Missouri River Recovery Program

DRAFT

Missouri River Recovery Management Plan and Environmental Impact Statement

NAVIGATION ENVIRONMENTAL CONSEQUENCES ANALYSIS TECHNICAL REPORT

December 2016

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Missouri River Recovery Management Plan and Environmental Impact Statement

Navigation
Environmental Consequences Analysis

Technical Report

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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
Corps	U.S. Army Corps of Engineers
cfs	cubic feet per second
DSS	Data Storage System
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EQ	environmental quality (account)
ER	Engineering Regulation
ESH	emergent sandbar habitat
H&H	hydrologic and hydraulic
HEC	Hydrologic Engineering Center
M&I	municipal and industrial
MRRIC	Missouri River Recovery Implementation Committee
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 (account)
OSE	other social effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
RAS	River Analysis System
RED	regional economic development (account)
ResSim	Reservoir System Simulation
R, R, & R	Non-routine repair, replacement, and rehabilitation costs
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WCSC	Waterborne Commerce Statistics Center

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1.0 Introduction

The U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion in 2000 that found actions proposed by the U.S. Army Corps of Engineers (USACE) on the Missouri River would jeopardize the continued existence of three federally listed species: the piping plover, interior least tern, and pallid sturgeon. The Biological Opinion (amended in 2003, or BiOp) recommended a variety of recovery actions that are currently being implemented by the Missouri River Recovery Program (MRRP). The USACE in cooperation with the USFWS is developing the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS). The purpose of the MRRMP-EIS is to develop a management plan that includes a suite of actions which would remove or preclude jeopardy status for the piping plover, the interior least tern, and the pallid sturgeon using Corps authorities.

The purpose of the 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-Draft 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 Draft EIS evaluates the following Management Plan alternatives. A detailed description of the alternatives is provided in the Draft EIS, Chapter 2, but the following provides a summary of the alternatives:

- **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 BiOp compliance. Management actions under No Action include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse. The construction of habitat will be focused in the Garrison and Gavins reaches for ESH (an average rate of 107 acres per year) and between Ponca to the mouth near St. Louis for 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 No Action 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 3,546 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 only create ESH through mechanical means at an average rate of 391 acres per year across the entire system. 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 additional 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.
- **Alternative 4 – Spring ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 240 acres per year across the entire system. 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 (current operations), with the addition of a spring release designed to create ESH for the least tern and piping plover. An additional 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 309 acres per year across the entire system. This alternative is based on Alternative 1 (current operations), with the addition of a release in the fall designed to create sandbar habitat for the least tern and piping plover. An additional 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 303 acres per year across the entire system. 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 or would be terminated whenever flood targets are exceeded. An additional 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 Draft-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, which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

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

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

1.3 Approach for Evaluating Navigation Consequences of Missouri River Recovery Management Plan

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. Changes in the physical characteristics of the Missouri River (Box 1) such as amount of water in system storage or level of flows cause changes in the performance of the navigation system. These changes in navigation system performance are measured using metrics of service level or navigation season (Box 2). As changes occur in the service level and length and timing of the navigation season, the amount moving on the waterway and the cost of moving on the waterway is affected (Box 3). For example, releasing more water during the winter could lead to reduced navigation service levels during the navigation season which would increase the cost for carriers and could force some shippers to choose a different mode of transportation for their commodities. Changes in carrier's cost and shipper behaviors are captured by the analysis of changes in the national economic development (NED) benefits. Finally, the change in NED benefits cause This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to navigation**.**

Figure 2 shows the overall approach used to estimate the impacts to navigation from Management Plan alternatives. The environmental consequences analysis first focused on an evaluation of changes in Missouri River system operations including reservoir releases and river flows under each Management Plan alternative. As shown in Figure 2, the analysis uses USACE Hydraulic Engineering Center Reservoir System Simulation (HEC ResSim) modeled service levels flows for the period of record between 1931 and 2012 for each alternative along with navigation season length and service level criteria to determine changes in service level and season length under each of the alternatives.

The effect on navigation season and service levels for each alternative provides inputs needed to evaluate changes in NED to navigation. The analysis also incorporated data from the Waterborne Commerce Statistics Center (WCSC) to identify the types of industries and amount of tonnage that may be impacted by changing conditions. Then the Transportation Savings Value Functions were used to determine changes in transportation savings for each industry based on the flow levels under each alternative.

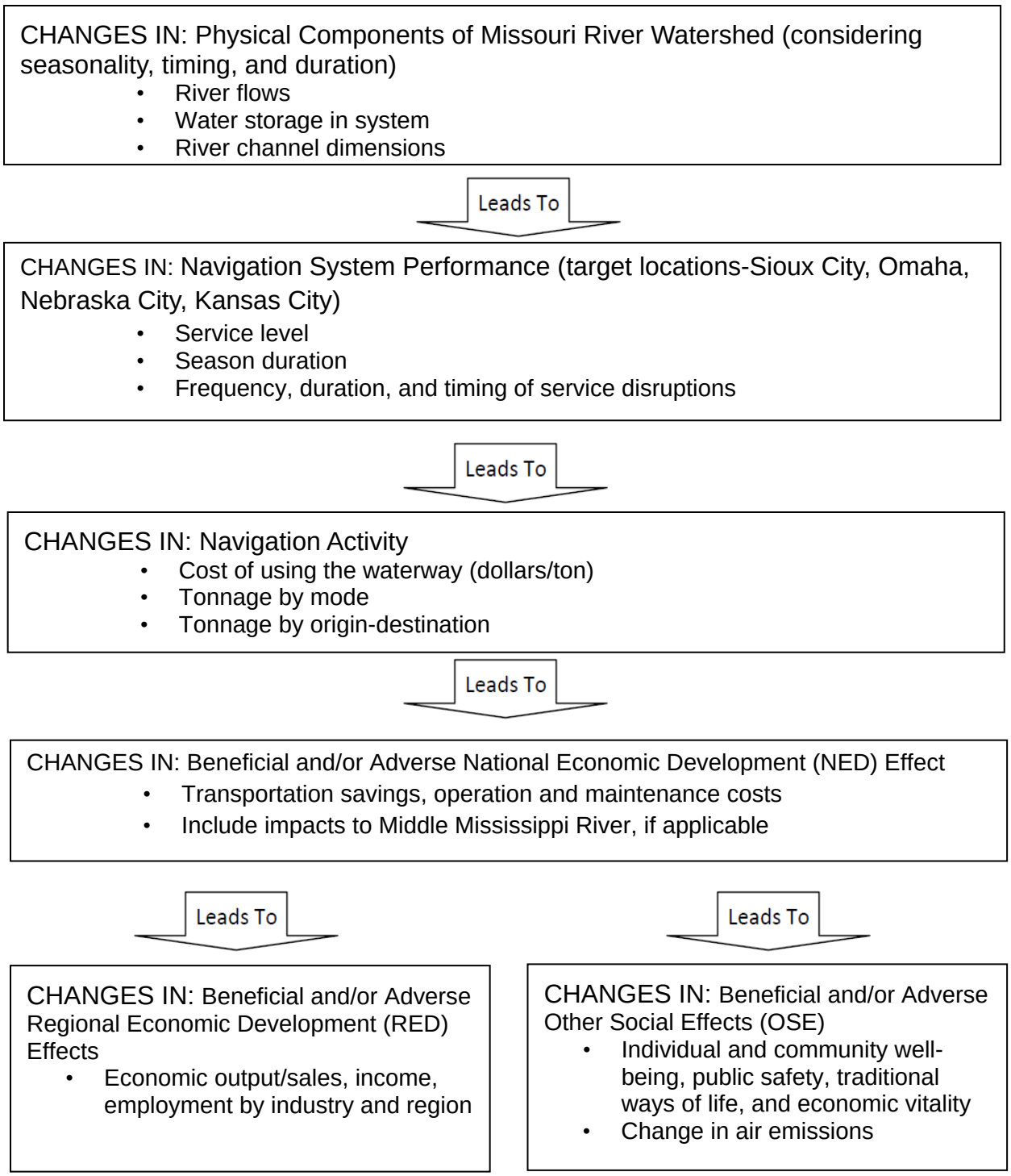


Figure 1. Flow Chart of Inputs Considered in Navigation Evaluation

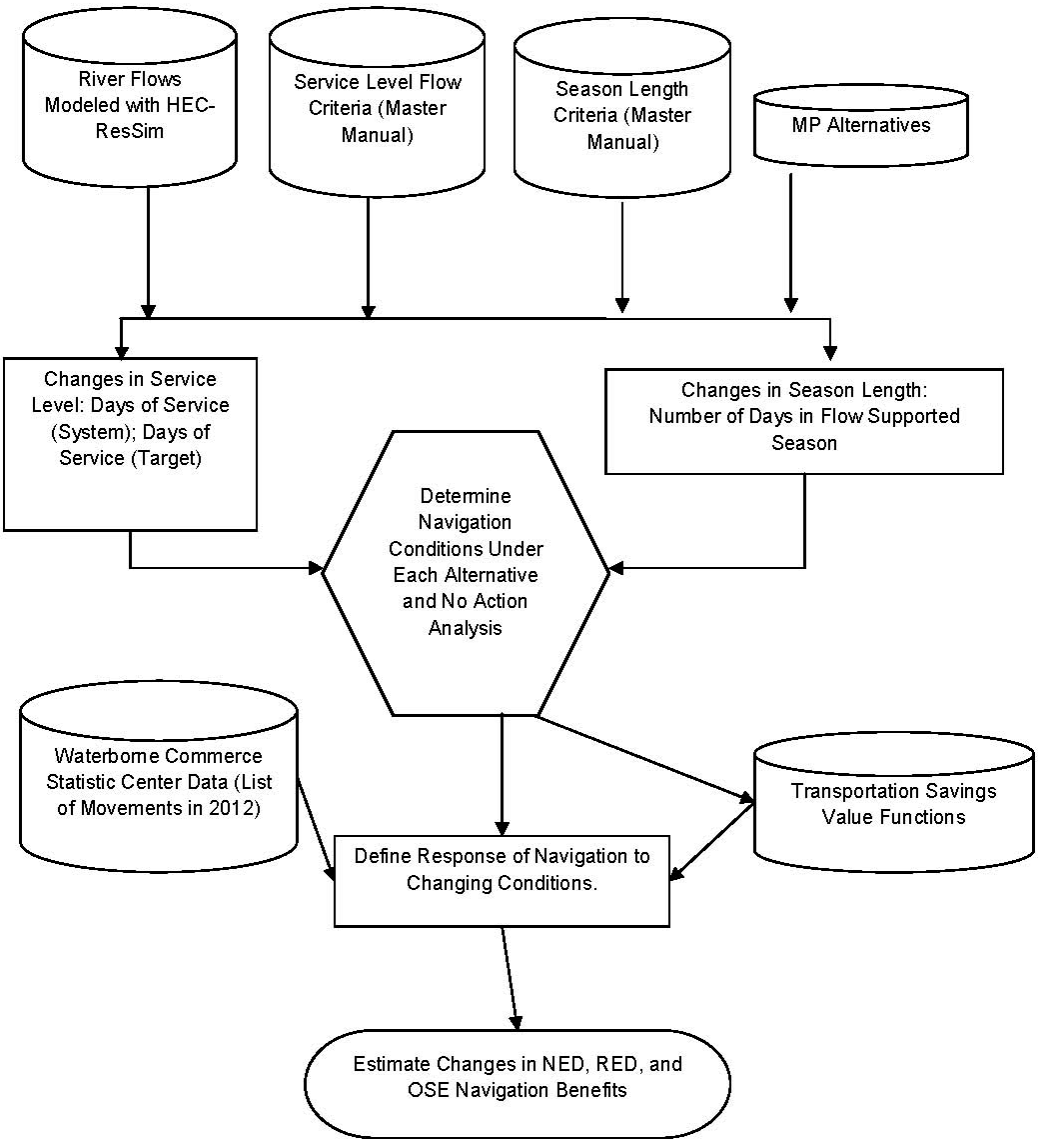


Figure 2. Environmental Consequences Approach for Navigation

By combining the transportation savings functions, WCSC movement data, and statistical analysis of the hydrologic and hydraulic (H & H) river flows, the economic changes in transportation savings for each alternative were determined. The following sections in this report provide further details on the NED, RED, and OSE methodology for navigation

The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

2.0 Methodology and Assumptions

The methodology includes a summary of assumptions and risk and uncertainty considerations. The initial step in the process, evaluating the relationship between river conditions and navigation, is then described, as well as the subsequent steps to assess the NED, RED, and OSE impacts.

2.1 Assumptions for Analysis

In modeling the consequences to navigation from the MRRMP for the draft EIS, the project team established a set of assumptions. The important assumptions used in the modeling effort are as follows.

- 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-period of record under each of the MRRMP-EIS alternatives as well as Alternative 1 (No Action).
- The impacts shown for Alternative 1 (No Action) are for the purpose of providing a baseline and allowing for a comparison of the alternatives. The H & H data for Alternative 1 is based on historical record and displays periods when navigation did not occur or is reduced. This means Alternative 1 will show impacts to NED, RED, and OSE accounts.
- The Service Level component of the H & H model was chosen to be used for modeling of the navigation impacts. Since the modeled tributary flows would be the same for all alternatives, the navigation impact analysis focused on how the releases from Gavins Point could be changed by the alternatives.
- The analysis assesses impacts to navigation only during the navigation season when flows are provided to support navigation (March 14 to an end date that varies by alternative and year). The exception is when a split navigation season would occur. If a summer month showed zero support to navigation, then the impact was assessed and included in the analysis.
- Years when service level flows were unable to provide support for navigation were not included in the analysis. This amounted to seven years being excluded from the navigation impact analysis for all alternatives.
- This analysis relies on the transportation savings functions and assumptions from “Table 25: Transportation Savings Value Functions” of the Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998). While this it cannot list the assumptions used to generate the transportation savings function These transportations savings functions represent the transportation rate savings For additional material discussion on assumptions please review this document.
- The Transportation Savings Value (TSV) functions were not indexed to FY 16 values because the analysis assumed that the relative difference between the overland costs and waterway costs has not changed over time. Transportation rate savings equal the difference between over land costs and waterway costs, but separate waterway costs or overland costs were not available. Without separate overland cost values and waterway cost values, the USACE Planning Center of Expertise for Inland Navigation (PCXIN)

recommended not indexing the transportation savings values since the appropriate technique would be to apply indexes to each component.

- The TSV function were not updated with a new transportation rate study because an analysis of the hydrologic data showed the alternatives having relatively small changes on navigation metrics including small changes in the number of days of navigation flow support and small changes in the amount of flow provided. The existing available rates represent a conservative approach to estimating the impacts. The transportation rates were estimated for movements which occurred on the Missouri River in the mid-1990s when a greater variety of commodities moved at higher tonnage levels than is currently moving on the water. For example, in 1992, 1993, and 1994 commercial tonnage ranged from 1.4 million tons to 1.8 million tons, but in 2012 only 0.2 million tons moved on the water. Since the commodities types and the amount of a commodity affect the transportation savings values, the existing transportation saving rates are likely higher than would be measured using data from more recent years.
- The Waterborne Commerce Statistics Center (WCSC) data shows sand and gravel commodities moving on the water when less than minimum service is occurring, but Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998) states the towing companies would be seriously impacted by flows less than minimum service. This analysis assumes that traffic has the potential to move off the water when flows are less than minimum service (29,000 cfs).
- The MRRMP-EIS navigation economic analysis assumes that sand and gravel operators are impacted when flows drop below 7 ft.

2.2 Risk and Uncertainty

Risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall Management Plan 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 period of record. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future and would not be captured by the HEC-RAS models or carried through to the navigation model described is this document. The project team has attempted to address risk and uncertainty in the Management Plan 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. All of the alternatives were modeled to estimate impacts to navigation industry.

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. Alternative responses include industries leaving the waterway or industries using the waterway to a greater extent.

2.3 National Economic Development Method

The National Economic Development (NED) navigation impact analysis estimates the changes in NED values that may occur due to MRRP Management Plan alternatives based on the guidance developed under the Principles and Guidelines (P&G) for water resources studies. The NED analysis for navigation is based on two components: 1) the transportation savings and 2) the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs. Once these two values are known, the change in R, R, & R costs can be subtracted from the transportation savings to estimate the net NED values for each alternative. This relationship is shown with the following equation (Equation 1):

Equation 1: The net NED Value Calculations

$$\text{net NED}_{year}=(\text{Transportation Savings})_{year}-(\text{Change in R, R \& R Cost})_{year}$$

A description for estimating transportation savings and R, R, & R costs are further explained below.

2.3.1 Transportation Savings

The first part of Equation 1 is the transportation savings. The transportation savings represent the difference in the value of resources required to transport commodities between the waterway and overland. This difference between the overland costs and waterway costs can be altered by the alternatives in the following ways:

- **Cost of using the waterway (same origin-destination; same mode):** For traffic that uses a waterway both with and without project conditions, the benefit or loss is the change in the economic cost of using the waterway. This cost difference represents an economic efficiency (or economic loss) because resources will be released for productive use elsewhere in the economy. Actions that reduce or increase the length of the navigation season (including disruption in service) or the level of service (depth of the channel) affect the performance of navigation. For example, barges that have the ability to be more fully loaded (e.g., by deeper channel) may lead to a reduction in transportation costs.
- **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 and rail transportation). Truck and rail typically cost more than navigation, resulting in higher transportation costs for industries that ship their commodities. Modal shifts represent a cost difference between shipping cargo on the waterways and shipping the cargo on land with the next best transportation mode. There is an economic loss to the national economy because there is an increase in resources needed to use a more costly transportation mode.

The next sections details the methodology used to compute net NED calculations to assess the impacts to navigation:

As shown in Equation 2, the transportation savings component of net NED is the product of three variables: the percentage of navigation days within a month, the reference condition year tonnage, and transportation rate savings.

Equation 2: The Annual Transportation Saving Calculations

$$(\text{Transportation Savings})_{\text{year}} = (\text{Savings})_{\text{commodity, month, reach, service flow}} * (\text{Percent Navigation Days})_{\text{year, month, service level}} * (\text{Tons})_{\text{commodity, month, reach}}$$

Where

- $(\text{Percent Navigation Days})_{\text{year, month, service level}}$ = the percentage of navigation days within a month in a specific year that fall within a service level category. For example, if July (31 days of navigation) in year x had 31 days at full service level (35,000 cfs), then the (Percent Navigation Days) for full service in July equals 100 percent.
- $(\text{Tons})_{\text{commodity, month, reach}}$ = Reference Condition year tonnage by commodity group, by month, and by reach. Reference condition year is identified as 2012. As shown in Equation 2, this is the only year since 2011 that navigation has not been interrupted, delayed, or shortened by drought or high water.
- $(\text{Savings})_{\text{commodity, month, reach, service flow}}$ = the transportation savings functions were estimated using functions provided in the *Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised)* (1998). These functions estimate the transportation rate savings across service levels and were generated by reach, by month, and by commodity group.

These components of the transportation savings calculation are further described below.

Variable – Savings Functions

The transportation savings value functions are key to understanding how transportation savings change according to Missouri River navigation service levels. These functions were generated by the Tennessee Valley Authority (TVA) during the navigation economic analysis conducted for the 1998 Master Manual review. These functions show how the transportation rate savings for 283 dock-to-dock pairs changed according to various service levels on the Missouri River. According to *Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised)* (1998), the dock-to-dock pairs were primarily drawn from traffic movements in 1992, 1993, and preliminary 1994 data provided by Waterborne Commerce Statistics Center (WCSC). The transportation savings value functions are broken down by commodity groups (Agricultural Products, Chemicals, Crude Materials, Manufactured Goods, and Sand/ Stone / Rock), by reach (Sioux City, Omaha, Nebraska City, and Kansas City) and are created for flows ranging from 23,000 cfs to 65,000 cfs. The full listing of TSV functions is shown in Appendix A, but the following table (Table 1) shows a sample of the TSV functions.

Table 1. Sample of Transportation Savings Value Functions Table

Reach	Commodity	Month	Flow 23000 (cfs) FY 1995 $	Flow 26000 (cfs) FY 1995 $	Flow 29000 (cfs) FY 1995 $	Flow 32000 (cfs) FY 1995 $	Flow 35000 (cfs) FY 1995 $	Flow 45000 (cfs) FY 1995 $	Flow 55000 (cfs) FY 1995 $	Flow 65000 (cfs) FY 1995 $
Sioux City	Chemicals	Mar		20,110	26,543	40,013	51,625	56,851	51,081	36,288
Sioux City	Chemicals	Apr		53,836	65,260	88,173	107,92	116,81	107,577	82,327
Sioux City	Chemicals	May		27,181	31,401	39,366	46,234	49,324	46,113	37,334
Sioux City	Chemicals	Jun		6,828	10,252	17,753	24,219	27,129	24,103	15,839
Sioux City	Chemicals	Jul			531	1,767	2,832	3,311	2,812	1,451
Sioux City	Chemicals	Aug		14,740	18,246	25,400	31,567	34,342	31,457	23,574
Sioux City	Chemicals	Sep		28,325	36,576	53,845	68,732	75,431	68,466	49,439
Sioux City	Chemicals	Oct		6,924	10,983	19,954	27,688	31,169	27,549	17,665

Source: “Table 25: Transportation Savings Value Function”, pg 31-33, Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998)

The 1998 Master Manual Review and Update Study estimated the transportation savings value functions using various transportation models and rates to estimate the waterway cost and over land cost for the relevant movements. Then, Tennessee Valley Authority (TVA) and University of Tennessee Center for Transportation Research (UT-CTR) used the Barge Costing Model (BCM) to calculate the changes in cost due to flow changes. To estimate how costs change by flows, the BCM 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 / CTR examined the list of movements to determine which would shift transportation modes and those that would shift the origin or destination. The analysis did not consider any new movements that could occur. These responses were built into the transportation savings functions.

In order to use the transportation rate savings functions for the current MRRPMP-EIS navigation impact analysis, the TSV were converted into dollars per ton by dividing by the Missouri River tonnage for 1994. The result of converting dividing TSV by 1994 tonnage is shown in Table 2.

Table 2. Sample of Transportation Savings Value (TSV) Functions in Dollars Per Ton

Reach	Commodity	Month	Flow 23000 (cfs) $ per ton	Flow 26000 (cfs) $ per ton	Flow 29000 (cfs) $ per ton	Flow 32000 (cfs) $ per ton	Flow 35000 (cfs) $ per ton	Flow 45000 (cfs) $ per ton	Flow 55000 (cfs) $ per ton	Flow 65000 (cfs) $ per ton
Sioux City	Chemicals	Mar	0.00	0.00	0.00	0.00	1.18	1.56	2.36	3.04
Sioux City	Chemicals	Apr	0.00	0.00	0.00	0.00	2.18	2.64	3.56	4.36
Sioux City	Chemicals	May	0.00	0.00	0.00	0.00	3.33	3.84	4.82	5.66
Sioux City	Chemicals	Jun	0.00	0.00	0.00	0.00	0.72	1.08	1.86	2.54
Sioux City	Chemicals	Jul	0.00	0.00	0.00	0.00	0.00	0.39	1.28	2.05
Sioux City	Chemicals	Aug	0.00	0.00	0.00	0.00	2.03	2.51	3.50	4.34
Sioux City	Chemicals	Sep	0.00	0.00	0.00	0.00	1.35	1.74	2.57	3.28
Sioux City	Chemicals	Oct	0.00	0.00	0.00	0.00	0.67	1.07	1.94	2.69
Sioux City	Chemicals	Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sioux City	Chemicals	Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

As shown in Equation 2, WCSC tonnage is multiplied by the transportation savings (TS) value functions. To generate a valid transportation savings value, the WCSC tonnage commodity groups and reaches must match the commodity groups and reaches from the TS value functions. The WCSC database contains several different coding systems to group commodities; however, they do not match exactly with the TS value function commodity groupings. Therefore the cross-reference table (Table 3) was built to relate WCSC commodity groups to TS value function commodity groups. The WCSC Commodity Group is a commodity classification group that has been used in the past to report tonnage moving on the Missouri River.

Table 3. Commodity Group Cross Reference Table

Master Manual Commodity Group	Transportation Savings Commodity Group
All Others	Crude Materials
Primary Metal	Crude Materials
Stone, Clay, Cem	Manufactured Goods
Petro & Coke	Petroleum Products
Chemicals	Chemicals
Fertilizers	Chemicals
Food & Kindred	Agricultural Products
Non-Metallic	Crude Materials
Farm Products	Agricultural Products
Dredge Material	
Sands and Gravel	Sand/ Stone/ Rock
Waterway Improvement Material	

Variable - Percent of Navigation Days by Service Level over the Period of Record

As noted above, the first component of Transportation $\text{Savings}_{\text{year}}$, as shown in Equation 2, is the percentage of navigation days for each month of the navigation season over the period of record that fall within a service level category, $(\text{Percent Navigation Days})_{\text{month, service level}}$. The percentage of navigation days within a month in a specific year that fall within a service level category is estimated using the "service level" component of the Hydrologic Engineering Center Reservoir System Simulation (HEC-ResSim) model. The service level component of HEC-ResSim model represents the daily minimum discharge required for a level of navigation service as defined in the Master Manual and determined from available system storage. This is done with the following steps:

A. Compare the daily service level component value from HEC-ResSim to the service level criteria listed in Table 4.
B. Add up the number of days within a month within each service level.
C. Divide total days within each service level by the number of navigable days within a month. The number of navigable days within a month depends on the start and end of season. The season was assumed to start on March 14 every year since this was the first day of service level data for all years. The end of the season varied by year and was determined by the last date of ResSim data.

Table 4. Service Level Flow Criteria Based on Gavins Point Releases for Navigation Analysis Based on Master Manual

Flow Value	Description	Draft
NA	Navigation support flows were not provided	0
0	No navigation service provide (to account for split seasons)	0.0
<23000	Less than Min Service Level	0
> 23000, < 25999	Min Service Level - 8,000 cfs	6.0
>26000, < 28999	Min Service Level -3,000 cfs	7
>29000, < 31999	Min Service Level;	7.5
> 32000, < 34999	Reduced Service Level	8
>35000, < 44999	Full Service Level	8.5
> 45000, < 54999	Full Service Level + 10,000 cfs	9
> 55000, < 64999	Full Service Level + 20,000 cfs	9.0
> 65000,	Full Service Level + 30,000 cfs	8

Source: (1) Missouri River Mainstem Reservoir System Master Water Control Manual Missouri River Basin (2006), Appendix G: Navigation, pg G-2. And (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

A sample of the results based on the above steps is shown in Table 5.

Table 5. Sample Results for Estimating the Percentage of Navigation Days Within a Service Level Within a Month

Month	Year	Alt 1 No Action Service Level										
		NA	0	<23000	>23000, <25999	>26000, <28999	>29000, <31999	>32000, <34999	>35000, <44999	>45000, <54999	>55000, <64999	>65000,
Apr	13	0.0%	0.0%	0.0%	0.0%	0.0%	96.7%	0.0%	3.3%	0.0%	0.0%	0.0%
May	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Jun	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%

Variable - Tons

The second component in Equation 2 estimates the tonnage by commodity group, month, and river reach for a representative year(s). The Waterborne Commerce Statistics Center (WCSC) provides historical data on Missouri River movements by commodity group by river reach and for each month of the navigation season. For this effort, the navigation economic analysis considers traffic levels before and after 2011 as suggested by stakeholders. 2012 WCSC data is used as one representative year for the analysis as it is most recent year of full navigation service and did not experience any interruptions, delays, or shortened navigation season as shown in Table 6.

Table 6. Tonnage, Service Levels, and Season Start and End Dates, 1999-2014

				TARGET FLOWS March 15 Check				TARGET FLOWS July 1 Check				SEASON DATE	
Year	Reservoir System Supported Length of Season	Commercial Tons	Annual Total Tons	Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	Sioux City, IA	Omaha, NE	Nebraska City, NE	Kansas City, MO	1st Half Start	2nd Half Finish
1999	8(1)	1,575,686	9,252,125	Full								April	Dec
2000	8	1,343,611	8,733,311	Full				Reduced				April	Dec
2001	8	1,287,600	9,731,600	Reduced								April	Dec
2002	8 (2)	1,025,000	8,266,000	Min				Min				April	Dec
2003	8	669,608	8,050,273	Min				Min				April	Nov
2004	6 1/2	525,498	8,207,219	Min				Min				April	Oct
2005	6 1/2	284,641	8,360,747	Min				Min				April	Oct
2006	6 1/2	195,290	8,380,226	Min				Min				April	Oct
2007	6 3/4	302,769	6,701,625	Min				Min				April	Oct
2008	7	174,800	5,680,968	Min				Min				April	Oct
2009	8	269,563	5,035,744	Min				Full				April	Nov
2010	8(1)	379,492	4,829,714	Full								April	Dec
2011	8(1)	230,439	3,831,925	Full				Flood*				April	Sept*
2012	8	200,330	3,908,987	Full								April	Dec
2013	8	244,576	4,104,505	Min				Reduced				April	Dec
2014	8(1)	240,398	4,617,934	Reduced				Full				April	Dec

* Releases determined by flood control storage evacuation critiera and not adjusted to meet specific navigation targets. Different sections of the river were open and closed at different times.

(1) 10-day extension of season provided.

(2) To protect endangered shore birds below Gavins Point Dam, the Corps did not support navigation from July 3 to August 14, 2002. Average days towing industry off the river was 23 days.

SOURCES:

(1) Table 16 Navigation Season Target Flows (pg 63) and Table 17 Missouri River Tonnage and Season Length (pg 64)
Missouri River Mainstem Reservoir System Summary of Actual 2014 Regulation,
Available at: http://www.nwd-mr.usace.army.mil/rcc/aop.html

(2) USACE Waterborne Commerce Statistics Center Data on tons and commodities

Calculation - Multiply the service flow levels percentages by the reference condition year tonnage

As shown in the annual Transportation Savings equation (Equation 2), estimating the change in transportation savings by service levels involves multiplying the percentage of navigation days by the reference condition year tons:

Equation 3: Percent Tonnage Variable Equation

$$(\text{Percent Tonnage})_{\text{month, service level, commodity, reach}}$$
$$= (\text{Percent Navigation Days})_{\text{month, service level}} * (\text{Tons})_{\text{commodity, month, reach}}$$

For this analysis, this is accomplished by combining the percentage of time within a month for each service level category and reference condition year tonnage pulled from the WCSC database.

Calculation - Multiply the percent tonnage by the per ton transportation rate savings

Multiplying the reference condition year tonnage by the percentage of time within a month for each service level category creates the “Percent Tonnage” variable (Equation 3). Then as shown in Equation 4, the Percent Tonnage variable is multiplied by the savings per ton estimated. The results equal the annual transportation rate savings in dollars for each service level category (0, <23,000, 23,000 to 25,999, etc.), under each alternative. These transportation rate savings are summed across service level categories to generate an annual transportation rate savings for each alternative.

Equation 4: Annual Transportation Savings Equation with Percent Tonnage Variable

$$(\text{Transportation Savings})_{\text{year}}$$
$$= (\text{Percent Tonnage})_{\text{month, service level, commodity, reach}} * (\text{Savings})_{\text{commodity, month, reach, service flow}}$$

2.3.2 Change in Non-Routine Repair, Replacement, and Rehabilitation (R, R, & R) Costs

The second part of the net NED as shown in Equation 1 is the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs. The R, R, & R costs include (1) support for two river field offices including any funds necessary for rescues, funds for repairs of equipment, funds for staff, and funds for other expenses; (2) repair, replacement, and rehabilitation of river structures; (3) emergency dredging that is required for extreme river conditions. The basis for estimating the change in R, R, & R is the incremental annual operation and maintenance cost functions provided within “Table 15: Incremental Annual O & M Cost Function ($ Millions / Year)” of the Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised) (1998). During the 1998 analysis, the Corps of Engineers Missouri River Maintenance Task Group and the Coast Guard assumed that an eight-month full season was standard for R, R, & R costs. Then, the team estimated how lengthy periods of reduced flows or increased flows would increase the level of emergency dredging based on historical emergency dredging water experiences during these periods. The change in R, R, & R costs are presented in Table 7.

Table 7. Incremental Annual R, R, & R Cost Function

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)
Months	**Million FY 2016 $ / Year**	**Million FY 2016 $ / Year**	**Million FY 2016 $ / Year**	**Million FY 2016 $ / Year**	**Million FY 2016 $ / Year**
8	7.62	4.19	0.00	2.25	3.39
7	6.66	3.62	-0.42	1.66	2.70
6	5.52	2.86	-0.84	1.07	2.02

Source: 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) (1998)

To estimate the change in R, R, & R costs for varying season lengths, the numbers presented in "Table 15: Incremental Annual O & M Cost Function ($ Millions / Year)" were updated to FY 16 dollars using the USACE Civil Works Construction Cost Index System (CWCCIS) for the Waterway Industry and then underwent a linear regression. The following equations were the result of the regression (Table 8):

Table 8. Equations for Estimating the Change in R, R, & R Costs by Number of Months of Navigation Service Level

Service Level	Change in R, R, & R Costs by Month Functions
Minimum Service Equation (29,000 cfs)	y = 0.1422x
Reduced Service Equation (32,000 cfs)	y = 0.0768x
Full Service Equation (35,000 cfs)	y = 0.0631x - 0.5048
Full Service + 20,000 (55,000 cfs) Equation	y = 0.0364x
Full Service + 30,000 (65,000 cfs) Equation	y = 0.0588x

y = million dollars annually; x = months

Calculation - Calculate the number of months within a year that fall within a service level category

The change in R, R, and R cost functions generated in the previous step require knowing the number of months within a year that fall into a specific flow category. The number of months within a flow category is calculated by dividing the number of days within a flow category for that month by the number of navigable days. For example if HEC-Resim estimated the service level for August in year x would have 31 days with flows between 29,000 cfs and 32,000 cfs and there were 31 navigable days in the month, then a "1.00" was entered under the 29,000 cfs column. Next the monthly values were totaled for each year. For example, if year x contained seven other months with flows between 29,000 cfs and 32,000 cfs, then an eight was entered for the number of months.

To obtain the annual change in R, R, & R costs, the functions for each service level were summed as represented with the following equation:

Equation 5: Change in non-routine Repair, Replacement, and Rehabilitation (RR&R) Costs

$$\text{Change in R, R, \& R Cost})_{year} = (\text{Change in R, R, \& R Cost})_{29,000} + (\text{Change in R, R, \& R Cost})_{32,000} + (\text{Change in R, R, \& R Cost})_{35,000} + (\text{Change in R, R, \& R Cost})_{55,000} + (\text{Change in R, R, \& R Cost})_{65,000}$$

Where

- $(\text{Change in R, R, \& R Cost})_{29,000}$ = the change in R, R, & R costs when service level equals 29,000 cfs. It is estimated with the following equation: 0.1422 * (Number of Navigable Months).
- $(\text{Change in R, R, \& R Cost})_{32,000}$ = the change in R, R, & R costs when service level equals 32,000 cfs. It is estimated with the following equation: 0.0768 * (Number of Navigable Months).
- $(\text{Change in R, R, \& R Cost})_{35,000}$ = the change in R, R, & R costs when service level equals 35,000 cfs. It is estimated with the following equation: 0.0631 * (Number of Navigable Months)-0.5048.
- $(\text{Change in R, R, \& R Cost})_{55,000}$ = the change in R, R, & R costs when service level equals 55,000 cfs. It is estimated with the following equation: 0.0364 * (Number of Navigable Months).
- $(\text{Change in R, R, \& R Cost})_{65,000}$ = the change in R, R, & R costs when service level equals 65,000 cfs. It is estimated with the following equation: 0.0588 * (Number of Navigable Months).

The change in R, R, & R costs is then subtracted from the transportation savings to estimate the net NED benefits for each alternative.

2.3.3 Annualizing NED values

The NED results of the MRRMP-DEIS alternatives shown in this document are often presented in the form of average annual values. The average annual values for transportation rate savings, the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs, and the net NED were calculated by summing the 75 annual values and dividing by 75. Seven drought years were not considered since navigation support flows were not provided in these years and the intent of the analysis is to understand how releases for navigation will be impacted by the alternatives.

It should be also noted that a discount rate was not used on the annual values because calculating the present value of the 82 years of record gives undue weight to the order in which the hydrology occurred (the historic record) and the intent of the model is to understand how alternatives will respond under a range of possible flow conditions that could occur in a given year. This action was recommended by the ATR of the model.

2.4 Regional Economic Development (RED) Method

As defined in the Introduction, t*he regional economic development (RED)* account registers changes in the distribution of regional economic activity. Two types of regional economic activity examined for the Missouri River Recovery Management Plan and Environmental Impact Statement (MRRMP-EIS) analysis were water compelled rate benefits and regional job and income impacts from changes in NED. The rest of this section discusses the methods employed to examine the water compelled rate benefits and the regional job and income impacts.

2.4.1 Water Compelled Rate Benefits

Water compelled rate benefits are defined as reduction in cost for over land 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 could rise.

To determine the measurability of water-compelled railroad rate benefits, USACE contacted Dr. Mark Burton and Dr. Larry Bray with the University of Tennessee Center for Transportation Research (UT-CTR). The UT-CTR was chosen for the analysis because Dr. Burton has conducted several previous analyses of Missouri River water compelled rate benefits and Dr. Bray is an expert in economics of transportation. To generate a conclusion, Dr. Burton and Dr. Bray conducted literature research and analyzed current Missouri River waterway and railroad. The analysis identified the following key trends and characteristics:

- Traffic that might have moved on the Missouri River either moves by rail at unaffected rates or has migrated to waterborne movement on the Arkansas River.
- While railroads within the region have capacity for traffic, there is not enough waterway traffic on the Missouri to capture.

Due to these points, Dr. Burton and Dr. Bray concluded that measurable water-compelled railroad rates attributable to Missouri River commercial navigation seem improbable. However, Dr. Burton and Dr. Bray did note if expectations regarding the Missouri River’s reliability and long-run availability are reversed then railroads may become sensitivity to Missouri River navigation in order to retain existing traffic or respond to new opportunities.

For a discussion on the history of water compelled rate benefits, a discussion on the interrelationship between railroads and water navigation, and other insights please consult section with the MRRMP-EIS document entitled, “Missouri River Water-Compelled Railroad Rates: Review and Qualitative Update”.

2.4.2 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 products 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 sand and gravel,

food, and farm materials that would be anticipated to be shipped by navigation on the Missouri River under the MRRMP-DEIS alternatives.

The regional economic analysis was conducted using IMPLAN® Pro and RECONS, both of which are 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® Pro is an I-O data and software system that is widely used by academics, government, and industry. RECONS is a certified Corps model that customizes IMPLAN® Pro’s ratios and multipliers to Corps 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 inflated to 2016 dollars with the GDP deflator (OMB 2016).

Two regional economic evaluations were conducted to estimate the RED impacts: 1) impacts to the commercial sand and gravel and associated truck transportation; and 2) impacts to the waterway industries. The methodology for these evaluations is summarized in this section.[1] Although the NED analysis included an 82-year period of analysis, there were five scenarios on which the RED analysis was focused for both of the evaluations: the best year (highest navigation year); the worst year (the lowest navigation year); the average annual over the 82-year period of analysis; the average of the eight worst years relative to Alternative 1; and the average of the eight best years relative to Alternative 1. These eight worst and best year statistics allow an understanding of the skewness of impacts and magnitude of impacts in the largest difference years.

Commercial Sand and Gravel Production and Associated Truck Transportation

When navigation on the Missouri River is not available or reduced, the production of sand and gravel from the river could also be reduced or altogether ceased if navigation were not available, with impacts to revenues or sales to the commercial sand dredging and gravel industry. This lost sales for the commercial sand dredging industry is based on a conservative assumption because if sand cannot be dredged from the Missouri River, it could likely be

1 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 MRRMP-EIS alternatives. Because of the small amount of non-sand and gravel commodities affected and the relatively small impacts to transportation savings in the NED evaluation, RED impacts to industries that ship their products -- other than commercial sand and gravel -- were not further evaluated in the RED evaluation.

produced from alternate sources.[2] The value of changes in sand and gravel production was calculated using the quantity of commercial sand and gravel shipped on Missouri River from the NED evaluation and price of commercial sand and gravel, as estimated in the Missouri River Commercial Dredging Final EIS (USACE 2011). The price of commercial sand and gravel represents the free-on-board price paid to dredge operators, and does not include shipping costs to transport processed sand from distribution centers to end users. The commercial sand and gravel price per ton was $4.40 in 2008 dollars.

In addition to losses in sales for the commercial sand dredging industry, the truck transportation would also experience a negative impact due to reduced sand and gravel production. Shifts in commercial sand and gravel production would result in an ancillary effect on the truck shipping industry, which provides the mechanism to transport commercial sand and gravel from sellers to buyers. When commercial sand and gravel production cannot occur due to adverse river conditions, there would also be an associated reduction in truck transportation. The regional economic evaluation used information from the Missouri River Commercial Dredging Final EIS (USACE 2011) to estimate the sales to truck transportation that would be affected under the MRRMP-EIS alternatives. The transportation cost per ton was calculated based on the difference between the cost to end users in the Kansas City segment ($7.72) and the average production cost per ton ($4.40) (USACE 2011). The transportation cost was estimated to be $3.32 per ton in 2008 dollars.

The RED evaluation used the sand and gravel tonnage moved on the Nebraska City and Kansas City reaches (there were no products moved in the Sioux City and Omaha reaches) from the NED evaluation. The study area was the state of Missouri, consistent with the regional economic analysis in the Missouri River Commercial Dredging Final EIS, because Missouri represents the core area of potential impacts from reductions in the loss of commercial sand and gravel production from the Missouri River. The price of commercial sand and gravel and truck transportation costs per ton were applied to the movements. The value of sand and gravel production and the truck transportation costs were then used as inputs (direct effects) into the IMPLAN® Pro model using the appropriate sector. The economic impacts were then estimated for each of the five scenarios.

Waterway Industries

The MRRMP-EIS alternatives could affect other commodities shipped on the Missouri River in addition to commercial sand and gravel. When navigation is unavailable or reduced, adverse impacts occur to jobs, income and sales associated with the waterway industries, including the shipping industries, terminal operators, and loading and unloading services. Although the commodities that can no longer be shipped via navigation would likely be shipped using an

[2] The Commercial Dredging Final EIS provides the following information on alternate sources of sand (USACE 2011). Four general types of sand and gravel mining operations represent an alternate source to material dredged from the lower Missouri River. The most comparable alternate source of sand and gravel is material dredged from the Kansas and Mississippi Rivers, which potentially could serve demand centers in the western and eastern sides of Missouri, respectively. Sand produced from these sources is generally considered to be Class A (natural) sand and meets material specifications for road and other construction projects. Other alternate sources include floodplain open-pit mines and quarries, instream mining, and manufactured sand. However, the suitability, availability, and cost of production of these sources vary widely.

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 reach and no shipments in the Sioux City and Omaha river reaches. It was assumed that most of the Nebraska City reach shipments were moving through the Kansas City reach, 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 vast majority of products being shipped are within Missouri. Over the past five years, 90 percent of products shipped in the Kansas City reach had both the origin and destination within the river reach.

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 using shipper rates from the Ohio River System that are then allocated to both the waterway industries and port services sectors to estimate the economic impacts.[3] 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.

2.5 Other Social Effects (OSE) Methods

Burning fossil fuels generates several criteria pollutants including carbon monoxide, nitrous oxides (NOx), and particulate matter (PM) along with hydrocarbons (HC), a precursor to photochemical smog. The Texas A & M University Texas Transportation Institute (TTI) (2012) 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 less fossil fuels are burned when a commodity is transported by water compared to truck or rail. Since moving commodities on the waterway results in less emissions, changes to the waterway could potentially affect the pollution associated with the provision of transportation services. These type of impacts fall under the OSE account which according to Principles and Guidelines (1983) shows the urban and community impacts and effects on life, health and safety. This navigation impact analysis assesses the OSE impacts by (1) characterizing the current state of air quality within the region and (2) conducting a preliminary analysis of changes in emissions using estimates for the potential tonnage that could move off the water due to MRRPMP alternatives and published emission factors for inland waterway vessels and trucks.

An analysis of the potential impact to the OSE account requires knowing the current status of pollution emissions within the relevant area. To characterize the current state of air quality within

[3] Please see the RECONS User Guide (http://www.iwr.usace.army.mil/Portals/70/docs/missions/RECONS_USER_GUIDE.PDF) and RECONS Methodology Manual (http://www.iwr.usace.army.mil/Portals/70/docs/missions/RECONS_%20MethodologyManual-2.pdf) for additional details on the inland waterway module assumptions and methods.

the region, the navigation impact analysis obtained a list of all counties that do not meet National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants from the U.S. Environmental Protection Agency (EPA) Green Book Nonattainment Areas. The list of nonattainment counties was cross-referenced with a list of counties within 50 miles of the Missouri River to help map counties within the relevant region.

The analysis also includes a preliminary estimate of changes in pollution levels due to commodities switching mode of transportation. These preliminary estimates are found by multiplying the tonnage that could move off the water for each alternative by emission factors for the truck and inland towing. This was done in the following steps:

1. Estimate the amount of tonnage moving off the water for each alternative - This variable was determined during the NED analysis and is the product of the percent of time within a month that navigation service levels fall below minimum and 2012 tonnage levels (reference condition year)
2. Estimate the emissions if the tonnage traveled on the water and if the tonnage traveled by truck - The factors used to estimate the emission for inland towing and truck were provided by Texas A & M University, Texas Transportation Institute (2012) and are shown in Table 9. The truck emission rates were chosen because they are the maximum rates for carbon monoxide, nitrogen oxides, and particulate matter among the transportation modes. Using the maximum rate generates a more conservative estimate of the emission changes for each alternative.
3. Subtract the estimate for the water emissions from the estimate for the truck emission – The intent of the navigation impact analysis is to determine the difference in emissions if the tonnage moves off the water. Therefore, the emissions that would occur if the tonnage traveled by water are subtracted from the emissions that are estimated to occur if the tonnage traveled by truck.
4. Repeat process for each pollutant and roll up results - The process was conducted for HC, CO, NOx, and PM. This allowed for a summary on the change in emissions that would occur for each pollutant over the period of record. This number was divided by 75 to determine the annual average emissions. Since seven years in the period of record (82 years) did not have navigation, these years were not included in average annual calculations.

Table 9. Summary of Emissions - Grams Per Ton-Mile

	Hydrocarbons (HC) Grams / ton-mile	**Carbon Monoxide (CO) Grams / ton-mile**	**Nitrogen Oxides (NOx) Grams / ton-mile**	**Particulate Matter (PM) Grams / ton-mile**
Inland Towing	0.01737	0.04621	0.46907	0.01164
Eastern Railroad	0.02419	0.06434	0.65312	0.01624
Western Railroad	0.02423	0.06445	0.65423	0.01621
Truck	0.020	0.136	0.732	0.018

SOURCE: Texas A & M University, Texas Transportation Institute. 2012. Available at: http://www.marad.dot.gov/resources/maritime-publications/

2.6 Environmental Quality Methods

According to Principles and Guidelines (1983), the environmental quality (EQ) account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms. Impacts to navigation from alternatives proposed by the MRRMP-EIS that may cause changes to the EQ account are covered under the OSE account. This includes the potential change in emissions that could occur due to any alternation of current navigation activity.

3.0 NED Evaluation Results

The NED analysis for navigation impacts focused on two NED values: 1) the transportation savings and 2) the change in non-routine repair, replacement, and rehabilitation (R, R, & R) costs. Once these two NED values are known, the change R, R, & R costs can be subtracted from the transportation savings to estimate the net NED benefits for each alternatives.

Equation 6: The net NED Value Calculations

$$\text{net NED}_{year}=(\text{Transportation Savings})_{year}-(\text{Change in R, R \& R Cost})_{year}$$

Table 10 presents the statistics for the transportation savings for each of the alternatives. The average annual transportation rate savings for the alternatives ranges from $1.21 million to $1.26 million. Alternative 2 shows the greatest relative impact to navigation with a 0.05 percent decrease from Alternative 1 in transportation savings. This decline is to be anticipated since Alternative 2 is the only alternative with split navigation seasons. Alternatives 3 through 6 show two percent difference or less with Alternative 1. However, Alternative 3 ($0.002 million) and Alternative 5 ($0.001 million) have slightly beneficial impacts to navigation while Alternative 4 (-$0.022 million) and Alternative 6 (-$0.016) show relatively large adverse impacts to navigation due to shorter navigation seasons caused by years that have a full spring release under Alternative 4 and spawning cue flows under Alternative 6.

Table 10. Estimated Changes in Transportation Savings for Each MRRMP-EIS Alternatives with 2012 as Reference Condition Year

All Locations	Alternative 1 (million $)	Alternative 2 (million $)	Alternative 3 (million $)	Alternative 4 (million $)	Alternative 5 (million $)	Alternative 6 (million $)
Total That Occurred Over the Period of Record	$95.36	$91.75	$95.52	$93.69	$95.46	$94.15
Average Annual Value	$1.26	$1.21	$1.26	$1.23	$1.26	$1.24
Change in Average from Alternative 1		-$0.048	$0.002	-$0.022	$0.001	-$0.016
Percentage Change in Average from Alternative 1		-3.792%	0.165%	-1.751%	0.103%	-1.275%

Table 11 summarizes the changes to non-routine repair, replacement, and rehabilitation (R, R, & R) costs. Among the alternatives, the average annual change varies slightly from $0.52 million to $0.57 million. Alternative 2 shows a slight decrease (-$0.019 million) in change in R, R, & R costs because it has shorter full service seasons. According Table 15: Incremental Annual O&M Cost Function" in the *Master Water Control Manual Missouri River Review and Update Study, Volume 6A-R: Economic Studies Navigation Economics (Revised)* (1998), a six month full service navigation season reduces the R, R, & R costs. In comparison, Alternative 4 ($0.023 million) shows a higher change in R, R, & R costs than Alternative 1. The higher R, R, & R costs are due to several different years when Alternative 1 has an eight-month full service navigation season and Alternative 4 shows a three month full service season along with a 5 month reduced service season due to a full spring release.

Table 11. Estimated Changes in R, R, & R Costs for Each MRRMP-EIS Alternatives with 2012 as Reference Condition Year

All Locations	Alternative 1 (million $)	Alternative 2 (million $)	Alternative 3 (million $)	Alternative 4 (million $)	Alternative 5 (million $)	Alternative 6 (million $)
Total Change in R, R, & R Costs That Occurred Over the Period of Record	$41.00	$39.54	$40.98	$42.74	$41.57	$42.95
Average Annual Change in R, R, & R Costs	$0.54	$0.52	$0.54	$0.56	$0.55	$0.57
Change in Average from Alternative 1		-$0.019	$0.000	$0.023	$0.007	$0.026
Percentage Change in Average from Alternative 1		-3.57%	-0.06%	4.24%	1.38%	4.75%

Table 12 shows the net NED value for navigation. These values are derived by subtracting the change in R, R, & R costs (Table 11) from the average annual transportation savings (Table 10). The total net NED over the period ranged from $50.96 million under Alternative 4 to $54.55 million under Alternative 3. Total average annual NED value ranged from $0.67 million under Alternative 4 to $0.72 million under Alternative 3.

When comparing the alternatives, the following relationships should be noted:

- Over the period of record, the total transportation savings for the alternative ranges from $91.75 million (Alternative 2) to $95.52 million (Alternative 3). However, after factoring in the change in R, R, & R costs, the net NED values range from $50.96 million (Alternative 4) to $54.55 million (Alternative 3).
- All alternatives show less than a seven percent difference (Alternative 3 with 0.39 percent to Alternative 4 with -6.27 percent) in net NED relative to Alternative 1.

- Considering only the transportation savings, Alternative 2 (-$0.048 million) has the greatest impact. However when the change in R, R, & R costs are counted, Alternative 4 shows the greatest change in Net NED value (-$0.045 million) relative to Alternative 1. These two alternatives demonstrate the greatest impacts because Alternative 2 has split navigation seasons and Alternative 4 experiences higher change in R, R, & R costs due to greater number of months within reduced service level and minimum service level.
- With Alternative 2 and 4, partial spring releases reduce navigation service levels for months following the release.
- Alternative 2 shows less of an impact to NED value than Alternative 4 because of several years when splitting the navigation seasons causes shorter full service seasons which reduce the change in R, R, & R costs.
- With the exception of Alternative 3 ($0.002 million), all alternatives demonstrate a negative net NED impact to navigation.
- Alternative 5 is expected to have the least negative impact of the alternatives.

Table 12. Estimated Changes in Net NED Value for Each MRRMP-EIS Alternatives with 2012 as Reference Condition Year

All Locations	Alternative 1 (million $)	Alternative 2 (million $)	Alternative 3 (million $)	Alternative 4 (million $)	Alternative 5 (million $)	Alternative 6 (million $)
Total net NED That Occurred Over the Period of Record	$54.36	$52.21	$54.55	$50.96	$53.89	$51.20
Average Annual Net NED value	$0.72	$0.69	$0.72	$0.67	$0.71	$0.67
Change in Average from Alternative 1		-$0.028	$0.002	-$0.045	-$0.006	-$0.042
Percentage Change in Average from Alternative 1		-3.96%	0.34%	-6.27%	-0.86%	-5.82%

3.1 Alternative 1 – No Action

Under the no-action alternative, the Missouri River Recovery Program would continue its current implementations plans. This includes management actions that are in compliance with the BiOp. Management actions that may have impacts to navigation including spawning cue flow releases from Gavins Point Dam.

As shown in Table 13**,** the annual net NED values, transportation savings minus change in R, R, & R costs, for Alternative 1 would range between $0.006 million and $1.45 million with an average of $0.72 million. The reason for the range is due to the period of record covering 82 years which covers a multitude of conditions. This range in annual net NED values is also presented in Figure 3 which contains a stacked bar graph of the number of months within each a year that falls within an estimated service level flows category. For example, the late 1950's show that most of the months are categorizes as either no service or minimal service, so the net

NED value, the black line, during these years is relatively low. As expected, Figure 3 shows a clear relationship between the level of service and net NED value.

Table 13. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 1 (FY 16 Values)

Costs	Alternative 1 Transportation Savings	Alternative 1 R, R, & R Costs	Alternative 1 Net NED Value
Total That Occurred Over the Period of Record (million $)	$95.36	$41.00	$54.36
Average Annual Value (million $)	**$1.26**	**$0.54**	**$0.72**
Max Annual Over the Period of Record (million $)	$1.46	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.942	$0	$0.006

*Numbers may not match exactly due to rounding

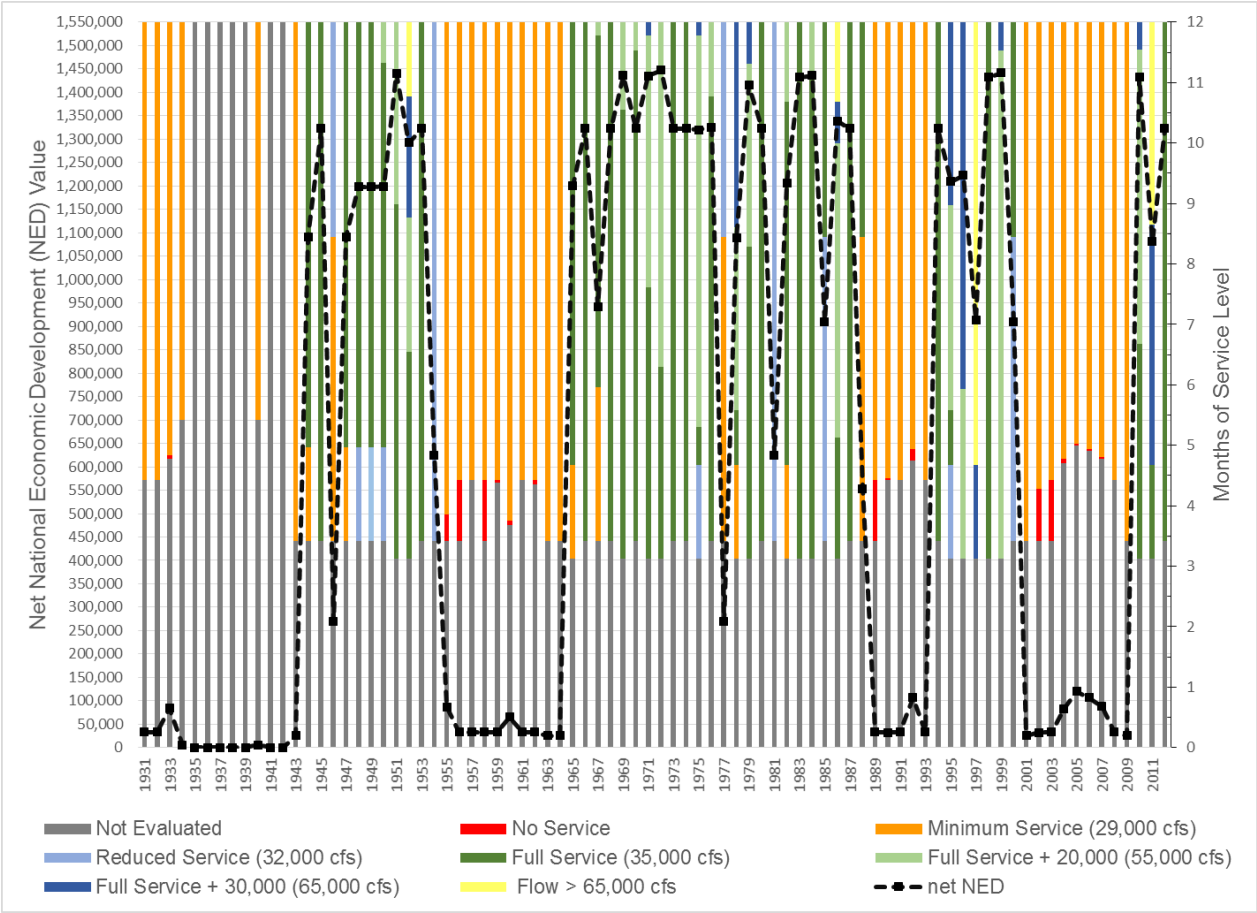


Figure 3. Net National Economic Development (NED) value and Number of Months Within a Year At Various Service Levels for Alternative 1

3.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The NED Analysis for Alternative 2 is summarized in Table 14. The management actions would result in Alternative 2 having an average annual net NED of $0.69 million and an annual net NED range between $0.006 million to a maximum of $1.45 million. Under Alternative 2, Missouri River navigation would lose an average of $0.028 million per year in net NED benefits to adapt to changing conditions of the river relative to Alternative 1. This represents an overall decrease in net NED to 3.96 percent compared to Alternative 1.

Table 14. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 2 (FY 2016 Values)

Costs	Alternative 2 Transportation Savings	Alternative 2 R, R, & R Costs	Alternative 2 Net NED Value
Total That Occurred Over the Period of Record (million $)	$91.75	$39.54	$52.21
Average Annual Value (million $)	**$1.21**	**$0.52**	**$0.69**
Max Annual Over the Period of Record (million $)	$1.45	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.909	-$0.104	$0.006
Change from Alternative 1 (million $)	-$0.048	-$0.019	-$0.028
% Change from Alternative 1	-3.79%	-3.57%	-3.96%
*Numbers may not match exactly due to rounding			

When evaluating the impacts of each of the MRRMP-EIS alternatives, it is helpful to examine the annual impacts. However when analyzing the annual impacts it is necessary to identify years with split navigation season (Table 15).

Table 15. Years with Split Navigation Seasons in Alternative 2

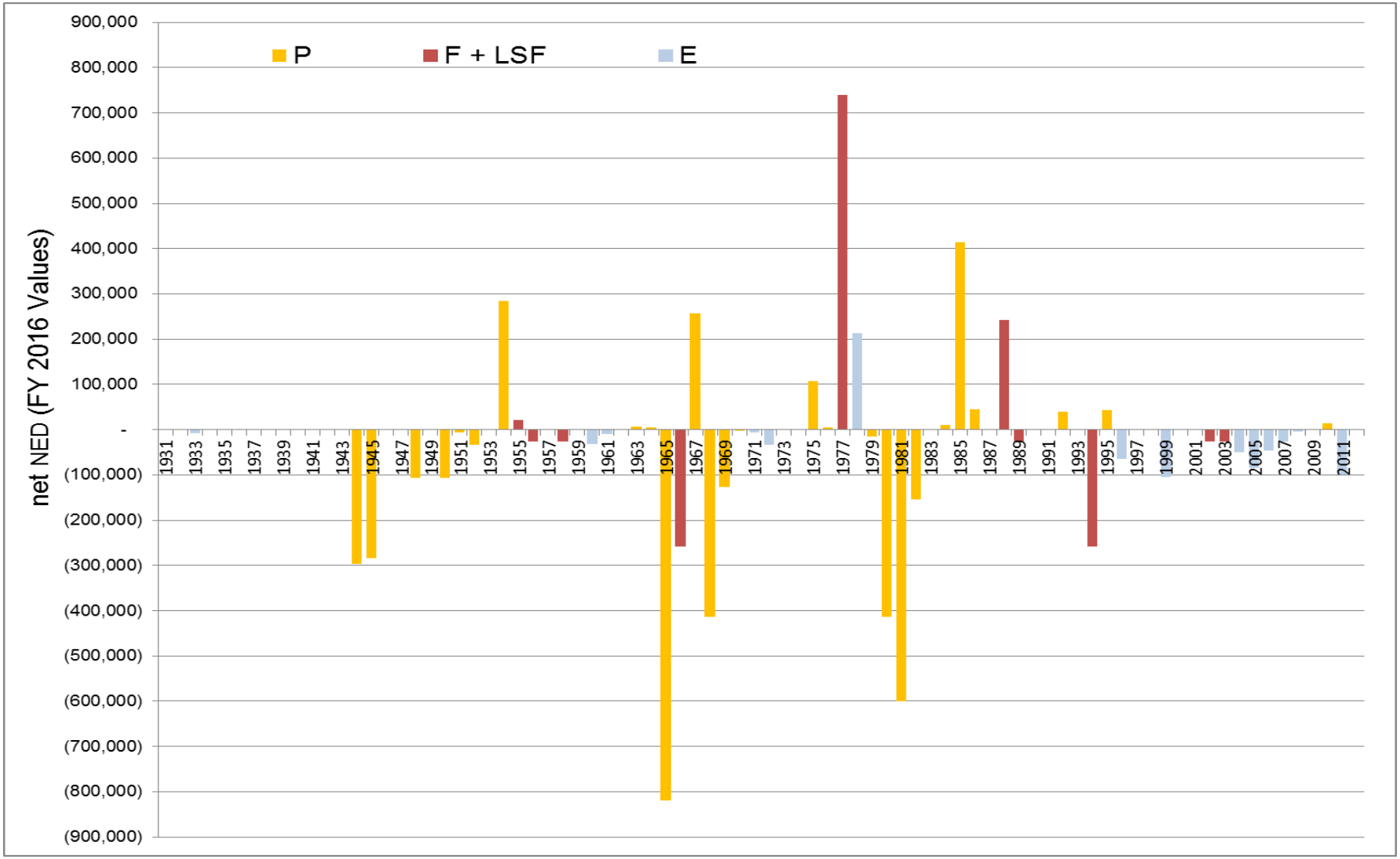
1955	1956	1958	1966	1977
1988	1989	1994	2002	2003

The annual differences in net NED value between Alternative 1 and Alternative 2 are shown in Figure 4**.** The difference in NED costs for each year is color-coded based on the type of release occurring each year. Some notable trends found in Figure 4 are the following:

- Alternative 2 contains ten years of full releases plus low summer flows and 44 years with partial release.
- Of the ten full releases plus low summer flows simulate occurrence, seven cause negative impacts to navigation NED values. However the greatest beneficial impact of Alternative 2 in comparison to Alternative 1 occurs under simulated full release low summer flow conditions similar to 1977. Under these conditions, Alternative 2 has a total of six month supported navigation season with three months in full service and three months in reduce service. Meanwhile, Alternative 1 simulates an eight month supported navigation season with five months at minimum service and three months in reduced service. The shorter season but higher service level for Alternative 2 results in lower

transportation savings, but it also reduces R, R, & R costs. The result is conditions similar to those occurring in 1977 having the highest beneficial impact of $0.74 million.

- Of the 44 partial releases simulated over the period of record, 14 would have an adverse impact on NED navigation benefits with the greatest impact (-$0.819 million) occurring in conditions similar to 1965. Partial releases under conditions similar to those that occurred in the mid-1940s, the late 1960s, and the early 1980s cause annual adverse impacts that are greater than $0.200 million.



P – Partial Release; F + LSF – Full Release plus Low Summer Flow; E – Eliminated Release

Figure 4. Alternative 2 Difference in Net NED Relative to Alternative 1

3.3 Alternative 3 – Mechanical Construction Only

Management actions included under Alternative 3 would include those that focus on the creation of ESH through mechanical means. This alternative would have a small, beneficial impact on navigation.

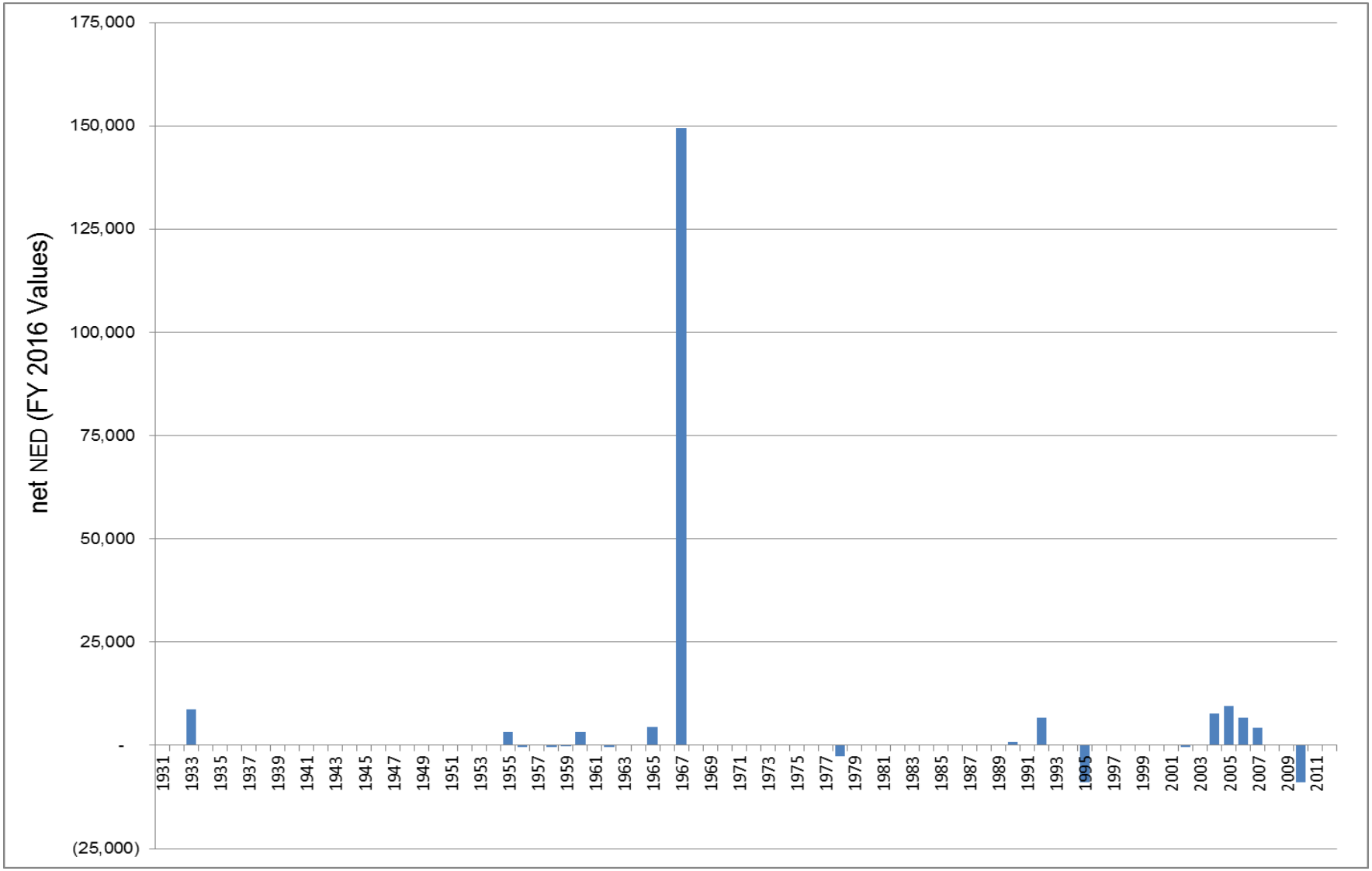
The NED results for Alternative 3 are summarized in Table 16. Overall, Alternative 3 has a small, positive impact ($0.002 million) on Missouri River navigation relative to Alternative 1. The result is an increase of 0.34 percent relative to Alternative 1. It should be noted that this analysis focused on the impact to the river rather than specific impacts at ESH locations on the river. A discussion of the qualitative impacts to navigation section of the Environmental Consideration.

Table 16. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 3 (FY 2016 Values)

Costs	Alternative 3 Transportation Savings	Alternative 3 R, R, & R Costs	Alternative 3 Net NED value
Total That Occurred Over the Period of Record (million $)	$95.52	$40.98	$54.55
Average Annual Value (million $)	**$1.26**	**$0.54**	**$0.72**
Max Annual Over the Period of Record (million $)	$1.46	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.942	$0.000	$0.006
Change from Alternative 1 (million $)	$0.002	$0.000	$0.002
% Change from Alternative 1	0.17%	0.06%	0.34%

*Numbers may not match exactly due to rounding

As shown by the minimum and maximum annual differences in net NED value in Figure 5. Alternative 1 and Alternative 3 have similar simulated results. In 1967, Alternative 3 offers an increase of $0.150 million in net NED. While the transportation savings between Alternative 1 and Alternative 3 in 1967 were similar, the R, R, & R costs for Alternative 1 were more expensive due to Alternative 1 having a navigation season with greater amount of time classified as minimal service. This resulted in Alternative 3 have a net NED in 1967 that is 16 percent higher than Alternative 1, but over the period of record Alternative 3 is slight beneficial impact of 0.34 percent.



There are no releases or low summer flows in Alternative 3

Figure 5. Alternative 3 Difference in Net NED Relative to Alternative 1

3.4 Alternative 4 – Spring ESH Creating Release

Alternative 4 develops ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Both actions have the potential to affect navigation. As shown in Table 17, relative to Alternative 1 Alternative 4 has an average annual change in net NED value of -$0.045 million which equates to decrease of 6.27 percent on net NED value. While annual net NED value for Alternative 4 ranges from a minimum of $0.06 million to a maximum of $1.45 million, the annual difference between Alternative 4 and Alternative 1 ranged from -$0.413 million to $0.053 million.

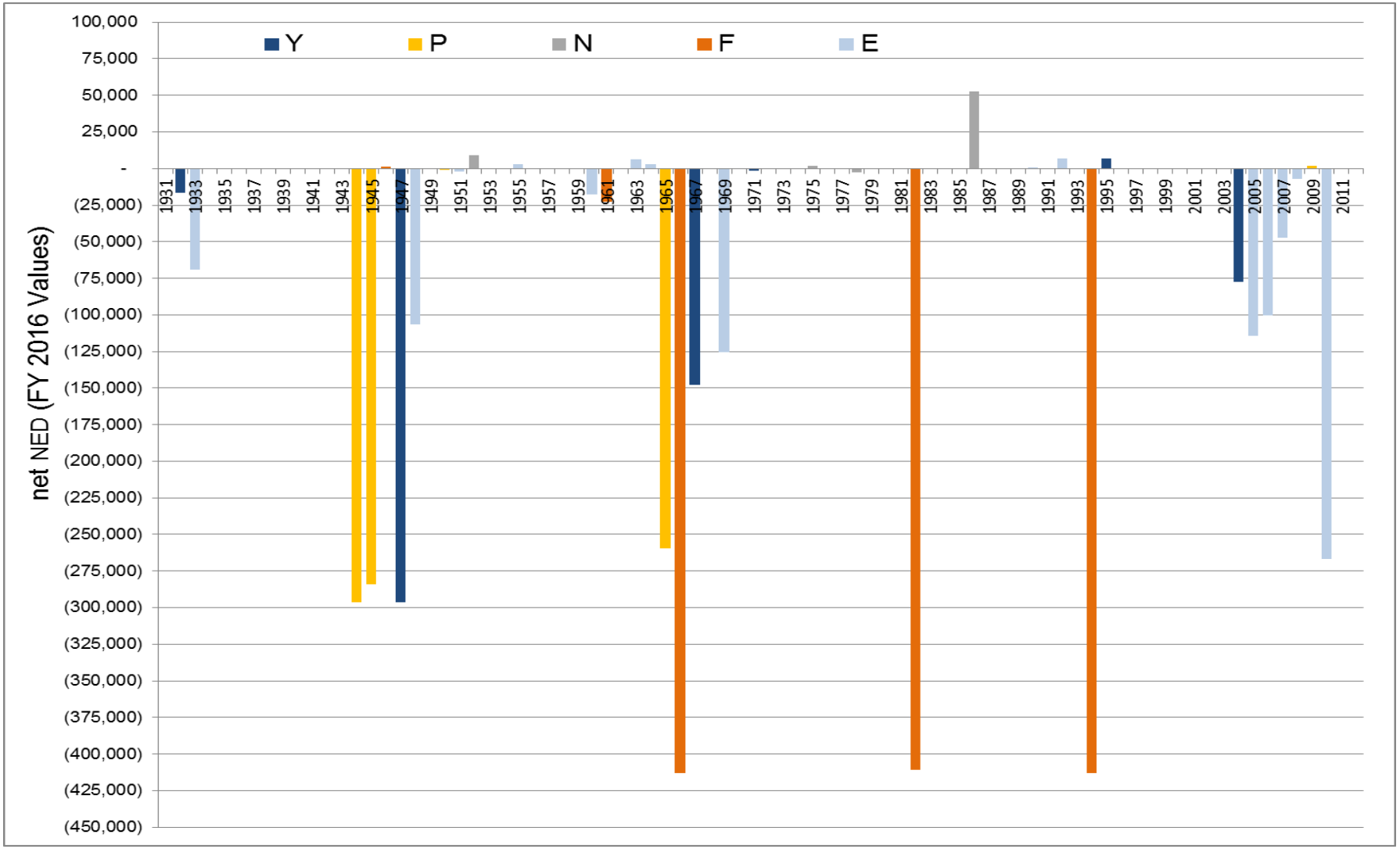
Table 17. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 4 (FY 2016 Values)

Costs	Alternative 4 Transportation Savings	Alternative 4 R, R, & R Costs	Alternative 4 Net NED value
Total That Occurred Over the Period of Record (million $)	$93.69	$42.74	$50.96
Average Annual Value (million $)	**$1.23**	**$0.56**	**$0.67**
Max Annual Over the Period of Record (million $)	$1.46	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.942	$0	$0.006
Change from Alternative 1 (million $)	-$0.022	$0.023	-$0.045
% Change from Alternative 1	-1.75%	4.24%	-6.27%

*Numbers may not match exactly due to rounding

Figure 6 presents the annual differences in net NED value between Alternative 1 and Alternative 4. The difference in NED costs for each year is color-coded based on the type of release occurring each year. Some notable trends include the following:

- Under conditions to similar to those modeled for 1966, 1982, and 1994, full releases would likely result in the greatest decrease (>$0.41 million) between Alternative 4 and Alternative 1. While the length of the supported season between Alternative 1 and Alternative 4 would be the same, the full release reduces the service level. This reduction in service level increases the R, R, & R costs along with reducing the transportation savings resulting in an adverse impact to the net NED compared to Alternative 1. Of the ten full releases simulated, five simulation conditions saw adverse changes in navigation benefits, four resulted in no change, and one caused a small beneficial impact (<$0.002 million) in navigation benefits.
- While the full releases resulted in the largest difference between Alternative 1 and Alternative 4, some simulated conditions showed partial releases causing adverse impacts. For example, conditions similar to those modeled for 1944, 1945, and 1965 resulted in the partial releases adversely impacting navigation benefits by greater than $0.255 million. Alternative 4 and Alternative 1 have similar transportation savings estimates ($1.3 million) for 1944 and 1945, but the simulated partial spring releases reduce the service level which increases the R, R, & R costs. These higher R, R, & R costs are the result of spring flows reducing the service levels in the early months before they can be increased towards the end of the navigation season. Of the five partial releases scheduled, four result in adverse impacts and one has a slight beneficial impact (<$0.002 million)
- Of the 82 years simulated for Alternative 4, with 26 had an adverse impact compared to Alternative 1 and 45 years showed the no difference with Alternative 1.



Y = Year after a full release, P = partial release, N = natural release, F = full release, E = eliminated release

Figure 6. Alternative 4 Difference in Net NED Relative to Alternative 1

3.5 Alternative 5 – Fall ESH Creating Release

Alternative 5 develops ESH habitat through both mechanical and reservoir releases that would occur during the fall months. The NED results for Alternative 5 are summarized in Table 18. While Alternative 5 has a small, beneficial impact on transportation savings ($0.001 million), the change in R, R, & R costs between Alternative 5 and Alternative 1 ($0.007 million) results in an overall net decline in NED of $0.006 million. This is a minor decrease of 0.86 percent in net NED relative to Alternative 1. The annual difference between Alternative 5 and Alternative 1 ranges from -$0.284 million to $0.010 million.

Table 18. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 5 (FY 2016 Values)

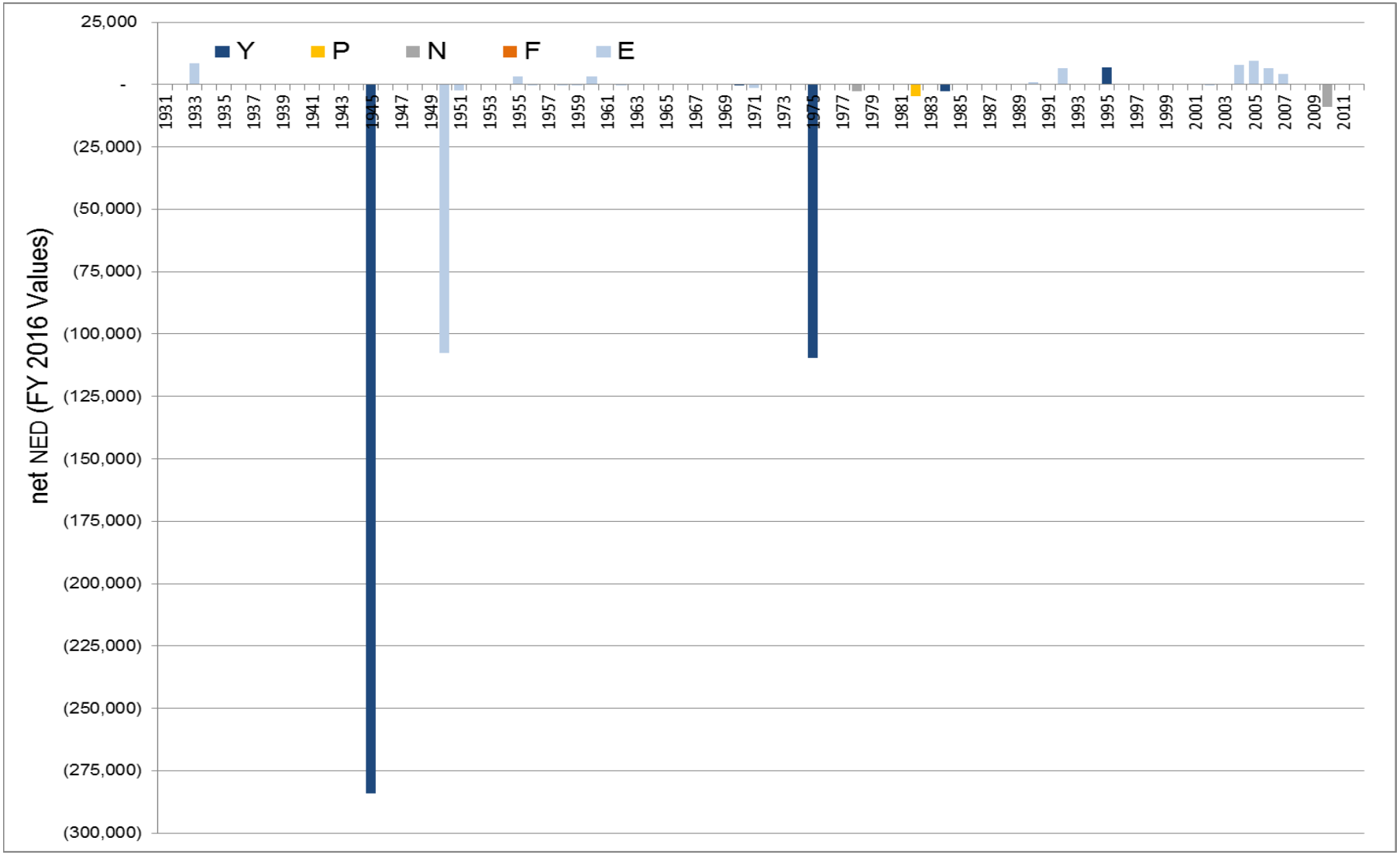
Costs	Alternative 5 Transportation Savings	Alternative 5 R, R, & R Costs	Alternative 5 Net NED value
Total That Occurred Over the Period of Record (million $)	$95.46	$41.57	$53.89
Average Annual Value (million $)	**$1.26**	**$0.55**	**$0.71**
Max Annual Over the Period of Record (million $)	$1.46	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.942	$0.000	$0.006
Change from Alternative 1 (million $)	$0.001	$0.007	-$0.006
% Change from Alternative 1	0.1030%	1.38%	-0.86%

*Numbers may not match exactly due to rounding

Figure 7 presents the annual differences in net NED value between Alternative 1 and Alternative 5. The difference in NED costs for each year is color-coded based on the type of release occurring each year. Figure 7 shows that fall releases under Alternative 5 cause negative impacts, but they do not occur until the year after the release. As shown in Table 19, Alternative 5 has seven fall releases occurring throughout the 82 year period and under simulated conditions similar to 1944, 1969, 1974, and 1983 the fall releases caused adverse impacts in the following years. However, the adverse impacts simulated for conditions similar to 1970 and 1984 are less than $0.002 million while the adverse impacts simulated for conditions similar to 1945 and 1975 are -$0.284 million and -$0.109 million, respectively. Since Alternative 5 is simulated to have three months at reduced service levels and Alternative 1 is simulated to have eight months at full service, the R, R, & R costs for Alternative 5 are much higher.

Table 19. Years within Alternative 5 with Fall Release

	Years With Fall Release
1	1944 – Negative impact in 1945
2	1948
3	1965
4	1969 – Negative impact in 1970
5	1974 – Negative impact in 1975
6	1983 – Negative impact in 1984
7	1994



Y = Year after a full release, P = partial release, N = natural release, F = full release, E = eliminated release

Figure 7. Alternative 5 Difference in Net NED Relative to Alternative 1

3.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 develops ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. This analysis focuses on the impacts the bi-model pulses would have on navigation.

The net NED results for Alternative 6 are summarized in Table 20. Relative to Alternative 1, Alternative 6 reduces transportation savings by $16,000 and increases R, R, & R costs by $0.026 million. Over the period of record, the difference between Alternative 6 and Alternative 1 in annual net NED varies between -$0.599 million to $0.12 million with an average of -$0.042 million which equates to a decrease of 5.82 percent.

Table 20. Transportation Savings; R, R, & R Costs, and Net NED for Alternative 6 (FY 2016 Values)

Costs	Alternative 6 Transportation Savings	Alternative 6 R, R, & R Costs	Alternative 6 Net NED value
Total That Occurred Over the Period of Record (million $)	$94.15	$42.95	$51.2
Average Annual Value (million $)	**$1.24**	**$0.57**	**$0.67**
Max Annual Over the Period of Record (million $)	$1.46	$1.22	$1.45
Min Annual Value Over the Period of Record (million $)	$0.94	$0	$0.006
Change from Alternative 1 (million $)	-$0.016	$0.026	-$0.042
% Change from Alternative 1	-1.275%	4.75%	-5.82%

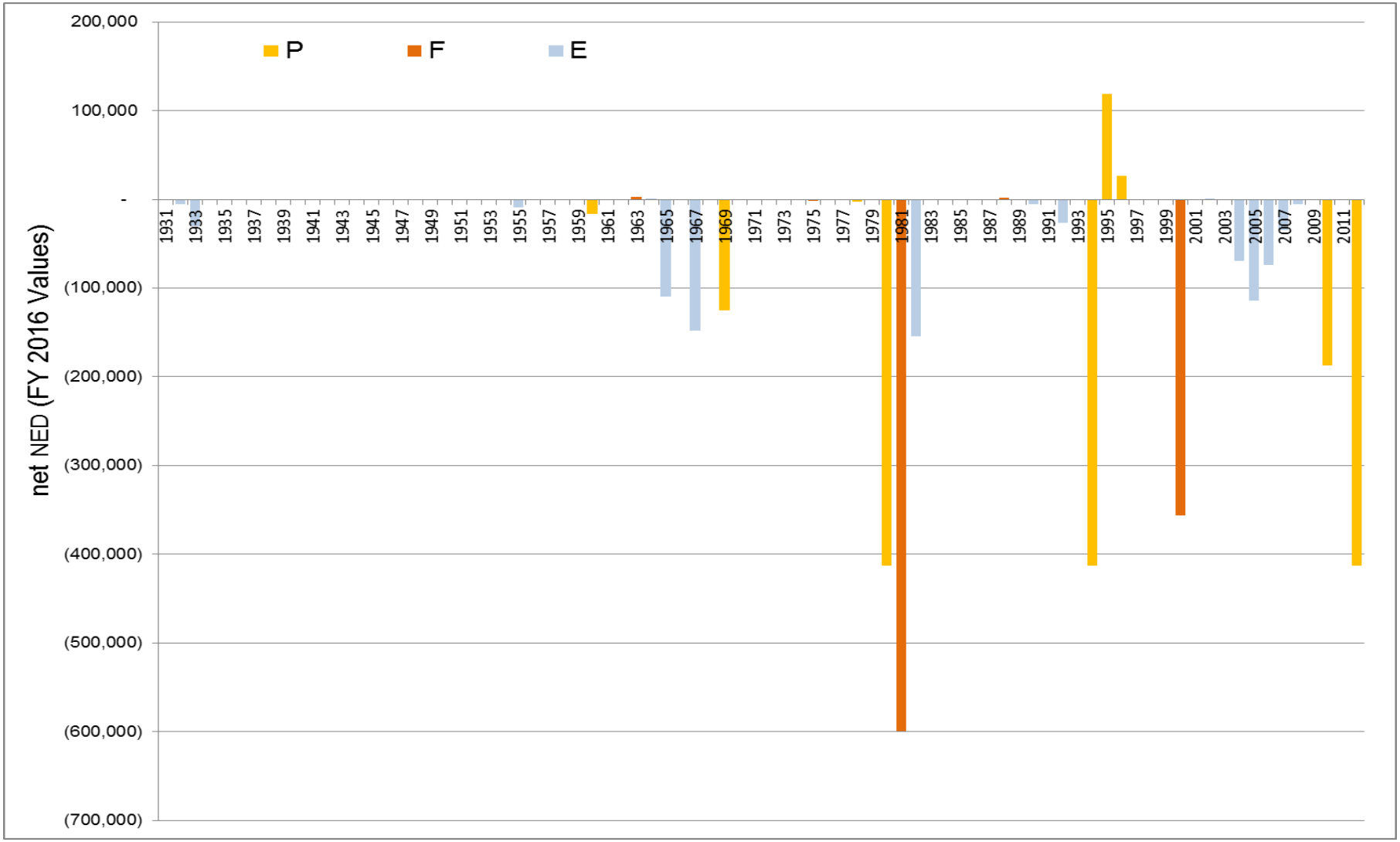
*Numbers may not match exactly due to rounding

Figure 8 presents the annual differences in net NED value between Alternative 1 and Alternative 6. The difference in NED costs for each year is color-coded based on the type of release occurring each year. Some notable trends include the following:

- Alternative 6 experiences a decrease in annual net NED in the early 1980s. The partial spring release in 1980 and the full spring release in 1981 reduce the navigation service level and shorten the season length. This reduction in service level increases the negative NED component, the R, R, & R costs, which erodes the positive component of the NED value, the transportation savings, and increases the difference between Alternative 6 and Alternative 1.
- As noted in Table 21, Alternative 6 contains eleven years with full release and 33 years of partial releases. However, as shown in Figure 8 only four years with full release (1970, 1975, 1981, 2000) show negative impacts and only nine years with partial releases (1950, 1951, 1960, 1969, 1978, 1980, 1994, 2010, 2012) demonstrate negative impacts.

Table 21. Years with Full or Partial Spawning Cue Releases in Alternative 6

Years With Full Release = 11	1931, 1953, 1956, 1963, 1966, 1970, 1975, 1981; 1988; 2000; 2003
Years With Partial Release = 33	1943 – 1952; 1959 – 1961; 1969; 1973-1974; 1978 – 1980; 1984 – 1987; 1994 – 1999; 2009 - 2012



P – Partial Release; F – Full Release; E – Eliminated Release

Figure 8. Alternative 6 Difference in Net NED Relative to Alternative 1

4.0 RED Evaluation Results

4.1 Summary of Regional Economic Development Results

A summary of the RED impacts for employment, labor income, and sales for all of the MRRMP-EIS alternatives are summarized in Tables 22, 23, and 24, respectively. Alternatives 2, 4, and 6 would result in adverse impacts to RED benefits associated with navigation. Commercial sand dredging and associated truck transportation would experience the largest impacts because these sand and gravel movements account for the bulk of the commodities shipped on the Missouri River. During the eight lowest navigation years relative to Alternative 1, Alternatives 2, 4, and 6 would result in reduced employment between 23 and 40 jobs, most of which would occur in the commercial sand and gravel dredging and truck transportation sectors. Alternative 2 would have the largest adverse impacts with the low summer flow directly affecting navigation on the Missouri River during these events. 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 during the fall season. Alternatives 3 and 5 would result in small beneficial impacts to RED relative to Alternative 1 due to an increase in service level flows from the lack of spring plenary pulse increasing the system storage slightly under Alternative 3 and the fall release under Alternative 5.

Table 22. Direct, Indirect, and Induced Employment under the MRRMP-EIS Alternatives

Type of Impact	Year/Scenario	Alternative					
		1	2	3	4	5	6
Commercial Sand Dredging and Associated Transportation	Average Annual Employment	258.0	250.8	258.4	253.5	258.4	254.9
	Change in Average Annual Employment	NA	-7.2	0.4	-4.5	0.4	-3.0
	8 Worst Years Relative to Alternative 1 (average)	NA	-39.3	0.0	-33.9	0.0	-22.8
	8 Best Years Relative to Alternative 1 (average)	NA	1.7	3.0	0.8	3.0	0.0
Waterway Industries	Average Annual Employment	26.5	25.8	26.6	26.2	26.6	26.3
	Change in Average Annual Employment	NA	-0.7	0.1	-0.3	0.1	-0.2
	8 Worst Years Relative to Alternative 1 (average)	NA	-5.0	0.0	-2.6	0.0	-1.8
	8 Best Years Relative to Alternative 1 (average)	NA	0.1	0.2	0.1	0.2	0.0
Total	Average Annual Employment	284.5	276.6	285.0	279.7	285.0	281.2
	Change in Average Annual Employment	NA	-7.9	0.5	-4.8	0.5	-3.2
	8 Worst Years Relative to Alternative 1 (average)	NA	-40.0	0.1	-34.2	0.1	-23.0
	8 Best Years Relative to Alternative 1 (average)	NA	1.8	3.2	0.9	3.2	0.0

Table 23. Direct, Indirect, and Induced Labor Income under the MRRMP-EIS Alternatives (Thousands of 2016$)

Type of Impact	Year/Scenario	Alternative					
		1	2	3	4	5	6
Commercial Sand Dredging and Associated Transportation	Average Annual Labor Income	$17,693	$17,202	$17,723	$17,385	$17,723	$17,486
	Change in Average Annual Labor Income	NA	-$491	$30	-$308	$30	-$207
	8 Worst Years Relative to Alternative 1 (average)	NA	-$2,694	$0	-$2,328	$0	-$1,564
	8 Best Years Relative to Alternative 1 (average)	NA	$119	$209	$57	$209	$0
Waterway Industries	Average Annual Labor Income	$1,561	$1,517	$1,564	$1,542	$1,564	$1,549
	Change in Average Annual Labor Income	NA	-$44	$3	-$18	$3	-$12
	8 Worst Years Relative to Alternative 1 (average)	NA	-$297	$0	-$155	$0	-$105
	8 Best Years Relative to Alternative 1 (average)	NA	$8	$14	$8	$14	$0
Total	Average Annual Labor Income	$19,254	$18,720	$19,287	$18,928	$19,287	$19,035
	Change in Average Annual Labor Income	NA	-$534	$33	-$326	$33	-$219
	8 Worst Years Relative to Alternative 1 (average)	NA	-$2,738	$3	-$2,346	$3	-$1,576
	8 Best Years Relative to Alternative 1 (average)	NA	-$178	$209	-$98	$209	-$105

Table 24. Direct, Indirect, and Induced Sales under the MRRMP-EIS Alternatives (Thousands of 2016$)

Type of Impact	Year/Scenario	Alternative					
		1	2	3	4	5	6
Commercial Sand Dredging and Associated Transportation	Average Annual Sales/Revenues	$54,936	$53,413	$55,030	$53,981	$55,030	$54,294
	Change in Average Annual Sales/Revenues	NA	-$1,523	$94	-$955	$94	-$642
	8 Worst Years Relative to Alternative 1 (average)	NA	-$8,365	$0	-$7,228	$0	-$4,857
	8 Best Years Relative to Alternative 1 (average)	NA	$370	$648	$177	$648	$0
Waterway Industries	Average Annual Sales/Revenues	$4,819	$4,398	$4,828	$4,762	$4,828	$4,782
	Change in Average Annual Sales/Revenues	NA	-$421	$10	-$57	$10	-$37
	8 Worst Years Relative to Alternative 1 (average)	NA	-$917	$0	-$477	$0	-$325
	8 Best Years Relative to Alternative 1 (average)	NA	$24	$43	$12	$43	$0
Total	Average Annual Sales/Revenues	$59,754	$57,810	$59,858	$58,742	$59,858	$59,075
	Change in Average Annual Sales/Revenues	NA	-$1,944	$103	-$1,012	$103	-$679
	8 Worst Years Relative to Alternative 1 (average)	NA	-$8,786	$10	-$7,705	$0	-$5,182
	8 Best Years Relative to Alternative 1 (average)	NA	-$547	$648	$189	$691	$0

4.1 Alternative 1 – No Action

Under Alternative 1, RED benefits associated with the value of commercial sand and gravel produced from the Missouri River, transportation benefits, and other shipments on the waterway would support on average over the period of analysis 284 direct and multiplier jobs and $19.3 million in labor income. Over the period of analysis (excluding years when there was no navigation supported by the USACE), during the worst navigation year, there would be no jobs and income supported with no tonnage moved, while in the highest navigation year with the greatest tonnage of commodious shipped, there would be 287 jobs and $19.5 million in labor income. Table 25 provides a summary of RED benefits under Alternative 1.

The largest RED benefits would be associated with commercial sand and gravel because the vast majority of shipments are commercial sand and gravel. During years when navigation is eliminated or reduced, the reduced ability to produce commercial sand and gravel from the Missouri River would likely be at least partially offset by production from alternative sources. However, sourcing lower quality, more expensive sand and gravel from other rivers or off of the river, and/or relatively higher transportation costs would likely result in higher material costs for construction projects within Missouri and the region, with potential adverse RED impacts. Overall, there would be adverse impacts to the RED effects associated with the commercial

sand dredging industry during years when navigation is reduced or eliminated. In the worst years, these impacts would be negligible in the large economic context in which these activities take place but could be important for the commercial sand dredging industry.

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 within Missouri, the vast majority of the economic impacts would occur within Missouri, although there may be some very small economic impacts to adjacent states where these commodities would be shipped to or from. Overall, even in the worst years where navigation would be reduced or eliminated, there would be negligible impacts to waterway industries and supporting sectors.

Table 25. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 1 (thousands of 2016$)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total RED Benefits
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	258	27	284
	Smallest Annual Movement of Commodities on the Missouri River	0	0	0
	Largest Annual Movement of Commodities on the Missouri River	261	27	287
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,693	$1,561	$19,254
	Smallest Annual Movement of Commodities on the Missouri River	0	0	0
	Largest Annual Movement of Commodities on the Missouri River	$17,876	$1,575	$19,451
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$54,936	$4,819	$59,754
	Smallest Annual Movement of Commodities on the Missouri River	0	0	0
	Largest Annual Movement of Commodities on the Missouri River	$55,505	$4,861	$60,367

4.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Low summer flows under Alternative 2 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Under Alternative 2, average annual RED benefits supported by navigation would be 277 jobs and $18.7 million in labor income. When compared to Alternative 1, Alternative 2 would result in 8 fewer jobs and $534,000 in labor income on average over the period of analysis associated with the reduced ability to navigate on the Missouri River. Table 26 summarizes the RED impacts under Alternative 2.

Table 26. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 2 and Compared to Alternative 1 (Thousands of 2016 Dollars)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total RED Benefits
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	251	26	277
	Change in Annual Average RED Benefits Relative to Alternative 1	-7	-1	-8
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-39	-5	-44
	Average Annual Change in 8 Best Years Relative to Alternative 1	2	0	2
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,202	$1,517	$18,719
	Change in Annual Average RED Benefits Relative to Alternative 1	-$490	-$43	-$534
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,694	-$297	-$2,991
	Average Annual Change in 8 Best Years Relative to Alternative 1	$119	$8	$127
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$53,412	$4,397	$57,810
	Change in Annual Average RED Benefits Relative to Alternative 1	-$1,523	-$421	-$1,944
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$8,365	-$917	-$9,282
	Average Annual Change in 8 Best Years Relative to Alternative 1	$370,321	$24,188	$394,509

Shortened or eliminated navigation seasons under Alternative 2 during low summer flows or when system storage did not meet navigation targets would have an adverse impact on the commercial sand dredging industry, truck transportation, and waterway industries and supporting sectors. Under Alternative 2, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 44 jobs and $3.0 million in labor income, with most of the impacts associated with commercial sand dredging and truck transportation. Alternative 2 would result in relatively larger adverse RED impacts compared to Alternative 1 for the commercial sand dredging industry; in the years with the largest adverse impacts relative to Alternative 1 (i.e., during the low summer flow events). These impacts would be negligible in the large regional economic context in which these activities take place but could be important to the commercial sand dredging industry, truck transportation, and supporting sectors. Because the need to source alternative sand would be greater under Alternative 2, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There

would be negligible adverse impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

4.3 Alternative 3 – Mechanical Construction Only

Under Alternative 3, average annual RED benefits supported by navigation would be 285 jobs and 19.3 million in labor income. Alternative 3 would result in negligible changes in navigation compared to Alternative 1. Table 27 summarizes the RED impacts under Alternative 3. Overall, similar to Alternative 1, there would be adverse impacts to the RED effects associated with the commercial sand dredging industry during years when navigation is reduced or eliminated, although there would be a negligible change in RED impacts compared to Alternative 1. There would be negligible impacts to waterway industries and supporting sectors under Alternative 3.

Table 27. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 3 and Compared to Alternative 1 (Thousands of 2016 Dollars)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total RED Benefits
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	258	27	285
	Change in Annual Average RED Benefits Relative to Alternative 1	0	0	0
	Average Annual Change in 8 Worst Years Relative to Alternative 1	0	0	0
	Average Annual Change in 8 Best Years Relative to Alternative 1	3	0	3
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,723	$1,564	$19,287
	Change in Annual Average RED Benefits Relative to Alternative 1	$30	$3	$33
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0	$0	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$208	$14	$222
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$55,029	$4,828	$59,857
	Change in Annual Average RED Benefits Relative to Alternative 1	$94	$10	$103
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0	$0	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$647	$43	$690

4.4 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, average annual RED benefits supported by navigation would be 280 jobs and $18.9 million in labor income. Spring releases under Alternative 4 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Compared to Alternative 1, Alternative 4 would result in 4 fewer jobs and $326,000 in labor income on average over the period of analysis associated with the reduced ability to navigate in some years. Table 28 summarizes the RED impacts under Alternative 4.

Table 28. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 4 and Compared to Alternative 1 (Thousands of 2016$)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total RED Benefits
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	253	26	280
	Change in Annual Average RED Benefits Relative to Alternative 1	-4	0	-4
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-34	-3	-37
	Average Annual Change in 8 Best Years Relative to Alternative 1	1	0	1
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,385	$1,542	$18,928
	Change in Annual Average RED Benefits Relative to Alternative 1	-$308	-$18	-$326
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$2,328	-$155	-$2,482
	Average Annual Change in 8 Best Years Relative to Alternative 1	$57	$4	$61
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$53,981	$4,762	$58,742
	Change in Annual Average RED Benefits over 82 years Relative to Alternative 1	-$955	-$57	-$1,012
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$7,228	-$477	-$7,705
	Average Annual Change in 8 Best Years Relative to Alternative 1	$177	$12	$188

Under Alternative 4, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 37 jobs and $2.5 million in labor income, with most of the impacts associated with commercial sand dredging and truck transportation. Impacts would be similar to those described under Alternative 2 with negligible impacts to regional economic

conditions in the large economic context in which these activities take place but could be important to the commercial sand dredging industry. Because the need to source alternative sand would be greater under Alternative 4, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There would be negligible adverse impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

4.5 Alternative 5 – Fall ESH Creating Release

Under Alternative 5, average annual RED benefits supported by navigation would be 285 jobs and $19.3 million in labor income. Alternative 5 would result in a negligible change in RED impacts compared to Alternative 1. Table 29 summarizes the RED impacts under Alternative 5. Overall, there would be a negligible change in RED impacts compared to Alternative 1 for the commercial sand dredging, truck transportation, and waterway industries and supporting sectors under Alternative 5.

Table 29. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 5 and Compared to Alternative 1 (Thousands of 2016$)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total Economic Loss
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	258	27	285
	Change in Annual Average RED Benefits Relative to Alternative 1	0	0	0
	Average Annual Change in 8 Worst Years Relative to Alternative 1	0	0	0
	Average Annual Change in 8 Best Years Relative to Alternative 1	3	0	3
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,723	$1,564	$19,287
	Change in Annual Average RED Benefits Relative to Alternative 1	$30	$3	$33
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0	$0	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$208	$14	$222
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$55,029	$4,828	$59,857
	Change in Annual Average RED Benefits Relative to Alternative 1	$94	$10	$103
	Average Annual Change in 8 Worst Years Relative to Alternative 1	$0	$0	$0
	Average Annual Change in 8 Best Years Relative to Alternative 1	$648	$43	$690

4.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Under Alternative 6, average annual RED benefits supported by navigation would be 281 jobs and $19.0 million in labor income. Spawning cue pulses under Alternative 6 would have a greater adverse RED impact on commercial sand dredging and navigation on the Missouri River when compared to Alternative 1. Under Alternative 6, the adverse conditions that would affect the ability to navigate and dredge commercial sand and gravel from the Missouri River over the period of analysis would result in an average annual reduction of 3 jobs and $219,000 in labor income. Table 30 summarizes the RED impacts under Alternative 6.

Table 30. Total RED Benefits Associated with Navigation on the Missouri River under Alternative 6 and Compared to Alternative 1 (Thousands of 2016$)

Economic Impact Parameter	Year	Commercial Sand Dredging and Associated Transportation Impacts	Waterway Industries	Total RED Benefits
Direct, Indirect, and Induced Jobs	Annual Average RED benefits	255	26	281
	Change in Annual Average RED Benefits Relative to Alternative 1	-3	0	-3
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-23	-2	-25
	Average Annual Change in 8 Best Years Relative to Alternative 1	0	0	0
Direct, Indirect, and Induced Labor Income	Annual Average RED benefits	$17,486	$1,549	$19,035
	Change in Annual Average RED Benefits Relative to Alternative 1	-$207	-$12	-$219
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$1,564	-$105	-$1,670
	Average Annual Change in 8 Best Years Relative to Alternative 1	$0	$0	$0
Direct, Indirect, and Induced Sales	Annual Average RED benefits	$54,294	$4,782	$59,075
	Change in Annual Average RED Benefits Relative to Alternative 1	-$642	-$37	-$679
	Average Annual Change in 8 Worst Years Relative to Alternative 1	-$4,857	-$325	-$5,182
	Average Annual Change in 8 Best Years Relative to Alternative 1	$0	$0	$0

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 commercial sand dredging industry, truck transportation, and waterway industries and supporting sectors. Under Alternative 6, the economic impacts in the eight worst years relative to Alternative 1 would result in an average reduction of 25 jobs and $1.7 million in labor income, with most of the impact associated with commercial sand dredging and truck transportation. Impacts would be similar to

those described under Alternative 2 with negligible impacts to regional economic conditions in the large economic context in which these activities take place but could be important to these industries. Because the need to source alternative sand would be greater under Alternative 6, there could potentially be relatively higher material costs for construction projects within Missouri and the region. There would be negligible adverse impacts to waterway industries and supporting sectors, even in the years with the largest reductions in shipments compared to Alternative 1.

5.0 OSE Results

5.1 Summary of Other Social Effects (OSE) Impacts

The OSE value captures the potential effects on life, health, and safety. When analyzing the potential impacts to navigation, an examination of the OSE value often studies how the switching of commodity transportation from river to overland could affect pollutant emissions. This OSE analysis discusses the non-attainment areas in the region and provides estimates for the potential changes in emissions.

5.1.1 Current non-attainment areas with the study area

The Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS) for six common air pollutants. The following pollutants are designated as criteria pollutants due to their links to harming health, the environment, and property (EPA 2016):

- **Particulate Matter (PM)** - The EPA defines PMs as “a complex mixture of extremely small particles and liquid droplets that get into the air” (2016). Inhalation of PMs impacts health by affecting the heart and lungs.
- **Photochemical Oxidants including Ground-Level Ozone** - Nitrogen oxides (NOx) and volatile organic compounds (VOC) react to form ground level ozone. According to the EPA, the main sources of ground level ozone are industrial facilities, electric utilities, motor vehicles, gasoline vapors, and chemical solvents. Ozone can negatively affect vegetation and ecosystems as well as cause health problems for children, the elderly, and people with lung diseases such as asthma. (EPA, 2016)
- **Carbon Monoxide (CO)** - A colorless, odorless gas emitted mainly from mobile sources such as cars, trucks, boats, and trains. CO impacts health by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. (EPA, 2016)
- **Sulfur oxides (SOx)** – The term sulfur oxides (SOx) covers a group of gaseous compounds, but SO_2 is the focus for the group. The largest emitters of SO_2 are power plants and other industrial facilities that burn fossil fuels. SO_2 impacts plants by damaging foliage and decreasing growth. High concentrations of SO_2 in the air can lead to the formation of other sulfur oxides which react with other compounds in the atmosphere to contribute to PM pollution. (EPA, 2016)
- **Nitrogen Oxides (NOx)** – The nitrogen oxides group includes nitrous acid, nitric acid, and nitrogen dioxide (NO_2), but the EPA set NO_2 as the indicator for the group. Cars, trucks and buses, power plants, and off-road equipment are the main sources of NO_2 emissions. NO_2 is linked to respiratory illnesses and contributes to the formation of ground-level ozone and fine particle pollution. (EPA, 2016)

- **Lead** - Lead emissions originate from ore and metals processing, burning of leaded fuel, waste incinerators, utilities, and lead-acid battery manufacturers. According to the EPA, “lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system” (EPA, 2016).

If an area of the country contains air pollution levels that persistently exceed the NAAQS for any of the criteria pollutants, then the area may be designated as a "nonattainment" for that pollutant. As shown in Figure 9 and in Table 31, there are currently 11 counties within 50 miles of Missouri River designated as nonattainment for one or more criteria pollutants. While six of the counties border the Mississippi River, the five with borders on the Missouri River are the following:

- Pottawattamie County in Iowa is across the river from Omaha, Nebraska and is designated nonattainment for lead levels.
- Jackson County, Missouri near Kansas City is designated nonattainment for SOx.
- Franklin County, Missouri near St. Louis is designated nonattainment for ozone and PM 2.5.
- St. Charles County, Missouri near St. Louis is designated nonattainment for ozone and PM 2.5.
- St. Louis County, Missouri is designated nonattainment for ozone and PM 2.5.

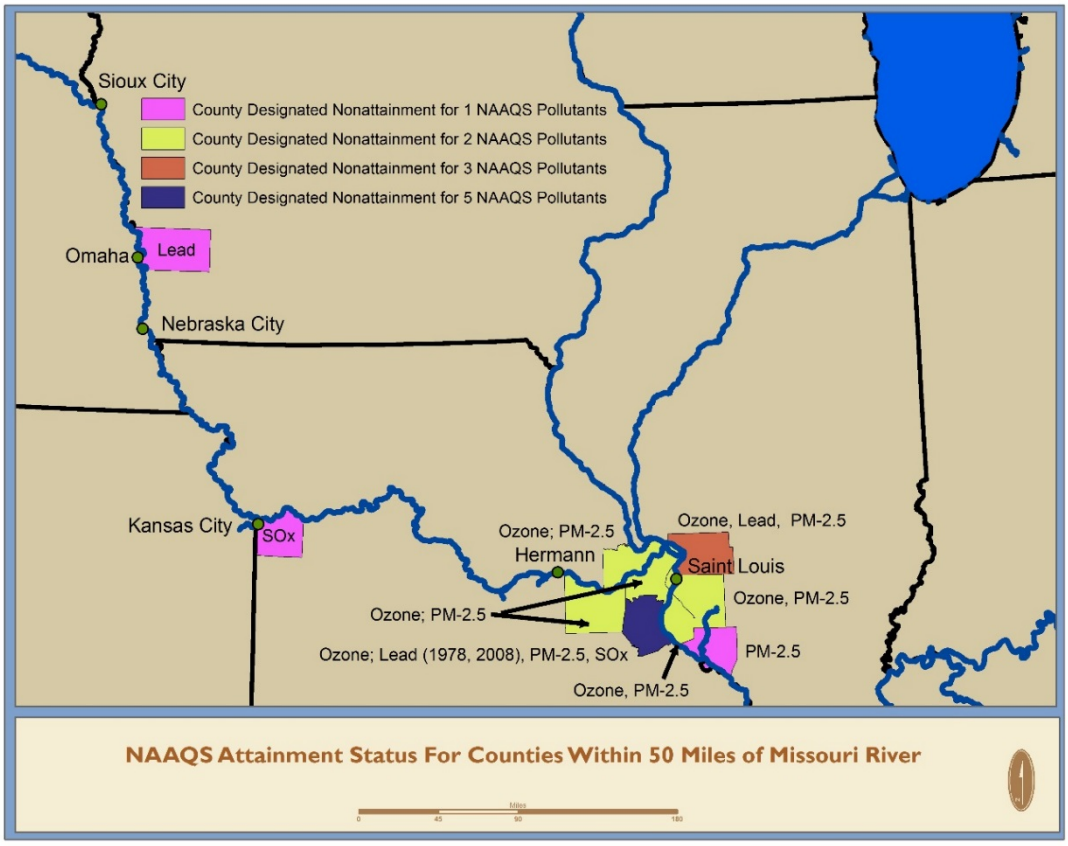


Figure 9. Location of NAAQS Nonattainment Within 50 Miles of Missouri River

Table 31. List of Nonattainment Counties within 50 Miles of Missouri River

	State	County	Non-Attainment Pollutant Categories (2016)
1	Illinois	Madison	Ozone, Lead, PM-2.5
2	Illinois	Monroe	Ozone, PM-2.5
3	Illinois	Randolph	PM-2.5
4	Illinois	St. Clair	Ozone, PM-2.5
5	Iowa	Pottawattamie	Lead
6	Missouri	Franklin	Ozone, PM-2.5
7	Missouri	Jackson	SOx
8	Missouri	Jefferson	Ozone; Lead (1978, 2008), PM-2.5, SOx
9	Missouri	St. Charles	Ozone; PM-2.5
10	Missouri	St. Louis County	Ozone; PM-2.5
11	Missouri	St. Louis City	Ozone; PM-2.5

Source: EPA 2016. Green Book Nonattainment Areas https://www3.epa.gov/airquality/greenbook/anayo_mo.html

While most of the counties are designated nonattainment for only one or two criteria pollutants, Jefferson County, Missouri, an area containing many of St. Louis' southern suburbs, is classified nonattainment for five criteria pollutants (ozone, lead 1978 standard, lead 2008 standard, PM 2.5, and SOx). There are no NOx nonattainment areas in the country. The following counties have been designated as maintenance: Los Angeles Co (P), Orange Co, Riverside Co (P), and San Bernardino Co (P).

5.1.2 All Alternatives

Estimating the change in emissions potentially caused by commodities shifting from water to land due to alternatives within the Missouri River Recovery Management Plan (MRRMP) relies on two components: the emission factors for the different transportation modes and the amount of commodities moving off the water. Since the emission factors are constant for all alternatives, a useful discussion involves examining the tonnage moving off the water. As shown in Table 32, the annual average ranges from 67,630 tons for Alternative 3 and 5 to 150,524 tons for Alternative 2. When comparing the alternatives, the following relationships should be noted:

- The impacts shown for the Alternative 1 (No Action) are for the purpose of providing a baseline and allowing for a comparison of the alternatives. The H & H data for Alternative 1 is based on historical record and displays periods when navigation did not occur or was reduced to below minimum. This is the reason for Alternative 1 showing some tonnage as moving off water.
- The alternatives with the greatest impact are Alternative 2 with an average of 152.5 thousand tons moving off the water annually and Alternative 4 with an average of 145.3 thousand tons moving off the water annually. Alternative 2 demonstrates a greater impact than other alternatives due to ten years with split navigation seasons. Any tonnage in the reference condition that moved during the months when navigation did not occur are assumed to be moved off the water. The reason Alternative 4 shows greater impacts than other alternatives is because the partial spring releases reduce the navigation service level and shortens the season length. Movements within the

reference condition that would occur after the season ended is assumed to be moved off the water.

- Alternative 3 and Alternative 5 show the same level of impacts for tonnage moving off the water which is a slightly reduction (-9,762 average annual tons) in comparison to Alternative 1. The hydrologic and hydraulic (H & H) model results for Alternative 3 and Alternative 5 do vary, but the alternatives do show the same period of less than minimum service level. In other words, the variation between the alternatives occurs during periods when navigation service level is above minimum.

Table 32. Tonnage Estimated to Move Off Water for Each Alternative

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Total Commodities Moved Off Waterway Over the Period of Record	Thousand tons	5,882	11,440	5,140	10,901	5,140	9,927
Average Annual Commodities Moved Off Waterway	Thousand tons	78.4	152.5	68.5	145.3	68.5	132.4
Change in Average Annual from Alternative 1	Thousand tons		74.1	-9.9	66.9	-9.9	53.9
Percent Change in Average Annual From Alternative 1			94%	-13%	85%	-13%	69%

Though the EPA sets NAAQS for six criteria pollutants, the navigation impact analysis focused on hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM) because these pollutants are the product of burning more fuels. To estimate the emission

Tables 33, 34, 35, and 36 present the results for changes in HC, CO, NOx, and PM, respectively. These tables provide estimates for five variables:

- Total change in emissions over the period of record – This value represents the total change in emissions over the 82 year period of record for each alternative and is in grams per mile.
- An average annual change in emissions – This value represents the total change in emissions divided by 75 years. Since seven years in the period of record (82 years) did not have navigation, these years were not included in average annual calculations.
- Annual number of cars – This value symbolizes the number of cars that would be needed to generate that same level of emissions. It is merely for purposes of providing reference regarding the level of emissions and does not express the number of cars needed to move the tonnage. It was estimated by divided the annual change in emissions by the average grams per mile emissions for a car from the EPA's Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks (2008).
- Change and Percent Change from Alternative 1 – These values show the absolute and the percent difference in the emission levels between Alternative 1 and the other alternatives.

Some notable trends found in Tables 33, 34, 35, and 36 are the following:

- The values in the row “Percent Change in Average Annual From Alternative 1” are the same as shown in Table 32. This is because the tonnages that move off the water are the only changing variable among the alternatives.
- Since tonnage moving off the water is the only variable different among the alternatives, the relationship between the alternatives remains the same as shown in Table 32. For example, Alternative 2 has the greatest change in emissions for each pollutant (HC, CO, NOx, PM) in comparison to the other alternatives and Alternative 3 and Alternative 5 show the same level of emissions for each pollutant.
- The PM emissions are impacted the least among the pollutants with an average annual range of 436 grams per mile for Alternative 3 and Alternative 5 and 970 grams per mile for Alternative 2. However, PM shows the highest equivalent number of cars (102,556 cars to 228,258 cars). This is due to cars having low emission rates of 0.0044 grams per mile for particulate matter less than ten micrometers and 0.0041 for particulate matter less than 2.5 micrometers. Dividing the change in PM emission by the average of these numbers results in a greater number of cars than the other pollutants.
- The pollutant impacted the most by the alternatives is NOx with an average annual increase ranging from 18,019 grams per mile for Alternative 3 and Alternative 5 to 57,872 grams per mile for Alternative 2. As discussed in Section 2.5, estimating the emissions for each pollutant required subtracting the emissions that occur if the commodities traveled over water from the emissions that occur if the commodities travel by truck. As shown in Table 9, NOx demonstrates the greatest difference (0.26 grams per ton-mile) in emissions between inland towing and truck. This difference is why NOx is the pollutant impacted the most by the alternatives.

Table 33. Change in Hydrocarbons Emissions for Each Alternative

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
HC - Total Change in Emissions Over Period of Record	1000 g / mile	15.5	30.1	13.5	28.7	13.5	26.1
HC - Annual Average Change	1000 g / mile	0.2	0.4	0.2	0.4	0.2	0.3
HC - Annual Equivalent Number of Cars	cars	205	398	179	380	179	346
Change in Average Annual from Alternative 1	1000 g / mile		0.2	0.0	0.2	0.0	0.1
Percent Change in Average Annual From Alternative 1			94%	-13%	85%	-13%	69%

Table 34. Change in Carbon Dioxide Emissions for Each Alternative

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
CO - Total Change in Emissions Over Period of Record	1000 g / mile	528.1	1,027.2	461.5	978.8	461.5	891.4
CO - Annual Average Change	1000 g / mile	7.0	13.7	6.2	13.1	6.2	11.9

CO - Annual Equivalent Number of Cars	cars	749	1,457	655	1,388	655	1,264
Change in Average Annual from Alternative 1	1000 g / mile		6.7	-0.9	6.0	-0.9	4.8
Percent Change in Average Annual From Alternative 1			94%	-13%	85%	-13%	69%

Table 35. Change in Nitrous Oxide Emissions for Each Alternative

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
NOx - Total Emissions Over Period of Record	1000 g / mile	1,546.5	3,007.9	1,351.4	2,866.2	1,351.4	2,610.2
NOx - Annual Average Change	1000 g / mile	20.6	40.1	18.0	38.2	18.0	34.8
NOx - Annual Equivalent Number of Cars	cars	29,755	57,872	26,002	55,145	26,002	50,221
Change in Average Annual from Alternative 1	1000 g / mile		19.5	-2.6	17.6	-2.6	14.2
Percent Change in Average Annual From Alternative 1			94%	-13%	85%	-13%	69%

Table 36. Change in Particulate Matter Emissions for Each Alternative

	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
PM - Total Emissions Over Period of Record	1000 g / mile	37.4	72.8	32.7	69.3	32.7	63.1
PM - Annual Average Change	1000 g / mile	0.5	1.0	0.4	0.9	0.4	0.8
PM - Annual Equivalent Number of Cars	cars	117,359	228,258	102,556	217,503	102,556	198,081
Change in Average Annual from Alternative 1	1000 g / mile		35.3	-4.7	31.9	-4.7	25.7
Percent Change in Average Annual From Alternative 1			94%	-13%	85%	-13%	69%

5.2 Alternative 1 – No Action

Under the no-action alternative, the Missouri River Recovery Program would continue its current implementations plans. The impacts shown for the Alternative 1 (No Action) are for the purpose of providing a baseline and allowing for a comparison of the alternatives. The H & H data for Alternative 1 is based on historical record and displays periods when navigation did not occur or was reduced, so Alternative 1 shows commodities moving off the water as well as changes in emissions.

The OSE impacts for Alternative are summarized in Table 37. Of the four navigable reaches only two, the Nebraska City reach which ranges from RM 370 to RM 563 and Kansas City Reach which ranges from RM 0 to RM 369, are impacted by Alternative 1. For both reaches, the pollutant most affected by Alternative 1 is NOx with the Nebraska City reach seeing an annual average of approximately 1.6 thousand grams per mile of NOx and Kansas City reach showing an annual average of 19 thousand grams per mile of NOx. A total of 1.54 million grams per mile over 82 year period of record is estimated for Missouri River region with approximately 92 percent of these emissions occurring within the Kansas City reach. The impact of Alternative 1 on NOx is important to consider since NOx reacts in the atmosphere to form low-level ozone and Franklin County, MO; Madison County, IL; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO, are designated as nonattainment status for ozone.

Table 37. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 1 by Reach

Reach	Total Commodities Move Off Water Over 82 Year Period	Change in HC Over 82 Year Period	Average Annual Change in HC	Change in CO Over 82 Year Period	Average Annual Change in CO	Change in NOx Over 82 Year Period	Average Annual Change in NOx	Change in PM Over 82 Year Period	Average Annual Change in PM
	Thousand Tons	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**
Sioux City	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Omaha	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska City	449	1.2	0.0	40.3	0.5	118.1	1.6	2.9	0.0
Kansas City	5,433	14.3	0.2	487.8	6.5	1,428.4	19.0	34.6	0.5
TOTAL	**5,882**	**15.5**	**0.2**	**528.1**	**7.0**	**1,546.5**	**20.6**	**37.4**	**0.5**

5.3 Alternatives 2 – USFWS 2003 Biological Opinion Projected Actions

The results of the OSE analysis for Alternative 2 are summarized in Table 38. Alternative 2 shows 11.4 million tons moving off water which will result in average annual emissions of 0.4 thousand grams per mile of HC, 13.7 thousand grams per mile of CO, 40.1 thousand grams per mile of NOx; and 1 thousand grams per mile of PM. The pollutant with the greatest increase in emissions is NOx which may react in the atmosphere to form ozone. Over 86 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. These counties are currently designated by the EPA as nonattainment status for ozone. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

Table 38. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 2 by Reach

Reach	Total Commodities Move Off Water Over 82 Year Period	Change in HC Over 82 Year Period	Average Annual Change in HC	Change in CO Over 82 Year Period	Average Annual Change in CO	Change in NOx Over 82 Year Period	Average Annual Change in NOx	Change in PM Over 82 Year Period	Average Annual Change in PM
	Thousand Tons	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**	**1000 g / mile**
Sioux City	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Omaha	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska City	1,579	4.2	0.1	141.8	1.9	415.1	5.5	10.0	0.1
Kansas City	9,861	25.9	0.3	885.4	11.8	2,592.7	34.6	62.7	0.8
TOTAL	11,440	30.1	0.4	1,027.2	13.7	3,007.9	40.1	72.8	1.0

5.4 Alternative 3 (Mechanical Construction Only) and Alternative 5 (Fall ESH Creating Release)

Similar H & H profiles for Alternative 3 and Alternative 5 means the tonnage estimated to move off the water is the same for both alternatives, so the OSE results, summarized in Table 39**,** are the same for both alternatives. Both Alternative 3 and Alternative 5 will cause 5.14 million tons to move off water which will result in average annual emissions of 0.2 thousand grams per mile of HC, 6.2 thousand grams per mile of CO, 18.0 thousand grams per mile of NOx, and 0.4 thousand grams per mile of PM. The pollutant with the greatest increase in emissions is NOx which may react in the atmosphere to form ozone. Over 93 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

Table 39. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 3 and Alternative 5 by Reach

Reach	Total Commodities Move Off Water Over 82 Year Period	Change in HC Over 82 Year Period	Average Annual Change in HC	Change in CO Over 82 Year Period	Average Annual Change in CO	Change in NOx Over 82 Year Period	Average Annual Change in NOx	Change in PM Over 82 Year Period	Average Annual Change in PM
	Thousand Tons	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile
Sioux City	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Omaha	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska City	339	0.9	0.0	30.4	0.4	89.1	1.2	2.2	0.0
Kansas City	4,801	12.6	0.2	431.1	5.7	1,262.4	16.8	30.5	0.4
TOTAL	**5,140**	**13.5**	**0.2**	**461.5**	**6.2**	**1,351.4**	**18.0**	**32.7**	**0.4**

5.5 Alternative 4 – Spring ESH Creating Release

The OSE results for Alternative 4 are summarized in Table 40. Under Alternative 4, 10.9 million tons are estimated to move off the water which will result in average annual emissions of 0.4 thousand grams per mile of HC, 13.1 thousand grams per mile of CO, 38.2 thousand grams per mile of NOx, and 0.9 thousand grams per mile of PM. Over 85 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

Table 40. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 4 by Reach

Reach	Total Commodities Move Off Water Over 82 Year Period	Change in HC Over 82 Year Period	Average Annual Change in HC	Change in CO Over 82 Year Period	Average Annual Change in CO	Change in NOx Over 82 Year Period	Average Annual Change in NOx	Change in PM Over 82 Year Period	Average Annual Change in PM
	Thousand Tons	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile
Sioux City	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Omaha	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska City	1,543	4.1	0.1	138.5	1.8	405.7	5.4	9.8	0.1
Kansas City	9,358	24.6	0.3	840.3	11.2	2,460.5	32.8	59.5	0.8
TOTAL	**10,901**	**28.7**	**0.4**	**978.8**	**13.1**	**2,866.2**	**38.2**	**69.3**	**0.9**

5.6 Alternative 6 – Pallid Sturgeon Spawning Cue

The OSE results for Alternative 6 are summarized in Table 41. Under Alternative 6, 9.9 million tons are estimated to move off the water which will result in average annual emissions of 0.3 thousand grams per mile of HC, 11.9 thousand grams per mile of CO, 34.8 thousand grams per mile of NOx, and 0.8 thousand grams per mile of PM. Over 87 percent of the emissions will occur within the Kansas City reach (RM 0 to RM 369) which contains the following counties which are designated as nonattainment areas for ozone: Franklin County, MO; St. Charles County, MO, St. Louis County, MO; and St. Louis City, MO. It should also be noted that nearby Madison County, IL is also designated as nonattainment for ozone by the EPA.

Table 41. Tonnage Off the Water and Total and Annual Change in Emissions for Alternative 6 by Reach

Reach	Total Commodities Move Off Water Over 82 Year Period	Change in HC Over 82 Year Period	Average Annual Change in HC	Change in CO Over 82 Year Period	Average Annual Change in CO	Change in NOx Over 82 Year Period	Average Annual Change in NOx	Change in PM Over 82 Year Period	Average Annual Change in PM
	Thousand Tons	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile	1000 g / mile
Sioux City	0	0	0	0	0	0	0	0	0
Omaha	0	0	0	0	0	0	0	0	0
Nebraska City	1,253	3.3	0.0	112.5	1.5	329.3	4.4	8.0	0.1
Kansas City	8,675	22.8	0.3	778.9	10.4	2,280.9	30.4	55.2	0.7
TOTAL	**9,927**	**26.1**	**0.3**	**891.4**	**11.9**	**2,610.2**	**34.8**	**63.1**	**0.8**

6.0 EQ Results

The results for the EQ account are covered in the OSE results.

7.0 Literature Cited

Office of Management and Budget (OMB). 2016. Table 10.1 – Gross Domestic Product and Deflators used in the Historical Tables: 1940-2018.

Petersen, Margaret S. 1997. “Chapter 2: Planning for Canalization”, *Engineering and Design – Monograph Prepared by M. Petersen on Inland Navigation and Canalization*. EP 1110-2-14. Washington, D.C.: CECW-EH, November 30. Available at: http://140.194.76.129/publications/eng-pamphlets/EP_1110-2-14/toc.htm.

Texas A & M University, Texas Transportation Institute. 2012. *Waterways: Working for America*. Washington, D.C.: U.S. Department of Transportation, Maritime Administration and National Waterways Foundation. Available at: http://www.marad.dot.gov/resources/maritime-publications/.

Tennessee Valley Authority Navigation and Hydraulic Engineering, 2002. “Appendix 10: Sand and Gravel Dredging”. *Transportation Rate Analysis Missouri River Master Manual Review*. Knoxville, TN: TVA March.

U.S. Army Corp of Engineers. 2000. Engineer Regulation 1105-2-100: Planning Guidance Notebook. Available at: http://planning.usace.army.mil/toolbox/current.cfm?Title=Planning%20Guidance%20Notebook&ThisPage=PlanGuideNotebook&Side=No.

U.S. Army Corps of Engineers. 2011. Missouri River Commercial Dredging Final EIS. Chapter 4.10 Economic and Demographics. February.

---. 2016. Engineering Manual 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS): Amendment #8 Tables Revised as of 31 March 2016. Available at http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1304.pdf.

U.S. Army Corp of Engineers, Institute for Water Resources (IWR). 2011. Regional Economic Development (RED) Procedures Handbook. 2011-RPT-01. March 2011. 71 pages.

U.S. Army Corp of Engineers, Northwestern Division, Missouri River Basin Water Management Division (ND-MRBWMD). 1998 *Missouri River Master Water Control Manual Review and Update Study: Volume 6A-R Economic Studies Navigation Economics (Revised)*.

--. 2004. *Missouri River Master Water Control Manual Review and Update Final Environmental Impact Statement (FEIS)*, Volume 1: Main Report, Part 1, Section 3: Description of Existing Environment, 3.13 Navigation. Available at: http://www.nwd-mr.usace.army.mil/mmanual/feis/Index.htm.

---. 2006. *Missouri River Mainstem Reservoir System Master Water Control Manual Missouri River Basin.* Available at: http://www.nwd-mr.usace.army.mil/mmanual/mast-man.htm.

---. 2006. Missouri River Mainstem Reservoir System Master Water Control Manual Missouri River Basin, Part VII – Current Water Control Plan for the System, Paragraph 7-13 Navigation Purpose System Regulation. Available at: http://www.nwd-mr.usace.army.mil/mmanual/mast-man.htm.

---. 2015. *Missouri River Mainstem Reservoir System Summary of Actual 2014 Regulation*, July Available at: http://www.nwd-mr.usace.army.mil/rcc/aop.html.

U.S. Army Corp of Engineers, Waterborne Commerce Statistics Center (WCSC). 2016. TOWS Database: Missouri River and the Middle Mississippi Commodity Data 2000–2014. USACE,. Obtained May 29, 2016.

U.S. Army Corp of Engineers, Water Resources Support Center (WRSC). 1987. *Ports on the Missouri, Arkansas, Verdigris, White, and Ouachita Rivers*. Port Series 68. Washington D.C.: Government Printing Office.

---. 2002. *Ports on the Missouri, Arkansas, Verdigris, White, and Ouachita Rivers*. Port Series 68. Washington D.C.: Government Printing Office.

U.S. Environmental Protection Agency, Office of Transportation and Air Quality. 2008. “Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks”. *Emission Facts*. EPA420-F-08-024, October: Available at: https://www3.epa.gov/otaq/consumer/420f08024.pdf.

U.S. Environmental Protection Agency. 2016. *Criteria Pollutants*. U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/criteria-air-pollutants.

--. 2016. *Green Book Nonattainment Areas*. “National Area and County-Level Multi-Pollutant Information, Nonattainment/Maintenance Area Status for Each County by Year for All Criteria Pollutants” [Data file] Retrieved from https://www3.epa.gov/airquality/greenbook/anayo_mo.html.

U.S. Water Resources Council. 1983. Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies, March 10, 1983.

8.0 Appendix A: Transportation Savings Value Functions

These are 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) (1998).

			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)

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