4.5 WATER RESOURCES

4.5.1 Introduction

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

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

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

4.5.2 Methodology and Approach

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

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

4.5.3 Proposed Action

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

4.5.3.1 Suspended Sediment

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

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

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

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

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

Note: mg/l = Milligrams per liter.

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

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

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

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

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

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

All Segments

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

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

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

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

Kansas City and St. Charles Segments

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

Alternate Sources

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

4.5.3.2 Contaminants

Under the Proposed Action, dredging would increase, which would increase the potential for local suspended sediment and contaminants in pore water (water contained in the spaces between sediment grains). Background sediment contamination in the LOMR is likely, but the degree of contamination has not been extensively documented (Jacobson, Blevins, and Bitner 2009). Some studies have indicated various levels of pesticides and metal concentrations in sediments at various locations in the

LOMR (Jacobson, Blevins, and Bitner 2009; Poulton et al. 2005; Echols et al. 2008). As noted under "Suspended Sediment," dredging under the Proposed Action would increase the number of localized areas where sediment at and downstream of the dredging site would be temporarily suspended. Contaminants may be released into the water column in particulate or dissolved form from suspended sediment (USEPA 1996). The degree of potential desorption and dispersal of interstitial pore water would depend on the concentration and properties of the suspended contaminant and site-specific conditions. Many strongly adsorbed contaminants, including hydrophobic organics (such as PCBs) and some inorganic species, tend to remain strongly adsorbed to sediments even after mechanical resuspension into the water column from dredging (USACE 1988). Metal releases are more complex than hydrophobic organic species because of the presence of acid-volatile sulfides in the sediment (USEPA 1996). Acid-volatile sulfides typically interact with metals to render the metal biologically immobile by reacting with the metal to form a highly insoluble and stable sulfide. In general, metals concentrations sampled along the LOMR were not remarkably elevated, and the acid-volatile sulfide values suggest a low potential for toxicity from suspended sediments containing these metals (Poulton et al. 2005).

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

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

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

Jacobson et al. (2009) suggest that individual restoration projects that discharge sediment into the river would result in a minor localized effect, but these actions may contribute to a cumulative effect depending on the location and sequence of the projects. Potential cumulative impacts on water quality are discussed in Chapter 5. As discussed above, the Dredgers have indicated that dredges typically maintain a distance of approximately 3,000 feet from other dredges. Because the typical sediment plume and any associated contaminants would extend less than 1,300 feet downstream of the dredge, minimal—if any—overlap would be expected in sediment plumes that contain adsorbed contaminants under typical conditions. Further, due to the flow rates in the LOMR, any concentration of contaminants released to the water columns would be diluted to near background levels prior to reaching downstream dredging sites.

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

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

All Segments

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

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

Alternate Sources

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

4.5.3.3 Alluvial Aquifer Levels and Interactions

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

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

Because cobble is less readily mobilized, it would tend to accumulate over time in those locations that are subject to increased dredging as sand within the desired size range is removed from the river bed by dredging. Depending on the type of dredge, coarse material is deposited on the river bed below the dredge or to the side of the dredge. As a result, rows of coarse material can form on the river bottom as the dredge moves up and down the river. Bed sediment also can become coarser below dredging operations as finer material is picked up by the river to replenish what was deposited in the dredging depression (Kondolf 1997). These effects are relatively local and tend to accumulate in the areas with the most dredging (Simons, Li, and Associates 1985). While changes to sediment concentrations may result from dredging in the LOMR, data have not been collected in the LOMR to definitively characterize the dispersal patterns of fine-grained sand and silt or cobble after dredging.

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

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

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

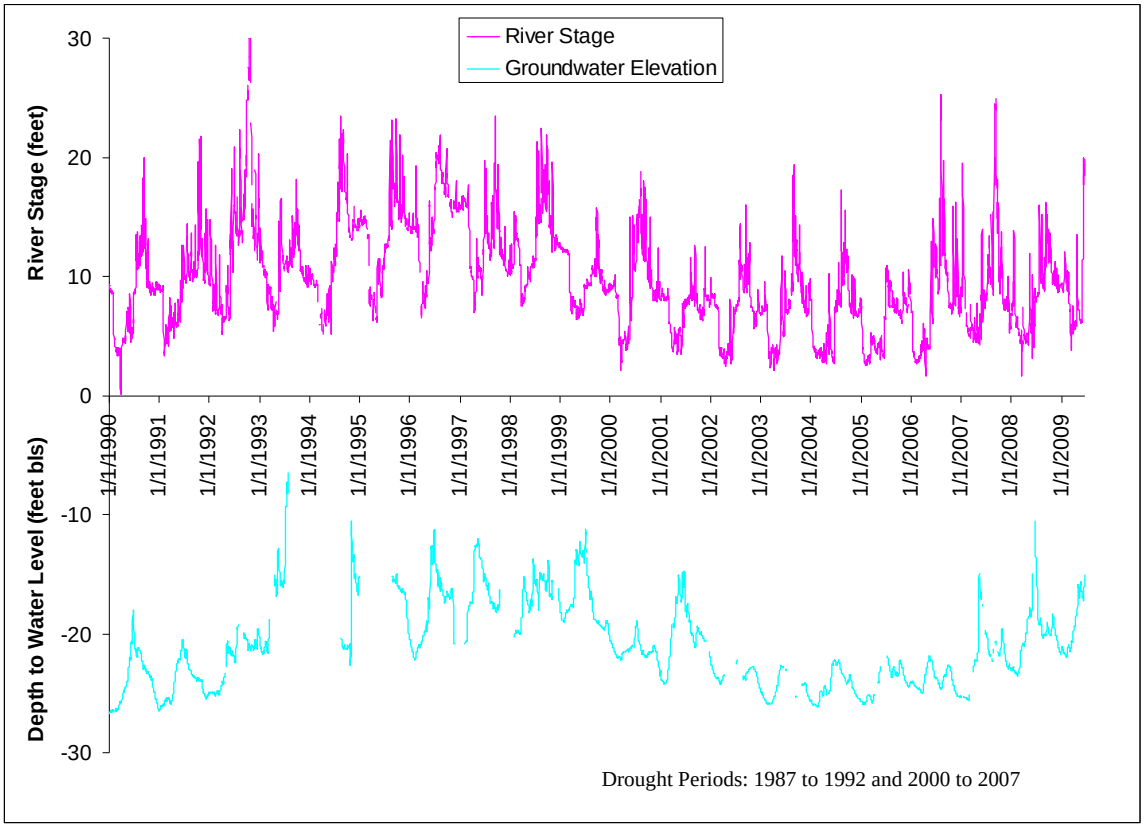

Figure 4.5-1. Groundwater Level and River Stage at St. Joseph

Sources: USGS 2010a, 2001b.

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

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

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

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

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

All Segments

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

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

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

Alternate Sources

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

4.5.4 No Action Alternative

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

4.5.4.1 Suspended Sediment and Contaminants

All Segments

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

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

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

Alternate Sources

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

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

4.5.4.2 Alluvial Aquifer Levels and Interactions

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

All Segments

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

Alternate Sources

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

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

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

4.5.5 Alternative A

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

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

4.5.5.1 Suspended Sediment

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

St. Joseph Segment

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

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

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

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

Alternate Sources

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

4.5.5.2 Contaminants

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

St. Joseph Segment

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

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

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

Alternate Sources

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

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

4.5.5.3 Alluvial Aquifer Levels and Interactions

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

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

St. Joseph Segment

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

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

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

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

Alternate Sources

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

4.5.6 Alternative B

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

4.5.6.1 Suspended Sediment

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

St. Joseph Segment

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

Waverly Segment

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

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

Kansas City, Jefferson City, and St. Charles Segments

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

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

Alternate Sources

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

4.5.6.2 Contaminants

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

St. Joseph and Waverly Segments

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

Kansas City, Jefferson City, and St. Charles Segments

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

Alternate Sources

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

4.5.6.3 Alluvial Aquifer Levels and Interactions

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

All Segments

Because groundwater levels generally mirror river stage (but of lesser magnitude), in the short term, river bed degradation would result in a slight to moderate change in groundwater levels at locations near the LOMR. The effects of river bed degradation on groundwater levels at greater distances from

the LOMR could range from no effect to a moderate change in the depth to groundwater during low-flow periods. Low-flow river stages likely would decrease in all segments under Alternative B, which would affect the depth to the alluvial aquifer during low-flow periods.

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

St. Joseph and Waverly Segments

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

Kansas City, Jefferson City, and St. Charles Segment

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

Alternate Sources

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

4.5.7 Alternative C

The quantity of material dredged from the LOMR, compared to existing levels of dredging, would not change under Alternative C. Direct and indirect impacts to groundwater resources associated with

dredging in the LOMR would continue at levels similar to those currently occurring. Because no alternate sources of sand and gravel would be required, no impacts from extraction and mining of alternate sources would occur under this alternative.

4.5.7.1 Suspended Sediment

All Segments

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

Kansas City Segment

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

St. Charles Segment

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

Alternate Sources

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

4.5.7.2 Contaminants

All Segments

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

Alternate Sources

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

4.5.7.3 Alluvial Aquifer Levels and Interactions

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

St. Joseph and St. Charles Segments

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

Kansas City and Jefferson City Segments

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

Waverly Segment

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

Alternate Sources

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

4.5.8 Summary of Impacts

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

Table 4.5-2 Summary of Potential Impacts on Water Resources

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

Table 4.5-2 Summary of Potential Impacts on Water Resources

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

Table 4.5-2 Summary of Potential Impacts on Water Resources

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

Notes:

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

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