CHAPTER 5

Cumulative Impacts

5.1 INTRODUCTION

"Cumulative impacts" are defined as the impact on the environment that results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes the actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR Section1508.7). Chapter 3, Affected Environment presents information about past and present environmental conditions—including future trends, where appropriate. Chapter 4, Environmental Consequences presents the environmental and socioeconomic consequences of implementing the Proposed Action and alternatives described in Chapter 2. This chapter addresses the cumulative impacts of commercial dredging of sand and gravel and other past, present, and reasonably foreseeable future actions.

The cumulative impact analysis chapter is intended to provide a broader, more expansive assessment of potential impacts associated with implementing the Proposed Action and alternatives considering the wide array of other activities, new and ongoing projects, and programs in the Project area and vicinity. In this way, the potential interactions between commercial dredging of sand and gravel and reasonably foreseeable projects and programs can be explored, and any significant adverse or beneficial cumulative impacts can be identified and considered.

The identification of reasonably foreseeable future actions and trends involves some uncertainty, as does the assessment of the level of impacts now and in the future. Many of the future actions and programs depend on funding and authorizations, economic conditions within the Project area, legislative actions at state and federal levels, and the results of ongoing studies and evaluations (e.g., USACE 2007a; NRC 2010; USACE 2009a, 2009b), which introduces further uncertainty. In addition, some of the management programs, such as the 2003 Biological Opinion and the MRRP (2010a) incorporate adaptive management – the adjustments or changes in operation and management made in response to experimental actions and environmental monitoring results.

The cumulative effects analysis is designed to explore the range of potential cumulative impacts, recognizing that uncertainty. As described by the National Research Council (2002), one of the most significant scientific unknowns in the Missouri River ecosystem is how the ecosystem will respond to management actions designed to improve ecological conditions.

5.1.1 Geographic Boundaries and Time Period

Although the geographic and temporal scope of the cumulative effects analysis is broader than the scope of analysis used in Chapter 4 to assess direct and indirect effects, a practical delineation of the spatial and temporal scales was needed for cumulative impacts.

In Chapter 4, the geographic scope included the main channel and floodplain of the Missouri River from RM 0 to RM 498, the most downstream portions of tributaries to the Missouri to the extent that they may be indirectly affected by bed degradation, and the region surrounding the Project Area to the extent that specific resources may be affected by dredging or use of alternate sources of sand and gravel. The cumulative impact analysis includes this entire area, as well as geographic areas beyond, depending on the resources at issue. For example, cumulative impacts for water quality include consideration of the potential impacts on sediment and nutrient contributions in the Mississippi River and Gulf of Mexico (Gulf) as well as the potential cumulative impacts on nutrient contribution to anoxic zones in the Gulf. Similarly, air quality and the effects of GHG emissions on global warming are discussed. The selections of geographic boundaries were based on natural boundaries of the resources of concern.

For the cumulative analysis, a 20-year time frame was evaluated.

5.2 PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS

5.2.1 Past Actions

The Missouri River ecosystem was historically a highly dynamic, highly variable river system; but it experienced a marked ecological transformation during the 20th century. At the beginning of the century, the Missouri River was notorious for large floods, for a sinuous and meandering river channel that moved freely across its floodplain, and for massive sediment transport. Prior to channelization and flow regulation, the lower Missouri River was braided to highly sinuous, a form naturally found in rivers with broad floodplains and heavy sediment loads. The river was characterized by log jams, snags, whirlpools, chutes, bars, cut-off channels, and secondary channels around bars. The main channel

typically had a deep thalweg (the deepest part of the river) that contained the faster-moving flow and a shallower section(s) on one or both sides of the channel.

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

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

Today, the Missouri River is one of the most highly modified and managed rivers in the world. The history of the development of the Missouri River, the reservoir systems, and the BSNP, and the associated impacts on the Missouri River ecosystem are described elsewhere in this document. Because they have been described in detail in many accounts (Galat et al. 1994; NRC 2002; USACE 2009a, 2003; USFWS 2003), they are not discussed further here.

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

5.2.2 Present and Future Actions

The actions under each of the alternatives would influence the long-term efforts associated with the mitigation, restoration and recovery efforts in the LOMR. Many of the current actions and planning efforts in the LOMR focus on assessment of management actions; development of planning alternatives; and development and implementation of mitigation, restoration, and recovery efforts. The goals of many of these initiatives are to implement recovery actions associated with degradation of the river from the past flow management and channelization efforts associated with the Missouri River Mainstem Reservoir System (System) and the BSNP. Regional Sediment Management in the Missouri River Basin by the USACE includes a number of components. It recognizes sediment as a resource and attempts to provide a system-wide approach. It includes USACE activities related to navigation channel maintenance, ecosystem restoration, flood control, hydro system operations, ESA species recovery actions, and regulatory actions (Stark and Boyd 2009).

The following sections provide a summary of relevant actions, programs, and studies that are considered under the cumulative effects analyses. The summary is not intended to be exhaustive but rather to describe the components of the programs that could, along with the Proposed Action or alternatives, result in potential cumulative impacts in the LOMR. Programs that are considered for the cumulative effects assessment include flow management under the Master Manual; infrastructure development and management under the BSNP; the MRRP and the various components considered under this effort, including the 2003 Biological Opinion, the MRERP, and the Missouri River Fish and Wildlife Mitigation Project; and the Big Muddy National Fish and Wildlife Refuge expansion. Other ongoing studies and evaluations that may affect sediment, flow, and habitat management actions in the LOMR include the MRAPS and the Missouri River Bed Degradation Feasibility Study.

5.2.2.1 Master Water Control Manual

The Master Manual was prepared as directed in the USACE Water Management Regulation (ER 1110-2-240), which prescribes the policies and procedures to be followed by the USACE in carrying out water management activities—including establishment and updating of water control plans. The Master Manual includes provisions for adaptive management measures, as implemented under the Annual Operating Plan (AOP). An AOP is prepared each year, based on the water control criteria contained in the Master Manual, in order to detail reservoir regulation of the System for the current operating year. Because the System is so large, it can respond to extreme conditions of longer than 1-year duration; therefore, the AOP also provides an outlook for planning purposes in future years (USACE 2006).

In March 2006, the Master Manual was revised to include technical criteria for a spring pulse to address requirements established under the terms of the 2003 Biological Opinion for bi-modal spring pulse releases from Gavins Point Dam to benefit the listed pallid sturgeon. The *Missouri River Mainstem Reservoir System 2009–2010 Annual Operating Plan* (2009–2010 AOP) provides for spring pulses and also includes safeguards to minimize the risk of flooding associated with the spring pulses. Spring pulses may be reduced or eliminated when downstream flow limits are reached (USACE 2009b). The goal of the spring pulses is to implement a more natural flow regimen to benefit native fish and wildlife while seeking balance with social, economic, and cultural resources (Reinig and Roth 2010).

The 2009–2010 AOP also includes provisions for unbalancing the Fort Peck, Garrison, and Oahe Reservoirs for the first time under the revised Master Manual, to benefit the endangered species and reservoir fishery. The criteria for unbalancing are based on recommendations provided by the Missouri River Association of States and Tribes, the Missouri River Natural Resources Committee, and the USFWS to benefit reservoir fisheries and the federally endangered interior least tern and federally threatened piping plover. The unbalancing of the three reservoirs will be transitioned to in 2010 and will be implemented beginning in 2011 (USACE 2009b).

Given the adaptive management associated with the AOP and flow management, potential cumulative effects of the flow regime management in association with the Proposed Action and alternatives are difficult to determine. If operational changes resulted in significant changes in flow management, additional, as yet unidentified cumulative effects could be associated with the changes in the flow regime. However, any significant change to the Master Manual and associated operations would require an assessment of impacts, including cumulative impacts, prior to implementation of a significantly modified flow regime.

5.2.2.2 Bank Stabilization and Navigation Program

The BSNP structures (i.e., revetments, dikes, and levees) were constructed to restrict lateral movement of the river channel with the intent of maintaining a navigation channel (see also Section 3.2.4.2). Construction and maintenance of the BSNP have resulted in channelization of the river and straighter and faster flows, leading to a reduced amount of sediment dispersal and reduced accumulation in the channel bottom. These factors have contributed to lowering of the river bed and lowering of the average water surface elevations with associated main channel and tributary river bed degradation. The river bed degradation results in and contributes to a variety of impacts, such as river bank erosion; tributary headcutting; loss of shoreline habitat; and impacts to infrastructure, such as scouring of bridge abutments and exposure of water withdrawal structures above the water line during low-flow periods

(see also Section 3.4). Channelization and reduction in sediments result in fewer sand bars and floodplain areas and the associated shoreline vegetation and fish and wildlife habitats. The contribution of each factor and the extent of river bed degradation can vary, resulting in different impacts at different locations on the river as discussed in Chapter 4. These factors can lead to cumulative effects in the LOMR in terms of the interrelationships and incremental impacts accruing over time and geographically within the river system.

Over the last 20 years, the USACE has performed channel maintenance dredging approximately five times. The quantity dredged with each activity was between 30,000 and 200,000 tons; the material was moved less than 500 feet within the high banks of the river and resulted in no net gain or loss of sediments. Current plans are to maintain BSNP structures to the existing heights. The USACE anticipates that, without evidence of a surplus of sediment in the river and river aggradation, future infrastructure repair or replacement projects will not be constructed with material dredged out of the river, nor will future levees be constructed with material dredged out of the river (USACE 2010d).

5.2.2.3 2003 Biological Opinion

As stated in Section 3.6.2.2, the USACE entered into official Section 7 consultation under the ESA with the USFWS in 1989. Various factors and further consultation led to issuance of a Biological Opinion in 2000, with an amendment in 2003 (see Section 3.2.6.1). The 2003 Biological Opinion led to implementation of specific mitigation efforts, as discussed below.

5.2.2.4 Missouri River Recovery Program

The collective set of actions being taken in response to the 2003 Biological Opinion and other restoration program elements is known as the MRRP. The purposes of the MRRP, initiated in 2006, are to restore a portion of the Missouri River ecosystem and habitat for fish and wildlife, while maintaining the congressionally authorized uses of the river, and to implement actions to accomplish Missouri River ecosystem recovery goals in coordination and collaboration with agency partners and stakeholders (MRRP 2010a, Reinig and Roth 2010).

The key recovery goals of the MRRP are habitat creation, hatchery support, flow modification, science program, and public involvement (see Section 3.2.6.1). The MRRP consists of various components (Figure 5.2-1), including the USACE Record of Decision related to the 2003 Biological Opinion and the Master Manual; the Missouri River Fish and Wildlife Mitigation Project; and the 2007 Water Resources Development Act, which includes the MRERP and the Missouri River Recovery Implementation

Committee (MRRIC). Each of these programs includes goals and requirements associated with recovery of the Missouri River.

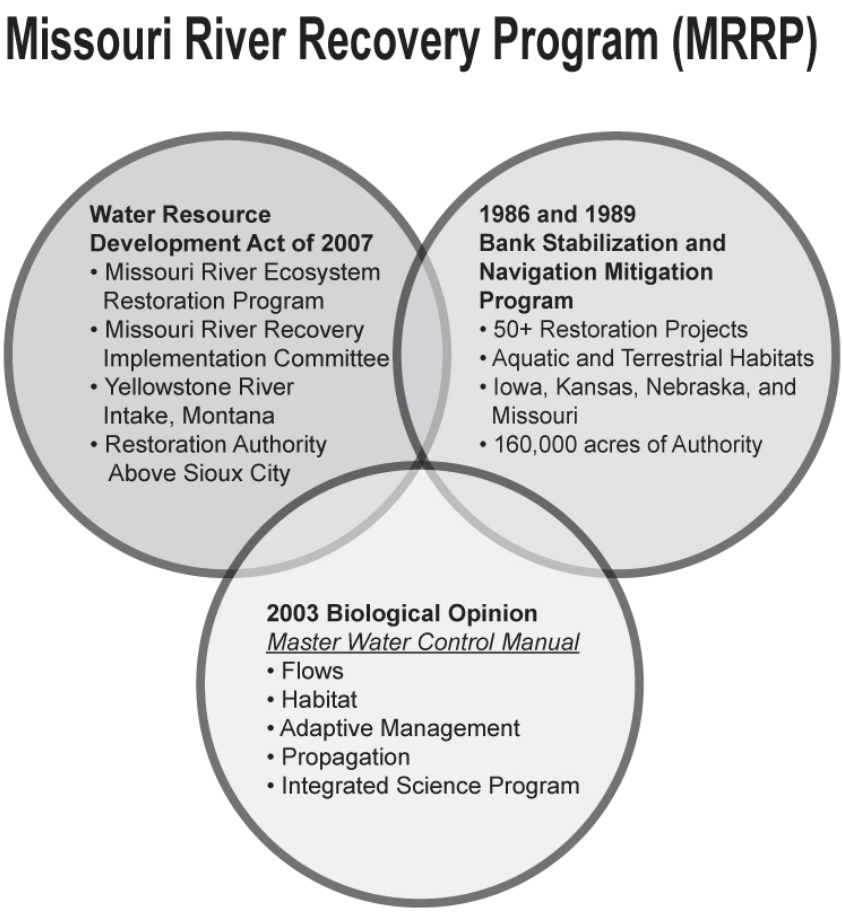


Figure 5.2-1 USACE Programs and Authorizations Embodied in the Missouri River Recovery Program

The 2003 Biological Opinion mandates restoration of 20,000 acres of shallow-water habitat by 2020. Shallow-water habitat is being created by a variety of mechanisms, including widening of the main river channel, restoring old chutes, and restoring abandoned side channels (Reinig and Roth 2010). Designs have stipulated that most sediment excavated to create shallow-water habitat will be placed directly in the river or will be side cast to eventually be delivered to the river as banks erode (Jacobson, Blevins, and Bitner 2009).

Recently, the Missouri Clean Water Commission raised concerns about the effect on water quality from the planned erosion and the construction practice of placing excavated material directly into the river. On March 12, 2008, the Missouri Clean Water Commission ordered the immediate cessation of the

discharge of sediment and topsoil into the waters of Missouri by the USACE in connection with all Missouri River shallow-water habitat construction projects. The USACE is addressing those concerns by contaminant and nutrient testing of bank material and study of the effect of the material on the river morphology and ecology. In addition, the USACE contracted with the National Research Council to address the topics of Missouri River sediment, its physical and biological importance, relationship to water quality and nutrient loading, how its dynamics and roles in the river system have changed over time, and its roles in contemporary river management decisions. Completed between the publication of the DEIS and the FEIS, key conclusions of the NRC (2010) Report are integrated in the following sections

5.2.2.5 Missouri River Ecosystem Restoration Plan

As discussed in Section 3.2.6.6, the MRERP will identify the actions required to: (1) mitigate losses of aquatic and terrestrial habitat; (2) recover federally listed species under the ESA; and (3) restore the ecosystem to prevent further declines among other native species (MRRP 2010a). The MRERP will consider ongoing programs and actions related to mitigation, recovery, and restoration; identify priorities for mitigation, recovery, and restoration throughout the Missouri River basin; outline a long-term adaptive management approach for restoration of the river; and guide future program- and site-specific action development to ensure that the overall goals of MRERP are met in the long term (USFWS 2010). The results of the MRERP could guide and change future mitigation and actions within the LOMR, thus influencing future actions and cumulative effects within the LOMR.

Potential exceptions of activities anticipated at this time that would result in changes to the channel configuration and the sediment loads of the river, and related cumulative effects, are associated with the MRRP mitigation efforts and potential management outcomes as a result of the Degradation Study. The MRRP estimates that between 400 and 520 million tons of sediment could be reintroduced to the Missouri River over the next 25 years, primarily from sediments currently stabilized in the overbank by the BSNP (USACE 2010d).

5.2.2.6 Missouri River Fish and Wildlife Mitigation Project

The USACE began implementation of the Missouri River Fish and Wildlife Mitigation Project in 1991. Since that time, approximately 27,000 acres of land have been purchased from willing sellers, and easements on another 13,200 acres of existing public lands have been obtained in which mitigation efforts are underway or completed. Mitigation efforts include measures such as river structure modification, side channel/backwater and floodplain reconnection; to date, over 50 different mitigation

sites are in various stages of acquisition and development (USACE 2009a, 2010a). In the Water Resources Development Act of 1999 (Section 334[b]), the Missouri River Fish and Wildlife Mitigation Project was reauthorized to include an additional 118,650 acres of land to be purchased from willing sellers on which to develop, restore, or enhance fish and wildlife mitigation sites. The total amount of land authorized for purchase from willing sellers and public interests is currently 166,750 acres (USACE 2010a). The mitigation efforts would result in a beneficial cumulative effect as a result of reestablishing habitat and connectivity in the areas where lands are acquired in the LOMR.

5.2.2.7 Big Muddy National Fish and Wildlife Refuge Expansion

Another long-term influencing factor in the Missouri River basin is the USFWS proposed expansion of the Big Muddy National Fish and Wildlife Refuge from the currently approved 16,628 acres to a total of 60,000 acres. Expansion would be accomplished by acquiring from willing sellers an additional 43,372 acres along the Missouri River floodplain from Kansas City to St. Louis, Missouri, and the lower 10 miles of major tributaries. Management goals of the refuge are to restore portions of the acquired areas to a natural floodplain condition, including bottomland forests; improve and restore wetland values; improve fishery and wildlife resources; and provide additional public area for fish- and wildlife-dependent recreation. In the EIS for the proposed expansion, the USFWS states that mining of materials such as stone, sand, and gravel in the bluffs, floodplain, and channel of the river are not expected to conflict with refuge objectives; however, transporting the materials over refuge lands could require special consideration by the USFWS (USFWS 1999). The efforts associated with the Big Muddy National Fish and Wildlife Refuge would result in a long-term positive influence on cumulative effects in the LOMR due to habitat and connectivity restoration efforts within the Missouri River floodplain.

5.2.2.8 Other Potential Future Actions in the Lower Missouri River

Other potential projects that could influence cumulative impacts in the LOMR include levee construction (specifically L-142), future transportation improvements, and energy development projects associated with nuclear power plants or placement of hydrokinetic turbines in the river channel.

Levee Construction (L-142)

The proposed L-142 levee is an unconstructed unit of the Missouri River Levee System authorized by the 1941(Public Law) and 1944 Flood Control Acts (PL 228, 77th Congress, 1st Session and PL 534, 78th Congress, 2nd Session). The project includes constructing approximately 4.7 miles of earthen levee and drainage structures through the levee, closing gap structures at road gaps, ramping the Katy

Trail over the levee, developing mitigation areas, and relocating roads and utilities. The purpose of the proposed levee is to provide flood damage reduction and protect 1,400 acres of property in North Jefferson City, Missouri. Based on an initial appraisal report completed in June 1991, the project was classified active, and funds were allocated in November 1992 to prepare a General Reevaluation Report (GRR). Because the Missouri River Levee System is an ongoing construction project, the GRR is part of the planning, engineering, and design phase of project development (USACE 2010e).

Transportation Improvement Projects

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

Energy Development Projects

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

In April 2008, Free Flow Power Company submitted preliminary permit applications to FERC to study 25 regions of the mainstem of the Missouri River for the feasibility of placing hydrokinetic turbines to produce electricity. FERC granted the permits in October 2008 and February 2009. In September 2009, Free Flow Power withdrew the preliminary permit applications, stating that—based on consultation and analysis of bathymetry and velocity—depth, river bed degradation, and the uncertainty surrounding the renewal of dredging permits were significant obstacles to hydrokinetic development at

that time (Free Flow Power Company 2009). Consequently, the proposed placement of hydrokinetic turbines within the mainstem of the Missouri River is not considered a reasonably foreseeable action and is not included in the cumulative effects analysis.

5.2.3 Potential Future Actions Associated with Study Recommendations

5.2.3.1 Missouri River Bed Degradation Feasibility Study

The Missouri River Bed Degradation Reconnaissance Study determined that there was a federal interest in implementing solutions to water resources problems and opportunities related to river bed degradation within the lower 498 miles of the Missouri River, developed a project management plan, and is negotiating a feasibility cost-share agreement with non-federal partners for the next phase of study – a feasibility study. The Missouri River Bed Degradation Feasibility Study would address river bed degradation and its effects on the short-term and long-term stability of the federal flood risk management systems and would ensure continued flood protection for areas currently protected by those systems. In addition, the feasibility study would determine whether structural or operating changes might minimize or eliminate impacts of river bed degradation on the navigation system. The feasibility study would consider approaches to maintain or enhance the viability of federally constructed ecosystem projects and address the potential for protection of local infrastructure. The study could result in efforts to widen the river within the Kansas City reach in order to reduce flood heights and reduce scour of the river bed during flood events. One possible approach to change the configuration and to remove accretion in this reach would be to notch the dikes along the bank and allow the river to erode the accretion. The USACE estimates that it likely would take from 10 to 15 years to achieve this; if the river is widened 150 feet through a 30-mile reach, for example, up to 25 million tons of sediments could be reintroduced into the river (USACE 2010d).

5.2.3.2 Missouri River Recovery and Associated Sediment Management Study (NRC 2010)

The Missouri River Recovery and Associated Sediment Management Study is a comprehensive study of sediment in and from the Missouri River basin (see Section 3.2.6.8). A National Research Council committee was established in July 2008, at the request of the USACE, to address a series of questions designed to help understand the role and significance of sediment in the Missouri River and how it relates to the adequacy of the USACE management strategies and restoration tools (NRC 2010).

As discussed in Section 3.2.6.10, the Missouri River Recovery and Associated Sediment Management Study was designed to include an assessment of how and why sediment is a significant variable in the

environmental restoration of a river system like the Missouri River, and the significance of the Missouri River sediments to the Gulf hypoxia problem and to restoration of Louisiana coastal wetlands. This study was largely precipitated by concerns and action by the Missouri Clean Water Commission regarding techniques used by the USACE during construction of several MRRP projects in Missouri that involved discharging sediment into the river. Although the study is now complete, work on several MRRP projects in Missouri is still halted (MoRast 2010).

The findings and recommendations associated with this study likely will influence future mitigation efforts in the LOMR, and in particular mitigation efforts associated with creation of shallow-water habitat.

5.2.3.3 Missouri River Authorized Purposes Study

In 2009, Congress authorized the Corps to conduct the Missouri River Authorized Purposes Study (MRAPS). The act directs the Secretary of the Army to review the original project purposes of the Flood Control Act of 1944 to determine if changes to the authorized project purposes and existing federal water resource infrastructure may be warranted. The MRAPS is a broad-based multi-purpose study that is anticipated to culminate in a comprehensive feasibility-type report with an integrated EIS. The MRAPS will evaluate the study area as a comprehensive system of projects, infrastructure, and natural resources and will provide a detailed review of the existing project purposes and conditions. An evaluation of the current needs and problems in the study area could lead to consideration of operational and infrastructure alternatives. Issues associated with the MRAPS study are likely to include, but will not be limited to, the following:

- Existing infrastructure and resource conditions;
- Statutory and legal responsibilities, including relevant court decisions;
- Effects of potential alternatives on uses, including but not limited to, flood control, navigation, fish and wildlife, irrigation, power, recreation, water supply, and water quality control;
- Defining the relationship with current USACE programs, including the MRRP, the MRERP, and the BSNP; and
- Analysis of effects to the Mississippi River from potential actions or alternatives that are examined in the Missouri River basin.

The study was begun in October 2009, with an authorized cost of $25 million, and could be completed in five years if funding is available (website: http://www.mraps.org/). Because of the timeline for

completion of this study and the uncertainty of its findings and any changes in management of the Missouri River system as a result, the implications of this study for cumulative impact analysis is not reasonably foreseeable.

5.2.3.3 Lewis and Clarke Sediment Management Study

The Lewis and Clarke Sediment Management Study is an engineering viability study that will examine the possibilities for moving sediment in the delta by mechanically controlling water levels and flows. The study will evaluate alternatives that use currently existing infrastructure as well as alternatives that may require infrastructure modifications. The USACE will consider many factors in evaluating alternatives, including variations in water flow, reservoir elevations, and flow duration. The outcome of the study is not reasonably foreseeable and therefore cannot be included in consideration of cumulative impacts.

5.3 CUMULATIVE IMPACT ASSESSMENT

5.3.1 Identification of Cumulatively Affected Resources

A cumulative impact analysis requires identification of the specific resources and ecological components with the potential to be affected by the incremental impacts of the Proposed Action and alternatives, and other actions similarly affecting the resource in the same geographic area and time frame. Criteria used in identifying cumulatively affected resources include whether (1) the resource is especially vulnerable to incremental impacts; (2) other similar actions in the same geographic area may result in similar impacts on the resource; (3) impacts have been historically significant for the resource; and (4) cumulative impacts concerns have been previously analyzed and identified (USEPA 1999). The resources judged to be cumulatively affected for this Project include:

- Geomorphology (river geomorphology and sediment);
- Water quality (in particular, nutrients);
- Aquatic resources (shallow-water habitats and aquatic habitat diversity) and federally listed species;
- Economics;
- Cultural resources and infrastructure; and
- Greenhouse gas emissions and climate change.

River geomorphology is the primary cumulatively affected resource. River geomorphology is affected by other actions, projects, and programs as they influence sediment dynamics (i.e., sediment budget, composition, and transport) and sediment management in the LOMR. These factors subsequently influence channel form and geometry, and the location and abundance of habitat features in the river as well as river bed degradation and aggradation. Projects and programs that similarly affect sediment dynamics and channel degradation include the BSNP and maintenance program; and creation of habitat under the MRRP, which is discussed in subsequent sections along with other programs that could influence sediment dynamics in the LOMR.

Aquatic resources and habitats and federally threatened and endangered species are included in the cumulative impact analysis because of the vulnerability of the resources and evidence of historically significant impacts. The impacts of river bed degradation and sediment dynamics on these species and aquatic habitats in the LOMR are well established (Hesse et al. 1989; USFWS 2003; Jacobson, Blevins, and Bitner 2009). This cumulative impact extends to the general integrity of the riverine ecosystem and biodiversity, as shallow-water habitats have been identified as important to native species in the LOMR (USFWS 2003). A number of other projects and programs are in place and have been designed to address these resources.

Water resources in general were not considered to be cumulatively affected because dredging does not affect water quantity or water use in ways beyond those discussed in the Environmental Consequences analysis. Dredging does not create water quality conditions that violate state or federal standards, and no other projects and programs or trends in water quality were identified that would directly interact with dredging to produce cumulative impacts on water quantity. In regard to water quality, the incremental impacts of dredging were generally determined to be minor; and no other reasonably foreseeable actions, projects, or programs were identified that would directly interact with dredging to produce cumulative impacts on water quality. However, given the attention that has been directed in recent years to the nutrient contributions of the Missouri and Mississippi Rivers to the anoxic zone conditions in the Gulf, the analysis considers the contribution of dredging as a potential cumulative impact on water quality, specifically nutrients.

For the purposes of this section, cultural resources and infrastructure are included together in the cumulative analysis due the ongoing nature of the USACE management actions that occur in the LOMR and the similar effects of those actions on cultural resources and infrastructure affected by the Proposed Action and alternatives. USACE flow regime management, alterations to and maintenance of the BSNP, and the MRRP have the potential to act synergistically to affect cultural resources and

infrastructure—as all of these actions contribute to tributary headcutting, erosion, and scour in the LOMR.

Air quality and climate change could be cumulatively affected by the Proposed Action or alternatives, and the potential for cumulative GHG contributions and cumulative impacts on climate were specifically addressed. The broader sand and gravel market areas are included when evaluating alternate sources of sand and gravel, and some entire counties are considered when evaluating potential air quality impacts.

The remainder of the resources addressed in the EIS—navigation and transportation; wetlands, floodplains, and terrestrial ecology; land use and recreation; noise; and visual and aesthetic resources—were judged not to be cumulatively affected. These resources did not meet the general criteria outline above, commercial dredging of sand and gravel and operations were judged not to significantly affect these resources, the potential range of cumulative impacts were adequately addressed in the geomorphology impact analysis, or no other reasonably foreseeable future projects or programs would interact with dredging to create impacts that would be synergistic on these resources.

It should be recognized that the resource-specific impact analyses (in Chapter 4) for the resources most affected by commercial dredging of sand and gravel in the LOMR were based on a quantitative cumulative analysis. These include the impact analyses for geomorphology, socioeconomics, and air resources. The geomorphic assessment included a sediment budget and analysis for the entire LOMR, including the effects of annual variations in hydrology as the basis for its conclusions.

The following sections describe the resources judged to be cumulatively affected for this Project.

5.3.2 Geomorphology

A number of factors have caused and will continue to cause changes in the balance of river sediment in the Missouri River basin and corresponding changes in channel form, geometry, and fluvial habitats. These factors include, but are not limited to, development and operation of reservoirs, creation of the navigation channel, increased water use, periods of flood and drought, commercial dredging of sand and gravel, and changes in land use. Corresponding impacts, previously discussed throughout sections of the EIS, are continually being addressed as part of the USACE management of the Missouri River system (USACE 2010a).

The ongoing and reasonably foreseeable projects evaluated for potential cumulative impacts on geomorphology are those with the potential to change the sediment supply or sediment transport and

that are likely to interact with commercial dredging of sand and gravel. The most significant project in terms of potential for changes in sediment availability is the Shallow Water Habitat Program mandated by the 2003 Biological Opinion and embodied in the MRRP. Assuming that the Shallow Water Habitat Program continues to be constructed to meet the goals described in the MRRP, construction of shallow-water habitat, dike notching, and side channel construction could substantially affect sediment loads and channel geometry, and have the potential to affect river bed and water surface elevations.

The goal of the Shallow Water Habitat Program is to create 20,000 acres of shallow-water habitat by 2020 in the lower 735 miles of the Missouri River (USFWS 2003). This habitat would be created throughout the Project area, primarily by creating chutes and side channels and notching dikes toward the shore so that the river bank erodes. To achieve the overall goal, an average of 10–20 acres of shallow-water habitat would be created per mile, and existing shallow-water habitat would be maintained (USFWS 2003). Factors potentially limiting implementation of these restoration projects include the availability of land in the floodplain that is public land or private land belonging to willing sellers and resolving issues associated with the concerns of the Missouri Clean Water Commission about sediment effects on water quality.

Because restoration activities in the LOMR typically involve construction of side channels in the floodplain or erosion of sediment from the channel banks, most projects have taken place on available public lands. Figure 5.3-1 shows the location of restoration activities in the LOMR as of March 2010. The availability of suitable land for restoration activities may limit implementation of the project in the long term. In particular, restoration options in urban areas with extensive infrastructure are more limited than in less developed areas because of the proximity of urban infrastructure to the river and the limited amount of public land available for restoration. None of the completed projects have occurred in urban areas where commercial dredging has been concentrated (Figure 5.3-1).

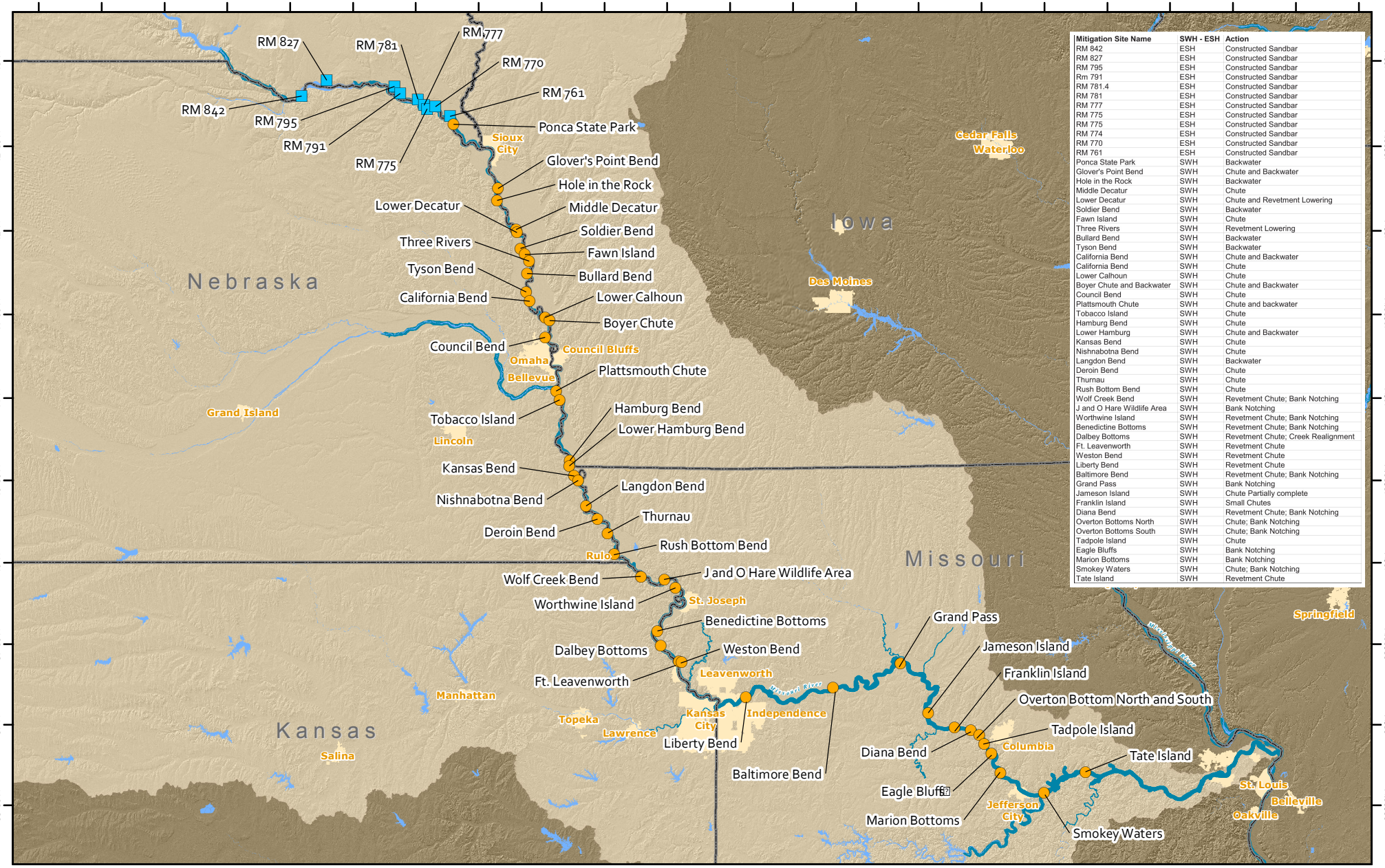
In 2008, the USACE halted restoration projects in Missouri because the Missouri Clean Water Commission was concerned about water quality issues related to increased sediment discharges associated with USACE restoration projects. This issue has not been resolved to date and may affect the ability of the USACE to meet the goals described in the 2003 Biological Opinion if it is not resolved in a timely manner.

The direct effects of MRRP restoration activities on the geomorphic characteristics of the LMOR in the Project area include changes to sediment availability in the mainstem LOMR and changes in channel geometry at the project sites. Potential indirect impacts include downriver changes in sediment loads and size distributions, including aggradation in some areas and changes in channel geometry due to aggradation behind and between dikes. Jacobson, Blevins, and Bitner (2009) estimated that the MRRP

would release approximately 3.7 million tons of sediment per year, consisting of approximately 78 percent sand, over the 15-year life of the project. This amount of sand represents approximately 135 percent of the suspended and bed load sand estimate (1994–2006) for the USGS gage at Hermann, Missouri (RM 97). This estimate does not imply that all of the sediment is suitable for commercial dredging or would be transported down the river past the Hermann site, but rather it provides a reference comparison of the estimated cumulative increase in sediment loads from the whole project to a location with known data. Although initial studies indicate a high proportion of sand in the accreted floodplains, the size fraction is likely to be highly variable and finer than the size fraction currently being transported as bed material load by the LOMR. This is likely since the river conditions under which the sediment was originally deposited were different from the current configuration of the river. Therefore the amount suitable for dredging or available for creation of SWH may be less than the 78 percent estimate suggests.

Transport of sediment from restoration projects would be highly variable and would depend on factors such as variable flow rates, transport rates, residence times, and geomorphic configuration of the river (Jacobson, Blevins, and Bitner 2009; Kondolf 1997). With the exception of areas with concentrated commercial dredging, the transport capacity of the river is in relative balance with the sediment load for most of the LOMR (Jacobson, Blevins, and Bitner 2009) (see Figure 3.4-31 in Section 3.4). A substantial influx of sediment likely would exceed the local transport capacity and would result in deposition and aggradation. This is one of the purposes of the project, to create shallow-water habitat outside of the navigation channel. Initially, most deposition would occur immediately downriver from project sites, but over time, the increased sediment load would be transported downriver as material was deposited and remobilized repeatedly.

Table 5.3-1 lists the MRRP activities started or completed by the USACE in the Project area and the estimated amount of sediment released into the LOMR at the time of construction and from erosion since completion. The total estimated amount of sediment (of all size fractions, not only bed material load) released into the river is approximately 3.8 million tons directly from construction of the projects over a 5-year period and approximately 7 million additional tons from erosion over an 8-year period after completion of the projects. With the exception of some dike notching, no new projects have been started or completed since 2008; however, erosion from previously completed projects continues.



Mitigation Site Name	SWH - ESH	Action
RM 842	ESH	Constructed Sandbar
RM 827	ESH	Constructed Sandbar
RM 795	ESH	Constructed Sandbar
Rm 791	ESH	Constructed Sandbar
RM 781.4	ESH	Constructed Sandbar
RM 781	ESH	Constructed Sandbar
RM 777	ESH	Constructed Sandbar
RM 775	ESH	Constructed Sandbar
RM 775	ESH	Constructed Sandbar
RM 774	ESH	Constructed Sandbar
RM 770	ESH	Constructed Sandbar
RM 761	ESH	Constructed Sandbar
Ponca State Park	SWH	Backwater
Glover's Point Bend	SWH	Chute and Backwater
Hole in the Rock	SWH	Backwater
Middle Decatur	SWH	Chute
Lower Decatur	SWH	Chute and Revetment Lowering
Soldier Bend	SWH	Backwater
Fawn Island	SWH	Chute
Three Rivers	SWH	Revetment Lowering
Bullard Bend	SWH	Backwater
Tyson Bend	SWH	Backwater
California Bend	SWH	Chute and Backwater
California Bend	SWH	Chute
Lower Calhoun	SWH	Chute
Boyer Chute and Backwater	SWH	Chute and Backwater
Council Bend	SWH	Chute
Plattsmouth Chute	SWH	Chute and backwater
Tobacco Island	SWH	Chute
Hamburg Bend	SWH	Chute
Lower Hamburg	SWH	Chute and Backwater
Kansas Bend	SWH	Chute
Nishnabotna Bend	SWH	Chute
Langdon Bend	SWH	Backwater
Deroin Bend	SWH	Chute
Thurnau	SWH	Chute
Rush Bottom Bend	SWH	Chute
Wolf Creek Bend	SWH	Revetment Chute; Bank Notching
J and O Hare Wildlife Area	SWH	Bank Notching
Worthwine Island	SWH	Revetment Chute; Bank Notching
Benedictine Bottoms	SWH	Revetment Chute; Bank Notching
Dalbey Bottoms	SWH	Revetment Chute; Creek Realignment
Ft. Leavenworth	SWH	Revetment Chute
Weston Bend	SWH	Revetment Chute
Liberty Bend	SWH	Revetment Chute
Baltimore Bend	SWH	Revetment Chute; Bank Notching
Grand Pass	SWH	Bank Notching
Jameson Island	SWH	Chute Partially complete
Franklin Island	SWH	Small Chutes
Diana Bend	SWH	Revetment Chute; Bank Notching
Overton Bottoms North	SWH	Chute; Bank Notching
Overton Bottoms South	SWH	Chute; Bank Notching
Tadpole Island	SWH	Chute
Eagle Bluffs	SWH	Bank Notching
Marion Bottoms	SWH	Bank Notching
Smokey Waters	SWH	Chute; Bank Notching
Tate Island	SWH	Revetment Chute

0 20 40 60 80 100 Miles

0 20 40 60 80 100 Kilometers

LEGEND

- Shallow Water Habitat
- Emergent Sand Bar Habitat
- River
- Lake/Reservoir
- Metropolitan Area (pop. >35,000)
- State Boundary
- Missouri River Basin

Figure 5.3-1
Locations of Emergent Sand Bar Habitat and Shallow Water Habitat Restoration Sites (2010)

Missouri River Commercial Dredging EIS

SD MN WI NE IA IL KS MO TX OK AR TN

February 2011

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Map Projection: Mercator, WGS84

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Table 5.3-1 Missouri River Recovery Program Activities Started or Completed in the Project Area

Project Name	River Mile	Side of River (facing downstream)	Completion Year	Material Placement Location	Total Excavation (tons)	In-River Disposal (tons)	Project Length (miles)	Estimated Amount Eroded into River Since Completion (tons)
Wolf Creek – Revetment Chute A	481	L	2006	In river	220,819	295,897	0.61	111,893
Wolf Creek – Bank Notches (11)	477–481	L	2006	In river	243,348	243,348	0.44	80,710
Monkey Mountain – Pilot A	465.8	L	2004	In river	49,272	49,272	0.17	46,775
Monkey Mountain – Pilot B	465.4	L	2004	In river	32,401	32,401	0.14	38,521
Monkey Mountain – Bank Notches (5)	464–466	L	2004	In river	75,804	75,804	0.15	41,272
Monkey Mountain – Pilot C	464.5	L	2004	In river	71,971	71,971	0.16	44,023
Worthwine Island – Pilot A	459.25	L	2004	In river	182,117	182,117	0.47	129,319
Worthwine Island – Bank Notches (11)	456–459	L	2004	In river	134,917	134,917	0.33	90,798
Worthwine Island	458	L	2006	Along levee, built sand bars in channel	536,000	134,000	1.70	623,666
Benedictine Bottoms – Bank Notches (9)	425–429	R	2004	In river	132,499	132,499	0.27	74,290
Benedictine Bottoms – Pilot A	424.1	R	2004	In river	128,010	128,010	0.38	104,556
Fort Leavenworth – Pilot A	404	R	2002	In river	4,690	4,690	0.07	--
Weston Bend – Pilot A	403.1	L	2004	In river	48,240	48,240	0.14	38,521
Weston Bend – Pilot B	403	L	2004	In river	30,820	30,820	0.09	24,763
Liberty Bend – Pilot A	351.2	R	2004	In river	85,760	85,760	0.20	55,029
Baltimore Bottoms – Revetment Chute	300.7	R	Started 2007 – incomplete	In river	143,112	143,112	0.33	45,399
Baltimore Bottoms – Bank Notches (8)	296–301	R	2004	In river	131,320	131,320	0.27	74,290
Baltimore Bottom B&C	298	R	Started 2007 – incomplete	In river	171,520	171,520	1.80	247,632
Grand Pass – Bank Notches (5)	268–272	R	2004	In river	80,400	80,400	0.15	41,272

Table 5.3-1 Missouri River Recovery Program Activities Started or Completed in the Project Area

Project Name	River Mile	Side of River (facing downstream)	Completion Year	Material Placement Location	Total Excavation (tons)	In-River Disposal (tons)	Project Length (miles)	Estimated Amount Eroded into River Since Completion (tons)
Jameson Island	213	R	2007	In river	743,700	536,000	1.90	522,779
Franklin Island – Pilot A	194.35	L	2004	In river	22,780	22,780	0.06	16,509
Franklin Island – Chute 1	194.3	L	2004	Side cast	46,900	--	0.11	60,532
Franklin Island – Chute 2	194.15	L	2004	Side cast	46,900	--	0.13	71,538
Franklin Island – Chute 3	194	L	2004	Side cast	58,960	--	0.11	60,532
Franklin Island – Chute 4	193.9	L	2004	Side cast	54,940	--	0.13	71,538
Franklin Island – Chute 5	193.8	L	2004	Side cast	67,000	--	0.13	71,538
Franklin Island – Chute 6	193.65	L	2004	Side cast	54,940	--	0.12	66,035
Franklin Island – Bank Notches (3)	192–194	L	2004	In river	60,300	60,300	0.09	24,763
Diana Bend – Chute A	187.4	L	2004	In river	80,400	80,400	0.13	35,769
Diana Bend – Bank Notches (2)	187-188	L	2004	In river	24,120	24,120	0.06	16,509
Diana Bend – Pilot B	186.9	L	2004	In river	62,980	62,980	0.11	30,266
Diana Bend – Pilot C	186.7	L	2004	In river	48,240	48,240	0.09	24,763
Overton – Bank Notches (16)	179–188	R	2003	In river	283,008	283,008	0.74	237,543
Overton	187	R	2002	Side cast	147,400	--	1.60	1,173,959
Overton	187	R	2003	Side cast	377,344	--	1.60	1,027,214
Overton – Pilot A	184.1	R	2003	Side cast	19,296	--	0.14	44,941
Overton – Pilot B	183.7	R	2003	Side cast	7,102	--	0.08	25,680
Overton – Pilot C	183.4	R	2003	Side cast	8,040	--	0.06	19,260
Overton – Chute 1	183.1	R	2003	Side cast	37,922	--	0.16	102,721
Overton – Chute 2	182.9	R	2003	Side cast	53,600	--	0.23	147,662

Table 5.3-1 Missouri River Recovery Program Activities Started or Completed in the Project Area

Project Name	River Mile	Side of River (facing downstream)	Completion Year	Material Placement Location	Total Excavation (tons)	In-River Disposal (tons)	Project Length (miles)	Estimated Amount Eroded into River Since Completion (tons)
Tadpole Island	179	R	2006	Side cast	1,072,000	--	1.80	660,352
Eagle Bluffs – Bank Notches (12)	172–178	L	2004	In river	237,180	237,180	0.36	99,053
Marion Bend – Bank Notches (9)	159–163	R	2004	In river	164,820	164,820	0.27	74,290
Smokey Waters – Chute A	132.9	R	2004	Side cast	310,880	--	0.53	291,655
Smokey Waters – Bank Notches (5)	130–133	R	2004	In river	95,140	95,140	0.15	41,272
Tate Island – Pilot A	112.4	L	2003	In river	3,196	3,196	0.03	9,630
Tate Island – Pilot B	112.2	L	2003	In river	3,930	3,930	0.11	35,310
Total						3,798,192		6,976,344

Sediment from MRRP activities upriver from the Project area (Figure 5.3-1) has contributed approximately 8.7 million tons directly from construction and approximately 14.6 million tons from subsequent erosion between 2000 and 2010. Any sediment mobilized from past and existing restoration projects (Table 5.3-1) was included in the sediment transport data and bed material load estimates presented in Section 3.4.5 (that analysis included sediment transport and flow data from 1994 to 2009). As indicated in Table 5.3-1 and in Figure 5.3-1, the projects are spread throughout the Project area but generally are located outside of urban areas where concentrated dredging occurs.

If the moratorium on sediment disposal into the mainstem LOMR is resolved and construction of restoration projects resumes in the short term, the effect of the additional sediment on the impacts from dredging described in Section 4.2 likely would be minor for several reasons. The size fraction of sediment released from restoration activities is likely to be highly variable, and may have a significant portion transported as washload, which would not be available for deposition downriver. The short-term impacts of the MRRP would be an influx of sediment downriver from restoration sites and deposition and aggradation in some reaches of the river. The areas of deposition and aggradation would not necessarily coincide with areas of concentrated dredging. Because the river tends to remain in balance with respect to sediment and transport capacity, sediment released at any given restoration site would not necessarily be deposited in areas of commercial dredging of sand and gravel unless the source of sediment was upriver and close to an area being dredged. Areas of concentrated dredging historically have occurred near urban centers, where MRRP projects are unlikely to be situated.

In addition, the number of restoration projects that could be completed within the next 3–5 years is limited because the USACE has the capacity to implement only a few projects each year. Each project would contribute an initial amount of sediment directly associated with construction, without sufficient time for additional sediment contributions from erosion in the short term.

In the long term, the impact of MRRP restoration activities would be dispersed, and widespread aggradation likely would occur as sediment is deposited and transported down through the LOMR system. Increases in both low-flow water surface elevations and high-flow water surface elevations likely would occur over time as sediment accumulates and slowly changes the channel geometry. In some areas, high-flow water elevations may be slightly reduced in the local area of a restoration project because of the cross-sectional area of the channel increasing as sediment erodes.

Increased aggradation would offset some of the impacts of commercial dredging in that the average bed elevation is likely to increase over time throughout the river. In areas where aggradation is occurring in conjunction with dredging, dredge depressions in the river may refill more quickly and reduce both downriver degradation and the potential for headcutting on the upriver side of the dredge

operation. River bed degradation is still likely to occur in areas of concentrated dredging at levels similar to those described in Section 4.2 because of the localized nature of dredging impacts, but would be relative to the average river bed elevation changes resulting from the MRRP. The cumulative effect likely would be less overall river bed degradation in areas of concentrated dredging.

5.3.2.1 Long-Term Changes in Precipitation and Flows in the Lower Missouri River Basin

A factor that may offset the effects of the sediment influx from the MRRP is the long-term average increase in flows on the LOMR. Figures 3.4-8 and 3.4-14 (in Section 3.4) show increasing trends in precipitation and mainstem flows, respectively. Increasing flows likely would increase the sediment transport capacity of the LOMR, depending in part on how the increased flow occurs. If the increased mean annual flow is a result of more frequent high-flow events, the transport capacity may increase more than if the increased flow results from an increase in moderate- or low-flow events.

5.3.2.2 Site-Specific Cumulative Geomorphic Impacts

Big Muddy National Fish and Wildlife Refuge Expansion

As described above, the Big Muddy National Fish and Wildlife Refuge expansion project proposes to restore floodplain connectivity and habitat in portions of the LOMR near the existing refuge. The project is unlikely to cause cumulative geomorphic impacts in the short term but could change the channel geometry and water surface elevations in the affected areas of the Big Muddy National Fish and Wildlife Refuge expansion in the long term. Assuming that the expansion progresses as intended, the long-term impacts on the geomorphology of certain reaches of the LOMR study area may be substantial. Because most of the proposed expansion areas would be distant from areas of concentrated dredging near urban centers, the cumulative impact of the Big Muddy National Fish and Wildlife Refuge expansion project with the direct and indirect impacts of the Proposed Action or alternatives is not likely to be substantial.

Missouri River Bed Degradation Feasibility Study

The primary objective of the Missouri River Bed Degradation Feasibility Study is to evaluate the potential for federal interest in implementing solutions to water resources problems and opportunities related to river bed degradation in the LOMR. The study could recommend reconfiguring the BSNP structures in order to address river bed degradation. Implementation of such measures would result in potential impacts that, when considered together with commercial dredging of sand and gravel, could cumulatively affect river bed elevations, water surface elevations, and channel geometry at locations in

the LOMR. However, the actual outcome of the study is not reasonably foreseeable and therefore cannot be included in consideration of cumulative impacts.

5.3.2.3 Summary of Cumulative Geomorphic Impacts

The activities identified in Section 5.2.2 would result in cumulative impacts in conjunction with dredging impacts on river bed degradation in the Missouri River. In the above discussion, there is general recognition that these activities have in the past, currently, and may in the future contribute to the extent of river bed degradation. This discussion fully recognizes that river bed degradation is an ongoing component of the LOMR geomorphology. It is also recognized that dredging results in an additive impact on river bed degradation. Therefore dredging impacts must be evaluated cumulatively with the other activities discussed in this section.

5.3.3 Water Quality

Commercial dredging of sand and gravel disturbs and suspends large amounts of river bottom sediments each year in the LOMR. The potential exists for cumulative impacts on water quality to accompany this activity even though the site-specific incremental impacts of dredging on water quality generally are considered to be minor (see Section 4.5). Nutrients are of particular importance when considering cumulative impacts because nutrients are pervasive in aquatic environments and strongly influence trophic status, dissolved oxygen dynamics, and primary production. Other present or reasonably foreseeable future actions or trends that could affect the potential for cumulative impacts on water quality include restoration activities under the MRRP and BSNP maintenance. These activities introduce large quantities of sediment into the LOMR that may affect trends in watershed loadings of nutrients in the Missouri River basin. In addition, nutrient loading from the Mississippi River, into which the Missouri River basin empties, has been implicated as one of the primary causes of hypoxia in the Gulf (Sutula, Bianchi, and McKee 2004). These potential cumulative impacts are discussed below.

5.3.3.1 Channel and Habitat Restoration Activities

As discussed under geomorphic cumulative impacts, restoration activities under the MRRP and BSNP have contributed and would continue to contribute and suspend large quantities of sediment through various activities intended to create shallow-water habitat and alter channel conveyance. Some of the floodplain sediments contributed to the river by these activities have been affected by past agricultural activities, including the use of fertilizers.

As previously noted, the USACE stopped work in Missouri in 2008 to address concerns raised by the Missouri Clean Water Commission regarding effects on water quality caused by construction of shallow-water habitat restoration projects as part of the MRRP. A sediment testing program was developed for construction sites and was implemented with cooperation and input from the MDNR and the Clean Water Commission. The USACE conducted soil, river water, and elutriate testing to determine the effects on phosphorous and nitrogen levels in the LOMR from introducing and suspending floodplain sediment to the river. The results indicated 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 2007a**).** The USACE indicated that this was most likely due to adsorption of phosphorous to the sediment. Likewise, it is also likely that remobilized sediment adsorbs total phosphorous from the river water (Soballe 2009). Nitrogen concentrations were not found to exceed water quality standards during testing (USACE 2007a).

Further, Jacobson, Blevins, and Bitner (2009) present the likely total annual nitrogen and phosphorous loads, based on the USACE testing results, as a percentage of the overall nutrient load delivered to Hermann, Missouri from one of the tested shallow-water habitat creation sites (Jameson Island). Assuming that the entire amount of sediment from the habitat creation project entered the Missouri River in 1 year and all of that sediment was mobilized and delivered to the LOMR (Hermann) in a 1-year time span, Jacobson, Blevins, and Bitner (2009) calculated that approximately 0.23 percent of total nitrogen and 2.6 percent of total phosphorous loads in the LOMR would be attributed to this restoration site. Based on these findings, Jacobson, Blevins, and Bitner (2009) concluded that the addition of sediment from individual restoration sites would be unlikely to significantly contribute to existing nutrient loads in the LOMR but may contribute to a cumulative impact, depending on the location and sequence of the projects (Jacobson, Blevins, and Bitner 2009).

As discussed in Sections 3.7 and 4.5, the temporary suspension of sediment during dredging likely would release limited amounts of nutrients into the LOMR water column and is not likely to result in exceedance of water quality standards. 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). The quantity of sediment suspended as result of dredging would be substantially smaller than that introduced during creation of shallow-water habitat. USACE testing found that the introduction and suspension of sediment during creation of shallow-water habitat would not exceed water quality criteria. Given the above information, dredging of sand and gravel would contribute a very small incremental

increase to cumulative nutrient loading in the river and is not likely to affect the attainment of water quality standards.

5.3.3.2 Hypoxia in the Gulf of Mexico

Hypoxia is primarily a problem for estuaries and coastal waters; the dissolved oxygen concentrations in hypoxic waters are less than 2–3 parts per million (ppm). Hypoxia can be caused by a variety of factors, including excess nutrients (primarily nitrogen and phosphorus) and water body stratification due to saline or temperature gradients. Excess nutrients, often referred to as "eutrophication," promote algal growth. As dead algae decompose, oxygen is consumed in the process, resulting in low levels of oxygen in the water.

Nitrogen from the Mississippi River basin, into which the Missouri River basin empties, has been implicated as one of the primary causes of hypoxia in the Gulf (Sutula, Bianchi, and McKee 2004). New information concerning the role of phosphorous in the hypoxic zone in the Gulf has recently emerged (USEPA 2007). Phosphorous is now believed to be an important limiting constituent during spring and summer in lower salinity, near-shore coastal waters (USEPA 2007). Both nitrogen and phosphorous contribute to the excessive phytoplankton production and the associated hypoxia in the Gulf. Because of the role of these nutrients in hypoxia, the USEPA scientific advisory board has called for reductions in both nitrogen and phosphorous (USEPA 2007).

The USGS annually predicts the extent of the Gulf hypoxic zone based on upstream hydrologic and nutrient data. The greatest nutrient runoff from the Mississippi River basin has been found to occur from land uses in the upper Mississippi and Ohio-Tennessee River subbasins (USEPA 2007). The net nutrient flux contributed by the Missouri River is modeled through data obtained from the Hermann, Missouri sampling station (USGS 2007). Typically, the Missouri River basin contributes approximately 20 percent of the total phosphorous and approximately 15 percent of the total nitrogen loads to the Gulf via the Mississippi River (Soballe 2009).

The combined results of Soballe (2009); Jacobson, Blevins, and Bitner (2009); and the USACE sediment and water quality testing efforts are useful in assessing the potential contribution of dredging to cumulative nutrient loadings to the Gulf. Soballe (2009) concluded that the Missouri River basin contributes approximately 20 percent of the total phosphorous and approximately 15 percent of the total nitrogen loads to the Gulf via the Mississippi River. As noted above, Jacobson, Blevins, and Bitner (2009) concluded on the basis of USACE testing results that total nitrogen and phosphorous loadings from a restoration site (Jameson Island) were approximately 0.23 percent of total annual nitrogen loads

and approximately 2.6 percent of total annual phosphorous loads in the LOMR. The analysis in Section 4.5 concluded that commercial dredging of sand and gravel would contribute a very small incremental increase in nutrient loading to the LOMR. Based on these findings, commercial dredging of sand and gravel, when added to restoration activities, would constitute a small cumulative impact to nutrient loading to the Gulf in any given year. As pointed out by Jacobson, Blevins, and Bitner (2009), the actual contribution would depend on the location and sequence of the restoration projects.

The findings of the NRC Study (NRC 2010), published between the DEIS and the FEIS, largely confirmed the conclusions outlined above. The NRC found it unlikely that total nitrogen loads from the SWH projects would be significant compared to current nitrogen loads transported in the Missouri River The NRC comparison of potential phosphorus loads from Corps SWH projects, with load increments required to produce measureable changes in the areal extent of Gulf hypoxia, showed that these projects would not significantly change the extent of the hypoxic area in the Gulf of Mexico. The rate at which the sediments, and the associated phosphorus within those sediments, are transported is important in determining their downstream effects. Under most conditions, sediment settling and storage processes in the Missouri and Mississippi River channels will attenuate the load and spread delivery to the Gulf over a long period of time (e.g., years). Because potential sediment loading from SWH incorporated data collected with dredging ongoing at current levels, there is little indication of a potential cumulative effect of dredging and SWH projects on Gulf hypoxia.

5.3.3.3 Nutrient Trends in the Missouri River

The USGS completed a comparative analysis between the baseline period of 1980–1996; 5-year moving averages thereafter indicate a decrease in the average annual streamflow and fluxes of nitrogen to the Gulf (Battaglin et al. 2010). However, the analysis found an increase in the flux of total phosphorus between the baseline period and subsequent 5-year periods. Study results attributed the decreases in annual nutrient fluxes that have occurred between the 1980–1996 baseline period and more recent years to natural causes (climate and streamflow) and not management actions or other human-controlled activities in the Mississippi-Atchafalaya River basin.

The inputs of water (streamflow), total nitrogen, and total phosphorus from the Missouri River basin, (as measured at Hermann, Missouri) as a percentage of the Gulf totals have decreased (Battaglin et al. 2010). Total nitrogen flux from the Missouri River basin (as a percentage of the Gulf total) averaged 15 percent for 1980–2006; 16 percent for the 1980–1996 baseline period; and 12, 13, and 11 percent for the 2000–2004, 2001–2005, and 2002–2006 5-year periods, respectively. Total phosphorous flux from the Missouri River basin (as a percentage of the Gulf total) averaged 21 percent for 1980–2006;

21 percent for the 1980–1996 baseline period; and 19, 20, and 16 percent for the 2000–2004, 2001–2005, and 2002–2006 5-year periods, respectively.

Actions that introduce nutrients to receiving waters include migration of fertilizer from agricultural fields, golf courses, and lawns; erosion of soil containing nutrients; disposal of animal manure; atmospheric deposition of nitrogen; sewage treatment plant discharges; and other industrial discharges (USEPA 2007). Land-disturbing activities can be a significant source of sediment phosphorous, especially when eroded sediments are rich in nutrients from past agricultural practices (USEPA 2007). Any past, current, or future projects introducing nutrients via these mechanisms would cumulatively contribute to nutrient loading in the LOMR.

Given the variable trends in nutrient flux in the Missouri River and the very small incremental increase of dredging of sand and gravel to cumulative nutrient loading in the LOMR, there appears to be little potential for cumulative impacts on nutrient loading and little likelihood of effects on waters meeting water quality standards.

5.3.4 Aquatic Resources

As previously described in Sections 4.6 and 5.2, development of the Missouri River has resulted in dramatic cumulative impacts on the riverine habitats and aquatic resources of the Missouri River (Jacobson, Blevins, and Bitner 2009) as well as restoration programs and projects that will affect aquatic resources of the LOMR. Early restoration efforts focused on efforts to restore a variety of aquatic and riparian habitats (Jacobson, Blevins, and Bitner 2009); following the 2003 Biological Opinion, management efforts have emphasized the creation of shallow-water aquatic habitat. Shallow-water habitat is thought to be important for rearing of larval and juvenile pallid sturgeon as well as essential habitat to support native aquatic species and biodiversity (USFWS 2003). Shallow-water habitat is generally recognized as 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 et al. 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 2010a). Considerable management efforts and funds have and continue to be directed toward restoration of shallow-water habitats, and the USACE is required to meet the shallow-water habitat goals of the 2003 Biological Opinion. 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, Blevins, and Bitner 2009).

Commercial dredging of sand and gravel, taken together with past development of the river and ongoing and future habitat restoration efforts, cumulatively affect aquatic resources, particularly sediment dynamics, geomorphic processes that form shallow-water habitats, and potentially the success of restoring and maintaining shallow-water habitats in certain parts of the LOMR. As described below, the incremental contribution of commercial dredging to cumulative impacts likely would be greatest in urban areas and where river bed degradation is currently greatest and is projected to continue.

The goal of the MRRP is to create 20,000 acres of shallow-water habitat, with 20-30 acres of shallow-water habitat per mile in place by 2020. Current and future restoration activities are spatially limited by several factors, including (1) the current suspension of restoration activities in the State of Missouri; and (2) the availability of suitable land for restoration activities, which is limited by the availability of existing public land or the willingness of private landowners to make their land available for restoration. Restoration activities also are limited in urban areas with extensive infrastructure that limit options for restoration activities.

In addition to limited land available for restoration, urban areas are more likely to be affected by dredging-related river bed degradation (Section 3.4.6.3). River bed degradation can affect existing shallow-water habitat by lowering the low-flow water surface elevation and converting shallow-water habitat to sand bars or mudflats. Reduced low-flow water surface elevations, one result of channel degradation, can allow for the establishment of vegetation in exposed shallow habitats that traps sediment and results in a buildup of sediment and loss of shallow-water habitat. This process is also described in Section 4.2.2.3 and can result in increased high-flow surface elevations as the channel traps sediment and is reduced in volume. In urban areas, the combined factors of increased likelihood of river bed degradation due to commercial dredging under the action alternatives, the limited amount of existing shallow-water habitat, and the limited availability of land for restoration activities may limit the creation of shallow-water habitat.

River bed degradation impacts would affect both naturally occurring and man-made shallow water habitat currently in the LOMR and has the potential to reduce effectiveness of the creation of shallow-water habitat in the future. However, it is recognized that the response of shallow-water habitat to river bed degradation and flows in the LOMR is complex and poorly understood. Under the Proposed Action and alternatives, portions of the LOMR would undergo river bed degradation in some to all river segments, which could lead to increased loss or alteration of shallow-water habitat abundance, diversity, and connectivity in both the short term (within 5 years) and the long term (20 years). When

considered in conjunction with the shallow-water habitat programs, commercial dredging could result in a decrease in the quantity of natural or created shallow-water habitat in those segments with the potential for increased river bed degradation and shallow-water habitat loss. Because the rate of erosion of naturally occurring and man-made shallow-water habitat is not known at this time, the rate of erosion of these habitats cannot be determined. Nevertheless, it is anticipated that river bed degradation associated with commercial dredging has the potential to counteract some of the positive benefits associated with the habitat creation programs.

The other factor likely influencing the rate of shallow-water habitat creation was the extended drought from 2000 to 2007 (Section 3.4.4.5), which also resulted in lower water surface elevations and the establishment of vegetation on channel banks and sand bars. The specific contribution of each factor (commercial dredging and the extended drought) has not been determined, but both likely contribute to the loss of existing shallow-water habitat and could affect efforts at achieving the goals of the 2003 Biological Opinion.

5.3.5 Economics

The analysis of economic impacts is an important component of a cumulative impact analysis because the economic well-being of local communities depends not only on the impact of individual projects and programs but also is influenced by a wide range of activities and macroeconomic trends. The economic analysis presented in Chapter 4 is inherently a cumulative analysis. It evaluated a 40-county primary market area for production of commercial sand and gravel. The regional economic analysis was conducted at the state level and considered both direct and indirect economic impacts across all industries using a regional economic modeling approach. Specifically, the economic analysis presented in Chapter 4 focused on potential impacts on the construction sand and gravel market served by supplies from the LOMR, impacts on the regional economy, fiscal impacts, economic impacts associated with river bed degradation, and environmental justice.

From a market perspective, the economic analysis considers the cumulative impacts of changes in production at existing sand and gravel operations in the region that represent alternate sources to commercial dredging operations in the LOMR. Reductions in LOMR dredging under some alternatives likely would result in increased production from existing alternate sources of supply in the short term to satisfy existing demand, in addition to an increase in the delivered cost of sand and gravel to consumers based on higher transportation costs. In response to reduced supplies from the LOMR, it is also likely that new sand and gravel operations would be developed in the Missouri River floodplain over the long term to meet future demand more cost efficiently. The long-term cumulative impacts

associated with new floodplain operations most likely would be a decline in the cost of sand and gravel in the region relative to the use of existing alternate sources in the region because new floodplain sources likely would be located in proximity to areas with greatest demand. A reduction in the delivered cost of sand and gravel would benefit the construction industry with lower-cost inputs to production. However, new floodplain sources may not be as cost effective as commercial dredging from the LOMR under the alternatives where dredging is allowed; new floodplain sources would result in an increase in the average cost of sand and gravel relative to existing conditions.

Other factors that could influence the cumulative impacts of sand and gravel production on the regional economy include considerable changes in demand, which is driven by demographic shifts, government expenditures on infrastructure development, and overall changes in economic activity in the region. In addition to population growth, the MoDOT generates one of the largest demands for regional sand and gravel, for road building. Future transportation projects implemented by the MoDOT would affect the demand for sand and gravel in the region, potentially resulting in effects on market prices.

Transportation projects in Missouri are guided by Missouri's Long-Range Transportation Plan (with a planning horizon of 20 years) and the STIP (covering a 5-year period). According to the 2010–2014 STIP, highway and bridge expenditures are expected to decline from approximately $3.0 billion in 2010 to $2.0 billion by 2014, attributed primarily to the end of the existing bond programs that have funded recent transportation improvements in the state (MoDOT 2010). If transportation funding continued to decline and the number and magnitude of new projects was reduced, total demand for construction sand and gravel from the LOMR could decrease, resulting in downward pressure on sand and gravel prices. If commercial dredging slowed in response, river bed degradation and its associated economic impacts would be lessened. Conversely, it would be expected that, if demand for sand and gravel increased over time in response to transportation requirements, prices likely would increase and the economic effects related to river bed degradation could increase.

Beyond some reasonably foreseeable projects such as the State of Missouri STIP and apparent delays and cancellation of certain large infrastructure projects proposed in the Project area as previously discussed, future economic trends are not reasonably foreseeable. In other words, future economic activity in the Missouri region is difficult to forecast because no specific available data are sufficiently reliable to predict future economic conditions. Consequently, it would be speculative to assess the regional impacts of future economic activity in conjunction with proposed changes in commercial dredging. Therefore, the extent of cumulative impacts on economic conditions is best represented by the analysis presented in Chapter 4.

5.3.6 Cultural Resources and Infrastructure

As previously noted in Section 4.13, the terrestrial and submerged cultural resources and the infrastructure located in the Project area may be adversely affected by the indirect effects of river bed degradation, headcutting, erosion, and scouring of the bed of the LOMR and its tributaries near bridge abutments. Effects to cultural resources and infrastructure are intimately linked to changes in the LOMR's geomorphology and how water flows are managed. Maintenance of the BSNP may both prevent and contribute to effects to cultural resources and infrastructure over time. Maintaining the BSNP structures contributes cumulatively to the same indirect effects as the Proposed Action and alternatives; however, by keeping the BSNP operational, the system prevents flooding and more widespread erosion from occurring within the Missouri River Valley, thus reducing broader effects to cultural resources and infrastructure.

For the reasons stated in Section 5.3.2, MRRP-related restoration activities have not occurred in urban areas and therefore have little likelihood of affecting the same cultural resources and infrastructure as those potentially affected by the Proposed Action and alternatives. While MRRP-related activities, such as construction of shallow-water habitat, dike notching, and side channel construction may affect cultural resources and infrastructure in specific areas, these restoration activities and associated effects would occur primarily in areas where concentrated dredging does not occur. The effects to cultural resources and infrastructure from MRRP-related activities, therefore, would not act synergistically with the effects from the Proposed Action and alternatives.

The USACE management of flow regimes in the LOMR has some potential to affect cultural resources and infrastructure throughout the Project area. Because of the adaptive management strategy for the LOMR, it is difficult to evaluate and anticipate how these management regimes would combine with the Proposed Action and alternatives to affect cultural resources and infrastructure (see Section 5.2.2.1). However, potential effects on cultural resources and infrastructure will be addressed in the EIS for the MRRP.

5.3.7 Greenhouse Gas Emissions and Climate Change

5.3.7.1 Impacts of the Proposed Action on Global Climate Change (Project Impacts)

The cause of global climate change is generally accepted to be the increased production of GHGs resulting from, among other things, human activities worldwide. Unlike criteria pollutant impacts, which are local and regional, climate change impacts occur at a global level. In addition, the relatively long

lifespan and persistence of GHGs require that climate change be considered a cumulative and global impact. It is unlikely that any increase in global temperature or sea level could be attributed to the emissions resulting from a single project. Rather, it is more appropriate to conclude that the GHG emissions associated with the Proposed Action and alternatives would combine with emissions across the United States and the globe to cumulatively contribute to global climate change.

Estimated GHG emissions generated by the Proposed Action and alternatives are presented in Section 4-14 and Table 5.3-2. These emissions are minuscule in comparison to current and projected global GHG emissions. Attributing any observed climate change to GHG emissions produced by the various alternatives would be speculative; in addition, no scientific or regulatory consensus exists regarding when project-related GHG emissions would be considered adverse in the context of NEPA. For this analysis, a net increase in GHG emissions compared to baseline emissions (see Table 5.3-2) was considered an adverse impact related to climate change.

To put the Proposed Action and alternatives in perspective, total estimated GHG emissions were compared to the most recent global and national GHG inventories.[1] Emissions generated by construction of new facilities were amortized assuming a 5-year project lifetime and were included in the emissions totals. Based on the estimates presented in Table 5.3-2, the Proposed Action and alternatives would result in only a very small increase in national and international emissions of GHGs.

While GHG emissions from the Proposed Action and alternatives may be negligible relative to total national and global emissions, scientific consensus concludes that, given the seriousness of climate change, small contributions of GHGs may be cumulatively considerable. For example, as shown in Table 5.3-2, implementation of the Proposed Action would generate 47,616 metric tons of new GHG emissions. This is equivalent to adding approximately 31,744 typical passenger cars to the road (USEPA 2009). Consequently, because the Proposed Action and Alternatives A, B and C would result in a net increase in GHG emissions compared to baseline conditions, impacts on climate change are considered cumulatively adverse. GHG emissions under the No Action Alternative are anticipated to be similar to existing conditions. However, because emissions could not be quantified and may be slightly higher depending on the type of alternative source and changes in shipping patterns, impacts on climate change from the No Action Alternative are considered cumulatively adverse to ensure a conservative analysis.

[1] A “GHG inventory” is a quantification of all GHG emissions and sinks within a selected physical and/or economic boundary. GHG inventories can be performed on a large scale (e.g., for global and national entities) or on a small scale (e.g., for a particular building or person).

Table 5.3-2 Annual Project-Level Greenhouse Gas Emissions in U.S. and Global Contexts

Emissions Type	CO_2e (metric tons)
2008 USEPA national GHG emissions inventory	6,956,800,000
2004 IPCC global GHG emissions inventory	49,000,000,000

Scenario	GHG Emissions (metric tons CO_2e)	Percentage of 2008 National Emissions (%)	Percentage of 2004 Global Emissions (%)
Proposed Action GHG emissions[a]	47,616	0.000684	0.000097
No Action Alternative GHG emissions[b]	32,904	0.000473	0.000067
Alternative A GHG emissions[a,c]	11,506	0.000181	0.000026
Alternative B GHG emissions[a,c]	12,131	0.000182	0.000026
Alternative C GHG emissions[a]	5,324	0.000053	0.000008

Notes:

CO_2e = Carbon dioxide equivalent.
GHG = Greenhouse gases.
IPCC = International Panel on Climate Change.
USEPA = U.S. Environmental Protection Agency.

[a] Construction emissions have been amortized over a 5-year period.

[b] Emissions were assumed to equal emissions generated by recent (2004–2008) operations on the LOMR.

[c] Includes estimated emissions produced by dredging of alternate sources. Alternate source emissions were approximated by dividing the total emissions produced by dredging in the LOMR under the Proposed Action and each alternative by the number of permitted tons. This value was multiplied by the expected volume of sand and gravel to be extracted from alternate sources. See footnotes 4 and 5 in Section 4-14.

Sources: IPCC 2007a, USEPA 2010, Section 4-14.

Impacts of Global Climate Change on the Proposed Action (Climate Impacts)

As discussed in the recent GHG guidance published by the CEQ, "Climate change can affect the integrity of a development or structure by exposing it to a greater risk of floods, storm surges or higher temperatures" (Sutley 2010). A high degree of scientific uncertainty exists with regard to characterizing future climates and to predicting how various ecological and social systems will react to any changes in the existing climate. This uncertainty stems from questions surrounding the pace of technological change, the availability and type of future fuel supplies, and climate sensitivity and feedbacks (National Highway Traffic Safety Administration 2008).

Given the speculative nature of future changes in the global climate, an evaluation of climate impacts on the Proposed Action and alternatives involves considerable uncertainty. Consequently, these impacts are discussed qualitatively and are limited to those aspects of the environment directly related

to the Proposed Action and alternatives that involve changes in water availability or quantity, increases in the frequency or severity of extreme weather events, changes in rainfall patterns, and changes in temperature. Issues less useful to the decision-making process (e.g., changes in species profiles, noise levels, and aesthetics) are not discussed.

Although specific estimates and statistics may vary between sources, the following climate change impacts are predicted for the Project area (IPCC 2007b, Ojima and Lackett 2002, Saunders and Maxwell 2005**,** Interstate Council on Water Policy 2008)[2]: warmer temperatures, smaller snowpack, earlier snowmelt, reduced river flows and water quantities, increased drought, increased spring flooding, increased winter precipitation (rain), and changes in evapotranspiration and soil moisture. Some of these impacts seem contradictory, and considerable uncertainty is associated with the predictions.

All of the above climate impacts have implications for commercial dredging of sand and gravel. Initial studies of climate change scenarios indicate that the effect on precipitation and water yield in the Missouri basin would vary with location. The upper Missouri watershed (above the mainstem dams) would likely see an increase in water yields, and the lower portion (the project area) would likely see reduced water yields (Stone et al 2001). Records of precipitation and discharge in the project area over the past 60 to 80 years (respectively) have shown upward trends, although the cause has not been directly attributed to climate change (Figure 3.4-8 and 3.4-14). Changes in river flows also may alter the amount and location of sediment deposited along the river bottom.

While climate impacts in the Project area will develop and intensify toward the end of the 21st century, not all changes will occur gradually. Extreme weather events may be rapid and may occur with little warming (Ojima and Lackett 2002). Moreover, recent trends demonstrate that long-term warming and other climatic shifts are already underway. Perhaps the climate impact of most concern for dredging operations is the decreased snowpack levels. From 1990 to 2006, snowpack levels in the Missouri River basin were below average for 14 of the 16 years (Saunders and Maxwell 2005).

Based on the above indications, dredging of sand and gravel in the LOMR may be affected by changing river flows due to climate change in the future and, potentially, changes in river sediment loads.

[2] While these climate effects are predicted for the Project area, all sources stress the speculative nature of climate effects and need for further research to corroborate their data.

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