that processing amounts would decrease under Alternative C compared to existing conditions.

St. Charles Segment

Under Alternative C, the Edward N. Rau Contractor Company would construct a new onshore facility (Rau–Washington) in the St. Charles segment near RM 67. The facility would be built on land designated by the City of Washington for heavy industrial use and therefore would not conflict with the zoning designation. The land appears undeveloped and is partially vegetated. The area adjacent to the proposed facility site is also zoned for heavy industrial use; therefore, the facility would not conflict with the adjacent land use. Existing facilities in the St. Charles segment would continue to operate as they do now, except that processing quantities would be lower under Alternative C, which would not disrupt adjacent land use.

Alternate Sources

Under Alternative C, no new alternate sources of sand and gravel would be required. Therefore, no new construction would occur either in the short term or the long term for the purposes of providing alternate sources of sand and gravel.

4.9.7.2 Changes in Recreational Boating

All Segments

Under Alternative C, dredging would be similar to existing conditions. No additional barge traffic would be present under Alternative C. Therefore, increased interference with recreational boaters would not occur.

Alternate Sources

No new alternate sources would be required under Alternative C. Therefore, no new dredging would occur on the Kansas or Mississippi River, and no changes to recreational boating would occur on those rivers.

4.9.7.3 Changes in Access to Boat Ramps

St. Joseph Segment

Under Alternative C, slight river bed aggradation or degradation in the short term, and slight river bed degradation in the long term would occur in the St. Joseph segment. Low-flow surface water elevations would slightly decrease in the long term. Slight changes are not likely to result in substantial changes in the potential for scour to damage boat ramps.

Kansas City Segment

Under Alternative C, slight to moderate river bed degradation and decreases in low-flow water surface elevations would occur in the short term. Substantial river bed degradation and moderate to substantial decreases in low-flow surface water elevations would occur in the long term. If multiple boat ramps are damaged and forced to close, boat ramps would become less accessible. If only one ramp in a specific reach was forced to close, another boat ramp would remain available. The likelihood of disruptions to boat ramp access would increase in the long term. Proper maintenance of boat ramps would reduce the likelihood of scour problems and damage from fluctuations in water surface elevations, and the resulting disruptions to recreational uses.

Waverly Segment

Under Alternative C, slight river bed aggradation or degradation would occur in the short term and the long term in the Waverly segment. Low-flow surface water elevations would not change. Slight changes are not likely to result in substantial changes in the potential for scour to damage boat ramps.

Jefferson City Segment

Under Alternative C, slight river bed degradation would occur in the short term, and moderate to substantial river bed degradation would occur in the long term in the Jefferson City segment. Low-flow surface water elevations would decrease slightly in the short term, and would experience moderate to substantial decreases in the long term. If the boat ramp in the Capital Sand—Jefferson City reach (Noren boat ramp) and the boat ramp in the Capital Sand—Boonville reach (Franklin Island boat ramp) were damaged by scour and required closure during low-flow periods, no other public access points would be available near the reach. Although this instance would disrupt boat ramp access, proper maintenance of the ramps to address scour issues would reduce the likelihood of needing to close the boat ramps. The likelihood of boat ramp access disruptions would increase in the long term.

St. Charles Segment

Under Alternative C, slight river bed degradation in the St. Charles segment would occur in the short term; moderate to substantial river bed degradation likely would occur in the long term. Low-flow water surface elevations would decrease slightly in the short term and decrease slightly to moderately in the long term. If proper maintenance to address scour issues was not completed on a ramp on which a reach is solely dependent, and river bed degradation or low-flows damaged that ramp, boat ramp access would be disrupted and related recreational opportunities would decrease. The likelihood of boat ramp access disruptions would increase in the long term in the St. Charles segment under Alternative C.

4.9.7.4 Changes in Wetlands-Related Recreational Opportunities

Kansas City, Jefferson, and St. Charles Segments

Under Alternative C, changes in groundwater levels in the Kansas City, Jefferson City, and St. Charles segments could result in conversion of forested wetlands, scrub-shrub wetlands, and emergent wetlands suitable for several wetland-dependent state-listed species, migratory birds, and common wildlife species to upland forests, scrublands, and grasslands or seasonal wetlands more suitable to upland-dependent species. Also, this conversion of wetlands to uplands could remove these areas from federal regulation under Section 404 of the CWA and allow them to be cleared, filled, and used for agriculture or residential or commercial development. Conversion of wetland habitat to upland habitat could reduce recreational opportunities specifically related to wetlands, such as watching, hunting, trapping, and fishing wetland fish and wildlife species, particularly if the reduced opportunities occurred within designated recreation areas. However, within designated recreation areas, recreational

opportunities such as hiking and camping, and watching, hunting, and trapping upland wildlife would increase if wetlands were converted to uplands. The same impacts could occur on private lands unless the landowner chooses to clear or develop those new uplands that were previously regulated as wetlands. Table 4.9-3 shows the acreage of wetland loss by type of wetland habitat, as an indication of the potential disruptions to wetlands-related recreational opportunities.

Table 4.9-3 Potentially Converted Wetlands under Alternative C (acres)

Segment	Forested Wetlands	Scrub-Shrub Wetlands	Emergent Wetlands
St. Joseph	0	0	0
Kansas City	0	1.34	52.37
Waverly	0	0	0
Jefferson City	0	1.93	55.4
St. Charles	6.66	2.36	91.34

St. Joseph and Waverly Segments

Under Alternative C, changes in groundwater levels potentially resulting in conversion or alteration of wetlands would not occur or would be slight in the Waverly and Jefferson City segments. Therefore, wetlands-related recreational opportunities are not expected to change because of changes in groundwater in these segments.

Alternate Sources

Under Alternative C, dredging at alternate locations would not be required to meet regional demand. Therefore, floodplains and wetlands would not change, and no changes to wetlands-related recreational activities would occur.

4.9.7.5 Changes in Access to Portions of Land-Based Recreation Trails

St. Joseph and Kansas City Segments

No land-based recreation trails of statewide or national importance are located in the St. Joseph or Kansas City segment; therefore, no impacts on recreation trail access would occur under Alternative C.

Waverly Segment

Under Alternative C, high-flow surface water elevations in the Waverly segment would not change, with no associated potential increase in the occurrence or severity of washouts along the Katy Trail and the Historic Trail.

Jefferson City and St. Charles Segments

Under Alternative C, high-flow water surface elevations would increase in the long term in the Jefferson City and St. Charles segments, which could prolong or make more frequent access limitations during flood events. Limits to trail access related to washouts would be reduced to the extent that the trails are regularly maintained and repaired, as needed, by the MDNR. The access limitations would be temporary and likely would occur during periods of low use (i.e., during or immediately following storms).

Alternate Sources

No additional dredging would occur at alternate sources that could change high-flow water surface elevations. Therefore, no disruptions to trail access would occur under Alternative C related to using alternate sources for sand and gravel.

4.9.7.6 Changes in Recreational Fishing Opportunities

St. Joseph, Waverly, and Jefferson City Segments

Under Alternative C, the rate of entrainment and noise production would not change substantially. Recreational fishing opportunities therefore would not change.

Kansas City and St. Charles Segments

Sand plant construction under Alternative C would require land-clearing activities in the St. Charles segment during construction that could result in overland runoff or erosion from uncontained storm water. These changes in water quality could impact reproduction, growth, and recruitment or result in the mortality of individual aquatic species downstream of the new sand plant facilities. Recreational fishing opportunities would decrease to the extent that fish populations decline.

Alternate Sources

No alternate sources of supply would be required under Alternative C; therefore, no changes in fish population or related changes in recreational fishing opportunities would occur.

4.9.8 Summary of Impacts

Table 4.9-4 presents a summary of potential impacts on land use and recreation for the Proposed Action and the alternatives.

4.9.9 References

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Table 4.9-4 Summary of Potential Impacts on Land Use and Recreation

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Changes in existing or planned land uses	• Permanent minimal reduction in prime farmland in St. Joseph segment; zoning conflict requiring zoning change and special use permit in St. Joseph segment; no disruptions to adjacent land uses resulting from new facilities in St. Joseph or St. Charles segment.	• No changes in existing or planned land uses. • Potential land use conflicts at alternate sources.	• Permanent minimal reduction in prime farmland in St. Joseph segment; zoning conflict requiring zoning change and special use permit in St. Joseph segment; no disruptions to adjacent land uses resulting from new facilities in St. Joseph or St. Charles segment. • Potential land use conflicts at alternate sources.	• Permanent minimal reduction in prime farmland in St. Joseph segment; zoning conflict requiring zoning change and special use permit in St. Joseph segment; no disruptions to adjacent land uses resulting from new facilities in St. Joseph or St. Charles segment. • Potential land use conflicts at alternate sources.	• Permanent minimal reduction in prime farmland in St. Joseph segment; zoning conflict requiring zoning change and special use permit in St. Joseph segment; no disruptions to adjacent land uses resulting from new facilities in St. Joseph or St. Charles segment.
Changes in recreational boating	• Potential interference with boaters and change in recreational experience because of additional barges and tugs in all segments in the short term and the long term.	• Increase in recreational access and opportunities because of reduction in number of barges and dredges in all segments; less interference from barges and dredges. • Potential interference with boaters due to additional barges/tugs on Mississippi River.	• Potential increased interference with boaters because of additional barges and tugs in St. Joseph segment in the short term and the long term; less interference with boaters because of fewer barges and tugs in Kansas City, Waverly, Jefferson City, and St. Charles segments in the short term and the long term. • Potential interference with boaters due to additional barges/tugs on Mississippi River.	• Potential increased interference with boaters because of additional barges and tugs in St. Joseph and Waverly segments in the short term and the long term; less interference with boaters because of fewer barges and tugs in Kansas City, Jefferson City, and St. Charles segments in the short term and the long term. • Potential interference with boaters due to additional barges/tugs on Mississippi River.	• No change in recreational access or opportunities because of no change in number of barges and dredges on river.

Table 4.9-4 Summary of Potential Impacts on Land Use and Recreation

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Changes in access to boat ramps	• Increase in scour problems and resulting access disruptions in St. Joseph, Kansas City, Jefferson City, and St. Charles segments in the long term.	• Reduced potential for scour at boat ramps and increased recreation access in all segments in the long term; highest increase in access likely in Kansas City segment. • Potential decreased boat ramp access on the Mississippi River.	• No likely increases in scour; no expected change in access to boat ramps. • Potential decreased boat ramp access on the Mississippi River.	• Increase in scour problems and resulting access disruptions in St. Joseph, Kansas City, Jefferson City, and St. Charles segments in the long term. • Potential decreased boat ramp access on the Mississippi River.	• Increase in scour problems and resulting access disruptions in Kansas City, Jefferson City, and St. Charles segments in the long term.
Changes in wetlands-related recreational opportunities	• Loss of forested wetlands, scrub-shrub wetlands, and emergent wetlands from lowered groundwater levels, resulting in removal of suitable habitat and reduction in wetlands-related recreational opportunities in all segments except Waverly segment in the short term and the long term.	• Potential long-term loss of wetlands and related recreational opportunities because of development of open-pit mines in the Missouri River floodplain. • Potential loss of wetland-related recreational uses on the Kansas or Mississippi Rivers.	• Potential long-term loss of wetlands and related recreational opportunities because of development of open-pit mines in the Missouri River floodplain. • Potential loss of wetland-related recreational uses on the Kansas or Mississippi Rivers.	• Loss of forested wetlands, scrub-shrub wetlands, and emergent wetlands resulting in removal of suitable habitat and reduction in wetlands-related recreational opportunities in St. Joseph, Kansas City, and St. Charles segments in the short term and the long term. • Potential long-term loss of wetlands and related recreational opportunities because of development of open-pit mines in the Missouri River floodplain. • Potential loss of wetland-related recreational uses on the Kansas or Mississippi Rivers.	• Loss of forested wetlands, scrub-shrub wetlands, and emergent wetlands resulting in removal of suitable habitat and reduction in wetlands-related recreational opportunities in St. Joseph, Kansas City, Jefferson City, and St. Charles segments in the short term and the long term.

Table 4.9-4 Summary of Potential Impacts on Land Use and Recreation

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Changes in access to portions of land-based recreation trails	• Long-term increases in high-flow water surface elevations in Jefferson City and St. Charles segments could prolong or make more frequent access limitations during flood events.	• Long-term increases in high-flow water surface elevations in Jefferson City and St. Charles segments could prolong or make more frequent access limitations during flood events. • Potential trail access improvement near Mississippi or Kansas Rivers.	• Long-term increases in high-flow water surface elevations in Jefferson City segment could prolong or make more frequent access limitations during flood events. • Potential trail access improvement near Mississippi or Kansas Rivers.	• Long-term increases in high-flow water surface elevations in Jefferson City and St. Charles segments could prolong or make more frequent access limitations during flood events. • Potential trail access improvement near Mississippi or Kansas Rivers.	• Long-term increases in high-flow water surface elevations in Jefferson City and St. Charles segments could prolong or make more frequent access limitations during flood events.
Changes in recreational fishing opportunities	• Potential decrease in recreational fishing opportunities because of increased dredging (all segments) and construction of sand plants.	• No change or potential increase in recreational fishing opportunities because of termination of dredging activity. • Potential decrease in recreational fishing opportunities at alternate sources.	• Potential slight decrease in recreational fishing opportunities because of decreased dredging in all segments except St. Joseph and construction of sand plants in Kansas City and St. Charles segments. • Potential decrease in recreational fishing opportunities at alternate sources.	• Potential decrease in recreational fishing opportunities because of increased dredging in St. Joseph and Waverly segments and construction of sand plants in Kansas City and St. Charles segments. • Potential decrease in recreational fishing opportunities at alternate sources.	• Potential slight decrease in recreational fishing opportunities because of construction of sand plants in Kansas City and St. Charles segments.

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4.10 ECONOMICS AND DEMOGRAPHICS

4.10.1 Introduction

This section evaluates the economic-related effects associated with changes in sand and gravel production from the LOMR as defined by the various alternatives under consideration. From a market perspective, changes in sand and gravel production from the Missouri River would affect the ability of the commercial dredging industry to meet regional demand for these commodities and likely would result in shifts in production among commercial dredge operators and suppliers of sand and gravel from alternate sources located in the region. These shifts could affect the cost of sand and gravel to consumers in the short term (mainly because of changes in transportation costs from alternate sources) and in the long term (based on the relative differences in production costs between existing and potential new sources developed in the region). Additional impacts could be experienced by industries that are dependent on sand and gravel as an input to production, such as concrete and asphalt manufacturing and general construction. Changes in permitted dredging volumes would result in direct economic impacts on existing dredge operators and their employees, and would result in indirect economic effects throughout the region based on inter-industry linkages and household spending patterns. These changes would result in fiscal impacts on public agencies that realize royalties and tax revenues generated by sand and gravel production. Indirect economic impacts also are attributed to river bed degradation in the LOMR, which has been correlated, in part, with ongoing dredging activity. These degradation-related effects are focused on infrastructure damages and related operations and maintenance costs; but they may also affect agricultural production, recreation use, water supplies and water quality, and river navigation. Finally, the economic effects on select demographic groups are considered in the context of environmental justice. In summary, the following types of impacts have been analyzed for each alternative under consideration:

- Industry and market effects;
- Regional economic effects;
- Effects on tax revenues;
- Economic effects related to river bed degradation; and
- Environmental justice.

4.10.2 Assessment Methods and Results

As described above, the economic impacts considered here are multi-faceted, and the methods used in the analysis vary depending on the type of impact being evaluated. This section provides an overview of the methodologies used to evaluate economic impacts and an overview of the temporal and geographic scope of the analysis. This section also presents impact summary tables that outline the results for select economic parameters considered in the analysis.

4.10.2.1 Temporal Scope

The economic analysis is divided into short-term and long-term effects. Short-term effects are those likely to occur before any structural shifts in the sand and gravel market took place in order to achieve equilibrium, such as development of new mining operations over the long term in response to changes in permitted dredging volumes. It is anticipated that short-term effects would extend over an approximately 5-year period, which is the estimated time required for new sand and gravel mining operations to be developed and put into operation. The short-term analysis captures any shifts in production from the LOMR to existing land-based mining operations that could produce substitute supplies. Because it is not possible to predict the location or production capacity at potential new mining operations in the Project area, only short-term economic effects are quantified. Long-term effects would extend beyond the approximately 5-year period and are primarily addressed qualitatively.

To the extent that impacts are quantified, the focus is on average annual costs and benefits, which could be extrapolated over both the short term and long term, where applicable. Monetary results are presented in constant 2008 dollars.

4.10.2.2 Geographic Scope

The geographic scope of the economic analysis is driven by the locations of current and proposed sand and gravel production from the LOMR, alternate supply sources, and centers of demand. Although extraction of construction sand and gravel from the LOMR occurs within the physical confines of the river, the economic analysis is structured on the basis of individual market areas surrounding each river segment, which represent the main sources of demand for sand and gravel and include areas in Missouri, Kansas, and Illinois. As noted in Section 3.12, the “primary market area” is defined as the area encompassing an approximately 25-mile-wide radius[1] from the processing facilities (sand plants)

[1] The 25-mile radius was selected based on discussions with existing dredge operators and is indicative of the relative low-value product and high transportation costs required to ship aggregates longer distances.

associated with existing and proposed dredging operations and is comprised of the individual market areas. This area is also representative of the functional economic area associated with commercial dredging. All impacts are presented by individual market areas serving the five river segments that comprise the primary market area. A description of the primary and individual market areas is presented in Section 3.12.3 (see Table 3.12-1 and Figure 3.12-1). Some effects outside the primary market area are considered to illustrate how changes in dredging in the LOMR affect other areas throughout Missouri and adjacent states.

From a supply perspective, the locations of future dredging activity are outlined in the dredging permit applications. Of more concern for this analysis, however, are the locations of existing and proposed sand and gravel processing plants along the LOMR, which would serve as the distribution points to customers. Therefore, the location of supplies provided by dredging in the LOMR is based on distribution points rather than where material is extracted from the river. In addition, the geographic scope captures most alternate supply sources within Missouri, as well as areas in eastern Kansas and western Illinois. These alternate sources are located both inside and outside the primary market area.

From the perspective of market demands, the analysis is focused on counties along the LOMR corridor that are currently served by existing dredging operations, including the urban areas of St. Louis, Jefferson City, Kansas City, and St. Joseph. The analysis of the construction sand and gravel market covers all counties within the primary market area, including areas outside the state of Missouri in Kansas and Illinois. For the regional economic analysis, which evaluates economy-wide effects, the geographic scope is limited to areas within Missouri; the regional economic effects outside the state are addressed qualitatively.

4.10.2.3 Data Sources

To estimate the direct economic impacts on dredge operators and their employees, interviews were conducted with existing operators to obtain a range of financial and operations information. Information on alternate supplies was collected from multiple sources, including MDNR, IDNR, and the Kansas State Conservation Commission. The expansion capacity of existing supply sources was based on different factors depending on the type of supply, including information from existing permits and historical production levels; refer to Section 2.3.2 for more information. USGS information was used in estimating existing and projected freight-on-board (FOB)[2] prices for construction sand and gravel. The demand for construction sand and gravel from the LOMR was based on production data provided by

[2] FOB prices reflect the cost of the good plus the services of loading those goods onto a vehicle or vessel at a named location but exclude shipping costs. FOB is also referred to as “free on board.”

the Dredgers to the USACE. Dredging amounts in the LOMR between 2004 and 2008 are considered representative of existing market demand because dredging was generally unconstrained prior to 2007 and since 2007 (when dredging limits were put into effect), dredging occurred below authorized levels. The allocation of demand across market areas was based on population data from the U.S. Census Bureau. For the regional economic modeling, IMPLAN (IMpact Analysis for PLANning) software and data were used, which quantify trade flows among regions, regional purchase coefficients, and other industry-specific information. Finally, multiple industry representatives and mining operators were contacted to discuss industry operations and validate data parameters.

4.10.2.4 Transportation Cost Model

The market analysis for construction sand and gravel is based on a transportation cost model that simulates the market for LOMR sand and gravel within the study area, which includes Missouri and parts of Kansas and Illinois. The model simulates the existing demand for the approximately 6.9 million tons of LOMR sand and gravel produced annually between 2004 and 2008; it is not a supply-and-demand model for the entire sand and gravel market in the region. The model estimates the current transportation costs of shipping the approximately 6.9 million tons of LOMR sand and gravel; then, as necessary for the various alternatives, the model predicts production levels at alternate supply sources based on available supplies, relative prices, and transportation costs.

Based on the assumption that demand centers will purchase sand and gravel from the least expensive sources (including transportation costs), the model estimates the quantity of sand and gravel delivered from each supply source to each demand center and the associated average cost to each demand center. Specifically, the model minimizes the cost to supply sand and gravel to each demand center subject to recent levels of demand, available supplies, and minimum requirements for sand and gravel that meet MoDOT and KDOT specifications.

The model selects the amount of sand ($Sand_{sd}$) to be transported from each supply source to each demand center such that cost is minimized, where cost is equivalent to:

$$Cost = \sum_{s=1}^{S} \sum_{d=1}^{D} Sand_{sd} * (Travelcost_{sd} + Price_{s})$$

based on the following notation:

Notation	Description	Unit	Range and Values
S	Supply sources, includes river- and land-based operations	index	s = 1,..., S
D	Demand centers for sand and gravel	index	d= 1,..., D
$Sand_{sd}$	Quantity of sand shipped from s to d	tons per year	--
$Distance_{sd}$	Transport distance between s and d	miles	--
Costpermile	Unit cost of transporting sand and gravel	$0.20/mile	--
$Travelcost_{sd}$	Costpermile * $Distance_{sd}$	$ per ton	--
$Price_s$	Price of sand and gravel from supply source s	$ per ton	--
Cost	Total cost of all delivered product	$	--

Key parameters in the model include demand for LOMR sand and gravel by various demand points within the study area, the supply of LOMR sand and gravel under each alternative, and the available supplies from alternate sources in the region. It also considers the location of supply and demand centers and associated transportation distances, FOB prices, and shipping costs. For the analysis, supply sources include existing and proposed dredging operations and alternate mining operations that are currently in production in the three-state region (see Section 2.3.2 for more information on alternate sources of sand and gravel in the region). Because only existing supply sources are considered, the analysis represents a short-term evaluation of the sand and gravel market. The demand centers are defined as the population centers in the counties that comprise the primary market area (see Table 3.12-1 and Figure 3.12-1). The transportation cost model is run on General Algebraic Modeling System (GAMS) software, which consists of a language compiler and solvers for mathematical programming and optimization problems.[3]

A set of modeling assumptions were developed to simulate the sand and gravel market in the region. These assumptions include:

- The historical demand for construction sand and gravel from the LOMR of approximately 6.9 million tons per year was assumed to remain static in the future. This estimate is based on production data between 2004 and 2008, which covers periods of both economic expansion and recession.

[3] Additional information about GAMS software can be found on their webpage (www.gams.com).

- The demand for sand and gravel was limited to the counties identified in the primary market area. Demand was allocated to these counties based on the relative size of their population within each market area.
- The demand for sand and gravel from the LOMR by the MoDOT and the KDOT was based on data provided directly by these agencies. The combined demand by these agencies is approximately 553,000 tons per year, or approximately 8.0 percent of total demand.
- The supply of sand and gravel from the LOMR from existing and proposed dredge operators was based on volumes allowed under the Proposed Action and alternatives and existing patterns of production across individual sand plants. It was assumed that permit applicants would realize a proportional change in permitted dredging volumes in line with changes between requested dredging volumes and total allowed dredging volumes across the Proposed Action and alternatives.[4]
- Only existing alternate mining operations would affect the market for sand and gravel in the short term. It was assumed that no new mines would be developed.
- The available supply of sand and gravel from alternate supply sources was based on estimates of excess capacity. For sources permitted by the USACE, "excess capacity" was defined as the difference between existing production levels and permitted volumes. For all other sources, excess capacity was calculated based on estimates of existing production relative to peak production levels as outlined in USGS reports.
- A limited set of supply sources was assumed to be able to meet MoDOT and KDOT material specification requirements. These include all river-based sources (i.e., Missouri, Mississippi, and Kansas Rivers), floodplain open-pit mines in Kansas, and those mining operations in Missouri designated as approved sources of Class A sand and gravel by the MoDOT.
- The transportation distance between supply sources and demand sources was based on straight-line distance rather than the distance travelled along the existing road network.
- Transportation options were limited to truck shipping at an estimated cost of $0.20 per mile.

The results derived from the transportation-cost model are presented in Tables 4.10-1 and 4.10-2, which focus on the production and costs of construction sand and gravel, respectively. These tables

[4] The analysis does not take into account the financial feasibility of individual mining operations in response to potential reductions in permitted dredging volumes. It is acknowledged that threshold volumes of production are required for certain mining operations to be financially viable, below which business may fail. As a planning-level analysis, it is beyond the scope of this study to evaluate the financial feasibility of individual operators.

show results for existing conditions, the Proposed Action, and the alternatives. These results are discussed below under the Proposed Action and the alternatives.

Table 4.10-1 Production of Construction Sand and Gravel (tons/year)[a]

Market Area	Existing Conditions	Proposed Action[c]	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph	327,000	327,000	14,000	364,000	860,000	327,000
Dredging from LOMR[b]	327,000	327,000	0	350,000	860,000	327,000
Alternate sources	0	0	14,000	14,000	0	0
Kansas City	2,659,000	2,369,000	237,000	777,000	1,467,000	2,657,000
Dredging from LOMR[b]	2,659,000	2,369,000	0	540,000	1,230,000	2,657,000
Alternate sources	0	0	237,000	237,000	237,000	0
Waverly	678,000	968,000	0	500,000	1,140,000	680,000
Dredging from LOMR[b]	678,000	968,000	0	500,000	1,140,000	680,000
Alternate sources	0	0	0	0	0	0
Jefferson City	1,579,000	1,579,000	27,000	457,000	1,007,000	1,579,000
Dredging from LOMR[b]	1,579,000	1,579,000	0	430,000	980,000	1,579,000
Alternate sources	0	0	27,000	27,000	27,000	0
St. Charles	1,649,000	1,649,000	2,453,000	2,385,000	1,799,000	1,649,000
Dredging from LOMR[b]	1,649,000	1,649,000	0	370,000	840,000	1,649,000
Alternate sources	0	0	2,453,000	2,015,000	959,000	0
Outside primary market area[d]	0	0	4,161,000	2,409,000	619,000	0
Dredging from LOMR	0	0	0	0	0	0
Alternate sources	0	0	4,161,000	2,409,000	619,000	0
Total	6,892,000	6,892,000	6,892,000	6,892,000	6,892,000	6,892,000
Dredging from LOMR	6,892,000	6,892,000	0	2,190,000	5,050,000	6,892,000
Alternate sources	0	0	6,892,000	4,702,000	1,842,000	0

Notes:

LOMR = Lower Missouri River.
N/A = Not applicable.

[a] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the LOMR.

[b] Represents location of dredging in the LOMR based on river segments.

[c] Results shown for the Proposed Action are based on volumes to meet existing and historical demand; the analysis of the entire permit request is evaluated qualitatively in the text.

[d] The "primary market area" represents the total of the five individual market areas serving each segment.

Source: ENTRIX 2010.

Table 4.10-2 Short-Term Costs of Construction Sand and Gravel ($/ton)[a, b]

Market Area	Existing Conditions	Proposed Action[b]	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph	$7.39	$7.39	$34.77	$7.80	$7.39	$7.39
Kansas City	$7.98	$7.72	$31.27	$16.46	$8.45	$7.97
Waverly	$9.53	$7.72	$42.91	$24.40	$8.39	$8.97
Jefferson City	$9.25	$8.69	$28.09	$16.71	$9.86	$9.35
St. Charles	$7.34	$7.10	$8.60	$7.63	$7.14	$8.58

[a] Represents cost to end user; including freight-on-board (FOB) price and transportation costs.

[b] Based on volumes meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River; the analysis of the entire permit request is evaluated qualitatively in the text.

Source: ENTRIX 2010.

4.10.2.5 Regional Economic Model (IMPLAN)

The regional economic analysis measures total economic impacts in the study area based on inter-industry linkages across affected economic sectors. The regional economic analysis was conducted using IMPLAN, a regional economic model that is based on the principles of input-output (I-O) analysis. I-O analysis is a means of measuring the flow of commodities and services among industries, institutions, and final consumers within an economy. An I-O model captures all the monetary market transactions for consumption in a given time period accounting for inter-industry linkages and the availability of regionally produced goods and services. The primary input for I-O analysis is the dollar change in purchases of products or services for final use; this is referred to as “final demand.” Industries respond to meet demands directly, or indirectly (by supplying goods and services to those industries responding directly to final demand changes). The primary metrics estimated by the IMPLAN model are output (or value of production), employment, and income across affected industries within a study area. In estimating impacts, the model considers direct,[5] indirect,[6] and induced[7] effects, which are based on the “multiplier” effect. In this context, a multiplier is a factor of proportionality that measures the additional economic activity generated in response to the initial influx of money within an economy. For example, a theoretical output multiplier of 1.5 in the mining industry indicates that every $100,000 of mining production (the direct output of this industry) supports a total of $150,000 in economic production throughout the economy (total output of all industries), including the initial

5 Direct effects represent the impacts for the expenditures and/or production values specified as direct final demand changes.

6 Indirect effects represent the impacts caused by the iteration of industries purchasing from industries resulting from the direct final demand changes.

7 Induced effects represent the impacts on all local industries caused by the expenditures of new household income generated by the direct and indirect effects resulting from the direct final demand changes.

$100,000 in mining output. Several types of multipliers are produced by an I-O model, including output, employment, and income multipliers.

For this Project, three main drivers were considered in the analysis of regional economic effects, as described below.

- Changes in sand and gravel production – Changes in construction sand and gravel production would result directly from the Proposed Action and alternatives based on proposed dredging. Changes in production, which account for shifts in production from alternate sources, would cause a ripple effect on all support industries that provide inputs to the mining industry. The value of changes in sand and gravel production was calculated using the quantity of production across supply sources and current FOB prices as estimated by the USGS.

- Changes in truck shipping volumes – Shifts in construction sand and gravel production also would result in an ancillary effect on the truck shipping industry, which provides the mechanism to transport sand and gravel from sellers to buyers. In turn, changes in truck shipping volumes would affect support industries via inter-industry linkages. The value of shipping output was calculated using estimates of transportation distance and representative shipping costs.

- Changes in consumer income – Changes in the cost of sand and gravel also would affect household income levels of consumers of construction sand and gravel products. These effects reflect changes in the disposable income of consumers of sand and gravel products based on the assumption that any changes in wholesale costs incurred by the manufacturing and construction industries would be passed on to end users in the form of higher product costs. Household income effects at the consumer level were calculated based on the quantity and cost of sand and gravel delivered across demand centers.

Estimates of direct effects for all three types of impacts were derived from the results of the transportation cost model; these direct effects represent the primary inputs to the regional economic model

For this analysis, a multi-region input-output (MRIO) modeling framework was utilized according to the delineation of individual market areas. The MRIO framework allows the trade flows among market areas to be tracked and quantified. Because some alternatives would result in displacement of sand and gravel production from proximity to the LOMR to other parts of the state, an additional area was integrated into the modeling, which captures all areas outside the primary market area within Missouri.

For the purposes of the regional economic modeling, only areas within Missouri were evaluated quantitatively because it represents the core area of potential impacts. Further, structuring the regional economic models this way allows for a statewide perspective on potential impacts and avoids the difficulties with discerning impacts across multiple states. Regional economic impacts outside the state are addressed qualitatively. Impact summary tables for the regional economic analysis are presented under each alternative below.

4.10.2.6 Approach to Fiscal Effects

Based on changes in local economic activity, fiscal impacts are also anticipated with and without continued dredging activity. The fiscal analysis focuses on changes in royalty payments paid to the State of Kansas; royalty payments are not required in Missouri. Changes in royalty payments were calculated based on changes in the value of sand production by supply sources within and adjacent to Kansas and the applicable royalty rate of $0.15 per ton. The fiscal analysis also qualitatively addresses other tax revenues generated by sand and gravel production based on changes in spending and production in the study area. Table 4.10-3 shows estimated short-term sand royalty payments to the State of Kansas under the Proposed Action and alternatives.

Table 4.10-3 Short-Term Annual Royalty Payments to the State of Kansas[a]

Market Area[b]	Existing Conditions	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph[c]	$49,000	$49,000	$0	$53,000	$129,000	$49,000
Kansas City[c]	$64,000	$57,000	$22,000	$35,000	$52,000	$64,000
Waverly	$0	$0	$0	$0	$0	$0
Jefferson City	$0	$0	$0	$0	$0	$0
St. Charles	$0	$0	$0	$0	$0	$0
Outside primary market area[d]	$0	$0	$97,000	$97,000	$44,000	$0
Total	$113,000	$106,000	$119,000	$185,000	$224,000	$113,000

[a] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[b] Represents location of dredging within the LOMR based on river segments.

[c] Sand production data and royalty payments paid to the State of Kansas are not available by market area. For this analysis it was assumed that all sand production from the St. Joseph market area and approximately 16 percent of sand production from the Kansas City market area are subject to sand royalties.

[d] The "primary market area" represents the total of the five individual market areas serving each segment.

Source: ENTRIX 2010.

4.10.2.7 Approach to Economic Effects Associated with River Bed Degradation

Several potential economic impacts are attributed to the effects of river bed degradation in the LOMR. Potential economic impacts could be realized if continued river bed degradation leads to changes in infrastructure replacement and maintenance levels or infrastructure failure (see Section 4.3), agricultural production and costs (see Section 4.9), recreation use and spending (see Section 4.9), water supply availability and quality (see Section 4.5), and river navigation (see Section 4.4). The analysis presented in this EIS establishes a linkage between commercial dredging and river bed degradation, although it is acknowledged that dredging is only one contributing factor. Due to the difficulty in estimating system-wide economic impacts associated with river bed degradation, this analysis uses a case study approach to quantifying impacts based on existing research on this topic, particularly for infrastructure-related impacts. In cases where information is not readily available, the economic effects associated with river bed degradation are addressed qualitatively.

4.10.2.8 Approach to Environmental Justice Effects

"Environmental justice" is generally defined as the "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (USEPA 2010). The purpose of an environmental justice analysis is to identify the range of human health, environmental, and economic impacts that could result in significant and disproportionate adverse effects on low-income or minority populations potentially affected by proposed federal actions.

This environmental justice analysis was prepared in compliance with EO 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations) dated February 11, 1994, and Title VI of the Civil Rights Act of 1964. EO 12898 requires each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."

The environmental justice analysis focuses on whether minority and low-income communities in the study area would be disproportionately affected from an economic standpoint because of changes in dredging from the LOMR. The presence of minority and low-income communities of interest in the study area are identified based on demographic data on race and ethnicity and various income parameters. The economic effects of the Proposed Action and alternatives have been reviewed to

qualitatively determine whether these groups would be disproportionately affected relative to the general population.

The physical effects of the Proposed Action and alternatives, including impacts on air quality and noise from sand plant operations, would not result in environmental justice impacts. The existing and proposed sand plants are generally located in agricultural or industrial areas, and not in proximity to residential areas (see Table 2.2-4). Therefore, potential air quality and noise impacts would be concentrated in areas with similar land uses and low population densities. Because these effects would not be realized in residential areas, which could contain minority and/or low-income populations, the related environmental justice effects would be negligible.

To determine whether the Project would result in environmental justice impacts, the racial and socioeconomic characteristics of the affected population were reviewed. As shown in Table 3.12-4, the population in the primary market area is predominantly white (80.1 percent). Racial minorities make up the remaining 19.9 percent of the population, including the Black/African American population (accounting for 15.3 percent of the population in the primary market area). As expected, the racial composition of the population in the primary market area is slightly more diverse, but comparable, to that across Missouri based on the location of major urban centers along the river corridor. Across market areas, the racial diversity is greatest around the St. Charles and Kansas City market areas; however, no individual market area appears to include considerably greater minority populations relative to the primary market area or Missouri as a whole.

Key economic indicators of social well-being are presented in Table 3.12-5. Relative to figures for the state of Missouri, these indicators show that the primary market area has lower unemployment rates (6.6 percent compared to 8.3 percent), higher per-capita income levels ($38,707 compared to $33,964), and lower poverty rates (11.2 percent compared to 13.3 percent). At the segment market area level, the Jefferson City, Waverly, and St. Joseph market areas have slightly lower income levels compared to state levels, and only the Jefferson City market area has a higher poverty rate (14.3 percent). Overall, the extent of low-income populations in the Project area appears to be limited.

4.10.3 Proposed Action

Under the Proposed Action, up to approximately 11.6 million tons per year of construction sand and gravel would be authorized to be dredged from the LOMR by existing and new dredge operators. The requested volume exceeds existing demand, which is estimated at approximately 6.9 million tons per year. Because permitted dredging would be substantially higher than existing and historical demand, it

is estimated that production would generally come from dredging operations with lowest costs, based primarily on proximity to demand centers.

The analysis of the Proposed Action assumes that production would occur only up to existing demand levels as there would be no market for sand and gravel beyond that point (holding production outside the LOMR constant). Under this assumption, however, the Proposed Action provides added flexibility to commercial dredge operators to meet demand because permitted volumes would exceed market demands. The economic effects of this assumption have been quantified and included in the results tables. In order to evaluate the full range of economic impacts associated with the Proposed Action, this analysis also considers production occurring up to fully permitted volumes although existing demand may not warrant this level of production. Because commercial dredging is unlikely to exceed recent demands and represents a theoretical maximum only, the economic effects of this alternative assumption are evaluated qualitatively.

The key findings of the economic analysis of the Proposed Action are:

- Overall, commercial dredging of sand and gravel from the LOMR would remain constant at levels consistent with existing demand (6.9 millions tons per year). There would be relatively minor shifts in production across market areas and individual sand plants.
- Due to the added flexibility provided by permitted dredging, commercial dredging within the LOMR would shift to locations that are most proximate to demand centers, resulting in a decrease in the delivered costs of construction sand and gravel in most market areas.
- Regional economic activity attributed to mining production would be relatively unchanged within the primary market area and the state of Missouri.
- Shipping requirements would be reduced in response to a more optimal distribution pattern between suppliers and consumers, resulting in regional economic impacts on the truck shipping and related support industries, including a loss of $3.9 million in production value annually and nearly 30 jobs in the state of Missouri.
- The estimated decrease in costs of construction sand and gravel would increase income levels of consumers, which would stimulate economic activity and partially offset potential impacts associated with the reduced demand for truck shipping.

- Net regional economic activity at the state level would be comparable to existing conditions accounting for minor changes in sand and gravel production, decreases in shipping requirements, and increases in consumer income levels.
- Because production would remain relatively stable in the Kansas City and St. Joseph market areas, estimated sand royalty payments paid to the State of Kansas would be largely unchanged.

4.10.3.1 Industry and Market Area Effects

Under the Proposed Action, commercial sand and gravel production within the LOMR would continue into the future. If dredging activity continues at levels to meet existing demand, the total overall quantity of sand and gravel produced from the LOMR would not change—a total of approximately 6.9 million tons of construction sand and gravel would be produced annually. As shown in Table 4.10-1, however, the locations of production across river segments would change based on the requested volumes and locations of dredging by permit applicants. In addition, new sand and gravel processing facilities would be developed to serve new dredging operations, thereby providing new options to meet recent demand levels. Because requested dredging volumes exceed recent demand under the Proposed Action, it is assumed that the market would dictate that dredging production would occur at locations most proximate to demand centers, resulting in overall reductions in the cost of sand and gravel across market areas in the short term.

On the other hand, if it is assumed that sand and gravel production reaches maximum permit levels under the Proposed Action (approximately 11.6 million tons annually), two outcomes would be likely. One is that dredge operators would attempt to sell their product in the open market—including new markets that are not currently served by LOMR supplies—which could displace existing land-based mining operations that currently serve these markets. The ability for dredge operators to compete in these new markets would depend on the relative price and quality differential between sand and gravel dredged from the LOMR and material that is mined from other sources. If the delivered price for dredged material is substantially lower than other sources or the difference in quality is sought by end users, the LOMR supplies could force other sand and gravel producers out of their existing markets. This would result in economic benefits to dredge operators and their employees, and adverse economic effects on other mining operators in the region.

Under maximum production, the other outcome is that dredge operators produce their full permit amount but elect to stockpile the excess sand and gravel that cannot be sold to the existing markets

they serve. This would provide operating reserves and added flexibility for dredge operators to meet future demands, and would not affect other sand and gravel producers in the region in the short term.

Based on the results of the transportation cost model presented in Table 4.10-2, dredging activity under the Proposed Action would result in minor effects on the cost of construction sand and gravel in the individual market areas; the costs include FOB prices and transportation costs.

Under the Proposed Action, the average FOB price of construction sand and gravel across all market areas is approximately $4.91 per ton, as estimated by the transportation cost model based on FOB values reported by USGS across the Project area. As shown in the table, however, the delivered cost of sand and gravel ranges from $7.10 to $8.69 per ton;[8] this is lower than existing conditions in all market areas, except for St. Joseph where price is expected to remain constant. The anticipated reductions in cost are attributed to projected shifts in production to sand plants that are relatively closer to demand centers in an effort to minimize costs, thereby resulting in a more cost-efficient pattern of distribution from suppliers to consumers. In the case of full production of requested permit levels, the influx of new supplies would tend to result in downward pressures on the FOB prices for sand and gravel and the related costs to customers, based on supplies exceeding demand. These downward pressures could be compounded if the production costs for dredge operators are lower than those for non-river mining operations. The non-river mining operations could be displaced from the market if they became uncompetitive from a cost and pricing standpoint.

The cost of construction sand and gravel also affects the production costs for industries that use sand and gravel as an input to production; these costs may ultimately be passed on to the consumers and the general public. The construction industry would be primarily affected, including road construction projects implemented by state and local transportation agencies. These projects require substantial amounts of concrete and asphalt that is produced with sand and gravel from the LOMR. Similarly, residential and commercial developments with large demands for concrete would be affected. Based on the expected decrease in the cost of sand and gravel throughout the market area under the Proposed Action, a minor reduction in construction costs could be realized as a cost savings to the public, either in the form of reduced taxes (for public sector projects) or relatively less expensive homes and goods and services supported by commercial development.

[8] Transportation costs account for the difference between total cost and average FOB price.

St. Joseph Market Area

Construction sand and gravel production in the St. Joseph market area would remain constant at approximately 327,000 tons annually under the Proposed Action, which is unchanged relative to existing conditions. Based on requested volumes, existing dredging operations in the St. Joseph market area would have sufficient capacity to meet the demand for sand and gravel in the St. Joseph market area using similar transportation patterns to deliver materials from distribution facilities to customers. Further, additional production in the St. Joseph market area would not be required to meet demands in other market areas (e.g., Kansas City) as production levels in the other market areas would be sufficient to meet local demand and are closer than the sand plant facility at St. Joseph. Accordingly, the delivered cost of sand and gravel in the St. Joseph market area is expected to remain constant at an estimated $7.39 per ton under the Proposed Action in the short term, with no cost-related effects to the construction industry.

Kansas City Market Area

Under the Proposed Action, construction sand and gravel production in the Kansas City market area is estimated at nearly 2.4 million tons per year, a decline of 290,000 tons per year relative to existing conditions. The decline in dredging in the Kansas City market area is attributed to a shift in production from the Kansas City segment to the Waverly segment, where additional production would be used to meet the demand in the eastern Kansas City market area. More specifically, the need for sand and gravel production in the Kansas City market area would decline because excess supplies from the Waverly market area (i.e., supplies beyond what are needed to meet local demand) would be distributed at sand plants in the Kansas City area and help to meet demands in the Kansas City market, thereby reducing the sand and gravel production needs from the Kansas City segment. Although a minor decrease in production is expected, development of new production capacity at the proposed Waldron sand plant would provide for a more optimal distribution of sand and gravel to customers in the Kansas City market, resulting in a minor decline in costs. Specifically, the cost of sand and gravel in the Kansas City market area is an estimated $7.72 per delivered ton under the Proposed Action in the short term, compared to $7.98 per ton under existing conditions. The resultant cost-related benefits in the construction industry would be minor.

Waverly Market Area

Construction sand and gravel production in the Waverly market area is expected to increase from 678,000 to 968,000 tons per year under the Proposed Action, which is attributed to meeting local demands in the Waverly market area by local sand plants, as well as helping to meet demands in the

Kansas City market with excess supplies from the area, as described above. The cost of sand and gravel in the Waverly market area in the short term is expected to fall to $7.72 per ton compared to $9.53 under existing conditions, a decline of 19.0 percent. The reduction in cost is attributed to increased supplies and a more cost-efficient pattern of production from existing sand plants based on transportation costs between points of supply and demand. The reduction in the cost of sand and gravel would generate moderate cost savings in the construction industry.

Jefferson City Market Area

Sand and gravel production in the Jefferson City market area is expected to remain stable under the Proposed Action, at approximately 1.6 million tons annually. At the same time, the cost of sand and gravel is expected to decrease from $9.25 per delivered ton under existing conditions to $8.69 per ton under the Proposed Action in the short term, a 6.1-percent decline that is attributed to a more cost-efficient pattern of production across sand plants. Nevertheless, the average per-ton cost in the Jefferson City market area would continue to be the highest in the study area. The reduction in cost would result in minor cost-related benefits in the construction industry.

St. Charles Market Area

Construction sand and gravel production in the St. Charles market area would remain constant under the Proposed Action at approximately 1.6 million tons annually. If production shifts to sand plants most proximate to demand points, the cost of sand and gravel in the St. Charles market area is expected to fall to an estimated $7.10 per ton under the Proposed Action in the short term, an approximately 3.2-percent decline relative to existing conditions. This decrease would result in minor cost-related benefits in the construction industry.

4.10.3.2 Regional Economic Effects

Changes in the quantity of construction sand and gravel produced by commercial dredgers operating in the LOMR, in conjunction with price effects, would result in direct economic impacts on commercial dredge operators, notwithstanding any economic benefits and impacts accruing to alternate suppliers in the region. Because additional dredgers would operate in the LOMR under the Proposed Action, shifts in production across operators is expected. Accordingly, the economic benefits associated with dredging activity would shift from certain operators to others. If market demand for sand and gravel remains constant, the shift in production across operators could force smaller or less efficient dredgers out of business. However, the net economic benefits across all commercial dredge operators and employees are expected to remain relatively stable under the Proposed Action. Specifically, the value

of sand and gravel production by commercial dredgers under the Proposed Action based on volumes to meet existing demand would be an estimated $33.8 million annually, which would directly support approximately 196 jobs and $13.9 million in labor income in the mining industry. The direct benefits would be concentrated in Missouri, as most of the sand plants utilized by proposed dredging operations would be located in the state.[9] If dredging reaches full allocation under the Proposed Action (up to 11.6 million tons per year), which would exceed demand, an increase in economic benefits would be realized by commercial dredging operations—potentially at the expense of other sand and gravel producers in the region.

The benefits of sand and gravel production extend beyond the mining industry into other parts of the regional economy based on inter-industry linkages. Further, changes in mining production drive changes in the truck shipping industry and household income levels, which also generate regional economic effects. The short-term regional economic effects under the Proposed Action are summarized in Table 4.10-4; the effects are based on the locations of sand and gravel distribution rather than dredging locations.

Within Missouri, the total value of output (including indirect and induced effects in related industries) generated by sand and gravel production under the Proposed Action in the short term would be an estimated $59.4 million annually; total labor income would be $22.0 million; and 374 total jobs would be supported. Because total sand and gravel production levels under the Proposed Action would be relatively constant compared to existing conditions, the statewide values for total output, income, and employment also would be relatively stable. The regional economic effects associated with truck shipping activity in the short term include $20.5 million in total output, $7.6 million in total labor income, and 165 jobs; these amounts are lower than existing conditions based on a more cost-effective pattern of production resulting in less shipping required to meet demand. Last, because the cost of sand and gravel would be relatively lower under the Proposed Action, the public would have more disposable income to spend in the regional economy. These incremental income benefits include $2.5 million in total output, $785,000 in total labor income, and approximately 23 new jobs in the short term.

[9] The exception is the existing sand plant located in Alton, Illinois, which serves the St. Charles market area.

Table 4.10-4 Short-Term Regional Economic Effects under the Proposed Action [a, b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
St. Joseph						
Sand and gravel production	$1,615,000	$2,360,000	$489,000	$709,000	9	15
Truck transportation	$382,000	$608,000	$133,000	$204,000	3	5
Household income (change)[f]	$0	$6,000	$0	$1,000	0	0
Kansas City						
Sand and gravel production	$12,679,000	$24,190,000	$5,268,000	$8,976,000	74	145
Truck transportation	$4,915,000	$8,426,000	$1,940,000	$3,250,000	34	64
Household income (change)[f]	$0	$604,000	$0	$203,000	0	5
Waverly						
Sand and gravel production	$3,289,000	$4,404,000	$1,195,000	$1,517,000	19	29
Truck transportation	$687,000	$926,000	$236,000	$313,000	6	9
Household income (change)[f]	$0	$597,000	$0	$160,000	0	6
Jefferson City						
Sand and gravel production	$8,244,000	$13,782,000	$3,165,000	$4,894,000	48	91
Truck transportation	$3,045,000	$4,859,000	$1,088,000	$1,721,000	25	43
Household income (change)[f]	$0	$786,000	$0	$241,000	0	8
St. Charles						
Sand and gravel production	$7,428,000	$13,592,000	$3,493,000	$5,586,000	43	86
Truck transportation	$2,808,000	$5,282,000	$1,092,000	$2,006,000	20	41
Household income (change)[f]	$0	$414,000	$0	$137,000	0	3
Outside Primary Market Area[g]						
Sand and gravel production	$0	$1,108,000	$0	$360,000	0	9
Truck transportation	$0	$385,000	$0	$139,000	0	4
Household income (change)[h]	$0	$136,000	$0	$43,000	0	1
Total (State of Missouri)						
Sand and gravel production	$33,255,000	$59,437,000	$13,611,000	$22,041,000	193	374
Truck transportation	$11,837,000	$20,486,000	$4,489,000	$7,633,000	89	165
Household income (change)	$0	$2,543,000	$0	$785,000	0	23

Table 4.10-4 Short-Term Regional Economic Effects under the Proposed Action [a, b, c]

[a] Monetary values are reported in 2008 dollars and represent annualized effects.

[b] Regional economic effects are limited to changes in final demands in Missouri; changes in economic activity in adjacent states are excluded from the results.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the individual market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (river segment) of production.

[e] Includes direct, indirect, and induced effects resulting from activity in the target market area and linkages to other market areas.

[f] Represents regional economic effects attributed to changes in household income resulting from changes in the cost of construction sand and gravel.

[g] The "primary market area" represents the total of the five individual market areas serving each segment.

[h] Household income effects were not considered for areas outside the primary market area because no changes in the cost of sand and gravel are anticipated; the results shown are based on linkages with the primary market area.

Source: ENTRIX 2010.

St. Joseph Market Area

The short-term regional economic effects in the St. Joseph market area under the Proposed Action are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $2.4 million annually (+$44,000),
  - Increase in total labor income to $709,000 annually (+$13,000), and
  - Increase in total employment to 15 jobs (increase of less than one job).
- Truck transportation activity
  - Increase in total output to $608,000 annually (+$3,000),
  - Increase in total labor income to $204,000 annually (+$1,000), and
  - Increase in total employment to five jobs (increase of less than one job).
- Change in household income
  - Increase in total output by $6,000 annually,
  - Increase in total labor income by $1,000 annually, and
  - Increase in total employment by less than one job.

Kansas City Market Area

The short-term regional economic effects in the Kansas City market area under the Proposed Action are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $24.2 million annually (-$2.2 million),
  - Decrease in total labor income to $9.0 million annually (-$849,000), and
  - Decrease in total employment to 145 jobs (-13 jobs).
- Truck transportation activity
  - Decrease in total output to $8.4 million annually (-$2.8 million),
  - Decrease in total labor income to $3.3 million annually (-$1.1 million), and
  - Decrease in total employment to 64 jobs (-21 jobs).
- Change in household income
  - Increase in total output by $604,000 annually,
  - Increase in total labor income by $203,000 annually, and
  - Increase in total employment by five jobs.

Development of a new sand plant at Waldron also would generate short-term economic benefits in the Kansas City market area from new construction activity.

Waverly Market Area

The short-term regional economic effects in the Waverly market area under the Proposed Action are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $4.4 million annually (+$1.9 million),
  - Increase in total labor income to $1.5 million annually (+$668,000), and
  - Increase in total employment to 29 jobs (+13 jobs).
- Truck transportation activity
  - Increase in total output to $926,000 annually (+$345,000),
  - Increase in total labor income to $313,000 annually (+$117,000), and
  - Increase in total employment to nine jobs (+3 jobs).

- Change in household income
  - Increase in total output by $597,000 annually,
  - Increase in total labor income by $160,000 annually, and
  - Increase in total employment by six jobs.

Jefferson City Market Area

The short-term regional economic effects in the Jefferson City market area under the Proposed Action are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $13.8 million annually (+$301,000),
  - Increase in total labor income to $4.9 million annually (+$106,000), and
  - Increase in total employment to 91 jobs (+2 jobs).
- Truck transportation activity
  - Decrease in total output to $4.9 million annually (-$770,000),
  - Decrease in total labor income to $1.7 million annually (-273,000), and
  - Decrease in total employment to 43 jobs (-7 jobs).
- Change in household income
  - Increase in total output by $786,000 annually,
  - Increase in total labor income by $241,000 annually, and
  - Increase in total employment by eight jobs.

St. Charles Market Area

The short-term regional economic effects in the St. Charles market area under the Proposed Action are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $13.6 million annually (-$162,000),
  - Decrease in total labor income to $5.6 million annually (-$66,000), and
  - Decrease in total employment to 86 jobs (-1 job).

- Truck transportation activity
  - Decrease in total output to $5.3 million annually (-$706,000),
  - Decrease in total labor income to $2.0 million annually (-$268,000), and
  - Decrease in total employment to 41 jobs (-5 jobs).
- Change in household income
  - Increase in total output by $414,000 annually,
  - Increase in total labor income by $137,000 annually, and
  - Increase in total employment by three jobs.

Development of a new sand plant at Washington, Missouri also would generate short-term economic benefits in the St. Charles market area from new construction activity.

4.10.3.3 Tax Revenue Effects

Mining operations, both in-river dredging and land-based mines, generate multiple forms of tax revenue that provide fiscal benefits to all levels of government. Representative sources of tax revenues include, but are not limited to:

- Sales taxes (paid to states based on the value of taxable goods and services used in the sand and gravel production process),
- Franchise taxes (business taxes paid to states by corporations),
- Income taxes (paid to state and federal governments based on income received by operators and employees of sand and gravel operations),
- Payroll taxes (FICA) (paid to the federal government by employees and employers of sand and gravel operations) ,
- Property taxes (paid to local governments based on the value of real property holdings, such as sand and gravel processing facilities),
- Value of Waterway fuel taxes (fuel tax paid by commercial waterway operators, including commercial dredgers on the LOMR, to the Inland Waterways Trust Fund), and
- Royalty payments (paid to the State of Kansas for sand production in the state or adjacent to the state in the LOMR).

Generally, the level of mining activity and production drives the level of tax revenues generated by mining operations. Under the Proposed Action, commercial sand and gravel dredging along the LOMR likely would remain unchanged if production remains at levels to meet existing demand. Under this scenario, tax revenues are expected to remain fairly stable in the short term, except for royalty payments, which are based on the location of production. Table 4.10-3 shows estimated sand royalty payments to the State of Kansas under the Proposed Action and alternatives. Under the Proposed Action, dredging production would shift from the Kansas City market area (to the Waverly market area) and dredging would not change in the St. Joseph market area; these are the two market areas that are subject to royalty payments on production from the LOMR.[10] Overall, it is expected that royalty payments to the State of Kansas would decrease to approximately $106,000 per year under the Proposed Action in the short term, a 6.2-percent decline relative to existing conditions. This represents a minor economic impact of the Proposed Action.

St. Joseph Market Area

Sand and gravel production from the St. Joseph market area under the Proposed Action is expected to remain stable at 327,000 tons annually to meet existing demand; therefore, tax revenues realized by local, state, and federal governments are expected to remain stable. Because dredging in the St. Joseph market area would not change, sand royalty payments to the State of Kansas would continue at approximately $49,000 per year in the short term.

If sand and gravel production occurs at maximum permitted levels (1.2 million tons per year under the Proposed Action), tax revenues and sand royalties would be substantially higher.

Kansas City Market Area

Under the Proposed Action, sand and gravel production from the Kansas City market area to meet the existing demand would decrease to 2.4 million tons annually from 2.7 million tons annually under existing conditions. This decrease in sand and gravel production would decrease tax revenues realized by local, state, and federal governments. A decrease in production in the Kansas City market area would generate approximately $57,000 annually in royalties to the State of Kansas in the short term, compared to $64,000 under existing conditions.

If sand and gravel production occurs at maximum permitted levels (4.1 million tons per year under the Proposed Action), tax revenues would be substantially higher.

[10] It was assumed that all dredging production in the St. Joseph market area and approximately 16 percent of dredging production in the Kansas City market area would be subject to State of Kansas royalty payments.

Waverly Market Area

Sand and gravel production in the Waverly market area would increase under the Proposed Action to approximately 968,000 tons per year if production remains at levels to meet existing demand; therefore, tax revenues realized by local, state, and federal governments are expected to increase accordingly. No sand royalty payments are generated by production in the Waverly market area.

If sand and gravel production occurs at maximum permitted levels (1.0 million tons per year under the Proposed Action), tax revenues would be slightly higher.

Jefferson City Market Area

Sand and gravel production in the Jefferson City market area would remain largely unchanged under the Proposed Action (approximately 1.6 million tons per year) if production remains at levels to meet existing demand; therefore, tax revenues realized by local, state, and federal governments are expected to remain stable. No sand royalty payments are generated by production in the Jefferson City market area.

If sand and gravel production occurs at maximum permitted levels (2.8 million tons per year under the Proposed Action), tax revenues would be substantially higher.

St. Charles Market Area

Sand and gravel production in the St. Charles market area is expected to remain constant under the Proposed Action (1.6 million tons per year) if production remains at levels to meet existing demand; therefore, no change is expected in tax revenues realized by local, state, and federal governments. No sand royalty payments are generated by production in the St. Charles market area.

If sand and gravel production occurs at maximum permitted levels (4.4 million tons per year under the Proposed Action), tax revenues would be substantially higher.

4.10.3.4 Economic Effects Related to River Bed Degradation

River bed degradation in the LOMR could result in a range of economic impacts associated with costs of infrastructure maintenance and replacement and infrastructure failure; water supply and treatment costs; and changes in agricultural production, recreation use levels and associated spending, and river navigation. A description of ongoing economic effects related to river bed degradation is presented in the Affected Environment (Section 3.12.7.8), and additional information concerning potential impacts on infrastructure is presented in Section 4.3. It is anticipated that potential economic effects related to

river bed degradation under the Proposed Action and alternatives would be similar to those described in Section 3.12, as discussed generally below.

Under the Proposed Action, with the volume of sand and gravel production at levels to meet existing demand, the existing economic effects related to river bed degradation likely would continue. These potential economic effects include:

- Costs of infrastructure maintenance and replacement (in response to damage to infrastructure related to river bed degradation, including impacts on water intakes that serve municipal and/or industrial water users, levees and dikes, bridge and pipeline crossings, and wharf and dock facilities).
- Costs associated with reductions in flood control benefits provided by the regional levee system that may be compromised by the adverse effects of river bed degradation, including the potential for catastrophic levee failure that would result in loss of life and disruption of business operations.
- Costs related to water supply and water quality (in response to the potential need to secure alternative water sources due to declining well productivity and/or inoperability of water supply intakes, and increased treatment costs if water quality deteriorates below threshold levels).
- Incremental costs to farmers (in response to increased groundwater pumping costs if groundwater levels are lowered).
- Reduction in recreation spending benefits (in response to reduced recreational boating access and navigability, reductions in the quality of fishing opportunities in the river, and the presence of commercial barges that may compromise the overall recreational quality of the river).
- Avoided costs associated with river channel maintenance (in response to maintenance dredging performed by commercial dredge operators).

The general types of river bed degradation effects discussed above apply to all market areas considered in this analysis.

St. Joseph, Jefferson City, and St. Charles Market Areas

Based on recent levels of demand, dredging is expected to continue at historical levels under the Proposed Action in the St. Joseph, Jefferson City and St. Charles market areas—resulting in a continuation of existing river bed degradation and related economic impacts as referenced above and described in Section 3.12.7.8. Continued river bed degradation could compromise the integrity of

regional levee systems along the LOMR. It has been estimated that federal levees protect investment values of approximately $2.4 billion in the St. Joseph area, $67 million in the Jefferson City area, and $11 million in the St. Charles area. At this time, however, the change in the probability of levee failure under the Proposed Action and alternatives is unknown; therefore, it is not possible to quantify changes in flood control benefits.

If production occurs at maximum permitted levels, the potential economic impacts attributed to river bed degradation could be more severe relative to existing conditions, including a higher probability of levee failure and associated damages.

Kansas City Market Area

The production level in the Kansas City market area is expected to decline under the Proposed Action based on recent levels of demand. A reduction in dredging could result in less river bed degradation and related economic impacts under this alternative compared to existing conditions, although residual economic impacts are expected. Specifically, under the Proposed Action, the risk of levee failure would continue in the Kansas City area, where levees provide protection to about $19 billion in investment value. If production occurs at maximum permitted levels, the potential economic impacts associated with river bed degradation could be more severe than under existing conditions, including a higher probability of levee failure and associated damages.

Waverly Market Area

Based on recent levels of demand, dredging is expected to increase under the Proposed Action in the Waverly market area—resulting in the potential for increased river bed degradation and related economic impacts compared to existing conditions. An increase in river bed degradation would increase the risk of levee failure in the Waverly area, where levees protect approximately $15 million in investment value. If production occurs at maximum permitted levels, these potential adverse impacts could be more severe, including a higher probability of levee failure and associated damages.

4.10.3.5 Environmental Justice Effects

The analysis of environmental justice impacts takes into account the extent of minority and low-income populations in the study area, and the types and magnitude of socioeconomic effects anticipated under the Proposed Action and alternatives based on production levels anticipated to meet existing demand for sand and gravel in the primary market area.

St. Joseph Market Area

Under the Proposed Action, changes in economic activity are expected to be negligible in the St. Joseph market area. Therefore, no adverse economic effects would be realized by minority or low-income populations, and no adverse environmental justice impacts would occur.

Kansas City Market Area

In the Kansas City market area, implementation of the Proposed Action would result in a minor decrease in employment and income based on reductions in dredging and shipping requirements. To the extent that minority or low-income populations comprise these industries, the Project could result in loss of jobs and income in minority and low-income populations. From a regional perspective, the economic impacts in the mining and transportation industries would be partially offset by the potential economic benefits attributed to reductions in sand and gravel costs, which would be realized by the general population including minority and low-income populations. Overall, the magnitude of net economic impacts in the Kansas City region would be negligible relative to the size of local economy. For example, estimated net reduction of jobs in the Kansas City market area under the Proposed Action is 30 jobs, compared to an employment base of nearly 1.2 million jobs. Moreover, it is unlikely that the economic impacts in this region would fall disproportionately on minority or low-income populations. No adverse environmental justice impacts are anticipated in the Kansas City market area from an economic standpoint. Potential risks of levee failure in the Kansas City area attributed to river bed degradation could affect minority and low-income populations; however, these risks have not been quantified.

Under the Proposed Action, employment and personal income would increase in the Waverly market area, primarily for workers in the mining and transportation industries. Similarly, the regional economic benefits attributed to the lower sand and gravel costs would extend to the general population in the Waverly market area, which could provide economic benefits to the general population. No adverse environmental justice impacts are anticipated.

Jefferson City Market Area

In the Jefferson City market area, the Proposed Action would result in a minor increase in employment and income based on dredging production and sand and gravel costs, while the decrease in shipping requirements would adversely affect employment and income levels. To the extent that minority and low-income populations comprise the transportation industry, the Proposed Action could result in loss of jobs and income in minority and low-income populations. From a regional perspective, the net

economic impacts of the Proposed Action would be positive. Therefore, no adverse environmental justice impacts are anticipated.

St. Charles Market Area

In the St. Charles market area, a minor decrease in employment and income would be associated with the decline in the value of dredging production and reduced shipping requirements. To the extent that minority and low-income populations comprise these industries, the Proposed Action could result in loss of jobs and income in minority and low-income populations. From a regional perspective, the net economic effects would be negative, with a slight decrease in employment and income levels. However, these impacts would be negligible relative to the size of local economies. In the St. Charles market area, the net loss of approximately three jobs would be relative to a total employment base of nearly 1.7 million jobs. Moreover, it is unlikely that the economic impacts expected in these regions would fall disproportionately on minority and low-income populations. No adverse environmental justice impacts are anticipated.

4.10.4 No Action Alternative

Under the No Action Alternative, commercial dredging permits would not be renewed and production of construction sand and gravel from the LOMR would cease. Recent demand for sand and gravel from the river would need to be met by alternate sources in the region in the short term, including non-river mining operations inside and outside the primary market area. A comprehensive review of alternate sand and gravel mining operations in the region is presented in Section 2.3.2. The analysis of short-term economic effects has been quantified below. Long-term economic effects, which consider development of new mining operations in the region, are evaluated qualitatively.

The key findings of the economic analysis of the No Action Alternative include the following:

- Commercial dredging of sand and gravel from the LOMR would cease, but production at alternate sources are expected to make up the difference to meet existing demand. Alternate sources include commercial dredging in the Kansas and Mississippi River systems and land-based mines in the state of Missouri.

- Because the location of alternate sand and gravel sources are relatively more distant to demand centers, the No Action Alternative would result in substantial increases in the delivered costs of construction sand and gravel, except in the St. Charles area, where the availability of nearby sources would result in only minor increases in cost.

- Regional economic activity attributed to mining production would be substantially affected in the primary market area, resulting in a loss of $40.6 million in economic output and approximately 273 total jobs. These impacts would be partially offset by regional economic benefits attributed to production increases occurring outside the primary market area in other parts of Missouri, including increases of $23.8 million in annual output and 175 jobs. Shifts in production to other states, including Kansas and Illinois, represent economic leakages outside Missouri.

- Shipping requirements would increase substantially in order to transport materials from alternate sources to demand centers. The regional economic benefits in the truck shipping and related support industries in Missouri would include an increase of $150.3 million in production value annually and approximately 1,305 jobs, which outweigh the regional impacts in the mining industry.

- Estimated increases in construction sand and gravel costs would decrease income levels of consumers, which would reduce economic activity in Missouri, including a loss of approximately $91.3 million in output value and 813 total jobs.

- Net regional economic activity at the state level would be higher relative to existing conditions based on the shift from the mining sector to the transportation sector. Overall, economic output and employment at the state level are expected to increase by $42.3 million annually and 395 jobs, respectively.

- Estimated sand royalty payments paid to the State of Kansas would be slightly higher based on shifts in production to mining operations in Kansas.

4.10.4.1 Industry and Market Effects

As shown in Table 4.10-1, although sand and gravel would not be produced from the LOMR under the No Action Alternative, excess capacity across existing alternate sources in the region likely would be sufficient to meet existing demand over the short term. These alternate sources include the Mississippi and Kansas Rivers; open-pit mines in Missouri, Kansas, and Illinois, including floodplain production off of the Meramec River; and in-stream mining operations in Missouri. The effects of shifting sand and gravel production from the LOMR to alternate supply sources in the short term would be an increase in the cost of sand and gravel to end users resulting primarily from an increase in transportation costs. The short-term costs of construction sand and gravel across market areas are presented in Table 4.10 2. Under the No Action Alternative, the average FOB price is estimated at $5.13 per ton, but accounting for transportation costs, total delivered costs could reach as high as $42.91 per ton in

the short term. It is anticipated that the greatest cost impacts would occur in the Waverly market area, followed by the St. Joseph, Kansas City, Jefferson City, and St. Charles market areas. In addition, there could be quality differences between natural river sand from the LOMR compared to some alternate sources, potentially requiring additional processing in the production of concrete and asphalt (e.g., more cement or asphalt oil), thus further increasing costs. Overall, the anticipated increase in the cost of construction sand and gravel under the No Action Alternative likely would result in a general increase in constructions costs in the region.

In the long term, it is likely that new floodplain open-pit mining operations would be developed in proximity to existing demand centers. Development of new floodplain operations would reduce transportation distances and costs, and would restore equilibrium in the sand and gravel industry in response to market forces. However, development of new mining operations involves substantial capital investment and planning costs that would factor into the cost of sand and gravel. Representative types of expenditures associated with new floodplain operations include up-front costs, such as site exploration and testing, planning and permitting, and land acquisition and development. Operational costs are attributed to stripping and wasted fines. Lastly, off-river mining operations are subject to land reclamation requirements, which could require substantial expenditures in the future. It has been estimated that the net added costs of new floodplain mines is over $4 per ton, which could make it relatively less cost effective compared to river dredging (Holliday Sand & Gravel Company 2010). Beyond costs, other issues associated with floodplain mine developments include lack of willing sellers of land, public opposition, and lengthy planning and permitting processes.

St. Joseph Market Area

Although no sand and gravel would be produced from the LOMR in the St. Joseph market area under the No Action Alternative, production by alternate sources would increase in the St. Joseph market area in the short term. Increased production at alternate sources in the St. Joseph market area is estimated at approximately 14,000 tons per year, which could help offset losses in production from the LOMR in the region that totaled 327,000 tons annually under existing conditions. Other sand and gravel supplies from outside the primary market area would need to be imported from outside the region to meet existing demands. With added transportation costs, the cost of sand and gravel in the St. Joseph market area is expected to increase to an estimated $34.77 per ton under the No Action Alternative in the short term, which is nearly five times as high as costs under existing conditions. This increase would result in substantial short-term cost-related impacts in the construction industry.

Kansas City Market Area

No sand and gravel would be produced from the LOMR in the Kansas City market area under the No Action Alternative; however, production by alternate sources would increase in the Kansas City market area in the short term. Under the No Action Alternative, construction sand and gravel production in the Kansas City market area is estimated at 237,000 tons per year, which is substantially less than the existing demand of nearly 2.7 million tons annually. Other sand and gravel supplies would be imported from outside the region to meet existing demands. The short-term cost of sand and gravel in the Kansas City market area is an estimated $31.27 per delivered ton under the No Action Alternative, compared to $7.98 per ton under existing conditions—a nearly four-fold increase. The resultant cost-related impacts in the construction industry would be substantial in the short term.

Waverly Market Area

No sand and gravel would be produced from the LOMR in the Waverly market area under the No Action Alternative. In addition, there are no alternate supply sources in the Waverly market area. Therefore, sand and gravel production in the region would be zero, and the region would need to rely on sand and gravel imported from outside the primary market area. Consequently, the short-term cost of sand and gravel in the Waverly market area is expected to increase to $42.91 per ton under the No Action Alternative compared to $9.53 under existing conditions. With the lack of alternate sources nearby, the Waverly market area would be subject to the highest delivered cost of sand and gravel of all the market areas. Further, the short-term impacts on costs in the construction industry would be substantial.

Jefferson City Market Area

No sand and gravel would be produced from the LOMR in the Jefferson City market area under the No Action Alternative, but production by alternate sources would increase in the Jefferson City market area in the short term. It is estimated that production at alternate sources in the Jefferson City market area would increase by 27,000 tons annually, which is substantially below the existing demand of nearly 1.6 million tons per year in the area. Based on the cost of importing sand and gravel to the region, the delivered cost of sand and gravel is expected to increase from $9.25 per ton under existing conditions to $28.09 per ton under the No Action Alternative in the short term. The short-term impacts on costs in the construction industry would be substantial.

St. Charles Market Area

No sand and gravel would be produced from the LOMR in the St. Charles market area under the No Action Alternative, but production by alternate sources would increase in the St. Charles market area in the short term. In fact, it is estimated that increased production of sand and gravel from alternate supply sources in the region, including the Mississippi River, would not only fully offset lost production from the LOMR (approximately 1.6 million tons per year under existing conditions) but also would serve other nearby market areas (e.g., Jefferson City). Overall, total production of sand and gravel by alternate sources in the St. Charles market area would be an estimated 2.5 million tons annually. Consequently, the cost impacts in the St. Charles market area are the lowest of all the market areas because the incremental transportation costs are relatively low. The short-term cost of sand and gravel in the St. Charles market area is expected to increase to $8.60 per ton under the No Action Alternative, an approximately 17.2-percent increase relative to existing conditions. This increase represents a moderate cost-related impact to the construction industry in the short term.

4.10.4.2 Regional Economic Effects

Under the No Action Alternative, sand and gravel production would shift from commercial dredging operations to alternate supply sources in the region. Accordingly, no economic activity would be supported by commercial dredging in the short term and the long term. Existing dredging operations would experience substantial adverse economic impacts in the form of lost revenues and profits at the firm level and lost income and jobs for dredging employees. Specifically, commercial dredging operations would incur annual losses of $33.7 million in economic output (or gross revenues), $13.9 million in labor income, and approximately 196 jobs; these effects would extend indefinitely. Under the No Action alternative, the adverse economic impacts in the mining industry would be partially offset at the regional level by direct economic benefits accruing to alternate mining operations and their employees in some market areas. In the short term, these benefits would be realized by existing mining operations; in the long term, these benefits could extend to new mining operations developed in the region.

As explained above, the direct benefits of sand and gravel production extend beyond the mining industry. Mining production has ancillary effects on the truck shipping industry and household income levels, which also generate regional economic effects. The short-term regional economic effects under the No Action Alternative are presented in Table 4.10-5, which account for shifts in production to alternate supply sources both inside and outside the primary market area, including areas outside of Missouri. The total value of output (including indirect and induced effects in related industries)

generated by sand and gravel production under the No Action Alternative is an estimated $42.5 million annually, total labor income is $15.4 million, and 273 total jobs would be supported across the state. Many of these benefits would be realized by mining operations outside the primary market area in the short term. Due to the shift in economic benefits to areas outside Missouri, these figures are considerably lower than statewide economic benefits under existing conditions. In the long term, anticipated development of new mining operations in proximity to the LOMR would serve to retain these benefits within the primary market area.

Table 4.10-5 Short-Term Regional Economic Effects under the No Action Alternative[a ,b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
St. Joseph						
Sand and gravel production	$68,000	$97,000	$21,000	$29,000	1	1
Truck transportation	$22,000	$43,000	$8,000	$14,000	0	0
Household income (change)[f]	$0	-$5,925,000	$0	-$1,814,000	0	-58
Kansas City						
Sand and gravel production	$433,000	$928,000	$180,000	$340,000	2	5
Truck transportation	$225,000	$1,232,000	$89,000	$474,000	2	10
Household income (change)[f]	$0	-$42,517,000	$0	-$14,143,000	0	-347
Waverly						
Sand and gravel production	$0	$12,000	$0	$4,000	0	0
Truck transportation	$0	$32,000	$0	$10,000	0	0
Household income (change)[f]	$0	-$11,034,000	$0	-$2,961,000	0	-110
Jefferson City						
Sand and gravel production	$139,000	$352,000	$54,000	$124,000	1	2
Truck transportation	$99,000	$527,000	$36,000	$180,000	1	4
Household income (change)[f]	$0	-$25,549,000	$0	-$7,821,000	0	-246
St. Charles						
Sand and gravel production	$9,210,000	$16,463,000	$4,332,000	$6,780,000	32	83
Truck transportation	$21,922,000	$40,628,000	$8,529,000	$15,423,000	156	312
Household income (change)[f]	$0	-$3,018,000	$0	-$1,012,000	0	-23
Outside Primary Market Area[g]						
Sand and gravel production	$17,105,000	$24,644,000	$5,946,000	$8,173,000	119	182
Truck transportation	$87,619,000	$132,281,000	$32,162,000	$47,752,000	693	1,174
Household income (change)[h]	$0	-$3,271,000	$0	-$1,009,000	0	-30

Table 4.10-5 Short-Term Regional Economic Effects under the No Action Alternative[a ,b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
Total (State of Missouri)						
Sand and gravel production	$26,956,000	$42,495,000	$10,532,000	$15,449,000	155	273
Truck transportation	$109,888,000	$174,744,000	$40,823,000	$63,853,000	852	1,501
Household income (change)	$0	-$91,313,000	$0	-$28,760,000	0	-813

[a] Monetary values are reported in 2008 dollars and represent annualized effects.

[b] Regional economic effects are limited to changes in final demands in Missouri; changes in economic activity in adjacent states are excluded from the results.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (segment) of production.

[e] Includes direct, indirect, and induced effects resulting from activity in the target market area and linkages to other market areas.

[f] Represents regional economic effects attributed to changes in household income resulting from changes in the cost of construction sand and gravel.

[g] The "primary market area" represents the total of the five individual market areas serving each segment.

[h] Household income effects were not considered for areas outside the primary market area because no changes in the cost of sand and gravel are anticipated; the results shown are based on linkages with the primary market area.

Source: ENTRIX 2010.

Conversely, increased transportation requirements under the No Action Alternative would generate substantial benefits in the truck shipping industry in the short term. The regional economic benefits attributed to truck shipping activity include $174.7 million in total output, $63.9 million in total labor income, and approximately 1,501 jobs. These figures are substantially higher relative to existing conditions; however, most of the benefits would occur outside the primary market area. Within the primary market area, transportation-related effects vary considerably depending on proximity of demand centers to alternate supply sources. In the long term, the transportation benefits outside the primary market area would dissipate as new mines were developed near demand centers, thereby reducing the need for long-distance shipping.

The substantial increases in the short-term cost of sand and gravel across market areas would result in a reduction in household income levels if costs are passed through to the public. The anticipated reduction in household income would adversely affect regional economic conditions, including a loss of $91.3 million in total output, $28.8 million in total labor income, and approximately 813 jobs throughout Missouri. In the long term, the cost of sand and gravel is expected to decrease relative to short-term levels in response to development of new mining operations in proximity to demand centers; this would minimize income-related impacts on consumers.

No short-term construction-related economic impacts would be associated with development of new sand plants by permit applicants under the No Action Alternative. In the long term, however, it is anticipated that the region could realize substantial construction benefits from development of new land-based mining operations. Because it is not possible to predict the location, size, or required expenditures for new mining developments, the temporary construction benefits that would occur over the long term have not been quantified.

St. Joseph Market Area

The short-term regional economic effects in the St. Joseph market area under the No Action Alternative are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $97,000 annually (-$2.2 million),
  - Decrease in total labor income to $29,000 annually (-$667,000), and
  - Decrease in total employment to one job (-14 jobs).
- Truck transportation activity
  - Decrease in total output to $43,000 annually (-$561,000),
  - Decrease in total labor income to $14,000 annually (-$189,000), and
  - Decrease in total employment to less than one job (-5 jobs).
- Change in household income
  - Decrease in total output by $5.9 million annually,
  - Decrease in total labor income by $1.8 million annually, and
  - Decrease in total employment by 58 jobs.

Kansas City Market Area

The short-term regional economic effects in the Kansas City market area under the No Action Alternative are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $928,000 annually (-$24.5 million),
  - Decrease in total labor income to $340,000 annually (-$9.5 million), and

  - Decrease in total employment to five jobs (-153 jobs).
- Truck transportation activity
  - Decrease in total output to $1.2 million annually (-$10. million),
  - Decrease in total labor income to $474,000 annually (-$3.9 million), and
  - Decrease in total employment to 10 jobs (-75 jobs).
- Change in household income
  - Decrease in total output by $42.5 million annually,
  - Decrease in total labor income by $14.1 million annually, and
  - Decrease in total employment by 347 jobs.

Under the No Action Alternative, no new sand plant would be developed at Waldron and there would be no short-term construction benefits in the Kansas City market area.

Waverly Market Area

The short-term regional economic effects in the Waverly market area under the No Action Alternative are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $12,000 annually (-2.4 million),
  - Decrease in total labor income to $4,000 annually (-$845,000), and
  - Decrease in total employment to less than one job (-16 jobs).
- Truck transportation activity
  - Decrease in total output to $32,000 annually (-$549,000),
  - Decrease in total labor income to $10,000 annually (-$186,000), and
  - Decrease in total employment less than one job (-5 jobs).
- Change in household income
  - Decrease in total output by $11.0 million annually,
  - Decrease in total labor income by $3.0 million annually, and
  - Decrease in total employment by 110 jobs.

Jefferson City Market Area

The short-term regional economic effects in the Jefferson City market area under the No Action Alternative are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $352,000 annually (-$13.1 million),
  - Decrease in total labor income to $124,000 annually (-$4.7 million), and
  - Decrease in total employment to two jobs (-86 jobs).
- Truck transportation activity
  - Decrease in total output to $527,000 annually (-$5.1 million),
  - Decrease in total labor income to $180,000 annually (-$1.8 million), and
  - Decrease in total employment to four jobs (-45 jobs).
- Change in household income
  - Decrease in total output by $25.5 million annually,
  - Decrease in total labor income by $7.8 million annually, and
  - Decrease in total employment by 246 jobs.

St. Charles Market Area

The short-term regional economic effects in the St. Charles market area under the No Action Alternative are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $16.5 million annually (+$2.7 million),
  - Increase in total labor income to $6.8 million annually (+$1.1 million), and
  - Decrease in total employment to 83 jobs (-4 jobs).
- Truck transportation activity
  - Increase in total output to $40.6 million annually (+$34.6 million),
  - Increase in total labor income to $15.4 million annually (+$13.1 million), and
  - Increase in total employment to 312 jobs (+266 jobs).

- Change in household income
  - Decrease in total output by $3.0 million annually,
  - Decrease in total labor income by $1.0 million annually, and
  - Decrease in total employment by 23 jobs.

Under the No Action Alternative, no new sand plant would be developed at Washington, and there would be no short-term construction benefits in the St. Charles market area.

4.10.4.3 Tax Revenue Effects

The types of tax revenues generated by mining activity under the No Action Alternative would be similar to those listed for the Proposed Action (see Section 4.10.3.3). However, certain types of tax revenues realized by local governments in Missouri would be reduced in response to production shifts outside the state to adjacent states (i.e., Kansas and Illinois), including state franchise and income taxes. In addition, county-level property taxes may decline if existing dredge operators sell their land holdings or idle existing sand plants. Value of Waterway fuel taxes from LOMR dredging also would decline to zero under the No Action Alternative. At the federal level, income and payroll taxes should not be affected as losses from the state of Missouri likely would be offset by increases in other states. In the long term, anticipated development of new mining operations in Missouri would generate a range of new tax revenues.

In the context of sand royalty payments paid to the State of Kansas, it is anticipated that royalties generated under the No Action Alternative would be largely unchanged in the short term relative to existing conditions (see Table 4.10-3). In lieu of royalty payments from commercial dredging operations on the LOMR, royalties would be paid by alternate sources located in Kansas—including dredging operations in the Kansas River and other floodplain open-pit mine operations—that are expected to increase production in response to displaced supplies from the LOMR. Overall, royalty payments paid to the State of Kansas are estimated at $119,000 per year under the No Action Alternative in the short term, a 5.4-percent increase relative to existing conditions. This would be a minor economic benefit of the No Action Alternative. In the long term, sand royalties likely would decrease as new mining operations were developed in Missouri to offset displaced supplies from the LOMR; new sources in Missouri outside the LOMR would not be subject to royalty payments.

St. Joseph Market Area

Sand and gravel production from the St. Joseph market area is expected to decrease to 14,000 tons annually under the No Action Alternative, reflecting the lack of alternate sources in the region. A decrease in sand and gravel production in the St. Joseph market area would decrease tax revenues realized by local, state, and federal governments in the short term; but these losses may be offset by increased mining activity elsewhere in Missouri. Because none of the production in the St. Joseph market area would be subject to sand royalty payments, sand royalties generated from the region would fall from approximately $49,000 per year to $0 in the short term. The loss in sand royalties would be offset by increased sand and gravel production outside the primary market area in other parts of Kansas.

Kansas City Market Area

Under the No Action Alternative, sand and gravel production from the Kansas City market area would decrease to 237,000 tons per year in the short term, a decline from approximately 2.7 million tons annually under existing conditions. The decrease in production would reduce tax revenues realized by local, state, and federal governments. Sand and gravel production in the Kansas City market area that would be subject to royalties includes increased dredging from the Kansas River and floodplain open-pit mine production elsewhere in Kansas. Sand royalty payments from the Kansas City market area are expected to decline to approximately $22,000 annually in the short term, down from $64,000 under existing conditions. The loss in sand royalties would be offset from increased sand and gravel production outside the primary market area in other parts of Kansas.

Waverly and Jefferson City Market Areas

Under the No Action Alternative, there would be no sand and gravel production in the Waverly market area and production in the Jefferson City market area would decline to 27,000 tons per year. Consequently, tax revenues realized by local, state, and federal governments would be substantially reduced in the short term. No sand royalty payments are generated by production in the Waverly or Jefferson City market areas.

St. Charles Market Area

Sand and gravel production at alternate sources in the St. Charles market area is expected to increase to nearly 2.5 million tons annually under the No Action Alternative, up from approximately 1.6 million tons in dredging production under existing conditions. Consequently, tax revenues realized by local,

state, and federal governments are expected to increase in the short term. No sand royalty payments are generated by production in the St. Charles market area.

4.10.4.4 Economic Effects Related to River Bed Degradation

The general types of economic impacts associated with bed degradation are presented in Section 4.10.3.4. Because dredging of commercial sand and gravel throughout the LOMR would cease under the No Action Alternative, river bed degradation associated with dredging would stop. Therefore, no incremental economic impacts related to river bed degradation are expected under the No Action Alternative. In fact, the potential economic costs associated with river bed degradation would be avoided over the long term (current degradation impacts could continue into the short term), which is considered an economic benefit of the No Action Alternative. These benefits may include avoided costs with infrastructure repair, maintenance, and replacement (e.g., water supply intakes), as well as substantially decreasing the probability of failure of the major urban levees that protect approximately $21.4 billion in investment along the LOMR.

All Market Areas

No incremental economic effects related to river bed degradation associated with dredging are expected under the No Action Alternative as commercial dredging in the LOMR would cease in all river segments. The economic benefits (i.e., avoided costs) described above would apply to all market areas.

4.10.4.5 Environmental Justice Effects

Section 4.10.3.5 presents a general overview of environmental justice and the social and demographic characteristics of the primary market area. The analysis of environmental justice effects under the No Action Alternative is presented below by market area.

St. Joseph and Jefferson City Market Areas

Under the No Action Alternative, reductions in sand and gravel production, reductions in truck transportation, and related increases in the cost of sand and gravel in the St. Joseph and Jefferson City market areas would result in adverse economic impacts. The direct impacts would be concentrated on people working in the commercial dredging and transportation industries. To the extent that employees in these industries are comprised of significant minority or low-income populations, environmental justice impacts could occur. At the regional scale, anticipated declines in household income levels could affect low-income populations in these market areas, which are slightly more prevalent relevant to

the state overall; however, these income effects would tend to affect the general population and would not fall disproportionately on low-income groups. As a result, no adverse environmental justice impacts are anticipated.

Kansas City Market Area

Reductions in sand and gravel production and related cost increases in the Kansas City market area would result in adverse economic impacts under the No Action Alternative. The direct impacts would be concentrated on people working in the commercial dredging and transportation industries. To the extent that employees in these industries are comprised of significant minority or low-income populations, environmental justice impacts could occur. The percentage of minority population in the Kansas City market area is higher relative to the percentage for the state, but it is unlikely that the economic impacts occurring at the regional level would fall disproportionately on minority groups. No adverse environmental justice impacts are anticipated. In fact, the reduced probability of levee failure in the Kansas City area under the No Action Alternative could benefit minority and low-income populations; however, these risks have not been quantified.

Waverly Market Area

Under the No Action Alternative, reductions in sand and gravel production, reductions in truck transportation, and related increases in the cost of sand and gravel in the Waverly market area would result in adverse economic impacts. The direct impacts would be concentrated on people working in the commercial dredging and transportation industries. To the extent that employees in these industries are comprised of significant minority or low-income populations, environmental justice impacts could occur. At the regional scale, anticipated economic impacts could affect the general population in the Waverly market area; however, this area is not characterized by significant minority or low-income populations, and these effects are not expected to fall disproportionately on these groups. Therefore, no adverse environmental justice impacts are anticipated.

St. Charles Market Area

Under the No Action Alternative, the St. Charles market area would experience a substantial decline in dredging production from the LOMR, which would be offset by increased production by alternate sources. The direct impacts would be concentrated on people working in the commercial dredging industry. To the extent that employees in these industries are comprised of significant minority or low-income populations, environmental justice impacts could occur. From a regional perspective, reductions in household income levels attributed to the increase in the cost of sand and gravel would

affect the general population, which includes a relatively larger minority population than the state overall, but it is unlikely that these regional economic impacts would fall disproportionately on minority groups. No adverse environmental justice impacts are anticipated.

4.10.5 Alternative A

Under Alternative A, commercial sand and gravel dredging in the LOMR would be permitted up to a maximum of approximately 2.2 million tons annually. Because permitted volumes would be less than recent demand levels (approximately 6.9 million tons per year), it is anticipated that alternate sources in the region would increase production to offset losses from the LOMR. The analysis of short-term economic effects has been quantified below. Long-term economic effects, which consider development of new mining operations in the region, are evaluated qualitatively.

The key findings of the economic analysis of Alternative A include the following:

- Commercial dredging of sand and gravel from the LOMR would decline to nearly 2.2 million tons per year, while production at alternate sources would increase by approximately 4.7 million tons in order to satisfy existing demand. Production would shift substantially across market areas and individual sand plants.
- Based primarily on higher transportation requirements, the delivered costs of construction sand and gravel would increase in all market areas.
- Regional economic activity attributed to mining production would be substantially affected in the primary market area, resulting in a loss of $25.0 million in economic output and approximately 171 total jobs. These impacts would be partially offset by regional economic benefits attributed to production increases occurring outside the primary market area in other parts of Missouri, including increases of $13.7 million in annual output and 101 jobs. Shifts in production to other states, including Kansas and Illinois, represent economic leakages outside Missouri.
- This alternative would increase shipping requirements and generate economic benefits in the truck shipping industry. The regional economic benefits associated with increased truck shipping include an increase of $54.5 million in annual production value and approximately 475 jobs in Missouri, which outweigh the regional impacts in the mining industry.
- Estimated increases in construction sand and gravel costs would decrease income levels of consumers, which would reduce economic activity, including a loss of approximately $32.8 million in output value and 292 total jobs in Missouri.

- Net regional economic activity at the state level would be higher relative to existing conditions based on the shift from the mining sector to the transportation sector. Overall, economic output and employment at the state level are expected to increase by $10.3 million annually and 112 jobs, respectively.
- Estimated sand royalty payments paid to the State of Kansas would increase substantially under Alternative A in response to continuation of commercial dredging in the St. Joseph and Kansas City market areas and shifts in production to mining operations in Kansas.

4.10.5.1 Industry and Market Effects

It is anticipated that sand and gravel production from the LOMR under Alternative A would reach maximum permitted levels (approximately 2.2 million tons annually), a decline of 68 percent relative to existing conditions (Table 4.10-1). In response to market pressures, alternate sources in the region likely would increase production, resulting in an increase in the delivered cost of sand and gravel due primarily to increased transportation costs. The short-term costs of construction sand and gravel across market areas are presented in Table 4.10-2. Under Alternative A, the average FOB price is an estimated $5.08 per ton, and all market areas would realize an increase in the delivered cost of sand and gravel costs relative to existing conditions. Based on the differences in quality between natural river sand from the LOMR and sand from some alternate sources, additional processing may be required in the production of concrete and asphalt, thereby further increasing costs to end users. The anticipated increase in the cost of sand and gravel under Alternative A likely would result in an overall increase in construction costs in the region.

In the long term, it is likely that new floodplain open-pit mining operations would be developed in proximity to existing demand centers, restoring equilibrium in the sand and gravel market, which would serve to minimize potential cost increases anticipated in the short term. However, floodplain open-pit mining would not be as cost effective as river dredging (see Section 4.10.4.1 for more information on the issues and costs associated with floodplain open-pit mining).

St. Joseph Market Area

Approximately 350,000 tons of sand and gravel would be produced annually from the LOMR in the St. Joseph market area under Alternative A, supplemented by an increase of approximately 14,000 tons by alternate sources in the St. Joseph market area. Production in the St. Joseph market area would exceed existing demand in the region (approximately 327,000 tons annually). However, the short-term cost of sand and gravel in the St. Joseph market area is expected to increase slightly (to $7.80 per ton)

under Alternative A, an increase of approximately 5.5 percent relative to existing conditions. Despite increased production in the St. Joseph market area, the estimated higher cost reflects lower production volumes in the Kansas City market area, which would draw sand and gravel produced in the St. Joseph market area in the short term. Therefore, the St. Joseph market area would be required to import sand and gravel from more distant areas, which would result in added transportation costs and an increase in the overall delivered cost of sand and gravel in the short term. Alternative A would result in minor cost-related effects for the construction industry.

Kansas City Market Area

In the Kansas City market area, sand and gravel production from the LOMR is expected to reach the maximum permitted volume (540,000 tons annually) under Alternative A. It is estimated that alternate sources in the region would increase production by an additional 237,000 tons per year. However, total production in the Kansas City market area would fall substantially short of recent levels of demand (nearly 2.7 million tons per year). The imported sand and gravel supplies from outside the market area would result in higher transportation costs; therefore, the delivered cost of sand and gravel in the Kansas City market area is expected to increase to $16.46 per ton under Alternative A in the short term, an increase of approximately 106 percent relative to existing conditions. The resultant cost-related impacts in the construction industry would be substantial in the short term.

Waverly Market Area

Approximately 500,000 tons of sand and gravel would be produced annually from the LOMR in the Waverly market area under Alternative A, which is less than existing demand levels (678,000 tons per year). In response to declines in production in the Waverly market area and in conjunction with supplies likely being drawn out of the region in response to substantial reductions in dredging in the Kansas City market area, the Waverly market area would need to rely on more distant alternate sources in the region in the short term. Accordingly, the cost of sand and gravel in the Waverly market area under Alternative A is expected to increase from 9.53 per ton under existing conditions to $24.40 per ton—the highest delivered cost of sand and gravel across market areas. The increased cost would cause a substantial short-term impact on the construction industry.

Jefferson City Market Area

Approximately 457,000 tons of sand gravel would be produced annually in the Jefferson City market area under Alternative A, of which 430,000 tons would come from commercial dredging operations in the LOMR and 27,000 tons would be produced by alternate sources in the region. Total production in

the Jefferson City market area would not meet existing demand in the region (approximately 1.6 million tons annually), thereby requiring sand and gravel to be imported to the area at higher costs. Under Alternative A, the cost of sand and gravel in the Jefferson City market area is expected to increase to $16.71 per ton in the short term, an 81-percent increase relative to existing conditions. The resultant increase in construction costs in the region would be a substantial adverse effect in the short term..

St. Charles Market Area

Sand and gravel production from the St. Charles market area is expected to reach 370,000 tons annually under Alternative A, and an additional approximately 2.0 million tons would be produced by alternate sources in the region. Total supplies would exceed existing demand (approximately 1.6 million tons per year) in response to demands in other nearby market areas (e.g., Jefferson City). Based on the relative abundance of alternate sources in the St. Charles market area, the cost of sand and gravel is estimated to increase to only $7.63 per ton under Alternative A in the short term, an approximately 4.1-percent increase relative to existing conditions. The increase would cause minor cost-related effects in the construction industry.

4.10.5.2 Regional Economic Effects

Sand and gravel production would shift in part from in-river dredging to alternate sources in the region under Alternative A. As a result, existing dredging operations would incur direct economic losses over the long term in the form of lost revenues and profits at the firm level and lost income and jobs for employees. Estimated impacts include a loss of $23.0 million in economic output (or gross revenues), $9.7 million in labor income, and approximately 134 jobs. Although adverse economic impacts are associated with Alternative A, these impacts would be partially offset at the industry level in the short term by direct economic benefits accruing to alternate mining operations currently in operation and their employees. In the long-term, these benefits would accrue to new mining operations developed in the region to offset the displaced supplies from the LOMR.

The short-term regional economic effects under Alternative A are presented in Table 4.10-6; the estimates account for shifts in production to alternate supply sources both inside and outside the primary market area, including areas outside Missouri. Within Missouri, the total value of output generated by sand and gravel production under Alternative A would be $48.0 million annually, total labor income would be $17.6 million, and a total of 301 total jobs would be supported. Many of these benefits would be realized by mining operations outside the primary market area in the short term and

by new mining operations in the long term. These figures are lower than the statewide economic benefits under existing conditions based on leakages of economic benefits to areas outside the state.

Table 4.10-6 Short-Term Regional Economic Effects under Alternative A [a, b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
St. Joseph						
Sand and gravel production	$1,797,000	$2,561,000	$544,000	$770,000	11	17
Truck transportation	$473,000	$750,000	$165,000	$251,000	4	7
Household income (change)[f]	$0	-$135,000	$0	-$39,000	0	-1
Kansas City						
Sand and gravel production	$3,843,000	$7,632,000	$1,597,000	$2,818,000	22	45
Truck transportation	$1,241,000	$2,682,000	$490,000	$1,035,000	9	21
Household income (change)[f]	$0	-$15,566,000	$0	-$5,180,000	0	-127
Waverly						
Sand and gravel production	$1,589,000	$2,138,000	$577,000	$736,000	9	14
Truck transportation	$598,000	$815,000	$205,000	$275,000	5	7
Household income (change)[f]	$0	-$4,909,000	$0	-$1,317,000	0	-49
Jefferson City						
Sand and gravel production	$2,385,000	$4,327,000	$915,000	$1,535,000	14	29
Truck transportation	$1,074,000	$1,928,000	$384,000	$680,000	9	17
Household income (change)[f]	$0	-$10,106,000	$0	-$3,094,000	0	-97
St. Charles						
Sand and gravel production	$9,356,000	$16,792,000	$4,401,000	$6,913,000	37	89
Truck transportation	$12,483,000	$23,068,000	$4,856,000	$8,756,000	89	177
Household income (change)[f]	$0	-$850,000	$0	-$287,000	0	-6
Outside Primary Market Area[g]						
Sand and gravel production	$9,704,000	$14,507,000	$3,373,000	$4,809,000	67	107
Truck transportation	$32,732,000	$49,660,000	$12,015,000	$17,928,000	259	441
Household income (change)[g]	$0	-$1,278,000	$0	-$396,000	0	-12
Total (State of Missouri)						
Sand and gravel production	$28,674,000	$47,957,000	$11,407,000	$17,581,000	160	301
Truck transportation	$48,601,000	$78,904,000	$18,115,000	$28,927,000	375	670
Household income (change)	$0	-$32,844,000	$0	-$10,313,000	0	-292

Table 4.10-6 Short-Term Regional Economic Effects under Alternative A [a, b, c]

[a] Monetary values are reported in 2008 dollars and represent annualized effects.

[b] Regional economic effects are limited to changes in final demands in Missouri; changes in economic activity in adjacent states are excluded from the results.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (segment) of production.

[e] Includes direct, indirect, and induced effects resulting from activity in the target market area and linkages to other market areas.

[f] Represents regional economic effects attributed to changes in household income resulting from changes in the cost of construction sand and gravel.

[g] The "primary market area" represents the total of the five individual market areas serving each segment.

[h] Household income effects were not considered for areas outside the primary market area because no changes in the cost of sand and gravel are anticipated; the results shown are based on linkages with the primary market area.

Source: ENTRIX 2010.

Conversely, increased transportation requirements under Alternative A would result in substantial benefits in the truck shipping industry. The regional economic benefits in Missouri associated with truck shipping activity include $78.9 million in total output, $28.9 million in total labor income, and 670 jobs. At the state level, these figures are substantially higher relative to existing conditions; however, most of these benefits would occur outside the primary market area. Across the individual market areas, transportation-related effects would vary considerably depending on proximity to alternate supply sources. In the long term, these transportation benefits would decline as new mines were developed in closer proximity to demand centers.

Increases in the cost of sand and gravel under Alternative A would result in household income effects assuming that costs are passed through to the public. Potential reductions in household income would result in estimated losses of $32.8 million in total output, $10.3 million in total labor income, and approximately 292 jobs throughout Missouri. In the long term, income-related impacts would be minimized as new mining operations were developed and sand and gravel costs declined relative to short-term levels.

Similar to the Proposed Action, temporary construction benefits would be associated with development of new sand plants by the permit applicants. In addition, the region could realize temporary construction benefits from development of new off-river mining operations in the long term, in response to reductions in allowable dredging. Because it is not possible to predict the size, cost, or reliance on the local construction industry for new mining developments, these construction benefits have not been quantified.

St. Joseph Market Area

The short-term regional economic effects in the St. Joseph market area under Alternative A are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $2.6 million annually (+$245,000),
  - Increase in total labor income to $770,000 annually (+$74,000), and
  - Increase in total employment to 17 jobs (+2 jobs).
- Truck transportation activity
  - Increase in total output to $750,000 annually (+$146,000),
  - Increase in total labor income to $251,000 annually (+$49,000), and
  - Increase in total employment to 7 jobs (+1 job).
- Change in household income
  - Decrease in total output by $135,000 annually,
  - Decrease in total labor income by $39,000 annually, and
  - Decrease in total employment by 1 job.

Kansas City Market Area

The short-term regional economic effects in the Kansas City market area under Alternative A are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $7.6 million annually (-$18.8 million),
  - Decrease in total labor income to $2.8 million annually (-$7.0 million), and
  - Decrease in total employment to 45 jobs (-112 jobs).
- Truck transportation activity
  - Decrease in total output to $2.7 million annually (-$8.5 million),
  - Decrease in total labor income to $1.0 million annually (-$3.3 million), and
  - Decrease in total employment to 21 jobs (-64 jobs).

- Change in household income
  - Decrease in total output by $15.6 million annually,
  - Decrease in total labor income by $5.2 million annually, and
  - Decrease in total employment by 127 jobs.

Development of a new sand plant at Waldron also would generate short-term economic benefits in the Kansas City market area from new construction activity.

Waverly Market Area

The short-term regional economic effects in the Waverly market area under Alternative A are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $2.1 million annually (-$330,000),
  - Increase in total labor income to $736,000 annually (-$113,000), and
  - Increase in total employment to 14 jobs (-2 jobs).
- Truck transportation activity
  - Increase in total output to $815,000 annually (+$234,000),
  - Increase in total labor income to $275,000 annually (+$79,000), and
  - Increase in total employment to 7 jobs (+2 jobs).
- Change in household income
  - Decrease in total output by $4.9 million annually,
  - Decrease in total labor income by $1.3 million annually, and
  - Decrease in total employment by 49 jobs.

Jefferson City Market Area

The short-term regional economic effects in the Jefferson City market area under Alternative A are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $4.3 million annually (-$9.1 million),

  - Decrease in total labor income to $1.6 million annually (-$3.3 million), and
  - Decrease in total employment to 29 jobs (-60 jobs).
- Truck transportation activity
  - Decrease in total output to $1.9 million annually (-$3.7 million),
  - Decrease in total labor income to $680,000 annually (-$1.3 million), and
  - Decrease in total employment to 17 jobs (-33 jobs).
- Change in household income
  - Decrease in total output by $10.1 million annually,
  - Decrease in total labor income by $3.1 million annually, and
  - Decrease in total employment by 97 jobs.

St. Charles Market Area

The short-term regional economic effects in the St. Charles market area under Alternative A are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $16.8 million annually (+$3.0 million),
  - Increase in total labor income to $6.9 million annually (+$1.3 million), and
  - Increase in total employment to 89 jobs (+2 jobs).
- Truck transportation activity
  - Increase in total output to $23.1 million annually (+$17.0 million),
  - Increase in total labor income to $8.8 million annually (+$6.5 million), and
  - Increase in total employment to 177 jobs (+131 jobs).
- Change in household income
  - Decrease in total output by $850,000 annually,
  - Decrease in total labor income by $287,000 annually, and
  - Decrease in total employment by 6 jobs.

Development of a new sand plant at Washington, Missouri also would generate short-term construction benefits in the St. Charles market area.

4.10.5.3 Tax Revenue Effects

The types of tax revenues generated by mining activity under Alternative A would be similar to those listed for the Proposed Action in Section 4.10.3.3. However, some types of tax revenues realized by local governments in Missouri, including state franchise and income taxes, would be reduced in response to production shifts to adjacent states in the short term. In addition, county-level property taxes may decline if existing dredge operators sell their land holdings or idle existing sand plants. Value of Waterway fuel taxes from dredging in the LOMR also would decline in proportion to reductions in dredging under Alternative A. At the federal level, income and payroll taxes should not be affected, as losses from Missouri likely would be offset in other states. In the long term, new tax revenues would be generated by the anticipated development of new mining operations in Missouri.

It is anticipated that sand royalties generated under Alternative A would be higher relative to existing conditions in the short term, as shown in Table 4.10-3. In this case, royalties would be paid based on production from commercial dredging in the St. Joseph and Kansas City market areas, as well as from alternate sources located in Kansas. Under Alternative A, total royalties paid to the State of Kansas resulting from changes in dredging activity are an estimated $185,000 per year in the short term, an 86-percent increase relative to existing conditions; this is an economic benefit. In the long term, sand royalties would decline relative to short-term levels as production shifted to new land-based mining operations in Missouri.

St. Joseph Market Area

An increase in sand and gravel production in the St. Joseph market area would increase tax revenues realized by local, state, and federal governments in the short term. In addition, sand royalties generated from production in this region would increase slightly, from approximately $49,000 to $53,000 per year.

Kansas City Market Area

The decrease in sand and gravel production in the Kansas City market area would decrease tax revenues realized by local, state, and federal governments in the short term. Some of the sand and gravel production in the Kansas City market area would be subject to royalties. Sand royalties generated by production in the Kansas City market area are expected to decline to approximately

$35,000 annually, down from $64,000 annually under existing conditions. The short-term loss in sand royalties would be offset from increased sand and gravel production outside the primary market area in other parts of Kansas.

Waverly and Jefferson City Market Areas

The decrease in sand and gravel production in the Waverly and Jefferson City market areas would decrease tax revenues realized by local, state, and federal governments in the short term. No sand royalty payments are generated by production in the Waverly or Jefferson City market area.

St. Charles Market Area

An increase in sand and gravel production in the Waverly and St. Charles market areas would increase tax revenues realized by local, state, and federal governments. No sand royalty payments are generated by production in the St. Charles market area.

4.10.5.4 Economic Effects Related to River Bed Degradation

The general types of river bed degradation effects discussed in Section 4.10.3.4 apply to all market areas considered in this analysis. Because the volume of commercial dredging of sand and gravel would fall to approximately 2.2 million tons annually, down from approximately 6.9 million tons annually under existing conditions, potential economic impacts attributed to river bed degradation caused by dredging would be reduced considerably under Alternative A, which could result in a range of avoided costs such as infrastructure repair, maintenance, and replacement costs and potential flood damages associated with levee failures.

St. Joseph Market Area

Dredging in the St. Joseph market area is expected to be slightly higher under Alternative A relative to existing conditions; therefore, the potential exists for increased river bed degradation and related economic impacts under this alternative.

Kansas City, Waverly, Jefferson City, and St. Charles Market Areas

Dredging in the Kansas City, Waverly, Jefferson City and St. Charles market areas is expected to be substantially lower under Alternative A relative to existing conditions; therefore, the potential exists for reduced river bed degradation, which could result in a range of economic benefits (i.e., avoided costs).

4.10.5.5 Environmental Justice Effects

Section 4.10.3.5 presents a general overview of environmental justice and social and demographic characteristics of the primary market area. The short-term analysis of environmental justice effects for Alternative A is presented below by market area.

St. Joseph Market Area

In the St. Joseph market area, the minor increase in sand and gravel production under Alternative A would generate limited benefits to people working in the mining and transportation industries, including commercial dredgers. However, the minor increase in the cost of sand and gravel would result in reductions in household income levels. Because these effects are minor (loss of one total job) and would affect the population generally (i.e., are not expected to fall disproportionately on low-income populations) in the St. Joseph market area, no environmental justice impacts are anticipated.

Kansas City Market Area

Reductions in sand and gravel production and related cost increases in the Kansas City market area would result in adverse economic impacts under Alternative A. The direct impacts would be concentrated on concentrated on people working in the commercial dredging and transportation industries. To the extent that these industries are comprised of minority or low-income populations, environmental justice impacts could occur. At the regional level, reductions in employment and income throughout the Kansas City economy would adversely affect the general population, which is characterized by a relatively larger minority population compared to the state overall. It is unlikely, however, that these regional economic impacts would fall disproportionately on minority groups. Therefore, no adverse environmental justice impacts are anticipated. In addition, the reduced risk of levee failure in the Kansas City area would result in avoided flood damages that could affect minority and low-income populations; however, these risks have not been quantified.

Waverly Market Area

In the Waverly market area, commercial dredging is expected to decrease, which would result in economic impacts to commercial dredgers and their employees, while limited economic benefits would accrue to the transportation industry. To the extent that the mining industry is comprised of minority or low-income populations, environmental justice impacts could occur. At the same time, the cost of sand and gravel would substantially increase, which would result in reductions in household income and related decreases in income and employment throughout the region. Because the Waverly market

area is not characterized by large minority or low-income population groups, no adverse environmental justice impacts are anticipated.

Jefferson City Market Area

Reductions in sand and gravel production and related cost increases in the Jefferson City market area would result in adverse economic impacts under Alternative A, including reductions in income and employment levels. The direct impacts would be concentrated on people working in the mining and transportation industries. To the extent that these industries are comprised of minority or low-income populations, environmental justice impacts could occur. At a regional level, anticipated declines in household income and other economy-wide impacts would affect the general population, including low-income populations that are more prevalent in the Jefferson City market area relative to the state overall. These impacts are minor when compared to the size of the regional economy, however, and are not expected to fall disproportionately on low-income groups. No adverse environmental justice impacts are anticipated.

St. Charles Market Area

Under Alternative A, production by commercial dredgers would decrease substantially in the St. Charles market area, which would be fully offset by increases in sand and gravel production at alternate sources away from the river. To the extent that employees in the commercial dredging industry are comprised of significant minority or low-income populations, environmental justice impacts could occur. Economic benefits are also expected elsewhere in the mining industry and in the transportation industry. Anticipated increases in the cost of sand and gravel would result in economy-wide reductions in household income levels. These effects are minor, however, and would not fall disproportionately on the relatively large minority population in the St. Charles market area or on low-income groups. No adverse environmental justice impacts are anticipated.

4.10.6 Alternative B

Commercial sand and gravel dredging in the LOMR would be permitted up to a maximum of approximately 5.1 million tons annually under Alternative B. Because permitted volumes are less than recent demand levels (approximately 6.9 million tons per year), it is anticipated that alternate sources in the region would increase production to offset losses from the LOMR. The analysis of short-term economic effects has been quantified below. Long-term economic effects, which consider development of new mining operations in the region, are evaluated qualitatively.

The key findings of the economic analysis of Alternative B include the following:

- Commercial dredging of sand and gravel from the LOMR would meet most of the existing demand for sand and gravel from the LOMR, and alternate sources would be able to accommodate displaced supplies. There would be substantial shifts in production across market areas and individual sand plants.

- Based on production shifts across market areas, changes in the delivered costs of construction sand and gravel would vary by market area. Cost increases are expected in the Kansas City and Jefferson City market areas. Cost decreases are anticipated in the Waverly and St. Charles market areas. Costs in the St. Joseph market area would remain constant.

- Regional economic activity attributed to mining production decline in the primary market area, including losses of $9.5 million in economic output and approximately 63 total jobs. These impacts would be partially offset by regional economic benefits attributed to production increases occurring outside the primary market area in other parts of Missouri, including $2.8 million in annual output and 21 jobs. Shifts in production to other states, including Kansas and Illinois, represent economic leakages outside Missouri.

- Based on anticipated transportation patterns, total shipping requirements would decrease under Alternative B. The regional economic impacts in the truck shipping and related support industries in Missouri include a decrease of $1.7 million in annual production value and approximately seven jobs. These impacts would be incremental to regional impacts in the mining industry.

- Estimated changes in costs of construction sand and gravel would generate a net overall decrease in consumer income levels, which would reduce economic activity, including a loss of approximately $719,000 in output value and seven total jobs.

- Net regional economic activity at the state level would decline relative to existing conditions based on the simultaneous reductions in the mining and transportation sectors. In total, economic output is expected to decrease by $9.2 million annually, and employment would fall by 55 total jobs.

- Estimated sand royalty payments paid to the State of Kansas would be highest under Alternative B based primarily on shifts in production to the St. Joseph market area.

4.10.6.1 Industry and Market Effects

Under Alternative B, sand and gravel production from the LOMR is expected to reach maximum permitted levels (5.1 million tons annually), a 27-percent reduction compared to existing conditions (Table 4.10-1). Alternate sources in the region would be expected to increase production levels in some market areas, which would cause the delivered cost of sand and gravel to increase in areas where shipping distances are increased. Conversely, transportation requirements in other market areas would decrease in response to new sand plants being developed close to alternate sources. The short-term costs of sand and gravel under Alternative B are summarized in Table 4.10-2. Under this alternative, the average FOB price is estimated to be $4.95 per ton. When considering transportation costs, the effect on total costs varies across market areas. Based on quality differences between natural river sand from the LOMR and from some alternate sources, additional processing may be required in the production of concrete and asphalt, thereby further increasing costs to end-users in areas served by alternate sources. Anticipated increases in the short-term cost of sand and gravel in some market areas under Alternative B likely would result in an increase in construction costs in those areas.

In the long term, it is likely that new floodplain open-pit mining operations would be developed in proximity to existing demand centers and would restore equilibrium in the sand and gravel market, thereby reducing costs relative to short-term levels. However, floodplain open-pit mining is not likely as cost effective as river dredging, potentially resulting in long-term increases in sand and gravel costs relative to existing conditions (see Section 4.10.4.1 for more information on the issues and costs associated with floodplain open-pit mining).

St. Joseph Market Area

Under Alternative B, approximately 860,000 tons of sand and gravel would be produced annually from the St. Joseph market area. Production in the St. Joseph market area would exceed existing demand in the region (approximately 327,000 tons annually); therefore, production by alternate sources would not increase and excess supplies likely would be exported to other market areas. Overall, the short-term cost of sand and gravel in the St. Joseph market area is expected to remain stable at $7.39 per ton under Alternative B, with no cost-related effects in the construction industry.

Kansas City Market Area

In the Kansas City market area, sand and gravel production under Alternative B is expected to reach the maximum permitted volume, approximately 1.2 million tons per year, which would be supplemented

by an additional 237,000 tons produced by alternate sources in the region. Supply levels, however, would still not be able to meet the recent level of demand (nearly 2.7 million tons per year), and sand and gravel would need to be imported to the region, resulting in higher transportation costs. The delivered cost of sand and gravel in the Kansas City market area is expected to increase to $8.45 per ton under Alternative B in the short term, an increase of 5.9 percent relative to existing conditions. This would cause construction costs in the region to increase.

Waverly Market Area

Under Alternative B, approximately 1.1 million tons of sand and gravel would be produced from the Waverly market area, which is greater than existing demand (678,000 tons per year). Production by alternate sources would not increase in the market area as dredging would be sufficient to meet local demand. Based on increased supplies and a more cost-efficient pattern of distribution from sand plants to consumers, the cost of sand and gravel in the Waverly market area is expected to decrease to $8.39 per ton under Alternative B in the short term, down from $9.53 under existing conditions. This would lower costs in the construction industry.

Jefferson City Market Area

In the Jefferson City market area, approximately 980,000 tons of sand and gravel would be produced by commercial dredging operations on the LOMR, and an additional 27,000 tons would be produced by alternate sources in the area under Alternative B. Total production in the Jefferson City market area, however, would not meet existing demand (approximately 1.6 million tons annually), thereby requiring sand and gravel to be imported at higher costs. Under Alternative B, the cost of sand and gravel in the Jefferson City market area is expected to increase to $9.86 per ton in the short term, a 6.6 -percent increase relative to existing conditions. This would result in increased construction costs in the region.

St. Charles Market Area

Sand and gravel production from the St. Charles market area is expected to reach 840,000 tons annually under Alternative B, and an additional 959,000 tons would be produced by alternate sources in the region. Total supplies would be sufficient to meet existing demand (approximately 1.6 million tons per year). Based on the proximity of existing mining operations, including alternate sources, to demand centers in the St. Charles market area, the cost of sand and gravel is estimated to decrease slightly to $7.14 per ton under Alternative B in the short term, an approximately 2.7-percent decline relative to existing conditions. This would result in lower construction costs in the region.

4.10.6.2 Regional Economic Effects

Under Alternative B, sand and gravel production by commercial dredging operations would decline from 6.9 million to 5.1 million tons per year. This would result in direct economic impacts realized by dredge operators and their employees, including declines in revenues and profits, labor income, and jobs. Specifically, commercial dredging operations would realize annual losses of $8.9 million in economic output (or gross revenues), $4.2 million in labor income, and approximately 52 jobs in the long term. The direct economic impact to commercial dredging operations is an adverse economic impact under Alternative B. At the industry level, however, these impacts would be partially offset by economic benefits accruing to alternate mining operations and their employees in the short term and to new mining operations in the long term.

Table 4.10-7 presents the short-term regional economic effects in Missouri under Alternative B. The total annual value of output generated by sand and gravel production under Alternative B is $52.6 million, total labor income is $19.1 million, and a total of 329 jobs would be supported. Because much of the sand and gravel production would remain in the LOMR, only a small portion of these benefits would accrue to mining operations outside the primary market area. Overall, the statewide economic benefits anticipated under Alternative B are lower than existing conditions based on shifts in production to areas outside the state. In the long term, anticipated development of new mining operations in proximity to the LOMR would serve to retain these benefits within the primary market area.

In the short term, increased transportation requirements under Alternative B would generate benefits in the truck shipping industry; however, some of these benefits would be exported to adjacent states. In Missouri, the regional economic activity associated with truck shipping activity includes $22.7 million in total annual output, $8.3 million in total labor income, and 188 jobs, which are lower higher than existing conditions and concentrated within the primary market area. In the long term, the transportation benefits outside the primary market area would decline as new mines are developed near demand centers, resulting in decreased demand for truck shipping.

As indicated above, changes in the cost of sand and gravel would vary by market area. Overall, the net effect would be a decline in household income levels across the state, assuming that costs are passed through to the public. Reductions in household income would result in estimated annual losses of $719,000 in total output, $241,000 in total labor income, and approximately seven jobs throughout Missouri. In the long term, the cost of sand and gravel is expected to decline relative to short-term

levels with the development of new mining operations, thereby minimizing income-related impacts on consumers.

Table 4.10-7 Short-Term Regional Economic Effects under Alternative B [a,b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
St. Joseph						
Sand and gravel production	$4,249,000	$6,048,000	$1,287,000	$1,820,000	25	39
Truck transportation	$2,363,000	$3,702,000	$825,000	$1,243,000	20	33
Household income (change)[f]	$0	$3,000	$0	$1,000	0	0
Kansas City						
Sand and gravel production	$8,203,000	$16,214,000	$3,408,000	$5,990,000	47	97
Truck transportation	$3,067,000	$5,719,000	$1,210,000	$2,207,000	21	44
Household income (change)[f]	$0	-$710,000	$0	-$234,000	0	-6
Waverly						
Sand and gravel production	$3,622,000	$4,861,000	$1,317,000	$1,674,000	21	32
Truck transportation	$952,000	$1,286,000	$326,000	$435,000	8	12
Household income (change)[f]	$0	$374,000	$0	$100,000	0	4
Jefferson City						
Sand and gravel production	$5,257,000	$9,429,000	$2,018,000	$3,346,000	31	63
Truck transportation	$2,200,000	$3,680,000	$786,000	$1,302,000	18	32
Household income (change)[f]	$0	-$736,000	$0	-$223,000	0	-7
St. Charles						
Sand and gravel production	$6,817,000	$12,380,000	$3,206,000	$5,091,000	33	72
Truck transportation	$2,992,000	$5,586,000	$1,164,000	$2,120,000	21	43
Household income (change)[f]	$0	$302,000	$0	$99,000	0	2
Outside Primary Market Area[g]						
Sand and gravel production	$1,678,000	$3,619,000	$583,000	$1,196,000	12	27
Truck transportation	$1,447,000	$2,709,000	$531,000	$980,000	11	25
Household income (change)[h]	$0	$48,000	$0	$17,000	0	0
Total (State of Missouri)						
Sand and gravel production	$29,826,000	$52,552,000	$11,819,000	$19,117,000	168	329
Truck transportation	$13,021,000	$22,682,000	$4,843,000	$8,287,000	101	188
Household income (change)	$0	-$719,000	$0	-$241,000	0	-7

Table 4.10-7 Short-Term Regional Economic Effects under Alternative B [a,b, c]

[a] Monetary values are reported in 2008 dollars and represent annualized effects.

[b] Regional economic effects are limited to changes in final demands in the State of Missouri; changes in economic activity in adjacent states are excluded from the results.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (segment) of production.

[e] Includes direct, indirect, and induced effects resulting from activity in the target market area and linkages to other market areas.

[f] Represents regional economic effects attributed to changes in household income resulting from changes in the cost of construction sand and gravel.

[g] The "primary market area" represents the total of the five individual market areas serving each segment.

[h] Household income effects were not considered for areas outside the primary market area because no changes in the cost of sand and gravel are anticipated; the results shown are based on linkages with the primary market area.

Source: ENTRIX 2010.

Similar to the Proposed Action, temporary construction benefits would be associated with development of new sand plants by the permit applicants. The short-term construction benefits would include increases in economic output, labor income, and employment. Although not quantified as part of this study, the magnitude of these indirect benefits would be driven by the extent of construction expenditures in the local area and availability of local construction workers to serve the project.

In addition, the region could realize temporary construction benefits from development of new off-river mining operations in the long term. Because it is not possible to predict the size, cost, or reliance on the local construction industry for new mining developments, these construction benefits have not been quantified.

St. Joseph Market Area

The short-term regional economic effects in the St. Joseph market area under Alternative B are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $6.0 million annually (+$3.7 million),
  - Increase in total labor income to $1.8 million annually (+$1.1 million), and
  - Increase in total employment to 39 jobs (+24 jobs).
- Truck transportation activity
  - Increase in total output to $3.7 million annually (+$3.1 million),

  - Increase in total labor income to $1.2 million annually (+$1.0 million), and
  - Increase in total employment to 33 jobs (+27 jobs).
- Change in household income
  - Increase in total output by $3,000 annually,
  - Increase in total labor income by $1,000 annually, and
  - Increase in total employment by less than one job.

Kansas City Market Area

The short-term regional economic effects in the Kansas City market area under Alternative B are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $16.2 million annually (-$10.2 million),
  - Decrease in total labor income to $5.9 million annually (-$3.8 million), and
  - Decrease in total employment to 97 jobs (-61 jobs).
- Truck transportation activity
  - Decrease in total output to $5.7 million annually (-$5.5 million),
  - Decrease in total labor income to $2.2 million annually (-$2.1 million), and
  - Decrease in total employment to 44 jobs (-41 jobs).
- Change in household income
  - Decrease in total output by $710,000 annually,
  - Decrease in total labor income by $234,000 annually, and
  - Decrease in total employment by six jobs.

Development of a new sand plant at Waldron also would generate short-term construction benefits in the Kansas City market area.

Waverly Market Area

The short-term regional economic effects in the Waverly market area under Alternative B are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $4.9 million annually (+$2.4 million),
  - Increase in total labor income to $1.7 million annually (+$825,000), and
  - Increase in total employment to 32 jobs (+16 jobs).
- Truck transportation activity
  - Increase in total output to $1.3 million annually (+$705,000),
  - Increase in total labor income to $435,000 annually (+$238,000), and
  - Increase in total employment to 12 jobs (+7 jobs).
- Change in household income
  - Increase in total output by $374,000 annually,
  - Increase in total labor income by $100,000 annually, and
  - Increase in total employment by four jobs.

Jefferson City Market Area

The short-term regional economic effects in the Jefferson City market area under Alternative B are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $9.4 million annually (-$4.0 million),
  - Decrease in total labor income to $3.3 million annually (-$1.4 million), and
  - Decrease in total employment to 63 jobs (-26 jobs).
- Truck transportation activity
  - Decrease in total output to $3.7 million annually (-$1.9 million),
  - Decrease in total labor income to $1.3 million annually (-$692,000), and
  - Decrease in total employment to 32 jobs (-17 jobs).

- Change in household income
  - Decrease in total output by $736,000 annually,
  - Decrease in total labor income by $223,000 annually, and
  - Decrease in total employment by seven jobs.

St. Charles Market Area

The short-term regional economic effects in the St. Charles market area under Alternative B are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $12.4 million annually (-$1.4 million),
  - Decrease in total labor income to $5.1 million annually (-$561,000), and
  - Decrease in total employment to 72 jobs (-15 jobs).
- Truck transportation activity
  - Decrease in total output to $5.6 million annually (-$403,000),
  - Decrease in total labor income to $2.1 million annually (-$154,000), and
  - Decrease in total employment to 43 jobs (-3 jobs).
- Change in household income
  - Increase in total output by $302,000 annually,
  - Increase in total labor income by $99,000 annually, and
  - Increase in total employment by two jobs.

Development of a new sand plant at Washington, Missouri also would generate short-term construction benefits in the St. Charles market area.

4.10.6.3 Tax Revenue Effects

The types of tax revenues generated by mining activity under Alternative B would be similar to those described for the Proposed Action in Section 4.10.3.3. However, some types of tax revenues realized by local governments in Missouri, including state franchise and income taxes, would be reduced in response to production shifts to adjacent states in the short term. In addition, county-level property taxes may decline if existing dredge operators sell their land holdings or idle existing sand plants.

Value of Waterway fuel taxes from dredging in the LOMR also would decline in proportion to reductions in dredging under Alternative B. At the federal level, income and payroll taxes should not be affected, as losses from Missouri likely would be offset in other states. In the long term, development of new mining operations in Missouri would generate tax revenues.

Sand royalties paid to the State of Kansas would be the highest under Alternative B in the short term (Table 4.10-3). Increased sand royalties are expected in response to increased dredging in the St. Joseph market area and additional production by alternate sources in Kansas outside the primary market area. Under Alternative B, total royalties paid to the State of Kansas resulting from changes in dredging activity is an estimated $224,000 per year in the short term, up from $113,000 per year under existing conditions. This is an economic benefit of Alternative B. In the long term, development of new mining operations in Missouri would reduce sand royalties paid to the State of Kansas relative to short-term levels.

St. Joseph Market Area

An increase in sand and gravel production in the St. Joseph market area would increase tax revenues realized by local, state, and federal governments. In addition, sand royalties generated from production in this region would increase substantially, from approximately $49,000 to $129,000 per year in the short term.

Kansas City Market Area

The decrease in sand and gravel production in the Kansas City market area would decrease tax revenues realized by local, state, and federal governments. Some of the gravel production in the Kansas City market area would be subject to royalties. Sand royalties generated by production in the Kansas City market area are expected to decline to approximately $52,000 annually in the short term, down from $64,000 under existing conditions. The loss in sand royalties would be offset by increased sand and gravel production outside the primary market area in other parts of Kansas.

Waverly and St. Charles Market Areas

An increase in sand and gravel production in the Waverly and St. Charles market areas would increase tax revenues realized by local, state, and federal governments. No sand royalty payments are generated by production in the Waverly or St. Charles market areas.

Jefferson City Market Area

The decrease in sand and gravel production in the Jefferson City market area would decrease tax revenues realized by local, state, and federal governments. No sand royalty payments are generated by production in the Jefferson City market area.

4.10.6.4 Economic Effects Related to River Bed Degradation

The general types of river bed degradation effects discussed in Section 4.10.3.4 apply to all market areas in considered in this analysis. Because the volume of commercial sand and gravel dredging would fall to approximately 5.1 million tons annually, down from 6.9 million tons under existing conditions, potential economic impacts attributed to dredging-related river bed degradation would be reduced under Alternative B. These avoided costs are considered a beneficial impact of Alternative B, including avoided expenditures on infrastructure repair, maintenance, and replacement and potential flood damages.

St. Joseph and Waverly Market Areas

Dredging in the St. Joseph and Waverly market areas is expected to be substantially higher under Alternative B relative to existing conditions; therefore, the potential exists for increased river bed degradation and related economic impacts.

Kansas City, Jefferson City, and St. Charles Market Areas

Dredging in the Kansas City, Jefferson City, and St. Charles market areas is expected to be substantially lower under Alternative B relative to existing conditions; therefore, river bed degradation could be reduced, which could generate economic benefits (i.e., avoided costs).

4.10.6.5 Environmental Justice Effects

Section 4.10.3.5 presents a general overview of environmental justice and social and demographic characteristics of the primary market area. The analysis of environmental justice effects by market area is presented below.

St. Joseph Market Area

Under Alternative B, sand and gravel production in the St. Joseph market area would substantially increase, generating a range of economic benefits to commercial dredge operators and their employees, as well as benefits to workers in the transportation industry. In addition, the cost of sand

and gravel in the region would not change, with no effect on regional household income levels. No adverse economic effects are expected in the St. Joseph market area; therefore, there would be no adverse environmental justice impacts.

Kansas City Market Area

Reductions in sand and gravel production and related cost increases in the Kansas City market area would result in adverse economic impacts under Alternative B. The direct impacts would be concentrated on the commercial dredging and transportation industries. To the extent that these industries are characterized by minority or low-income populations, environmental justice impacts could occur. At the regional level, reductions in employment and income throughout the Kansas City economy would adversely affect the general population, which has a larger minority population than the state overall. However, it is unlikely that these regional economic impacts would fall disproportionately on minority groups. Therefore, no adverse environmental justice impacts are anticipated. In addition, the reduced probability of levee failure in the Kansas City area from reductions in dredging would avoid potential impacts on low-income and minority populations in the region; however, these risks have not been quantified.

Waverly Market Area

In the Waverly market area, commercial dredging is expected to increase substantially under Alternative B, which would generate economic benefits for commercial dredge operators and their employees and workers in the transportation industry. Further, the slight decrease in the cost of sand and gravel in the region would result in higher household income levels and related increases in income and employment throughout the region. No adverse economic effects are expected in the Waverly market area; therefore, there would be no adverse environmental justice impacts.

Jefferson City Market Area

Reductions in sand and gravel production and related cost increases in the Jefferson City market area would result in adverse economic impacts under Alternative B, including reductions in income and employment levels. The direct impacts would be concentrated on the commercial dredging and transportation industries. To the extent that these industries are characterized by minority or low-income populations, environmental justice impacts could occur. At a regional level, anticipated declines in household income and other economy-wide impacts would affect the general population, including low-income populations in the Jefferson City market area. However, these impacts are minor when

compared to the size of the economy in the region and are not expected to fall disproportionately on low-income groups. No adverse environmental justice impacts are anticipated.

St. Charles Market Area

Under Alternative B, production by commercial dredgers would decline substantially in the St. Charles market area and would not be fully offset by increases in sand and gravel production outside the river. The direct impacts on dredgers and their employees and transportation workers could represent an environmental justice issue to the extent that these groups are characterized by large minority or low-income populations. Conversely, a minor decrease in the cost of sand and gravel would result in economy-wide increases in household income levels. The net economic effect in the St. Charles market area is negligible in the context of the size of the regional economy. Further, any adverse economic impacts are not expected to fall disproportionately on the minority or low-income populations in the St. Charles market area. No adverse environmental justice impacts are anticipated.

4.10.7 Alternative C

Alternative C would allow commercial sand and gravel dredging in the LOMR up to recent levels of production, approximately 6.9 million tons per year. In addition, production levels across river segments would remain stable. Accordingly, sand and gravel production levels from alternate sources in the region would not change, and no long-term impacts are likely to be associated with development of new mining operations in the regions.

The key findings of the economic analysis of Alternative C include the following:

- Commercial dredging of sand and gravel from the LOMR would remain constant at levels consistent with existing demand (6.9 millions tons per year). There would be negligible shifts in production across market areas; however, shifts in production across individual sand plants could occur based on the presence of new dredging operations.
- For analytical purposes, dredging allocations to individual operators under Alternative C does not offer the flexibility to meet recent demands as is the case under the Proposed Action. As a result, allocations under this alternative would not result in a cost-efficient transportation pattern in some market areas. Accordingly, the delivered cost of construction sand and gravel would increase slightly in some market areas (i.e., Jefferson City and St. Charles). Other areas (i.e., Kansas City and Waverly) would experience a minor decrease in costs. No cost effects are expected in the St. Joseph market area.

- Regional economic activity attributed to mining production would be relatively unchanged within the primary market area and the state of Missouri.
- Shipping requirements would increase slightly in response to a less optimal distribution pattern between suppliers and consumers, resulting in regional economic benefits in the truck shipping and related support industries. These benefits include an increase of $2.9 million in annual production value and approximately 22 jobs in Missouri.
- Estimated changes in construction sand and gravel costs would result in a net decline in consumer income levels, which would decrease economic activity and partially offset potential benefits associated with mining production and truck shipping activity.
- Total regional economic activity at the state level would be slightly higher relative to existing conditions accounting for regional benefits in the mining and truck shipping industries, which outweigh declines in consumer income levels. Overall, there would be a net increase of $1.4 million in annual output and 11 additional jobs.
- Because production would remain relatively stable in the Kansas City and St. Joseph market areas, estimated sand royalty payments paid to the State of Kansas would remain stable.

4.10.7.1 Industry and Market Effects

Under Alternative C, total sand and gravel production from the LOMR would be the same as existing conditions, approximately 6.9 million tons per year (Table 4.10-1). However, the number of commercial dredge operators would increase based on new permit applicants, and new sand plants would be developed to serve these new operations. In addition, although estimated production levels are constant across river segments, assumed dredging levels by individual operators would differ relative to existing conditions because estimates of dredging production were developed based on requested permit volumes. Therefore, the transportation requirement for delivering sand and gravel from supply sources to demand centers would be different, which would affect the delivered costs of sand and gravel in certain market areas. The short-term costs of sand and gravel under Alternative C are summarized in Table 4.10-2, which includes an average FOB price of $4.89 per ton. Because all sand and gravel produced under this alternative would come from the LOMR, the quality of product used by customers would not change, and no incremental processing costs would be incurred. Anticipated increases (decreases) in the cost of sand and gravel across market areas under Alternative C likely would result in an increase (decrease) in construction costs in those areas. Finally, no new floodplain open-pit mining operations would be developed in the region in response to reduced supplies from the

LOMR. As a result, the short-term effects on the cost of construction sand and gravel described below are representative of long-term conditions.

St. Joseph Market Area

Approximately 327,000 tons of sand and gravel produced from the St. Joseph market area under Alternative C would be sufficient to meet recent demand. Consequently, the delivered cost of sand and gravel ($7.39 per ton) would not change in the short term, with no cost-related effects in the construction industry.

Kansas City Market Area

Under Alternative C, the estimated 2.7 million tons of sand and gravel that would be produced from the Kansas City market area would be sufficient to meet recent demand. Based on a more cost-efficient distribution pattern, in part due to the proposed sand plant in the Kansas City market area, transportation costs would decline, and the delivered cost of sand and gravel would fall slightly to $7.97 per ton (from $7.98 per ton) in the short term. Impacts on construction costs in the region would be negligible.

Waverly Market Area

Approximately 680,000 tons of sand and gravel would be produced annually from the Waverly market area under Alternative C, which would be sufficient to meet recent demand. The cost of sand and gravel in the region would decline to $8.97 per ton in the short term, a 5.9-percent reduction. There would be minor cost-related benefits in the construction industry.

Jefferson City Market Area

In the Jefferson City market area, an estimated 1.6 million tons of sand and gravel would be produced under Alternative C, which would be sufficient to meet recent demand. Based on the reallocation of permitted production levels across commercial dredge operators, transportation costs would be higher and the delivered cost of sand and gravel would increase in the short term from $9.25 per ton under existing conditions to $9.35 per ton, an approximately 1.1-percent increase. This would result in minor cost-related benefits in the construction industry.

St. Charles Market Area

Approximately 1.6 million tons of sand and gravel would be produced from the St. Charles market area under Alternative C, which would be sufficient to meet recent demand. Based on development of a

new sand plant and reallocation of permitted volumes across dredge operators, transportation costs are expected to increase and drive the delivered cost of sand and gravel in the short term from $7.34 per ton under existing conditions up to $8.58 per ton, an approximately 17-percent increase. This would result in increased costs in the construction industry.

4.10.7.2 Regional Economic Effects

Under Alternative C, sand and gravel production by commercial dredging operations would stay constant at 6.9 million tons per year. Therefore, any changes in net economic activity realized by commercial dredge operators, as a group, would be negligible. However, individual operators could be affected based on potential changes in permitted levels of production. It is not possible to evaluate impacts at the individual dredger level.

At the regional level, there would be only minor changes in economic activity supported by commercial dredging operations in the LOMR under Alternative C; these short-term effects are summarized in Table 4.10-8. Because no new mining operations are anticipated to be developed (as no supplies would be displaced from the LOMR), the short-term effects on the regional economy are representative of long-term conditions.

The total annual value of output generated by commercial dredging is $59.7 million, total labor income is $22.2 million, and a total of 374 jobs would be supported within Missouri. Only a small portion of these benefits would accrue to locations outside the primary market areas. Overall, the statewide economic benefits of sand and gravel production anticipated under Alternative C are slightly higher than, but comparable to, benefits realized under existing conditions.

Table 4.10-8 Short-Term Regional Economic Effects under Alternative C [a, b, c]

	Output (Annual)		Labor Income (Annual)		Employment	
Market Area[d]	Direct	Total[e]	Direct	Total[e]	Direct	Total[e]
St. Joseph						
Sand and gravel production	$1,615,000	$2,326,000	$489,000	$699,000	9	15
Truck transportation	$382,000	$605,000	$133,000	$203,000	3	5
Household income (change)[f]	$0	$2,000	$0	$1,000	0	0
Kansas City						
Sand and gravel production	$13,763,000	$25,916,000	$5,718,000	$9,630,000	80	155
Truck transportation	$6,309,000	$10,653,000	$2,490,000	$4,107,000	44	81
Household income (change)[f]	$0	$56,000	$0	$19,000	0	0

Table 4.10-8 Short-Term Regional Economic Effects under Alternative C [a, b, c]

Waverly						
Sand and gravel production	$2,161,000	$2,913,000	$785,000	$1,002,000	13	19
Truck transportation	$475,000	$646,000	$163,000	$218,000	4	6
Household income (change)[f]	$0	$185,000	$0	$50,000	0	2
Jefferson City						
Sand and gravel production	$8,244,000	$13,551,000	$3,165,000	$4,813,000	48	89
Truck transportation	$3,657,000	$5,783,000	$1,306,000	$2,049,000	30	51
Household income (change)[f]	$0	-$113,000	$0	-$34,000	0	-1
St. Charles						
Sand and gravel production	$7,716,000	$14,114,000	$3,629,000	$5,800,000	45	89
Truck transportation	$4,917,000	$9,170,000	$1,913,000	$3,481,000	35	70
Household income (change)[f]	$0	-$2,063,000	$0	-$679,000	0	-16
Outside Primary Market Area[g]						
Sand and gravel production	$0	$896,000	$0	$285,000	0	7
Truck transportation	$0	$388,000	$0	$139,000	0	4
Household income (change)[h]	$0	$27,000	$0	$9,000	0	0
Total (State of Missouri)						
Sand and gravel production	$33,499,000	$59,716,000	$13,787,000	$22,230,000	195	374
Truck transportation	$15,739,000	$27,246,000	$6,006,000	$10,198,000	116	218
Household income (change)	$0	-$1,906,000	$0	-$634,000	0	-15

[a] Monetary values are reported in 2008 dollars and represent annualized effects.

[b] Regional economic effects are limited to changes in final demands in the State of Missouri; changes in economic activity in adjacent states are excluded from the results.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (segment) of production.

[e] Includes direct, indirect, and induced effects resulting from activity in the target market area and linkages to other market areas.

[f] Represents regional economic effects attributed to changes in household income resulting from changes in the cost of construction sand and gravel.

[g] The "primary market area" represents the total of the five individual market areas serving each segment.

[h] Household income effects were not considered for areas outside the primary market area because no changes in the cost of sand and gravel are anticipated; the results shown are based on linkages with the primary market area.

Source: ENTRIX 2010.

Increases in transportation requirements under Alternative C would generate limited benefits in the truck shipping industry. Regional economic activity in Missouri that is supported by truck shipping activity includes $27.2 million in total annual output, $10.2 million in total labor income, and 218 jobs. These benefits are higher than existing conditions and would be concentrated in the primary market area.

As indicated above, changes in the cost of sand and gravel would vary by market area. Overall, the net effect is a decline in household income levels across the state, assuming that increased costs are passed through to the public. Reductions in household income would result in estimated annual losses of $1.9 million in total output, $634,000 in total labor income, and approximately 15 jobs throughout Missouri.

The short-term construction benefits associated with development of new sand plants along the LOMR would include increases in economic output, labor income, and employment. Although not quantified as part of this study, the magnitude of these indirect benefits would be driven by the extent of construction expenditures in the local area and the availability of local construction workers to serve the project.

St. Joseph Market Area

The short-term regional economic effects in the St. Joseph market area under Alternative C are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $2.3 million annually (+$10,000),
  - Increase in total labor income to $699,000 annually (+$3,000), and
  - Increase in total employment to 15 jobs (increase of less than 1 job).
- Truck transportation activity
  - Increase in total output to $605,000 annually (+$1,000),
  - Increase in total labor income to $203,000 annually (increase of less than $1,000), and
  - Increase in total employment to five jobs (increase of less than 1 job).
- Change in household income
  - Increase in total output by $2,000 annually,
  - Increase in total labor income by $1,000 annually, and
  - Increase in total employment by less than one job.

Kansas City Market Area

The short-term regional economic effects in the Kansas City market area under Alternative C are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Decrease in total output to $25.9 million annually (-$515,000),
  - Decrease in total labor income to $9.6 million annually (-$195,000), and
  - Decrease in total employment to 155 jobs (-3 jobs).
- Truck transportation activity
  - Decrease in total output to $10.7 million annually (-$569,000),
  - Decrease in total labor income to $4.1 million annually (-$219,000), and
  - Decrease in total employment to 81 jobs (-4 jobs).
- Change in household income
  - Increase in total output by $56,000 annually,
  - Increase in total labor income by $19,000 annually, and
  - Increase in total employment by less than 1 job.

Development of a new sand plant at Waldron also would generate short-term construction benefits in the Kansas City market area.

Waverly Market Area

The short-term regional economic effects in the Waverly market area under Alternative C are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $2.9 million annually (+$445,000),
  - Increase in total labor income to $1.0 million annually (+$154,000), and
  - Increase in total employment to 19 jobs (+3 jobs).
- Truck transportation activity
  - Increase in total output to $646,000 annually (+$65,000),

  - Increase in total labor income to $218,000 annually (+$22,000), and
  - Increase in total employment to six jobs (+1 job).
- Change in household income
  - Increase in total output by less than $185,000 annually,
  - Increase in total labor income by less than $50,000 annually, and
  - Increase in total employment by two jobs.

Jefferson City Market Area

The short-term regional economic effects in the Jefferson City market area under Alternative C are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $13.6 million annually (+$70,000),
  - Increase in total labor income to $4.8 million annually (+ $25,000), and
  - Increase in total employment to 89 jobs (increase of less than 1 job).
- Truck transportation activity
  - Increase in total output to $5.8 million annually (+$156,000),
  - Increase in total labor income to $2.0 million annually (+$55,000), and
  - Increase in total employment to 51 jobs (+1 job).
- Change in household income
  - Decrease in total output by $113,000 annually,
  - Decrease in total labor income by $34,000 annually, and
  - Decrease in total employment by one job.

St. Charles Market Area

The short-term regional economic effects in the St. Charles market area under Alternative C are as follows (values in parentheses represent changes relative to existing conditions):

- Construction sand and gravel production
  - Increase in total output to $14.1 million annually (+$360,000),

  - Increase in total labor income to $5.8 million annually (+$148,000), and
  - Increase in total employment to 89 jobs (+2 jobs).
- Truck transportation activity
  - Increase in total output to $9.2 million annually (+$3.2 million),
  - Increase in total labor income to $3.5 million annually (+$1.2 million), and
  - Increase in total employment to 70 jobs (+24 jobs).
- Change in household income
  - Decrease in total output by $2.1 million annually,
  - Decrease in total labor income by $679,000 annually, and
  - Decrease in total employment by 16 jobs.

Development of a new sand plant at Washington, Missouri also would generate short-term construction benefits in the St. Charles market area.

4.10.7.3 Tax Revenue Effects

The types and magnitude of tax revenues generated by commercial sand and gravel dredging under Alternative C would be similar to those described for the Proposed Action. Similarly, sand royalties paid to the State of Kansas would remain unchanged under Alternative C at $113,000 per year in the short term (Table 4.10-3). Because no new mining operations are anticipated to be developed (as supplies from the LOMR would not be displaced), the short-term effects on the tax revenues are representative of long-term conditions.

St. Joseph and Kansas City Market Areas

Sand and gravel production in the St. Joseph and Kansas City market areas would not change; therefore, tax revenues realized by local, state, and federal governments would not change. In addition, sand royalties generated from production in the St. Joseph and Kansas City market areas would stay constant at approximately $49,000 and $64,000 per year, respectively.

Waverly, Jefferson City, and St. Charles Market Areas

Sand and gravel production in the Waverly, Jefferson City, and St. Charles market areas would not change; therefore, tax revenues realized by local, state, and federal governments would not change. No sand royalty payments are generated by production in these market areas.

4.10.7.4 Economic Effects Related to River Bed Degradation

Under Alternative C, the volume of commercial sand and gravel dredging would be unchanged relative to existing conditions, approximately 6.9 million tons annually. Therefore, Alternative C would result in a continuation of degradation-related economic impacts, as described in Section 3.12.7.8.

All Market Areas

The general types of river bed degradation effects discussed in Section 4.10.3.4 apply to all market areas. The volumes of commercial sand and gravel dredged in the St. Joseph, Kansas City, Waverly, Jefferson City, and St. Charles market areas would not change under Alternative C. Therefore, existing economic effects related to river bed degradation would continue over the long term.

4.10.7.5 Environmental Justice Effects

Section 4.10.3.5 presents a general overview of environmental justice and social and demographic characteristics of the primary market area. The analysis of environmental justice effects by market area is presented below.

St. Joseph, Kansas City, Waverly, and Jefferson City Market Areas

There would be negligible changes in regional economic activity in the St. Joseph, Kansas City, Waverly, and Jefferson City market areas under Alternative C. Therefore, no environmental justice impacts are anticipated. Continued river bed degradation in the LOMR has the potential to contribute to levee failure—particularly in the Kansas City area—which could adversely affect low-income and minority populations; however, these risks have not been quantified.

St. Charles Market Area

Under Alternative C, production levels would remain constant in the St. Charles market area, but the cost of sand and gravel would increase due to increased transportation requirements. This would result in benefits to the transportation industry but decreased household income levels in the region. The net economic effect attributed to income changes is minor in the context of the size of the regional economy. Further, any adverse economic impacts are not expected to fall disproportionately on the minority or low-income populations in the St. Charles market area. No adverse environmental justice impacts are anticipated.

4.10.8 Summary of Impacts

Overall, the sand and gravel resources in the region appear to be sufficient as a substitute for displaced supplies from the LOMR in the short term, including resources that would meet material specification requirements for road construction maintained by the MoDOT and KDOT. However, the proximity of these alternate sources to demand centers varies substantially across market areas and directly affects the short-term cost of sand and gravel to consumers based on changes in transportation costs. Generally, for alternatives that decrease dredging in the LOMR, the delivered costs of construction sand and gravel would increase in response to higher transportation costs. Conversely, increased dredging in certain market areas would increase available supplies and provide more flexibility in meeting regional demands, thereby reducing costs. In the long term, development of new mining operations in response to displaced supplies from the LOMR would minimize potential increases in the cost of construction sand and gravel in the region.

From a regional perspective, increases in sand and gravel production levels, whether from dredging in the LOMR or from alternate sources, would benefit local economic conditions, including increased output, income, and employment. Conversely, decreases in sand and gravel production would adversely affect the local economy. Regional economic effects associated with changes in sand and gravel production need to be considered in conjunction with the benefits and impacts associated with changes in transportation activity and household income levels.A summary of short-term regional economic effects for the Proposed Action and alternatives is presented in Table 4.10-9. In the long term, regional economic impacts would depend the location, size, and production levels of new mining operations developed in the region.

Tax revenue impacts, specifically impacts on sand royalties, are location specific; increases in dredging from the LOMR and other production in Kansas would result in increased royalties.

Potential economic impacts associated with river bed degradation are difficult to quantify but would be proportional to the amount of dredging allowed under the alternatives. Continued dredging in the LOMR could result in ongoing expenditures for infrastructure repair, maintenance, and replacement. In addition, the potential for levee failure could jeopardize billions of dollars in investment protected by regional levee systems.

Finally, environmental justice impacts are not expected under the Proposed Action or any alternative based on racial and socioeconomic characteristics of the population in the study area. The potential for levee failure with continued dredging from the LOMR could result in levee failure, thereby affecting low-

income and minority populations residing in the floodplain; however, these risks have not been quantified.

No mitigation measures are proposed for socioeconomic impacts. Table 4.10-10 presents a summary comparison of the potential short-term economic impacts and benefits for the Proposed Action and alternatives.

4.10.9 References

ENTRIX. 2010. IMPLAN (IMpact Analysis for PLANning) software modeling results. Modeling completed June 10, 2010.

Holliday Sand & Gravel Company, L.L.C. 2010. Response to Data Request. January 25, 2010.

USEPA (U.S. Environmental Protection Agency). 2010. Environmental Justice definition. Website (http://www.epa.gov/environmentaljustice/) accessed on June 14, 2010.

Table 4.10-9 Short-Term Regional Economic Effects Proposed Action and Alternatives ($ millions) [a, b, c]

	Existing Conditions[e]			Proposed Action[f]			No Action Alternative[f]			Alternative A[f]			Alternative B[f]			Alternative C[f]		
Market Area[d]	Output (Annual)	Labor Income (Annual)	Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs
St. Joseph																		
Sand and gravel production	$2.316	$0.696	15	$0.044	$0.013	0	-$2.219	-$0.667	-14	$0.245	$0.074	2	$3.732	$1.123	24	$0.010	$0.003	0
Truck transportation	$0.604	$0.203	5	$0.003	$0.001	0	-$0.561	-$0.189	-5	$0.146	$0.049	1	$3.098	$1.040	27	$0.001	$0.000	0
Household income (change)	$0.000	$0.000	0	$0.006	$0.001	0	-$5.925	-$1.814	-58	-$0.135	-$0.039	-1	$0.003	$0.001	0	$0.002	$0.001	0
Total – St. Joseph Market Area	$2.920	$0.899	20	$0.053	$0.016	0	-$8.705	-$2.670	-77	$0.255	$0.084	2	$6.832	$2.164	51	$0.013	$0.004	0
Kansas City																		
Sand and gravel production	$26.431	$9.825	158	-$2.241	-$0.849	-13	-$25.503	-$9.486	-153	-$18.799	-$7.007	-112	-$10.217	-$3.835	-61	-$0.515	-$0.195	-3
Truck transportation	$11.222	$4.327	85	-$2.796	-$1.077	-21	-$9.990	-$3.853	-75	-$8.540	-$3.292	-64	-$5.503	-$2.119	-41	-$0.569	-$0.219	-4
Household income (change)	$0.000	$0.000	0	$0.604	$0.203	5	-$42.517	-$14.143	-347	-$15.566	-$5.180	-127	-$0.710	-$0.234	-6	$0.056	$0.019	0
Total – Kansas City Market Area	$37.653	$14.152	243	-$4.432	-$1.724	-30	-$78.010	-$27.482	-574	-$42.905	-$15.480	-304	-$16.430	-$6.189	-108	-$1.027	-$0.395	-7
Waverly																		
Sand and gravel production	$2.467	$0.849	16	$1.937	$0.668	13	-$2.455	-$0.845	-16	-$0.330	-$0.113	-2	$2.394	$0.825	16	$0.446	$0.154	3
Truck transportation	$0.581	$0.196	5	$0.345	$0.117	3	-$0.549	-$0.186	-5	$0.234	$0.079	2	$0.705	$0.238	6	$0.065	$0.022	1
Household income (change)	$0.000	$0.000	0	$0.597	$0.160	6	-$11.034	-$2.961	-110	-$4.909	-$1.317	-49	$0.374	$0.100	4	$0.185	$0.050	2
Total – Waverly Market Area	$3.048	$1.045	21	$2.879	$0.945	22	-$14.038	-$3.992	-131	-$5.005	-$1.351	-49	$3.473	$1.164	26	$0.695	$0.225	5
Jefferson City																		
Sand and gravel production	$13.481	$4.788	88	$0.301	$0.106	2	-$13.129	-$4.665	-86	-$9.154	-$3.253	-60	-$4.052	-$1.442	-26	$0.070	$0.025	1
Truck transportation	$5.628	$1.994	50	-$0.769	-$0.273	-7	-$5.101	-$1.814	-45	-$3.699	-$1.314	-33	-$1.947	-$0.692	-17	$0.155	$0.055	1
Household income (change)	$0.000	$0.000	0	$0.786	$0.241	8	-$25.549	-$7.821	-246	-$10.106	-$3.094	-97	-$0.736	-$0.223	-7	-$0.113	-$0.034	-1
Total – Jefferson City Market Area	$19.109	$6.782	138	$0.318	$0.074	3	-$43.779	-$14.300	-377	-$22.960	-$7.662	-190	-$6.736	-$2.357	-50	$0.113	$0.046	1
St. Charles																		
Sand and gravel production	$13.754	$5.652	87	-$0.162	-$0.066	-1	$2.709	$1.128	-4	$3.038	$1.261	2	-$1.374	-$0.561	-15	$0.360	$0.148	2
Truck transportation	$5.988	$2.274	46	-$0.706	-$0.268	-5	$34.640	$13.149	266	$17.080	$6.483	131	-$0.403	-$0.154	-3	$3.182	$1.207	24
Household income (change)	$0.000	$0.000	0	$0.414	$0.137	3	-$3.018	-$1.012	-23	-$0.850	-$0.287	-6	$0.302	$0.099	2	-$2.063	-$0.679	-16
Total – St. Charles Market Area	$19.742	$7.926	133	-$0.454	-$0.198	-3	$34.330	$13.266	239	$19.269	$7.457	126	-$1.474	-$0.616	-16	$1.479	$0.677	10
Primary Market Area (LOMR)[g]																		
Sand and gravel production	$58.449	$21.811	364	-$0.121	-$0.129	1	-$40.598	-$14.535	-273	-$25.000	-$9.039	-171	-$9.517	-$3.890	-63	$0.371	$0.134	3
Truck transportation	$24.024	$8.994	192	-$3.923	-$1.500	-30	$18.439	$7.107	135	$5.220	$2.004	37	-$4.051	-$1.687	-28	$2.834	$1.065	22
Household income (change)	$0.000	$0.000	0	$2.407	$0.742	22	-$88.042	-$27.751	-783	-$31.566	-$9.918	-281	-$0.767	-$0.258	-7	-$1.932	-$0.643	-15
Total – Primary Market Area	$82.473	$30.805	556	-$1.636	-$0.887	-8	-$110.201	-$35.178	-921	-$51.346	-$16.952	-414	-$14.335	-$5.834	-98	$1.273	$0.557	10

Table 4.10-9 Short-Term Regional Economic Effects Proposed Action and Alternatives ($ millions) [a, b, c]

	Existing Conditions[e]			Proposed Action[f]			No Action Alternative[f]			Alternative A[f]			Alternative B[f]			Alternative C[f]		
Market Area[d]	Output (Annual)	Labor Income (Annual)	Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs	Change in Output (Annual)	Change in Labor Income (Annual)	Change in Jobs
Outside Primary Market Area																		
Sand and gravel production	$0.831	$0.263	7	$0.277	$0.097	2	$23.813	$7.911	175	$13.676	$4.547	101	$2.788	$0.933	21	$0.065	$0.023	1
Truck transportation	$0.370	$0.132	4	$0.014	$0.007	0	$131.911	$47.620	1,170	$49.290	$17.796	437	$2.339	$0.848	21	$0.018	$0.007	0
Household income	$0.000	$0.000	0	$0.136	$0.043	1	-$3.271	-$1.009	-30	-$1.278	-$0.396	-12	$0.048	$0.017	0	$0.027	$0.009	0
Total – Outside Primary Market Area	$1.202	$0.395	10	$0.427	$0.147	4	$152.453	$54.521	1,315	$61.688	$21.947	526	$5.175	$1.797	42	$0.109	$0.038	1
Total (State of Missouri)																		
Sand and gravel production	$59.280	$22.073	371	$0.156	-$0.032	3	-$16.785	-$6.624	-97	-$11.324	-$4.492	-70	-$6.729	-$2.957	-42	$0.436	$0.157	3
Truck transportation	$24.394	$9.126	195	-$3.908	-$1.493	-30	$150.350	$54.727	1,305	$54.510	$19.801	475	-$1.712	-$0.839	-7	$2.852	$1.072	22
Household income (change)	$0.000	$0.000	0	$2.543	$0.785	23	-$91.313	-$28.760	-813	-$32.844	-$10.313	-292	-$0.719	-$0.241	-7	-$1.906	-$0.634	-15
Total – State of Missouri	$83.675	$31.200	566	-$1.209	-$0.740	-4	$42.252	$19,343	395	$10.342	$4.995	112	-$9.160	-$4.037	-55	$1.382	$0.595	11

[a] Monetary values are reported in 2008 dollars.

[b] Values in the table represent total impacts, which include direct, indirect, and induced effects.

[c] Based on meeting 2004–2008 average annual demand for construction sand and gravel from the lower Missouri River (LOMR).

[d] Represents the market area served by sand and gravel production from the LOMR and captures the economic activity associated with sand and gravel distribution rather than location (segment) of production.

[e] Values for existing conditions are reported in absolute terms.

[f] Values for the Proposed Action and alternatives represent changes relative to existing conditions.

[g] The "primary market area" represents the total of the five individual market areas.

Source: ENTRIX 2010.

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph Market Area					
Regional sand and gravel production	• No change in dredging from LOMR (327,000 MM tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (0 tons annually) • Increase in production from alternate sources (14,000 tons annually)	• Increase in dredging from LOMR (350,000 tons annually) • Increase in production from alternate sources (14,000 tons annually)	• Increase in dredging from LOMR (860,000 annually) • No change in production from alternate sources	• No change in dredging from LOMR (327,000 tons annually) • No change in production from alternate sources
Cost of sand and gravel	• No change in total cost ($7.39/ton)	• Increase in total cost ($34.77/ton)	• Increase in total cost ($7.80/ton)	• No change in total cost ($7.39/ton)	• No change in total cost ($7.39/ton)
Economic impacts on commercial dredge operators and employees	• No change in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Increase in direct benefits to dredging operations	• Increase in direct benefits to dredging operations	• No change in direct benefits to dredging operations
Regional economic effects – sand and gravel production	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output and labor income (see Table 4.10-9)
Regional economic effects – transportation	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output and labor income (see Table 4.10-9)
Regional economic effects – household income levels	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output and labor income (see Table 4.10-9)	• Increase in total output and labor income (see Table 4.10-9)
Tax revenues (other than sand royalties)	• No change in tax revenues to local, state, or federal governments	• Decrease in tax revenues to local, state, and federal governments	• Increase in tax revenues to local, state, and federal governments	• Increase in tax revenues to local, state, and federal governments	• No change in tax revenues to local, state, or federal governments

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Joseph Market Area (continued)					
Sand royalties	• No change in sand royalties to State of Kansas ($49,000 annually)	• Decrease in sand royalties to State of Kansas ($0 annually)	• Increase in sand royalties to State of Kansas ($53,000 annually)	• Increase in sand royalties to State of Kansas ($129,000 annually)	• No change in sand royalties to State of Kansas ($49,000 annually)
Economic effects associated with river bed degradation	• Potential for continued river bed degradation and related economic impacts	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential for increase in river bed degradation and related economic impacts	• Potential for increase in river bed degradation and related economic impacts	• Potential for continued river bed degradation and related economic impacts
Environmental justice impacts	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Negligible environmental justice impacts on minority and low-income groups in the general population	• No environmental justice impacts on minority or low-income groups in the general population	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups
Kansas City Market Area					
Regional sand and gravel production	• Decrease in dredging from LOMR (2.4 MM tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (0 tons annually) • Increase in production from alternate sources (237,000 tons annually)	• Decrease in dredging from LOMR (540,000 tons annually) • Increase in production from alternate sources (237,000 tons annually)	• Decrease in dredging from LOMR (1.2 MM tons annually) • Increase in production from alternate sources (237,000 tons annually)	• Negligible change in dredging from LOMR (2.7 MM tons annually) • No change in production from alternate sources
Cost of sand and gravel	• Decrease in total cost ($7.72/ton)	• Increase in total cost ($31.27/ton)	• Increase in total cost ($16.46/ton)	• Increase in total cost ($8.45/ton)	• Decrease in total cost ($7.97/ton)
Economic impacts on commercial dredge operators and employees	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease direct benefits to dredging operations

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Kansas City Market Area (continued)					
Regional economic effects – sand and gravel production	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – transportation	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – household income levels	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Tax revenues (other than sand royalties)	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Negligible decrease in tax revenues to local, state, and federal governments
Sand royalties	• Decrease in sand royalties to State of Kansas ($57,000 annually)	• Decrease in sand royalties to State of Kansas ($22,000 annually)	• Decrease in sand royalties to State of Kansas ($35,000 annually)	• Decrease in sand royalties to State of Kansas ($52,000 annually)	• No change in sand royalties to State of Kansas ($64,000 annually)
Economic effects associated with river bed degradation	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential for continued river bed degradation and related economic impacts

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Environmental justice impacts	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining industry; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups in the general population
Waverly Market Area					
Regional sand and gravel production	• Increase in dredging from LOMR (968,000 tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (0 tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (500,000 tons annually) • No change in production from alternate sources	• Increase in dredging from LOMR (1.1 MM tons annually) • No change in production from alternate sources	• Negligible increase in dredging from LOMR (680,000 tons annually) • No change in production from alternate sources
Cost of sand and gravel	• Decrease in total cost ($7.72/ton)	• Increase in total cost ($42.91/ton)	• Increase in total cost ($24.40/ton)	• Decrease in total cost ($8.39/ton)	• Decrease in total cost ($8.97/ton)
Economic impacts on commercial dredge operators and employees	• Increase in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Increase in direct benefits to dredging operations	• Increase in direct benefits to dredging operations
Regional economic effects – sand and gravel production	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – transportation	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Waverly Market Area (continued)					
Regional economic effects – household income levels	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Tax revenues (other than sand royalties)	• Increase in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Increase in tax revenues to local, state, and federal governments	• Negligible increase in tax revenues to local, state, and federal governments
Sand royalties	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)
Economic effects associated with river bed degradation	• Potential for increase in river bed degradation and related economic impacts	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential for increase in river bed degradation and related economic impacts	• Potential for continued river bed degradation and related economic impacts
Environmental justice impacts	• Potential economic benefits resulting in benefits on minority and low-income groups	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining industry; negligible impacts on minority and low-income groups in the general population	• Potential economic benefits resulting in benefits on minority and low-income groups	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups in the general population
Jefferson City Market Area					
Regional sand and gravel production	• No change in dredging from LOMR (1.6 MM tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (0 tons annually) • Increase in production from alternate sources (27,000 tons annually)	• Decrease in dredging from LOMR (430,000 tons annually) • Increase in production from alternate sources (27,000 tons annually)	• Decrease in dredging from LOMR (980,000 tons annually) • Increase in production from alternate sources (27,000 tons annually)	• No change in dredging from LOMR (1.6 MM tons annually) • No change in production from alternate sources

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Jefferson City Market Area (continued)					
Cost of sand and gravel	• Decrease in total cost ($8.69/ton)	• Increase in total cost ($28.09/ton)	• Increase in total cost ($16.71/ton)	• Increase in total cost ($9.86/ton)	• Increase in total cost ($9.35/ton)
Economic impacts on commercial dredge operators and employees	• No change in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• No change in direct benefits to dredging operations
Regional economic effects – sand and gravel production	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – transportation	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – household income levels	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)
Tax revenues (other than sand royalties)	• No change in tax revenues to local, state, or federal governments	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• Decrease in tax revenues to local, state, and federal governments	• No change in tax revenues to local, state, or federal governments
Sand royalties	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)
Economic effects associated with river bed degradation	• Potential for continued river bed degradation and related economic impacts	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential for continued river bed degradation and related economic impacts

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Jefferson City Market Area (continued)					
Environmental justice impacts	• Potential environmental justice impacts on employees in the transportation industry; beneficial economic effects on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups in the general population
St. Charles Market Area					
Regional sand and gravel production	• No change in dredging from LOMR (1.6 MM tons annually) • No change in production from alternate sources	• Decrease in dredging from LOMR (0 tons annually) • Increase in production from alternate sources (2.5 MM tons annually)	• Decrease in dredging from LOMR (370,000 tons annually) • Increase in production from alternate sources (2.0 MM tons annually)	• Decrease in dredging from LOMR (840,000 tons annually) • Increase in production from alternate sources (959,000 tons annually)	• No change in dredging from LOMR (1.6 MM tons annually) • No change in production from alternate sources
Cost of sand and gravel	• Decrease in total cost ($7.10/ton)	• Increase in total cost ($8.60/ton)	• Increase in total cost ($7.63/ton)	• Decrease in total cost ($7.14/ton)	• Increase in total cost ($8.58/ton)
Economic impacts on commercial dredge operators and employees	• Negligible increase in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Decrease in direct benefits to dredging operations	• Negligible decrease in direct benefits to dredging operations
Regional economic effects – sand and gravel production	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output and labor income; decrease in employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)
Regional economic effects – transportation	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)

Table 4.10-10 Summary of Potential Short-Term Economic Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
St. Charles Market Area (continued)					
Regional economic effects – household income levels	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)	• Increase in total output, labor income, and employment (see Table 4.10-9)	• Decrease in total output, labor income, and employment (see Table 4.10-9)
Tax revenues (other than sand royalties)	• No change in tax revenues to local, state, or federal governments	• Increase in tax revenues to local, state, and federal governments	• Increase in tax revenues to local, state, and federal governments	• Increase in tax revenues to local, state, and federal governments	• No change in tax revenues to local, state, or federal governments
Sand royalties	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)	• No change in sand royalties to State of Kansas ($0 annually)
Economic effects associated with river bed degradation	• Potential for continued river bed degradation and related economic impacts	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential decrease in river bed degradation resulting in economic benefits (avoided costs)	• Potential for continued river bed degradation and related economic impacts
Environmental justice impacts	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining industry; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining industry; negligible impacts on minority and low-income groups in the general population	• Potential environmental justice impacts on employees in the mining and transportation industries; negligible impacts on minority and low-income groups in the general population	• Negligible economic impacts anticipated, including environmental justice impacts on minority and low-income groups in the general population

Notes:

LOMR = Lower Missouri River.
MM = Million.

4.11 NOISE

4.11.1 Introduction

This section describes the environmental consequences associated with implementation of the Proposed Action and alternatives. Analysis methods and effect conclusions are discussed.

4.11.2 Assessment Methods

Construction activities are considered to be temporary, short-tem activities because they would cease after facility construction is complete. Dredging also is considered to be a recurrent, short-term activity because it would not occur permanently in any given location. Processing facility operations are considered to be long-term, permanent operations because they occur at a fixed location for an extended period of time.

The noise standards in Table 3.13-2 were used to determine whether Project-related activities would result in adverse noise levels. The following thresholds are used, specific to this Project.

Dredging and construction operations:

- 75 dBA-L_{eq} daytime (7:00 a.m. to 10:00 p.m.)
- 65 dBA-L_{eq} nighttime (10:00 p.m. to 7:00 a.m.)

Processing facility operations:

- 65 L_{dn}

The following discussion describes how various components of the Project are evaluated.

4.11.2.1 Construction

Activities under the Proposed Action and alternatives may call for construction of new facilities or expansion of existing facilities. The USEPA has developed generalized noise levels for various phases of construction associated with domestic housing, nonresidential construction, industrial construction, and public works construction (USEPA 1971). Noise levels for industrial construction are used for this assessment. Table 4.11-1 summarizes noise levels for each phase of typical industrial construction. It

also shows the distance within which the daytime and nighttime thresholds identified above would be exceeded.

Table 4.11-1 Construction Noise Levels for Industrial Facility Construction

Construction Phase	Noise Level at 50 Feet	Distance (feet) within Which the Indicated Noise Level Is Exceeded	
		75 dBA[a]	65 dBA[b]
Ground clearing	87	200	630
Excavation	90	280	890
Foundations	89	250	790
Building/facility construction	85	160	500
Finishing and cleanup	89	250	790

Note: dBA = A-weighted decibel(s).

[a] Daytime threshold.
[b] Nighttime threshold.

Source: USEPA 1971.

4.11.2.2 Dredging

Each Dredger has provided information on dredging operations, including the number and size of engines used on each dredge and tugboat. Noise from dredging and tugboat operations has been estimated from these data using methods recommended by Hoover & Keith (2000). Tables 3.13-5 and 3.13-6 in Section 3.13 summarize the noise levels generated by each dredge or tug boat. Under the Proposed Action and alternatives, noise generated by dredges and tug boats was assumed to be unchanged. The duration and location of dredging, however, would change.

4.11.2.3 Processing Operations

Existing sand plants within the Project area use front-end loaders, cranes, conveyors, and other processing equipment. Based on information provided by the MDNR (Zeaman pers. comm.), it was assumed that each plant has, at minimum, a crane, four loaders, and one dozer. Noise generated by this equipment has been estimated using noise source levels developed by the FHWA (2006). Simultaneous operation of this equipment would result in source noise level of approximately 83 dBA-L_{eq} at 50 feet. Noise from other equipment at these facilities has been estimated using data from a plant with screens, crushers, conveyor belts, cyclones, sand classifiers, and screws (Bauer and Spencer 2008). This facility produces a reference sound level of approximately 89 dBA at 50 feet. The

combined sound level of all of the equipment is 90 dBA-L_{eq} at 50 feet. Assuming continuous operation between 7:00 a.m. and 7:00 p.m., this level of noise corresponds to 87 L_{dn} at 50 feet.

For the purposes of this assessment, it was assumed that all facilities with annual production of 250,000 tons or less would produce a sound level of 87 L_{dn} at 50 feet. For larger facilities, the source noise level was scaled up based on the amount of production in excess of 250,000 tons/yr. As discussed in Section 3.14.2, a doubling of sound energy corresponds to a 3-dB increase in noise. Therefore, a doubling of delivered product volume was assumed to result in a 3-dB increase in facility noise. The change in noise level associated with larger or smaller changes in product volume also can be calculated directly. For example, a 10-percent increase in product volume would result in a 0.4-dB increase in noise.

Trucks that deliver product also are a source of noise on local roadways. Haul truck noise was calculated based on estimated truck volumes developed from the annual delivered product volume from each facility and assumptions regarding the number of delivery days and typical truck capacity. Dredging operations typically occur 10 months per year. Truck deliveries can occur 10–12 months per year. Truck deliveries have been estimated assuming 10 months per year to provide a conservative estimate of daily truck trips. Table 3.13-7 summarizes the assumptions and estimated truck noise levels for existing conditions. Similar tables have been developed for the Proposed Action and each alternative.

4.11.2.4 Operations at Alternate Source Locations

Reductions in the quantity of sand and gravel dredged from the LOMR under the alternatives would need to be replaced by alternate sources. Over the long term, new sources likely would be developed near existing processing facilities and urban centers, which represent the largest sources of demand for construction sand and gravel. New mining operations likely would be located in the floodplain adjacent to the LOMR, which has comparable sand deposits and would allow use of dredging equipment that currently is used in river dredging. In the short term, however, replacement supplies likely would need to come from existing sources based on the extended startup period for new mines.

Alternate sources of sand and gravel include dredging from the Kansas or Mississippi River. Other sources of sand and gravel include floodplain open-pit mines and quarries, instream sand and gravel mines, and manufactured sand. Because of the speculative nature of when and where alternate sources would operate, potential noise impacts associated with alternate sources are discussed qualitatively.

4.11.3 Proposed Action

4.11.3.1 Short-Term Exposure of Noise-Sensitive Land Uses to Noise from Construction of New Facilities

St. Joseph Segment

No new facilities would be constructed in the St. Joseph segment. Therefore, no exceedances of the noise thresholds from construction of new facilities are expected in this segment under the Proposed Action.

Kansas City Segment

Under the Proposed Action, The Master's Dredging Company would construct a new facility (Master's–Waldron) in the Kansas City segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. No noise-sensitive land uses (including residences) are located within these distances at the proposed sand plant site. Accordingly, no exceedances of the noise thresholds from construction of new facilities are expected at this location.

Waverly and Jefferson City Segments

No new facilities would be constructed in the Waverly or Jefferson City segment. Therefore, no exceedances of the noise thresholds from construction of new facilities are expected in these segments under the Proposed Action.

St. Charles Segment

Under the Proposed Action, Edward N. Rau Contractor Company would construct a new facility (Rau–Washington) in the St. Charles segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. The Rau–Washington facility would be located within approximately 250 feet of existing residences, indicating the potential for construction activity at the proposed facility to result in noise levels that exceed the thresholds at nearby residences.

Alternate Sources

New facilities would not be constructed at alternate source locations under the Proposed Action. Therefore, no noise-sensitive land uses near alternate sources would experience short-term exposure to noise from construction of dredging-related facilities.

4.11.3.2 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Dredging

Tables 3.13-5 and 3.13-6 in Section 3.13 show the tug and dredging equipment used by each Dredger and the estimated noise level produced by each piece of equipment. These tables also show the distance within which noise from each tug or dredge is estimated to exceed 65 dBA-L_{eq}. Table 4.11-2 summarizes this information by Dredger within each segment. Table 4.11-2 also identifies general locations of residential neighborhoods that potentially experience noise levels exceeding 65 dBA-$L_{eq.}$

St. Joseph Segment

Tug and dredging equipment would operate in areas in the St. Joseph segment that have been dredged in recent years but likely would need to operate in areas not dredged in recent years to accommodate the increased amount of material that would be dredged under the Proposed Action. Although noise produced by individual tugs and dredges is not anticipated to increase, noise-sensitive land uses that are not currently exposed to dredging operation noise potentially could be exposed to noise from the expanded operations that would occur under the Proposed Action. Residences located within the distances indicated in Table 4.11-2 could be exposed to adverse noise effects that exceed the 65-dBA-L_{eq} threshold. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Kansas City Segment

Tug and dredging equipment would operate in areas in the Kansas City segment that have been dredged in recent years but likely would need to operate in areas not dredged in recent years to accommodate the increased amount of material that would be dredged under the Proposed Action. In addition, new dredging operations near the Master's–Waldron facility could result in dredging in areas that are outside the recently dredged areas. Although noise produced by individual tugs and dredges is not anticipated to increase, noise-sensitive land uses that are not currently exposed to dredging operation noise potentially could be exposed to noise from the expanded operations that would occur under the Proposed Action. Residences located within the distances indicated in Table 4.11-2 could be exposed to adverse noise effects that exceed the 65-dBA-Leq threshold. If dredging does not expand

beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Table 4.11-2 Summary of Noise Levels Produced by Tugs and Dredges for Each Dredger

Company Name (Facility)	River Mile	Distance (ft) within Which Tug Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Tug Noise	Distance (ft) within Which Dredge Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Dredge Noise
St. Joseph Segment					
Holliday Sand & Gravel Company (St. Joseph)	447.8	1,000–1,410	10–20 residences 2 miles upriver on north bank in St. Joseph, MO 10–20 residences 2.75 miles downriver on southeast bank in St. Joseph, MO	560–890	5-10 residences 2.75 miles downriver on southeast bank in St. Joseph, MO
Kansas City Segment					
The Master's Dredging Company (Waldron)	385	0 (no tugs)[a]	None	800–1,260	None
Holliday Sand & Gravel Company (Riverside)	372	1,000–1,410	None	560–890	None
Holliday Sand & Gravel Company (Randolph)	360	1,000–1,410	None	560–890	None
Waverly Segment					
Capital Sand Company (Lexington)	317.5	890–1,120	5–10 residences 2 miles downriver on east bank in Lexington, MO	560–630	None
Capital Sand Company (Carrollton)	287	890–1,120	25–50 residences 6 miles upriver of facility on southeast bank in Waverly, MO	560–630	5–10 residences 6 miles upriver of facility on southeast bank in Waverly, MO
Jefferson City Segment					
Capital Sand Company–St. Louis (Glasgow)	226.2	890–1,120	50–100 residences 0.25 mile upriver on northeast bank in Glasgow, MO	560–630	25–50 residences 0.25 mile upriver on northeast bank in Glasgow, MO
Capital Sand Company–St. Louis (Boonville)	196.2	890–1,120	25–50 residences 0.75 mile upriver on east bank in Boonville, MO 10–25 residences 0.5 mile downriver on east bank in Boonville, MO	560 to 630	5–10 residences approximately 0.75 mile upriver on east bank in Boonville, MO 5–10 residences 0.5 mile downriver on east bank in Boonville, MO

Table 4.11-2 Summary of Noise Levels Produced by Tugs and Dredges for Each Dredger

Company Name (Facility)	River Mile	Distance (ft) within Which Tug Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Tug Noise	Distance (ft) within Which Dredge Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Dredge Noise
Jefferson City Segment (continued)					
Capital Sand Company–St. Louis (Rocheport)	186.5	890–1,120	10–25 residences 9 miles upriver on east bank in Boonville, MO 5–10 residences 0.5 mile downriver on north bank in Rocheport, MO	560 to 630	5–10 residences 9 miles upriver on east bank in Boonville, MO
Hermann Sand & Gravel (Jefferson City)	146.5	800–1,120	250–500 residences 1–3 miles downriver on south bank in Jefferson City, MO	500	25–50 residences 1–3 miles downriver on south bank in Jefferson City, MO
Capital Sand Company–St. Louis (Jefferson City)	143.5	890–1,120	250–500 residences 0–2 miles upriver on south bank in Jefferson City, MO 25–50 residences 2.5 miles downriver on south bank in Jefferson City, MO	560 to 630	25–50 residences 0–2 miles upriver on south bank in Jefferson City, MO 10–25 residences 2.5 miles downriver on south bank in Jefferson City, MO
St. Charles Segment					
Hermann Sand & Gravel (Hermann)	97	800–1,120	5–10 residences 7.5 miles upriver on east bank in Gasconade, MO 75–150 residences 0.5–1.5 miles upriver on east bank in Hermann, MO	500	5–10 residences 0.5–1.5 miles upriver on east bank in Hermann, MO
Edward N. Rau Contractor Company (Washington)[b]	68	800–1,200 [b]	25-50 residences 0.0–0.5 mile upriver on south bank in Washington, MO 50–100 residences 0-1 mile downriver on south bank in Washington, MO	500[b]	Approx. 5–10 residences 0.0–0.5 mile upriver on south bank in Washington, MO
Capital Sand Company–St. Louis (Washington)	66	890–1,120	50–100 residences 1.5–3.0 miles upriver on south bank in Washington, MO	560 to 630	5–10 residences 3.0–3.5 miles upriver on south bank in Washington, MO

Table 4.11-2 Summary of Noise Levels Produced by Tugs and Dredges for Each Dredger

Company Name (Facility)	River Mile	Distance (ft) within Which Tug Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Tug Noise	Distance (ft) within Which Dredge Noise Could Exceed 65 dB-L_{eq}[c]	Residential Areas Potentially Affected by Dredge Noise
St. Charles Segment (continued)					
Limited Leasing Company (Bridgeton)	44	1,000–1,775	None	500	None
J.T. R. (St. Charles)	31.5	800–1,360	50–100 residences 0.75 mile upriver on west bank in St. Charles, MO 25–50 residences 2 miles upriver on west bank in St. Charles, MO	560	5–10 residences 2 miles upriver on west bank in St. Charles, MO
Limited Leasing Company (Chesterfield)	28	1,000–1,775	25–50 residences 1.25 miles upriver on west bank in St. Charles, MO 50–100 residences 4 miles upriver on west bank in St. Charles, MO 25–50 residences 5 miles upriver on west bank in St. Charles, MO	500	5–10 residences 5 miles upriver on west bank in St. Charles, MO
J.T.R. (Riverview)	16.5	800–1,360	10–25 residences 3 miles upriver on east bank in Florissant, MO	560	None
Limited Leasing Company (Fort Belle)	8	1,000–1,775	50–100 residences 0-1.5 miles upriver on south bank in Black Jack, MO	500	10–25 residences 0–1.5 miles upriver on south bank in Black Jack, MO

[a] The Master's Dredging Company would operate a system that pumps dredged material directly from the river as slurry to the processing plant. It would not operate any tugs.

[b] Edward N. Rau Contractor Company would not operate any tugs or dredges. The company would contract with Hermann Sand & Gravel Company or another Dredger to dredge for them near their Washington facility. Tug/dredging noise levels for Hermann equipment are indicated.

[c] This assumes that tugs and dredges are operating at a fixed distance from a noise-sensitive use for at least 1 hour. Tug operations typically are associated with movement of dredges and barges and therefore typically are transitory. As such, distances within which tug noise would exceed 65 dB-Leq typically would be much less than the amount shown.

Waverly and Jefferson City Segments

Tug and dredging equipment would operate in areas in the Waverly and Jefferson City segments that have been dredged in recent years but likely would need to operate in areas not dredged in recent years to accommodate the increased amount of material that would be dredged under the Proposed Action. Although noise produced by individual tugs and dredges is not anticipated to increase, noise-

sensitive land uses that are not currently exposed to dredging operation noise could be exposed to noise from the expanded operations that would occur under this alternative. Residences located within the distances indicated in Table 4.11-2 could be exposed to adverse noise effects that exceed the 65-dBA-Leq threshold. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

St. Charles Segment

Tug and dredging equipment would operate in areas in the St. Charles segment that have been dredged in recent years but likely would need to operate in areas not dredged in recent years to accommodate the increased amount of material that would be dredged under the Proposed Action. In addition, new dredging operations near the Rau–Washington facility could result in dredging in areas that have not been dredged in recent years. Although noise produced by individual tugs and dredges is not anticipated to increase, noise-sensitive land uses that are not currently exposed to dredging operation noise could be exposed to noise from the expanded operations that would occur under the Proposed Action. Residences located within the distances indicated in Table 4.11-2 could be exposed to adverse noise effects that exceed the 65-dBA-Leq threshold. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-3.

Alternate Sources

Dredging would not increase at alternate source locations under the Proposed Action. Therefore, no noise-sensitive land uses near alternate sources would experience long-term exposure to noise from additional dredging operations.

4.11.3.3 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Processing Facility Operations

Table 4.11-3 summarizes the projected annual tons of material that would be delivered from each facility within each segment under the Proposed Action. The table also shows the estimated distance to the 65-L_{dn} contour. The contour distance is then compared to the distance to the nearest residence to determine whether an adverse effect (i.e., a noise level above the threshold) has the potential to occur. Table 4.11-3 indicates the potential for operations at several facilities to result in noise levels at residences that exceed the threshold.

Table 4.11-3 Summary of Facility Processing and Haul Truck Noise – Proposed Action

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65-L_{dn} Contour (ft)	Distance to Nearest Residence (ft)	65-L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 ft)[d]
St. Joseph Segment										
Holliday Sand & Gravel Company (St. Joseph)	447.8	1,150,0000	94	1350	850	Yes	5324	266	532	61
Kansas City Segment										
The Master's Dredging Company (Waldron) [e]	385	1,000,000	93	1,259	3,300	No	4,630	231	463	61
Holliday Sand & Gravel Company (Riverside)	372	1,669,668	95	1627	2,900	No	7730	386	773	63
Holliday Sand & Gravel Company (Randolph)	360	1,730,332	95	1656	3,800	No	8011	401	801	63
Waverly Segment										
Capital Sand Company (Lexington)	317.5	624,275	91	995	2,700	No	2890	145	289	59
Capital Sand Company (Carrollton)	287	41,325	87	629	4,000	No	191	10	19	50
Jefferson City Segment										
Capital Sand Company–St. Louis (Glasgow)	226.2	202,519	87	629	600	Yes	938	47	94	54
Capital Sand Company–St. Louis (Boonville)	196.2	16,850	87	629	1,900	No	78	4	8	48
Capital Sand Company–St. Louis (Rocheport)	186.5	405,281	89	801	1,350	No	1876	94	188	57
Hermann Sand & Gravel (Jefferson City)	146.5	500,000	90	890	5,200	No	2,315	116	231	58
Capital Sand Company–St. Louis (Jefferson City)	143.5	1,625,350	95	1605	1,900	No	7525	376	752	63

Table 4.11-3 Summary of Facility Processing and Haul Truck Noise – Proposed Action

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65-L_{dn} Contour (ft)	Distance to Nearest Residence (ft)	65-L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 ft)[d]
St. Charles Segment										
Hermann Sand & Gravel (Hermann)	97	500,000	90	890	1,900	No	2,315	116	231	58
Edward N. Rau Contractor Company (Washington)[f]	68	100,000	87	629	250	Yes	463	23	46	52
Capital Sand Company–St. Louis (Washington)	66	1,304,000	93	1280	1,700	No	4789	239	479	61
Limited Leasing Company (Bridgeton)	44	350,000	88	745	2,800	No	1,620	81	162	57
J.T. R. (St. Charles)	31.5	1,348,775	94	1,462	600	Yes	6,244	312	624	62
Limited Leasing Company (Chesterfield)	28	650,000	91	1,015	2,400	No	3,009	150	301	59
J.T.R. (Riverview)	16.5	201,225	87	629	2,300	No	932	47	93	54
Limited Leasing Company (Fort Belle)	8	100,000	87	629	850	No	463	23	46	52

[a] Based on a processing source level of 90 dBA-L_{eq} at 50 feet and continuous operation between 7:00 a.m and 7:00 p.m. (87 L_{dn} at 50 ft) for facilities producing 250,000 tons/year or less. For larger facilities, the source noise level was scaled up based on the amount of production in excess of 250,000 tons/yr. As discussed in Section 3.14.2, a doubling of sound energy corresponds to a 3-dB increase in noise. Therefore, a doubling of delivered product volume was assumed to result in a 3-dB increase in facility noise.

[b] Assumes 216 delivery days per year (10 months of operation per year 5 days a week). Deliveries can occur 10–12 months per year. Assuming 10 months provides a conservative estimate of daily truck volumes and noise.

[c] Assumes average truck capacity of 20 tons.

[d] Calculated using FHWA Traffic Noise Model Version 2.1 assuming: average truck speed of 45 miles per hour (mph) on local road near plant.

-Two truck trips (out and in from facility) per delivery.

-Daily truck trips equally distributed over eight-hour work day during daytime hours.

-Average truck speed of 45 mph on local road near plant.

[e] New proposed facility.

Table 4.11-3 also shows the noise level predicted to result from trucking operations. The predicted traffic noise level at 50 feet from the roadway is identified. In no case is traffic noise predicted to exceed 65 L_{dn} at 50 feet. Because noise-sensitive uses typically would be located at least this distance from the roadway, no adverse effects from trucking are anticipated.

St. Joseph Segment

Under the Proposed Action, noise levels would exceed the 65-L_{dn} threshold at the residences closest to the Holliday–St. Joseph facility in the St. Joseph segment.

Kansas City and Waverly Segments

Under the Proposed Action, noise levels would not exceed the 65-L_{dn} threshold at the nearest residences to any of the facilities in the Kansas City or Waverly segment.

Jefferson City Segment

Under the Proposed Action, the 65-L_{dn} threshold would be exceeded at the residences closest to the Capital–Glasgow facility in the Jefferson City segment.

St. Charles Segment

Under the Proposed Action, the 65-L_{dn} threshold would be exceeded at the residences closest to the J.T.R.–St. Charles facility and the proposed Rau–Washington facility in the St. Charles segment.

Alternate Sources

Processing would not increase at alternate source locations under the Proposed Action. Therefore, no noise-sensitive land uses near alternate sources would experience long-term exposure to noise from additional processing operations.

4.11.4 No Action Alternative

4.11.4.1 Short-Term Exposure of Noise-Sensitive Land Uses to Noise from Construction of New Facilities

All Segments

Under the No Action Alternative, no new facilities would be constructed in any segment. Therefore, no noise levels would exceed thresholds due to new dredging-related construction.

Alternate Sources

In the short term, new alternate source facilities likely would not be constructed. Replacement supplies probably would need to come from existing sources, based on the extended startup period for new mining operations.

In the long term, new sources of material likely would be developed near existing processing facilities and urban centers, which represent the largest sources of demand for construction sand and gravel. New mining operations likely would be located in the floodplain adjacent to the LOMR. Alternate sources of sand and gravel include dredging from the Kansas or Mississippi River, open-pit mining in the LOMR floodplain, instream mining in the LOMR, and manufactured sand.

Development of floodplain or instream mining operations could involve construction of new facilities. Expansion of existing facilities along the Kansas and Mississippi Rivers also could involve construction activities. It is not possible at this time to identify specifically where this potential construction activity could occur. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold.

4.11.4.2 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Dredging and Mining

All Segments

No dredging would occur under the No Action Alternative. Noise levels in the segments would decrease due to the decrease in general activity, equipment use, dredge operations, and barges and tugs associated with dredging.

Alternate Sources

Noise generated by alternate source mining operations would vary depending on the type of mining, timing, and location. It is not possible at this time to identify specifically where new or expanded mining would occur. Table 4.11-3 provides a general indication of the distance within which 65 dBA-L_{eq} can be exceeded near facility operations of various sizes. This indicates that there is potential for new or expanded mining operations to expose nearby noise-sensitive uses to noise exceeding 65 dBA-L_{eq}.

4.11.4.3 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Processing Facility Operations

All Segments

No processing operations would occur in any segment under the No Action Alternative. Noise levels in the segments would decrease due to the decrease in processing.

Alternate Sources

Noise generated by processing at alternate source locations would vary depending on the type of processing, timing, and location of facilities. At this time It is not possible to identify specifically where new or expanded mining would occur. Processing in the short term and at the combined existing and new alternate source facilities in the long term could result in additional noise level exceedances at nearby noise-sensitive land uses.

4.11.5 Alternative A

4.11.5.1 Short-Term Exposure of Noise-Sensitive Land Uses to Noise from Construction of New Facilities

St. Joseph Segment

No new facilities would be constructed in the St. Joseph segment under Alternative A. Therefore, no exceedances of the noise thresholds from construction of new facilities are expected in this segment.

Kansas City Segment

Under Alternative A, The Master's Dredging Company would construct a new facility (Master's–Waldron) in the Kansas City segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. No noise-sensitive land uses are located within these distances at the proposed facility site. Accordingly, no exceedances of the noise thresholds from construction of new facilities are expected at this location.

Waverly and Jefferson City Segments

No new facilities would be constructed in the Waverly or Jefferson City segment under Alternative A. Therefore, no exceedances of the noise thresholds from construction of new facilities are expected in these segments.

St. Charles Segment

Under Alternative A, Edward N. Rau Contractor would construct a new facility (Rau–Washington) in the St. Charles segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. The Rau–Washington facility would be located within approximately 250 feet of existing residences, indicating the potential for construction activity at the proposed facility to result in noise levels that exceed the thresholds at nearby residences.

Alternate Sources

In the short term, replacement supplies would probably need to come from existing sources, based on the extended startup period for new mining operations. In the long term, development of floodplain or instream mining operations could involve the construction of new facilities. Expansion of existing facilities along the Kansas and Mississippi Rivers also could involve construction activities. It is not possible at this time to identify specifically where this potential construction activity could occur. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold.

4.11.5.2 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Dredging and Mining

Tables 3.13-5 and 3.13-6 show the tug and dredging equipment used by each Dredger, along with the estimated noise level produced by each piece of equipment. These tables also show the distance within which noise from each tug or dredge is estimated to exceed 65 dBA-L_{eq}. Table 4.11-2 summarizes this information by Dredger within each segment.

St. Joseph Segment

Under Alternative A, production would increase by 7 percent in the St. Joseph segment. Noise-sensitive land uses that have not been exposed to noise from dredging operations in recent years could become exposed to noise from these dredging operations. Residences located within the distances shown in Table 4.11-2 could be exposed to adverse noise effects. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Kansas City, Waverly, Jefferson City, and St. Charles Segments

Under Alternative A, material production would be 27–80 percent less than existing conditions in the Kansas City, Waverly, Jefferson City, and St. Charles Segments, accounting for the new Rau–Washington facility in the St. Charles Segment. Overall, dredging equipment would operate in areas that have been dredged in recent years and probably would not need to operate beyond recently dredged areas. Noise produced by tugs and dredges is not anticipated to change. Although with reduced activity, there generally would be less opportunity for noise-sensitive uses to be exposed to excessive noise, certain noise-sensitive land uses not exposed to dredging operation noise in recent years could become exposed to additional noise under Alternative A. Residences located within the distances shown in Table 4.11-2 could be exposed to threshold-exceeding noise levels. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Alternate Sources

In the short term, replacement supplies would probably need to come from existing sources, based on the extended startup period for new mining operations. In the long term, development of floodplain or instream mining operations could involve the construction of new facilities. Expansion of existing facilities along the Kansas and Mississippi Rivers also could involve construction activities. It is not possible at this time to identify specifically where new or expanded dredging or mining operations would occur. Table 4.11-3, however, does provide a general indication of the distance within which 65 dBA-L_{eq} can be exceeded near facility operations of various sizes. This indicates that there is potential for new or expanded dredging operations to expose nearby noise-sensitive land uses to noise exceeding 65 dBA-L_{eq}.

4.11.5.3 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Processing Facility Operations

Table 4.11-4 summarizes the projected annual tons of material that would be delivered from each facility within each segment under Alternative A. From this information, a reference noise level generated by operation of each facility has been developed. The distance to the 65-L_{dn} contour has been developed from this reference distance. The contour distance is compared to the distance to the nearest residences, in order to determine whether an adverse effect (i.e., a noise level above the threshold) potentially would occur. Table 4.11-4 indicates the potential for operations at several facilities to result in noise levels at residences that exceed the threshold.

Table 4.11-4 also shows the noise level predicted to result from trucking operations under Alternative A. The predicted traffic noise level at 50 feet from the roadway is identified. In no case is traffic noise predicted to exceed 65 L_{dn} at 50 feet. Because noise-sensitive uses typically would be located at least this distance from the roadway, no adverse effects from trucking are anticipated under Alternative A.

St. Joseph, Kansas City, and Waverly Segments

Under Alternative A, noise levels would not exceed thresholds at the residences nearest any of the facilities in the St. Joseph, Kansas City, or Waverly segment.

Jefferson City Segment

Under Alternative A, noise levels would be exceeded in the Jefferson City segment at the residences closest to the Capital–Glasgow facility.

St. Charles Segment

Under Alternative A, noise levels would be exceeded at the residences closest to the J.T.R.–St. Charles facility and the new Rau–Washington facility in the St. Charles segment.

Table 4.11-4 Summary of Facility Processing and Haul Truck Noise – Alternative A

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Joseph Segment										
Holliday Sand & Gravel Company (St. Joseph)	447.8	350,000	88	745	850	No	1620	81	162	57
Kansas City Segment										
The Master's Dredging Company (Waldron) [e]	385	153,031	87	629	3,300	No	708	35	71	53
Holliday Sand & Gravel Company (Riverside)	372	211,147	87	629	2,900	No	978	49	98	55
Holliday Sand & Gravel Company (Randolph)	360	354,313	89	749	3,800	No	1640	82	164	57
Waverly Segment										
Capital Sand Company (Lexington)	317.5	301,604	88	691	2,700	No	1396	70	140	56
Capital Sand Company (Carrollton)	287	19,965	87	629	4,000	No	92	5	9	48
Jefferson City Segment										
Capital Sand Company–St. Louis (Glasgow)	226.2	29,954	87	629	600	Yes	139	7	14	49
Capital Sand Company–St. Louis (Boonville)	196.2	2,492	87	629	1,900	No	12	1	1	47
Capital Sand Company–St. Louis (Rocheport)	186.5	59,944	87	629	1,350	No	278	14	28	51
Hermann Sand & Gravel (Jefferson City)	146.5	97,210	87	629	5,200	No	450	23	45	52
Capital Sand Company–St. Louis (Jefferson City)	143.5	240,000	87	629	1,900	No	1111	56	111	55

Table 4.11-4 Summary of Facility Processing and Haul Truck Noise – Alternative A

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Charles Segment										
Hermann Sand & Gravel (Hermann)	97	44,719	87	629	1,900	No	207	10	21	50
Edward N. Rau Contractor Company (Washington)[f]	68	8,944	87	629	250	Yes	41	2	4	47
Capital Sand Company–St. Louis (Washington)	66	70,382	87	629	1,700	No	326	16	33	51
Limited Leasing Company (Bridgeton)	44	31,303	87	629	2,800	No	145	7	14	49
J.T. R. (St. Charles)	31.5	120,632	87	629	600	Yes	558	28	56	53
Limited Leasing Company (Chesterfield)	28	58,135	87	629	2,400	No	269	13	27	50
J.T.R. (Riverview)	16.5	17,997	87	629	2,300	No	83	4	8	48
Limited Leasing Company (Fort Belle)	8	8,944	87	629	850	No	41	2	4	47

[a] Based on a processing source level of 90 dBA-L_{eq} at 50 feet and continuous operation between 7:00 a.m and 7:00 p.m. (87 L_{dn} at 50 ft) for facilities producing 250,000 tons/year or less. For larger facilities, the source noise level was scaled up based on the amount of production in excess of 250,000 tons/yr. As discussed in Section 3.14.2, a doubling of sound energy corresponds to a 3-dB increase in noise. Therefore, a doubling of delivered product volume was assumed to result in a 3-dB increase in facility noise.

[b] Assumes 216 delivery days per year (10 months of operation per year 5 days a week). Deliveries can occur 10–12 months per year. (Assuming 10 months provides a conservative estimate of daily truck volumes and noise.)

[c] Assumes average truck capacity of 20 tons.

[d] Calculated using FHWA Traffic Noise Model Version 2.1 assuming: average truck speed of 45 miles per hour (mph) on local road near plant.

- Two truck trips (out and in from facility) per delivery.
- Daily truck trips equally distributed over eight-hour work day during daytime hours.
- Average truck speed of 45 mph on local road near plant.

[e] New proposed facility.

Alternate Sources

In the short term, replacement supplies would probably need to come from existing sources, based on the extended startup period for new mining operations. In the long term, development of floodplain or instream mining operations could involve the construction of new facilities. Expansion of existing facilities along the Kansas and Mississippi Rivers also could involve construction activities. It is not possible at this time to identify specifically where new or expanded processing would occur.
Table 4.11-4 provides a general indication of the distance within which 65 dBA-L_{eq} can be exceeded near facility operations of various sizes. Increased processing in the short term at existing facilities and in the long term at existing and new facilities could result in exposure of nearby noise-sensitive uses to noise levels exceeding 65 dBA-L_{eq}.

4.11.6 Alternative B

4.11.6.1 Short-Term Exposure of Noise-Sensitive Land Uses to Noise from Construction of New Facilities

St. Joseph Segment

No new facilities would be constructed in the St. Joseph segment under Alternative B. Therefore, no exceedances of the noise thresholds from construction of new dredging-related facilities are expected.

Kansas City Segment

Under Alternative B, Waldron (Master's) would construct a new facility in the Kansas City segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. No noise-sensitive land uses are located within these distances at the proposed project site. Accordingly, no exceedances of the noise thresholds from construction of new facilities are expected at this location.

Waverly and Jefferson City Segments

Under Alternative B, no new facilities would be constructed in the Waverly or Jefferson City segment. Therefore, no exceedances of the noise thresholds from construction of new facilities are expected.

St. Charles Segment

Under Alternative B, Washington (Rau) would construct a new facility in the St. Charles segment. Table 4.11-2 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. The Rau facility would be located within approximately 250 feet of existing residences, indicating the potential for construction activity at the proposed Rau facility to result in noise levels that exceed the thresholds at nearby residences.

Alternate Sources

In the short term under Alternative B, replacement supplies would probably need to come from existing sources, based on the extended startup period for new mining operations. Alternate sources of sand and gravel include dredging from the Kansas or Mississippi River, open-pit mining in the LOMR floodplain, instream mining in the LOMR, and manufactured sand. Development of floodplain or instream mining operations could involve the construction of new facilities. Expansion of existing facilities along the Kansas and Mississippi Rivers also could involve construction activities. It is not possible at this time to identify specifically where this potential construction activity could occur. Table 4.11-2 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold.

4.11.6.2 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Dredging and Mining

Tables 3-13.5 and 3.13-6 show the tug and dredging equipment used by each operator along with the estimated noise level produced by each piece of equipment. These tables also show the distance within which noise from each tug or dredge is estimated to exceed 65 dBA-L_{eq}. Table 4.11-3 summarizes this information by operator within each segment.

St. Joseph and Waverly Segments

Relative to existing conditions, production would increase by 163 percent in the St. Joseph segment and by 68 percent in the Waverly segment under Alternative B. Noise-sensitive land uses that have not been exposed to dredging operation noise in recent years could become exposed to noise from these dredging operations. Residences located within the distances shown in Table 4.11-2 could be exposed

to adverse noise effects. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Kansas City, Jefferson City, and St. Charles Segments

Under Alternative B, production would be from 38 to 53 percent less than existing conditions in the Kansas City, Jefferson City, and St. Charles segments, accounting for the new Rau Washington facility in the St. Charles segment. The reduced activity generally would result in less opportunity for noise-sensitive uses to be exposed to excessive noise. Residences located within the distances shown in Table 4.11-2 could be exposed to noise levels that exceed thresholds. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Alternate Sources

It is not possible at this time to identify specifically where new or expanded dredging or mining would occur. Table 4.11-4 indicates the distance within which 65 dBA-L_{eq} can be exceeded near facility operations of various sizes, and the potential for new or expanded dredging operations to expose nearby noise-sensitive use to noise exceeding 65 dBA-L_{eq}.

4.11.6.3 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Processing Facility Operations

Table 4.11-5 summarizes the projected annual tons of material that would be delivered from each facility within each segment under Alternative B. From this information, a reference noise level generated by operation of each facility has been developed. The distance to the 65-L_{dn} contour has been developed from this reference distance. The contour distance is compared to the distance from the nearest residences to determine whether an adverse effect (i.e., a noise level above the threshold), potentially would occur. Table 4.11-5 indicates the potential for operations at several facilities to result in noise levels at residences that exceed the threshold.

Table 4.11-5 shows the noise level predicted to result from trucking operations under Alternative B. The predicted traffic noise level at 50 feet from the roadway is identified. In no case is traffic noise predicted to exceed 65 L_{dn} at 50 feet. Because noise-sensitive uses typically would be located at least this distance from the roadway, no adverse effects from trucking are anticipated under Alternative B.

St. Joseph Segment

Under Alternative B, noise levels from processing facility operations would be exceeded at the residences closest to the St. Joseph (Holliday) facility.

Kansas City and Waverly Segments

Under Alternative B, noise levels from processing facility operations would not exceed thresholds at the residences nearest any of the facilities in the Kansas City or Waverly segment.

Jefferson City Segment

Under Alternative B, noise levels from processing facility operations would be exceeded at the residences closest to the Glasgow (Capital) facility.

St. Charles Segment

Under Alternative B, noise levels from processing facility operations would be exceeded at the residences closest to the St. Charles (J.T.R.) facility and the new Washington (Rau) facility.

Alternate Sources

It is not possible at this time to identify specifically where new or expanded processing would occur. Table 4.11-5 provides a general indication of the distance within which 65 dBA-L_{eq} can be exceeded near facility operations of various sizes. In the short term (from existing alternate sources) and in the long term (from existing and new alternate sources), nearby noise-sensitive land uses could be exposed to noise exceeding 65 dBA-L_{eq} from processing facility operations.

4.11.7 Alternative C

4.11.7.1 Short-Term Exposure of Noise-Sensitive Land Uses to Noise from Construction of New Facilities

St. Joseph Segment

No new facilities would be constructed in the St. Joseph segment under Alternative C. Therefore, no exceedances of the noise thresholds from construction of new dredging-related facilities are expected.

Table 4.11-5 Summary of Facility Processing and Haul Truck Noise – Alternative B

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Joseph Segment										
Holliday Sand & Gravel Company (St. Joseph)	447.8	860,000	92	1167	850	Yes	3981	199	398	60
Kansas City										
The Master's Dredging Company (Waldron) [e]	385.0	348,570	88	743	3,300	No	3300	1614	81	57
Holliday Sand & Gravel Company (Riverside)	372.0	480,946	90	873	2,900	No	2227	111	223	58
Holliday Sand & Gravel Company (Randolph)	360.0	807,306	92	1131	3,800	No	3738	187	374	60
Waverly Segment										
Capital Sand Company (Lexington)	317.5	687,657	91	1044	2,700	No	3184	159	318	59
Capital Sand Company (Carrollton)	287.0	45,521	87	629	4,000	No	211	11	21	50
Jefferson City Segment										
Capital Sand Company–St. Louis (Glasgow)	226.2	68,267	87	629	600	Yes	315	16	32	51
Capital Sand Company–St. Louis (Boonville)	196.2	5,680	87	629	1,900	No	26	1	3	47
Capital Sand Company–St. Louis (Rocheport)	186.5	136,616	87	629	1,350	No	632	32	63	53
Hermann Sand & Gravel (Jefferson City)	146.5	221,548	87	629	5,200	No	1026	51	103	55
Capital Sand Company–St. Louis (Jefferson City)	143.5	547,889	90	1046	1,900	No	2537	127	254	58

Table 4.11-5 Summary of Facility Processing and Haul Truck Noise – Alternative B

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Charles Segment										
Hermann Sand & Gravel (Hermann)	97.0	101,525	87	629	1,900	No	470	24	47	52
Edward N. Rau Contractor Company (Washington)[f]	68.0	20,305	87	629	250	Yes	94	5	9	48
Capital Sand Company–St. Louis (Washington)	66.0	159,785	87	629	1,700	No	740	37	74	54
Limited Leasing Company (Bridgeton)	44.0	71,067	87	629	2,800	No	329	16	33	51
J.T. R. (St. Charles)	31.5	273,868	87	629	600	Yes	1,268	63	127	56
Limited Leasing Company (Chesterfield)	28.0	131,982	87	629	2,400	No	611	31	61	53
J.T.R. (Riverview)	16.5	40,859	87	629	2,300	No	189	9	19	50
Limited Leasing Company (Fort Belle)	8.0	20,305	87	629	850	No	94	5	9	48

[a] Based on a processing source level of 90 dBA-L_{eq} at 50 feet and continuous operation between 7:00 a.m and 7:00 p.m. (87 L_{dn} at 50 ft) for facilities producing 250,000 tons/year or less. For larger facilities, the source noise level was scaled up based on the amount of production in excess of 250,000 tons/yr. As discussed in Section 3.14.2, a doubling of sound energy corresponds to a 3-dB increase in noise. Therefore, a doubling of delivered product volume was assumed to result in a 3-dB increase in facility noise.

[b] Assumes 216 delivery days per year (10 months of operation per year 5 days a week). Deliveries can occur 10–12 months per year. Assuming 10 months provides a conservative estimate of daily truck volumes and noise.

[c] Assumes average truck capacity of 20 tons.

[d] Calculated using FHWA Traffic Noise Model Version 2.1 assuming: average truck speed of 45 miles per hour (mph) on local road near plant.

- Two truck trips (out and in from facility) per delivery.
- Daily truck trips equally distributed over eight-hour work day during daytime hours.
- Average truck speed of 45 mph on local road near plant.

[e] New proposed facility.

Kansas City Segment

Under Alternative C, Waldron (Master's) would construct a new facility in the Kansas City segment. Table 4.11-1 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. No noise-sensitive land uses are located within these distances at the proposed site. Accordingly, no exceedances of the noise thresholds from construction of new facilities are expected at this location.

Waverly and Jefferson City Segments

Under Alternative C, no new facilities would be constructed in the Waverly or Jefferson City segment. Therefore, no exceedances of the noise thresholds from construction of new dredging-related facilities are expected.

St. Charles Segment

Under Alternative C, Washington (Rau) would construct a new facility in the St. Charles segment. Table 4.11-2 indicates that noise-sensitive land uses located within approximately 500–900 feet of active construction could be exposed to noise exceeding the 65-dBA-L_{eq} nighttime threshold, and residences located within approximately 160–280 feet of active construction could be exposed to noise exceeding the 75-dBA-L_{eq} daytime threshold. The Rau facility would be located within approximately 250 feet of existing residences, indicating the potential for construction activity at the proposed Rau facility to result in noise levels that exceed the thresholds at nearby residences. .

Alternate Sources

Demand for sand and gravel under Alternative C would be the same as under existing conditions. Therefore, new facilities would not be constructed at alternate source locations and exceedances of noise thresholds from construction of new dredging-related facilities would not occur.

4.11.7.2 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Dredging Operations

All Segments

Tables 3.13-5 and 3.13-6 show the tug and dredging equipment used by each Dredger along with the estimated noise level produced by each piece of equipment. These tables also show the distance

within which noise from each tug or dredge is estimated to exceed 65 dBA-L_{eq}. Table 4.11-2 summarizes this information by Dredger within each segment.

Under Alternative C, production within each segment would remain at current levels. Noise produced by tugs and dredges is not anticipated to change. By maintaining the existing production levels in each segment, there generally would be little potential for residences not recently exposed to dredging noise to be exposed to dredging noise under Alternative C. Table 4.11-2 shows areas potentially exposed to noise in excess of 65 dBA under recent dredging conditions. If dredging does not expand beyond areas dredged in recent years, areas potentially exposed to noise in excess of 65 dBA would be the same as indicated in Table 4.11-2.

Alternate Sources

Alternative C would not require additional dredging at alternate source locations. Therefore, noise level exceedances due to additional dredging at alternate source locations would not occur.

4.11.7.3 Long-Term Exposure of Noise-Sensitive Land Uses to Noise from Processing Facility Operations

Table 4.11-6 summarizes the projected annual tons of material that would be delivered from each facility in each segment under Alternative C. From this information, a reference noise level generated by operation of each facility has been developed. The distance to the 65-L_{dn} contour has been developed from this reference distance. The contour distance is compared to the distance to the nearest residences to determine whether an adverse effect (i.e., a noise level above the threshold) has the potential to occur. Table 4.11-6 indicates the potential for operations at several facilities to result in an adverse effect.

Table 4.11-6 also shows the noise level predicted to result from trucking operations under Alternative C. The predicted traffic noise level at 50 feet from the roadway is identified. In no case is traffic noise predicted to exceed 65 L_{dn} at 50 feet. Because noise-sensitive uses typically would be located at least this distance from the roadway, no adverse effects from trucking are anticipated.

St. Joseph, Kansas City, and Waverly Segments

Under Alternative C, noise levels would not exceed thresholds at the residences nearest any of the facilities in the St. Joseph, Kansas City, or Waverly segment.

Table 4.11-6 Summary of Facility Processing and Haul Truck Noise – Alternative C

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Joseph Segment										
Holliday Sand & Gravel Company (St. Joseph)	447.8	330,000	88	723	850	No	1528	76	153	56
Kansas City Segment										
The Master's Dredging Company (Waldron) [e]	385	753,818	92	1093	3,300	No	3490	174	349	60
Holliday Sand & Gravel Company (Riverside)	372	1,282,761	94	1426	2,900	No	5939	297	594	62
Holliday Sand & Gravel Company (Randolph)	360	866,087	92	1172	3,800	No	4010	200	401	60
Waverly Segment										
Capital Sand Company (Lexington)	317.5	410,182	89	806	2,700	No	1899	95	190	57
Capital Sand Company (Carrollton)	287	27,153	87	629	4,000	No	126	6	13	49
Jefferson City Segment										
Capital Sand Company–St. Louis (Glasgow)	226.2	110,063	87	629	600	Yes	510	25	51	52
Capital Sand Company–St. Louis (Boonville)	196.2	9,157	87	629	1,900	No	42	2	4	47
Capital Sand Company–St. Louis (Rocheport)	186.5	220,258	87	629	1,350	No	1020	51	102	55
Hermann Sand & Gravel (Jefferson City)	146.5	357,190	89	752	5,200	No	1654	83	165	57
Capital Sand Company–St. Louis (Jefferson City)	143.5	883,331	92	1,183	1,900	No	4089	204	409	60

Table 4.11-6 Summary of Facility Processing and Haul Truck Noise – Alternative C

Company Name (Facility)	River Mile	Annual Tons Delivered	Facility Reference Noise Level (L_{eq} at 50 ft)[a]	Distance to Processing Noise 65 L_{dn} Contour (feet)	Distance to Nearest Residence (feet)	65 L_{dn} Exceeded at Nearest Residence?	Estimated Tons per Day[b]	Estimated Truck Deliveries Per Day[c]	Trips Per Day	Haul Truck Noise Level (L_{dn} at 50 feet)[d]
St. Charles Segment										
Hermann Sand & Gravel (Hermann)	97	199,342	87	629	1,900	No	923	46	92	54
Edward N. Rau Contractor Company (Washington)[e]	68	39,868	87	629	250	Yes	185	9	18	49
Capital Sand Company–St. Louis (Washington)	66	313,736	88	705	1,700	No	1453	73	145	56
Limited Leasing Company (Bridgeton)	44	139,596	87	629	2,800	No	646	32	65	53
J.T. R. (St. Charles)	31.5	537,734	90	923	600	Yes	2491	125	249	58
Limited Leasing Company (Chesterfield)	28	259,250	87	641	2,400	No	1,200	60	120	55
J.T.R. (Riverview)	16.5	80,258	87	629	2,300	No	372	19	37	51
Limited Leasing Company (Fort Belle)	8	39,885	87	629	850	No	185	9	18	49

[a] Based on a processing source level of 90 dBA-L_{eq} at 50 feet and continuous operation between 7:00 a.m and 7:00 p.m. (87 L_{dn} at 50 ft) for facilities producing 250,000 tons/year or less. For larger facilities, the source noise level was scaled up based on the amount of production in excess of 250,000 tons/yr. As discussed in Section 3.14.2, a doubling of sound energy corresponds to a 3-dB increase in noise. Therefore, a doubling of delivered product volume was assumed to result in a 3-dB increase in facility noise.

[b] Assumes 216 delivery days per year (10 months of operation per year 5 days a week). Deliveries can occur 10–12 months per year. Assuming 10 months provides a conservative estimate of daily truck volumes and noise.

[c] Assumes average truck capacity of 20 tons.

[d] Calculated using FHWA Traffic Noise Model Version 2.1 assuming: average truck speed of 45 miles per hour (mph) on local road near plant.

- Two truck trips (out and in from facility) per delivery.
- Daily truck trips equally distributed over eight-hour work day during daytime hours.
- Average truck speed of 45 mph on local road near plant.

[e] New proposed facility.

Jefferson City Segment

Under Alternative C, noise levels would be exceeded at the residences closest to the Capital–Glasgow facility in the Jefferson City Segment.

St. Charles Segment

Under Alternative C, noise levels would be exceeded at the residences closest to the J.T.R.–St. Charles facility and the new Rau–Washington facility.

Alternate Sources

Alternative C would not require additional sand and gravel processing at alternate source locations. Therefore, noise level exceedances due to additional processing at alternate source locations would not occur.

4.11.8 Summary of Impacts

Table 4.11-7 presents a summary of potential noise impacts for the Proposed Action and the alternatives.

Table 4.11-7 Summary of Potential Noise Impacts

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Construction impacts	• Short-term exposure of noise-sensitive land uses to noise from construction of the Rau facility.	• Potential exposure of noise-sensitive land uses to noise from construction of new alternate sources.	• Short-term exposure of noise-sensitive land uses to noise from construction of the Rau facility. • Potential exposure of noise-sensitive land uses to noise from construction of new alternate sources.	• Short-term exposure of noise-sensitive land uses to noise from construction of the Rau facility. • Potential exposure of noise-sensitive land uses to noise from construction of new alternate sources.	• Short-term exposure of noise-sensitive land uses to noise from construction of the Rau facility.
Dredging impacts	• Long-term exposure of noise-sensitive land uses to noise from increased dredging operations.	• Decreases in noise levels because dredging would no longer occur. • Potential exposure of noise-sensitive land uses to noise from expanded dredging at alternate sources.	• Long-term exposure of noise-sensitive land uses to noise from slightly increased dredging operations in St. Joseph segment. • Potential exposure of noise-sensitive land uses to noise from expanded dredging at alternate sources.	• Long-term exposure of noise-sensitive land uses to noise from increased dredging operations in St. Joseph and Waverly segments. • Potential exposure of noise-sensitive land uses to noise from expanded dredging at alternate sources.	• Continued long-term exposure of noise-sensitive land uses to noise from dredging operations.
Processing impacts	• Long-term exposure of noise-sensitive land uses to noise from processing facility operations (St. Joseph, Jefferson City, and St. Charles segments).	• Decreases in noise levels because processing would no longer occur. • Potential exposure of noise-sensitive land uses to noise from expanded processing at alternate sources.	• Long-term exposure of noise-sensitive land uses to noise from processing facility operations (Jefferson City and St. Charles segments). • Potential exposure of noise-sensitive land uses to noise from expanded processing at alternate sources.	• Long-term exposure of noise-sensitive land uses to noise from processing facility operations (St. Joseph, Jefferson City, and St. Charles segments). • Potential exposure of noise-sensitive land uses to noise from expanded processing at alternate sources.	• Long-term exposure of noise-sensitive land uses to noise from processing facility operations (Jefferson City and St. Charles segments).

4.11.9 References

4.11.9.1 Printed Literature

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4.11.9.2 Personal Communication

Zeaman, Bill. Chief, Non-Coal Unit. Missouri Department of Natural Resources, Jefferson City, Missouri. Email to Laura Smith, ICF International. February 9, 2010.

4.12 VISUAL AND AESTHETIC RESOURCES

4.12.1 Introduction

This section describes the impact analysis relating to visual resources for the Proposed Action and alternatives, and the methods used to determine the potential impacts. Potential impacts on visual and aesthetic resources addressed in the impact analysis include:

- Visual impacts associated with new sand plants;
- Changes to a scenic vista or the existing visual character or quality of a site and its surroundings;
- Creation of a new source of substantial light or glare that would affect public views;
- Visual impacts caused by new or expanded facilities for alternate sources of sand and gravel; and
- Impacts to visual resources along a scenic highway associated with alternate sources of sand and gravel.

4.12.2 Assessment Methods

Impacts on visual and aesthetic resources were evaluated by comparing the proposed operations of the Proposed Action and alternatives with the existing visual and aesthetic resources. The analysis was based on:

- Google Earth and Maps Street View;
- Photographic documentation of key views of and from the Project area (October 13 through 15, 2009); and
- Review of the Project in regard to compliance with state and local ordinances and regulations and professional standards pertaining to visual quality.

It is expected that visual and aesthetic impacts would occur over the life of the Project, and possibly post-Project, because of potential permanent or semi-permanent changes to resources. Increasing the amount of tugs and barges on the river would create short-term visual impacts occurring over the approximate 5-year dredging permit period. Long-term visual impacts would result from permanent changes to the visual environment, such as land use changes associated with new sand plants and loss of views from reduced access to vantage points. No impacts to designated scenic highways or roads would be associated with dredging on the LOMR because none exist in the Project vicinity.

Potential changes in visual resources at alternate source locations due to new facilities or expanded mining or dredging operations are discussed qualitatively.

4.12.2.1 Professional Standards

Professional standards result from professional and direct expertise gained by staff working on visual analyses and consulting with other experienced staff, subconsultants, and clients on visual effects, including knowledge gained from public input on a broad range of projects. The methodology represents collective knowledge that is professionally agreed upon and represents common, general public concerns. According to professional standards, a project may be considered to cause an adverse impact if it would substantially:

- Conflict with local guidelines or goals related to visual quality;
- Alter the existing natural viewsheds, including changes in natural terrain;
- Alter the existing visual quality of the region or eliminate visual resources;
- Increase light and glare in the project vicinity;
- Result in backscatter light into the nighttime sky;
- Result in a reduction of sunlight or introduction of shadows in community areas;
- Obstruct or permanently reduce visually important features; or
- Result in long-term (that is, persisting for 2 years or more) adverse visual changes or contrasts to the existing landscape as viewed from areas with high visual sensitivity.

4.12.3 Proposed Action

4.12.3.1 Visual Impacts from New Construction

St. Joseph, Waverly, and Jefferson City Segments

Under the Proposed Action, no new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segments. Therefore, no visual impacts from new construction would occur.

Kansas City Segment

Under the Proposed Action, a new 20- to 60-acre sand plant would be built near RM 388 in the Kansas City segment. There are two possible plant site locations. Plant Site 1 is located just north of Waldron

Road and approximately 0.25 mile from the river at its northwestern edge; Plant Site 2 is located at the western terminus of Moores Ferry Road, immediately along the edge of the river. Both Plant Sites 1 and 2 are located at the same bend in the river, in an area that is currently in agricultural production and adjacent to riparian vegetation along the river that varies in width from 50 feet to over 600 feet. Waldron and Moores Ferry Roads terminate at a levee with an unpaved road. Several rural residential properties are located west of State Route 45 (River Road) and north and south of Waldron Road. Residents would have more immediate views of Plant Site 1, because it is closer to residences. Construction activities at Plant Site 2 would be more readily visible to recreationists on the river because construction would occur along the river's edge. Noah's Ark Airport, a private airport offering charter flights, is located west of River Road and between Waldron and Moores Ferry Roads (Airport-Data.com, One Sky Jets 2010). Flights leaving from the airport would view construction activities at either site from the air. Views from River Road would vary based on the presence of roadside vegetation.

Construction activities under the Proposed Action would create temporary changes in views of and from the source areas. Construction activities would introduce heavy equipment and associated vehicles, including dozers, graders, scrapers, and trucks, into the viewshed of recreationists on the river, public roadways, and rural residences. In addition, construction traffic would increase the presence of trucks on affected local roadways. The length of time needed to construct the facility is unknown.

As described above, the new facility would be located in the viewshed of nearby roadways, rural residences, and recreationists on the river with views and vistas that include the site, and would result in a permanent change in views in the immediate area. Under the Proposed Action, the new facility at either location would convert areas to unvegetated swaths of land and piles of sand and gravel with associated mining infrastructure, introducing these features into a viewshed where none presently exist. These features would contrast sharply with the more natural areas that were present prior to construction of the facility. The new facility would convert the land use from agricultural to industrial, and from land that is vegetated to land that is largely unvegetated, creating new landscape scars. In addition, the new facility would be visible from the river, part of the Lewis and Clark Water Trail that is identified in the SCORP as a trail of statewide importance. A new facility at either of these locations would introduce barges and dredging operations along portions of the river where none presently exist, which would affect views. Truck traffic on local roadways would greatly increase to transport sand and gravel; the increased traffic would negatively affect views from rural residences located along Waldron and River Roads and roadway users on affected roadways.

St. Charles Segment

Under the Proposed Action, a new facility would be constructed at RM 67 in Washington, Missouri, close to the Washington City River Access and Washington Bridge. The new facility would be visible from the river, which is part of the Lewis and Clark Water Trail, and could be visible from the Katy Trail. Both of these trails are identified in the SCORP as trails of statewide importance. The new facility would be located in a developed area, in proximity to low-density, suburban residential development; local roadways of Washington; and numerous businesses. Temporary construction-related impacts on visual resources associated with the new facility would include views of equipment onsite, cleared land, and trucks on local roads. A new facility at this location in the St. Charles segment would increase barges and dredging operations along portions of the river with ongoing operations nearby at the new Edward N. Rau Contractor Company Washington facility. The new facility and additional barges and tugs would be an addition to area views.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, visual impacts at alternate source locations due to new construction would not occur.

4.12.3.2 Changes to Scenic Vistas, Scenic Routes, or Visual Character or Quality

St. Joseph Segment

Scenic vistas exist from bridge crossings, roadways along the river, trails, and residences and businesses with expansive views across agricultural fields. The Proposed Action would greatly increase the visual presence of tugs and barges on the river by increasing the frequency of trips back and forth to sand plants (see Table 4.4-1 in Section 4.4). The increase in barge trips would be 252 percent in the St. Joseph segment. More tugs and barges on the river under the Proposed Action also would affect views by recreationists on the river.

The increased dredging amounts compared to existing conditions (252 percent) would mean that much more dredging operations would be visible along the river. Dredging operations create noise and movement that would draw viewers' attention to these areas, making them more noticeable.

In addition, indirect visual impacts may result from changes in river bed elevations. To the extent that the river bed degrades and low-flow water surface elevations decrease, boat ramps could become less accessible and affect the ability of recreational boaters to access river views. Under the Proposed Action, short-term slight river bed degradation and low-flow water surface elevation decreases would

occur. In the long term, moderate to substantial river bed degradation and moderate to substantial decreases in low-flow water surface elevations would occur in the St. Joseph segment. The long term moderate or substantial geomorphic effects could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would experience these adverse impacts to views.

Kansas City Segment

The Proposed Action would increase the occurrence of tugs and barges in views from nearby bridge crossings, roadways, trails, residences, and businesses with expansive views across agricultural fields and from the river itself. Barge trips would increase by 53 percent in the Kansas City segment (Table 4.4-1 in Section 4.4).

Dredging amounts would increase by 53 percent, resulting in more visible dredging activity along the shoreline. The noise and movement associated with dredging operations would draw viewers' attention to these areas.

Short-term moderate river bed degradation and moderate decreases in low-flow water surface elevations would occur. In the long term, substantial river bed degradation and substantial decreases in low-flow water surface elevations would occur. These effects could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

Waverly Segment

The Proposed Action would not substantially change the occurrence of tugs and barges in views from nearby bridge crossings, roadways, trails, residences, or businesses with expansive views across agricultural fields and from the river itself. The number of barge trips would increase by 48 percent in the Waverly segment (Table 4.4-1 in Section 4.4).

Dredging would increase by 48 percent in the Waverly segment under the Proposed Action, resulting in more dredging activity visible along the shoreline. The noise and movement associated with dredging operations would draw viewers' attention to these areas.

In the short term, slight river bed degradation or aggradation and slight increases or decreases in low-flow water surface elevations would occur. In the long term, slight river bed degradation and a slight decrease in low-flow water surface elevations would occur. These small effects would not likely lead to reduced visual access to the river.

Jefferson City Segment

The Proposed Action would increase the occurrence of tugs and barges in views from nearby bridge crossings, roadways, trails, residences, and businesses with expansive views across agricultural fields, and from the river itself. Barge trips would increase by 74 percent in the Jefferson City segment (Table 4.4-1 in Section 4.4).

Dredging would increase by 74 percent in the Jefferson City segment under the Proposed Action, resulting in more dredging activity visible along the shoreline. The noise and movement associated with dredging operations would draw viewers' attention to these areas.

Short-term moderate river bed degradation and slight decreases in low-flow water surface elevations would occur under the Proposed Action. In the long term, substantial river bed degradation and moderate decreases in low-flow water surface elevations would occur. These effects could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

St. Charles Segment

The Proposed Action would increase the occurrence of tugs and barges in views from nearby bridge crossings, roadways, trails, residences, and businesses with expansive views across agricultural fields, and from the river itself. Barge trips would increase by 166 percent in the St. Charles segment (Table 4.4-1 in Section 4.4).

Dredging amounts would increase by 166 percent in the St. Charles segment under the Proposed Action, resulting in much more dredging activity visible along the shoreline. The noise and movement associated with dredging operations would draw viewers' attention to these areas.

Short-term moderate river bed degradation and moderate decreases in low-flow water surface elevations would occur. In the long term, substantial river bed degradation and moderate to substantial decreases in low-flow water surface elevations would occur. These effects could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes to scenic vistas, scenic routes, or visual character or quality would not occur at alternate source locations.

4.12.3.3 Changes in Light or Glare

St. Joseph, Waverly, and Jefferson City Segments

The Proposed Action would substantially increase the number of barges that would be used and visible on the water; barges have surfaces that reflect light. Due to the reflective nature of the river's surface and because equipment would be moving and not stationary, the increased glare from equipment at any given location would not substantially increase existing glare. Sand and gravel stockpiles, which produce glare, would remain onshore.

Kansas City and St. Charles Segments

The Proposed Action would substantially increase the number of barges that would be used and visible on the water; barges have surfaces that reflect light. Due to the reflective nature of the river's surface and because equipment would be moving and not stationary, the increased glare from equipment at any given location would not substantially increase existing glare in the segment. Sand and gravel stockpiles, which produce glare, would be located onshore.

The new sand plants that would be constructed and would operate in these two segments under the Proposed Action would increase the amount of glare present in the segments by removing vegetative ground covering, exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses. Nighttime lighting would be minimal at the new facilities and would not adversely affect viewer groups.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, changes in light or glare would not occur at alternate source locations.

4.12.4 No Action Alternative

4.12.4.1 Visual Impacts from New Construction

All Segments

No new facilities would be constructed under the No Action Alternative. Therefore, no impacts to visual resources would result in any segment.

Alternate Sources

Under the No Action Alternative, alternate sources of sand and gravel would be provided by existing facilities and supplies in the short term. Construction of any new facilities needed to support long-term demand would create temporary changes in views of and from the alternate source areas. Construction activities would introduce heavy equipment and associated vehicles, including dozers, graders, scrapers, and trucks, into the viewshed from the river, public roadways, and rural residences. In addition, construction traffic would increase the presence of trucks on affected local roadways. The length of time needed to construct individual projects is unknown, as are site-specific conditions that may affect visual resources and, in turn, sensitive receptors.

4.12.4.2 Changes to Scenic Vistas, Scenic Routes, or Existing Visual Character or Quality

All Segments

Scenic vistas and views are present from bridge crossings and roadways along the river. Under the No Action Alternative, current dredging permits would not be renewed, and dredging would cease on the LOMR. Barges and dredges no longer would be used and visible on the water. The remaining gravel and sand stockpiles would be exhausted onshore, leaving behind a denuded landscape scar and, potentially, deserted infrastructure. As described in Chapter 2, the future use of these facilities is speculative. As such, water-based and onshore views from residential areas, onshore recreational facilities, water-based recreation activities, roadways and bridges, and other public vantages could be affected by the No Action Alternative, but the extent of the impact would depend on the future use of the buildings and equipment.

The absence of barges and dredges on the LOMR under the No Action Alternative would improve visual resources because industrial watercraft and operations would no longer be present.

In the short term, slight to moderate river bed aggradation would occur under the No Action Alternative, along with changes in low-flow surface water elevations ranging from no change to a moderate increase. Views would not change as a result of changes in river bed and water surface elevations.

Alternate Sources

In the short term, alternate sources of sand and gravel would be provided by existing facilities and supplies. To support the long term demand, facilities may need to be expanded or new facilities may need to be constructed, including along the Mississippi and Kansas Rivers. New and expanded facilities under the No Action Alternative would convert areas that typically would be vegetated to large,

unvegetated swaths of land with piles of sand and gravel and associated mining infrastructure. This would expand existing landscape scars or create new ones. These features would contrast sharply with the more natural areas that were present prior to construction of new facilities or those natural areas surrounding the existing facilities, and would detract from existing views. In addition, dredging operations create noise and movement that would draw viewers' attention to these areas, making them more noticeable. All viewer groups would be affected.

Several highways designated by federal, state, and local jurisdictions as scenic highways are located in the vicinity of alternate source locations, including along the Mississippi and Kansas Rivers. Operations at some alternate source sites under the No Action Alternative would have the potential to adversely affect visual resources along a scenic highway while other sites would not.

4.12.4.3 Changes in Light or Glare

All Segments

Under the No Action Alternative, barges and dredges no longer would be used and visible on the water. Views of the river would improve because existing sources of light and glare would no longer exist. The absence of barges and dredges on the LOMR would improve visual resources because glare-causing elements, such as equipment and lighter-colored sand and gravel piles with large surface areas, would no longer be present.

Alternate Sources

In the short term, alternate sources of sand and gravel would be provided by existing facilities and supplies. Under the No Action Alternative, new facilities could be required for alternate sources of sand and gravel to meet the long-term demand, including along the Mississippi and Kansas Rivers. New facilities would convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated infrastructure. These features would increase the amount of glare by removing vegetative ground covering, exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses. In addition, structures and site lighting have the potential to increase light and glare.

4.12.5 Alternative A

4.12.5.1 Visual Impacts from New Construction

St. Joseph, Waverly, and Jefferson City Segments

Under Alternative A, no new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment. Therefore, no visual impacts from new construction would occur.

Kansas City Segment

Under Alternative A, a new 20- to 60-acre sand plant would be built near RM 388 in the Kansas City segment. Of the two possible plant locations, residents would have more immediate views of Plant Site 1. Construction activities at Plant Site 2 would be more readily visible to viewers on the river because construction would occur along the river's edge. Flights leaving from Noah's Ark Airport would view construction activities at either site from the air. Views from River Road would vary based on the presence of roadside vegetation.

Construction activities under Alternative A would create temporary changes in views of and from the source areas for viewers on the river, public roadways, and rural residences, in addition to increasing the presence of trucks on affected local roadways.

The presence of the new facility under Alternative A would result in a permanent change in views in the immediate area because of conversion of land to unvegetated swaths of land and piles of sand and gravel with associated mining infrastructure. These features would contrast sharply with the more natural areas that were present prior to construction of the facility. The new facility would be visible from the river, part of the Lewis and Clark Water Trail that is identified in the SCORP as a trail of statewide importance. A new facility at either location would introduce barges and dredging operations along portions of the river where none presently exist. Truck traffic on local roadways would greatly increase to transport sand and gravel; the increased traffic would negatively affect the views of rural residents located along Waldron and River Roads and roadway users on affected roadways.

St. Charles Segment

Under Alternative A, the new facility would be visible from the river, which is part of the Lewis and Clark Water Trail, and could be visible from the Katy Trail. Both trails are identified in the SCORP as trails of statewide importance. The new facility would be located in a developed area, in proximity to low-density, suburban residential development; local roadways of Washington; and numerous businesses.

Temporary construction-related impacts on visual resources associated with the new facility would include views of equipment on site, cleared land, and trucks on local roads. A new facility at this location would increase barges and dredging operations along portions of the river with ongoing operations nearby at the new Edward N. Rau Contractor Company Washington facility. The new facility and additional barges and tugs would be an addition to area views.

Alternate Sources

In the short term under Alternative A, alternate sources of sand and gravel would be provided by existing facilities and supplies. In the long term, the market would respond by supporting construction of new facilities to meet demand, which would create temporary changes in views of and from the alternate source areas. In general, construction activities would introduce heavy equipment and associated vehicles, including dozers, graders, scrapers, and trucks, into the viewshed from nearby rivers, public roadways, and rural residences. In addition, construction traffic would increase the presence of trucks on affected local roadways.

4.12.5.2 Changes to Scenic Vistas, Scenic Routes, or Existing Visual Character or Quality

St. Joseph Segment

Scenic vistas exist from bridge crossings, roadways along the river, trails, and residences and businesses with expansive views across agricultural fields. Alternative A would slightly increase the visual presence of tugs and barges on the river by increasing the number of trips by 7 percent (see Table 4.4-1 in Section 4.4). Over the course of 1 year, this increase would not be noticeable and is considered a negligible adverse impact on views.

The increased dredging amounts compared to existing conditions (7 percent) would mean that more dredging operations would become visible along the river. Dredging operations create noise and movement that would draw viewers' attention to these areas, making them more noticeable.

In the short term, slight river bed degradation or aggradation would occur. In the long term, slight river bed degradation and a slight decrease in low-flow water surface elevations would occur. These slight changes likely would not result in substantial changes in accessing views from boat ramps.

Kansas City, Jefferson City, and St. Charles Segments

Alternative A would result in a 73 to 80 percent decrease in both dredging and the number of barges that would be visible on the water in each of the Kansas City, Jefferson City, and St. Charles segments

(see Table 4.4-1 in Section 4.4). Reducing the number of barges on the river would benefit the visual character and quality in these segments. Decreases in dredging would remove some dredging operations from views of the river and river banks. The new facilities in the Kansas City and St. Charles segments would change views of these segments.

Changes in river bed and surface water elevations under Alternative A would be slight in both the short term and the long term in these segments. Therefore, the changes in river bed and surface water elevations would not result in substantial loss of access to locations that provide views of the river, such as boat ramps.

Waverly Segment

Alternative A would result in a 26 percent decrease in both dredging and the number of barges that would be visible on the water in the Waverly segment (see Table 4.4-1 in Section 4.4). Reducing the number of barges on the river would benefit the visual character and quality in these segments. Decreases in dredging would remove some dredging operations from views of the river and river banks. Changes in river bed and surface water elevations would be slight in both the short term and the long term in these segments, and therefore would not result in substantial loss of access to locations along the river that provide views, such as boat ramps.

Alternate Sources

In the short term and the long term, expanded mining and dredging at locations of alternate sources of sand and gravel under Alternative A could convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated mining infrastructure. These features would contrast with the more natural areas that were present prior to construction of new facilities, and would detract from existing views. In addition, dredging operations create noise and movement that would draw viewers' attention to these areas, making them more noticeable.

4.12.5.3 Changes in Light or Glare

St. Joseph Segment

Under Alternative A, the number of barges that would be used and visible on the water would increase; barges have surfaces that reflect light. Because of the reflective nature of the river's surface, an increase in the number of barges of only 7 percent, and the equipment moving and not being stationary, the increased glare from equipment at any given location would not substantially increase existing glare.

Kansas City and St. Charles Segments

Barge trips under Alternative A would decrease by 80 percent in the Kansas City segment and 78 percent in the St. Charles segment (see Table 4.4-1 in Section 4.4), resulting in improved views in the area due to less glare from barges. Sand and gravel stockpiles located onshore would continue to produce light and glare similar to existing conditions. Light and glare associated with operation of the new facilities would increase total light and glare in the area.

Waverly Segment

Under Alternative A, barge trips would decrease by 26 percent in the Waverly segment, resulting in improved views in the area. Sand and gravel stockpiles located onshore would continue to produce light and glare similar to existing conditions.

Jefferson City Segment

Barge trips under Alternative A would decrease by 73 percent (Table 4.4-1 in Section 4.4), resulting in improved views in the area due to less glare from barges. Sand and gravel stockpiles located onshore would continue to produce light and glare similar to existing conditions.

Alternate Sources

In the long term, new facilities could be required for alternate sources of sand and gravel to meet the demand under Alternative A, including along the Mississippi and Kansas Rivers. New facilities would convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated infrastructure. These features would increase the amount of glare by removing vegetative ground covering, exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses. In addition, new structures and lighting have the potential to increase light and glare in the long term.

4.12.6 Alternative B

4.12.6.1 Visual Impacts from New Construction

St. Joseph, Waverly, and Jefferson City Segments

Under Alternative B, no new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment. Therefore, no visual impacts from new construction would occur.

Kansas City Segment

Under Alternative B, a new 20 to 60 acre sand plant would be built near RM 388 in the Kansas City segment. Of the two possible site locations, residents would have more immediate views of Plant Site 1. Construction activities at Plant Site 2 would be more readily visible to viewers on the river because construction would occur along the river's edge. Flights leaving from Noah's Ark Airport would view construction activities at either site from the air. Views from River Road would vary based on the presence of roadside vegetation.

Construction activities would create temporary changes in views of and from the source areas for viewers on the river, public roadways, and rural residences, in addition to increasing the presence of trucks on affected local roadways.

The presence of the new facility in the Kansas City segment under Alternative B would result in a permanent change in views in the immediate area from the conversion of land to unvegetated swaths of land and piles of sand and gravel with associated mining infrastructure. These features would contrast sharply with the more natural areas that were present prior to construction of the facility. The new facility would be visible from the river, part of the Lewis and Clark Water Trail that is identified in the SCORP as a trail of statewide importance. A new facility at either location would introduce barges and dredging operations along portions of the river where none presently exist. Truck traffic on local roadways would greatly increase to transport sand and gravel; the increased traffic would negatively affect the views of rural residents located along Waldron and River Roads and roadway users on affected roadways.

St. Charles Segment

The new facility under Alternative B in the St. Charles segment would be visible from the river, which is part of the Lewis and Clark Water Trail, and could be visible from the Katy Trail. Both trails are identified in the SCORP as trails of statewide importance. The new facility would be located in a developed area, in proximity to low-density, suburban residential development; local roadways of Washington; and numerous businesses. Temporary construction-related impacts on visual resources associated with the new facility would include views of equipment on site, cleared land, and trucks on local roads. A new facility at this location would increase barges and dredging operations along portions of the river with ongoing operations nearby at the new Edward N. Rau Contractor Company Washington facility. The new facility and additional barges and tugs would be an addition to area views.

Alternate Sources

Under Alternative B, alternate sources of sand and gravel would be provided by existing facilities and supplies in the short term. Construction of any new facilities needed to support long-term demand would create temporary changes in views of and from the source areas. In general, construction activities would introduce heavy equipment and associated vehicles, including dozers, graders, scrapers, and trucks, into the viewshed from nearby rivers, public roadways, and rural residences. In addition, construction traffic would increase the presence of trucks on affected local roadways.

4.12.6.2 Changes to Scenic Vistas, Scenic Routes, or Existing Visual Character or Quality

St. Joseph Segment

Scenic vistas exist from bridge crossings, roadways along the river, trails, and residences and businesses with expansive views across agricultural fields. Barge trips and dredging amounts would increase by 163 percent under Alternative B, resulting in the addition of barges and dredging activity to nearby scenic vistas (Table 4.4-1 in Section 4.4). Increased dredging would adversely affect the visual quality of viewsheds. Slight river bed degradation would occur in the short term, and slight to moderate river bed degradation would occur in the long term. Low-flow surface water elevations would decrease slightly in the short term and slightly to moderately in the long term. The moderate, long-term changes could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views.

Kansas City Segment

Scenic vistas are present from bridge crossings, from roadways along the river, and from vantages with expansive views across agricultural fields or similar conditions. A 54 percent decrease in dredging and in the number of barges that would be visible on the water would occur in the Kansas City segment (Table 4.4-1 in Section 4.4) under Alternative B. Reducing the number of barges on the river would benefit the visual character and quality of this segment of the LOMR. Decreases in dredging would remove some dredging operations from views of the river and river banks. In the short term, slight river bed degradation and slight decreases in low-flow water surface elevations would occur. In the long term, moderate river bed degradation and slight to moderate decreases in low-flow water surface elevations would occur. These effects could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

Waverly Segment

Scenic vistas exist from bridge crossings, roadways along the river, trails, and residences and businesses with expansive views across agricultural fields. Barge trips and dredging would increase by 68 percent, resulting in the addition of barges and dredging activity to nearby scenic vistas (Table 4.4-1 in Section 4.4) under Alternative B. Increased dredging would adversely affect the visual quality of viewsheds. Slight aggradation or river bed degradation would occur in the short term, and slight river bed degradation would occur in the long term. Low-flow surface water elevations would increase or decrease slightly in the short term and slightly decrease in the long term. These slight changes likely would not result in substantial changes in accessing views from boat ramps and other viewing locations along the river.

Jefferson City Segment

Scenic vistas are present from bridge crossings, from roadways along the river, and from vantages with expansive views across agricultural fields or similar conditions. A 38-percent decrease in dredging and in the number of barges that would be visible on the water would occur in the Jefferson City segment under Alternative B (Table 4.4-1 in Section 4.4). Reducing the number of barges on the river would benefit the visual character and quality of this segment of the LOMR. In the short term, slight river bed degradation would occur. In the long term, slight to moderate river bed degradation and slight decreases in low-flow water surface elevations would occur. The moderate long-term river bed degradation could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

St. Charles Segment

Scenic vistas are present from bridge crossings, from roadways along the river, and from vantages with expansive views across agricultural fields or similar conditions. A 49 percent decrease in the number of barges that would be visible on the water would occur in the St. Charles segment under Alternative B (see Table 4.4-1 in Section 4.4). Reducing the number of barges on the river would benefit the visual character and quality of this segment of the LOMR. In the short term, slight river bed degradation would occur. In the long term, slight to moderate river bed degradation and slight to moderate decreases in low-flow water surface elevations would occur. The moderate geomorphic changes could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views. All viewer groups would be affected by this adverse, potential loss of views.

Alternate Sources

In the short term and the long term, expanded mining and dredging at locations of alternate sources of sand and gravel under Alternative B could convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated mining infrastructure. These features would contrast with the more natural areas that were present prior to construction of new facilities and would detract from existing views. In addition, dredging operations create noise and movement that would draw viewers' attention to these areas, making them more noticeable.

4.12.6.3 Changes in Light or Glare

St. Joseph Segment

Under Alternative B, the number of barges that would be used and visible in the St. Joseph segment would increase by 163 percent. Barges have surfaces that reflect light. Due to the reflective nature of the river's surface and because equipment would be moving and not stationary, the increased glare from equipment at any given location would not substantially increase glare. Sand and gravel stockpiles, which produce glare, would remain onshore.

Kansas City and St. Charles Segments

Under Alternative B, barge trips would decrease by 54 percent in the Kansas City segment and 38 percent in the St. Charles segment (see Table 4.4-1 in Section 4.4), resulting in improved views in the area due to less glare. Sand and gravel stockpiles located onshore would continue to produce light and glare similar to existing conditions. Light and glare associated with operation of the new facilities would increase total light and glare in the area. Nighttime lighting would be minimal at the new facilities and would not adversely affect viewer groups. However, the new facilities would convert areas that typically would be vegetated to a large, unvegetated swath of land and piles of sand and gravel with associated infrastructure. These features would increase the amount of glare in each of these segments by removing vegetative ground covering, exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses.

Waverly Segment

Under Alternative B, barge trips would increase by 68 percent in the Waverly segment. The increased number of barges on the river would increase glare produced by equipment on the river. Due to the reflective nature of the river's surface and because equipment would be moving and not stationary, the

incremental increase in glare related to the additional barges would not substantially increase total glare in the segment.

Jefferson City Segment

Under Alternative B, barge trips would decrease by 38 percent in the Jefferson City segment (see Table 4.4-1 in Section 4.4), resulting in improved views in the area due to less glare. Sand and gravel stockpiles located onshore would continue to produce light and glare similar to existing conditions.

Alternate Sources

Under Alternative B, new facilities could be required for alternate sources of sand and gravel to meet the long-term demand, including along the Mississippi and Kansas Rivers. New facilities would convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated infrastructure. These features would increase the amount of glare by removing vegetative ground covering, exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses. In addition, structures and site lighting have the potential to increase light and glare.

4.12.7 Alternative C

4.12.7.1 Visual Impacts from New Construction

St. Joseph, Waverly, and Jefferson City Segments

Under Alternative C, no new facilities would be constructed in the St. Joseph, Waverly, or Jefferson City segment. Therefore, no visual impacts from new construction would occur.

Kansas City Segment

Under Alternative C, a new 20 to 60 acre sand plant would be built near RM 388 in the Kansas City segment. Of the two possible plant locations, residents would have more immediate views of Plant Site 1. Construction activities at Plant Site 2 would be more readily visible to viewers on the river because construction would occur along the river's edge. Flights leaving from Noah's Ark Airport would view construction activities at either site from the air. Views from River Road would vary based on the presence of roadside vegetation.

Construction activities under Alternative C would create temporary changes in views of and from the source areas for viewers on the river, public roadways, and rural residences, in addition to increasing the presence of trucks on affected local roadways.

The presence of the new facility under Alternative C would result in a permanent change in views in the immediate area because of conversion of land to unvegetated swaths of land and piles of sand and gravel with associated mining infrastructure. These features would contrast sharply with the more natural areas that were present prior to construction of the facility. The new facility would be visible from the river, part of the Lewis and Clark Water Trail that is identified in the SCORP as a trail of statewide importance. A new facility at either location would introduce barges and dredging operations along portions of the river where none presently exist. Truck traffic on local roadways would greatly increase to transport sand and gravel; the increased traffic would negatively affect the views of rural residents located along Waldron and River Roads and roadway users on affected roadways.

St. Charles Segment

Under Alternative C, the new facility would be visible from the river, which is part of the Lewis and Clark Water Trail, and could be visible from the Katy Trail. Both trails are identified in the SCORP as trails of statewide importance. The new facility would be located in a developed area, in proximity to low-density, suburban residential development; local roadways of Washington; and numerous businesses. Temporary construction-related impacts on visual resources associated with the new facility would include views of equipment on site, cleared land, and trucks on local roads. A new facility at this location would increase barges and dredging operations along portions of the river, with ongoing operations nearby at the new Edward N. Rau Contractor Company Washington facility. The new facility and additional barges and tugs would be an addition to area views.

Alternate Sources

No new construction is expected in the short term or the long-term at locations of alternate sources of sand and gravel because current dredging would continue on the LOMR to meet regional demand.

4.12.7.2 Changes to Scenic Vistas, Scenic Routes, or Existing Visual Character or Quality

St. Joseph Segment

Under Alternative C, dredging amounts and barge trips would increase by less than 1 percent in the St. Joseph segment, resulting in negligible changes to scenic or visual resources. In the short term, slight changes in river bed elevations would occur; in the long term, slight changes to both river bed and low-

flow surface water elevations would occur. These slight changes likely would not result in substantial changes in accessing views from boat ramps, other viewing points along the river, or boats on the river.

Kansas City Segment

Under Alternative C, dredging amounts and barge trips would not change in the Kansas City segment, resulting in no changes to scenic or visual resources. In the short term, slight to moderate river bed degradation would occur along with slight to moderate decreases in low-flow surface water elevations. In the long term, substantial river bed degradation and moderate to substantial decreases in low-flow surface water elevations would occur. Moderate to substantial changes in river bed and low-flow water surface elevations could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views.

Waverly Segment

Under Alternative C, dredging amounts and barge trips would not change in the Waverly segment, resulting in no changes to scenic or visual resources. In the short term and long term, slight changes in river bed elevations would occur. No change in low-flow surface water elevations is expected in the short term or long term. The slight river bed elevation changes likely would not result in substantial changes in accessing views from boat ramps, other viewing points along the river, or boats on the river.

Jefferson City Segment

Under Alternative C, dredging amounts and barge trips would not change in the Jefferson City segment, resulting in no changes to scenic or visual resources. In the short term, slight river bed degradation would occur along with slight decreases in low-flow surface water elevations. In the long term, moderate to substantial river bed degradation and moderate to substantial decreases in low-flow surface water elevations would occur. Moderate to substantial changes in river bed and low-flow water surface elevations could result in boat ramps becoming less accessible, which would affect the ability of recreational boaters to access river views.

St. Charles Segment

Under Alternative C, barge trips would not change in the St. Charles segment, resulting in no changes to scenic or visual resources. In the short term, slight river bed degradation would occur along with slight decreases in low-flow surface water elevations. In the long term, moderate to substantial river bed degradation and slight to moderate decreases in low-flow surface water elevations would occur. Moderate to substantial changes in river bed and low-flow water surface elevations could result in boat

ramps becoming less accessible, which would affect the ability of recreational boaters to access river views.

Alternate Sources

No new construction is expected in the short term or the long-term at locations of alternate sources of sand and gravel because current dredging would continue on the LOMR to meet regional demand.

4.12.7.3 Changes in Light or Glare

St. Joseph, Waverly, and Jefferson City Segments

Barge trips would increase by 0–1 percent in the St. Joseph, Waverly, and Jefferson City segments under Alternative C, resulting in no adverse glare-related visual change in the Project area. Views would remain similar to existing conditions. Views may change in the future, consistent with future trends and continuing changes to river bed elevations and water surface elevations. Sand and gravel stockpiles, which produce glare, would remain onshore.

Kansas City and St. Charles Segments

Under Alternative B, the number of barge trips would not change in the Kansas City or St. Charles segment. Light and glare associated with operation of the new sand plants (one facility in each of these segments) would increase total light and glare in the area.

Alternate Sources

In the long term, new facilities could be required for alternate sources of sand and gravel to meet the demand under Alternative C, including along the Mississippi and Kansas Rivers. New facilities would convert areas that typically would be vegetated to large, unvegetated swaths of land with piles of sand and gravel and associated infrastructure. These features would increase the amount of glare by removing vegetative ground covering, by exposing lighter subsurface material, and by removing trees and shrubs that absorb light and act as buffers to adjacent land uses. In addition, new structures and lighting have the potential to increase light and glare in the long term.

4.12.8 Summary of Impacts

Table 4.12-1 presents a summary of potential impacts on visual and aesthetic resources for the Proposed Action and alternatives.

Table 4.12-1 Summary of Potential Impacts on Visual and Aesthetic Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Visual impacts from new construction	• Visual changes from construction activity in the short term; direct long-term changes in views from presence of new facilities in the Kansas City and St. Charles segments.	• Short-term views of trucks and construction equipment and long-term views of new plants at alternate sources.	• Visual changes from construction activity in the short term; direct long-term changes in views from presence of new facilities in the Kansas City and St. Charles segments. • Short-term views of trucks and construction equipment and long-term views of new plants at alternate sources.	• Visual changes from construction activity in the short term; direct long-term changes in views from presence of new facilities in the Kansas City and St. Charles segments. • Short-term views of trucks and construction equipment and long-term views of new plants at alternate sources.	• Visual changes from construction activity in the short term; direct long-term changes in views from presence of new facilities in the Kansas City and St. Charles segments.
Changes to scenic vistas, scenic routes, or visual character or quality	• Direct short-term and long-term change from increase in barges and tugs on river; potential indirect long-term reduced visual access if boat ramps were inaccessible; effect of barges most pronounced in St. Joseph and St. Charles segments.	• Improvement in views from fewer industrial activities, barges, and dredges; introduction into viewshed of possible vacant sites and abandoned equipment. • Potential change to scenic resources near alternate sources.	• Direct short-term change from slight increase of barges and tugs in St. Joseph segment; potential indirect long-term reduced visual access if boat ramps were inaccessible; addition to views of two new plants (Kansas City and St. Charles segments). • Potential change to scenic resources near alternate sources.	• Direct short-term change from visible increase of barges and tugs in St. Joseph and Waverly segments; potential indirect long-term reduced visual access if boats ramps were inaccessible; addition to views of two new plants (Kansas City and St. Charles segments). • Potential change to scenic resources near alternate sources.	• Potential indirect long-term reduced visual access if boats ramps were inaccessible; addition to views of two new plants (Kansas City and St. Charles segments).

Table 4.12-1 Summary of Potential Impacts on Visual and Aesthetic Resources

Category of Impact	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Changes in light or glare	• Direct long-term increase in light and glare from more barges on the LOMR, most pronounced for St. Joseph and St. Charles segments; direct long-term increase in light and glare from removal of vegetation and operation of new facilities in Kansas City and St. Charles segments.	• Less light and glare from reduction in number of barges and dredges on river and restoration of onshore facility sites. • Long-term increases in light and glare from new alternate source facilities.	• Direct long-term increase in light and glare from more barges on the LOMR, only for St. Joseph segment; direct long-term increase in light and glare from removal of vegetation and operation of new facilities in Kansas City and St. Charles segments. • Long-term increases in light and glare from new alternate source facilities.	• Direct long-term increase in light and glare from more barges on the LOMR, only for St. Joseph and Waverly segments; direct long-term increase in light and glare from removal of vegetation and operation of new facilities in Kansas City and St. Charles segments. • Long-term increases in light and glare from new alternate source facilities.	• Direct long-term increase in light and glare from removal of vegetation and operation of new facilities in Kansas City and St. Charles segments.

Note: LOMR = Lower Missouri River.

4.12.9 References

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4.13 CULTURAL RESOURCES

4.13.1 Introduction

Research and consultation identified 122 cultural resources in the Project APE. These resources include 91 shipwrecks, 12 Lewis and Clark campsites, 10 archaeological sites, and nine bridges. The Historic Trail also passes through the Project area. The majority of cultural resources (112, or 92 percent) have not been relocated or evaluated for inclusion in the NRHP. In terms of location, 107 sites were identified in the main channel of the LOMR, 13 were identified along the banks of tributaries, and two were identified at a proposed sand plant location. Project effects to the 122 NRHP-evaluated and unevaluated sites are discussed below.

4.13.2 Assessment Methods

As outlined in Section 3.16, NEPA and Section 106 of the NHPA processes are being coordinated for this Project. Consistent with Section 106 of the NHPA and for the purposes of this section, the term "effects" is used when considering Project effects on historic properties. The Section 106 process requires that project effects on NRHP-listed or-eligible sites be analyzed and, if necessary, mitigated. For this Project, effects on evaluated and unevaluated sites were preliminarily considered as no field work has been conducted to evaluate the significance of these sites. Potential effects to the 122 sites identified in the APE, which includes the main channel of the LOMR and a perennial tributary buffer of 20 feet wide and 0.25-mile long, were analyzed using the Criteria of Adverse Effect. Refer to Section 3.15.2 for a description of the APE.

4.13.2.1 Criteria of Adverse Effect

The Criteria of Adverse Effect, found in 36 CFR 800.5, were applied in determining effects to historic properties located in the Project APE. An adverse effect takes place when the undertaking alters, directly or indirectly, any of the characteristics of a historic property that qualify that property for inclusion in the NRHP. Adverse effects include, but are not limited to:

- Physical destruction of or damage to all or part of the property;
- Removal of a property from its historic location;
- Change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance; and

- Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features.

4.13.2.2 Direct and Indirect Effects Related to Project Activities

Adverse effects to historic properties identified in the APE include those effects that are caused at the same time and location as dredging (direct effect) and reasonably foreseeable effects that may occur later in time or may be later removed in distance (indirect effect). The principal direct adverse effect that could occur because of the Project is the destruction or damage to all or part of a property as a result of dredging. The analysis of direct effects has taken into account a number of restrictions historically placed on dredging operations through special conditions of USACE dredge permits. These conditions include:

- A 500-foot dredging exclusion zone for bridge piers and abutments and other infrastructure (including levees, pipelines, and submerged utility crossings);
- A 200-foot dredging exclusion zone for any other structures built or authorized by the U.S. Government;
- A 100-foot dredging exclusion zone for any normal bank line or island, without special authorization; and,
- A dredging exclusion zone for the shipwreck *Saluda*, which extends from RM 316.4 through RM 317.3, near Lexington, Missouri.
- The permittee must confine dredging to the reaches specified in the permit document. Requests for expansion or relocation of the specified reaches must identify the proposed new limits, in river miles, and the location of the unloading facility to be used. Copies of the relocation requests must be furnished to state and federal agencies, including the MDNR-SHPO and Kansas State Historical Society-SHPO for concurrence prior to approval of the request.

Because of the extensive history of dredging in the main channel of the LOMR, adverse effects to shipwrecks, Lewis and Clark sites, and bridges are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. Expansion of dredging activities to new areas would require further cultural resources consultation. Effects to unidentified sites located in the main channel could be addressed through USACE permit conditions, or an unanticipated discoveries plan could be developed under a Programmatic Agreement (PA) (refer to

Section 6.15). Those sites that may be adversely affected by headcutting, erosion, and construction of proposed sand plants also could be evaluated and assessed under a PA.

The principal indirect effects of dredging include tributary headcutting and erosion and scouring of the river bed near bridge abutments. These processes may (1) destroy or damage all or part of the property; or (2) expose archaeological resources, thereby, making an entire site or part of a site vulnerable to human disturbance such as looting or vandalism. Because tributary degradation has not been well quantified on the LOMR and each tributary is different with regard to size, degree of modification, length between the main channel and control points, degradation, and other factors, impacts on the geomorphology of each tributary were not analyzed individually. Instead, the geomorphic impact assessment characterizes the likelihood that tributary degradation would increase under an alternative based on the change in low-flow water surface elevations on the mainstem LOMR occurring near the tributary. The geomorphic analysis focused on tributaries in areas with concentrated dredging and river bed degradation under existing conditions, such as the areas around St. Joseph, Kansas City, Jefferson City, and St. Charles (Table 4.2-1). In general, low-flow water surface elevations on the LOMR would need to decrease a moderate (from 2 to 4 feet) or substantial (greater than 4 feet) amount before tributaries would likely be affected (see Section 4.2.3.4). The geomorphic analysis indicates that indirect effects to cultural resources would be most likely to occur in locations where dredging is the most concentrated (see Section 4.2).

4.13.3 Proposed Action

Under the Proposed Action, there are no direct effects to cultural resources. Indirect effects to cultural resources would be associated with tributary headcutting, erosion, and scour. If dredging were to continue at previously dredged locations, indirect effects associated with headcutting and erosion would likely occur along tributaries where dredging has been the most concentrated. Refer to Table 4.2-1 for a list of these tributaries. A total of five tributary sites (three archaeological sites in the Jefferson City segment, one shipwreck, and one Lewis and Clark campsite in the St. Charles segment) may be adversely affected under the Proposed Action. Undocumented sites located along tributaries where dredging has been the most concentrated also may be adversely effected. In addition, indirect effects under the Proposed Action would be associated with the proposed development of two sand plants. Two archaeological sites that are located in the St. Joseph segment may be adversely affected by sand plant construction and operation. Adverse effects may occur to undocumented or unidentified sites at potential sand plant locations.

4.13.3.1 St. Joseph Segment

Table 4.13-1 outlines the potential effects under the Proposed Action to the 20 known cultural resources in the St. Joseph segment and identifies mitigation measures that are in place or could be developed through a PA. No direct effects to sites have been identified. Indirect effects may occur at two sites that are located at potential sand plants locations and at undocumented sites located along two perennial tributaries.

Direct Effects

NRHP-eligible properties in the St. Joseph segment include two bridges. The Rulo Bridge and the Atchison Bridge are protected by dredging exclusion zones that have been established for all bridges along the LOMR. Therefore, there is no potential for direct effects to the NRHP-eligible bridges under the Proposed Action.

No direct effects would occur to the 16 unevaluated shipwrecks or the Lewis and Clark campsites identified in the main channel of the LOMR. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks and the Lewis and Clark sites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the St. Joseph segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that bed degradation of the LOMR would continue in the St. Joseph segment because of dredging under the Proposed Action. Therefore, scour attributable to dredging has the potential to adversely affect the Rulo Bridge and Atchison Bridge. The NDOR and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two bridges such that scour would not adversely affect the Rulo Bridge or Atchison Bridge under the Proposed Action.

Geomorphic analysis also indicates that tributary degradation would likely increase in areas of concentrated dredging in the St. Joseph segment under the Proposed Action. While no cultural resources were identified within the perennial tributary buffer, unidentified sites may exist and may be adversely affected by headcutting and erosion as a result of the Proposed Action. If dredging continues at previously dredged locations, undocumented cultural resources located along two perennial tributaries (Mace Creek and an unnamed tributary at RM 450.1) may be adversely affected.

Table 4.13-1 Effects to Cultural Resources in the St. Joseph Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	Rulo	MC	Listed	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (NDOR Bridge Inspection Program – effect minimization)
Shipwreck	*Bertha*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Emilie No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Denver City*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dorothy*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mt. Sterling*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Pathfinder*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri Mail*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Della*	MC	Unevaluated	No adverse effect	N/A
Bridge	Atchison	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Bridge Maintenance Program – effect minimization)
Shipwreck	*Arabian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hesperian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Platte Valley*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tom Morgan*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Minnie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Express*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	PL110	SP	Unevaluated	N/A	To be determined (Further work – under a PA)
Archaeological site	PL341	SP	Unevaluated	N/A	To be determined (Further work – under a PA)

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
NDOR = Nebraska Department of Roads.
N/A = Not applicable.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; SP = Proposed sand plant location.

Destruction or disturbance of these historic properties would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) identify sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Under the Proposed Action, one sand plant and associated infrastructure, which may encompass up to 60 acres, would be constructed at one of two locations along the river in the St. Joseph segment. Sand plant and pipeline construction has the potential to affect two unevaluated archaeological sites (PL341 and PL110). Previously unidentified prehistoric or historic archaeological sites also may exist at the proposed sand plant sites. The potential destruction or disturbance of such resources would constitute an adverse effect. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) verify the eligibility of these sites for listing in the NRHP; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.3.2 Kansas City Segment

Table 4.13-2 outlines the potential effects under the Proposed Action to 10 known cultural resources in the Kansas City segment and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table; however, indirect effects to undocumented sites located along 11 perennial tributaries are possible in the Kansas City segment.

Direct Effects

Four NRHP-eligible bridges are located in the Kansas City segment. Because dredging exclusion zones have been established for all bridges along the LOMR, there is no potential for direct effects to these properties under the Proposed Action.

No adverse direct effects would occur to the five unevaluated shipwrecks identified in the main channel of the LOMR. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Kansas City segment, further analysis through a PA could be undertaken.

Table 4.13-2 Effects to Cultural Resources in the Kansas City Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	PL288	T	Not eligible	N/A	No adverse effect
Bridge	Fairfax	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Fire Canoe*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bennett*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mike Bauer*	MC	Unevaluated	No adverse effect	N/A
Bridge	Armour-Swift-Burlington (ASB) Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Maintenance Division – effect minimization)
Shipwreck	*Glenmore*	MC	Unevaluated	No adverse effect	N/A
Bridge	Paseo	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Bridge	Liberty Bend	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Corvette*	MC	Unevaluated	No adverse effect	N/A

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
MoDOT = Missouri Department of Transportation.
N/A = Not applicable.
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.

[a] Location: main channel (MC), tributary (T).

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Kansas City segment would likely continue under the Proposed Action. Therefore, scour has the potential to adversely affect the four historic bridges. The MoDOT and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the historic properties such that scour would not adversely affect the bridges under the Proposed Action.

Archaeological site PL288 was found ineligible for listing in the NRHP based on survey and evaluation. Since this site is not eligible for listing in the NRHP, no adverse effects to this site would result from the Proposed Action.

Geomorphic analysis also indicates that tributary degradation is likely to increase in the Kansas City segment under the Proposed Action. While no cultural resources were identified within the perennial tributary buffer, unidentified sites may exist and may be adversely affected by headcutting and erosion under the Proposed Action. If dredging continues at previously dredged locations, any unanticipated site located along 11 perennial tributaries (refer to Table 4.2-1) may be adversely affected. Destruction or disturbance of these cultural resources would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) identify sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.3.3 Waverly Segment

Table 4.13-3 outlines the potential effects under the Proposed Action to 15 known cultural resources in the Waverly segment and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table, and no indirect effects are anticipated for undocumented sites along tributaries in this segment.

Direct Effects

There are no NRHP-eligible sites in the Waverly segment. One shipwreck, the *Saluda*, is protected by a no-dredge zone that was established in previous USACE permits; therefore, no direct effects would result to this resource under the Proposed Action. No adverse direct effects would occur to the other unevaluated shipwrecks identified in this segment. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Waverly segment, further analysis through a PA could be undertaken.

Indirect Effects

No cultural resources were identified along perennial tributaries in the Waverly segment. Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the

Waverly segment under the Proposed Action. Therefore, indirect effects to undocumented sites along tributaries in this segment are not anticipated.

Table 4.13-3 Effects to Cultural Resources in the Waverly Segment under the Proposed Action

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Wakendah*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Saluda*	MC	Unevaluated	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Shipwreck	*Nymph*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Zephyr*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Princess*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Leavenworth*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ariel*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Roy Lynds*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Eagle*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tropic*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Golong*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Govener Allen*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*T.T. Hilman*	MC	Unevaluated	No adverse effect	N/A

Notes:

NRHP = National Register of Historic Places.

USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel.

4.13.3.4 Jefferson City Segment

Table 4.13-4 outlines the potential effects under the Proposed Action to 27 known cultural resources in the Jefferson City segment. The table includes information about mitigation measures that are in place or could be developed through a PA. There are no direct effects to the sites identified in the table. Under the Proposed Action, indirect effects may occur to three archaeological sites and unidentified sites along six perennial tributaries in the Jefferson City segment.

Direct Effects

NRHP-eligible sites in the Jefferson City segment include one bridge and one shipwreck. Dredging exclusion zones have been established for all bridges along the LOMR. Therefore, the NRHP-eligible bridge would not be directly affected under the Proposed Action. The *Radnor* (23CP320), which is located along the banks of the LOMR in a water fluctuation zone, was determined to be eligible for listing in the NRHP. A 100-foot dredging exclusion zone has been established in the USACE dredge permits for any normal bank line. Therefore, the Proposed Action would not directly affect this site.

No direct effects would occur to the 18 unevaluated shipwrecks identified in the Jefferson City segment. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historical dredging locations, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Jefferson City segment would continue under the Proposed Action in areas of concentrated dredging. Although scour has the potential to adversely affect the Glasgow Railroad Bridge, the Kansas City Southern Railway Company (KCS) implements countermeasures to prevent bridge failure. These countermeasures would minimize indirect effects from the Proposed Action to this historic property such that no adverse effects would result.

Tributary degradation is likely to increase around the Jefferson City portion of the segment under the Proposed Action. If historic dredging areas are maintained, only six perennial tributaries in this segment are at increased risk of degradation (see Table 4.2-1). Because three archaeological sites (MU134/MU135, B01000, and BO1100), the shipwreck *Little Dick*, and one Lewis and Clark campsite are not located along tributaries that are predicted to degrade, these resources would not be adversely affected by the Proposed Action. The three archaeological sites (CO28, CO52, and CO108) that are located along tributaries near Jefferson City may be affected by headcutting and erosion attributable to dredging. In addition, unidentified archaeological sites located along the six perennial tributaries located near Jefferson City could be adversely affected by these conditions under the Proposed Action. Destruction or disturbance of these historic properties would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of

unidentified sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Table 4.13-4 Effects to Cultural Resources in the Jefferson City Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Joseph Kinney*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dart*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Timour*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Naomi*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Sonora*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*West Wind*	MC	Unevaluated	No adverse effect	N/A
Bridge	Glasgow Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (KCS Bridge Maintenance Program – avoidance)
Shipwreck	*Annie Lee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Plow Boy No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Radnor*	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Archaeological Site	MU134/MU135	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1000	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Little Dick*	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1100	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Marie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bright Light*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Martha Stevens*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Floyd*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CY28	T	Unevaluated	N/A	To be determined (Future work – under a PA)

Table 4.13-4 Effects to Cultural Resources in the Jefferson City Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	CO52	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Shipwreck	*Statie Fisher*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CO108	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Campsite	Lewis and Clark 1804	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Emma*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dew Drop*	MC	Unevaluated	No adverse effect	N/A

Notes:

KCS = Kansas City Southern Railway Company.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

4.13.3.5 St. Charles Segment

Table 4.13-5 outlines potential effects under the Proposed Action to 50 known cultural resource sites in the St. Charles segment. The table includes information about mitigation measures that are in place or could be developed through a PA. There are no direct effects to the resources identified below; however, indirect effects could occur to two known sites along tributaries and to undocumented sites along 19 perennial tributaries in the St. Charles segment.

Direct Effects

Two NRHP-eligible bridges are located in the St. Charles segment. Dredging exclusion zones have been established for all bridges along the LOMR. Therefore, no direct effects to these two NRHP-eligible bridges would occur under the Proposed Action.

No direct effects would occur to the 44 unevaluated shipwrecks or the Lewis and Clark campsites identified in main channel of this segment. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks and the Lewis and Clark campsites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging

exclusion zones are maintained. If dredging activities are planned outside historically dredged areas, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that bed degradation of the LOMR would continue in the St. Charles segment because of dredging under the Proposed Action. Although scour has the potential to adversely affect the Daniel Boone Bridge and the Washington Bridge, the MoDOT implements countermeasures to prevent bridge failure. These countermeasures would minimize effects to historic properties under the Proposed Action such that no adverse effects would result.

Table 4.13-5 Effects to Cultural Resources in the St. Charles Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*E.H. Durfee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Camden*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Gus Fowler*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New St. Paul*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Nodaway*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Robert Emmett*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 108.2)	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster (1932)*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mandan*	MC	Unevaluated	No adverse effect	N/A
Archaeological Site	GA184	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 104.3)	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Cappa*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Alert*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Washington*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lynchburgh*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Petral*	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 72.5)	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 72.1)	Unevaluated	No adverse effect	N/A

Table 4.13-5 Effects to Cultural Resources in the St. Charles Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	Washington Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*Seventy-Six*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Bell*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Duncan S. Carter*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Montana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lily*	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Bridge	*Daniel Boone Bridge*	MC	Eligible	No adverse effect (USACE – Avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*James Lyons*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*General McNeil*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ella Kimbrough*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 29.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Tyler*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 28.4)	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Anthony*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Luke*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Benton No. 1*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Far West*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Halycyon*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Haidee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Car of Commerce*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Hancock*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New Georgetown*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Julia*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 7.0)	Unevaluated	No adverse effect	N/A

Table 4.13-5 Effects to Cultural Resources in the St. Charles Segment under the Proposed Action

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Georgetown*	MC	Unevaluated	No adverse effect	N/A
Campground	Lewis and Clark	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Shipwreck	*Bald Eagle*	MC	Unevaluated	No adverse effect	N/A

Notes:
MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.
[a] Location: MC = Main channel; T = Tributary; I = Island; SC = Side channel; RM = River mile.

One Lewis and Clark campsite, one archaeological site (GA184), and two shipwrecks (*Lily* and *Petral*) are located along tributaries in the St. Charles segment. Geomorphic analysis indicates that, if dredging occurs at historic locations, 19 perennial tributaries in this segment are likely to experience increased river bed degradation (refer to Table 4.2-1). Archaeological site GA184 and the shipwreck *Petral* are not located along tributaries that are predicted to degrade and, therefore, are unlikely to be adversely affected by the Proposed Action. However, the shipwreck *Lily* and one Lewis and Clark campsite could be affected by headcutting and erosion attributable to dredging under the Proposed Action. In addition, unidentified archaeological sites located along the 19 perennial tributaries could be adversely affected by these conditions under the Proposed Action. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of unidentified sites with the potential to be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Under the Proposed Action, one sand plant and associated infrastructure, which would encompass approximately 25 acres, would be constructed approximately 0.5 mile from the river in the St. Charles segment. Construction of the sand plant and conveyor system has the potential to impact currently unidentified sites. Although a records search did not reveal cultural resources in this area, previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant location. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be

undertaken to (1) identify NRHP eligible sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.3.6 Alternate Sources

Under the Proposed Action, demand for sand and gravel would be met by dredging in the LOMR. Expansion of existing alternate sources of sand and gravel and development of new sources would not be necessary. No adverse effects on cultural resources would be associated with alternate sources under the Proposed Action.

4.13.4 No Action Alternative

4.13.4.1 All Segments

Under the No Action Alternative, dredging along the LOMR would cease. There would be no direct effects to cultural resources along the LOMR. Indirect effects on cultural resources associated with river bed degradation and tributary headcutting would remain at current levels.

4.13.4.2 Alternate Sources

Under the No Action Alternative, production of sand and gravel would shift to alternate sources, including expansion of existing locations in the short term and development of new locations in the long term.

Expansion of Existing Sources

In the long term, gravel mining operations would be expanded at existing river locations; floodplain open-pit mines, including open-pit mines for manufactured sand; and instream mines. Dredging operations could be expanded along the Mississippi and Kansas Rivers. Expanded operations in these rivers would have the potential to directly affect cultural resources if new sand plants were constructed or dredging shifted to locations that had not previously been dredged. In addition, continued dredging in these rivers may indirectly affect cultural resources (such as bridges) because of river bed degradation. River bed degradation has been documented along the Kansas River in the area of Kansas City (USACE 1990).

Existing floodplain open-pit mines are located in Missouri, Kansas, and Illinois. In cases that involve open-pit mines in US waters, a USACE permit under Section 404 of the Clean Water Act. Section 404 permits are subject to environmental review pursuant to NEPA (42 United States Code [USC] 4321 et

seq.) and Section 106 of the NHPA as codified in 36 CFR Part 800 or alternatively Appendix C to 33 CFR Part 325. Compliance with these regulations requires the USACE to take into account the potential for impacts to historic properties and to consult with the applicable SHPOs, tribes, and, if necessary, the ACHP. In cases that do not involve US waters, only the IDNR, Division of Water Resource Management, requires cultural resource consultation with the SHPO prior to authorization of a floodplain construction permit. Missouri and Kansas do not require cultural resource consultation or evaluation as a part of the permit process. Therefore, it is likely that adverse effects to cultural resources outside of US waters could occur from expansion of mining operations in these states.

Development of New Sources

Under the No Action Alternative, new sand and gravel sources would be developed in proximity to processing facilities and urban centers in Missouri and Kansas. These states do not require cultural resource identification, evaluation, or consultation as part of their permitting processes. Kansas considers effects to NRHP-listed properties as a result of projects that are supported by a government entity (KAR 118-3-1-16). This statute, however, would not apply to development of new sources of sand and gravel. It is probable that prehistoric or historic archaeological sites exist in potential alternate dredging and processing locations. Destruction or damage of cultural resources as a result of dredging or construction of sand plants would constitute an adverse effect.

4.13.5 Alternative A

Under Alternative A, dredging would continue at considerably reduced levels for most segments of the LOMR, and production would shift to alternate sources to provide additional gravel. As with the Proposed Action, there would be no direct effects on cultural resources under Alternative A. Geomorphic analysis indicates that the risk of dredging-related tributary degradation would be unlikely to increase in any segment under this alternative. Therefore, indirect effects associated with headcutting and erosion are not anticipated. However, the potential remains to adversely affect cultural resources at the two proposed sand plant locations. Because dredging would shift to alternate sources of sand and gravel (existing and new), the potential effects to cultural resources associated with alternate sources under Alternative A would be the same as those outlined for the No Action Alternative.

4.13.5.1 St. Joseph Segment

Table 4.13-6 outlines the potential effects under Alternative A to the 20 cultural resources in the St. Joseph segment and identifies mitigation measures that are in place or could be developed through a

PA. There are no direct or indirect effects to the sites in this segment under Alternative A, and indirect effects to undocumented sites are unlikely.

Table 4.13-6 Effects to Cultural Resources in the St. Joseph Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	Rulo	MC	Listed	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (NDOR Bridge Inspection Program – effect minimization)
Shipwreck	*Bertha*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Cark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Emilie No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Denver City*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dorothy*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mt. Sterling*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Pathfinder*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri Mail*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Della*	MC	Unevaluated	No adverse effect	N/A
Bridge	Atchison	MC	Eligible	No adverse effect (USACE – avoidance within dredging exclusion zone)	No adverse effect (BNSF Bridge Maintenance Program – effect minimization)
Shipwreck	*Arabian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hesperian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Platte Valley*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tom Morgan*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Minnie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Express*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	PL110	SP	Unevaluated	N/A	To be determined (Further work – under a PA)
Archaeological site	PL341	SP	Unevaluated	N/A	To be determined (Further work – under a PA)

Table 4.13-6 Effects to Cultural Resources in the St. Joseph Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
NDOR = Nebraska Department of Roads.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; SP = Proposed sand plant location.

Direct Effects

NRHP-eligible properties in the St. Joseph segment include two bridges. Rulo Bridge and the Atchison Bridge are protected by dredging exclusion zones that have been established for all bridges along the LOMR. Therefore, there is no potential for adverse direct effects to the NRHP-eligible bridges under Alternative A.

No adverse direct effects would occur to the 16 unevaluated shipwrecks or the Lewis and Clark campsites identified in the main channel of the LOMR. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks and the Lewis and Clark sites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the St. Joseph segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that localized areas of the St. Joseph segment would likely experience river bed degradation under Alternative A. Although scour attributable to dredging has the potential to adversely affect the Rulo Bridge and Atchison Bridge, the NDOR and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two bridges such that scour would not adversely affect the Rulo Bridge or Atchison Bridge under Alternative A.

Geomorphic analysis also indicates that tributary degradation would be unlikely to increase under Alternative A. Therefore, adverse effects to unidentified sites are unlikely under this alternative.

Under Alternative A, one sand plant and associated infrastructure, which may encompass up to 60 acres, would be constructed at one of two locations along the river in the St. Joseph segment. Sand plant and pipeline construction has the potential to affect two unevaluated archaeological sites (PL341 and PL110). Previously unidentified prehistoric or historic archaeological sites also may exist at the proposed sand plant sites. The potential destruction or disturbance of such resources would constitute an adverse effect. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of these sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.5.2 Kansas City Segment

Table 4.13-7 outlines the potential effects under Alternative A to the 10 identified cultural resources in the Kansas City segment and identifies mitigation measures that are in place. There are no direct or indirect effects to sites in this segment under Alternative A, and indirect effects to undocumented sites are unlikely.

Direct Effects

NRHP-eligible sites located in the Kansas City segment include four bridges. Because dredging exclusion zones have been established for all bridges along the LOMR, there is no potential for direct effects to these properties under Alternative A.

No adverse direct effects would occur to the five unevaluated shipwrecks identified in the main channel of the LOMR. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Kansas City segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation is likely to occur in localized areas of the Kansas City segment of the LOMR. Although scour has the potential to adversely affect the four historic bridges, the MoDOT and BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the historic bridges such that scour would not adversely affect the bridges under Alternative A.

Archaeological site PL288 was found ineligible for listing in the NRHP based on survey and evaluation. Therefore, no adverse indirect effects to this site would result from Alternative A.

Geomorphic analysis also indicates that tributary degradation would be unlikely to increase under Alternative A. Therefore, adverse indirect effects to undocumented sites along perennial tributaries are not probable under this alternative.

Table 4.13-7 Effects to Cultural Resources in the Kansas City Segment under Alternative A

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	PL288	T	Not eligible	N/A	No adverse effect
Bridge	Fairfax	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Fire Canoe*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bennett*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mike Bauer*	MC	Unevaluated	No adverse effect	N/A
Bridge	Armour-Swift-Burlington (ASB) Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Maintenance Division – effect minimization)
Shipwreck	*Glenmore*	MC	Unevaluated	No adverse effect	N/A
Bridge	Paseo	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Bridge	Liberty Bend	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Corvette*	MC	Unevaluated	No adverse effect	N/A

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

4.13.5.3 Waverly Segment

Table 4.13-8 outlines potential effects under Alternative A to the 15 known cultural resources in the Waverly segment and identifies mitigation measures that are in place. There are no direct or indirect effects to sites in this segment under Alternative A, and indirect effects to undocumented sites are unlikely.

Table 4.13-8 Effects to Cultural Resources in the Waverly Segment under Alternative A

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Wakendah*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Saluda*	MC	Unevaluated	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Shipwreck	*Nymph*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Zephyr*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Princess*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Leavenworth*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ariel*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Roy Lynds*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Eagle*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tropic*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Golong*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Govener Allen*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*T.T. Hilman*	MC	Unevaluated	No adverse effect	N/A

Notes:
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.
[a] Location: MC = Main channel.

Direct Effects

There are no NRHP-eligible sites in the Waverly segment. One shipwreck, the *Saluda*, is protected by a no dredge zone that was established in previous USACE permits; therefore, no adverse direct effects

to this resource would result under Alternative A. The other unevaluated shipwrecks identified in this segment would not experience direct effects under Alternative A. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks are not anticipated, provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Waverly segment, further analysis through the PA could be undertaken.

Indirect Effects

No cultural resources were identified along perennial tributaries in the Waverly segment. Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the Waverly segment under Alternative A. Therefore, indirect effects to undocumented sites along tributaries in this segment are not anticipated.

4.13.5.4 Jefferson City Segment

Table 4.13-9 outlines potential effects under Alternative A to the 27 cultural resources in the Jefferson City segment. The table includes information about mitigation measures that are in place. No direct or indirect effects to sites in this segment would result under Alternative A, and indirect effects to unidentified sites are unlikely.

Direct Effects

NRHP-eligible sites in the Jefferson City segment include one bridge and one shipwreck. Dredging exclusion zones have been established for all bridges along the LOMR; therefore, no direct effects to the Glasgow Railroad Bridge would occur under Alternative A. The *Radnor* (23CP320), which is located along the banks of the LOMR in a water fluctuation zone, was determined to be eligible for listing in the NRHP. A 100-foot dredging exclusion zone has been established in the USACE dredge permits for any normal bank line. Therefore, no direct adverse effects would result to this site under Alternative A.

No direct effects would occur to the 18 unevaluated shipwrecks identified in the Jefferson City segment. Because of the extensive history of dredging in the main channel of the LOMR, direct effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historical dredging locations, further analysis through a PA could be undertaken.

Table 4.13-9 Effects to Cultural Resources in the Jefferson City Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Joseph Kinney*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dart*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Timour*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Naomi*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Sonora*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*West Wind*	MC	Unevaluated	No adverse effect	N/A
Bridge	Glasgow Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (KCS Bridge Maintenance Program – avoidance)
Shipwreck	*Annie Lee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Plow Boy No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Radnor*	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Archaeological Site	MU134/MU135	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1000	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Little Dick*	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1100	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Marie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bright Light*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Martha Stevens*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Floyd*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CY28	T	Unevaluated	N/A	No adverse effect
Archaeological site	CO52	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Statie Fisher*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CO108	T	Unevaluated	N/A	No adverse effect

Table 4.13-9 Effects to Cultural Resources in the Jefferson City Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Campsite	Lewis and Clark 1804	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Emma*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dew Drop*	MC	Unevaluated	No adverse effect	N/A

Notes:

KCS = Kansas City Southern Railway Company.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Jefferson City segment would not worsen under Alternative A; however, bridge scour may occur in this region. The KCS implements countermeasures to prevent bridge failure. These countermeasures would minimize effects from Alternative A to the historic bridge such that no adverse indirect effects would result.

Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the Jefferson City segment under Alternative A. Therefore, adverse effects are not anticipated for the eight documented sites (six archaeological sites, shipwreck *Little Dick*, and one Lewis and Clark campsites) along the six perennial tributaries in the segment. Adverse indirect effects also are not anticipated for unidentified sites along these tributaries under Alternative A.

4.13.5.5 St. Charles Segment

Table 4.13-10 outlines the potential effects under Alternative A to the 50 known cultural resources in the St. Charles segment. The table includes information about mitigation measures that are in place. There are no direct or indirect effects to sites in this segment under Alternative A, and indirect effects to unidentified sites are unlikely.

Table 4.13-10 Effects to Cultural Resources in the St. Charles Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*E.H. Durfee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Camden*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Gus Fowler*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New St. Paul*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Nodaway*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Robert Emmett*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 108.2)	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster (1932)*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mandan*	MC	Unevaluated	No adverse effect	N/A
Archaeological Site	GA184	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 104.3)	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Cappa*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Alert*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Washington*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lynchburgh*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Petral*	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 72.5)	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 72.1)	Unevaluated	No adverse effect	N/A
Bridge	Washington Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*Seventy-Six*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Bell*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Duncan S. Carter*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Montana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lily*	T	Unevaluated	N/A	No adverse effect
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A

Table 4.13-10 Effects to Cultural Resources in the St. Charles Segment under Alternative A

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	*Daniel Boone Bridge*	MC	Eligible	No adverse effect (USACE – Avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*James Lyons*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*General McNeil*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ella Kimbrough*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 29.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Tyler*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 28.4)	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Anthony*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Luke*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Benton No. 1*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Far West*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Halycyon*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Haidee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Car of Commerce*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Hancock*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New Georgetown*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Julia*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 7.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Georgetown*	MC	Unevaluated	No adverse effect	N/A
Campground	Lewis and Clark	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Bald Eagle*	MC	Unevaluated	No adverse effect	N/A

Notes:

MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary; I = Island; SC = Side channel; RM = River mile.

No direct effects would occur to the 44 unevaluated shipwrecks or the Lewis and Clark campsites identified in the main channel of the St. Charles segment under Alternative A. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks and the Lewis and Clark campsites are not anticipated, provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation is unlikely to continue in the St. Charles segment under Alternative A; however, bridge scour may occur in this region. The MoDOT implements countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two historic bridges such that no adverse effects would result.

Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the St. Charles segment under Alternative A. Therefore, adverse indirect effects are not anticipated for the four sites (one Lewis and Clark campsite, archaeological site GA184, and two shipwrecks) identified along the tributaries. Adverse effects also are not predicted for unidentified sites along tributaries in this segment under Alternative A.

Under Alternative A, one sand plant and associated infrastructure, which would encompass approximately 25 acres, would be constructed approximately 0.5 mile from the river in the St. Charles segment. Construction of the sand plant and conveyor system has the potential to impact currently unidentified sites. Although a records search did not reveal cultural resources in this area, previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant location. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) identify NRHP-eligible sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.5.6 Alternate Sources

Under Alternative A, production of sand and gravel would shift to alternate sources, including expansion of existing sources in the short term and development of new sources in the long term.

Expansion of Existing Sources

In the short term, gravel mining would be expanded at existing river locations; floodplain open-pit mines, including open-pit mines for manufactured sand; and instream mines. Dredging operations

could be expanded along the Mississippi and Kansas Rivers. Expanded operations in these rivers could adversely affect cultural resources if new sand plants were constructed or dredging shifted to locations that had not previously been dredged. In addition, continued dredging in these rivers may indirectly affect cultural resources (such as bridges) through river bed degradation. River bed degradation has been documented along the Kansas River in the area of Kansas City (USACE 1990).

Existing floodplain open-pit mines are located in Missouri, Kansas, and Illinois. Only the Illinois Department of Natural Resources (IDNR), Division of Water Resource Management, requires cultural resource consultation with the SHPO prior to authorization of a floodplain construction permit. Missouri and Kansas do not require cultural resource consultation or evaluation as a part of the permit process. Therefore, it is probable that adverse effects to cultural resources would occur as a result of mining operation expansion in these states.

Development of New Sources

In the long term under Alternative A, new sand and gravel sources would be developed in proximity to processing facilities and urban centers in Missouri and Kansas. These states do not require cultural resource identification, evaluation, or consultation as part of their permitting processes. Kansas considers effects to NRHP-listed properties as a result of projects that are supported by a government entity (KAR 118-3-1-16). This statute, however, would not apply to development of new sources of sand and gravel. It is probable that prehistoric or historic archaeological sites exist in potential alternate dredging and processing locations. Destruction or damage of cultural resources as a result of dredging or sand plant facility construction would constitute an adverse effect.

4.13.6 Alternative B

Under Alternative B, dredging would continue at reduced levels in the LOMR, and production would shift to alternate sources to provide additional gravel in order to meet regional demand. As with the Proposed Action, there would be no direct effects to cultural resources under Alternative B. Indirect effects to cultural resources would be associated with tributary headcutting, erosion, and scour. Indirect effects associated with headcutting and erosion are likely to occur from continued dredging along tributaries where dredging has been the most concentrated. Refer to Table 4.2-1 for a list of these tributaries. Five tributary sites (three archaeological sites in the Jefferson City segment and one shipwreck and one campsite in the St. Charles segment) may be adversely affected under Alternative B. Undocumented sites located along tributaries where dredging has been the most concentrated also may be adversely affected. In addition, indirect effects are associated with the

proposed development of two sand plants under Alternative B. Two archaeological sites located in the St. Joseph segment may be adversely affected by sand plant construction and operation. Indirect adverse effects to undocumented or unidentified sites may result at potential sand plant locations. Because dredging would shift to alternate gravel sources (existing and new), the effects to cultural resources at locations of alternate sources would be the same as those described for the No Action Alternative.

4.13.6.1 St. Joseph Segment

Table 4.13-11 outlines potential effects under Alternative B to the 20 known cultural resources in the St. Joseph segment and identifies mitigation measures that are in place or could be developed through a PA. There are no direct effects to the sites identified in the table. Indirect effects may occur to two sites that are located at potential sand plants locations, and at undocumented sites located along two perennial tributaries.

Table 4.13-11 Effects to Cultural Resources in the St. Joseph Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	Rulo	MC	Listed	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (NDOR Bridge Inspection Program – effect minimization)
Shipwreck	*Bertha*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Emilie No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Denver City*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dorothy*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mt. Sterling*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Pathfinder*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri Mail*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Della*	MC	Unevaluated	No adverse effect	N/A
Bridge	Atchison	MC	Eligible	No adverse effect (USACE – avoidance within dredging exclusion zone)	No adverse effect (BNSF Bridge Maintenance Program – effect minimization)
Shipwreck	*Arabian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hesperian*	MC	Unevaluated	No adverse effect	N/A

Table 4.13-11 Effects to Cultural Resources in the St. Joseph Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Platte Valley*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tom Morgan*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Minnie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Express*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	PL110	SP	Unevaluated	N/A	To be determined (Further work – under a PA)
Archaeological site	PL341	SP	Unevaluated	N/A	To be determined (Further work – under a PA)

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
NDOR = Nebraska Department of Roads.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; SP = Proposed sand plant location.

Direct Effects

NRHP-eligible properties in the St. Joseph segment include two bridges. Rulo Bridge and the Atchison Bridge are protected by dredging exclusion zones that have been established for all bridges along the LOMR. Therefore, the NRHP-eligible bridges would not be directly affected under Alternative B.

No direct adverse effects would occur to the 16 unevaluated shipwrecks or the Lewis and Clark campsites identified in the main channel of the LOMR. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks or the Lewis and Clark sites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the St. Joseph segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation would continue in the St. Joseph segment because of dredging under Alternative B. Therefore, scour attributable to dredging has the potential to adversely affect the Rulo Bridge and Atchison Bridge. The NDOR and the BNSF implement

countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two bridges such that scour would not adversely affect the Rulo Bridge or Atchison Bridge under Alternative B.

Geomorphic analysis also indicates that tributary degradation would likely increase in areas of concentrated dredging in the St. Joseph segment under Alternative B. Although no cultural resources were identified within the perennial tributary buffer, unidentified sites may exist and may be adversely affected by headcutting and erosion under Alternative B. If dredging continues at previously dredged locations, unidentified sites located along two perennial tributaries (Mace Creek and an unnamed tributary at RM 450.1) may be adversely affected. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) identify sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Under Alternative B, one sand plant and associated infrastructure, which may encompass up to 60 acres, would be constructed at one of two locations along the river in the St. Joseph segment. Sand plant and pipeline construction has the potential to affect two unevaluated archaeological sites (PL341 and PL110). Previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant sites. The potential destruction or disturbance of such resources would constitute an adverse effect. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of these sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.6.2 Kansas City Segment

Table 4.13-12 outlines potential effects under Alternative B to the 10 known cultural resources in the Kansas City segment and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table; however, be indirect effects may result to undocumented sites located along 11 perennial tributaries in the segment.

Direct Effects

Four NRHP-eligible bridges are located in the Kansas City segment. Because dredging exclusion zones have been established for all bridges along the LOMR, the NRHP-eligible bridges would not be directly affected under Alternative B.

Table 4.13-12 Effects to Cultural Resources in the Kansas City Segment under Alternative B

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	PL288	T	Not eligible	N/A	No adverse effect
Bridge	Fairfax	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Fire Canoe*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bennett*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mike Bauer*	MC	Unevaluated	No adverse effect	N/A
Bridge	Armour-Swift-Burlington (ASB) Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Maintenance Division – effect minimization)
Shipwreck	*Glenmore*	MC	Unevaluated	No adverse effect	N/A
Bridge	Paseo	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Bridge	Liberty Bend	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Corvette*	MC	Unevaluated	No adverse effect	N/A

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

No direct adverse effects would occur to the five unevaluated shipwrecks identified in the main channel of the LOMR in the Kansas City segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Kansas City segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Kansas City segment would continue under Alternative B. Therefore, scour has the potential to adversely affect the four historic bridges. The MoDOT and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the four historic bridges such that scour would not adversely affect the bridges under the Alternative B.

Archaeological site PL288 was found ineligible for listing in the NRHP based on survey and evaluation. Therefore, there would be no adverse effects to this site under Alternative B.

Geomorphic analysis also indicates that tributary degradation would likely continue in the Kansas City segment under Alternative B. Although no cultural resources were identified within the perennial tributary buffer, unidentified sites may exist and may be adversely affected by headcutting and erosion. If dredging continues at previously dredged locations, unidentified cultural resources along 11 perennial tributaries (refer to Table 4.2-1) may be adversely affected. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) identify sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.6.3 Waverly Segment

Table 4.13-13 outlines potential effects under Alternative B to the 15 known cultural resources in the Waverly segment and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table, and indirect effects are not anticipated for undocumented sites located along tributaries in this segment.

Direct Effects

There are no NRHP-eligible sites in the Waverly segment. One shipwreck, the *Saluda*, is protected by a no dredge zone that was established in previous USACE permits; therefore, no adverse effects to this resource would result under Alternative B. There would be no adverse direct effects to the other unevaluated shipwrecks identified in this segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Waverly segment, further analysis through a PA could be undertaken.

Table 4.13-13 Effects to Cultural Resources in the Waverly Segment under Alternative B

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Wakendah*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Saluda*	MC	Unevaluated	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Shipwreck	*Nymph*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Zephyr*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Princess*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Leavenworth*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ariel*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Roy Lynds*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Eagle*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tropic*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Golong*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Govener Allen*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*T.T. Hilman*	MC	Unevaluated	No adverse effect	N/A

Notes:
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.
[a] Location: MC = Main channel.

Indirect Effects

No cultural resources were identified along perennial tributaries in the Waverly segment. Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the Waverly segment under Alternative B. Therefore, indirect effects to undocumented sites along tributaries in this segment are not expected.

4.13.6.4 Jefferson City Segment

Table 4.13-14 outlines potential effects under Alternative B to the 27 known cultural resources in the Jefferson City segment. The table includes information about mitigation measures that are in place or

could be developed through a PA. There are no direct effects to the sites identified in the table; however, indirect effects may occur to three archaeological sites and unidentified sites along six perennial tributaries in this segment under Alternative B.

Table 4.13-14 Effects to Cultural Resources in the Jefferson City Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Joseph Kinney*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dart*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Timour*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Naomi*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Sonora*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*West Wind*	MC	Unevaluated	No adverse effect	N/A
Bridge	Glasgow Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (KCS Bridge Maintenance Program – avoidance)
Shipwreck	*Annie Lee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Plow Boy No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Radnor*	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Archaeological Site	MU134/MU135	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1000	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Little Dick*	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1100	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Marie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bright Light*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Martha Stevens*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Floyd*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CY28	T	Unevaluated	N/A	To be determined (Future work – under a PA)

Table 4.13-14 Effects to Cultural Resources in the Jefferson City Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	CO52	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Shipwreck	*Statie Fisher*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CO108	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Campsite	Lewis and Clark 1804	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Emma*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dew Drop*	MC	Unevaluated	No adverse effect	N/A

Notes:

KCS = Kansas City Southern Railway Company.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

Direct Effects

NRHP-eligible sites in the Jefferson City segment include one bridge and one shipwreck. Dredging exclusion zones have been established for all bridges along the LOMR. Therefore, the NRHP-eligible bridge would not be directly affected under Alternative B. The *Radnor* (23CP320), which is located along the banks of the LOMR in a water fluctuation zone, was determined to be eligible for listing in the NRHP. A 100-foot exclusion zone has been established in the USACE dredge permits for any normal bank line. Therefore, there would be no adverse effects to this site under Alternative B.

No direct adverse effects would occur to the 18 unevaluated shipwrecks identified in this segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historical dredging locations, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Jefferson City segment would continue under Alternative B in the areas of concentrated dredging; therefore, scour has the potential to

adversely affect the Glasgow Railroad Bridge. The KCS implements countermeasures to prevent bridge failure. These countermeasures would minimize effects to the bridge such that no adverse effects would result.

Tributary degradation is likely to increase around the Jefferson City portion of the segment under Alternative B. If dredging continues in historically dredged areas, only six perennial tributaries in this segment are at an increased risk of river bed degradation (see Table 4.2-1). Because three archaeological sites (MU134/MU135, B01000, and BO1100), the shipwreck *Little Dick*, and one Lewis and Clark campsite are not located along tributaries that are predicted to degrade, these resources would not be adversely affected under Alternative B. Three archaeological sites (CO28, CO52, and CO108) that are located along tributaries near Jefferson City may be affected by headcutting and erosion attributable to dredging. In addition, unidentified archaeological sites located along the six perennial tributaries located near Jefferson City could be adversely affected by these conditions under Alternative B. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of unidentified sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.6.5 St. Charles Segment

Table 4.13-15 outlines potential effects under Alternative B to the 50 known cultural resources in the St. Charles segment. The table includes information about mitigation measures that are in place or could be developed through a PA. No direct effects have been identified to the resources in the table; however, indirect effects could occur to two tributary sites (one shipwreck and one Lewis and Clark campsite) and undocumented sites along 19 tributaries in the segment.

Direct Effects

Two NRHP-eligible bridges are located in the St. Charles segment. Dredging exclusion zones have been established for all bridges along the LOMR. Therefore, no adverse effects to these two NRHP-eligible bridges would occur under Alternative B.

Table 4.13-15 Effects to Cultural Resources in the St. Charles Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*E.H. Durfee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Camden*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Gus Fowler*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New St. Paul*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Nodaway*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Robert Emmett*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 108.2)	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster (1932)*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mandan*	MC	Unevaluated	No adverse effect	N/A
Archaeological Site	GA184	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 104.3)	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Cappa*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Alert*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Washington*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lynchburgh*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Petral*	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 72.5)	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 72.1)	Unevaluated	No adverse effect	N/A
Bridge	Washington Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*Seventy-Six*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Bell*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Duncan S. Carter*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Montana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lily*	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A

Table 4.13-15 Effects to Cultural Resources in the St. Charles Segment under Alternative B

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	*Daniel Boone Bridge*	MC	Eligible	No adverse effect (USACE – Avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*James Lyons*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*General McNeil*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ella Kimbrough*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 29.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Tyler*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 28.4)	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Anthony*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Luke*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Benton No. 1*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Far West*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Halycyon*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Haidee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Car of Commerce*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Hancock*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New Georgetown*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Julia*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 7.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Georgetown*	MC	Unevaluated	No adverse effect	N/A
Campground	Lewis and Clark	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Shipwreck	*Bald Eagle*	MC	Unevaluated	No adverse effect	N/A

Notes:

MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary; I = Island; SC = Side channel.; RM = River mile.

Under Alternative B, no direct adverse effects would occur to the 44 unevaluated shipwrecks or the Lewis and Clark campsites identified in main channel of the St. Charles segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks and the Lewis and Clark campsites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation would occur as a result of dredging proposed under Alternative B; therefore, scour has the potential to adversely affect the Daniel Boone Bridge and the Washington Bridge. The MoDOT implements countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two bridges such that no adverse effects would result.

One Lewis and Clark campsite, one archaeological site (GA184), and two shipwrecks (*Lily* and *Petral*) are located along tributaries in this segment. Geomorphic analysis indicates that, if dredging continues at historically dredged locations, 19 perennial tributaries in this segment are likely to experience increased degradation (refer to Table 4.2-1). Archaeological site GA184 and the shipwreck *Petral* are not located along tributaries that are predicted to degrade and, therefore, are unlikely to be adversely affected under Alternative B. However, the shipwreck *Lily* and one Lewis and Clark campsite could be affected by headcutting and erosion attributable to dredging under Alternative B. In addition, unidentified archaeological sites located along 19 perennial tributaries could be adversely affected by these conditions. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of unidentified sites with the potential to be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Under Alternative B, one sand plant and associated infrastructure, which would encompass approximately 25 acres, would be constructed approximately 0.5 mile from the river in the St. Charles segment. Construction of the sand plant and conveyor system has the potential to impact currently unidentified sites. Although a records search did not reveal cultural resources in this area, previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant location. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) identify NRHP eligible sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.6.6 Alternate Sources

Under Alternative B, production of sand and gravel would shift to alternate sources, including expansion of existing sources in the short term and development of new sources in the long term.

Expansion of Existing Sources

In the short term, gravel mining would be expanded at existing river locations; floodplain open-pit mines, including open-pit mines for manufactured sand; and instream mines. Dredging operations could be expanded along the Mississippi and Kansas Rivers. Expanded operations in these rivers would have the potential to adversely affect cultural resources if new sand plants were constructed or dredging shifted to locations that had not previously been dredged. In addition, continued dredging in these rivers may indirectly affect cultural resources (such as bridges) through river bed degradation. River bed degradation has been documented along the Kansas River in the area of Kansas City (USACE 1990).

Existing floodplain open-pit mines are located in Missouri, Kansas, and Illinois. Only the IDNR, Division of Water Resource Management, requires cultural resource consultation with the SHPO prior to authorization of a floodplain construction permit. Missouri and Kansas do not require cultural resource consultation or evaluation as a part of the permit process. Therefore, it is probable that adverse effects to cultural resources would occur as a result of mining operation expansion in these states.

Development of New Sources

In the long term under Alternative B, new sand and gravel sources would be developed in proximity to processing facilities and urban centers in Missouri and Kansas. These states do not require cultural resource identification, evaluation, or consultation as part of their permitting processes. Kansas considers effects to NRHP-listed properties as a result of projects that are supported by a government entity (KAR 118-3-1-16). This statute, however, would not apply to development of new sources of sand and gravel. It is probable that prehistoric or historic archaeological sites exist in potential alternate dredging and processing locations. Destruction or damage of cultural resources as a result of dredging or sand plant facility construction would constitute an adverse effect.

4.13.7 Alternative C

Under Alternative C, dredging would continue at the current level in the LOMR, and additional sources of sand and gravel would not be pursued. There would be no direct effects to cultural resources under Alternative C. Indirect effects to cultural resources would be associated with tributary headcutting,

erosion, and scour. If dredging continues at previously dredged locations, indirect effects associated with headcutting and erosion are likely to occur along tributaries where dredging has been the most concentrated. Refer to Table 4.2-1 for a list of these tributaries. A total of five tributary sites (three archaeological sites in the Jefferson City segment and one shipwreck and one campsite in the St. Charles segment) may be adversely affected under Alternative C. Undocumented sites located along tributaries where dredging has been the most concentrated in the Kansas City, Jefferson City, and St. Charles segments also may be adversely effected. In addition, indirect effects are associated with the proposed development of two sand plants under Alternative C. Two archaeological sites located in the St. Joseph segment may be adversely affected by sand plant construction and operation. There also may be adverse effects to undocumented or unidentified sites at potential sand plant locations.

4.13.7.1 St. Joseph Segment

Table 4.13-16 outlines potential effects under Alternative C to the 20 known cultural resources in the St. Joseph segment and identifies mitigation measures that are in place or could be developed through a PA. There are no direct effects to sites identified in the table. Indirect effects may occur to two sites, which are located at potential sand plant locations, and any unidentified sites located at the sand plant locations. No adverse effects are expected for unidentified sites located along tributaries in the St. Joseph segment.

Table 4.13-16 Effects to Cultural Resources in the St. Joseph Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	Rulo	MC	Listed	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (NDOR Bridge Inspection Program – effect minimization)
Shipwreck	*Bertha*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Cark	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Emilie No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Denver City*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dorothy*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mt. Sterling*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Pathfinder*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A

Table 4.13-16 Effects to Cultural Resources in the St. Joseph Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Missouri Mail*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Della*	MC	Unevaluated	No adverse effect	N/A
Bridge	Atchison	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Bridge Maintenance Program – effect minimization)
Shipwreck	*Arabian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hesperian*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Platte Valley*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tom Morgan*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Minnie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Express*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	PL110	SP	Unevaluated	N/A	To be determined (Further work – under a PA)
Archaeological site	PL341	SP	Unevaluated	N/A	To be determined (Further work – under a PA)

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
NDOR = Nebraska Department of Roads.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; SP = Proposed sand plant location.

Direct Effects

Two NRHP-eligible bridges are located in the St. Joseph segment. The Rulo Bridge and the Atchison Bridge are protected by dredging exclusion zones that have been established for all bridges along the LOMR. Therefore, the NRHP-eligible bridges in this segment would not be directly affected under Alternative C.

No direct adverse effects would occur to the 16 unevaluated shipwrecks or the Lewis and Clark campsites identified in the main channel of the LOMR in the St. Joseph segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks and the Lewis

and Clark sites are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the St. Joseph segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation would continue in the St. Joseph segment because of dredging under Alternative C; therefore, scour attributable to dredging has the potential to adversely affect the Rulo Bridge and Atchison Bridge. The NDOR and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the two bridges such that scour would not adversely affect the Rulo Bridge or Atchison Bridge in the St. Joseph Segment under Alternative C.

Geomorphic analysis indicates that tributary degradation in the St. Joseph segment would be unlikely to worsen under Alternative C. Therefore, no adverse effects are expected for unidentified sites located along tributaries in the segment.

Under Alternative C, one sand plant and associated infrastructure, which may encompass up to 60 acres, would be constructed at one of two locations along the river in the St. Joseph segment. Sand plant and pipeline construction has the potential to affect two unevaluated archaeological sites (PL341 and PL110). Previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant sites. The potential destruction or disturbance of such resources would constitute an adverse effect. Under a PA, and prior to clearing and construction activities, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of these sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.7.2 Kansas City Segment

Table 4.13-17 outlines potential effects to the 10 known cultural resources in the Kansas City segment under Alternative C and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table; however, there may be indirect effects to undocumented sites located along 11 perennial tributaries.

Table 4.13-17 Effects to Cultural Resources in the Kansas City Segment under Alternative C

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Archaeological site	PL288	T	Not eligible	N/A	No adverse effect
Bridge	Fairfax	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Fire Canoe*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bennett*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mike Bauer*	MC	Unevaluated	No adverse effect	N/A
Bridge	Armour-Swift-Burlington (ASB) Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (BNSF Maintenance Division – effect minimization)
Shipwreck	*Glenmore*	MC	Unevaluated	No adverse effect	N/A
Bridge	Paseo	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Bridge	Liberty Bend	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – effect minimization)
Shipwreck	*Corvette*	MC	Unevaluated	No adverse effect	N/A

Notes:

BNSF = Burlington Northern Santa Fe Railway Company.
MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

Direct Effects

Four NRHP-eligible bridges are located in the Kansas City segment. Because dredging exclusion zones have been established for all bridges along the LOMR, the NRHP-eligible bridges would not be directly affected under Alternative C.

No direct adverse effects would occur to the five unevaluated shipwrecks identified in the main channel of the LOMR in the Kansas City segment. Because of the extensive history of dredging in the main

channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Kansas City segment, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Kansas City segment would likely continue under Alternative C; therefore, scour has the potential to adversely affect the four historic bridges. The MoDOT and the BNSF implement countermeasures to prevent bridge failure. These countermeasures would minimize effects to the four historic bridges such that scour would not adversely affect the bridges under Alternative C.

Archaeological site PL288 was found ineligible for listing in the NRHP based on survey and evaluation. Therefore, there would be no adverse effects to this site under Alternative C.

Geomorphic analysis also indicates that tributary degradation is likely to increase in the Kansas City segment under Alternative C. Unidentified sites may exist and may be adversely affected by headcutting and erosion. If dredging continues at previously dredged locations, cultural resources located along 11 perennial tributaries (refer to Table 4.2-1) may be adversely affected. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) identify sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.7.3 Waverly Segment

Table 4.13-18 outlines potential effects under Alternative C to the 15 known cultural resources in the Waverly segment and identifies mitigation measures that are in place. There are no direct or indirect effects to the sites identified in the table. Indirect effects to known and unidentified cultural resources along tributaries in this segment are not anticipated.

Direct Effects

No NRHP-eligible sites are found in the Waverly segment. One shipwreck, the *Saluda*, is protected by a no dredge zone that was established in previous USACE permits; therefore, no adverse effects to this resource would result under Alternative C. There would be no adverse effects to the other unevaluated shipwrecks identified in this segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to

occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historically dredged areas in the Waverly segment, further analysis through a PA could be undertaken.

Table 4.13-18 Effects to Cultural Resources in the Waverly Segment under Alternative C

Site Type	Site Name	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Wakendah*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Saluda*	MC	Unevaluated	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Shipwreck	*Nymph*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Zephyr*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Missouri*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Princess*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Leavenworth*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ariel*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Roy Lynds*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Eagle*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Tropic*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Golong*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Govener Allen*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*T.T. Hilman*	MC	Unevaluated	No adverse effect	N/A

Notes:
NRHP = National Register of Historic Places.
USACE = U.S. Army Corps of Engineers.
[a] Location: MC = Main channel.

Indirect Effects

No cultural resources were identified along perennial tributaries in the Waverly segment. Geomorphic analysis indicates that dredging-related tributary degradation would be unlikely to increase in the Waverly segment under Alternative C. Therefore, indirect effects to unidentified sites along tributaries in this segment are not anticipated.

4.13.7.4 Jefferson City Segment

Table 4.13-19 outlines potential effects under Alternative C to the 27 known cultural resources in the Jefferson City segment. The table includes information about mitigation measures that are in place or could be developed through a PA. There are no direct effects to sites identified in the table; however, indirect effects may occur to three archaeological sites and unidentified sites along six perennial tributaries in this segment under Alternative C.

Table 4.13-19 Effects to Cultural Resources in the Jefferson City Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Joseph Kinney*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dart*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Timour*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Naomi*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Sonora*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*West Wind*	MC	Unevaluated	No adverse effect	N/A
Bridge	Glasgow Railroad Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (KCS Bridge Maintenance Program – avoidance)
Shipwreck	*Annie Lee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Plow Boy No. 2*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Radnor*	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	N/A
Archaeological Site	MU134/MU135	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1000	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Little Dick*	T	Unevaluated	N/A	No adverse effect
Archaeological Site	BO1100	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Marie*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Bright Light*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Martha Stevens*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Floyd*	MC	Unevaluated	No adverse effect	N/A

Table 4.13-19 Effects to Cultural Resources in the Jefferson City Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*Diana*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CY28	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Archaeological site	CO52	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Shipwreck	*Statie Fisher*	MC	Unevaluated	No adverse effect	N/A
Archaeological site	CO108	T	Unevaluated	N/A	To be determined (Future work – under a PA)
Campsite	Lewis and Clark 1804	T	Unevaluated	N/A	No adverse effect
Shipwreck	*Emma*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Dew Drop*	MC	Unevaluated	No adverse effect	N/A

Notes:

KCS = Kansas City Southern Railway Company.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.

[a] Location: MC = Main channel; T = Tributary.

Direct Effects

NRHP-eligible sites in the Jefferson City segment include one bridge and one shipwreck. Dredging exclusion zones have been established for all bridges along the LOMR. Therefore, the NRHP-eligible bridge would not be directly affected under Alternative C. The *Radnor* (23CP320), which is located along the banks of the LOMR in a water fluctuation zone, was determined to be eligible for listing in the NRHP. A 100-foot dredging exclusion zone has been established in the USACE dredge permits for any normal bank line. Therefore, there would be no adverse effects to the site under Alternative C.

No direct adverse effects would occur to the 18 unevaluated shipwrecks identified in this segment. Because of the extensive history of dredging in the main channel of the LOMR, effects to shipwrecks are not anticipated provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. If dredging activities are planned outside historical dredging locations, further analysis through a PA could be undertaken.

Indirect Effects

Geomorphic analysis indicates that river bed degradation in the Jefferson City segment would continue under Alternative C in areas of concentrated dredging; therefore, scour has the potential to adversely affect the Glasgow Railroad Bridge. The KCS implements countermeasures to prevent bridge failure. These countermeasures would minimize effects from Alternative C to the historic bridge such that no adverse effects would result.

Tributary degradation is likely to increase around the Jefferson City portion of the segment under Alternative C. If historical dredging areas are maintained, only six perennial tributaries in this segment are at an increased risk of degradation (see Table 4.2-1). Three archaeological sites (MU134/MU135, B01000, and BO1100), the shipwreck *Little Dick*, and one Lewis and Clark campsite are not located along tributaries that are predicted to degrade and, therefore, would not be adversely affected by Alternative C. Three archaeological sites (CO28, CO52, and CO108), which are located along tributaries near Jefferson City, may be affected by headcutting and erosion attributable to dredging. In addition, unidentified archaeological sites located along the six perennial tributaries near Jefferson City could be adversely affected by these conditions. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of unidentified sites that could be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.7.5 St. Charles Segment

Table 4.13-20 outlines potential effects under Alternative C to the 50 known cultural resources in the St. Charles segment. The table includes information about mitigation measures that are in place or could be developed through a PA. There are no direct effects to the resources identified in the table; however, indirect effects could occur to two tributary sites and undocumented sites along 19 tributaries in the segment.

Indirect Effects

Geomorphic analysis indicates that the river bed would continue to degrade under Alternative C; therefore, scour has the potential to adversely affect the Daniel Boone Bridge and the Washington Bridge. The MoDOT implements countermeasures to prevent bridge failure. These countermeasures would minimize effects to the bridges such that no adverse effects would result.

Table 4.13-20 Effects to Cultural Resources in the St. Charles Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Shipwreck	*E.H. Durfee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Camden*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Gus Fowler*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New St. Paul*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Nodaway*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Robert Emmett*	MC	Unevaluated	No adverse effect	N/A
Campsite	*1804 Lewis and Clark*	MC (RM 108.2)	Unevaluated	No adverse effect	N/A
Shipwreck	*Lancaster (1932)*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Mandan*	MC	Unevaluated	No adverse effect	N/A
Archaeological Site	GA184	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 104.3)	Unevaluated	No adverse effect	N/A
Shipwreck	*Chariton*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Cappa*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Alert*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Washington*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lynchburgh*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Petral*	T	Unevaluated	N/A	No adverse effect
Campsite	1804 Lewis and Clark	MC (RM 72.5)	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 72.1)	Unevaluated	No adverse effect	N/A
Bridge	Washington Bridge	MC	Eligible	No adverse effect (USACE – avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*Seventy-Six*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Bell*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Duncan S. Carter*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Montana*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Lily*	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Campsite	1806 Lewis and Clark	MC	Unevaluated	No adverse effect	N/A

Table 4.13-20 Effects to Cultural Resources in the St. Charles Segment under Alternative C

Site Type	Site Name/No.	Location[a]	NRHP Eligibility	Direct Effect (Further Work or Avoidance)	Indirect Effect (Further Work or Avoidance)
Bridge	*Daniel Boone Bridge*	MC	Eligible	No adverse effect (USACE – Avoidance through dredging exclusion zone)	No adverse effect (MoDOT Bridge Maintenance Program – avoidance)
Shipwreck	*James Lyons*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*General McNeil*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Ella Kimbrough*	MC	Unevaluated	No adverse effect	N/A
Campsite	1804 Lewis and Clark	MC (RM 29.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Tyler*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 28.4)	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Anthony*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Hermann*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*St. Luke*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Benton No. 1*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Far West*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Halycyon*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Haidee*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Car of Commerce*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*John Hancock*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*New Georgetown*	MC	Unevaluated	No adverse effect	N/A
Shipwreck	*Julia*	MC	Unevaluated	No adverse effect	N/A
Campsite	1806 Lewis and Clark	MC (RM 7.0)	Unevaluated	No adverse effect	N/A
Shipwreck	*Georgetown*	MC	Unevaluated	No adverse effect	N/A
Campground	Lewis and Clark	T	Unevaluated	N/A	To be determined (Further work – under a PA)
Shipwreck	*Bald Eagle*	MC	Unevaluated	No adverse effect	N/A

Notes:
MoDOT = Missouri Department of Transportation.
NRHP = National Register of Historic Places.
PA = Programmatic Agreement.
USACE = U.S. Army Corps of Engineers.
[a] Location: MC = Main channel; T = Tributary; I = Island; SC = Side channel; RM = River mile.

Geomorphic analysis also indicates that tributary degradation would occur in the St. Charles segment under Alternative C. One Lewis and Clark campsite, one archaeological site (GA184), and two shipwrecks (*Lily* and *Petral*) are located along tributaries in this segment. Analysis indicates that, if dredging occurs at previous locations, 19 perennial tributaries in this segment are likely to experience increased degradation (refer to Table 4.2-1). Archaeological site GA184 and the shipwreck *Petral* are not located along tributaries that are predicted to degrade and, therefore, are unlikely to be adversely affected under Alternative C. However, the shipwreck *Lily* and one Lewis and Clark campsite could be affected by headcutting and erosion attributable to dredging under Alternative C. In addition, unidentified archaeological sites located along 19 perennial tributaries could be adversely affected by these conditions. Destruction or disturbance of these sites would constitute an adverse effect. Under a PA, cultural resource surveys could be undertaken to (1) verify the eligibility for listing in the NRHP of unidentified sites with the potential to be affected by headcutting and erosion; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

Under Alternative C, one sand plant and associated infrastructure, which would encompass approximately 25 acres, would be constructed approximately 0.5 mile from the river in the St. Charles segment. Construction of the sand plant and conveyor system has the potential to impact currently unidentified sites. Although a records search did not reveal resources in this area, previously unidentified prehistoric or historic archaeological sites may exist at the proposed sand plant location. Under a PA, and prior to clearing and construction activities, cultural resource surveys would be undertaken to (1) verify NRHP eligible sites; and (2) determine whether Project planning to avoid, minimize, or mitigate adverse effects is possible.

4.13.7.6 Alternate Sources

Under Alternative C, demand for sand and gravel would be met by dredging in the LOMR. Expansion of existing alternate sources of sand and gravel and development of new sources would not be necessary. Therefore, no adverse effects to cultural resources associated with alternate sources are anticipated.

4.13.8 Summary of Effects

Table 4.13-21 provides a summary of potential effects on cultural resources for the Proposed Action and alternatives.

Table 4.13-21 Summary of Potential Effects on Cultural Resources

Category of Effect	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Direct effects (associated with destruction or damage to all or part of a property as a result of dredging)	• No direct effects to cultural resources (shipwrecks or Lewis and Clark sites) in main channel of the LOMR provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. • Potential direct effects to cultural resources if dredging occurs outside historically dredged areas.	• Dredging in the Mississippi or Kansas Rivers – potential direct effects to cultural resources. • Floodplain open-pit mines or other upland sources – potential adverse effects to cultural resources from sand plant construction. • Floodplain open-pit mines or other upland sources – potential adverse effects to cultural resources from expanded dredging operations.	• No direct effects to cultural resources (shipwrecks or Lewis and Clark sites) in main channel of the LOMR provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. • Potential direct effects to cultural resources if dredging occurs outside historically dredged areas.	• No direct effects to cultural resources (shipwrecks or Lewis and Clark sites) in main channel of the LOMR provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. • Potential direct effects to cultural resources if dredging occurs outside historically dredged areas.	• No direct effects to cultural resources (shipwrecks or Lewis and Clark sites) in main channel of the LOMR provided that dredging activities continue to occur in their historical locations and dredging exclusion zones are maintained. • Potential direct effects to cultural resources if dredging occurs outside historically dredged areas.
Indirect effects (associated with destruction or damage of a cultural resource as a result of river bed degradation, headcutting, erosion, and scouring of the river bed near bridge abutments)	• Indirect effects to bridges mitigated through counter-measures implemented by bridge owners. • Potential indirect effects to five documented cultural resources along tributaries as a result of headcutting and erosion. • Potential indirect effects to undocumented sites along perennial tributaries located in areas of concentrated dredging.	• No indirect effects to resources located in the LOMR or along LOMR tributaries.	• Indirect effects to bridges mitigated through counter-measures implemented by bridge owners. • No indirect effects to documented or undocumented cultural resources along tributaries.	• Indirect effects to bridges mitigated through counter-measures implemented by bridge owners. • Potential indirect effects to five documented cultural resources along tributaries as a result of headcutting and erosion. • Potential indirect effects to undocumented sites along perennial tributaries located in areas of concentrated dredging.	• Indirect effects to bridges mitigated through counter-measures implemented by bridge owners. • Potential indirect effects to five documented cultural resources along tributaries as a result of headcutting and erosion. • Potential indirect effects to undocumented sites along perennial tributaries located in areas of concentrated dredging.

Table 4.13-21 Summary of Potential Effects on Cultural Resources

Category of Effect	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Indirect effects (associated with destruction or damage of a cultural resource related to sand plant construction or operation, or expansion of dredging activities to new sites beyond the Missouri River)	• Potential indirect effects to two documented cultural resources at proposed sand plant locations. • Potential indirect effects to undocumented cultural resources at proposed sand plant locations.	• Potential indirect effects to two documented cultural resources at proposed sand plant locations. • Potential indirect effects to undocumented cultural resources at proposed sand plant locations. • Dredging in the Mississippi or Kansas River – potential indirect effects to cultural resources. • Floodplain open-pit mines or other upland sources – potential adverse effects to cultural resources from expanded dredging operations.	• Potential indirect effects to two documented cultural resources at proposed sand plant locations. • Potential indirect effects to undocumented cultural resources at proposed sand plant locations. • Dredging in the Mississippi or Kansas River – potential indirect effects to cultural resources. • Floodplain open-pit mines or other upland sources – potential adverse effects to cultural resources from expanded dredging operations.	• Potential indirect effects to two documented cultural resources at proposed sand plant locations. • Potential indirect effects to undocumented cultural resources at proposed sand plant locations. • Dredging in the Mississippi or Kansas River – potential indirect effects to cultural resources. • Floodplain open-pit mines or other upland sources – potential adverse effects to cultural resources from expanded dredging operations.	• Potential indirect effects to two documented cultural resources at proposed sand plant locations. • Potential indirect effects to undocumented cultural resources at proposed sand plant locations.

Note: LOMR = Lower Missouri River.

4.13.9 References

USACE (U.S. Army Corps of Engineers). 1990. Final Regulatory Report and Environmental Impact Statement – Commercial Dredging Activities on the Kansas River, Kansas: Kansas City District, Kansas City, MO. 78 pp. (plus appendices).

4.14 AIR QUALITY AND CLIMATE CHANGE

4.14.1 Introduction

This section describes the impact analysis related to air quality and climate change for the Proposed Action and alternatives. As discussed in Section 3.16, operation of dredges, tugboats, and materials-handling equipment powered by internal combustion engines can result in exhaust emissions. Direct impacts from these emissions can include degradation of local and regional air quality, as well as increases in GHGs that contribute to global climate change. Indirect impacts can include potential health risks posed to sensitive receptors following exposure to diesel particulate matter (DPM).

Dredging in the LOMR is a historical and ongoing activity. Air quality and climate change impacts would occur only if implementation of the Proposed Action or alternatives would change the intensity, frequency, number, or location of emission sources. For the purpose of this analysis, emissions generated under the Proposed Action and alternatives were compared to the existing emissions described in Section 3.16.

4.14.2 Assessment Methods

4.14.2.1 Quantification of Emissions

Dredging operations involve the following activities:

- Dredging (removal of sand and gravel from the river bed and transport of that material onshore);
- Onshore materials-handling (use of earth-moving equipment to transport and process the dredged material) and sand plants; and
- Transportation of sand and gravel to local market areas.

Emissions were quantified for each of these activities under the Proposed Action and alternatives. Please refer to Appendix D for a detailed discussion of the data and modeling techniques used to quantify emissions from dredging operations. The emissions calculations are also provided in Appendix D.

4.14.2.2 Generation of Construction Emissions

Emissions generated by construction activities include fugitive dust from site grading, and criteria pollutant and GHG exhaust emissions from construction equipment. These emissions would be temporary and would cease when construction activities are complete. Two new facilities, Waldron (the sand plant proposed by The Master's Dredging Company) and Washington (the sand plant proposed by Edward N. Rau Contractor Company), would be constructed under the Proposed Action, Alternative A, Alternative B, and Alternative C; however, limited information is available on when and how each site would be built. Emissions from construction activities were estimated using conservative assumptions to ensure that emissions were not under-represented. Please refer to Appendix D for an expanded discussion of the assumptions and techniques used in the emissions modeling.

Neither the MDNR nor the St. Louis Air Pollution Control Program has established construction emissions thresholds. Consequently, potential adverse impacts on air quality resulting from construction were evaluated by comparing the estimated emissions to the federal *de minimis* thresholds.

4.14.2.3 Conformity Analysis

As discussed in Section 3.16.6.1, the following counties in the Project area are classified as federal nonattainment areas for the 8-hour ozone standard and therefore are subject to conformity requirements: Franklin, Madison, St. Charles, and St. Louis. These counties are located in the St. Charles segment.

The calculation of emissions for dredging, materials-handling, and hauling sand and gravel for companies operating in the St. Charles segment (see Appendix D) were assigned to each nonattainment county using the locations of the onshore facilities (see Figure 2.2.-1). This step is necessary to ensure that emissions produced in each county are not under- or over-represented. The following sections provide additional detail on the methods used to apportion emissions generated for each activity of dredging operations.

Dredging

Because the operating locations of individual dredges and tugs within a specified segment are unknown, emissions generated by dredging activities were assumed to occur in counties with sand and gravel facilities. For example, because Capital Sand Company owns only one facility in the St. Charles segment (located in Franklin County), 100 percent of the dredging emissions calculated for Capital

Sand Company were assumed to occur in Franklin County. For companies operating in more than one county, the ratio of storage capacities among facilities was used to apportion emissions to individual counties.

Materials-Handling Equipment

Emissions from materials-handling equipment were assumed to occur at each onshore facility owned by the companies. For example, four facilities are located in St. Louis County. Emissions from materials-handling equipment in St. Louis County therefore were assumed to represent the sum total of emissions generated by equipment operating at each of these facilities.

Transportation of Sand and Gravel

Emissions from transporting sand and gravel were assumed to occur in the county from which the haul truck would originate. In other words, emissions generated by truck trips hauling sand and gravel from the four facilities in St. Louis County were included in the emissions inventory for St. Louis County. As discussed in Section 3.12, the market area served by each sand plant was assumed to be within a 25-mile radius of the facility. Therefore, it is likely that some of the trucks would travel outside the county from which they originated, depending on the facility location. Assuming that the total emissions generated by haul truck trips would occur within a single county is conservative and ensures that emissions are not under-represented.

Emissions from dredging, materials-handling equipment, and transportation of sand and gravel in each of the nonattainment counties were summed to obtain total emissions for the Proposed Action and alternatives. The difference in emissions relative to existing conditions, which represents the total emissions associated with implementation of the Proposed Action and alternatives, then was compared to the federal *de minimis* thresholds to determine conformity with federal regulations.

4.14.2.4 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

Increased health risks can result from prolonged exposure to elevated DPM concentrations. DPM emissions were calculated for the Proposed Action and alternatives (see Appendix D). However, a quantitative analysis of health risks is not appropriate for this document because the emissions quantified for this analysis are mass emissions that would be generated by sand and gravel operations, not the resulting DPM concentration that is the metric required for a health risk assessment (HRA).

A number of site-specific factors are required to calculate DPM concentrations caused by increased dredging operations. For example, the schedule and location of operating equipment, as well as meteorological conditions, are necessary to model pollutant dispersion and calculate relative concentrations downwind of the source of DPM. In addition, information on the location of specific receptors is required to perform an HRA. Because the site-specific information is unavailable, this analysis qualitatively evaluates the potential for adverse exposure to DPM based on the permit length and the proximity of sensitive receptors to onshore facilities (existing and proposed for construction).

The USEPA has issued basic guidance for the assessment of carcinogen health risks (USEPA 2005). A more robust and prescriptive guidance document also has been prepared by the Office of Environmental Health Hazard Assessment (OEHHA), which is part of the California State Department. Both documents stress that cancer health risks typically are associated with chronic exposures to carcinogenic substances. The USEPA states that an exposure period of 20 years or longer often is assumed for cancer development, while the OEHHA recommends using a 70-year exposure period for the cancer risk analysis (USEPA 2005, CARB 2000). In addition, both documents discuss the need to consider distance relationships between the source and potential receptor. Specifically, the OEHHA indicates that DPM concentrations decrease as a function of distance. In other words, the farther a receptor is from the source of DPM, the less severe the potential health risks. Based on professional practices, a radius of 1,000 feet therefore was used to identify receptors that may be adversely affected by increases in DPM.

4.14.2.5 Generation of Greenhouse Gas Emissions

GHGs from sand and gravel operations are primarily the result of fuel use by dredges, tugs, materials-handling equipment, and haul vehicles. In addition, the use of heavy-duty equipment during construction activities produces GHG emissions as engine exhaust. Emissions from these activities were quantified based on information summarized in Appendix D.

To date, specific thresholds to evaluate adverse impacts pertaining to GHG emissions have not been established by local decision-making agencies, the state, or the federal government. As discussed in Section 3.16-7.2, the CEQ has published Draft Guidance for the consideration of climate change impacts in NEPA analyses (Sutley 2010). The Draft Guidance suggests that the impacts of projects directly emitting GHGs in excess of 25,000 tons annually be considered in a qualitative and quantitative manner. However, the guidance stresses that, given the nature of GHGs and their persistence in the atmosphere, climate change impacts should be considered on a cumulative level. For consistency, this section presents a project-level analysis of GHG emissions. Please refer to Chapter 5, “Cumulative

Impacts," for a discussion of the cumulative GHG impacts expected under the Proposed Action and alternatives.

4.14.2.6 Generation of Emissions from Alternate Source Locations

Implementation of the No Action Alternative, Alternative A, and Alternative B would result in reduced commercial sand and gravel dredging on the LOMR. It is anticipated that, if dredging volumes are reduced, floodplain open-pit mining adjacent to the Missouri River likely would develop over the long term to meet regional demand for sand and gravel. However, because of the extended start-up period for new mines, replacement supplies over the next few years likely would come from existing sources located on the Kansas and Mississippi Rivers or from existing open-pit and instream mining operations in Missouri, Illinois, and Kansas (see Figure 2.3-2). A small portion of materials also may come from manufactured sand. Because it is not known when or where alternate sources would operate, potential air quality and climate impacts from these sources cannot be quantified and are discussed qualitatively.

4.14.2.7 Generation of Emissions from Sand Plant Operations

Sand plants can generate fugitive dust from processed materials and air pollutants from the upkeep of offices and employee commute trips. Under the Proposed Action and alternatives, emissions from operation of these sources are expected to negligibly affect air quality or climate change. Consequently, these emissions were excluded from the impact analysis. Please refer to Appendix D for additional detail.

4.14.3 Proposed Action

4.14.3.1 Construction Emissions That Exceed Thresholds

St. Joseph, Waverly, and Jefferson City Segments

Under the Proposed Action, no new onshore facilities or dredging-related construction is expected to occur in the St. Joseph, Waverly, or Jefferson City segment. Consequently, no emissions would be generated from construction of sand plants, and no impact would occur.

Kansas City Segment

Under the Proposed Action, The Master's Dredging Company would construct a new sand plant (Master's–Waldron) in Platte County, Missouri. Emissions associated with construction of this facility were quantified based on information summarized in Appendix D. Based on information provided by

the permit applicant and aerial images of existing sand and gravel facilities, it was assumed that the facility site would encompass 60 acres and contain one 1,000–square-foot general garage-type structure. The results of the air quality modeling are summarized in Table 4.14-1 and compared to the federal *de minimis* thresholds. The construction emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-1, emissions from construction of the Waldron sand plant would not exceed the federal *de minimis* thresholds and therefore would not represent an adverse air quality impact.

Table 4.14-1 Summary of Criteria Pollutant and Greenhouse Gas Emissions from Construction of The Master's Dredging Company Sand Plant at Waldron (tons/year)

				PM_{10}			$PM_{2.5}$			CO_2e (GHG)[a]
	VOC	NO_X	CO	Total	Exhaust	Dust	Total	Exhaust	Dust	
Construction emissions				17.84	2.99	16.35	4.78	2.75	3.41	5,704
Threshold	100	100	100	100	N/A[b]	N/A[b]	100	N/A[b]	N/A[b]	N/A[b]
Adverse effect?	No	No	No	No	N/A	N/A	No	N/A	N/A	N/A

Notes:

N/A = Not applicable.
VOC = Volatile organic compounds.
NO_x = Nitrogen dioxide.
CO = Carbon monoxide.
GHG = Greenhouse gas.
PM_{10} = Particulate matter less than 10 microns.
$PM_{2.5}$ = Particulate matter less than 2.5 microns.
CO_2e = Carbon dioxide equivalent, or total GHG emissions.

[a] Presented in metric tons. Emissions are discussed further in Section 4.14.3.4.

[b] Not applicable because there is no *de minimis* threshold for particulate matter exhaust, dust, or GHG emissions.

Source: Appendix D.

St. Charles Segment

Under the Proposed Action, Edward N. Rau Contractor Company would construct a new sand plant (Rau–Washington) in Franklin County, Missouri. Emissions associated with construction of this facility were quantified based on information summarized in Appendix D. Based on information provided by the permit applicant and aerial images of existing sand and gravel facilities, it was assumed that the facility site would encompass 25.6 acres and contain one 1,000–square foot general garage-type structure. The results of the air quality modeling are summarized in Table 4.14-2 and compared to the federal *de minimis* thresholds. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-2, emissions from construction of the Washington

sand plant would not exceed the federal *de minimis* thresholds and therefore would not represent an adverse air quality impact.

Table 4.14-2 Summary of Criteria Pollutant and Greenhouse Gas Emissions from Construction of the Edward N. Rau Contractor Company Proposed Sand Plant at Washington (tons/year)

				PM_{10}			$PM_{2.5}$			CO_2e (GHG)[a]
	VOC	NO_X	CO	Total	Exhaust	Dust	Total	Exhaust	Dust	
Construction emissions	1.56	18.03	7.14	6.77	1.49	3.78	3.54	1.37	0.79	2,726
Threshold	100	100	100	100	N/A[b]	N/A[b]	100	N/A[b]	N/A[b]	N/A[b]
Adverse effect?	No	No	No	No	N/A	N/A	No	N/A	N/A	N/A

Notes:

N/A = Not applicable.
VOC = Volatile organic compounds.
NO_X = Nitrogen dioxide.
CO = Carbon monoxide.
GHG = Greenhouse gas.
PM_{10} = Particulate matter less than 10 microns.
$PM_{2.5}$ = Particulate matter less than 2.5 microns.
CO_2e = Carbon dioxide equivalent, or total GHG emissions.

[a] Presented in metric tons. Emissions are discussed further in Section 4.14.3.4.

[b] Not applicable because there is no *de minimis* threshold for particulate matter exhaust, dust, or GHG emissions.

Alternate Sources

Alternate sources of sand and gravel would not be required under the Proposed Action. Therefore, no new construction is expected at alternate source locations, and no related construction emissions that could potentially exceed thresholds would occur.

4.14.3.2 Operations Emissions That Exceed Thresholds

St. Joseph, Kansas City, Waverly, and Jefferson City Segments

As discussed in Section 3.16, the St. Joseph, Kansas City, Waverly, and Jefferson City segments are located in counties classified as attainment areas with regard to the NAAQS. Consequently, conformity analyses were not required for these four segments.

St. Charles Segment

As discussed in Section 3.16, the St. Charles segment is located in counties classified as nonattainment areas with regard to the NAAQS. Consequently, a conformity analysis is required for the St. Charles segment. Total emissions generated by the Proposed Action in counties adjacent to the St. Charles segment (Franklin, Madison, St. Charles, and St. Louis Counties) are presented in Table 4.14-3. The difference in emissions relative to existing conditions, or the incremental increase in emissions associated with the Proposed Action, is compared to the federal *de minimis* thresholds.

Table 4.14-3 Conformity Analysis for the Proposed Action (tons/year)[a]

Counties Classified as Nonattainment	VOC	NO_X
Franklin County		
Emissions – Proposed Action[b,c]	6.11	96.22
Emissions – existing conditions	0.72	9.50
Proposed Action minus existing conditions[d]	+5.40	+86.72
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	609	1,465
Adverse effect?	No	No
Madison County		
Emissions – Proposed Action[b]	2.12	33.55
Emissions – existing conditions	0.84	13.13
Madison County (continued)		
Proposed Action minus existing conditions[d]	+1.28	+20.41
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	1,647	2,196
Adverse effect?	No	No
St. Charles County		
Emissions – Proposed Action[b]	5.26	100.66
Emissions – existing conditions	1.89	36.66
Proposed Action minus existing conditions[d]	+3.38	+64.00
Federal *de minimis* threshold	100	100

Table 4.14-3 Conformity Analysis for the Proposed Action (tons/year)[a]

Counties Classified as Nonattainment	VOC	NO_X
St. Charles County (continued)		
Regional significance threshold (10% of regional emissions inventory)	1,365	2,804
Adverse effect?	No	No
St. Louis County		
Emissions – Proposed Action[b]	12.48	240.32
Emissions – existing conditions	5.12	95.90
Proposed Action minus existing conditions[d]	+7.36	+144.42
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	6,012	6,486
Adverse effect?	No	Yes

Notes:

VOC = Volatile organic compounds.

NO_X = Oxides of nitrogen.

[a] Operations of sand plants may generate additional emissions of NO_X and VOC. However, any emissions were assumed to be negligible and would not affect the conformity determination.

[b] Represents sum total of emissions generated from dredging, materials-handling, and hauling sand and gravel.

[c] Because construction of an Edward N. Rau Contractor Company sand plant would occur concurrently with dredging activities, emissions generated from construction have been included in the total. Note that these emissions would occur only during 1 year of the 5-year permit period.

[d] Values may not match as a result of rounding.

Source: Appendix D.

As shown in Table 4.14-3, implementation of the Proposed Action would exceed the federal *de minimis* threshold of 100 tons/year of NO_X in St. Louis County. Because implementation of the Proposed Action would exceed the federal *de minimis* threshold for NO_X in St. Louis County, a general conformity determination was performed to demonstrate that total direct and indirect emissions of NO_X would conform to the SIP for ozone.

An inventory of regional ozone levels are provided in the SIP, and are used to benchmark the region's progress toward attainment of the NAAQS. Thus, regulations and emissions reduction commitments, which are based on an area's level of nonattainment, are continually evaluated against emissions inventories included in updated air quality plans. The conformity determination was therefore made by reviewing the emissions sources included in the inventory for the current SIP, and comparing these

sources to the equipment that would be operated under the Proposed Action. If dredgers, tug boats, materials-handling equipment, and haul trucks are included in the current SIP, it can be inferred that any emissions generated by the Proposed Action will be included and appropriately analyzed in future attainment plans.

Table 4.14-4 outlines the SIP categories for which emissions generated by equipment operated under the Proposed Action would be included in future emissions inventories. This information was obtained from the *2002 Base Year Emissions Inventory for the Missouri Portion of the St. Louis 8-Hour Ozone Nonattainment Are*a (MDNR 2007) and verified by the MDNR staff (Basham pers. comm.). Because equipment operated under the Proposed Action would be included in future inventories for the St. Louis area, regulations and environmental commitments developed by the MDNR to achieve attainment with the NAAQS would account for emissions generated by the Proposed Action. Consequently, the Proposed Action would not obstruct or conflict with the SIP.

Table 4.14-4 State Implementation Plan Emissions Categories

Equipment Operated under the Proposed Action	Corresponding State Implementation Plan Emissions Category
Diesel-powered materials-handling equipment	Non-road diesel – construction
Diesel-powered tug boats	Marine vessels – diesel
Diesel-powered dredgers	Marine vessels – diesel
Diesel-powered haul trucks	On-road mobile

Sources: MDNR 2007, Basham pers. comm.

Alternate Sources

Alternate sources of sand and gravel would not be required under the Proposed Action. Therefore, increased dredging and processing are not expected at alternate source locations, and no related operations emissions that could potentially exceed thresholds would occur.

4.14.3.3 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

St. Joseph Segment

In the St. Joseph segment, Holliday Sand & Gravel Company would operate the St. Joseph sand plant. This facility is located in an area that has been dredged historically; however, Table 4.14-5 indicates

that implementation of the Proposed Action would generate 9.31 additional tons/year of DPM relative to existing conditions. This increased production could result in elevated pollutant concentrations near the sources of DPM. As discussed above, limited information on site-specific conditions prevents determination of the exact concentrations.

As shown in Table 3.13-6, sensitive receptors are located within 1,000 feet of the St. Joseph facility operated by Holliday Sand & Gravel Company. Individuals at these sensitive receptors may be exposed to elevated health risks from dredging operations. In addition, dredging could expand to new areas in order to accommodate the increased amount of material permitted in this segment. Sensitive receptors in these areas that are not currently exposed to dredging activities could potentially be exposed to new DPM emissions from dredges and tugboats.

Although DPM concentrations are expected to increase under the Proposed Action, dredging would be permitted for only 5 years. If activities would continue beyond this period, a subsequent environmental analysis would need to be conducted. As previously discussed, cancer health risks typically are associated with long-term exposures on the order of 20–70 years (USEPA 2005, CARB 2000). Any exposure to increased concentrations of DPM therefore would be well below the recommended analysis duration for cancer risk assessments. In addition, elevated DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be even lower at the closest residence, which is 850 feet from the St. Joseph facility, than at the point of origin.

Kansas City Segment

In the Kansas City segment, Holliday Sand & Gravel Company would operate the Riverside and Randolph sand plants, and The Master's Dredging Company would operate the proposed Waldron sand plant. Although these facilities are located in an area that has been dredged historically, Table 4.14-5 indicates that implementation of the Proposed Action would generate 7.08 additional tons/year of DPM relative to existing conditions. This increased production could result in elevated pollutant concentrations near the sources of DPM. As discussed above, limited information on site-specific conditions prevents determination of the exact concentrations.

Although DPM likely would increase with implementation of the Proposed Action, Table 3.13-6 indicates that no sensitive receptors are within 1,000 feet of either facility. Consequently, there is no potential for sensitive receptors nearest the sand plants to be exposed to elevated health risks from dredging operations.

It is likely that dredging may expand to new areas in the segment in order to accommodate the increased amount of permitted material. This expansion may expose new sensitive receptors to DPM from dredges and tugs. As discussed above, any exposure would be temporary and well below the recommended duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). Moreover, DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be minimal at the nearest residence.

Table 4.14-5 Summary of Diesel Particulate Matter Emissions from Dredging in the Lower Missouri River under the Proposed Action and Alternatives (tons/year)

	Segment				
	St. Joseph	Kansas City	Waverly	Jefferson City	St. Charles
Proposed Action					
Emissions – Proposed Action	11.78	22.22	4.80	15.23	48.32
Emissions – existing conditions	2.47	15.15	3.29	9.19	16.90
Proposed Action minus existing conditions	+9.31	+7.08	+1.51	+6.04	+16.86
No Action Alternative					
Emissions – No Action Alternative	0.00	0.00	0.00	0.00	0.00
Emissions – existing conditions	2.47	15.15	3.29	9.19	16.90
No Action Alternative minus existing conditions	-2.47	-15.15	-3.29	-9.19	-16.90
Alternative A					
Emissions – Alternative A	4.70	2.71	3.79	2.27	4.10
Emissions – existing conditions	2.47	15.15	3.29	9.19	16.90
Alternative A minus existing conditions	+2.23	-12.43	+0.51	-6.92	-12.80
Alternative B					
Emissions – Alternative B	11.95	6.13	8.57	5.17	9.24
Emissions – existing conditions	2.47	15.15	3.29	9.19	16.90
Alternative B minus existing conditions	+9.48	-9.02	+5.29	-4.02	-7.66
Alternative C					
Emissions – Alternative C	2.24	16.10	3.46	9.02	18.48
Emissions – existing conditions	2.47	15.15	3.29	9.19	16.90
Alternative C minus existing conditions	-0.23	+0.96	+0.17	-0.17	+1.58

Waverly Segment

In the Waverly segment, Capital Sand Company would operate the Lexington and Carrollton sand plants. Although these facilities are located in areas that have been dredged historically, Table 4.14-5 indicates that implementation of the Proposed Action would generate 1.51 additional tons/year of DPM relative to existing conditions. Because this increase is negligible compared to existing emissions, it is unlikely that DPM concentrations would increase substantially. Consequently, there is no potential for sensitive receptors nearest onshore facilities to be exposed to elevated health risks from dredging operations in the segment.

New sensitive receptors may be exposed to DPM from dredges and tugs operating in locations that have not previously been dredged. As discussed above, any exposure of these receptors or those nearest the Carrollton facility would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). Moreover, DPM concentrations generated by dredging operations would dissipate as a function of distance and would be relatively low at the nearest sensitive receptors.

Jefferson City Segment

In the Jefferson City segment, Capital Sand Company and Hermann Sand & Gravel would operate the Jefferson City, Rocheport, Boonville, and Glasgow sand plants. Although these facilities are located in areas that have been dredged historically, Table 4.14-5 indicates that implementation of the Proposed Action would generate 6.04 additional tons/year of DPM relative to existing conditions. This increased production could result in elevated pollutant concentrations near the sources of DPM, although the exact concentration is unknown.

As shown in Table 3.13-6, sensitive receptors are located within 1,000 feet of the Glasgow sand plant. These individuals may be exposed to elevated health risks from dredging operations. In addition, new sensitive receptors may be exposed to DPM from dredges and tugs operating in locations that have not been dredged previously. As discussed above, any exposure of these receptors or those nearest the Glasgow sand plant would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). Moreover, DPM concentrations generated by dredging operations would dissipate as a function of distance and would be relatively low at the nearest residence, which is 600 feet from the Glasgow facility.

St. Charles Segment

In the St. Charles segment, Capital Sand Company, Limited Leasing Company, Edward N. Rau Contractor Company, J.T.R., and Hermann Sand & Gravel would operate the Washington, Fort Belle, Bridgeton, Alton, Chesterfield, Washington (Rau), St. Charles, Riverview, and Hermann sand plants. Although these facilities are located in areas that have been dredged historically, Table 4.14-5 indicates that implementation of the Proposed Action would generate 16.86 additional tons/year of DPM relative to existing conditions. This increased production likely would result in elevated pollutant concentrations near the sources of DPM, although the exact concentration is unknown.

As shown in Table 3.13-6, sensitive receptors are located within 1,000 feet of the Washington, St. Charles, Alton, and Fort Belle sand plants. These individuals may be exposed to elevated health risks from dredging operations. In addition, new sensitive receptors may be exposed to DPM from dredges and tugs operating in locations that had not been dredged previously. As discussed above, any exposure of these receptors or those nearest the Washington, St. Charles, Alton, and Fort Belle sand plants would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). Moreover, DPM concentrations generated by dredging operations would dissipate as a function of distance and would be relatively low at the nearest residence, which is 370 feet from the Washington (Rau) facility.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, DPM would not increase at alternate source locations and no related increased health risks would occur at sensitive receptors from exposure to DPMs.

4.14.3.4 Greenhouse Gas Emissions Resulting in Global Climate Change

All Segments

As shown in Table 4.14-6, the majority of GHG emissions generated by the Proposed Action would occur in the St. Joseph and St. Charles segments. However, because GHGs accumulate in the atmosphere and affect climate change on a global scale, the Proposed Action is evaluated as a whole rather than on a segment-by-segment basis.

Total GHG emissions produced by dredging operations in the LOMR under the Proposed Action are estimated at 78,834 metric tons of CO_2e per year (Table 4.14-6). GHG emissions from construction

activities are expected to generate an additional 8,430 metric tons. Calculating construction emissions over the 5-year permit lifetime results in 80,520 metric tons of CO_2e per year under the Proposed Action—an increase of 47,616 metric tons over existing conditions. This is equivalent to adding approximately 31,744 typical passenger vehicles to the road (USEPA 2009).

Table 4.14-6 Summary of Greenhouse Gas Emissions from Dredging in the Lower Missouri River under the Proposed Action and Alternatives (metric tons/year CO_2e)

	Segment					
	St. Joseph	**Kansas City**	**Waverly**	**Jefferson City**	**St. Charles**	**Total**
Proposed Action						
Emissions – Proposed Action	9,423	14,721	3,686	10,619	40,385	**78,834**
Emissions – existing conditions	1,624	8,297	2,450	6,493	14,039	**32,904**
Proposed Action minus existing conditions	+7,799	+6,423	+1,236	+4,126	+26,345	**+45,930**
No-Action Alternative						
Emissions – No Action Alternative	0	0	0	0	0	**0**
Emissions – existing conditions	1,624	8,297	2,450	6,493	14,039	**32,904**
No Action Alternative minus existing conditions	-1,624	-8,297	-2,450	-6,493	-14,039	**-32,904**
Alternative A						
Emissions – Alternative A	3,864	1,607	3,219	1,573	3,298	**13,560**
Emissions – existing conditions	1,624	8,297	2,450	6,493	14,039	**32,904**
Alternative A minus existing conditions	+2,239	-6,691	+769	-4,920	-10,741	**-19,344**
Alternative B						
Emissions – Alternative B	9,843	3,615	7,277	3,586	7,405	**31,726**
Emissions – existing conditions	1,624	8,297	2,450	6,493	14,039	**32,904**
Alternative B minus existing conditions	+8,219	-4,682	+4,827	-2,907	-6,635	**-1,178**
Alternative C						
Emissions – Alternative C	1,693	10,946	2,724	6,358	14,821	**36,542**
Emissions – existing conditions	1,624	8,297	2,450	6,493	14,039	**32,904**
Alternative C minus existing conditions	+69	+2,648	+274	-134	+781	**+3,638**

Notes:

CO_2e = Carbon dioxide equivalent.

GHG emissions from construction activities are expected to generate 8,430 metric tons of emissions separate from GHG emissions shown in this table.

Presented in metric tons.

As previously noted, GHG emissions tend to accumulate in the atmosphere because of their relatively long lifespan. Consequently, their impact on climate change is mostly independent of the point of emission. In other words, GHG emissions are more appropriately evaluated on a regional, state, or even national scale than at an individual project level. Further, it is unlikely that the GHGs emitted under the Proposed Action would cause an individually discernible impact on global climate change.

Alternate Sources

Alternate sources would not be required under the Proposed Action. Therefore, no contributions to GHG emissions would occur.

4.14.4 No Action Alternative

4.14.4.1 Construction Emissions That Exceed Thresholds

All Segments

Because no new dredging-related construction would occur in any segment under the No Action Alternative, no emissions from new dredging-related construction would occur.

Alternate Sources

As discussed in Section 4.14.2.6, limited information is available on the locations and types of dredging or mining that would replace sand and gravel supplies obtained from the LOMR. The basis for the following qualitative analysis is assumptions about existing dredging and mining locations and operations that could replace the current demand supplied through dredging in the LOMR.

As discussed in Chapter 2, the capacity of alternate sources in the market area are expected to be sufficient in the short term to replace the sand and gravel currently provided through dredging in the LOMR. However, the available capacity of alternate sources is dependent on several factors that are difficult to estimate. Although it is unlikely that new mining operations would be constructed in the near future, the variability of market supply and demand and the status of existing alternate sources may result in an immediate need for additional or expanded mining facilities. In addition, preparation for development of new, long-term alternate sources may result in minor amounts of construction and site preparation activities within the next 5 years.

If new sand and gravel facilities are constructed or expanded as a result of the No Action Alternative, it is likely that emissions would be similar to those presented in Tables 4.14-1 and 4.14-2, per facility. These emissions would be temporary and would cease when construction activities are completed. As shown in Tables 4.14-1 and 4.14-2, emissions generated by construction of one facility would be below the federal *de minimis* thresholds. However, if multiple facilities, or facilities larger than those analyzed in Tables 4.15-1 and 4.14-2, were constructed simultaneously within the same region, emissions could exceed the *de minimis* thresholds. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.4.2 Operations Emissions That Exceed Thresholds

All Segments

Under the No Action Alternative, commercial dredging in the LOMR would cease, and no dredging-related emissions would be generated. Implementation of the No Action Alternative therefore would result in a 100 percent decrease in dredging-related emissions on the LOMR compared to existing conditions. As such, the No Action Alternative would improve air quality in all river segments.

Alternate Sources

As shown in Figure 2.9-1, multiple locations for alternate sources of sand and gravel have been identified throughout Illinois, Kansas, and Missouri. In these states, several counties are classified as federal nonattainment and maintenance areas. Because replacement sand and gravel most likely would be obtained from sources closest to the existing demand centers along the LOMR, a 25-mile radius was used to identify nonattainment counties most likely to experience increased production from alternate sources. These counties and their nonattainment status are:

- Illinois
  - Ozone nonattainment: Jersey, Madison, Monroe, and St. Clair Counties; and
  - PM_{10} maintenance: the portion of Madison County near Granite City.

- Missouri
  - Ozone nonattainment: Franklin, Jefferson, St. Charles, and St. Louis Counties; and
  - CO maintenance: the portion of St. Louis County between I-270 and the Mississippi River.

To the extent that sand and gravel production shifts to locations in these counties, increased dredging activities may contribute to existing violations of the NAAQS. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.4.3 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

All Segments

No new dredging-related construction or commercial dredging operations would occur in any segment. Therefore, DPM in the atmosphere would decrease, and air quality would improve.

Alternate Sources

If sand and gravel operations at alternate source locations increase to meet local demand, emissions of DPM also would increase. The increased production likely would elevate DPM concentrations in the immediate area of operations. Sensitive receptors within 1,000 feet of these sources may be exposed to elevated health risks from sand and gravel operations. While many alternate sources may experience increased dredging or mining only until new long-term operations could be developed, some locations could experience long-term increases in production. Without detailed information on the locations of new and existing alternate sources, or on the location of sensitive receptors and the length of dredging operations, it is difficult to determine whether DPM concentrations would result in adverse health effects.

4.14.4.4 Greenhouse Gas Emissions Resulting in Global Climate Change

All Segments

No new dredging-related construction or commercial dredging operations would occur in any segment. Therefore, no contributions to GHG emissions in the atmosphere would occur.

Alternate Sources

The amount of GHG emissions generated by shifting sand and gravel production to alternate sources is largely dependent on the type of equipment that would be used to dredge or mine the material. As discussed in Chapter 2, the equipment required for dredging along the Mississippi and Kansas Rivers is similar to the equipment currently used on the LOMR, except that dredged material is not transported via barges and tugs on the Kansas River. Assuming that other fleet characteristics (for example, engine type, year, and horsepower) are similar to those on the LOMR, dredging emissions generated by shifting production to the Mississippi and Kansas Rivers likely would be less than emissions generated by existing equipment on the LOMR because no tugs would be used on the Kansas River. However, if material extracted from the Mississippi and Kansas Rivers must be hauled farther than materials dredged from the LOMR, total GHG emissions generated by these sources under the No Action Alternative may be greater than emissions produced under existing conditions.

Open-pit and instream mining operations typically do not involve the use of tugboats. Consequently, shifting production to land-based sources may result in a reduction in GHG emissions generated by dredging equipment relative to existing conditions. However, it is difficult to determine whether total emissions produced by these sources would be lower than emissions produced under existing conditions. As shown in Appendix D, tugboats are a more polluting transport on a pound-per-pound basis than haul trucks. If shipping distances do not change as a result of shifting production, GHG emissions would be lower from alternate sources. If shipping distances increase, GHG emissions produced by hauling sand and gravel would be higher. An increase in shipping distance may negate any reduction in GHG emissions achieved from not operating tugboats.

Based on the analysis above, GHG emissions produced under the No Action Alternative would likely be similar to emissions generated under existing conditions but may be slightly higher or lower depending on the type of alternate source and the changes in shipping patterns. If GHG emissions increase under the No Action Alternative as a result of additional shipping distances, the emissions most likely would be minor and would not cause an individually discernible impact on global climate change. This impact is not considered adverse.

4.14.5 Alternative A

Although Alternative A would increase current dredging operations in the St. Joseph segment and decrease operations in all other segments, total dredging for the combined segments would be reduced. Alternate sources would be required to meet the demand of local communities. The air

quality and climate change impacts of the alternate sources under Alternative A would be similar to those described for the No Action Alternative. Potential impacts related to alternate sources would be less under Alternative A, however, because less material would be needed from alternate sources.

4.14.5.1 Construction Emissions That Exceed Thresholds

St. Joseph, Waverly, and Jefferson City Segments

No new onshore facilities or dredging-related construction is expected to occur in the St. Joseph, Waverly, or Jefferson City segment; consequently, no construction emissions would occur.

Kansas City Segment

Under Alternative A, The Master's Dredging Company likely would construct a new sand plant (Master's–Waldron) in Platte County. Emissions generated by construction activities would be similar to those presented in Table 4.14-1. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-1, construction of the Waldron sand plant would not exceed the federal *de minimis* thresholds. This impact is not considered adverse.

St. Charles Segment

Under Alternative A, the Edward N. Rau Contractor Company likely would construct a new sand plant (Rau–Washington) in Franklin County. Emissions generated by construction would be similar to those presented in Table 4.14-2. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-2, construction of the Washington sand plant would not exceed the federal *de minimis* thresholds. This impact is not considered adverse.

Alternate Sources

To the extent that Alternative A results in construction of new or expanded facilities, potential emissions would be similar to those presented in Tables 4.14-1 and 4.14-2. If multiple facilities, or facilities larger than those analyzed in Tables 4-15.1 and 4.14-2, are constructed simultaneously within the same region, emissions could exceed the *de minimis* thresholds. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.5.2 Operations Emissions That Exceed Thresholds

St. Joseph, Kansas City, Waverly, and Jefferson City Segments

As previously noted, the St. Charles segment is the only segment in the Project area with counties classified as nonattainment areas with regard to the NAAQS. Consequently, a conformity analysis is required only for the St. Charles segment.

St. Charles Segment

Total emissions generated by dredging in the LOMR under Alternative A in Franklin, Madison, St. Charles, and St. Louis Counties are presented in Table 4.14-7. The difference in emissions from existing conditions is compared to the federal *de minimis* thresholds. As shown in Table 4.14-7, implementation of Alternative A would not exceed *de minimis* thresholds.

Alternate Sources

Alternative A would result in an increase in dredging and processing at alternate source locations at existing facilities in the short term and (potentially) at new facilities in the long term. As shown in Figure 2.9-1, multiple locations for alternate sources of sand and gravel have been identified throughout Illinois, Kansas, and Missouri. In these states, several counties are classified as federal nonattainment and maintenance areas. Because replacement sand and gravel most likely would be obtained from sources closest to the existing demand centers along the LOMR, a 25-mile radius was used to identify nonattainment counties most likely to experience increased production from alternate sources.

Table 4.14-7 Conformity Analysis for Alternative A[a] (tons/year)

Counties Classified as Nonattainment	VOC	NO_X
Franklin County		
Emissions – Alternative A[b,c]	1.85	22.38
Emissions – existing conditions	0.72	9.50
Alternative A minus existing conditions[d]	+1.13	+12.88
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	609	1,465
Adverse effect?	No	No
Madison County		
Emissions – Alternative A[b]	0.18	2.84
Emissions – existing conditions	0.84	13.13

Table 4.14-7 Conformity Analysis for Alternative A[a] (tons/year)

Alternative A minus existing conditions[d]	-0.66	-10.30
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	1,647	2,196
Adverse effect?	No	No
St. Charles County		
Emissions – Alternative A[b]	0.45	8.57
Emissions – existing conditions	1.89	36.66
Alternative A minus existing conditions[d]	-1.44	-28.09
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	1,365	2,804
Adverse effect?	No	No
St. Louis County		
Emissions – Alternative A[b]	1.06	20.36
Emissions – existing conditions	5.12	95.90
Alternative A minus existing conditions[d]	-4.06	-75.54
St. Louis County (continued)		
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	6,012	6,486
Adverse effect?	No	No

Notes:

VOC = Volatile organic compounds.

NO_X = Nitrogen dioxide.

[a] Operations of sand plants may generate additional emissions of NO_X and VOC. However, any emissions were assumed to be negligible and would not affect the conformity determination.

[b] Represents sum total of emissions generated from dredging, materials-handling, and hauling sand and gravel.

[c] Because construction of an Edward N. Rau Contractor Company sand plant would occur concurrently with dredging activities, emissions generated from construction have been included in the total. Note that these emissions would occur only during 1 year of the 5-year permit period.

[d] Values may not match as a result of rounding.

Source: Appendix D.

To the extent that sand and gravel production shifts to locations in these counties, increased dredging activities may contribute to existing violations of the NAAQS. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.5.3 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

St. Joseph Segment

Table 4.14-5 indicates that implementation of Alternative A would generate 2.23 additional tons/year of DPM relative to existing conditions in the St. Joseph segment. This increased production likely would result in elevated pollutant concentrations near the sources of DPM. As discussed above, limited information on site-specific conditions prevents determination of the exact concentrations.

Under Alternative A, it is likely that dredging may expand to new areas to accommodate the increased amount of material permitted in this segment. Sensitive receptors in these areas that currently are not exposed to dredging activities could be exposed to DPM from dredges and tugboats.

Although DPM concentrations in the St. Joseph segment are expected to increase under Alternative A, dredging activities would be permitted for only 5 years. If activities would continue beyond this period, a subsequent environmental analysis would need to be conducted. Any exposure to increased concentrations of DPM would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). In addition, elevated DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be even lower at the closest sensitive land uses. Consequently, Alternative A is not anticipated to expose sensitive receptors to elevated heath risks in the Waverly segment.

Kansas City Segment

Table 4.14-5 indicates that implementation of Alternative A would generate 12.43 fewer tons/year of DPM relative to existing conditions in the Kansas City segment. It therefore is logical to assume that DPM concentrations in the Kansas City segment would be reduced. This is an air quality benefit. Because permitted volumes are constrained in the Kansas City segment under Alternative A, it is not likely that dredging activities would expand to new locations. Consequently, Alternative A is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the Kansas City segment. This impact is not considered adverse.

Waverly Segment

Table 4.14-5 indicates that implementation of Alternative A would generate 0.51 additional tons/year of DPM relative to existing conditions in the Waverly segment. Because this increase is negligible compared to existing emissions, it is unlikely that DPM concentrations would increase substantially. Consequently, there is no potential for sensitive receptors nearest the Lexington and Carrollton facilities to be exposed to elevated health risks from dredging operations.

Under Alternative A, dredging may expand to new areas to accommodate the increased amount of material permitted in this segment. Sensitive receptors in these areas that are not currently exposed to dredging activities could be exposed to DPM from dredges and tugboats. However, any new exposure to DPM would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). In addition, elevated DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be even lower at the closest sensitive land uses. Consequently, Alternative A is not anticipated to expose sensitive receptors to elevated heath risks in the Waverly segment. This impact is not considered adverse.

Jefferson City Segment

Table 4.14-5 indicates that implementation of Alternative A would generate 6.92 fewer tons/year of DPM relative to existing conditions in the Jefferson City segment. It therefore is logical to assume that DPM concentrations in the Jefferson City segment would be reduced. This is an air quality benefit. Because permitted volumes are constrained in the Jefferson City segment under Alternative A, it is not likely that dredging activities would expand to new locations. Consequently, Alternative A is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the Jefferson City segment. This impact is not considered adverse.

St. Charles Segment

Table 4.14-5 indicates that implementation of Alternative A would generate 12.80 fewer tons/year of DPM relative to existing conditions in the St. Charles segment. It therefore is logical to assume that DPM concentrations in the St. Charles segment would be reduced. This is an air quality benefit. Because permitted volumes are constrained in this segment under Alternative A, it is not likely that dredging activities would expand to new locations. Consequently, Alternative A is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the St. Charles segment. This impact is not considered adverse.

If sand and gravel operations at alternate source locations increase in order to meet local demand, emissions of DPM also would increase. This increased production would likely elevate DPM concentrations in the immediate dredging or mining area. Sensitive receptors within 1,000 feet of these sources therefore may be exposed to elevated health risks. While it is likely that many alternate sources would be dredged or mined only until new long-term operations could be developed, some locations could be mined or dredged permanently. Without detailed information on the location of new and existing alternate sources, or on the location of sensitive receptors and the length of dredging operations, it is difficult to determine whether DPM concentrations would result in adverse health effects. Consequently, this is considered a potentially adverse effect.

4.14.5.4 Greenhouse Gas Emissions Resulting in Global Climate Change

All Segments

As shown in Table 4.14-6, the majority of GHG emissions generated under Alternative A would occur in the St. Joseph, Waverly, and St. Charles segments. However, because GHGs accumulate in the atmosphere and affect climate change on a global scale, Alternative A must be evaluated on a Project level rather than on a segment-by-segment basis.

Total GHG emissions produced by dredging operations in the LOMR are estimated at 13,560 metric tons of CO_2e per year. GHG emissions from construction activities are expected to generate an additional 8,430 metric tons. Amortizing the construction emissions over the 5-year permit lifetime results in 15,246 metric tons of CO_2e per year under Alternative A. This is a reduction of approximately 17,658 metric tons/year relative to existing conditions.

Alternate Sources

Additional GHG emissions would be generated by increased production of sand and gravel from alternate sources. Assuming that GHG emissions generated by these sources would be similar to emissions produced on the LOMR on a per-ton basis, removal of 4.71 million tons of sand from alternate source locations would generate approximately 29,000 metric tons of CO_2e per year. When combined with emissions generated along the LOMR and compared to existing conditions, Alternative A is expected to result in an increase of 11,506 metric tons of GHGs per year. This is equivalent to adding approximately 7,671 typical passenger vehicles to the road (USEPA 2009).

Because GHG emissions tend to accumulate globally, it is unlikely that the GHGs emitted under Alternative A would cause an individually discernible impact on global climate change. This impact is not considered adverse.

4.14.6 Alternative B

Alternative B would increase current dredging operations in the St. Joseph and Waverly segments and would decrease operations in all other segments; the total volume of dredging for the combined segments would be reduced. Alternate sources therefore would be required to meet the local demand for sand and gravel. The air quality and climate change impacts of the alternate sources under Alternative B were assumed to be similar to those described for the No Action Alternative; however, potential impacts would be less under Alternative B because less material would be needed from alternate sources.

4.14.6.1 Construction Emissions That Exceed Thresholds

St. Joseph, Waverly, and Jefferson City Segments

No new onshore facilities or dredging-related construction is expected to occur in the St. Joseph, Waverly, or Jefferson City segment. Consequently, no emissions from construction would occur.

Kansas City Segment

Under Alternative B, The Master's Dredging Company likely would construct a new sand plant (Master's–Waldron) in Platte County. Emissions generated by construction activities would be similar to those presented in Table 4.14-1. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-1, construction of the Waldron sand plant would not exceed the federal *de minimis* thresholds.

St. Charles Segment

Under Alternative B, the Edward N. Rau Contractor Company likely would construct a new sand plant (Rau–Washington) in Franklin County. Emissions generated by construction would be similar to those presented in Table 4.14-2. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-2, construction of the Washington sand plant would not exceed the federal *de minimis* thresholds.

Alternate Sources

To the extent that Alternative B results in construction of new or expanded facilities, potential emissions would be similar to those presented in Tables 4.14-1 and 4.14-2. If multiple facilities, or facilities larger than those analyzed in Tables 4-15.1 and 4.14-2, are constructed simultaneously within the same region, emissions could exceed the *de minimis* thresholds. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.6.2 Operations Emissions That Exceed Thresholds

St. Joseph, Kansas City, Waverly, and Jefferson City Segments

As previously noted, the St. Charles segment is the only segment in the Project area with counties classified as nonattainment areas with regard to the NAAQS. Consequently, a conformity analysis is required only for the St. Charles segment.

St. Charles Segment

Total emissions generated under Alternative B in Franklin, Madison, St. Charles, and St. Louis Counties are presented in Table 4.14-8. The difference in emissions from existing conditions is compared to the federal *de minimis* thresholds. As shown in Table 4.14-8, implementation of Alternative B would not exceed *de minimis* thresholds. This impact is not considered adverse.

Table 4.14-8 Conformity Analysis for Alternative B[a] (tons/year)

Counties Classified as Nonattainment	VOC	NO_X
Franklin County		
Emissions – Alternative B[b,c]	2.23	27.89
Emissions – existing conditions	0.72	9.50
Alternative B minus existing conditions[d]	+1.51	+18.39
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	609	1,465
Adverse effect?	No	No
Madison County		
Emissions – Alternative B[b]	0.41	6.44
Emissions – existing conditions	0.84	13.13
Alternative B minus existing conditions[d]	-0.43	-6.70
Federal *de minimis* threshold	100	100

Table 4.14-8 Conformity Analysis for Alternative B[a] (tons/year)

Regional significance threshold (10% of regional emissions inventory)	1,647	2,196
Adverse effect?	No	No
St. Charles County		
Emissions – Alternative B[b]	1.02	19.46
Emissions – existing conditions	1.89	36.66
Alternative B minus existing conditions[d]	-0.86	-17.20
Federal *de minimis* threshold	100	100
St. Charles County (continued)		
Regional significance threshold (10% of regional emissions inventory)	1,365	2,804
Adverse effect?	No	No
St. Louis County		
Emissions – Alternative B[b]	2.40	46.22
Emissions – existing conditions	5.12	95.90
Alternative B minus existing conditions[d]	-2.72	-49.68
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	6,012	6,486
Adverse effect?	No	No

Notes:

VOC = Volatile organic compounds.

NO_X = Nitrogen dioxide.

[a] Operations of sand plants may generate additional emissions of NO_X and VOC. However, any emissions were assumed to be negligible and would not affect the conformity determination.

[b] Represents sum total of emissions generated from dredging, materials-handling, and hauling sand and gravel.

[c] Because construction of an Edward N. Rau Contractor Company sand plant would occur concurrently with dredging activities, emissions generated from construction have been included in the total. Note that these emissions would occur only during 1 year of the 5-year permit period.

[d] Values may not match as a result of rounding.

Source: Appendix D.

Alternate Sources

Alternative B would result in an increase in dredging and processing at alternate source locations at existing facilities in the short term and (potentially) at new facilities in the long term. As shown in Figure 2.9-1, multiple locations for alternate sources of sand and gravel have been identified throughout Illinois, Kansas, and Missouri. In these states, several counties are classified as federal nonattainment

and maintenance areas. Because replacement sand and gravel most likely would be obtained from sources closest to the existing demand centers along the LOMR, a 25-mile radius was used to identify nonattainment counties most likely to experience increased production from alternate sources.

To the extent that sand and gravel production shifts to locations in these counties, increased dredging activities may contribute to existing violations of the NAAQS. In the absence of specific information on the number and locations of facilities to be constructed, this impact is considered potentially adverse.

4.14.6.3 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

St. Joseph Segment

Table 4.14-5 indicates that implementation of Alternative B would generate 9.48 additional tons/year of DPM relative to existing conditions in the St. Joseph segment. This increased production likely would result in elevated pollutant concentrations near the sources of DPM, although the exact concentration is unknown.

Under Alternative B, it is likely that dredging may expand to new areas to accommodate the increased amount of material permitted in this segment. Sensitive receptors in these areas that currently are not exposed to dredging activities could be exposed to DPM from dredges and tugboats.

Although DPM concentrations are expected to increase under Alternative B, dredging activities would be permitted for only 5 years. If activities would continue beyond this period, a subsequent environmental analysis would need to be conducted. Any exposure to increased concentrations of DPM would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). In addition, elevated DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be even lower at the closest sensitive land uses. Consequently, Alternative B is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the St. Joseph segment.

Kansas City Segment

Table 4.14-5 indicates that implementation of Alternative B would generate 9.02 fewer tons/year of DPM relative to existing conditions. It therefore is logical to assume that DPM concentrations in the Kansas City segment would be reduced. This is an air quality benefit. Because permitted volumes are

constrained under this alternative, it is not likely that dredging activities would expand to new locations. Consequently, Alternative B is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the Kansas City segment. This impact is not considered adverse.

Waverly Segment

Table 4.14-5 indicates that implementation of Alternative B would generate 5.29 additional tons/year of DPM relative to existing conditions. This increased production likely would result in elevated pollutant concentrations near the sources of DPM, although the exact concentration is unknown.

Under Alternative B, it is likely that dredging may expand to new areas to accommodate the increased amount of material permitted in this segment. Sensitive receptors in these areas that currently are not exposed to dredging activities could be exposed to DPM from dredges and tugboats.

Although DPM concentrations are expected to increase as a result of the Proposed Action, dredging activities would be permitted for only 5 years. If activities would continue beyond this period, a subsequent environmental analysis would need to be conducted. Any exposure to increased concentrations of DPM would be temporary and well below the recommended analysis duration for cancer risk assessments (20 years, recommended by the USEPA; and 70 years, recommended by the OEHHA). In addition, elevated DPM concentrations generated by dredging equipment would dissipate as a function of distance and therefore would be even lower at the closest sensitive land uses. Consequently, Alternative B is not anticipated to expose sensitive receptors to elevated heath risks from DPM in the Waverly segment. This impact is not considered adverse.

Jefferson City Segment

Table 4.14-5 indicates that implementation of Alternative B would generate 4.02 fewer tons/year of DPM relative to existing conditions. It therefore is logical to assume that DPM concentrations in the Jefferson City segment would be reduced. This is an air quality benefit. Because permitted volumes are constrained under this alternative, it is not likely that dredging activities would expand to new locations. Consequently, Alternative B is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the Jefferson City segment. This impact is not considered adverse.

St. Charles Segment

Table 4.14-5 indicates that implementation of Alternative B would generate 7.66 fewer tons/year of DPM relative to existing conditions. It therefore is logical to assume that DPM concentrations in the St.

Charles segment would be reduced. This is an air quality benefit. Because permitted volumes are constrained in the St. Charles segment under this alternative, it is not likely that dredging activities would expand to new locations. Consequently, Alternative B is not expected to increase the exposure of sensitive receptors to elevated health risks from DPM in the St. Charles segment. This impact is not considered adverse.

Alternate Sources

If sand and gravel operations at alternate source locations increase in order to meet local demand, emissions of DPM would also increase. This increased production would likely elevate DPM concentrations within the immediate dredging or mining area. Sensitive receptors within 1,000 feet of these sources may therefore be exposed to elevated health risks. While it is likely that many alternate sources would be dredged or mined only until new long-term operations could be developed, some locations could be mined or dredged permanently. Without detailed information on the location of new and existing alternate sources, or on the location of sensitive receptors and the length of dredging operations, it is difficult to determine whether DPM concentrations would result in adverse health effects. Consequently, this is considered a potentially adverse effect.

4.14.6.4 Greenhouse Gas Emissions Resulting in Global Climate Change

All Segments

As shown in Table 4.14-6, the majority of GHG emissions generated under Alternative B would occur in the St. Joseph, Waverly, and St. Charles segments. However, because GHGs accumulate in the atmosphere and affect climate change on a global scale, Alternative B must be evaluated on a Project level, rather than on a segment-by-segment basis.

Total GHG emissions produced by dredging operations in the LOMR are estimated at 31,726 metric tons of CO_2e per year. GHG emissions from construction activities are expected to generate an additional 8,430 metric tons. Amortizing construction emissions over the 5-year permit lifetime results in 33,421 metric tons of CO_2e per year under Alternative B—an increase of approximately 508 metric tons/year relative to existing conditions.

Alternate Sources

Additional GHG emissions would be generated by increased dredging of alternate sources. Assuming that GHG emissions generated by these sources would be similar to emissions produced on the LOMR on a per-ton basis, removal of 1.85 million tons of sand from alternate source locations would generate

approximately 11,600 metric tons of CO_2e per year. When combined with emissions generated along the LOMR and compared to existing conditions, Alternative B is expected to result in an increase of 12,131 metric tons of GHGs per year. This is equivalent to adding approximately 8,087 typical passenger vehicles to the road (USEPA 2009).

Because GHG emissions tend to accumulate globally, it is unlikely that the GHGs emitted under Alternative B would cause an individually discernible impact on global climate change. This impact is not considered adverse.

4.14.7 Alternative C

Although Alternative C would result in minor increases in current dredging operations in all segments of the river, the overall dredging volumes for the combined segments would be maintained. No alternate sources are expected to be required. Similar to the Proposed Action, two new facilities are proposed to meet demand, one in the St. Joseph segment and one in the St. Charles segment. The impacts associated with these facilities were assumed to be the same as described for the Proposed Action.

4.14.7.1 Construction Emissions That Exceed Thresholds

St. Joseph, Waverly, and Jefferson City Segments

No new onshore facilities or dredging-related construction is expected to occur in the St. Joseph, Waverly, or Jefferson City segment. Consequently, no construction emissions would occur.

Kansas City Segment

Under Alternative C, The Master's Dredging Company likely would construct a new sand plant (Master's–Waldron) in Platte County. Emissions generated by construction activities would be similar to those presented in Table 4.14-1. These emissions would be temporary and would cease when construction is complete. As shown in Table 4.14-1, construction of the Waldron sand plant would not exceed the federal *de minimis* thresholds.

St. Charles Segment

Under Alternative C, the Edward N. Rau Contractor Company likely would construct a new sand plant (Rau–Washington) in Franklin County. Emissions generated by construction would be similar to those presented in Table 4.14-2. These emissions would be temporary and would cease when construction

is complete. As shown in Table 4.14-2, construction of the Washington sand plant would not exceed the federal *de minimis* thresholds.

Alternate Sources

Alternative C would not result in new construction at alternate sources of supply. Therefore, no emissions would be associated with new construction at alternate sources under Alternative C.

4.14.7.2 Operations Emissions That Exceed Thresholds

St. Joseph, Kansas City, Waverly, and Jefferson City Segments

As previously noted, the St. Charles segment is the only segment in the Project area with counties classified as nonattainment areas with regard to the NAAQS. Consequently, a conformity analysis is required only for the St. Charles segment.

St. Charles Segment

Total emissions generated under Alternative C in Franklin, Madison, St. Charles, and St. Louis Counties are presented in Table 4.14-9. The difference in emissions from existing conditions is compared to the federal *de minimis* thresholds. As shown in Table 4.14-9, implementation of the Proposed Action would not exceed *de minimis* thresholds. This impact is not considered adverse.

Alternate Sources

Alternative C would not result in expanded dredging or processing at alternate sources. Therefore, no emissions would be associated with expanded dredging or processing at alternate sources under Alternative C.

Table 4.14-9 Conformity Analysis for Alternative C[a] (tons/year)

Counties Classified as Nonattainment	VOC	NO_X
Franklin County		
Emissions – Alternative C[b,c]	3.02	41.59
Emissions – existing conditions	0.72	9.50
Alternative C minus existing conditions[d]	+2.30	+32.09
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	609	1,465
Adverse effect?	No	No

Table 4.14-9 Conformity Analysis for Alternative C[a] (tons/year)

Counties Classified as Nonattainment	VOC	NO_X
Madison County		
Emissions – Alternative C[b]	0.80	12.65
Emissions – existing conditions	0.84	13.13
Alternative C minus existing conditions[d]	-0.04	-0.48
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	1,647	2,196
Adverse effect?	No	No
St. Charles County		
Emissions – Alternative C[b]	0.98	26.40
Emissions – existing conditions	0.55	5.65
Alternative C minus existing conditions[d]	+0.48	+6.18
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	1,365	2,804
Adverse effect?	No	No
St. Louis County		
Emissions – Alternative C[b]	4.72	90.79
Emissions – existing conditions	5.12	95.90
Alternative C minus existing conditions[d]	-0.40	-5.12
Federal *de minimis* threshold	100	100
Regional significance threshold (10% of regional emissions inventory)	6,012	6,486
Adverse effect?	No	No

Notes:

VOC = Volatile organic compounds.

NO_X = Nitrogen dioxide.

[a] Operations of sand plants may generate additional emissions of NO_X and VOC. However, any emissions were assumed to be negligible and would not affect the conformity determination.

[b] Represents sum total of emissions generated from dredging, materials-handling, and hauling sand and gravel.

[c] Because construction of an Edward N. Rau Contractor Company sand plant would occur concurrently with dredging activities, emissions generated from construction have been included in the total. Note that these emissions would occur only during 1 year of the 5-year permit period.

[d] Values may not match as a result of rounding.

Source: Appendix D.

4.14.7.3 Increased Health Risks from Exposure of Sensitive Receptors to Diesel Particulate Matter

St. Joseph Segment

Table 4.14-5 indicates that implementation of Alternative C would generate 0.23 fewer tons/year of DPM relative to existing conditions. It is unlikely that this minor reduction in production would affect DPM concentrations. Because permitted volumes would increase by only 0.94 percent, it also is unlikely that dredging would expand to new locations. Consequently, adverse impacts on sensitive receptors from exposure to DPM nearest the Holliday Sand & Gravel Company sand plant and throughout the segment would be similar to existing conditions.

Kansas City Segment

Table 4.14-5 indicates that implementation of Alternative C would generate 0.96 additional tons/year of DPM relative to existing conditions. It is unlikely that this minor increase in production would affect DPM concentrations. Because permitted volumes would increase by only 0.04 percent, it is unlikely that dredging would expand to new locations. Consequently, there is no potential for sensitive receptors throughout the Kansas City segment to be exposed to elevated health risks from DPM.

Waverly Segment

Table 4.14-5 indicates that implementation of Alternative C would generate 0.17 additional tons/year of DPM relative to existing conditions. It is unlikely that this minor increase in production would affect DPM concentrations. Because permitted volumes would increase by only 0.30 percent, it also is unlikely that dredging would expand to new locations. Consequently, exposure of sensitive receptors to DPM nearest the onshore facility and throughout the segment would be similar to existing conditions.

Jefferson City Segment

Table 4.14-5 indicates that implementation of Alternative C would generate 0.17 fewer tons/year of DPM relative to existing conditions. It is unlikely that this minor reduction in production would affect DPM concentrations. Because permitted volumes would increase by only 0.07 percent, it also is unlikely that dredging would expand to new locations. Consequently, exposure of sensitive receptors to DPM nearest the onshore facility and throughout the segment would be similar to existing conditions.

St. Charles Segment

Table 4.14-5 indicates that implementation of Alternative C would generate 1.58 additional tons/year of DPM relative to existing conditions. It is unlikely that this minor increase in production would affect DPM concentrations. Because permitted volumes would increase by only 0.04 percent, it also is unlikely that dredging would expand to new locations. Consequently, exposure of sensitive receptors to DPM nearest the onshore facility and throughout the segment would be similar to existing conditions.

Alternate Sources

Alternate sources would not be required under Alternative C. Therefore, DPM would not increase at alternate source locations, and no related increased health risks would occur at sensitive receptors from exposure to DPMs.

4.14.7.4 Greenhouse Gas Emissions Resulting in Global Climate Change

All Segments

As shown in Table 4.14-6, the majority of GHG emissions generated by Alternative C would occur in the Kansas City and St. Charles segments. However, because GHGs accumulate in the atmosphere and affect climate change on a global scale, Alternative C must be evaluated on a Project level, rather than on a segment-by-segment basis.

Total GHG emissions produced by dredging operations are estimated at 36,542 metric tons of CO_2e per year (Table 4.14-1). GHG emissions from construction activities are expected to generate an additional 8,430 metric tons. Amortizing the construction emissions over the 5-year permit lifetime results in 38,228 metric tons of CO_2e per year under Alternative C—an increase of 5,324 metric tons over existing conditions. This is equivalent to adding approximately 3,550 typical passenger vehicles to the road (USEPA 2009).

As previously noted, GHG emissions tend to accumulate in the atmosphere because of their relatively long lifespan. As a result, their impact on climate change is mostly independent of the point of emission. In other words, GHG emissions are more appropriately evaluated on a regional, state, or even national scale than on an individual project level. Further, it is unlikely that the GHGs emitted as part of Alternative C would cause an individually discernible impact on global climate change. This impact is not considered adverse.

Alternate Sources

Alternate sources would not be required under Alternative C. Therefore, no contributions to GHG emissions would occur.

4.14.8 Summary of Impacts

Table 4.14-10 contains a summary of potential impacts on air quality and climate change for the Proposed Action and alternatives.

Table 4.14-10 Summary of Potential Impacts for Air Quality and Climate Change

Impact Category	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Construction emissions (volatile organic compounds [VOC], oxides of nitrogen [NO_X], carbon monoxide [CO], and particular matter [PM])	• Minimal direct temporary emissions of VOC, NO_X, CO, and PM in the Kansas City and St. Charles segments from construction of new sand and gravel facilities.	• Direct temporary emissions of VOC, NO_X, CO, and PM in alternate source locations requiring construction or expansion of sand and gravel facilities.	• Minimal direct temporary emissions of VOC, NO_X, CO, and PM in the Kansas City and St. Charles segments from construction of new sand and gravel facilities. • Direct temporary emissions of VOC, NO_X, CO, and PM in alternate source locations requiring construction or expansion of sand and gravel facilities.	• Minimal direct temporary emissions of VOC, NO_X, CO, and PM in the Kansas City and St. Charles segments from construction of new sand and gravel facilities. • Direct temporary emissions of VOC, NO_X, CO, and PM in alternate source locations requiring construction or expansion of sand and gravel facilities.	• Minimal direct temporary emissions of VOC, NO_X, CO, and PM in the Kansas City and St. Charles segments from construction of new sand and gravel facilities.
Conformity	• Long-term direct emissions of NO_X in St. Louis County in excess of federal *de minimis* thresholds.	• Potential long-term direct emissions of NO_X in alternate source locations in excess of federal *de minimis* thresholds.	• Potential long-term direct emissions of NO_X in alternate source locations in excess of federal *de minimis* thresholds.	• Potential long-term direct emissions of NO_X in alternate source locations in excess of federal *de minimis* thresholds.	• No effect beyond those posed by existing conditions.
Diesel particulate matter (DPM)	• Negligible long-term indirect exposure of existing sensitive receptors to DPM from increased dredging activities in all river segments. • Negligible long-term indirect exposure of new sensitive receptors to DPM from increased dredging activities in all river segments.	• Potentially adverse long-term indirect exposure of existing and new sensitive receptors to DPM from increased dredging activities in alternate source locations.	• Negligible long-term indirect exposure of existing and new sensitive receptors to DPM from increased dredging activities in the St. Joseph and Waverly segments. • Potentially adverse long-term indirect exposure of existing and new sensitive receptors to DPM from increased dredging activities in alternate source locations.	• Negligible long-term indirect exposure of existing and new sensitive receptors to DPM from increased dredging activities in the St. Joseph and Waverly segments. • Potentially adverse long-term indirect exposure of existing and new sensitive receptors to DPM from increased dredging activities in alternate source locations.	• No effect beyond those posed by existing conditions.

Table 4.14-10 Summary of Potential Impacts for Air Quality and Climate Change

Impact Category	Proposed Action	No Action Alternative	Alternative A	Alternative B	Alternative C
Greenhouse gas (GHG)	• High long-term direct GHG emissions from dredging of the LOMR. • Temporary direct GHG emission from construction activities.	• Minimal long-term direct GHG emissions from dredging of alternate sources. • Temporary direct GHG emission from construction activities.	• Moderate long-term direct GHG emissions from dredging of the LOMR and alternate sources. • Temporary direct GHG emission from construction activities.	• Moderate long-term direct GHG emissions from dredging of the LOMR and alternate sources. • Temporary direct GHG emission from construction activities.	• Low long-term direct GHG emissions from dredging of the LOMR. • Temporary direct GHG emission from construction activities.

Note: LOMR = Lower Missouri River.

4.14.9 References

4.14.9.1 Printed Literature

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4.14.9.2 Personal Communication

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