Missouri River Recovery Management Plan and Environmental Impact Statement

Navigation Environmental Consequences Analysis

Technical Report

August 2018

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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
CO	carbon monoxide
cfs	cubic feet per second
EPA	U.S. Environmental Protection Agency
EQ	environmental quality
ER	Engineering Regulation
ESA	Endangered Species Act
ESH	emergent sandbar habitat
FY	fiscal year
H&H	hydrologic and hydraulic
HC	hydrocarbon
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HEC-ResSim	Hydrologic Engineering Center - Reservoir System Simulation
I-O	input-output
kg	kilograms
MRRP	Missouri River Recovery Program
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
NAAQS	National Ambient Air Quality Standards
NED	national economic development
NO_2	nitrogen dioxide
NOx	nitrous oxides
OD	origin destination
OSE	other social effects
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
PM	particulate matter
POR	period of record
RED	regional economic development
RR&R	repair, replacement, and rehabilitation
SO_2	sulfur dioxide
Sox	sulfur oxides
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UT-CTR	University of Tennessee Center for Transportation Research
WCSC	Waterborne Commerce Statistics Center

1.0 Introduction

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

The purpose of this Navigation Environmental Consequences Analysis Technical Report is to provide supplemental information on the navigation analysis and results in addition to the information presented in the MRRMP-EIS. Additional details on the national economic development (NED), regional economic development (RED), and other social effects (OSE) methodology and results are provided in this technical report. No environmental quality (EQ) analysis was undertaken for navigation.

1.1 Summary of Alternatives

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

- **Alternative 1 – No Action.** This is the No Action alternative, in which the Missouri River Recovery Program (MRRP) would continue to be implemented as it is currently, including a number of management actions associated with the MRRP and 2003 Amended Biological Opinion (BiOp) compliance. Management actions under Alternative 1 include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring pulse for pallid sturgeon. The construction of habitat would be focused in the Garrison and Gavins reaches for ESH (an average rate of 164 acres per year) and between Ponca to the mouth near St. Louis for pallid sturgeon early life stage habitat (3,999 additional acres constructed).
- **Alternative 2 – USFWS 2003 Biological Opinion Projected Actions**. This alternative represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (USFWS 2003). Whereas Alternative 1 only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that the USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. Considerably more early life stage habitat (10,758 additional acres constructed) and ESH (an average rate of 1,331 acres per year) would be constructed under Alternative 2 than under Alternative 1. In addition, a spring pallid sturgeon flow release would be implemented every year if specific conditions were met. Alternative 2 would also modify System operations to allow for summer flows that are sufficiently low to provide for early life stage habitat as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon.
- **Alternative 3 – Mechanical Construction**. The USACE would mechanically construct ESH at an average rate of 332 acres per year distributed between the Garrison, Fort Randall, and Gavins Point Reaches. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from System operations. The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as well as constructing new ESH. An estimated 3,380

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

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

1.2 USACE Planning Accounts

Alternative means of achieving species objectives will be evaluated including consideration for the effects of each action or alternative on a wide range of human considerations. Human considerations to be evaluated in the MRRMP-EIS alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to human considerations evaluated in the MRRMP-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR Parts 1500-1508). The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) also served as the central guiding regulation for the economic and environmental analysis included within the MRRMP-EIS. Further guidance that is specific to USACE is described in Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook (USACE 2000), which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

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

The accounts framework enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders, while ensuring impacts are not double counted. USACE planning accounts evaluated for navigation include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences to Navigation from the MRRMP-EIS

The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain lead to changes to the benefits and costs associated with navigation. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to navigation**.**

The environmental consequences analysis included a NED, RED, and OSE assessment. The NED analysis estimated the change in transportation rate savings to navigation under each of the MRRMP-EIS alternatives. The RED analysis used results from the NED analysis to estimate changes in sales, employment, and labor income resulting from each of the MRRMP-EIS alternatives. The OSE analysis considered urban and community impacts and effects on air emissions.

Figure 2 shows the overall approach used to estimate the impacts to navigation from MRRMP-EIS alternatives. The analysis first evaluated changes in Missouri River System operations including reservoir releases and river flows to determine changes in service level and season length under each of the alternatives in the MRRMP-EIS.

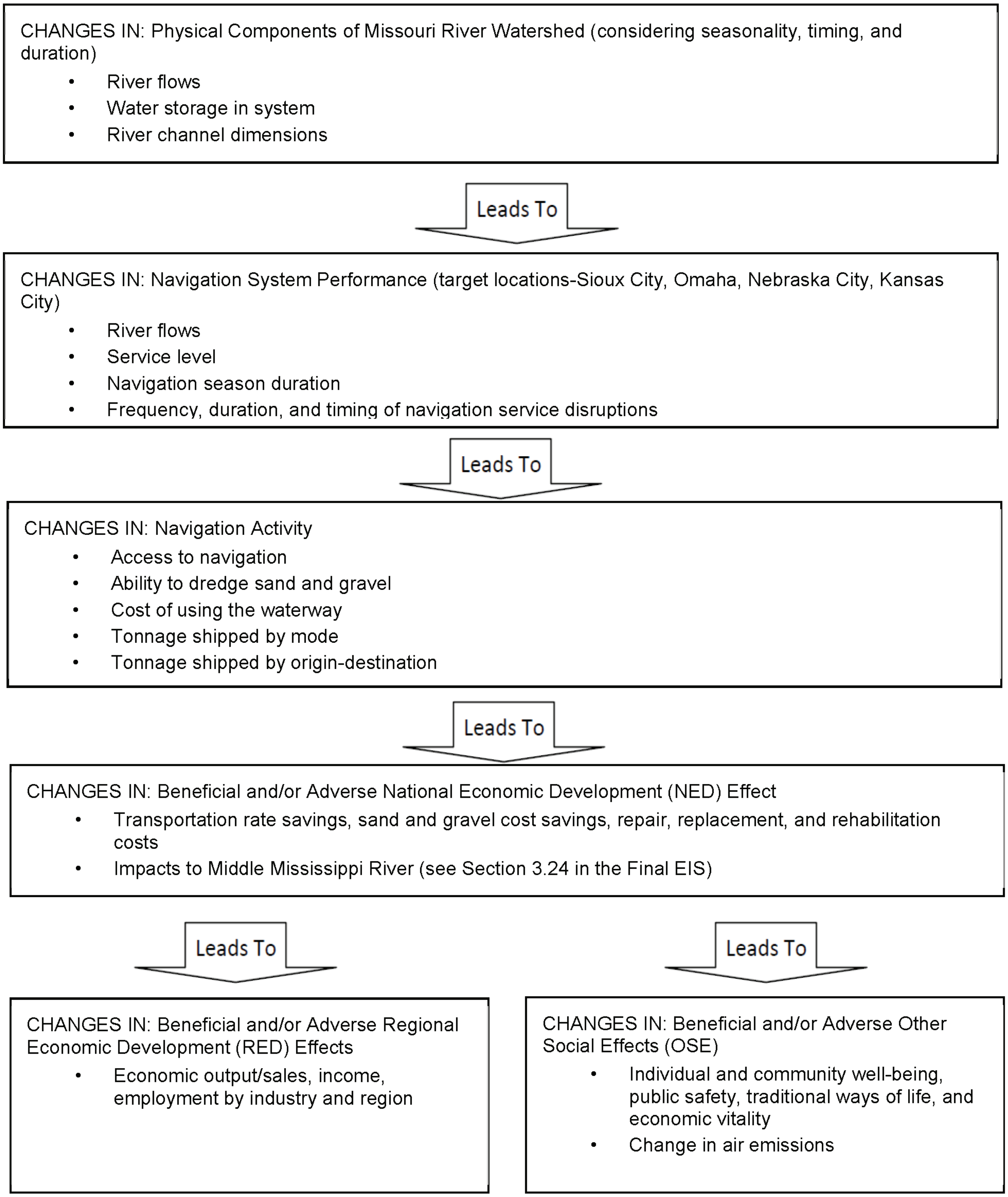


Figure 1. Flow Chart of Inputs Considered in Navigation Evaluation

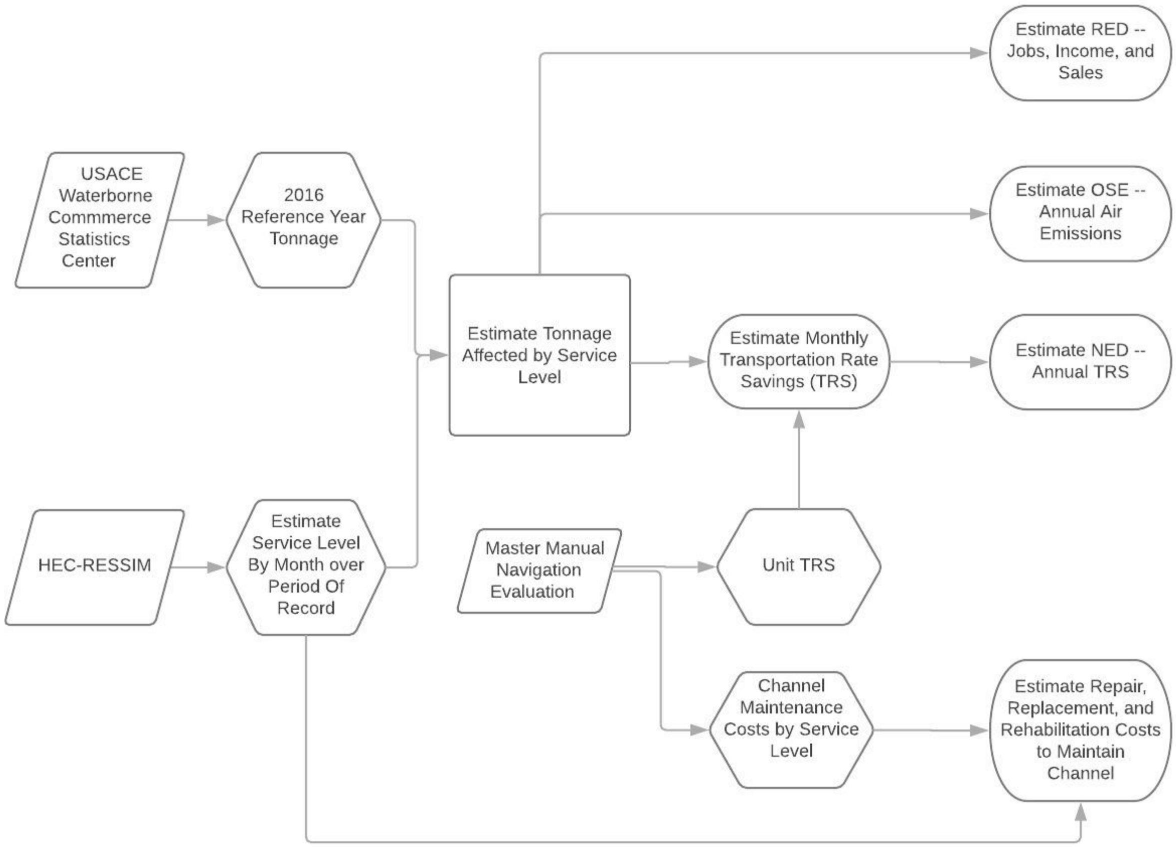


Figure 2. Approach for Evaluating Environmental Consequences to Navigation

The NED evaluation focused specifically on the commercial tonnage being shipped on the Missouri River. For the NED evaluation, the effect on navigation season and service levels for each alternative were integrated into the economic analysis, which calculated changes in transportation rate savings, to evaluate changes in NED to navigation. The NED evaluation also included an estimate of the repair, replacement, and rehabilitation (RR&R) costs of maintaining the navigation channel under the alternatives. Commercial sand and gravel dredging is evaluated in Section 3.11 of the Final MRRMP-EIS. In addition, this technical report also evaluates the impacts of low river flows on commercial sand and gravel dredging in terms of the ability to transport the sand and gravel from the dredging location to the sand plant.

The RED evaluation for navigation used the results from the NED analysis to evaluate how changes in the amount of commercial products transported on the river under the MRRMP-EIS alternatives may affect local economic conditions including sales, labor income, and employment. The OSE evaluation for navigation used tonnage amounts moved off the water for each alternative determined from the NED analysis to determine changes in air emissions and other potential health and safety concerns. The impacts to navigation on the middle Mississippi River are presented in the MRRMP-EIS, Section 3.24.

The calculations are performed over a modeled 82-year period of record (POR). Further details on the methodology are provided in the following sections.

1.4 Assumptions

The following assumptions were used in the evaluation of impacts to navigation from the MRRMP-EIS alternatives.

- The economic analysis uses data from the hydrologic and hydraulic (H&H) modeling of the river and reservoir System. The analysis assumes that the H&H models reasonably estimate river flows and reservoir levels over the 82-year POR under each of the MRRMP-EIS alternatives as well as Alternative 1 (No Action).
- The analysis evaluates impacts to navigation during the time period when USACE is providing flows in support of navigation (March 14 to an end date which varies by year). During the modeled POR between 1934 to 1942, under all alternatives, no navigation service is provided by the USACE since this is an extreme drought period. During these years, it is assumed that no tonnage is transported on the Missouri River and would all shift to alternate overland modes.
- Because commercial sand and gravel navigation moves sand and gravel from the dredging location to the port, it is assumed that there are no alternative modes that can be used to ship the sand and gravel. Therefore, a separate analysis was conducted to assess the potential impacts to commercial sand and gravel dredging associated with access to the resource through navigation.

1.5 Risk and Uncertainty

Risk and uncertainty are inherent in any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall MRRMP-EIS is associated with the operation of the Missouri River System and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 82-year POR. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future. For more discussion on climate change impacts is provided in the Hydrologic and Hydraulic Technical Report Climate Change. The project team has attempted to address risk and uncertainty in the MRRMP-EIS by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River. In addition, Section 3.15.2.10 of the MRRMP-EIS discusses potential navigation impacts associated with climate change.

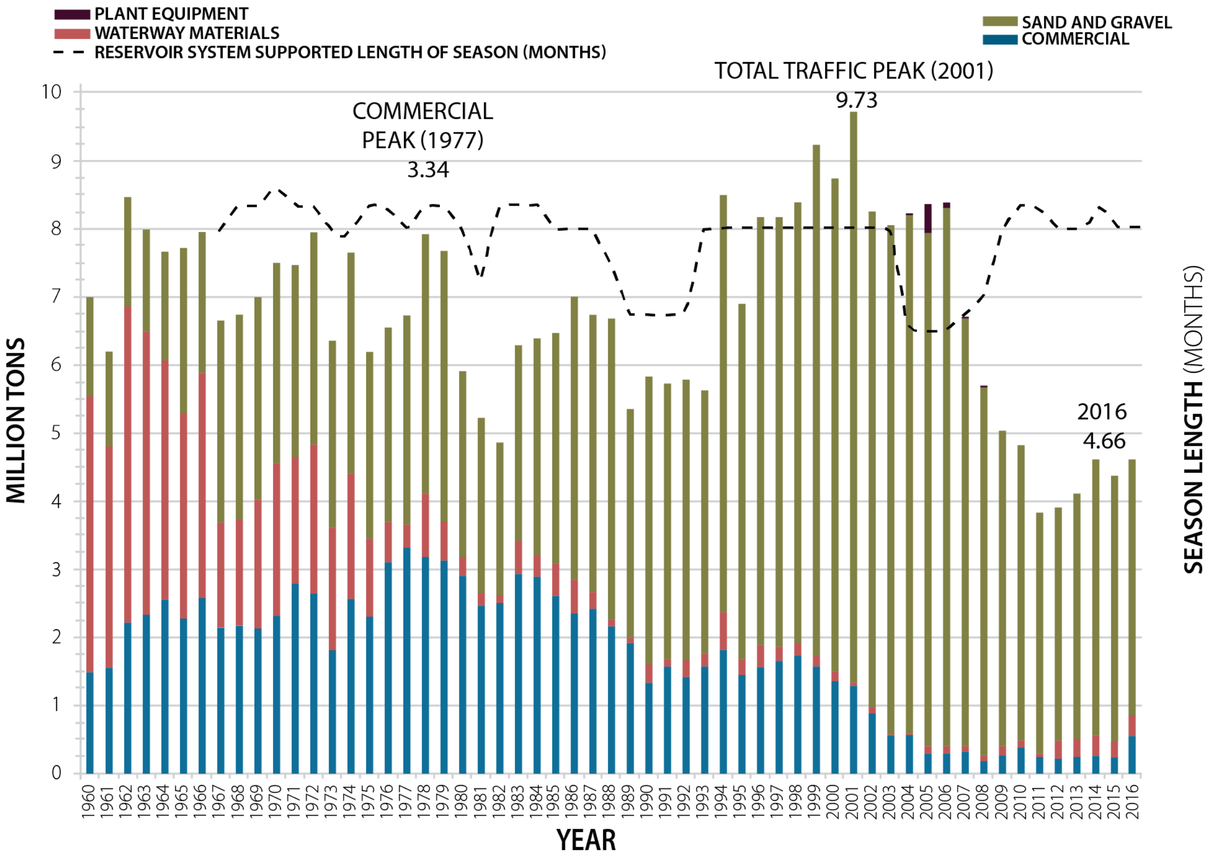
A source of uncertainty associated with the navigation analysis is predicting how the navigation industry would react to long-term changes in river and reservoir conditions. The transportation value functions used in this analysis represent how shippers would respond to various flow levels. However, while these functions capture responses that may be reasonable under current conditions or in the near future, unforeseen conditions may arise that may alter the response to changing conditions.

2.0 Methodology and Assumptions

This section describes the methods used to evaluate: (1) commercial navigation (not including sand and gravel); and (2) commercial sand and gravel dredging.

2.1 Commercial Navigation

The types of commodities traveling on the Missouri River are typically grouped into four broad categories (USACE 2006, Appendix G-1.1): sand and gravel, waterway improvement materials, commercial commodities, and oversized goods (plant equipment). Figure 3 presents tonnage levels for these four commodity groups from 1960 to 2016 along with the USACE System-supported navigation season length. The commercial traffic has generally been declining since 1977 and recent traffic has been dominated by sand and gravel.



Source: USACE 2018

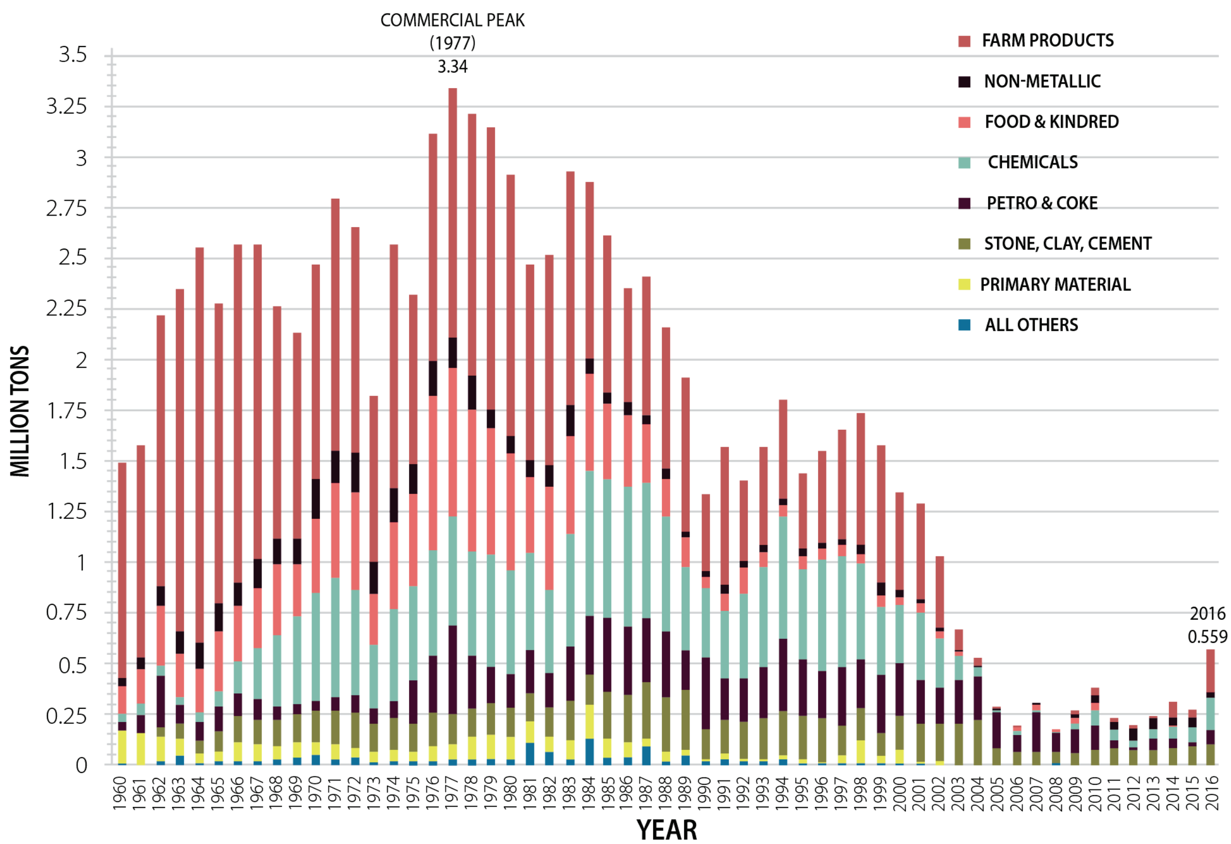
Figure 3. Total Navigation Tonnage and System Supported Length of Season (1960–2016)

Figure 4 summarizes the commercial commodities moved on the Missouri River, which can be associated with the following eight categories:

- Farm products, such as corn, sorghum, wheat, and soybeans.
- Non-metallic products, such as clays, salt including sea water, and limestone flux.
- Food and kindred materials, such as molasses, bran, sharps, and other cereal residue.
- Chemical products, including urea fertilizers, ammonium nitrate fertilizers, and sodium hydroxide.
- Petroleum products and coke, including pitch and pitch coke, fuel oils, and asphalt.

- Primary metals, such as iron and steel wire, flat rolled iron and steel, and aluminum.
- Stone, clay, and cement types, including Portland, aluminous, slag, or super sulfate.
- All other commercial cargo, including coal, wood, autos, machinery, and other materials.

Farm products were the main commercial commodities moving on the Missouri River from 1960 to 1992, accounting for 71 percent of total commercial tonnage in 1960. By 1992, the percentage for farm products had fallen to 29 percent of total commercial tonnage. From 1992 to 1997, slightly more chemical products, including fertilizers (an average of 0.51 million tons), were shipped on the Missouri River than farm products (an average of 0.46 million tons). However, farm products were the primary commodity shipped again from 1997 to 2002. From 2003 to 2010, petroleum products including pitch coke were the leading commodity moving on the Missouri River. From 2012 to 2016, the leading commercial commodity was stone, clay, and cement, which accounted for 29 percent of commercial cargo tonnage. Farm products accounted for 19 percent of the commercial commodities between 2012 and 2016.



Source: USACE 2018.

Figure 4. Commercial Tonnage by Category on the Missouri River, 1960–2016

2.1.1 National Economic Development Methodology

The navigation NED evaluation for commercial commodities estimates the changes in NED values that may result from implementing the MRRMP-EIS alternatives. The analysis is based on the guidance developed under the Principles and Guidelines (U.S. Water Resources Council

1983). The NED analysis for navigation is based on two components: (1) the transportation rate savings; and (2) the change in RR&R costs. Evaluation of transportation rate savings considers how changes in navigation season length and service levels under each alternative affect the cost of moving commodities by barge on the river. The evaluation of RR&R costs focuses on changes in repair, replacement and rehabilitation costs that result from changes in river conditions. The net NED for navigation for each alternative is calculated by subtracting the RR&R costs from the transportation rate savings. Further details on estimating transportation rate savings and RR&R costs are provided in this section.

Transportation Rate Savings

The transportation rate savings represents the difference in costs between water transportation and the next least costly transportation alternative. Transportation rate savings vary depending on the following conditions:

- **Change in service level (same origin-destination; same mode).** Transportation rate savings for water navigation are maximized when the waterway is operating at full service rather than at less-than-full service. Operating at less-than-full service increases the cost of using the waterway. For example, reduction in navigation flow targets produces higher costs due to the need to light load barges and the potential need for additional barges for a given trip.
- **Shift of mode (same origin-destination; different mode).** When opportunities to ship goods via waterway navigation decrease, a modal shift can occur (e.g., commodities that were formerly moved by barge are now moved by truck or rail). Transportation by truck or rail typically costs more than navigation, resulting in higher transportation costs for industries that ship their commodities. Modal shifts represent a cost difference between shipping freight on the waterways and shipping the freight overland with the least cost transportation mode.

Estimate Transportation Rate Savings by Service Level

The navigation evaluation used the unit transportation rate savings from the Transportation Rate Analysis: Master Manual Review from 2002 as the basis for the unit rate savings, updated to 2018 dollars. Because the Missouri River Master Manual transportation rate savings reflect the shipping characteristics and competitive influences specific to the Missouri River, the updated rates were determined to be the best estimates for transportation rate savings for this analysis (Burton pers. comm. 2017).

The transportation rate savings estimates were based on a transportation rate analysis for the Missouri River conducted by the TVA using inputs on commodity movements from the Waterborne Commerce Statistics Center (WCSC). The rate analysis calculated full transportation costs for a sampling of shipments with varying origin and destinations along the Missouri River.

For the transportation rate savings evaluation, freight rates were calculated for each movement for a route traversing the existing waterway system; an alternative route utilizing a least cost alternative mode; and an alternative multi-modal route via the Port of St. Louis on the Mississippi River. TVA estimated transportation rate savings for 283 dock-to-dock pairs according to various service levels on the Missouri River. The analyses included in the Master Manual were primarily drawn from traffic movements in 1992, 1993, and 1994. The transportation rate savings were categorized by commodity groups (Agricultural Products, Petroleum Products, Chemicals, Crude Materials, Manufactured Goods, and Sand / Stone / Rock) and by reach (Sioux City, Omaha, Nebraska City, and Kansas City) and were estimated for flows ranging from 23,000 cfs to 65,000 cfs.

The transportation rate savings analysis was based on a 340 movement survey of barge shipping in 1999 from users of the Missouri River Navigation System (either move in total or part on the Missouri River) for eight commodity groups. TVA and University of Tennessee Center for Transportation Research (UT-CTR) used the Barge Costing Model to calculate the changes in transportation costs due to flow changes. To estimate how costs change by flow level, the Barge Costing Model varies the loading levels of the barges, the number of barges, waterway speeds, horsepower ratios, and tow sizes. While these calculations covered the cost of using the waterway, TVA and UT-CTR examined the list of movements to determine which movements would shift transportation modes and/or shift the origin or destination. The analysis did not consider any new movements along the river.

The navigation NED evaluation used the unit transportation rate savings by commodity and the transportation rate savings by service level (USACE 1998, 2002). To maintain consistency with the WCSC tonnage commodity groups, the transportation rate savings commodity categories estimated by TVA were cross referenced with the new WCSC commodity groups. Table 1 summarizes the transportation rate savings from the Master Manual, the cross reference to the new categories, and the transportation rates savings in 2018 dollars used in this evaluation. The transportation rate savings were adjusted to 2018 dollars with the Producer Price Index for Inland Water Freight Transportation (US Bureau of Labor Statistics 2018).

Table 1. Unit Transportation Rate Savings by Commodity Group

TVA Commodity Group for Master Manual	Transportation Rate Savings per ton	WCSC Commodity Group	Transportation Rates Savings per ton (FY2018 $)
Metallic Minerals and Processed Metallic Products	$19.55 (FY2002 $)[a]	Crude Materials	$33.91
Other Manufactured Products	$14.16 (FY1995 $)[b]	Manufactured Goods[c]	$25.84
Petroleum & Coke	$10.96 (FY2002 $)[a]	Petroleum Products	$19.01
Chemicals	$11.68 (FY2002 $)[a]	Chemicals	$20.26
Farm Products	$12.69 (grain and other farm products) (FY2002 $)[a] $6.07 (grain products and other food products) (FY2002 $)[a]	Agricultural Products	$16.27

[a] Source is Table 2 of Transportation Rate Analysis: Missouri River Master Manual Review, page 25 (USACE 2002).

[b] Source is Table 3 for Other Manufactured Products from the Master Manual Navigation Economics Appendix A Transportation Rate Analysis, page 15, titled “NED Shipper Savings” (USACE 1998).

c The unit transportation rate savings for other manufactured goods from the 1998 analysis was used.

The NED transportation rate savings reflect differences in flow or service level. Table 2 summarizes the river flow ranges that correspond to the navigation services levels used in the analysis. The flow support for navigation provided by the USACE varied by year and was estimated with the Hydrologic Engineering Center – Reservoir System Simulation (HEC-ResSim) data.

Table 2. Navigation Service Level Flow Ranges for the Various Navigation Service Levels

River Flow Ranges (cfs)	Navigation Service Description
<23,000	Navigation support flows not provided
> 23,000, < 25,999	Minimum Service Level −8,000 cfs
>26,000, < 28,999	Minimum Service Level −3,000 cfs
>29,000, < 31,999	Minimum Service Level
> 32,000, < 34,999	Reduced Service Level
>35,000, < 44,999	Full Service Level
> 45,000, < 54,999	Full Service Level +10,000 cfs
> 55,000, < 64,999	Full Service Level +20,000 cfs
> 65,000	Full Service Level +30,000 cfs

Sources: Missouri River Mainstem Reservoir System Master Water Control Manual Missouri River Basin (USACE 2006), Appendix G: Navigation, pg G-2.

Table 10: Typical Draft (ft.) and Barge Loadings (Tons) of the Missouri River Master Water Control Manual Review and Update Study: Volume 6A-R Economic Studies Navigation Economics (Revised), pg 19.

Table 25 in the Missouri River Master Water Control Manual Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998), titled "Transportation Savings Value Functions" was used to index the full service (>35,000 <44,999) unit transportation rate saving values noted in Table 1 to the appropriate service levels by river reach and by month for each of the commodities. This allows the use of the 2002 Master Manual unit transportation rate savings, along with the transportation rate savings by service level to provide updated transportation rates savings by service level. Table 3 provides an example of the ratios used to index the unit transportation rate savings noted in Table 1.

Table 3. Example - Transportation Rate Savings Ratios for the Various Navigation Service Levels in Kansas City for Petroleum Products

Month	Service Level (cfs)						
	>26,000, < 28,999	>29,000, < 31,999	> 32,000, < 34,999	>35,000, < 44,999	> 45,000, < 54,999	> 55,000, < 64,999	> 65,000
Mar	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Apr	0.692	0.763	0.889	1.000	1.050	1.050	0.889
May	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Jun	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Jul	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Aug	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Sep	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Oct	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Nov	0.692	0.763	0.889	1.000	1.050	1.050	0.889
Dec	0.844	0.875	0.938	1.000	1.031	1.031	0.938

The result of this calculation (multiplying the unit transportation rate savings values in Table 1 by the ratios in Table 3) is the unit transportation rate savings by navigation service level, by commodity, by river reach, and by month. Table 4 provides an example of the per ton transportation rate savings for commodities in the Kansas City reach in the month of July. For all of the commercial commodities, movements were assumed to shift to alternative overland modes when river flows fall below 26,000 cfs, resulting in no transportation rate savings.

Table 4. Example - Unit Transportation Rate Savings by Navigation Service Level in Kansas City for Various Commodities in July (2018$, per Ton)

Commodity Group	Service Level (cfs)						
	>26,000, < 28,999	>29,000, < 31,999	> 32,000, < 34,999	>35,000, < 44,999	> 45,000, < 54,999	> 55,000, < 64,999	> 65,000
Chemicals	$15.7	$14.6	$19.4	$20.3	$21.6	$19.8	$17.7
Agricultural Products	$9.0	$10.2	$12.8	$16.3	$18.1	$17.8	$14.9
Crude Materials	$27.0	$28.6	$31.5	$33.9	$35.0	$33.9	$33.9
Manufactured Goods	$23.0	$23.9	$24.6	$25.8	$27.0	$26.0	$24.1
Petroleum Products	$13.2	$14.5	$16.9	$19.0	$20.0	$20.0	$16.9

Estimate Service Level by Month over the Period of Record

Once the unit transportation rate savings were estimated for different services levels, the transportation rate savings were then applied to the tonnage moved by service level expected under each of the alternatives in the MRRMP-EIS. Prior to estimating the tonnage affected, the project team estimated the percentage of days in each month at various service levels using data from the HEC-ResSim model. An example is provided in Table 5 and shows the percentage of days by service level for three months in an example year during the POR.

Table 5. Example - Percentage of Days Per Month by Service Level, Alternative 1, 1930

Month	Service Level (cfs)								
	0 - 22,999	23,000 - 25,999	26,000 - 28,999	29,000 - 31,999	32,000 - 34,999	35,000 - 44,999	45,000 - 54,999	55,000 - 64,999	> 65,000
March	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
April	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
May	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
June	0.0%	0.0%	0.0%	0.0%	3.3%	96.7%	0.0%	0.0%	0.0%
July	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
August	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
September	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
October	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
November	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%

Use Reference Year Tonnage to Estimate Monthly Tonnage Affected over the Period of Record

The next step in the analysis was to apply the percentage of days per month at various service levels over the POR (Table 5) to the reference-year tonnage by reach, month, and commodity. An assumption for the analysis is that the amount and types of commodities shipped on the river do not change unless flows fall below minimum service levels (e.g., 26,000 cfs) at which point commodities would shift from waterborne transportation to alternate overland modes of transportation. However, the transportation rate savings do change with flows (see Table 4) and are applied to a fixed volume of commodities that are allocated by service level from the HEC-ResSim data, by commodity, month, and river reach.

The WCSC provides historical data on Missouri River movements by commodity group by river reach and for each month of the navigation season. The year 2016 of the WCSC data was used as the reference year in the analysis because it was the most recent year of full navigation service that did not experience any interruptions, delays, or shortened navigation season. The 2016 reference year tonnage was allocated by month, commodity, and reach. For comparison, the commercial tonnage that moved on the river in 1994 was also used to provide a sensitivity analysis for the transportation rate savings (see Section 4.1.1). Table 6 provides the tonnage shipped by reach and commodity group on the river in 2016.

The percentage of time by service level over the POR for each of the alternatives (Table 5) was applied to the reference year tonnage (Table 6) to estimate the tonnage affected by service level, commodity group, month, and reach. Table 7 provides an example of the estimated monthly tonnage moved by service level for agricultural products in the Kansas City reach in 1930.

Table 6. Commercial Commodities Transported on the Missouri River, 2016 (Tons)

Commodity	2016 Tons
Agricultural Products	231,000
Chemicals	140,000
Crude Materials	W
Manufactured Goods	98,000
Petroleum Products	W
TOTAL	**559,000**

W = Withheld for proprietary reasons

Table 7. Example - Monthly Commercial Tonnage Affected for Agricultural Products, Kansas City Reach, 1930, Alternative 1

Month	Service Level (cfs)							
	0 – 25,999	26,000 - 28,999	29,000 - 31,999	32,000 - 34,999	35,000 - 44,999	45,000 - 54,999	55,000 - 64,999	>65,000
March	10,747	0	0	0	14,881	0	0	0
April	0	0	0	0	15,824	0	0	0
May	0	0	0	0	18,165	0	0	0
June	0	0	0	280	8,111	0	0	0
July	0	0	0	42,112	0	0	0	0
August	0	0	0	17,193	0	0	0	0
September	0	0	0	1,533	0	0	0	0
October	0	0	0	36,551	0	0	0	0
November	0	0	0	60,456	0	0	0	0

Apply Unit Transportation Rates Savings to Tonnage at Each Service Level under the MRRMP-EIS Alternatives

Once the commercial tonnage was estimated by service level over the POR (Table 7), the tonnage was multiplied by the unit transportation rate savings by month, reach, and commodity group to estimate the transportation rate savings for each of the MRRMP-EIS alternatives. Table 8 provides an example of the transportation rate savings by service level for agricultural products in the Kansas City reach in 1930 for Alternative 1.

Table 8. Example - Monthly Transportation Rate Savings, Agricultural Products, Kansas City Reach, 1930, Alternative 1

Month	Service Level (cfs)							
	0 – 25,999	26,000 - 28,999	29,000 - 31,999	32,000 - 34,999	35,000 - 44,999	45,000 - 54,999	55,000 - 64,999	>65,000
March	$0	$0	$0	$0	$242,092	$0	$0	$0
April	$0	$0	$0	$0	$257,433	$0	$0	$0
May	$0	$0	$0	$0	$295,518	$0	$0	$0
June	$0	$0	$0	$3,262	$131,959	$0	$0	$0
July	$0	$0	$0	$536,895	$0	$0	$0	$0
August	$0	$0	$0	$236,946	$0	$0	$0	$0
September	$0	$0	$0	$18,458	$0	$0	$0	$0
October	$0	$0	$0	$449,699	$0	$0	$0	$0
November	$0	$0	$0	$723,383	$0	$0	$0	$0

Annual Transportation Rate Savings

The final step in the process was to estimate the annual transportation savings for each alternative. The annual transportation savings is a summation of the monthly savings for all commodities shipped for all navigation service levels. Table 9 provides an example of the annual results. In addition to the annual results, the average annual navigation NED value is also provided in the evaluation.

Table 9. Example - Results for the Annual Transportation Rate Savings for All Commodity Groups and Service Levels (FY 2018$)

Year	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
2000	$9,914,449	$9,914,449	$9,914,449	$9,914,449	$9,914,449	$8,867,840
2001	$7,516,932	$7,516,932	$7,516,932	$7,516,932	$7,516,932	$7,516,932
2002	$6,461,436	$5,457,281	$6,461,436	$6,461,436	$6,461,436	$6,461,436
2003	$6,461,436	$5,457,281	$6,461,436	$6,407,759	$6,461,436	$6,461,436
2004	$6,007,621	$6,007,621	$6,083,257	$5,629,442	$6,083,257	$5,629,442
2005	$6,141,439	$6,205,438	$6,205,438	$5,629,442	$6,205,438	$5,629,442
2006	$5,993,440	$6,253,438	$6,045,439	$5,629,442	$6,045,439	$5,629,442
2007	$6,295,038	$6,419,837	$6,295,038	$5,795,841	$6,295,038	$5,920,640
2008	$6,434,598	$6,461,436	$6,461,436	$6,193,051	$6,461,436	$6,273,567

Year	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
2009	$7,516,932	$8,563,541	$7,516,932	$7,200,284	$7,516,932	$7,516,932
2010	$11,715,211	$12,283,723	$11,715,211	$11,662,691	$11,715,211	$12,284,619
2011	$11,964,938	$11,568,304	$11,876,955	$11,956,947	$11,816,392	$11,876,955
2012	$9,914,449	$9,914,449	$9,914,449	$9,914,449	$9,914,449	$9,914,449

Repair, Replacement, and Rehabilitation Costs

The second part of the NED analysis is the RR&R costs. The RR&R costs include: (1) support for field offices and staff; (2) RR&R of river structures; and (3) emergency dredging that is required for extreme river conditions. The RR&R costs for a range of flows and season lengths are based on the estimates from the Master Manual updated to fiscal year (FY) 2018 prices.[1] The analysis assumes that usable navigation depth decreases as releases in support of navigation decrease. As such, it is expected that costs would increase if dredging was required to maintain the authorized depth (9.0 feet) when flow to support navigation is reduced. Such cost estimates are somewhat uncertain and depend on the amount of dredging needed. The RR&R cost estimates for a range of flows and season lengths are shown in Table 10.

Table 10. Change in Annual Repair, Replacement, and Rehabilitation Cost Estimates by Service Level (Millions of 2018 Dollars per Year)

Season Length	Minimum Service (29,000 cfs)	Reduced Service (32,000 cfs)	Full Service (35,000 cfs)	Full Service + 20,000 (55,000 cfs)	Full Service + 30,000 (65,000 cfs)
8 months	$7.2	$3.9	$0.0	$2.1	$3.2
7 months	$6.3	$3.4	-$0.4[a]	$1.6	$2.5
6 months	$5.2	$2.7	-$0.8[a]	$1.0	$1.9

Source: Based on information included in Table 15: Incremental Annual O&M Cost Function, pg 23 in the Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (USACE 1998), updated to FY18 dollars using the USACE Civil Works Construction Cost Index System (USACE 2016).

Notes: A full service at eight months is the reference condition for the RR&R analysis (costs are equal to zero).

a: Negative values in this table represent cost savings relative to the reference condition (full service for 8 months).

To estimate RR&R costs for each alternative, the project team used linear regression using the data included in Table 10 adjusted per ton to estimate the cost given varying navigation season months. Table 11 shows the RR&R cost estimates from the regressions by service level. In Table 11, the variable “x” represents the months at a given navigation service level and “y” is the estimated cost for that service level.

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[1] The costs were adjusted to 2018 price levels with the USACE Civil Works Construction Cost Index System (USACE 2016).

Table 11. Equations for Estimating Repair, Replacement, and Rehabilitation Costs by Navigation Service Level (2018$)

Service Level	RR&R Cost Equations
Minimum Service Equation (29,000 cfs)	y = 0.1466x
Reduced Service Equation (32,000 cfs)	y = 0.0791x
Full Service Equation (35,000 cfs)	y = 0.065x - 0.5202
Full Service + 20,000 (55,000 cfs) Equation	y = 0.0375x
Full Service + 30,000 (65,000 cfs) Equation	y = 0.0606x

Note: Estimated with information from the USACE (USACE 1998).
y = RR&R costs (million dollars/year); x = months

The number of months within a service level was estimated from the HEC-ResSim data and used in the equations in Table 11 to estimate the cost by service level annually over the POR. To obtain the annual RR&R, costs by service level were aggregated annually across all service levels.

2.1.2 Regional Economic Development Method

As defined in the Introduction, the RED account evaluates changes in the distribution of regional economic activity. This section describes the results of a qualitative evaluation of water-compelled rates and provides a description of the methodology to evaluate the regional employment and income impacts.

Water Compelled Rate Benefits

Water compelled rate benefits are defined as reduction in rates for overland modes of transportation (particularly railroads) due to competition for transporting goods from the waterway. In other words, the rates charged by railroads in the region are said to be "water compelled" because they are theoretically lower than if the navigation channel were not available. If changes to navigation season or service levels reduce the ability to use the Missouri River for navigation, then it is suggested that competition is reduced and rates for alternative modes (i.e., rail and truck) could rise.

The Transportation experts from the UT-CTR provided a review of water-compelled rates for this study. The report includes a historical context of waterway and rail traffic along the Missouri River, noting the relatively recent issues with waterway reliability for navigation; describes past rail regulatory reforms; provides previous estimates of water-compelled effects; and describes the current rail environment that could have implications for these rates benefits.

The issues are complicated surrounding water-compelled rates and the dynamic economic conditions and context of the rail industry create uncertainties regarding the effect of Missouri River navigation on railroad pricing. However, the authors conclude that unless the reliability and long-run availability for navigation of the Missouri River are improved, water-compelled railroad rates attributable to Missouri River navigation seem improbable. Additional details are available in the "Missouri River Water-Compelled Railroad Rates: Review and Qualitative Update" (Burton and Bray 2016)

Regional Job and Income Impacts

The RED evaluation for navigation used the results from the NED analysis to evaluate how changes in the amount of commercial commodities transported on the river under the MRRMP-EIS alternatives may affect local economic conditions including sales, labor income, and employment. Specifically, this evaluation examined the amount of commercial traffic that would be anticipated to be shipped by navigation on the Missouri River under the MRRMP-EIS alternatives.

The regional economic analysis was conducted using RECONS, which is based on the principles of input-output (I-O) analysis. I-O analysis is a means of measuring the flow of commodities and services among industries, institutions, and final consumers within an economy. An I-O model captures all the monetary market transactions for consumption in a given time period accounting for inter-industry linkages and the availability of regionally produced goods and services. The primary input for I-O analysis is the dollar change in purchases of products or services for final use (i.e., final sales or revenues); this is referred to as “final demand change.” IMPLAN® is an I-O data and software system that is widely used by academics, government, and industry. RECONS is a certified USACE model that customizes IMPLAN®’s ratios and multipliers to USACE projects and study areas.

The regional economic impacts can be classified as direct, indirect, or induced sales and are measured through changes in employment, labor income, and sales. Direct effects represent the impacts of the production values or industry sales specified as final demand changes. Indirect effects represent the impacts caused by the iteration of industries purchasing goods and services to support the directly affected industries. Induced effects represent the economic impacts from all affected workers spending their income in the study area economy. The labor income and sales economic impact results were updated to 2018 dollars using the Gross Domestic Product deflator (OMB 2018).

The RED evaluation focused on the impacts to waterway industries using RECONS.[2] There were five scenarios on which the RED analysis was focused for this evaluation: the best year (highest navigation year); the worst year (the lowest navigation year); the average annual over the 82-year POR; the average of the eight worst years relative to Alternative 1; and the average of the eight best years relative to Alternative 1. The eight worst and best year statistics allow an understanding of the skewness of impacts and magnitude of impacts in the largest difference years.

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[2] The focus of the RED evaluation was on impacts to the waterway industries, which are defined as the navigators and shipping companies, port and warehousing services, and loading and unloading industries. As described in the NED section, overall shipping costs for commercial goods (other than commercial sand and gravel) could increase as shipping by alternate modes increase, or as a result of the higher waterway rates when operators have to light-load barges to navigate during adverse conditions under the alternatives in the MRRMP-EIS. Because of the small amount of non-sand and gravel commodities affected and the relatively small changes in transportation rate savings compared to Alternative 1 in the NED evaluation, RED impacts to industries that ship their products (i.e., fertilizer manufacturers, agricultural producers, utilities, etc.) were not further evaluated in the RED evaluation. However, the transportation rate savings (NED evaluation) provides an estimate of the potential changes in transportation costs.

When navigation is unavailable or reduced, there could be adverse impacts to jobs, income, and sales associated with the waterway industries, including the shipping industries, terminal operators, warehousing services, and loading and unloading services. Although some of the commodities that can no longer be shipped via navigation would likely be shipped using an alternate mode (e.g., by rail or truck), the analysis focused on the change in jobs, income, and sales in the waterway industry, and the resulting multiplier effect of these losses. With the transition of freight to other modes of transportation, there would be gains in employment, income, and sales in the alternative transportation sectors; therefore, the analysis presents a worst-case scenario for changes in regional economic losses in jobs, income, and sales.

The amount and types of commodities that would be affected by changes in navigation on the Missouri River under the MRRMP-EIS alternatives were obtained from the NED evaluation for the four navigation river reaches. There were a few movements in the Nebraska City and Omaha reaches and no shipments in the Sioux City river reach. It was assumed that most of the Nebraska City and Omaha reach shipments were moving through the Kansas City reach (and the tonnage figures supported this assumption), and therefore only the commodities moving on the Kansas City reach were used in the analysis to avoid double counting of impacts. The state of Missouri was used as the study area because the majority of products being shipped are to or from Missouri with the majority of the impact experienced in Missouri. Over the past five years, 91 percent of commercial products traveling on the Missouri River had either an origin or a destination within the state of Missouri. Since most of these commodities are transported to or from Missouri, some of the economic contribution would occur within Missouri, although there may be small economic effects in adjacent states where these commodities would be shipped to or from. The Inland Waterway module of RECONS was used for the analysis. Affected commodities were grouped into categories to be consistent with the Inland Waterway Module of RECONS. RECONS includes transportation costs per ton of commodities shipped that are allocated to both the waterway industries and port services sectors to estimate the economic impacts (USACE IWR n.d. 2013). Tonnage under each commodity category shipped on the river was the input into RECONS to estimate the economic impacts. The economic impacts were estimated for the five scenarios.

2.1.3 Other Social Effects Methods

Burning fossil fuels generates several criteria pollutants including carbon monoxide (CO), nitrous oxides (NOx), and particulate matter (PM) along with hydrocarbons (HC), a precursor to photochemical smog. The Texas A & M University Texas Transportation Institute (2017) estimates the same amount of fuel can move one ton of cargo 576 miles by barge, 413 miles by rail, or 155 miles by truck, so fewer fossil fuels are burned when a commodity is transported by water compared to truck or rail. Since moving commodities on the waterway results in fewer emissions compared to truck and rail, changes to navigation service could potentially affect air emissions and possibly impact health and safety. These types of impacts are considered in the OSE account.

The OSE evaluation focused on changes in air emissions under each of the alternatives. The analysis evaluated the potential changes in emissions using the estimated commercial tonnage that would shift from waterborne transportation to alternate overland modes from the NED evaluation. Published emission factors for inland waterway vessels, trucks, and rail were used from Texas A&M University, Transportation Institute (2017). In general, the changes in air emissions were estimated by multiplying the estimated tonnage that would shift off of the Missouri River by the emission factors for truck and rail transportation (per ton-mile). The air emission factors provided by Texas A & M University, Texas Transportation Institute (2017) are used in the evaluation and summarized in Table 12. The difference between the air emissions for navigation compared to the air emissions for truck and rail were then estimated.

Table 12. Summary of Emissions Rates (Grams per Ton-Mile)

	Hydrocarbons (HC)	Carbon Monoxide (CO)	Nitrogen Oxides (NOx)	Particulate Matter (PM)
Waterway	0.0094	0.0411	0.2087	0.0056
Railroad	0.0128	0.0558	0.2830	0.0075
Truck	0.0800	0.2700	0.9400	0.0500

Source: Texas A & M University, Texas Transportation Institute. 2017.

The next step in the air emissions evaluation was to multiply the air emissions per-ton mile by the miles traveled. The evaluation used information on the state-to-state origin destination (OD) pairs from the WCSC to estimate a weighted average for the number of miles traveled for the waterway. The weighted average was generated using the 2016 reported tonnage for each OD state pair. For example, if 40 percent of the tonnage travelled within Missouri, the mileage was weighted to reflect this distance. Circuity factors, which are multipliers to estimate distances to approximate actual travel distances, were used from the literature. A circuity factor of 1.3:1 for truck trip length and 1.1:1 for rail trip length were applied to the weighted average distance for the waterway trip (Texas A & M University 2017). The final step in the evaluation was to apply the emissions rates for waterway, railroad, and truck to the tonnage that shifts transportation modes and average mileage traveled to estimate the anticipated change in air emissions.

2.2 Commercial Sand and Gravel Dredging

Commercial sand and gravel dredging occurs on the Missouri River between St. Joseph and St. Louis, Missouri. This section focuses on how river flows and stages affect the ability to access, transport, and extract commercial sand and gravel on the Missouri River. When water levels are low, commercial dredgers need to dredge closer to their sand plants and use their dredges to maintain adequate depths for the dredge barges (USACE 2011, page 3.6-7). Commercial dredging generally occurs year-round when the wind chill is above freezing. During the winter months, during the non-navigation season when river flows are relatively lower, repair and maintenance activities are typically conducted on dredges and sand production is lower than in the spring, summer, and fall. However, at times during the winter months when conditions are favorable, commercial sand and gravel dredgers are able to operate within a limited range of their sand plants. Additional information on commercial sand and gravel dredging is provided in Section 3.11 of the Missouri River Commercial Dredging Final EIS (USACE 2011).

The commercial sand and gravel navigation evaluation used information on river flow and stage thresholds from the Missouri River Master Manual (Master Manual), Water Flow Changes and the Impact on the Missouri River Sand Industry, Appendix 10: Sand and Gravel Dredging (USACE 2002). As part of the Master Manual evaluation, the Tennessee Valley Authority conducted surveys with the sand and gravel companies that operate on the Missouri River. Dredging companies operating downstream of Kansas City noted that 26,000 cfs is a low flow threshold below which dredging operations would be affected. For example, dredgers noted that operations would have to be shifted to the lowest dock on the river to accommodate lower water levels, necessitating more trips and the possibility of purchasing new equipment if conditions persisted.

Dredging operators in the Kansas City and St. Joseph segments can also be affected by relatively higher river stages (USACE 2002); the evaluation assessed the number of days when river stages are above flood stage and above five feet below flood stage in Kansas City and St. Joseph.

USGS river gage data at St. Joseph, Kansas City, Waverly, Glasgow, Booneville, Jefferson City, Hermann, Washington, and St. Charles was reviewed between 2006 and 2016, along with the recorded sand and gravel extraction data to assess how rivers flows and stages affect dredgers. This information was used along with the Hydrologic Engineering Center – River Analysis System (HEC-RAS) data on the prevalence of low and high flows over the period of record under the MRRMP-EIS alternatives to assess potential impacts to commercial sand and gravel dredgers.

These high and low thresholds were compared to HEC-RAS data, showing the number of days when river flows were above and below these thresholds over the POR. An Excel® model was developed to assess how the MRRMP-EIS alternatives affect low river flows in the lower river. The river mile locations were chosen to be consistent with the U.S. Geological Survey gage locations. The data was queried daily and assessed during the navigation season (April through November) and non-navigation season (December through March). To assess the impacts of lower and higher river stages on dredging operations, an evaluation was conducted using the Hydroviz tool (based on HEC-RAS data) to assess the number of days when river flows are below 26,000 cfs and when river stages are above flood stage and above five feet below flood stage in Kansas City and St. Joseph. Lower and higher water levels can impact commercial sand and gravel dredging through the ability to extract material, the need to light-load barges, and the ability to move the dredged material from the barges to the conveyor at the dock.

3.0 Navigation Service Level and Season Length

Since the navigation economic model relies on the output of HEC ResSim model to estimate the impact of the alternatives, it is useful to examine the navigation operation statistics before showing the results of the NED, RED, and OSE analysis. The key navigation operation statistics to consider are service level and season length.

3.1 Service Level

The service level approximates the water volume necessary to achieve a normal 8-month navigation season with average downstream tributary flow contributions. To facilitate appropriate application of System multipurpose regulation criteria, a numeric “service level” has been adopted since the System was first filled in 1967. For the “full-service” level, the numeric service level value is 35,000 cfs. For the “minimum service” level, the numeric service level value is 29,000 cfs. The service level is used for selection of appropriate flow target values at previously established downstream control locations on the Missouri River. There are four flow target locations selected below Gavins Point to assure that the Missouri River has adequate water available for the entire downstream reach to achieve regulation objectives. For additional details on navigation service level, please see Section 3.15.1.2 of the Navigation Affected Environment FEIS.

As shown in Table 13, Alternatives 2, 4, and 6 would result in an average annual decrease in 2 days above minimum service level compared to Alternative 1. In the 8 worst difference years, Alternative 2 would have the largest impacts with an average of 37 fewer days compared to

Alternative 1 at minimum service level or above. When examining the number of days at full service level or above, Alternatives 2, 4, 5, and 6 would result in adverse impacts relative to Alternative 1. Alternative 4 would have the largest adverse impacts compared to Alternative 1, on average 11 fewer days at full service or above. In the average of the 8 worst years compared to Alternative 1, Alternative 4 would result in 104 fewer days at or above full-service levels compared to Alternative 1.

Table 13. Number of Days at or Above Minimum and Full-Service Levels over the Period of Record

Service Level	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Minimum Service Level or Above (29,000 cfs and above)						
Average number of days	225	223	225	223	225	223
Change in average number of days from Alternative 1	NA	-2	0	-2	0	-2
Average of the 8 Worst Difference Years from Alternative 1	NA	-37	0	-12	-5	-10
Average of the 8 Best Difference Years from Alternative 1	NA	9	2	0	2	1
Full Service Level or Above (35,000 cfs and above)						
Average number of days	98	96	99	87	97	93
Change in average number of days from Alternative 1	NA	-2	1	-11	-1	-5
Average of the 8 Worst Difference Years from Alternative 1	NA	-39	-4	-104	-20	-52
Average of the 8 Best Difference Years from Alternative 1	NA	15	10	0	9	5

3.2 Season Length

The season length represents the number of days that releases from the Mainstem System are operated to support navigation on the Missouri River given water-in-storage checks in March and July. Table 14 presents the average annual number of months of navigation seasons for each alternative over the POR. In addition, the average of the 8 worst and best difference years compared to Alternative 1 are also presented in Table 14. A full navigation season is defined as 8 months. Alternatives 2, 4, and 6 would result in adverse impacts to navigation season length, with these alternatives resulting in an average decrease of 0.1 month (or 3 days). In the 8 worst difference years, Alternative 2 would result in the most adverse impact of the alternatives with an average of 1.1 months shorter season length than under Alternative 1, due to low summer flow events.

Table 14. Season Length over the Period of Record (Months)

Season Length Statistic	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Average annual number of months	6.9	6.8	6.9	6.8	6.9	6.8
Change in average number of months from Alternative 1	NA	-0.1	0.0	-0.1	0.0	-0.1
Shortest season	0	0	0	0	0	0
Longest season	8.3	8.3	8.3	8.3	8.3	8.3
Average of the 8 Worst Difference Years from Alternative 1	NA	-1.1	0.0	-0.4	-0.1	-0.3
Average of the 8 Best Difference Years from Alternative 1	NA	0.3	0.1	0.0	0.1	0.0

4.0 Commercial Navigation

The NED benefits for navigation include two components: (1) the transportation rate savings; and (2) the change in RR&R costs. The RR&R costs are subtracted from the transportation rate savings to estimate the NED benefits for each alternative.

4.1 Summary of National Economic Development Results

This section presents the results of the transportation rate savings, RR&R costs, and navigation NED benefits for all the MRRMP-EIS alternatives.

4.1.1 Transportation Rate Savings

Table 15 presents the results for the transportation rate savings for each of the alternatives using 2016 as the reference tonnage year. Alternative 1 would result in an average annual transportation rate savings of $8.0 million, ranging from $0 (in the 1930s and 1940s) to $12.0 million during a full-service navigation year. Alternatives 2, 4, 5, and 6 show adverse impacts to navigation compared to Alternative 1. Alternative 4 shows the largest relative impact to navigation with a 2.0 percent decrease in average annual transportation rate savings compared to Alternative 1, which would be driven by the 10 years in the POR when a full spring release would reduce service levels in the year of or year following the release. Alternatives 2, 5, and 6 would result in average annual decreases in transportation rate savings of 0.6, 0.6, and 1.5 percent, respectively, compared to Alternative 1, due to the spawning cue releases and low summer flow (Alternative 2), fall releases (Alternative 5), and spawning cue releases (Alternative 6). In general, the releases shorten the navigation season or reduce the navigation service level in the current release year or subsequent years. Alternative 3 would result in a slight increase in transportation rate savings, about 0.2 percent compared to Alternative 1.

Table 15. Transportation Rate Savings for the MRRMP-EIS Alternatives (2018$)

Transportation Rate Savings	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Transportation Rate Savings Over the POR	$654,900,000	$650,700,000	$656,400,000	$641,700,000	$650,800,000	$645,100,000
Average Annual Transportation Rate Savings	$7,990,000	$7,940,000	$8,010,000	$7,830,000	$7,940,000	$7,870,000
Maximum Annual Savings	$12,040,000	$12,620,000	$12,040,000	$12,040,000	$12,040,000	$12,280,000
Minimum Annual Savings	$0	$0	$0	$0	$0	$0
Average Annual Change from Alternative 1	NA	-$51,000	$19,000	-$160,000	-$50,000	-$119,000
Average Annual Percent Change from Alternative 1	NA	-0.6%	0.2%	-2.0%	-0.6%	-1.5%

A sensitivity analysis for transportation rate savings assessed the impacts assuming a higher level of tonnage transported on the Missouri River. The evaluation used 1994 commercial tonnage levels to estimate the transportation rate savings and changes in transportation rate savings under the alternatives. 1994 supported a full navigation season and also resulted in the highest commercial tonnage shipped on the Missouri River since 1990. In 1994, commercial cargo tons were at a peak of 1.8 million tons, which is over 3.2 times greater than the 560,000 tons that traveled on the river in 2016. Given this, it was chosen for comparison with the 2016 reference year transportation rate savings impacts.

As shown in Table 16, the average annual transportation rate savings for each of the alternatives in 1994 increased by greater than $33.9 million, compared with the 2016 results. For example, the average annual transportation rate savings for Alternative 1 increased from $7.99 million (with 2016 tonnage) to $42.66 million (with 1994 tonnage). The difference in the average annual transportation rate savings between the alternatives and Alternative 1 ranged from an increase of $123,000 (Alternative 3) to a decrease of $923,000 (Alternative 4). Similar to the 2016 transportation rate savings results, the 1994 analysis shows that Alternatives 2, 4, 5, and 6 would have adverse impacts to navigation compared to Alternative 1, with Alternative 4 showing the largest relative impact (a reduction in transportation rate savings of 2.2%). The decrease in transportation rate savings under Alternatives 2, 4, 5, and 6 compared to Alternative 1 in percentage terms for the 1994 tonnage is slightly larger due to a different mix of commodities shipped in 1994. Overall, the navigation NED evaluation using the 1994 and 2016 tonnage levels would result in similar percent change from Alternative 1 and the same ranking of the alternatives.

Table 16. Transportation Rate Savings for the MRRMP-EIS Alternatives Using 1994 Tonnage (2018$)

Transportation Rate Savings	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Transportation Rate Savings Over the POR	$3,498,100,000	$3,450,500,000	$3,508,200,000	$3,422,400,000	$3,471,500,000	$3,443,300,000
Average Annual Transportation Rate Savings	$42,660,000	$42,080,000	$42,780,000	$41,740,000	$42,340,000	$41,990,000
Maximum Annual Savings	$66,860,000	$67,270,000	$66,860,000	$66,860,000	$66,860,000	$66,860,000
Minimum Annual Savings	$0	$0	$0	$0	$0	$0
Average Annual Change from Alternative 1	NA	-$581,000	$123,000	-$923,000	-$324,000	-$669,000
Average Annual Percent Change from Alternative 1	NA	-1.4%	0.3%	-2.2%	-0.8%	-1.6%

4.1.2 Change in Repair, Replacement, and Rehabilitation Costs

Table 17 summarizes the impacts to RR&R costs. Alternative 1 would result in an average annual RR&R cost of $570,000, ranging annually from $0 to $1.26 million. Alternative 2 would result in a small decrease ($16,000) in average annual RR&R costs compared to Alternative 1, which is driven by the reduced USACE costs for the split and shortened navigation season. The low summer flow would result in higher service levels and season length in the year that the low summer flow event is simulated from small increases in System storage, resulting in lower RR&R costs to maintain the navigation channel compared to Alternative 1. In comparison, Alternatives 4, 5, and 6 would cause higher RR&R costs than Alternative 1 because the spring releases and spawning cues on average would result in reduced System storage and more periods of minimum or reduced service compared to Alternative 1, which would require higher costs to maintain the navigation channel. Using the 1994 tonnage levels for comparison, the RR&R costs were the same as those costs given the 2016 tonnage levels.

Table 17. Repair, Replacement, and Rehabilitation Costs for the MRRMP-EIS Alternatives (2018$)

RR&R Costs	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total RR&R Costs Over the POR	$46,500,000	$45,100,000	$46,300,000	$48,100,000	$47,000,000	$47,200,000
Average Annual RR&R Costs	$570,000	$550,000	$570,000	$590,000	$570,000	$580,000
Maximum Annual Cost	$1,260,000	$1,260,000	$1,260,000	$1,260,000	$1,260,000	$1,260,000
Minimum Annual Cost	$0	$0	$0	$0	$0	$0
Average Annual Change in RR&R costs from Alternative 1	NA	-$16,000	-$2,000	$20,000	$7,000	$8,000
Average Annual Percent Change from Alternative 1	NA	-2.9%	-0.3%	3.5%	1.2%	1.4%

4.1.3 Navigation National Economic Development Benefits

Table 20 summarizes the NED benefits for navigation for each of the alternatives. These values are estimated by subtracting the RR&R costs (Table 19) from the transportation rate savings (Table 18). The average annual NED benefits ranged from $7.2 million under Alternative 4 to $7.4 million under Alternatives 1 and 3.

The following provides a summary of the results.

- All alternatives show less than a 2.5 percent change in average annual NED benefits relative to Alternative 1 (ranging from an increase under Alternative 3 of 0.3 percent to a decrease of 2.4 percent under Alternative 4).
- All alternatives would experience no navigation in eight years during extreme droughts years, as simulated in 1935-1942.
- Alternative 4 would result in the largest decrease in transportation rate savings and an increase in RR&R costs, resulting in the largest adverse impacts compared to Alternative 1. Similarly, Alternative 6 would result in decreased transportation rate savings and an increase in RR&R costs, resulting in an overall average annual decrease of 1.7 percent in navigation NED benefits compared to Alternative 1.
- Alternative 2 would result in a decrease in transportation rate savings and a decrease in RR&R costs, resulting in a decrease in average annual navigation NED benefits of $35,000 (0.5%).
- Alternative 3 would result in very small increases in navigation NED benefits compared to Alternative 1.

Table 18. Navigation National Economic Development Benefits for the MRRMP-EIS Alternatives (2018$)

NED Benefits	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Total NED Benefits over the POR	$608,400,000	$605,500,000	$610,100,000	$593,600,000	$603,710,000	$598,000,000
Average Annual NED Benefits	$7,420,000	$7,380,000	$7,440,000	$7,240,000	$7,360,000	$7,290,000
Maximum Annual NED Benefit	$11,980,000	$12,560,000	$11,980,000	$11,980,000	$11,980,000	$12,270,000
Minimum Annual NED Benefit	0	0	0	0	0	0
Average Annual Change from Alternative 1	NA	-$35,000	$21,000	-$181,000	-$57,000	-$127,000
Average Annual Percentage Change from Alternative 1	NA	-0.5%	0.3%	-2.4%	-0.8%	-1.7%

4.2 National Economic Development Results

4.2.1 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, the MRRP would continue its current implementation actions, which are in compliance with the BiOp. Management actions that may have impacts to navigation include the spring plenary pulse, which could affect the level of navigation service provided by the USACE.

As shown in Table 19 and Figure 5, the annual NED benefits for Alternative 1 would range between $0 and $12.0 million with an average of $7.4 million. Figure 3 shows annual transportation rate savings, RR&R costs, and navigation NED benefits for Alternative 1. The 82-year POR covers a broad range of water conditions as simulated based on historic hydrology, including droughts in the 1930s and early 1940s where no navigation was supported. Other notable drought periods include the mid-1950s to early 1960s, the late 1980s to early 1990s, and the mid-2000s.

Table 19. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits for Alternative 1 (2018$)

NED Benefits	Transportation Rate Savings	RR&R Costs	Navigation NED Benefits
Total NED Benefits over the POR	$654,900,000	$46,500,000	$608,400,000
Average Annual NED Benefits	$7,990,000	$570,000	$7,420,000
Highest Annual NED Benefits over the POR	$12,040,000	$1,260,000	$11,980,000
Lowest Annual NED Benefits over the POR	$0	$0	$0

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

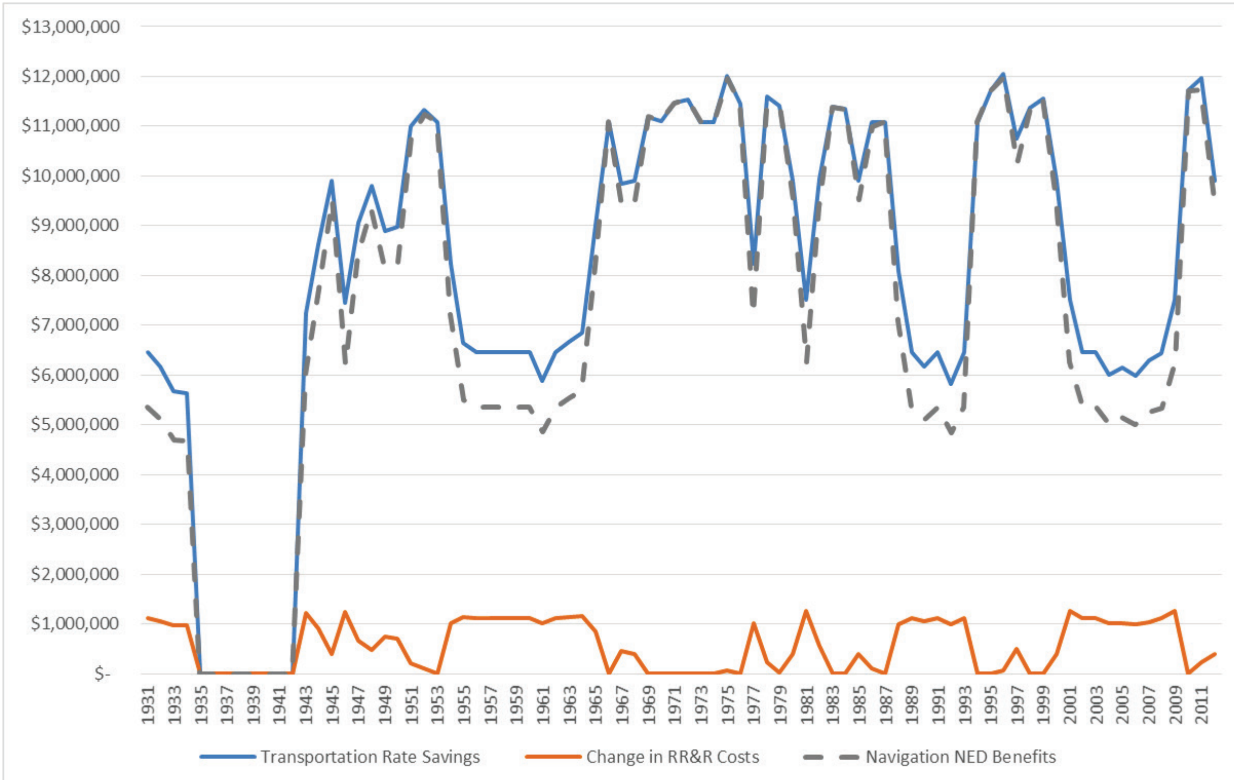

Figure 5. Annual Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits for Alternative 1 (2018$)

4.2.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 management actions include spawning cue releases and low summer flows that can result in split navigation seasons when fully implemented. The management actions under Alternative 2 would result in average annual NED benefits of $7.4 million, a decrease in NED benefits of 0.5 percent compared to Alternative 1. Alternative 2 would result in an average annual decrease of $35,000 per year in NED benefits driven by the split navigation season during the low summer flow events. The NED analysis for Alternative 2 is summarized in Table 20.

Table 20. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits under Alternative 2 (2018$)

NED Benefits	Transportation Rate Savings	RR&R Costs	NED Benefits
NED Benefits over the POR	$650,700,000	$45,100,000	$605,500,000
Average Annual NED Benefits	$7,940,000	$550,000	$7,380,000
Highest Annual NED Benefits Over the POR	$12,620,000	$1,260,000	$12,560,000
Lowest Annual NED Benefits over the POR	$0	$0	$0
Average Annual Change from Alternative 1	-$51,000	-$16,000	-$35,000

NED Benefits	Transportation Rate Savings	RR&R Costs	NED Benefits
NED Benefits over the POR	$650,700,000	$45,100,000	$605,500,000
Average Annual NED Benefits	$7,940,000	$550,000	$7,380,000
Highest Annual NED Benefits Over the POR	$12,620,000	$1,260,000	$12,560,000
Average Annual Percent Change from Alternative 1	-0.6%	-2.9%	-0.5%

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

Table 21 identifies the years with a split navigation season, which would occur in the years when the full bi-modal spawning cue release is implemented and in the subsequent year. The low summer flow and associated split navigation season would occur for approximately 10 weeks in the last week of June, July, and August. In addition, there are 31 years when partial releases would occur, which is defined as when one of the March or May spawning cues is fully implemented or when the March and/or May spawning cues is partially implemented. It should be noted that the "year after a full release" is also when a partial release and a low summer flow would occur under Alternative 2 (see Figures 4 and 5 below).

Table 21. Years with Split Navigation Seasons Simulated under Alternative 2

1963	1964	1988	1989	2002	2003

When evaluating the impacts from each of the alternatives in the MRRMP-EIS, it is helpful to examine the annual impacts. The annual differences in NED benefits between Alternative 1 and Alternative 2 over the POR for navigation NED benefits are shown in Figure 6. The difference in NED benefits for each year is color-coded based on the type of release occurring each year.

The six split navigation season years as simulated under Alternative 2 would result in adverse impacts to navigation NED benefits compared to Alternative 1 (Figure 6). These adverse impacts would be due to decreased transportation rate savings from split and shorter navigation seasons. When commodities can no longer be shipped during the summer season, they would be shipped via truck or rail, with no transportation rate savings accruing during this period. The years with full spawning cue releases and low summer flows and the year after when low summer flows would occur would result in an annual reduction of up to $2.0 million (24% decrease compared to Alternative 1 in those years) in transportation rate savings compared to Alternative 1.

The annual difference in navigation NED benefits are generally slightly greater than the transportation rate savings because the reduced RR&R costs under Alternative 2 would slightly offset the reductions in transportation rate savings. Under the years with low summer flows, the shorter season and higher service level under Alternative 2 causes greater RR&R cost savings compared to Alternative 1, partially offsetting the decrease in transportation rate savings.

Of the 31 partial releases simulated over the POR, nine would have an adverse impact on navigation NED benefits with the largest annual decrease ($1.2 million) occurring during conditions similar to those simulated for 1964. In general, the release of water in the spring would reduce the water in System storage compared to Alternative 1 during the criteria check in July 1, resulting in lower service levels and lower transportation rate savings and higher RR&R

costs compared to Alternative 1. However, the partial releases in some years would result in small increases in NED benefits. For example, in the simulated years of 1965, 1982, and 2009, navigation NED benefits would increase between $843,000 and $1.4 million in these simulated years compared to Alternative 1. In 1965 and 1982 the partial releases increase the service level during the release in May. In addition, in 1965, the low summer flows in 1963 increase System storage slightly in 1965, increasing the service level for navigation compared to Alternative 1. The low summer flows in 2002 and 2003 would result in slightly higher System storage in the mid to late 2000s under Alternative 2 compared to Alternative 1, with small increases in service levels relative to Alternative 1.

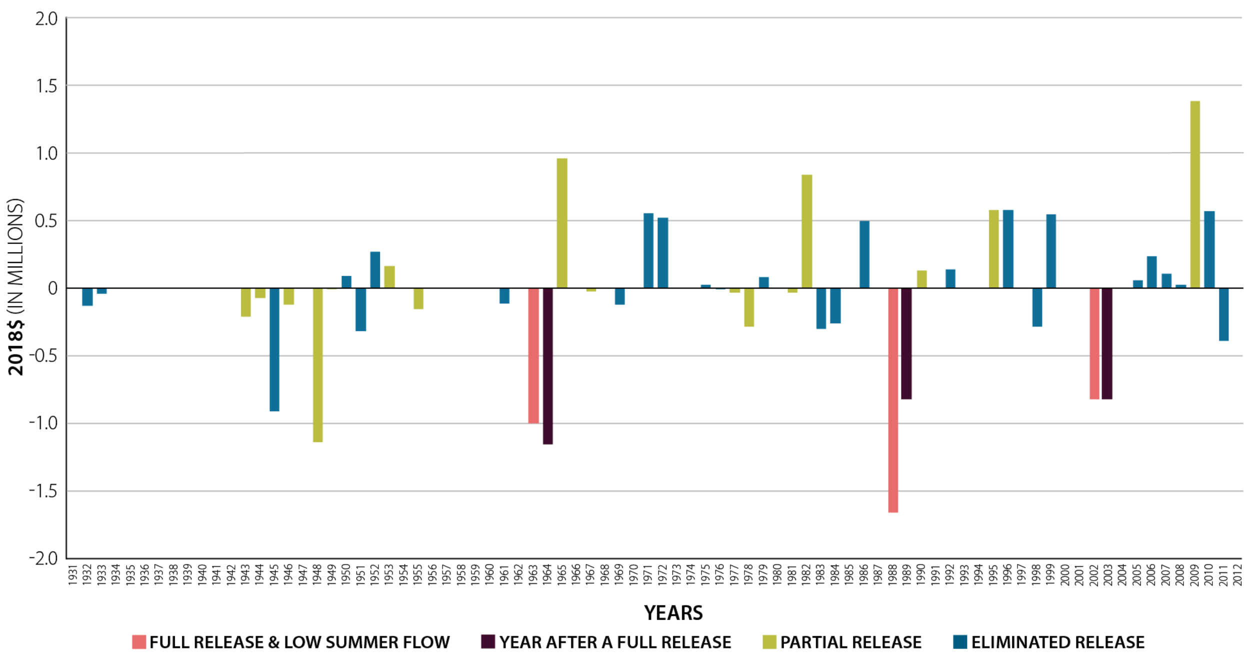

Figure 6. Alternative 2 Difference in Navigation National Economic Development Benefits Relative to Alternative 1

4.2.3 Alternative 3 – Mechanical Construction Only

Management actions included under Alternative 3 would include the creation of ESH through mechanical means. In addition, the spring plenary pulse under Alternative 1 would not take place under Alternative 3. The NED results for Alternative 3 are summarized in Table 22. Overall, Alternative 3 results in a very small average annual increase in navigation NED benefits ($21,000 or 0.3%) due to a slight increase in System storage relative to Alternative 1 because the spring plenary pulse does not occur under Alternative 3.

Table 22. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and National Economic Development Benefits for Alternative 3 (2018$)

NED Benefits	Transportation Rate Savings	Change in RR&R Costs	NED Benefits
Total NED Benefits over the POR	$656,400,000	$46,300,000	$610,100,000
Average Annual NED Benefits	$8,010,000	$570,000	$7,440,000
Highest Annual NED Benefits over the POR	$12,040,000	$1,260,000	$11,980,000
Lowest Annual NED Benefits over the POR	$0	$0	$0
Average Annual Change from Alternative 1	$19,000	-$2,000	$21,000
Average Annual Percent Change from Alternative 1	0.2%	-0.3%	0.3%

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

Figure 7 shows the change in navigation benefits by year for Alternative 3 relative to Alternative 1. In most years, Alternatives 1 and 3 have very similar navigation NED benefits. In general, transportation rates saving would increase and RR&R costs would decrease under Alternative 3 compared to Alternative 1. In 1949 and 1965, Alternative 3 would result in an increase of approximately $700,000 in annual navigation NED benefits relative to Alternative 1 because there was a slightly higher navigation service level under Alternative 3 due to the lack of spring plenary pulse compared to Alternative 1.

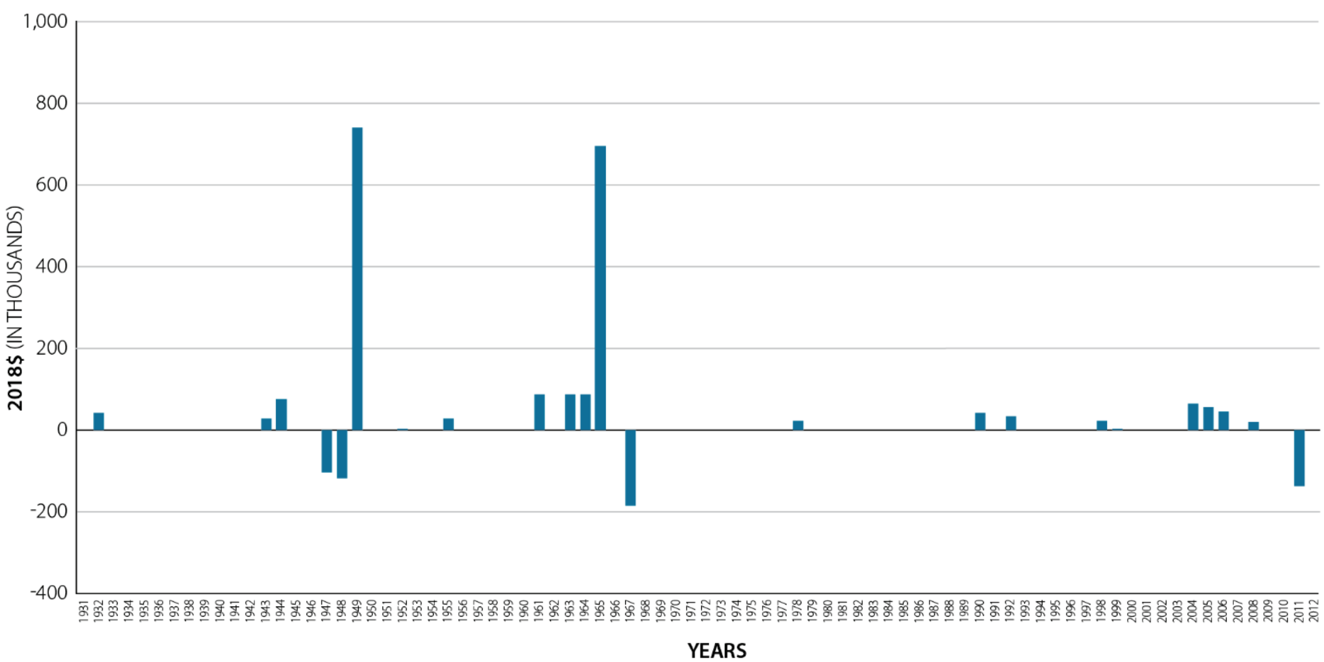

Figure 7. Alternative 3 Difference in Navigation National Economic Development Benefits Relative to Alternative 1

4.2.4 Alternative 4 – Spring ESH Creating Release

Alternative 4 management actions include the development of ESH habitat through both mechanical means and spring releases. As shown in Table 23, relative to Alternative 1, Alternative 4 has average annual navigation NED benefits of $7.2 million, an average annual decrease in navigation NED benefits of $181,000 or 2.4 percent. The annual navigation NED benefits would range from $0 to $12.0 million under Alternative 4.

Table 23. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits for Alternative 4 ($2018)

NED Benefits	Transportation Rate Savings	Change in RR&R Costs	NED Benefits
Total NED Benefits over the POR	$641,700,000	$48,100,000	$593,600,000
Average Annual NED Benefits	$7,830,000	$590,000	$7,240,000
Highest Annual NED Benefits over the POR	$12,040,000	$1,260,000	$11,980,000
Lowest Annual NED Benefits over the POR	$0	$0	$0
Average Annual Change in NED Benefits from Alternative 1	-$160,000	$20,000	-$181,000
Average Annual Percentage Change in Alternative 1	-2.0%	3.5%	-2.4%

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

Figure 8 presents the annual differences in navigation NED benefits between Alternative 1 and Alternative 4. The difference in NED benefits for each year is color-coded based on the type of release occurring each year. Under conditions similar to those modeled in 1967, 1982, and 1994, full releases under Alternative 4 would result in the greatest decreases of total NED benefits, more than $1,000,000 per year, compared to Alternative 1. While the length of the supported navigation season between Alternative 1 and Alternative 4 during these simulated years would usually be the same, the full releases cause reductions in System storage, which reduces the navigation service level provided by the USACE. The reduction in service level would increase the RR&R costs and reduce the transportation rate savings resulting in a decrease in the NED benefits compared to Alternative 1. Of the nine years when full implementation of the releases would be simulated, six years would experience decreases in NED benefits, while the other years had minimal to no changes compared to Alternative 1.

The years following a full release would result in adverse impacts to navigation through reduced System storage and navigation service levels. For example, conditions similar to those modeled for 1947 and 1964 would result in annual decreases of over $330,000 in navigation NED benefits. In these years, the partial spring releases reduce the service level, which decreases transportation rate savings under Alternative 4 compared to Alternative 1, with decreases in navigation NED benefits.

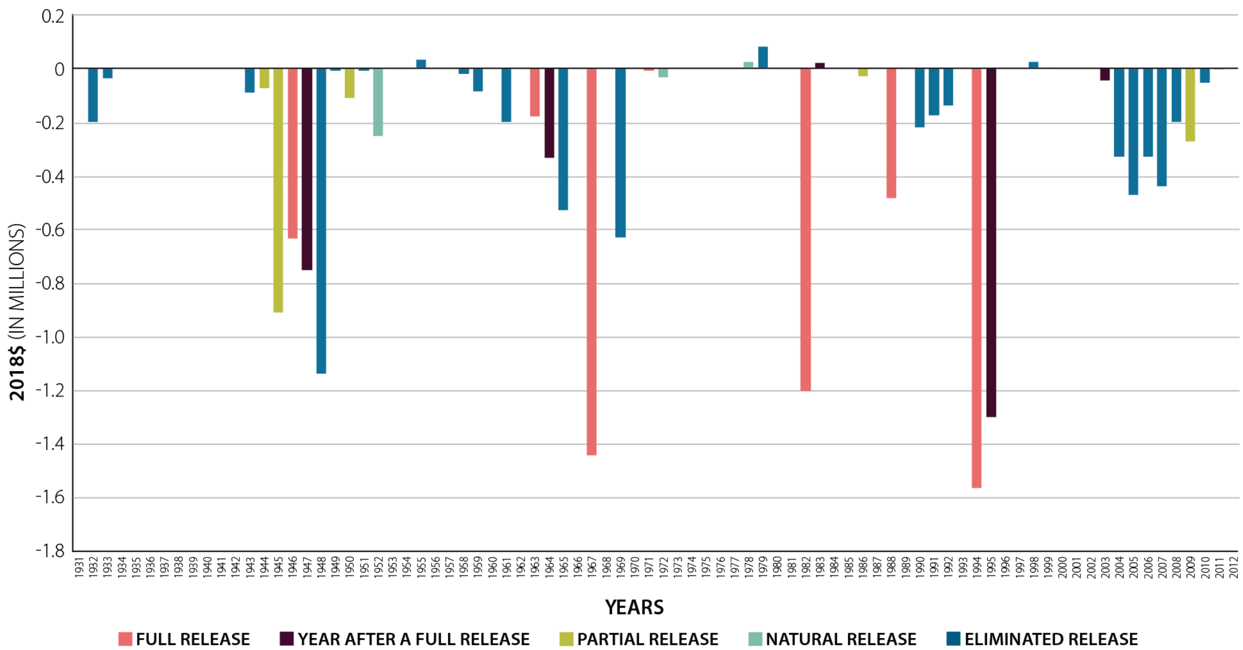

Figure 8. Alternative 4 Difference in Navigation National Economic Development Benefits Relative to Alternative 1

4.2.5 Alternative 5 – Fall ESH Creating Release

Alternative 5 management actions include developing ESH habitat through both mechanical and fall releases from Gavins Point Dam. The navigation NED results for Alternative 5 are summarized in Table 24. Alternative 5 results in some very small changes compared to Alternative 1. On average, there are slightly lower transportation rate savings and slightly higher RR&R costs, resulting in a small decrease in navigation NED benefits compared to Alternative 1 (-$57,000 or -0.8%).

Table 24. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits for Alternative 5 ($2018)

NED Benefits	Transportation Rate Savings	Change in RR&R Costs	NED Benefits
Total NED Benefits over the POR	$650,800,000	$47,050,000	$603,700,000
Average Annual NED Benefits	$7,940,000	$574,000	$7,360,000
Highest Annual NED Benefits over the POR	$12,040,000	$1,260,000	$11,980,000
Lowest Annual NED Benefits over the POR	$0	$0	$0
Average Annual Change from Alternative 1	-$50,000	$7,000	-$57,000
Average Annual Percentage Change from Alternative 1	-0.6%	1.2%	-0.8%

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

Figure 9 presents the annual navigation NED benefits for Alternative 5; each year is color-coded based on the release event. Most of the annual NED benefits are very similar for Alternative 5 and Alternative 1. Alternative 5 includes fall releases that would be fully implemented in seven years and partially implemented in two years over the POR. There are two years in which there are notable adverse impacts to navigation NED benefits: 1988 and 1995. The simulated years of 1988 and 1995 are years that follow a fully implemented fall release. In these years, the decreased NED benefits were caused by lower System storage levels and navigation service levels in subsequent years, resulting in relatively higher RR&R costs and decreases in transportation rate savings.

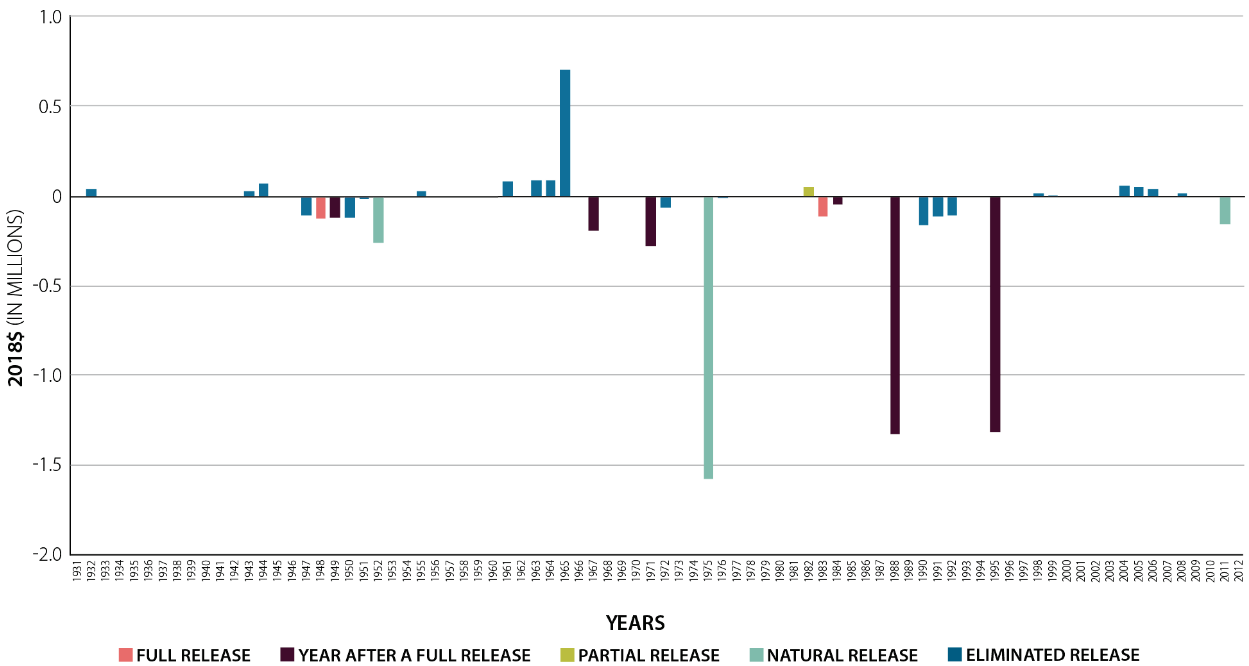

Figure 9. Alternative 5 Difference in Navigation National Economic Development Benefits Relative to Alternative 1

4.2.6 Alternative 6 – Pallid Sturgeon Spawning Cue

The management actions under Alternative 6 include developing ESH habitat through mechanical means and bi-modal spawning cue flow releases in March and May. The navigation NED results for Alternative 6 are summarized in Table 25. Relative to Alternative 1, Alternative 6 would reduce average annual transportation rate savings by $119,000 and increase RR&R costs by $8,000, with an average annual decrease in navigation NED benefits of $127,000 or -1.7 percent.

Table 25. Transportation Rate Savings, Repair, Replacement, and Rehabilitation Costs, and Navigation National Economic Development Benefits for Alternative 6 ($2018)

NED Benefits	Transportation Rate Savings	Change in RR&R Costs	NED Benefits
Total NED Benefits over the POR	$645,140,000	$47,200,000	$598,000,000
Average Annual NED Benefits	$7,870,000	$580,000	$7,290,000
Higher Annual NED Benefits over the POR	$12,280,000	$1,260,000	$12,270,000
Lowest Annual NED Benefits over the POR	$0	$0	$0
Average Annual Change in NED Benefits from Alternative 1	-$119,000	$8,000	-$127,000
Average Annual Percentage Change in NED Benefits from Alternative 1	-1.5%	1.4%	-1.7%

*Numbers may not compute exactly due to rounding. The lowest and highest years for the transportation rate savings, RR&R costs, and navigation NED benefits are not necessarily from one year.

Under Alternative 6, there would be six years with fully implemented spawning cue releases and 29 years of partial implementation, defined as full implementation of one of the spring releases (March or May) or partial release of one or both of the bimodal releases. Figure 10 summarizes the annual difference in navigation NED benefits between Alternative 1 and Alternative 6. Each year is color-coded based on the type of release that occurred in that year.

Adverse impacts occur during some of the full and partial release years, with three years experiencing a decrease of between $900,000 and $1.5 million in annual navigation NED benefits compared to Alternative 1. These impacts would be due to the releases reducing System storage, which would affect navigation service level causing a decrease in transportation rate savings and an increase in RR&R costs resulting in an overall decrease navigation NED benefits.

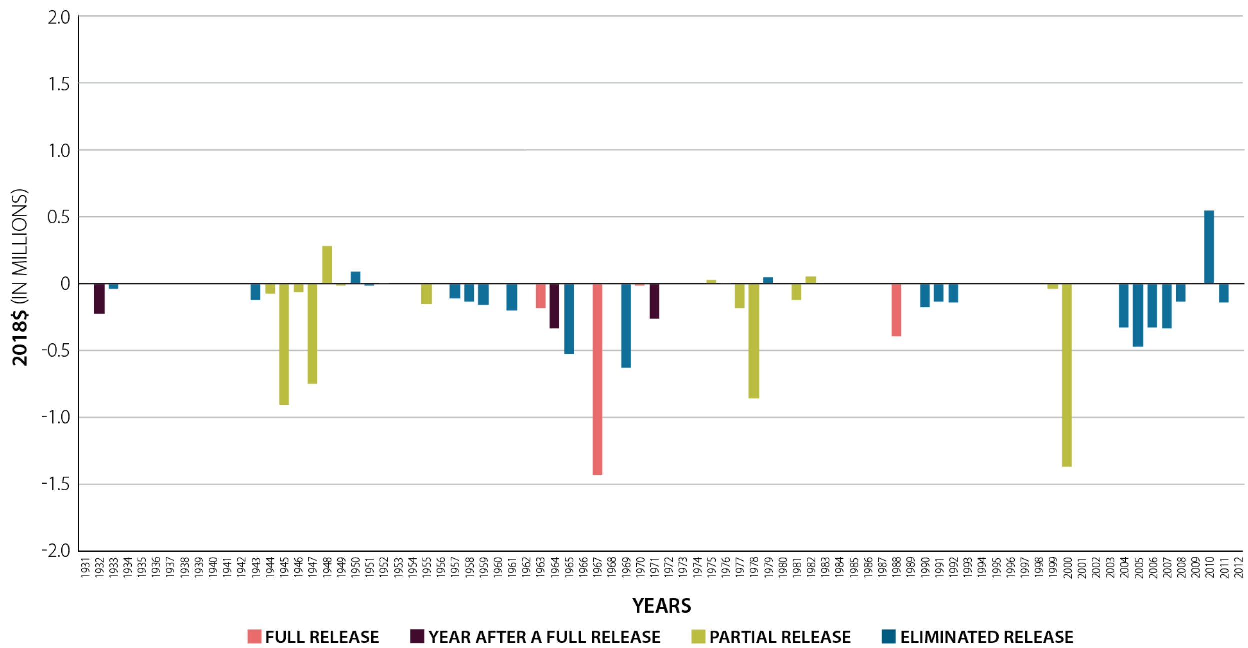

Figure 10. Alternative 6 Difference in Navigation National Economic Development Benefits Relative to Alternative 1

4.3 Regional Economic Development Results

The navigation RED evaluation summarizes the jobs, income, and sales impacts associated with the estimated commercial tonnage transported on the Missouri River. The commercial tonnage (not including sand and gravel) estimated to be transported on the Missouri River was calculated with the baseline tonnage (2016) and the tonnage estimated to shift off of the waterway to alternate overland modes over the period of record. The RED results are summarized in this section.

4.3.1 Summary of Regional Economic Development Results

A summary of the RED impacts for employment, labor income, and sales for all of the alternatives evaluated in the MRRMP-EIS are summarized in Tables 26, 27, and 28, respectively. Alternatives 2, 4 and 6 would result in adverse impacts to RED benefits associated with navigation. Alternative 4 would have the largest adverse impacts on average, with an average reduction in 2 jobs per year and $94,000 in labor income. In the eight worst change years compared to Alternative 1, Alternative 4 would result in an average annual reduction of 12 jobs and $666,000 in labor income. The spring release and spawning cue release under Alternatives 4 and 6 would result in lower System storage in the summer and fall as the reservoir System rebalances, with adverse impacts to navigation service level during the fall season, resulting in some of the tonnage shifting off of the river to alternate overland modes when river flows (and service levels) fall below 26,000 cfs. Please refer to Table 37 for a summary by alternatives of the estimated tonnage that would shift off the waterway to alternate overland modes. Alternatives 2, 3 and 5 would result in minimal changes in average annual RED benefits relative to Alternative 1. However, under Alternative 2, in the largest difference years from Alternative 1 during the low summer flow events (average of 8 largest difference years), a reduction in 14 annual jobs and $790,000 in labor income would occur, which is more adverse than Alternative 4 and 6.

Table 26. Direct, Indirect, and Induced Employment for Waterway Industries under the Alternatives in the MRRMP-EIS

Year/Scenario	Alternative					
	1	2	3	4	5	6
Average Annual Employment	154	154	154	152	154	152
Change in Average Annual Employment	NA	0	0	-2	0	-1
Percent Change in Average Annual Employment	NA	-0.1%	0.1%	-1.1%	-0.1%	-1.0%
8 Worst Years Relative to Alternative 1 (average)	NA	-14	0	-12	-4	-9
8 Best Years Relative to Alternative 1 (average)	NA	8	2	0	2	1

Table 27. Direct, Indirect, and Induced Labor Income for Waterway Industries under the Alternatives in the MRRMP-EIS (2018$)

Year/Scenario	Alternative					
	1	2	3	4	5	6
Average Annual Labor Income	$8,793,396	$8,782,047	$8,805,931	$8,699,195	$8,784,033	$8,708,140
Change in Average Annual Labor Income	NA	-$11,349	$12,535	-$94,201	-$9,363	-$85,256
Percent Change in Average Annual Labor Income	NA	-0.1%	0.1%	-1.1%	-0.1%	-1.0%
8 Worst Years Relative to Alternative 1 (average)	NA	-$789,164	$0	-$666,422	-$212,163	-$527,532
8 Best Years Relative to Alternative 1 (average)	NA	$482,404	$105,871	$6,737	$103,963	$60,301

Table 28. Direct, Indirect, and Induced Sales under the Alternatives in the MRRMP-EIS for Waterway Industries ($2018)

Year/Scenario	Alternative					
	1	2	3	4	5	6
Average Annual Sales/Revenues	$29,414,566	$29,376,603	$29,456,496	$29,099,457	$29,383,246	$29,129,378
Change in Average Annual Sales/Revenues	NA	-$37,963	$41,930	-$315,109	-$31,320	-$285,188
Percent Change in Average Annual Sales	NA	-0.1%	0.1%	-1.1%	-0.1%	-1.0%
8 Worst Years Relative to Alternative 1 (average)	NA	-$2,639,811	$0	-$2,229,231	-$709,701	-$1,764,633
8 Best Years Relative to Alternative 1 (average)	NA	$1,613,679	$354,149	$22,536	$347,763	$201,710

4.3.2 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

Under Alternative 1, RED benefits associated with the value of commercial shipments on the waterway would support on average over the POR 154 direct, indirect, and induced jobs and $8.8 million in total labor income. During the worst navigation years when there was no navigation, there would be no jobs and income supported when no tonnage is assumed to be transported by waterway, while in the highest navigation year with the greatest tonnage shipped, there would be 173 jobs and $9.9 million in labor income. Table 29 provides a summary of RED benefits under Alternative 1.

While Alternative 1 would have adverse impacts to the waterway industries when commodities can no longer be shipped via navigation on the Missouri River, these adverse impacts would be at least partially offset by revenue gains and employment growth in other transportation sectors (e.g., truck and rail transport). Since most of these commodities are moved to or from Missouri, the majority of the economic impacts would occur within Missouri, although there may be some small economic impacts to adjacent states where these commodities would be shipped to or from.

Table 29. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 1 (2018 dollars)

Economic Impact Parameter	Scenario	Regional Economic Contribution
Direct, Indirect, and Induced Jobs	Annual Average Employment	154
	Smallest Annual Movement of Commodities on the Missouri River	0
	Largest Annual Movement of Commodities on the Missouri River	173
Direct, Indirect, and Induced Labor Income	Annual Average Labor Income	$8,793,396
	Smallest Annual Movement of Commodities on the Missouri River	$0
	Largest Annual Movement of Commodities on the Missouri River	$9,917,027
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,414,566
	Smallest Annual Movement of Commodities on the Missouri River	$0
	Largest Annual Movement of Commodities on the Missouri River	$33,173,196

4.3.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Under Alternative 2, average annual RED benefits supported by navigation are estimated to be 154 jobs and $8.8 million in labor income. When compared to Alternative 1, Alternative 2 would result in a negligible change in jobs and $11,000 less in labor income on average over the POR associated with the reduced ability to navigate on the Missouri River. The eight worst years compared to Alternative 1 include years when a low summer flow would cause a split navigation season. During these years, there would be a reduction of 14 jobs and $789,000 in labor income on average per year associated with impacts to the waterway industries in the region. Table 30 summarizes the RED impacts under Alternative 2.

Table 30. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 2 and Compared to Alternative 1 (2018$)

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average Employment	154
	Change in Annual Average RED Benefits Relative to Alternative 1	0
	Percent Change in Average Annual Employment	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-14
	Average Annual Change in 8 Best Years Relative to Alternative 1	8
Direct, Indirect, and Induced Labor Income	Annual Average Labor Income	$8,782,047
	Change in Annual Average RED Benefits Relative to Alternative 1	-$11,349
	Percent Change in Average Annual Labor Income	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$789,164
	Average Annual Change in 8 Best Years Relative to Alternative 1	$482,404
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,376,603
	Change in Annual Average RED Benefits Relative to Alternative 1	-$37,963
	Percent Change in Average Annual Sales	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,639,811
	Average Annual Change in 8 Best Years Relative to Alternative 1	$1,613,679

4.3.4 Alternative 3 – Mechanical Construction Only

Under Alternative 3, average annual RED benefits supported by navigation would be 154 jobs and $8.8 million in labor income. Alternative 3 would result in negligible changes in jobs and income compared to Alternative 1. Table 31 summarizes the RED impacts under Alternative 3.

Table 31. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 3 and Compared to Alternative 1 ($2018)

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average Employment	154
	Change in Annual Average RED Benefits Relative to Alternative 1	0
	Percent Change in Average Annual Employment	0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	0
	Average Annual Change in 8 Best Years Relative to Alternative 1	2
Direct, Indirect, and Induced Labor Income	Annual Average Labor Income	$8,805,931
	Change in Annual Average RED Benefits Relative to Alternative 1	$12,535
	Percent Change in Average Annual Labor Income	0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$105,872
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,456,496
	Change in Annual Average RED Benefits Relative to Alternative 1	$41,930
	Percent Change in Average Annual Sales	0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$354,149

4.3.5 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, average annual RED benefits supported by navigation would be 152 jobs and $8.7 million in labor income. Compared to Alternative 1, Alternative 4 would result in two fewer jobs and $94,000 less in labor income on average per year over the POR associated with the reduced ability to navigate in some years. There would be small adverse impacts to waterway industries and supporting sectors in the years with the largest reductions in shipments compared to Alternative 1, resulting in a relative decrease of 12 jobs and $666,000 in labor income compared to Alternative 1. Table 32 summarizes the RED impacts under Alternative 4.

Table 32. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 4 and Compared to Alternative 1 (2018$)

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average Employment	152
	Change in Annual Average RED Benefits Relative to Alternative 1	-2
	Percent Change in Average Annual Employment	-1.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-12
	Average Annual Change in 8 Best Years Relative to Alternative 1	0
	Annual Average Labor Income	$8,699,195

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Labor Income	Change in Annual Average RED Benefits Relative to Alternative 1	-$94,201
	Percent Change in Average Annual Labor Income	-1.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$666,422
	Average Annual Change in 8 Best Years Relative to Alternative 1	$6,737
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,099,457
	Change in Annual Average RED Benefits over 82 years Relative to Alternative 1	-$315,109
	Percent Change in Average Annual Sales	-1.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,229,231
	Average Annual Change in 8 Best Years Relative to Alternative 1	$22,536

4.3.6 Alternative 5 – Fall ESH Creating Release

Under Alternative 5, average annual RED benefits supported by navigation would be 154 jobs and $8.8 million in labor income. Alternative 5 would result in negligible RED impacts compared to Alternative 1. Table 33 summarizes the RED impacts under Alternative 5.

Table 33. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 5 and Compared to Alternative 1 (2018$)

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average Employment	154
	Change in Annual Average RED Benefits Relative to Alternative 1	0
	Percent Change in Average Annual Employment	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-4
	Average Annual Change in 8 Best Years Relative to Alternative 1	2
Direct, Indirect, and Induced Labor Income	Annual Average Labor Income	$8,784,033
	Change in Annual Average RED Benefits Relative to Alternative 1	-$9,363
	Percent Change in Average Annual Labor Income	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$212,163
	Average Annual Change in 8 Best Years Relative to Alternative 1	$103,963
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,383,246
	Change in Annual Average RED Benefits Relative to Alternative 1	-$31,320
	Percent Change in Average Annual Sales	-0.1%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$709,701
	Average Annual Change in 8 Best Years Relative to Alternative 1	$347,763

4.3.7 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, average annual RED benefits supported by navigation would be 152 jobs and $8.7 million in labor income. Under Alternative 6, the adverse conditions that would affect the ability to navigate the Missouri River over the period of record would result in an average annual reduction of one job and $85,000 in labor income compared to Alternative 1. Reduced navigation service and shortened navigation seasons under Alternative 6 associated with reduced System storage as a result of spawning cue pulses would have an adverse impact on the waterway industries and supporting sectors. In the eight worst years relative to Alternative 1, there would be an average reduction in 9 jobs and $528,000 in labor income. Table 34 summarizes the RED impacts under Alternative 6.

Table 34. Total Regional Economic Development Benefits Associated with Waterway Industries on the Missouri River under Alternative 6 and Compared to Alternative 1 (2018$)

Economic Impact Parameter	Scenario	Regional Economic Impact
Direct, Indirect, and Induced Jobs	Annual Average Employment	152
	Change in Annual Average RED Benefits Relative to Alternative 1	-1
	Percent Change in Average Annual Employment	-1.0%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-9
	Average Annual Change in 8 Best Years Relative to Alternative 1	1
Direct, Indirect, and Induced Labor Income	Annual Average Labor Income	$8,708,140
	Change in Annual Average RED Benefits Relative to Alternative 1	-$85,256
	Percent Change in Average Annual Labor Income	-1.0%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$527,532
	Average Annual Change in 8 Best Years Relative to Alternative 1	$60,301
Direct, Indirect, and Induced Sales	Annual Average Sales	$29,129,378
	Change in Annual Average RED Benefits Relative to Alternative 1	-$285,188
	Percent Change in Average Annual Sales	-1.0%
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$1,764,633
	Average Annual Change in 8 Best Years Relative to Alternative 1	$201,710

4.4 Other Social Effects Results

The OSE for commercial navigation includes an assessment of how shifting modes from the waterway to overland could affect air emissions of carbon monoxide (CO), nitrous oxides (NOx), and particulate matter (PM), and hydrocarbons (HC). Section 4.1 summarizes the commercial tonnage (not including sand and gravel) estimated to shift off of the waterway to alternate overland modes over the POR, on which the OSE evaluation is based. A summary of the air emissions results is also presented in this section.

4.4.1 Commercial Tonnage that Shifts to Alternate Overland Modes of Transportation

The annual average amount of commodities shifting from waterway to overland transportation modes ranges from 56,800 tons for the Kansas City reach under Alternative 3 (the least amount of tonnage) to 62,900 tons under Alternative 4 (the greatest amount of tonnage) (Table 35). Drought conditions and relatively lower System storage under Alternative 3 would result. Tonnage is estimated to shift off of the river when river flows fall below 26,000 cfs during the navigation season or when the navigation season is shortened. Alternative 4 would result in the largest shift in mode; an annual average of 980 tons in the Omaha reach, 8,500 tons in the Nebraska City reach, and 62,900 tons in the Kansas City reach would shift transportation modes. Alternatives 4 and 6 would result in commodities being shipped by alternate transportation modes because the pulses and spawning cue releases cause reductions in System storage, causing shorter navigation seasons than experienced under Alternative 1. The split seasons proposed under Alternative 2 would result in an adverse impact to navigation, but would not be as adverse as under Alternative 4 and 6 because Alternative 2 low summer flow events would increase System storage in the months and sometime years following the low summer flow events, extending the navigation season. It should be noted that Alternative 3 would result in slightly less tonnage shifting off the waterway when compared to Alternative 1 due to slightly longer navigation seasons (higher System storage) under Alternative 3.

Table 35. Commercial Tonnage Estimated to Shift Modes under the MRRMP-EIS Alternatives

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Omaha							
Average Annual Commodities that Shift Mode	**Tons**	**690**	**650**	**640**	**980**	**690**	**990**
Average Annual Change in Tonnage Relative to Alternative 1	Tons	NA	-40	-50	290	0	300
Percent Change in Tonnage Relative to Alternative 1	%	NA	-6.0%	-7.0%	42.0%	0.0%	43.0%
Nebraska City							
Average Annual Commodities that Shifts Mode	**Tons**	**7,400**	**7,200**	**7,300**	**8,500**	**7,500**	**8,400**
Average Annual Change in Tonnage Relative to Alternative 1	Tons	NA	-200	-100	1,100	100	1,000
Percent Change in Tonnage Relative to Alternative 1	%	NA	-3.0%	-1.0%	15.0%	1.0%	14.0%
Kansas City							
Average Annual Commodities that Shifts Mode	**Tons**	**57,600**	**58,200**	**56,800**	**62,900**	**58,100**	**62,400**
Average Annual Change in Tonnage Relative to Alternative 1	Tons	NA	600	-800	5,300	500	4,800
Percent Change in Tonnage Relative to Alternative 1	%	NA	1.0%	-1.0%	9.0%	1.0%	8.0%

Note: These figures do not include the tonnage for commercial sand and gravel. The model assessed tonnage if it was transported within or through a river reach. Summing the tonnages across the river reaches would likely result in double counting because most of commodity shipments in the Omaha and Kansas City reach are likely also transported in the Kansas City reach.

4.4.2 Overview of Other Social Effects Results

The vast majority of impacts to air emissions results from tonnage shifting off of the waterway in the Kansas City reach.[3] Table 36 presents the average annual emissions of criteria air pollutants within the Kansas City reach if the diverted tonnage would be shipped by truck or rail. The top two rows within each pollutant section of Table 38 shows the change in emissions if all tonnage identified as shifting modes was transported by truck while the lower two rows in each section present the change in emissions if the identified tonnage is transported by rail. Alternatives 4 and 6 would result in very small adverse impacts to HC, CO, NOx, and PM; Alternative 4 would result in the largest increase in emissions compared to Alternative 1. The pollutant most affected by Alternatives 4 and 6 is NOx, with an average annual increase of 2,500 and 2,300 kilograms (kg), respectively, compared to Alternative 1. Alternative 2 would also result in adverse effects to air emissions, but to a lesser extent compared to Alternative 4 and Alternative 6.

Table 36. Air Emissions for Commodities that Shift Mode in the Kansas City Reach (kg)

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Hydrocarbon Emissions						
Annual Average Emissions – Shift in Mode to Truck	2,800	2,800	2,800	3,100	2,800	3,100
Change from Alternative 1		0	0	300	0	300
Annual Average Emissions – Shift in Mode to Rail	100	100	100	100	100	100
Change from Alternative 1	NA	0	0	0	0	0
Carbon Monoxide Emission						
Annual Average Emissions – Shift in Mode to Truck	9,000	9,100	8,900	9,800	9,100	9,700
Change from Alternative 1		100	-100	800	100	700
Annual Average Emissions – Shift in Mode to Rail	300	300	300	400	300	400
Change from Alternative 1	NA	0	0	100	0	100
Nitrous Oxide Emissions						
Annual Average Emissions – Shift in Mode to Truck	27,800	28,100	27,400	30,300	28,000	30,100
Change from Alternative 1		300	-400	2,500	200	2,300
Annual Average Emissions – Shift in Mode to Rail	1,700	1,700	1,600	1,800	1,700	1,800
Change from Alternative 1	NA	0	-100	100	0	100
Particulate Matter Emissions						
Annual Average Emissions – Shift in Mode to Truck	1,800	1,800	1,800	1,900	1,800	1,900
Change from Alternative 1	0	0	0	100	0	100
Annual Average Emissions – Shift in Mode to Rail	0	0	0	0	0	0
Change from Alternative 1	NA	0	0	0	0	0

Note: Numbers may not compute exactly due to rounding.

[3] The model assessed tonnage if it is transported within or through a river reach. Summing the tonnages across the river reaches would likely result in double counting because most of commodity shipments in the Omaha and Nebraska City reaches are also likely transported in the Kansas City reach.

4.4.3 Alternative 1 – No Action (Current System Operation and Current MRRP Implementation)

There would be tonnage that shifts off of the river to alternate overland modes of transportation in Omaha, Nebraska City, and Kansas City reaches. There would be only a small amount of affected tonnage in the Omaha and Nebraska City reaches, with negligible changes in air emissions in these reaches. As shown in Table 37, the pollutant with the largest range of emissions is NOx with an annual average change of 1,700 kg (rail) to 27,800 kg (truck) in the Kansas City reach. The second greatest range of emissions is CO with annual average air emissions ranging from 300 kg (rail) to 9,000 kg in the Kansas City reach. The estimates for NOx and CO are also important to consider since these compounds react in the atmosphere to form low-level ozone.

There are only negligible to small changes in emissions when assuming all diverted tonnage shifts to rail. The difference between unit rail emissions and waterway emissions is minimal because the railway emission factors are only slightly higher than the waterway emission factors (see Table 12, Summary of Emission Rates).

Table 37. Air Emissions for Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	30	110	330	20
Annual Average Emissions – Shift in Mode to Rail	0	0	20	0
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,200	3,600	200
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	2,800	9,000	27,800	1,800
Annual Average Emissions – Shift in Mode to Rail	100	300	1,700	0

Note: Numbers may not compute exactly due to rounding.

4.4.4 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 management actions include spawning cue releases and low summer flows that can result in split navigation seasons when fully implemented. As shown in Table 38, Alternative 2 would result in slightly less commercial cargo switching transportation modes for the Omaha and Nebraska City reaches than Alternative 1, so these reaches experience little to no change in criteria pollutant emissions. However, in comparison to Alternative 1, the Kansas City reach would experience a 1 percent increase if all affected tonnage shifted to truck for CO, NOx, and PM. Nitrous oxide air emissions would increase 300 kg if all of the diverted tonnage shifted to truck.

Table 38. Air Emissions for Alternative 2 and Relative to Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	30	100	310	20
Change from Alternative 1	0	-10	-20	0
Percent Change from Alternative 1	0%	-9%	-6%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	20	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,100	3,500	200
Change from Alternative 1	0	-100	-100	0
Percent Change from Alternative 1	0%	-8%	-3%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	2,800	9,100	28,100	1,800
Change from Alternative 1	0	100	300	0
Percent Change from Alternative 1	0%	1%	1%	0%
Annual Average Emissions – Shift in Mode to Rail	100	300	1,700	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%

Note: Numbers may not compute exactly due to rounding.

4.4.5 Alternative 3 – Mechanical Construction Only

Under Alternative 3, management actions would include the creation of ESH through mechanical means. In addition, the spring plenary pulse under Alternative 1 would not take place under Alternative 3. Alternative 3 is estimated to cause slightly less commercial cargo to shift transportation modes than under Alternative 1, so there would be very small changes in air emissions (Table 39).

Table 39. Air Emissions for Alternative 3 and Relative to Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	30	100	310	20
Change from Alternative 1	0	-10	-20	0
Percent Change from Alternative 1	0%	-9%	-6%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	20	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,100	3,500	200
Change from Alternative 1	0	-100	-100	0
Percent Change from Alternative 1	0%	-8%	-3%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	2,800	8,900	27,400	1,800
Change from Alternative 1	0	-100	-400	0
Percent Change from Alternative 1	0%	-1%	-1%	0%
Annual Average Emissions – Shift in Mode to Rail	100	300	1,600	0
Change from Alternative 1	0	0	-100	0
Percent Change from Alternative 1	0%	0%	-6%	0%

Note: Numbers may not compute exactly due to rounding.

4.4.6 Alternative 4 – Spring ESH Creating Release

Alternative 4 management actions include the development of ESH habitat through both mechanical means and spring releases. The spring releases cause System storage to decrease in some years, shortening the navigation seasons and moving commodities off the waterway to other modes of transportation. As shown in Table 39, Alternative 4 would result in 5,300 tons on average of commercial commodities that would shift from the waterway to alternate overland modes in the Kansas City reach compared to Alternative 1. This change is primarily driven by shorter navigation seasons under Alternative 4. For the Kansas City reach, the increase in NOx emissions under Alternative 4 will range from 100 kg (6%) for rail transport to 2,500 kg (9%) for truck transportation compared to Alternative 1, as shown in Table 40. Similar to the other alternatives, over 95 percent of the emissions for Alternative 4 will occur within the Kansas City reach, which could have adverse impacts on non-attainment counties. There would be small increases in average annual air emissions in the Nebraska City and Omaha reaches under Alternative 4 compared to Alternative 1; although the percent changes from Alternative 1 are notable, the changes in air emissions would be negligible in magnitude regional context.

Table 40. Air Emissions for Alternative 4 and Relative to Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	50	150	470	30
Change from Alternative 1	20	40	140	10
Percent Change from Alternative 1	67%	36%	42%	50%
Annual Average Emissions – Shift in Mode to Rail	0	0	30	0
Change from Alternative 1	0	0	10	0
Percent Change from Alternative 1	0%	0%	50%	0%
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,300	4,100	300
Change from Alternative 1	0	100	500	100
Percent Change from Alternative 1	0%	8%	14%	50%
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	3,100	9,800	30,300	1,900
Change from Alternative 1	300	800	2,500	100
Percent Change from Alternative 1	11%	9%	9%	6%
Annual Average Emissions – Shift in Mode to Rail	100	400	1,800	0
Change from Alternative 1	0	100	100	0
Percent Change from Alternative 1	0%	33%	6%	0%

Note: Numbers may not compute exactly due to rounding.

4.4.7 Alternative 5 – Fall ESH Creating Release

Alternative 5 management actions include developing ESH habitat through both mechanical and fall releases from Gavins Point Dam. Alternative 5 would result in slightly more commodities shifting to alternate transportation modes than would occur under Alternative 1. As shown in

Table 41, changes in the criteria pollutant emissions under Alternatives 5 would be negligible compared to Alternative 1.

Table 41. Air Emissions for Alternative 5 and Relative to Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	30	110	330	20
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	20	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,200	3,600	200
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	2,800	9,100	28,000	1,800
Change from Alternative 1	0	100	200	0
Percent Change from Alternative 1	0%	1%	1%	0%
Annual Average Emissions – Shift in Mode to Rail	100	300	1,700	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%

Note: Numbers may not compute exactly due to rounding.

4.4.8 Alternative 6 – Pallid Sturgeon Spawning Cue

The management actions under Alternative 6 include developing ESH habitat through mechanical means and bi-modal spawning cue flow releases in March and May. The spawning cue releases cause System storage to decrease in some years, shortening the navigation seasons in the year(s) following the releases, which increases the commodities that shift from the waterway to alternate modes of transportation. There would be small increases in average annual air emissions in the Nebraska City and Omaha reaches under Alternative 6 compared to

Alternative 1; although the percent changes are noticeable, the change in air emissions is negligible in a regional context.

As shown in Table 37, 62,400 tons would shift off the waterway in the Kansas City reach to alternate modes under Alternative 6, an increase of 8,500 tons (8 percent) compared to Alternative 1. As summarized in Table 42, NOx air emissions would have the largest change from Alternative 1, ranging from 100 kg (6%) for rail transportation to 2,300 kg (8%) for truck transportation in the Kansas City reach.

Table 42. Air Emissions for Alternative 6 and Relative to Alternative 1 by Reach (kg)

Reach	Hydrocarbon (HC)	Carbon Monoxide (CO)	Nitrous Oxides (NOx)	Particulate Matter (PM)
Omaha				
Annual Average Emissions – Shift in Mode to Truck	50	150	480	30
Change from Alternative 1	20	40	150	10
Percent Change from Alternative 1	67%	36%	45%	50%
Annual Average Emissions – Shift in Mode to Rail	0	10	30	0
Change from Alternative 1	0	10	10	0
Percent Change from Alternative 1	0%	0%	50%	0%
Nebraska City				
Annual Average Emissions – Shift in Mode to Truck	400	1,300	4,100	300
Change from Alternative 1	0	100	500	100
Percent Change from Alternative 1	0%	8%	14%	50%
Annual Average Emissions – Shift in Mode to Rail	0	0	200	0
Change from Alternative 1	0	0	0	0
Percent Change from Alternative 1	0%	0%	0%	0%
Kansas City				
Annual Average Emissions – Shift in Mode to Truck	3,100	9,700	30,100	1,900
Change from Alternative 1	300	700	2,300	100
Percent Change from Alternative 1	11%	8%	8%	6%
Annual Average Emissions – Shift in Mode to Rail	100	400	1,800	0
Change from Alternative 1	0	100	100	0
Percent Change from Alternative 1	0%	33%	6%	0%

Note: Numbers may not compute exactly due to rounding.

5.0 Commercial Sand and Gravel Dredging Results

According to the Master Manual (USACE 2002), lower water levels can impact commercial sand and gravel dredging through the ability to extract material as well as the extraction location (i.e., may need to dredge in areas closer to their plant or in relatively deeper river areas); the location for the unloading of the dredged material (i.e., may need to move to downstream docks); the need to light-load barges; and the ability to move the dredged material from the barges to the conveyor at the dock (i.e., may need special equipment for transfer). Higher river flows can affect the ability to dredge because some dredges and equipment are not suited for high flow conditions.

The 2006 recorded sand and gravel extraction data was evaluated when drought conditions caused river flows to drop below 26,000 cfs in the lower river. At some locations on the river, when river flows fell below 26,000 cfs, even when river flows were as low as 21,000 cfs, companies have been able to operate and extract material. However, in the downstream segments, for example in the St. Charles segment, near the confluence with the Mississippi River, some of the permitted dredges operated during low flow conditions in November 2006, while others were not operating.[4] Based on a review of the recorded sand and gravel extraction data, it is not certain if the reduced extraction volumes were due to the relatively lower river flows or due to other factors or a combination of multiple factors. The recorded extraction data also indicates that there are times during the navigation season when companies are not operating even though river flows are above 26,000 cfs.

On average, there is very little change in the number of days below 26,000 during the navigation season across the alternatives. Even in the eight worst-change years from Alternative 1, there are less than an average of 14 additional days below 26,000 under Alternatives 2, 4, and 6 across the river reaches from St. Joseph downstream (Table 43). In many other years, there are more days above this threshold compared to Alternative 1. On average there is a negligible change in average annual days below 26,000 cfs across all river reaches downstream of St. Joseph.

Given the small amount of change in river flows below 26,000 cfs compared to Alternative 1 and continued dredging extraction during low flow conditions, it’s likely that adverse impacts on average across the POR would be negligible; however, there could be small and adverse impacts to dredging operations (e.g., short delays in extraction) and potentially additional dredging operating costs under Alternatives 2, 4, and 6 during relatively drier years following the releases. These impacts would be localized and temporary and would occur in the fall months when the navigation season is coming to an end. There would be no to negligible impacts to dredging operations from low flow conditions under Alternatives 3 and 5 compared to Alternative 1 because of the minor change in the number of days below 26,000 cfs.

[4] The year 2006 was a relatively drier year, and the minimum navigation service level was provided through October 16th. In November 2006, no navigation service was supported.

Table 43. Prevalence of River Flows Below 26,000 cfs (Days below Threshold) during the Navigation Season (April through November)

Location and Statistic	Alternatives					
	1	2	3	4	5	6
St. Joseph (RM 448)						
Average Annual Days Below Threshold	27	28	26	28	27	28
Change Average Annual Days from Alternative 1	NA	1	0	2	0	2
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	14	0	11	4	9
Average Number of Days in the 8 Best Years, Change from Alternative 1	Na	-4	-2	0	-2	0
Kansas City (RM 366)						
Average Annual Days Below Threshold	20	20	20	21	20	22
Change Average Annual Days from Alternative 1	NA	0	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	7	0	9	4	9
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-7	-2	0	-2	0
Waverly (RM 293)						
Average Annual Days	19	19	19	20	19	20
Change Average Annual Days from Alternative 1	NA	0	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	6	0	9	3	8
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-8	-3	0	-3	0
Booneville (RM 197)						
Average Annual Days Below Threshold	16	15	15	17	16	17
Change Average Annual Days from Alternative 1	NA	-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	3	0	9	3	9
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-13	-2	0	-1	0
Jefferson City (RM 144)						
Average Annual Days Below Threshold	15	15	15	16	15	16
Change Average Annual Days from Alternative 1	NA	0	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	5	0	9	3	9
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-10	-1	0	-1	0
Hermann (RM 98)						
Average Annual Days Below Threshold	10	9	10	11	10	11

Location and Statistic	Alternatives					
	1	2	3	4	5	6
Change Average Annual Days from Alternative 1	NA	-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	3	0	7	1	8
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-11	-1	0	-1	0
Washington (RM 68)						
Average Annual Days Below Threshold	10	9	10	11	10	11
Change Average Annual Days from Alternative 1	NA	-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	2	1	7	2	7
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-10	-1	0	-1	0
St. Charles (RM 28)						
Average Annual Days Below Threshold	10	9	10	11	10	11
Change Average Annual Days from Alternative 1	NA	-1	0	1	0	1
Average Number of Days in the 8 Worst Years, Change from Alternative 1	NA	3	0	7	2	7
Average Number of Days in the 8 Best Years, Change from Alternative 1	NA	-10	-2	0	-1	0

Table 44 summarizes the days above the high river stage thresholds. For dredgers in the upper segments of the river (Kansas City and St. Joseph), relatively higher river flows can affect the ability of the dredgers to extract sand and gravel (USACE 2002). In the Master Manual, the industry noted that they are typically impacted when the river is five feet below flood stage. The flood stage at the USGS St. Joseph gage is 17 feet and 32 feet at the USGS Kansas City gage (National Weather Service 2018). On average, there is very little change in the number of days above flood stage under the alternatives in Kansas City and St. Joseph reaches. Considering the days at five feet below flood stage (27 feet at the Kansas City gage), there is very little change in stages at the Kansas City gage across the alternatives, with at most four more days in one year over the POR under Alternative 2 compared to Alternative 1 (average annual increase compared to Alternative 1 of 0.1 days). There would not be noticeable changes in higher river flows under the action alternatives in the Kansas City reach compared to the Alternative 1, with no to negligible impacts to dredging operators in this segment.

On average at St. Joseph, there would be four additional days under Alternative 4; and two additional days under Alternative 5; and three additional days under Alternative 6 above the river stage of twelve feet (five feet below flood stage) compared to the Alternative 1. An evaluation of the 2011 sand and gravel extraction data indicated that in the St. Joseph segment, dredgers were operating when river stages were between 12 and 17 feet. Because of the minimal change in river flows at flood stage and at five feet below flood stage across the alternatives, and because dredgers in St. Joseph have demonstrated that they can dredge when the river stage is between 12 and 17 feet, there would be negligible impacts to dredgers in the St. Joseph segment under the action alternatives compared to Alternative 1.

Table 44. Prevalence of River Stages Above Flood Stage during the Period of Record (Days Above Threshold)

Location	Alternatives					
	1	2	3	4	5	6
St. Joseph						
Days Above Flood Stage over the POR (17 ft)	1,222	995	1,252	1,242	1,224	1,247
Average Days Above Flood Stage over the POR (17 ft)	14.9	12.1	15.3	15.2	14.9	15.2
Change in Average Days Above Flood Stage over the POR	NA	-2.8	0.4	0.3	0.0	0.3
Total Days Above 5 Feet Below Flood Stage over the POR (12 ft)	4,318	3,978	4,385	4,662	4,470	4,575
Average Days Above 5 Feet Below Flood Stage over the POR (12 ft)	52.7	48.5	53.5	56.9	54.5	55.8
Change in Average Days Above 5 Feet Below Flood Stage over the POR	NA	-4.0	0.8	4.2	1.9	3.1
Kansas City						
Days Above Flood Stage over the POR (32 ft)	45	43	44	44	43	44
Average Days Above Flood Stage over the POR (32 ft)	0.6	0.5	0.5	0.5	0.5	0.5
Change in Average Days Above Flood Stage over the POR	NA	0.0	0.0	0.0	0.0	0.0
Days Above 5 Feet Below Flood Stage over the POR (27 ft)	263	269	258	250	259	257
Average Days Above 5 Feet Below Flood Stage over the POR (27 ft)	3.2	3.3	3.2	3.1	3.2	3.1
Change in Average Days Above 5 Feet Below Flood Stage over the POR	NA	0.1	-0.1	-0.2	-0.1	-0.1

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Appendix A: Transportation Savings Value Functions

This appendix provides the transportation savings value functions provided in the *Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics* (Revised) (USACE 1998). These values were used as a basis for updating the unit transportation rate savings to account for changes in service level.

			FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW
COMMODITY	**MONTH**	**REACH**	**23000**	**26000**	**29000**	**32000**	**35000**	**45000**	**55000**	**65000**
Agricultural Products	Mar	Sioux City		9,409	12,022	15,780	20,155	22,124	22,176	19,051
Agricultural Products	Apr	Sioux City		21,112	26,306	39,128	53,808	60,691	60,706	49,795
Agricultural Products	May	Sioux City		9,190	12,954	16,609	23,645	26,811	26,848	21,764
Agricultural Products	Jun	Sioux City		10,533	14,518	18,181	29,653	35,985	36,013	26,004
Agricultural Products	Jul	Sioux City		1,225	1,793	1,749	7,071	10,658	10,666	5,018
Agricultural Products	Aug	Sioux City		697	1,623	3,270	10,489	15,460	15,465	7,660
Agricultural Products	Sep	Sioux City		2,307	3,360	5,232	10,740	14,376	14,442	8,717
Agricultural Products	Oct	Sioux City					2,013	3,517	3,532	1,169
Agricultural Products	Nov	Sioux City		4,574	6,661	10,372	16,491	20,113	20,206	14,493
Chemicals	Mar	Sioux City		20,110	26,543	40,013	51,625	56,851	51,081	36,288
Chemicals	Apr	Sioux City		53,836	65,260	88,173	107,927	116,816	107,577	82,327
Chemicals	May	Sioux City		27,181	31,401	39,366	46,234	49,324	46,113	37,334
Chemicals	Jun	Sioux City		6,828	10,252	17,753	24,219	27,129	24,103	15,839
Chemicals	Jul	Sioux City			531	1,767	2,832	3,311	2,812	1,451
Chemicals	Aug	Sioux City		14,740	18,246	25,400	31,567	34,342	31,457	23,574
Chemicals	Sep	Sioux City		28,325	36,576	53,845	68,732	75,431	68,466	49,439
Chemicals	Oct	Sioux City		6,924	10,983	19,954	27,688	31,169	27,549	17,665
Crude Materials	Apr	Sioux City		12,008	12,645	13,778	14,755	15,194	14,682	14,682
Crude Materials	Aug	Sioux City		12,280	12,931	14,090	15,089	15,538	15,014	15,014
Crude Materials	Sep	Sioux City		12,078	12,719	13,858	14,841	15,283	14,767	14,767
Manufactured Goods	Jun	Sioux City		5,472	6,323	7,836	9,502	10,570	9,380	7,450
Manufactured Goods	Aug	Sioux City		4,571	5,282	6,545	7,634	8,124	7,610	6,223
Manufactured Goods	Oct	Sioux City		5,565	6,431	7,969	9,295	9,892	9,265	7,576
Manufactured Goods	Nov	Sioux City		4,587	5,300	6,568	7,661	8,153	7,637	6,245
Petroleum Products	May	Sioux City		22,079	25,741	32,333	38,100	40,722	40,722	32,333
Sand/ Stone/ Rock	Apr	Sioux City	23,877	23,877	23,877	23,877	23,877	23,877	23,877	23,877
Sand/ Stone/ Rock	May	Sioux City	47,152	47,152	47,152	47,152	47,152	47,152	47,152	47,152
Sand/ Stone/ Rock	Jun	Sioux City	6,069	6,069	6,069	6,069	6,069	6,069	6,069	6,069
Sand/ Stone/ Rock	Jul	Sioux City	20,824	20,824	20,824	20,824	20,824	20,824	20,824	20,824
Sand/ Stone/ Rock	Aug	Sioux City	8,514	8,514	8,514	8,514	8,514	8,514	8,514	8,514
Sand/ Stone/ Rock	Sep	Sioux City	6,069	6,069	6,069	6,069	6,069	6,069	6,069	6,069
Sand/ Stone/ Rock	Oct	Sioux City	6,244	6,244	6,244	6,244	6,244	6,244	6,244	6,244

SOURCE: Navigation Economics Master Manual Revised Draft Environmental Impact Statement (1998), Table 25: Transportation Savings Value Function (pg 31-33)

			FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW
COMMODITY	**MONTH**	**REACH**	**23000**	**26000**	**29000**	**32000**	**35000**	**45000**	**55000**	**65000**
Agricultural Products	Mar	Omaha			4,961	5,985	6,868	7,265	7,097	6,498
Agricultural Products	Apr	Omaha		15,326	22,734	35,904	47,258	52,367	52,354	44,284
Agricultural Products	May	Omaha		12,839	18,956	29,830	39,204	43,423	43,413	36,749
Agricultural Products	Jun	Omaha		8,222	12,437	19,932	26,393	29,300	29,256	24,671
Agricultural Products	Jul	Omaha		2,194	5,109	10,292	14,760	16,771	16,647	13,504
Agricultural Products	Aug	Omaha		11,306	18,801	32,126	43,613	48,782	48,645	40,448
Agricultural Products	Sep	Omaha		7,507	15,275	29,645	42,246	47,916	47,579	38,704
Agricultural Products	Oct	Omaha		9,196	20,204	42,271	62,245	71,233	70,736	56,631
Agricultural Products	Nov	Omaha		3,275	6,978	14,899	22,237	25,539	25,365	20,174
Chemicals	Mar	Omaha			1,070	3,562	5,709	6,675	5,672	2,926
Chemicals	Apr	Omaha			344	1,145	1,835	2,145	1,822	940
Chemicals	May	Omaha		3,351	5,002	8,547	11,604	12,979	11,370	7,489
Chemicals	Jun	Omaha		5,765	7,111	9,852	12,214	13,386	12,172	9,152
Chemicals	Jul	Omaha		21,860	23,332	35,465	42,723	46,805	42,822	32,544
Chemicals	Aug	Omaha		7,252	9,268	15,001	19,882	22,060	19,799	13,617
Chemicals	Sep	Omaha		21,406	26,439	37,934	47,782	52,196	46,911	34,431
Chemicals	Oct	Omaha		46,342	57,484	88,238	114,442	127,622	114,004	79,781
Chemicals	Nov	Omaha		11,119	12,977	18,502	22,370	24,425	22,040	16,847
Crude Materials	Oct	Omaha		4,744	5,654	7,271	8,666	9,293	8,643	8,643
Manufactured Goods	Mar	Omaha		5,905	7,769	14,169	18,472	22,365	20,192	13,073
Manufactured Goods	Apr	Omaha		15,989	17,536	25,959	33,955	40,111	39,375	25,503
Manufactured Goods	May	Omaha		13,869	15,309	22,128	28,557	33,370	32,620	21,662
Manufactured Goods	Jun	Omaha		12,052	13,218	16,743	19,970	22,078	21,523	16,400
Manufactured Goods	Jul	Omaha				5,758	11,466	16,631	16,631	5,758
Manufactured Goods	Aug	Omaha		12,462	13,667	17,270	20,566	22,707	22,133	16,915
Manufactured Goods	Sep	Omaha		16,737	18,623	27,734	36,332	42,797	41,724	27,065
Manufactured Goods	Oct	Omaha				2,782	5,540	8,035	8,035	2,782
Manufactured Goods	Nov	Omaha				6,821	13,585	19,704	19,704	6,821
Passengers	Apr	Omaha			6,762	6,762	6,762	6,762	6,762	6,762
Passengers	May	Omaha			27,116	27,116	27,116	27,116	27,116	27,116
Passengers	Jun	Omaha			45,093	45,093	45,093	45,093	45,093	45,093
Passengers	Jul	Omaha			55,880	55,880	55,880	55,880	55,880	55,880
Passengers	Aug	Omaha			51,630	51,630	51,630	51,630	51,630	51,630
Passengers	Sep	Omaha			37,003	37,003	37,003	37,003	37,003	37,003
Passengers	Oct	Omaha			7,531	7,531	7,531	7,531	7,531	7,531
Petroleum Products	Apr	Omaha		63,237	73,726	92,605	109,125	116,634	116,634	92,605
Petroleum Products	May	Omaha		22,415	26,133	32,825	38,681	41,342	41,342	32,825
Petroleum Products	Jun	Omaha		18,511	21,581	27,108	31,944	34,142	34,142	27,108
Petroleum Products	Jul	Omaha		41,800	48,733	61,212	72,132	77,095	77,095	61,212
Petroleum Products	Sep	Omaha		20,274	23,636	29,689	34,985	37,393	37,393	29,689
Petroleum Products	Oct	Omaha		58,587	68,304	85,796	101,101	108,057	108,057	85,796
Petroleum Products	Nov	Omaha		37,548	43,776	54,986	64,795	69,253	69,253	54,986

SOURCE: Navigation Economics Master Manual Revised Draft Environmental Impact Statement (1998), Table 25: Transportation Savings Value Function (pg 31-33)

			FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW	FLOW
COMMODITY	**MONTH**	**REACH**	**23000**	**26000**	**29000**	**32000**	**35000**	**45000**	**55000**	**65000**
Agricultural Products	Mar	Nebraska City		11,526	12,343	14,363	16,291	19,449	18,293	14,816
Agricultural Products	Apr	Nebraska City		21,497	26,860	28,525	40,933	48,822	47,472	36,491
Agricultural Products	May	Nebraska City		21,008	29,150	38,405	59,122	68,444	68,167	53,054
Agricultural Products	Jun	Nebraska City		6,230	10,248	14,296	23,867	28,175	27,973	21, 129
Agricultural Products	Jul	Nebraska City		40,839	49,681	58,992	81,529	92,526	92,003	74,539
Agricultural Products	Aug	Nebraska City		52,117	62,055	82,438	110,521	123,855	123,226	102,178
Agricultural Products	Sep	Nebraska City		18,644	21,879	27,347	35,164	38,971	38,821	32,559
Agricultural Products	Oct	Nebraska City		25,390	37,799	74,602	110,783	127,064	126,498	99,792
Agricultural Products	Nov	Nebraska City		27,613	35,809	51,350	71,577	80,679	79,656	65,352
Chemicals	May	Nebraska City			807	2,686	4,306	5,035	4,160	2,207
Chemicals	Jun	Nebraska City			621	2,065	3,309	3,870	3,288	1,696
Chemicals	Jul	Nebraska City			543	1,806	2,895	3,385	2,876	1,484
Chemicals	Oct	Nebraska City		1,190	1,647	2,459	3,468	4,232	3,187	2,074
Crude Materials	May	Nebraska City		29,483	30,994	33,679	35,994	37,036	35,776	35,776
Crude Materials	Jun	Nebraska City		47,941	50,398	54,764	58,528	60,222	58,173	58,173
Crude Materials	Jul	Nebraska City		44,607	46,892	50,955	54,458	56,034	54,127	54,127
Crude Materials	Aug	Nebraska City		31,323	32,927	35,780	38,240	39,347	38,008	38,008
Crude Materials	Sep	Nebraska City		30,925	32,509	35,326	37,754	38,847	37,525	37,525
Crude Materials	Oct	Nebraska City		48,167	50,635	55,022	58,804	60,506	58,447	58,447
Petroleum Products	May	Nebraska City		146,833	158,754	180,213	198,989	207,524	207,524	180,213
Petroleum Products	Jun	Nebraska City		52,570	57,375	66,024	73,592	77,032	77,032	66,024
Petroleum Products	Jul	Nebraska City		38,792	41,371	46,014	50,076	51,923	51,923	46,014
Petroleum Products	Sep	Nebraska City		32,862	35,046	36,979	42,420	43,984	43,984	38,979
Sand/ Stone/ Rock	Apr	Nebraska City	43,420	43,420	43,420	43,420	43,420	43,420	43,420	43,420
Sand/ Stone/ Rock	May	Nebraska City	70,373	70,373	70,373	70,373	70,373	70,373	70,373	70,373
Sand/ Stone/ Rock	Jun	Nebraska City	55,525	55,525	55,525	55,525	55,525	55,525	55,525	55,525
Sand/ Stone/ Rock	Jul	Nebraska City	3,540	3,540	3,540	3,540	3,540	3,540	3,540	3,540
Sand/ Stone/ Rock	Aug	Nebraska City	3,198	3,198	3,198	3,198	3,198	3,198	3,198	3,198
Sand/ Stone/ Rock	Sep	Nebraska City	2,738	2,738	2,738	2,738	2,738	2,738	2,738	2,738
Sand/ Stone/ Rock	Oct	Nebraska City	3,238	3,238	3,238	3,238	3,238	3,238	3,238	3,238
Sand/ Stone/ Rock	Nov	Nebraska City	2,570	2,570	2,570	2,570	2,570	2,570	2,570	2,570
Sand/ Stone/ Rock	Dec	Nebraska City	1,169	1,169	1,169	1,169	1,169	1,169	1,169	1,169

SOURCE: Navigation Economics Master Manual Revised Draft Environmental Impact Statement (1998), Table 25: Transportation Savings Value Function (pg 31-33)

COMMODITY	MONTH	REACH	FLOW 23000	FLOW 26000	FLOW 29000	FLOW 32000	FLOW 35000	FLOW 45000	FLOW 55000	FLOW 65000
Agricultural Products	Mar	Kansas City		12,538	16,880	25,424	35,135	40,323	40,380	31,949
Agricultural Products	Apr	Kansas City		24,610	27,073	31,574	35,819	37,917	37,257	33,997
Agricultural Products	May	Kansas City		50,237	54,312	61,673	68,178	71, 106	69,770	65,290
Agricultural Products	Jun	Kansas City		8,814	11,657	17,251	24,061	21,546	27,541	21,936
Agricultural Products	Jul	Kansas City		10,040	11,428	14,295	18,241	20,328	19,989	16,692
Agricultural Products	Aug	Kansas City		71,174	80,775	98,339	116,085	125,376	123,053	108,998
Agricultural Products	Sep	Kansas City		13,268	17,117	24,672	33,336	37,628	37,630	30,788
Agricultural Products	Oct	Kansas City		13,228	17,078	24,711	32,675	36,353	36,814	30,662
Agricultural Products	Nov	Kansas City		22,641	29,487	43,209	58,748	66,261	66,794	54,407
Agricultural Products	Dec	Kansas City		3,242	3,377	4,637	4,980	5,152	4,965	4,707
Chemicals	Mar	Kansas City		54,981	58,527	85,232	101,085	114,610	96,961	75,321
Chemicals	Apr	Kansas City		30,181	34,484	51,084	65,904	79,682	62,725	45, 156
Chemicals	May	Kansas City		16,970	19,536	30,917	40,738	49,307	38,294	26,586
Chemicals	Jun	Kansas City		15,964	16,736	21,873	25,889	28,888	25,042	20,150
Chemicals	Jul	Kansas City		36,976	34,475	45,752	47,719	50,753	46,549	41,767
Chemicals	Aug	Kansas City		38,825	37,969	48,016	51,426	54,286	50,269	44,450
Chemicals	Sep	Kansas City		46,575	50,971	66,569	81,231	90,862	78,358	60,767
Chemicals	Oct	Kansas City		39,986	42,590	57,539	70,015	78,414	67,622	52,024
Chemicals	Nov	Kansas City		44,273	47,476	60,421	73,574	82,118	71,629	55,548
Chemicals	Dec	Kansas City		35,377	35,688	41,767	45,667	48,403	44,200	38,896
Crude Materials	Apr	Kansas City		13,327	13,848	14,775	15,574	15,933	15,332	15,332
Crude Materials	May	Kansas City		39,625	41,175	43,930	46,305	47,374	45,587	45,587
Crude Materials	Jun	Kansas City		1,640	2,305	3,487	4,506	4,965	4,965	4,965
Crude Materials	Jul	Kansas City		38,195	40,446	44,449	47,899	49,452	47,831	47,831
Crude Materials	Aug	Kansas City		1,575	2,214	3,350	4,328	4,769	4,769	4,769
Crude Materials	Oct	Kansas City		24,294	25,244	26,933	28,389	29,045	27,949	27,949
Crude Materials	Nov	Kansas City		36,441	37,866	40,400	42,584	43,567	41,924	41,924
Manufactured Goods	Feb	Kansas City		16,100	16,707	17,251	17,740	18,183	17,789	16,882
Manufactured Goods	Mar	Kansas City		148,602	154,208	159,224	163,739	167,823	164,195	155,815
Manufactured Goods	Apr	Kansas City		39,061	40,535	41,853	43,040	44,114	43,160	40,957
Manufactured Goods	May	Kansas City		115,714	120,080	123,986	127,501	130,682	127,856	121,331
Manufactured Goods	Jun	Kansas City		121,004	125,569	129,654	133,330	136,656	133,702	126,878
Manufactured Goods	Jul	Kansas City		104,446	108,386	111,912	117,366	122,454	118,088	109,516
Manufactured Goods	Aug	Kansas City		103,597	107,505	111,002	118,992	126,546	120,162	108,626
Manufactured Goods	Sep	Kansas City		121,429	126,010	130,109	133,798	137,136	134,171	127,323
Manufactured Goods	Oct	Kansas City		135,252	141,774	151,139	157,146	162,579	157,962	147,222
Manufactured Goods	Nov	Kansas City		42,458	44,059	45,493	46,783	47,950	46,913	44,519
Manufactured Goods	Dec	Kansas City		113,695	118,807	123,622	128,184	132,530	129,665	120,975
Passengers	Jan	Kansas City			1,737	1,737	1,737	1,737	1,737	1,737
Passengers	Feb	Kansas City			5,781	5,781	5,781	5,781	5,781	5,781
Passengers	Mar	Kansas City			8,349	8,349	8,349	8,349	8,349	8,349
Passengers	Apr	Kansas City			57,950	57,950	57,950	57,950	57,950	57,950
Passengers	May	Kansas City			101,402	101,402	101,402	101,402	101,402	101,402
Passengers	Jun	Kansas City			72,148	72,148	72,148	72,148	72,148	72,148
Passengers	Jul	Kansas City			83,377	83,377	83,377	83,377	83,377	83,377
Passengers	Aug	Kansas City			115,927	115,927	115,927	115,927	115,927	115,927
Passengers	Oct	Kansas City			2,978	29,785	29,785	29,785	29,785	29,785
Passengers	Nov	Kansas City			9,888	9,888	9,888	9,888	9,888	9,888
Passengers	Dec	Kansas City			15,696	15,696	15,696	15,696	15,696	15,696
Petroleum Products	Mar	Kansas City		64,757	71,336	83,180	93,542	98,253	98,253	83,180
Petroleum Products	Apr	Kansas City		19,776	21,785	25,402	28,567	30,005	30,005	25,402
Petroleum Products	May	Kansas City		130,298	143,537	167,367	188,218	197,695	197,695	167,367
Petroleum Products	Jun	Kansas City		91,325	100,604	117,306	131,920	138,563	138,563	117,306
Petroleum Products	Jul	Kansas City		149,638	164,842	192,208	216,154	227,039	227,039	192,208
Petroleum Products	Aug	Kansas City		120,763	133,032	155,118	174,443	183,227	183,227	155,118
Petroleum Products	Sep	Kansas City		138,475	152,544	177,869	200,028	210,101	210,101	177,869
Petroleum Products	Oct	Kansas City		125,797	138,578	161,585	181,715	190,865	190,865	161,585
Petroleum Products	Nov	Kansas City		99,095	109,163	127,286	143,143	150,351	150,351	127,286
Petroleum Products	Dec	Kansas City		52,246	54,181	58,051	61,921	63,856	63,856	58,051
Sand/ Stone/ Rock	Jan	Kansas City	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888
Sand/ Stone/ Rock	Feb	Kansas City	51,990	51,990	51,990	51,990	51,990	51,990	51,990	51,990
Sand/ Stone/ Rock	Mar	Kansas City	197,362	197,362	197,362	197,362	197,362	197,362	197,362	197,362
Sand/ Stone/ Rock	Apr	Kansas City	86,266	86,266	86,266	86,266	86,266	86,266	86,266	86,266
Sand/ Stone/ Rock	May	Kansas City	84,132	84,132	84,132	84,132	84,132	84,132	84,132	84,132
Sand/ Stone/ Rock	Jun	Kansas City	37,747	37,747	37,747	37,747	37,747	37,747	37,747	37,747
Sand/ Stone/ Rock	Jul	Kansas City	206,243	206,243	206,243	206,243	206,243	206,243	206,243	206,243
Sand/ Stone/ Rock	Aug	Kansas City	229,202	229,202	229,202	229,202	229,202	229,202	229,202	229,202
Sand/ Stone/ Rock	Sep	Kansas City	204,756	204,756	204,756	204,756	204,756	204,756	204,756	204,756
Sand/ Stone/ Rock	Oct	Kansas City	139,744	139,744	139,744	139,744	139,744	139,744	139,744	139,744
Sand/ Stone/ Rock	Nov	Kansas City	83,108	83,108	83,108	83,108	83,108	83,108	83,108	83,108
Sand/ Stone/ Rock	Dec	Kansas City	116,213	116,213	116,213	116,213	116,213	116,213	116,213	116,213

SOURCE: Navigation Economics Master Manual Revised Draft Environmental Impact Statement (1998), Table 25: Transportation Savings Value Function (pg 31-33)