Missouri River Recovery Management Plan and Environmental Impact Statement

Irrigation Environmental Consequences Analysis

Technical Report

August 2018

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Acronyms and Abbreviations

BiOp	2003 Amended Biological Opinion
CSREES	Cooperative State Research, Education, and Extension Service
EIS	Environmental Impact Statement
EQ	environmental quality
ER	Engineering Regulation
ERS	USDA Economic Research Service
ESH	emergent sandbar habitat
H&H	hydrologic and hydraulic
HC	human considerations
HEC-DSS	Hydrologic Engineering Center - Data Storage System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HEC-ResSim	Hydrologic Engineering Center - Reservoir System Simulation
MRRIC	Missouri River Recovery Implementation Committee
MRRP	Missouri River Recovery Program
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
NED	national economic development
NOAA	National Oceanic and Atmospheric Administration
OSE	other social effects
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
RED	regional economic development
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

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

The purpose of the Irrigation Technical Report is to provide additional information and results on the impact analysis relevant to irrigation that was completed for the MRRMP-EIS. Additional details on the national economic development (NED) and regional economic development (RED) methodology and results are provided in this technical report. The other social effects (OSE) are presented in Section 3.14, Irrigation, of the MRRMP-EIS.

1.1 Summary of Alternatives

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

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

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

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

1.2 USACE Planning Accounts

Alternative means of achieving species objectives were evaluated including consideration for the effects of each action or alternative on a wide range of human considerations (HC). Human considerations to be evaluated in the MRRMP-EIS alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The HC effects 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 NED account displays changes in the economic value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.
- The RED account evaluates changes in the distribution of regional economic activity (i.e., jobs and income).
- The EQ account displays non-monetary effect of significant natural and cultural resources.
- The 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 that impacts are not double-counted. The HC objectives and metrics developed by the USACE and Missouri River Recovery Implementation Committee (MRRIC) are not only rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River, but were designed with consideration of the four accounts

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

The Missouri River Mainstem Reservoir System Master Water Control Manual reported that there were 1,026 intakes in 42 counties that use the Missouri River for irrigation purposes (USACE 2006). At the time of this analysis, 816 intakes along the Missouri River were permitted for irrigation use by state agencies. Under favorable operating conditions, water intakes are located below the surface of the river, enabling water from the reservoirs and river reaches to be pumped to agricultural fields within the floodplain. When river stages and reservoir elevations fall below required minimum operating requirements for irrigation intakes, intakes can no longer access to water. These shut downs adversely affect farm production, especially when water access is inhibited for consecutive days. The conceptual flow chart in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain can affect irrigation and crop yields. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to irrigation.

The environmental consequences analysis included a NED, RED, and OSE assessment. The NED analysis estimated the change in net farm income under each of the MRRMP-EIS alternatives. The RED analysis used results from the NED analysis to estimate changes in sales, employment, and labor income resulting from each of the MRRMP-EIS alternatives.

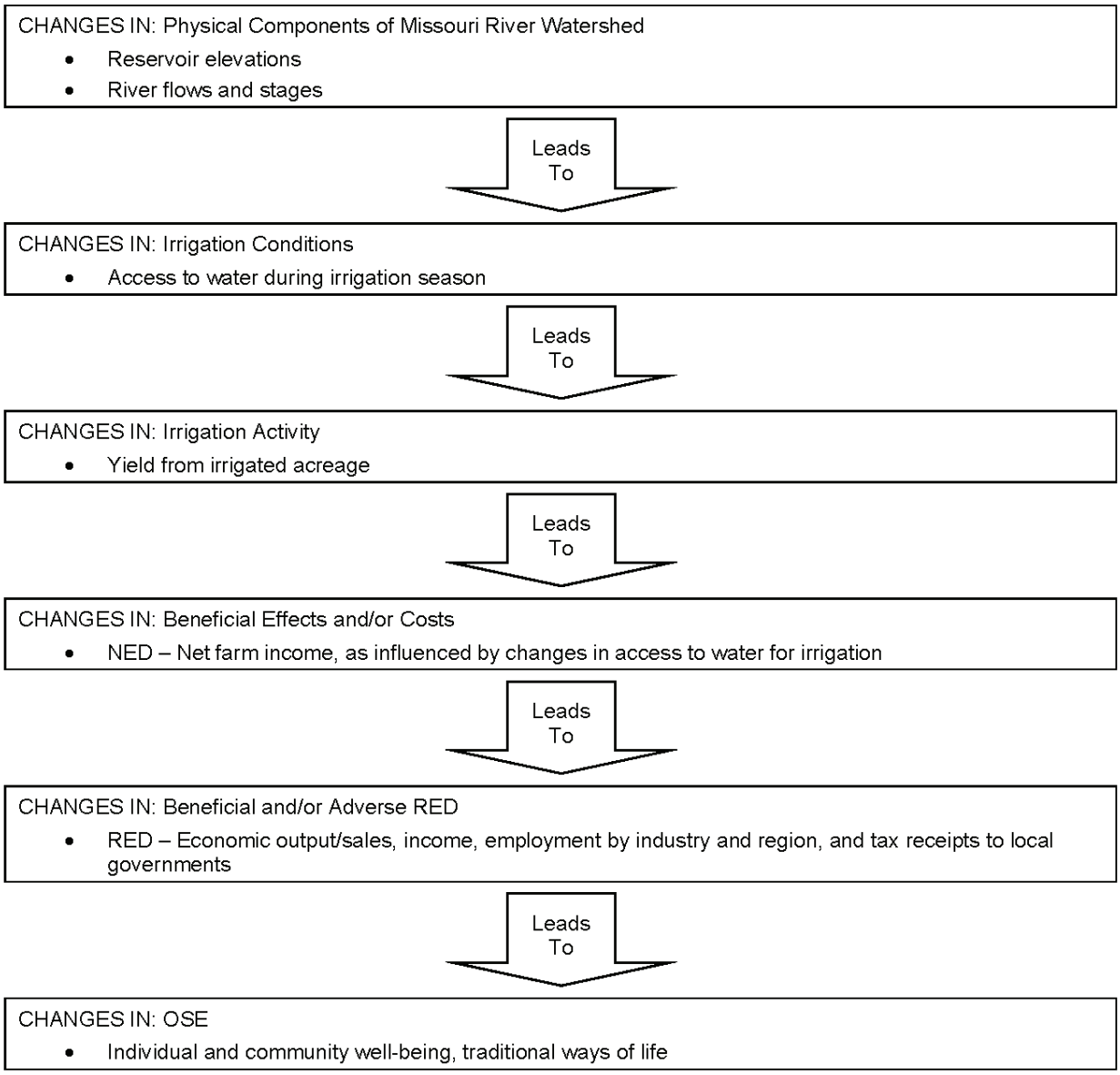

Figure 1. Flow Chart of Inputs Considered in the Irrigation Evaluation

The NED analysis followed a three-step process (Figure 2). The first step evaluated the changes in river conditions including changes in river stage, river flow and reservoir elevations at specified intervals along the river under each of the MRRMP-EIS alternatives. The results of this step were then integrated into the economic analysis, which estimated the change in yields due to changes in access to water from the Missouri River for irrigation. The calculations are performed over a modeled 82-year period of record (POR). Further details on the methodology are provided in the following sections. Figure 2 summarizes the overall NED analysis.

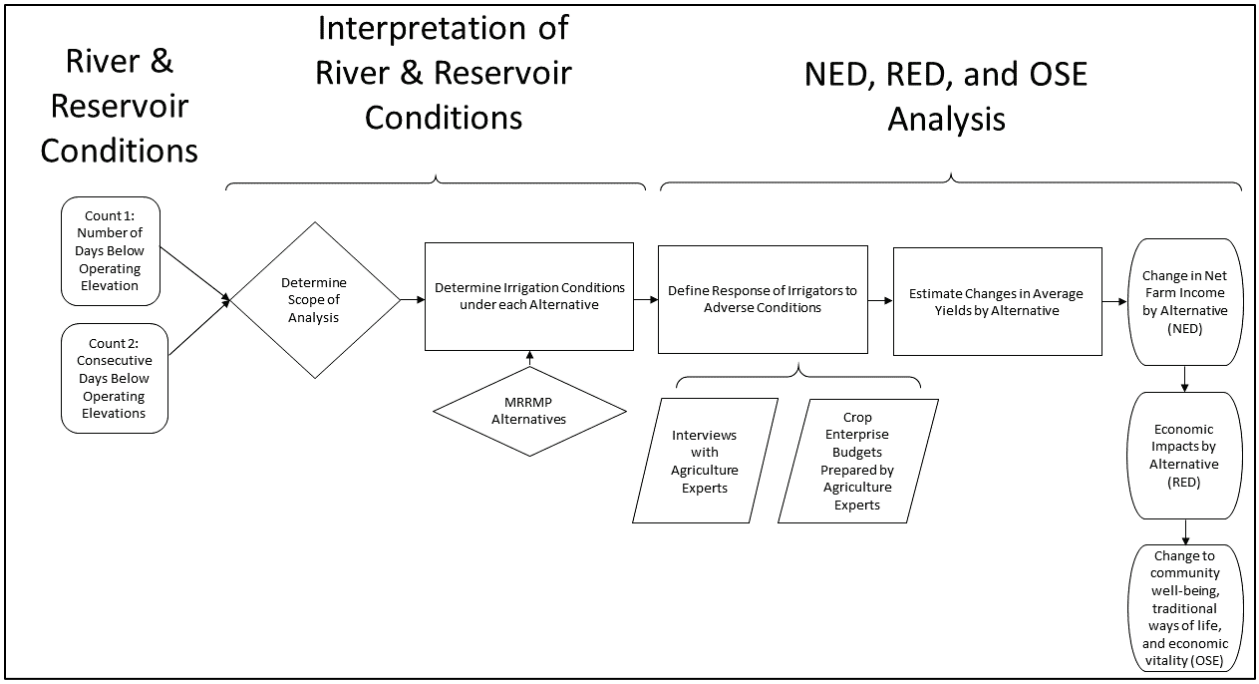

Figure 2. Approach for Evaluating Environmental Consequences to Irrigation

1.4 Assumptions

The following discussion highlights the assumptions used in the evaluation of impacts to irrigation operations from the MRRMP-EIS alternatives:

- The economic analysis uses data from the hydrologic and hydraulic (H&H) modeling of the river and reservoir System. The analysis assumes that the H&H models reasonably estimate river flows and reservoir levels over the POR under each of the MRRMP-EIS alternatives, as well as Alternative 1.
- Alternative 1 is considered the baseline against which the other alternatives are measured. Under Alternative 1, the Missouri River Recovery Program would continue to be implemented as it is currently. As noted in Section 3.1.1 of the MRRMP-EIS, Impact Assessment Methodology, Alternative 1 does not reflect actual past or future conditions but serves as a reasonable basis or “baseline” for comparing the impacts of the action alternatives on resources.
- It is assumed that if the water surface elevations or river flows fall below a minimum operating requirement the irrigation intake will lose access to water for a full day.
- Where available, detailed information on irrigation intake operating requirements were used in the analysis. When not available, the project team assumed that certain reported minimum operating requirements given for single irrigation intakes would apply to similar intakes located in the general vicinity.
- Based on interviews with irrigation intake owners and farm operators, it was assumed that impacts will increase as the number of consecutive days without access to water increases.

- Impacts to irrigation intakes are assumed to take the form of declining crop yields. As the number of days increases in which access to water is curtailed, the expected yield per acre is expected to decrease.
- Water used for irrigation is assumed to be constant for all irrigators and equal to the state average estimated in the 2013 Farm and Ranch Irrigation Survey (USDA 2013).
- Crop harvest patterns (i.e., the percentage of corn, alfalfa, and barley) for crops harvested using only Missouri River water are assumed to be equal to the harvest patterns for crops irrigated with water from any source, as reported in the 2012 Census of Agriculture (USDA 2012) or by the North Dakota State Water Commission (Sorenson 2017).
- State permit requirements in South Dakota and North Dakota require irrigators to report actual irrigated acreage by water source. Approximately 37.6 percent of acreage permitted to use Missouri River water in counties in these states was actually irrigated according to state records (South Dakota Department of Environment and Natural Resources and North Dakota State Water Commission). Because irrigators in Montana are not required to report actual acreage that is irrigated (versus permitted), it was assumed that the same percentage applied in Montana as was reported for South Dakota and North Dakota.
- Crop enterprise budgets were used for irrigation costs per acre and crop yields per acre (both irrigated and dryland). Every effort was made to use a budget that included the county under study. In the event that a suitable budget was not available, a budget prepared for a similar geography and rainfall pattern was used.
- The price per unit of crop production is assumed to be equal to the state-level normalized price estimates for commodities, as provided by the United States Department of Agriculture Economic Research Service (ERS) for 2017 (USDA 2017).

1.5 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 MRRMP-EIS is associated with the operation of the Missouri River System, and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 82-year POR. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future, and would not be captured by the Hydrologic Engineering Center - River Analysis System (HEC-RAS) models or carried through to the irrigation model described is this document. The project team has attempted to address risk and uncertainty in the MRRMP-EIS by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River. The HEC RAS data as simulated over the POR was used to estimate the impacts to irrigation intakes and agricultural production under each of the MRRMP-EIS alternatives.

2.0 Analysis of River and Reservoir Conditions

The purpose of the river conditions analysis was to link the H&H model outputs (e.g., HEC-RAS and ResSim) of river/reservoir operations under each of the MRRMP-EIS alternatives with the irrigation intake operating requirements. This analysis was completed in Microsoft Excel® and provided an estimate of the number of days irrigation intakes would have access to water at various locations along the river. The output of this model was used in the economic model to

evaluate potential NED and RED effects on changes in river flows, river stages, and reservoir elevations to irrigation operations accessing water from the Missouri River.

As river flows and reservoir elevations fall below irrigation intake minimum operating requirements, intakes become unavailable to provide water for crops. Minimum operating requirements for intakes were obtained from the Master Manual and verified by stakeholders, and represent the best available data on the actual flow/elevation requirements at each individual intake. This in turn can drive changes in crop yields and operation and maintenance costs of the intakes. The analysis of river conditions was developed using outputs from H&H models developed by the USACE. HEC-RAS and Hydrologic Engineering Center - Reservoir System Simulation (HEC-ResSim) data was used to provide a profile of river and reservoir behavior at locations that approximately corresponded to locations of irrigation intakes, in the form of HEC-DSS (Data Storage System) flat files. River and reservoir behavior for each location was analyzed over a period of 82 years, from 1930 to 2012.

The USACE developed the initial list of 1,027 irrigation intakes that were used for irrigation along the river from Montana to Nebraska from the Master Manual, which included minimum operating requirements at many of those intakes. These intakes were located in 42 counties between the Fort Peck Dam in Montana, and Rulo, Nebraska. This initial list of intakes did not include irrigators in Iowa, Missouri, and Kansas. Additional investigation with state Departments of Natural Resources confirmed that there are no intakes permitted for irrigation from the Missouri River in these states.

In order to reduce the processing time, individual intake locations were categorized into 242 groups that were located in close proximity and had similar access requirements. Groups did not cross county lines, shared a common required intake operating flow/elevation, were within ten river miles, and did not cross tribal or county boundaries. Each group included approximately four intakes. An Excel®-based analysis was developed to identify whether or not the river and reservoir conditions fell within the access requirements of the irrigation intake group.

Two metrics were developed in order to approximate access to water for irrigation under the MRRMP-EIS alternatives. The first metric was an estimate of the number of days river flows or reservoir elevations fall below minimum operating requirements. The total number of days below minimum operating requirements was estimated for each group of intakes in each county for each alternative for each year. The second metric was an estimate of the average consecutive length of time, in days, for all occurrences of river flows or reservoir elevations falling below minimum operating requirements during the irrigation season. The results obtained were assumed to be consistent for all intakes in the group. Results by intake group were then aggregated and averaged across the entire county for every county in the study area. Henceforward, whenever ‘minimum operating requirements for irrigation intakes’ is referenced, this refers to the average behavior for all irrigation intakes in a county.

3.0 Defining Scope of Analysis

The results of the river conditions analysis were used in part to define the extent of the economic analysis for irrigation operations under each of the MRRMP-EIS alternatives. In particular, the results of the river condition analysis were used to identify which intake groups by counties should be subject to further evaluation in the MRRMP-EIS. The team evaluated the river conditions to determine potential impacts for irrigation intakes in each county under each of

the MRRMP-EIS alternatives (Alternatives 2 through 6) compared to Alternative 1 (the No Action alternative).

A county was selected for further analysis if the river conditions results indicated that the county would experience a notable increase in the number of days river flows or reservoir elevations fall below minimum operating requirements for irrigation intakes under the MRRMP-EIS alternatives relative to Alternative 1. Note that because all alternatives showed considerable impacts during the drought years of the 1930s and early 1940s, the screening process largely focused on annual river conditions for years between 1942 and 2012. For more information on historic drought periods, refer to Section 3.2 in the MRRMP-EIS.

Three screening criteria were developed to determine the scope of analysis for irrigation. As the minimum operating requirements for irrigation intakes was completed at the county level, the screening criteria was also developed to apply to the county level. The screening criteria are defined as follows.

Considerable number of days with water levels below minimum operating requirements in a single year compared to Alternative 1. Counties were selected for further analysis if there was an increase in the number of days with water levels below minimum operating requirements by at least 30 days in any single year under any of the action MRRMP-EIS alternatives compared to Alternative 1. This criterion was designed to represent an infrequent event that could have the potential to have large impacts on irrigation operations. For example, the minimum operating requirements for irrigation intakes analysis showed that Valley County, Montana would experience an increase in the number of days below minimum operating requirements of 50 in 1973 under Alternatives 2,3,4, and 6, which resulted in this county being selected for further analysis.

Measurable increases in water levels below minimum operating requirements over several years. This criterion evaluated the counties that may experience a moderate increase in the number of days with water surface elevations below minimum operating requirements during a number of years under the MRRMP-EIS alternatives compared to Alternative 1. This criterion was calculated in two steps. First, a moderate increase in the number of days below minimum operating requirements was defined as approximately 10 percent of the growing season or an increase of 15 days in a single year, relative to Alternative 1. Second, the annual frequency with which counties experienced this moderate increase under any alternative was calculated. Counties that experienced a moderate increase in the number of days below minimum operating requirements in six or more years (the 90th percentile of such occurrences) were selected for additional evaluation. For example, under Alternative 6, intakes in Sully County in South Dakota would experience 14 years in which intakes would experience an increase by at least 15 days per year (primarily between 1956 and 1968) when water surface elevations would fall below minimum operating requirements and, as a result, this county was selected for additional analysis.

Increase in the number of consecutive days. This criterion measured the relative increase in the average number of consecutive days that intakes experience water surface elevations below minimum operating requirements from 1942 to 2012 for all action alternatives compared to Alternative 1. The sum of the average number of consecutive days per year over the total POR was analyzed for each county, and counties that fell into the 90th percentile (or top ten percent) for such occurrences were selected for further analysis to capture cumulative impacts of reductions in water access over time.

3.1 Initial Screening Results

Table 1 shows the results of the screening analysis described above and includes the counties that were identified for further analysis. There were 27 counties that were identified as meeting at least one of the criteria described above. Only six counties were selected on the basis of a single criterion: Brule (SD), Gregory (SD), Boyd (NE), Cass (NE), Otoe (NE), and Nemaha (NE) counties. Seven counties, primarily in South Dakota, were identified on the basis of meeting all three criteria.

Table 1. Counties Identified for Further Analysis in the Environmental Impact Statement

County	State	Single year impact	Moderate impact for several years	Cumulative impact on consecutive days
McCone	MT	x	x	
Valley	MT	x		
Roosevelt	MT	x	x	
Richland	MT	x	x	
Williams	ND			x
McKenzie	ND			
Mountrail	ND	x	x	x
McLean	ND	x		
Mercer	ND	x		
Oliver	ND	x		
Burleigh	ND	x		
Morton	ND	x		
Emmons	ND	x	x	x
Sioux	ND	x	x	x
Corson	SD	x	x	x
Campbell	SD			x
Walworth	SD			x
Dewey	SD	x	x	x
Potter	SD			x
Sully	SD	x	x	x
Stanley	SD	x	x	x
Hughes	SD			
Buffalo	SD			
Hyde	SD			
Lyman	SD			
Brule	SD		x	
Charles Mix	SD			
Gregory	SD		x	

County	State	Single year impact	Moderate impact for several years	Cumulative impact on consecutive days
Boyd	NE	x		
Bon Homme	SD			
Knox	NE			
Cedar	NE			
Yankton	SD			
Clay	SD			
Dixon	NE			
Union	SD			
Thurston	NE			
Burt	NE			
Washington	NE			
Cass	NE	x		
Otoe	NE	x		
Nemaha	NE	x		

3.2 Irrigated Acreage Criterion

Upon further review of the initial screening results, it was determined that some of the 27 counties had a relatively small number of acres that were irrigated with Missouri River surface water. An additional criterion was developed based on the number of irrigated acres within in each county. Counties that reported fewer than 1,000 acres irrigated in the most recent Census of Agriculture (USDA 2012) were eliminated from further study, including the following:

- Mountrail, North Dakota
- Sioux, North Dakota
- Corson, South Dakota
- Dewey, North Dakota
- Potter, South Dakota
- Stanley, South Dakota

If fewer than 1,000 acres were permitted for irrigation using Missouri River water (as reported by the state governing body responsible for overseeing state water rights and appropriations), these counties were also eliminated. Six counties were eliminated from further study on this basis, including:

- Gregory, South Dakota
- Boyd, Nebraska
- Knox, Nebraska
- Cass, Nebraska
- Otoe, Nebraska

- Nemaha, Nebraska

However, not all acres that are permitted for irrigation are, in fact, irrigated. If fewer than 1,000 acres were actually irrigated according to usage statistics gathered by the South Dakota Department of Environment and Natural Resources or the North Dakota State Water Commission, they were also eliminated from further study. Note that neither the Nebraska Department of Natural Resources nor the Montana Department of Natural Resources and Conservation require surface water right owners to report actual irrigated acreage. Three counties were eliminated from further consideration based on reported irrigated acreage include:

- Campbell, South Dakota
- Walworth, South Dakota
- Brule, South Dakota

The team made every effort to validate data developed by state departments of natural resources and water commissions. Given the relatively low number of permitted acres in southeast Nebraska, the project team made calls to water right owners in Nemaha, Nebraska, to verify that permitted acres were actually being irrigated. In this case, the listed owner of an appropriation with 873 permitted acres reported that the land and appropriation had been sold to the USACE several years ago and was no longer used for irrigation. The owner of another appropriation with 297 acres of permitted land also reported that the land had not been irrigated since 2010. Thus, Nemaha County was eliminated based on this information.

3.3 Scope of Analysis Results

Based on the results of the screening analysis, twelve counties in the upper basin were evaluated for potential for impacts of the MRRMP-EIS alternatives on irrigation operations. These twelve counties include approximately 102,951 permitted acres for irrigation using water from the Missouri River. The twelve identified counties for further analysis include the following:

- McCone, Montana
- Valley, Montana
- Roosevelt, Montana
- Richland, Montana
- Williams, North Dakota
- McLean, North Dakota
- Oliver, North Dakota
- Burleigh, North Dakota
- Morton, North Dakota
- Mercer, North Dakota
- Emmons, North Dakota
- Sully, South Dakota

4.0 Methodology

4.1 National Economic Development

The NED analysis for irrigation was defined as changes in net farm income from irrigated acreage using Missouri River water. The minimum operating requirements for irrigation intakes analysis showed that water surface elevations would fall below minimum operating requirements for many of the irrigation intakes evaluated under MRRMP-EIS alternatives, including Alternative 1. Because of the large variations in costs to access irrigation water and the difficulty in estimating these costs, the evaluation focused on the changes in crop yields resulting from reduced access to water and subsequent effects on net farm income.

An Excel®-based model was developed to evaluate the change in NED benefits for irrigation operations under the MRRMP-EIS alternatives for the twelve counties identified in the river condition analysis. The NED analysis for the twelve counties used data and information provided by the USACE, crop enterprise budgets developed by state agriculture extension agencies, state water permit data, crop data from the USDA, and weather information from the National Oceanic and Atmospheric Administration (NOAA). These data sources and the approach are described in this section.

4.1.1 Estimated Irrigated Acreage by Missouri River

Table 2 summarizes the acres permitted for irrigation from the Missouri River and actual acres irrigated according to survey data obtained from farm operators. The South Dakota Department of Environment of Natural Resources and North Dakota State Water Commission require irrigation permittees to report annual acres irrigated. For counties in North and South Dakota, the analysis utilized this data to estimate the number of acres irrigated with Missouri River water. Note that data on the number of permitted acres by county was from 2015. Actual acres irrigated is obtained from surveys conducted with farmer operators. The latest survey data available was from 2012. While the data on permitted acreage versus irrigated acreage represent two different years, according to the North Dakota Water Commission, the amount of permitted acres has been relatively stable on a year-by-year basis since 2011 (Sorenson 2018). Thus, the project team used the two different years data as needed for the analysis.

Irrigators in Montana are not required to report actual irrigated acreage. Thus, the project team estimated the proportion of permitted acres that are irrigated using data from North and South Dakota. The proportion of actual to permitted acres in North and South Dakota was applied to the number of total acres permitted in Montana. On average, 37.6 percent of total permitted acres are irrigated in these two states, and this percentage is assumed to be applicable for the four counties in Montana (Table 2).

Table 2. Estimated Irrigated Cropland Using Missouri River Water

County	State	Acres Permitted for Irrigation from Missouri River 2015[a]	Actual Acres Irrigated from Missouri[b] River 2012
McCone*	Montana	16,209	6,104
Valley*	Montana	4,978	1,875
Roosevelt*	Montana	21,284	8,015
Richland*	Montana	18,156	6,837

County	State	Acres Permitted for Irrigation from Missouri River 2015[a]	Actual Acres Irrigated from Missouri[b] River 2012
Williams	North Dakota	39,966	1,969
McLean	North Dakota	5,874	2,610
Oliver	North Dakota	6,784	3,643
Burleigh	North Dakota	4,723	2,543
Morton	North Dakota	3,985	1,848
Mercer	North Dakota	5,463	1,946
Emmons	North Dakota	9,508	5,496
Sully	South Dakota	22,950	7,744

* Note that actual acres irrigated from Missouri River in Montana have been estimated using the percentage of actual acres irrigated relative to the permitted acres irrigated in North Dakota and South Dakota (statewide).

a Montana Department of Natural Resources & Conservation, South Dakota Department of Environment and Natural Resources, or North Dakota State Water Commission surface water right permit, 2015

b South Dakota Department of Environment and Natural Resources or North Dakota State Water Commission actual water use reports, 2012

4.1.2 Estimated Cropping Patterns by County

For each county, production data (e.g., crop type, number of irrigated acres harvested) was obtained from the 2012 Census of Agriculture and from the North Dakota State Water Commission. A crop profile for each county was developed based on the number of irrigated acres harvested. In the case of South Dakota and North Dakota, the 'total' value is equal to the total number of acres irrigated by the Missouri River according to state permits. For South Dakota, the crop patterns in those acres are assumed to be identical to the Census of Agriculture's Irrigated Crops by Acres Harvested (USDA 2012). In North Dakota, crop patterns were provided by the State Water Commission (Sorenson 2017).[1] In Montana, actual acres irrigated was not provided. Crops for which no acreage is reported, or which were suppressed by the USDA for privacy concerns, are not included.

[1] In North Dakota, the crop totals below represent the total acres of crops irrigated by the Missouri River, as reported to the North Dakota State Water Commission (Sorenson 2017). The data differs from the State Water Commission online MapServices because the online service does not provide complete water use data (crop types, irrigated acres, etc.) for each permit.

Table 3. Estimated Crop Acres Irrigated by Missouri River

County	Alfalfa	Barley	Beans	Beets	Canola	Corn	Durum	Hay	Hay & Haylage	Peas	Potatoes	Soybeans	Sugarbeets	Wheat	Total
McCone, MT a			1,979			107		1,859	966					1,193	6,104
Valley, MT [a]		24				57		980	482	11				322	1,875
Roosevelt, MT [a]		203	636			46		1,388	1,394				256	4,092	8,015
Richland, MT [a]		820				558		1,402	745				1,191	2,120	6,837
Williams, ND [b]	100			35	205	382	52	310			328	125	15	417	1,969
McLean, ND [b]	61		406			1,798					280	65			2,610
Oliver, ND [b]	370					2,088						1,185			3,643
Burleigh, ND [b]			765			1,262						376		140	2,543
Morton, ND [b]	250					575		44				297			1,166
Mercer, ND [b]	126	251	430			1,139									1,946
Emmons, ND [b]	508		778			3,190				615		285		120	5,496
Sully, SD [a]						4,473		215	107			2,949			7,744

Sources:
a USDA 2012
b Sorenson 2017

4.1.3 Estimated Crop Yields and Costs

To estimate crop yields per acre in the twelve counties evaluated, the project team utilized crop enterprise budgets. Crop enterprise budgets are prepared by land grant universities that are part of the county's Cooperative State Research, Education, and Extension Service (CSREES). The CSREES supports technology transfer between research-based institutions and the agricultural community. As part of the CSREES, North Dakota and South Dakota prepare crop enterprise budgets for the benefit of the farming communities in their respective states. These crop-specific budgets include estimated costs for common inputs, such as fertilizer and pest control products, but also provide an estimated yield (NDSU 2014, 2016; SDSU 2014, 2016).

Montana State University has not prepared updated crop enterprise budgets in more than ten years and a researcher at the university recommended that farmers use budgets prepared for western North Dakota until new crop budgets can be prepared (Haynes 2016). For the purposes of this project, the western North Dakota budgets were used to obtain an estimated per-acre cost for most crops grown using surface irrigation methods and an estimated per-acre yield for farms in Montana.

The only exceptions are crops identified by the Census of Agriculture as hay, hay and haylage, beans, lentils, peas, and sugar beets. Hay and hay and haylage were assumed to be alfalfa in the state budgets. Beans, lentils, and peas all use dry bean budgets. Beans were considered an appropriate choice because lentils are an edible pulse (i.e., the plant's seed or fruit) in the legume family, and field peas are an edible grain legume crop.

No budget was available for sugar beets or potatoes in Montana, North Dakota, or South Dakota. However, comparable budgets were available for southeastern Idaho, where rainfall patterns are similar to the counties where sugar beets and potatoes are grown (University of Idaho 2017a, 2017b). All available information suggests that sugar beets cannot be grown in northern states without irrigation.

Also, a budget was not available for dryland alfalfa for Montana or North Dakota. However, the South Dakota 2016 projections prepared by South Dakota State University estimate a three-ton yield per acre for alfalfa grown under dryland conditions in the state. In Montana, one estimate suggests that dryland alfalfa production from 1984 through 2005 averaged 2.5 tons per acre. Based on this estimate, and the lower rainfall in Montana compared to South Dakota, an estimated yield of 2.5 tons per acre was assumed for dryland alfalfa production in Montana.

4.1.4 Estimate Irrigation Costs per Acre of Production

Numerous interviews with private irrigation intake maintenance providers, farmers, Farm Service Agency representatives, local agriculture extension service representatives, and academics were unable to provide data that could be used to build a consistent cost function for irrigation based on the number of days a water intake was operable (Ludeman 2016; Beck 2015). Irrigation costs for each crop were assumed to be constant regardless of actual irrigation conditions. The cost per irrigated acre was used from the crop enterprise budgets described above using the budgets' total listed costs, including both direct costs (including seed, herbicides, fungicides, fertilizer, irrigation expenses) and indirect costs (including depreciation, overhead, and land charge). No indirect costs were available for South Dakota budgets, so the sum of listed indirect costs used in Emmons County (which is located in close proximity of Sully on the border to South Dakota) were applied to Sully County.

In addition, because the river stages and reservoir levels are anticipated to be similar during extreme drought conditions under the No Action Alternative and the MRRMP-EIS alternatives, no significant investments in irrigation intakes are expected to be needed under the MRRMP-EIS alternatives.

4.1.5 Estimate Change in Yield Due to Reduced Access to Water

The project team estimated changes in yields due to different levels of water access expected to occur under the MRRMP-EIS Alternatives. Water access was defined as either minimum flow or water surface elevations which irrigation intakes could access water; below these minimum operating requirements for irrigation intakes were assumed to become non-operable. Information on minimum operating requirements for irrigation intakes were obtained from the Master Manual and interviews with stakeholders (reference). The team conservatively assumed that average yields would begin to decline as soon as access to water became limited and would continue to decline to a level equivalent to yields that can be realized under dryland farming conditions.

Irrigation Water Needs

In order to evaluate changes in yields associated with water access under the alternatives, the project team needed to estimate water needs using dryland farming methods and when using surface water irrigation. To estimate average precipitation, or the amount of water that would be available for crop production under dryland farming conditions, the project team used average annual recorded precipitation in 2014 (NOAA, 2014). This value represents precipitation recorded at all weather stations in each county averaged over the calendar year. This value was used as a baseline to estimate the number of inches of water available under dryland farming practices and was used to estimate the lowest potential yields that can be expected under any year evaluated.

In the twelve counties evaluated, the lowest recorded precipitation was in Richland County, North Dakota (Table 4). The average annual precipitation recorded at all weather stations in the county averaged just 16.4 inches over the calendar year. The highest recorded average precipitation was 20.4 inches, recorded in Sully County, South Dakota. In general, the upper reaches of the river had lower annual precipitation relative to lower reaches (NOAA 2014). Note that while this model does include precipitation in the analysis, evapotranspiration and crop soil properties are not considered.

To estimate the total number of acre-inches[2] of water applied using irrigation, the average recorded precipitation was added to the average acre-inches of water applied per irrigated acre. The source was the 2013 Farm and Ranch Irrigation Survey, which reports the average number of acre-feet of water applied for surface water operations (USDA 2013). Farmers using surface water on unenclosed (i.e., not protected by plastic greenhouse coverings) farms in Montana used the most water per irrigated acre, at 16.8 acre-inches. Farms in North Dakota applied the least per acre, only 6 acre-inches (Table 5).

[2] An acre-inch is equal to the volume of water that would cover one acre to a depth of one inch.

Table 4. Average Recorded County Precipitation, 2014

County	State	Inches
McCone	Montana	14.0
Valley	Montana	13.3
Roosevelt	Montana	15.0
Richland	Montana	13.2
Williams	North Dakota	16.9
McLean	North Dakota	20.3
Mercer	North Dakota	15.0
Oliver	North Dakota	19.9*
Burleigh	North Dakota	14.3
Morton	North Dakota	19.9
Emmons	North Dakota	17.8
Sully	South Dakota	20.4

Source: NOAA 2014.

*Due to a lack of recent data for Oliver County, nearby Morton is used instead

Table 5. Estimated Quantity of Water Applied from On-Farm Surface Water, Only Source, Applied in the Open, 2013

State	Average Acre-Inches
Montana	16.8
North Dakota	6.0
South Dakota	8.4

Source: USDA 2013.

Note: 'In the open,' in this context, means that the farm is not covered by a plastic covering, such as used in a greenhouse.

The total amount of water used for irrigation operations in each state can vary considerably as a result of differences in the amount of annual precipitation and variations and in irrigation practices and efficiency in irrigation systems. For instance, in Roosevelt County, Montana, irrigated acres were assumed to receive 30.4 acre-inches of water per year. However, across the state line in Williams County North Dakota, irrigated acres were assumed to receive only 16.2 acres-inches of water per year.[3]

3 Research suggests that, on the whole, irrigation systems in Montana are the least efficient included in the study area (ECONorthwest, 2008).

Estimated Changes in Yield Associated with Water Access

The next step in the NED analysis was to estimate how crop yields vary with changes in access to Missouri River water for irrigation purposes. The project team first estimated water availability during any given calendar year according to the following formula.

$$W = \left(\frac{I_2 - I_1}{D_2}\right) * (D_2 - D_1) + I_1$$

Where:

W = acre-inches of water applied

I_2 = the maximum number of acre-inches that would be applied for an intake with full access

I_1 = the minimum number of acre-inches to be applied under zero access (i.e., rely only on rainfall)

D_2 = total possible days of irrigation in irrigation season

D_1 = number of consecutive days without access to water in the current year under each alternative

It was assumed that production levels (yields) increases linearly as acre-inches of water increases (as calculated above). The minimum achievable yield for each crop is assumed to be equal to the yield achieved using dryland production techniques, as reported by crop enterprise budgets.

$$yield\ per\ acre = \frac{(Y_2 - Y_1)}{(I_2 - I_1)} * (W - I_2) + Y_1$$

Where:

Y_1 = expected yield per acre under dryland conditions

Y_2 = expected yield under full irrigation conditions

W = acre-inches of water applied in the calendar year (see previous formula)

I_1 = the minimum number of acre-inches that would be applied under dryland conditions (i.e., average annual rainfall)

I_2 = the maximum number of acre-inches that would be applied under full operability

4.1.6 Estimate Crop Production Value

The analysis estimated net farm income by considering the value of crop production minus production costs as reported in annual farm budgets. The gross sales (value of crop production) were calculated per crop, per alternative, for all actual acres irrigated by the Missouri River, for each of the counties being evaluated. Gross sales were calculated by summing the total production for each crop, for each alternative, and multiplying by the normalized price per crop. Almost all crops as listed by the Census of Agriculture 2012 were included in the prices developed by the ERS, with the exception of lentils and peas, both of which are priced as dry beans. Commodity prices for 2017 that were used in the analysis are included in Table 6.

An important point on net farm income is that, for all crop producers, the price received from year to year will vary considerably. The NED analysis used normalized 2017 commodity prices[4] as published by USDA in accordance with USACE economic guidance (U.S. Water Resources Council 1983; ER 1105-2-100 Appendix E; USACE Economic Guidance Memorandum) 16-02). In 2017, the price received per ton of hay production was relatively low. Producers' costs, as reported in crop budgets, don't necessarily mirror changes in commodity prices however. Thus, the results of the NED analysis show that in areas where hay and other low-valued crops are grown, net farm income can be negative.

Table 6. State-Level Normalized Commodities Price Estimates, 2017

State	Wheat, all types 1/ (bushel)	Corn for grain 1/ (bushel)	Oats 1/ (bushel)	Barley 1/ (bushel)	Hay, all types, baled (ton)	Dry beans (cwt.)	Sugar beets 2/ (ton)	Soybeans for beans (bushel)	Potatoes (cwt.)
Montana	$6.62	$5.09	$3.44	$5.93	$135.68	$28.91	$58.44		$12.84
Nebraska	$6.34	$4.99	$3.40		$115.57	$34.78	$56.71	$11.44	$11.33
North Dakota	$6.33	$4.45	$2.74	$5.52	$91.80	$31.70	$56.54	$11.18	$9.60
South Dakota	$6.26	$4.52	$3.19	$3.74	$124.14	$33.66		$11.19	

Source: USDA, ERS 2017.

4.1.7 Calculation of Net Farm Income

The project team calculated net farm income that would be realized under different river conditions under each alternative. Note that in this analysis, 'net farm income' refers to income from crops, and not from livestock or other farm products. Net farm income was calculated as follows:

- Average yield per crop X normalized price per crop = Gross sales per acre irrigated
- Gross sales per acre – average production costs per acre = Net farm income per acre
- Net income per acre X number of acres irrigated = Total Net Farm income per county.

In order to adjust net farm income into 2018 dollars, the total net farm income was adjusted using the 2018 chained price index developed by the United States Office of Management and Budget's Gross Domestic Product and Deflators Used in the Historical Tables: 1940–2023 (OMB 2018).

4.2 Regional Economic Development

The RED evaluation used information from the NED evaluation, specifically the change in gross sales (i.e., value of crop production) of irrigated crops grown in the twelve counties evaluated.

4 The USACE utilizes "normalized prices" developed by ERS which smooth out the effects of short-run seasonal and cyclical variations in prices for key agricultural crops. These prices are based on a five-year lagged average of actual market prices. For 2017, ERS estimated normalized prices for crops by multiplying the national-level normalized prices by the average ratios of the State-level market prices to the national market prices from 2013-2015 (USDA 2017).

The change in gross sales under each MRRMP-EIS alternatives relative to Alternative 1 was used to estimate change in regional economic activity measured by changes in employment, income, and sales. The analysis used the IMPLAN® Input-Output modeling system to describe the flow of dollars from purchasers to producers (IMPLAN 2015). For example, agriculture production requires inputs from farm equipment manufacturing and fertilizer producers. In addition, the workers from the farming and supporting sectors spend their income in the local economy, supporting induced jobs and income. A social accounting matrix is used in IMPLAN® to model these inter-industry transactions, industry-institution (institutions include households), and inter-institution transactions. The RED analysis used the appropriate state study area for the evaluation.

An external shock to a region can have a direct, indirect, and induced effect on the economy which are defined as follows:

- The *direct effect* includes the initial expenditures and production revenues made by the industry experiencing the economic change, much of which will be felt locally.
- Purchases made within the study area for goods and services required for production represent the *indirect effects*.
- *Induced effects* include the local spending by employees, both in the directly affected and indirectly affected industries.

5.0 National Economic Development Results

The NED analysis focused on estimating change in net farm income (reported in 2018 dollars) from irrigated agriculture using water from the Missouri River. For all counties, over the modeled POR, the alternative with the largest overall change in net farm income would be Alternative 6, with a decrease of $9.4M (Figure 3) compared to Alternative 1. Alternative 5 would have the largest beneficial impact, with an increase of net farm income of $3.6M relative to Alternative 1.

Table 7 summarizes the change in total net farm income for the modeled POR for each of the counties evaluated. Under Alternative 2, farm income would decline overall relative to Alternative 1, with the individual county changes ranging from a decline of 11.6 percent to an increase of 2.8 percent. Under Alternative 3, counties experience a decrease in net farm income of less than one percent to an increase of 2.8 percent relative to Alternative 1. Under Alternative 4, about half of the counties experience relatively small declines ranging from less than one percent to 12 percent, and the other half experience relatively small increases in total net farm income relative to Alternative 1. Under Alternative 5, counties in Montana experience small increases (1.4 percent) in net farm income relative to Alternative 1, while counties in North and South Dakota experience negligible changes in net farm income. Under Alternative 6, counties in Montana would experience small beneficial impacts on net farm income while counties in North Dakota and South Dakota would generally experience a decrease in net farm income relative to Alternative 1 not greater than 18.7 percent. Estimated average annual net farm income is summarized in Table 8 and indicates a similar trend as the change in total net farm income across the alternatives.

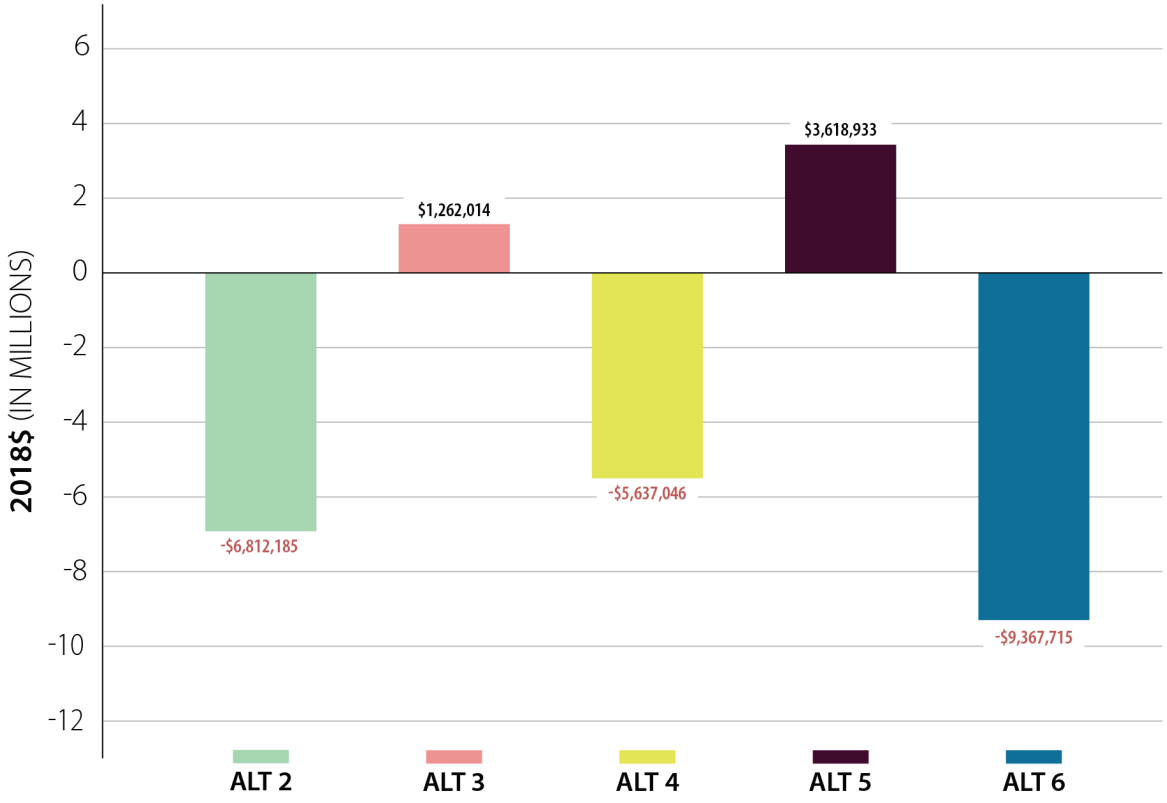

Figure 3. Change in Total Net Farm Income over the POR Relative to Alternative 1, All Counties (2018 Dollars)

Table 7. Total Net Farm Income by MRRMP-EIS Alternative (Thousands of 2018$)

Type of Impact	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
McCone						
Total Net Farm Income	$82,220	$82,051	$82,307	$83,142	$82,907	$82,550
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.2%	0.1%	1.1%	0.8%	0.4%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$168	$87	$922	$688	$330
Valley						
Total Net Farm Income	$35,888	$35,793	$35,942	$36,361	$36,254	$36,073
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.3%	0.1%	1.3%	1.0%	0.5%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$96	$54	$473	$366	$185
Roosevelt						
Total Net Farm Income	$69,526	$69,112	$69,606	$70,665	$70,708	$70,437
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.6%	0.1%	1.6%	1.7%	1.3%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$415	$80	$1,139	$1,182	$910
Richland						
Total Net Farm Income	$99,631	$98,545	$99,512	$101,134	$101,496	$100,647
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-1.1%	-0.1%	1.5%	1.9%	1.0%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$1,086	-$119	$1,503	$1,865	$1,016
Williams						
Total Net Farm Income	$45,721	$45,571	$45,739	$44,366	$45,461	$45,305
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.3%	0.0%	-3.0%	-0.6%	-0.9%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$150	$18	-$1,355	-$260	-$416
McLean						
Total Net Farm Income	$58,913	$58,666	$58,855	$58,190	$58,766	$57,978
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.4%	-0.1%	-1.2%	-0.2%	-1.6%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$247	-$58	-$724	-$147	-$935

Type of Impact	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Mercer						
Total Net Farm Income	$5,770	$5,760	$5,773	$5,082	$5,673	$5,398
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.2%	0.0%	-11.9%	-1.7%	-6.5%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$10	$3	-$688	-$97	-$372
Oliver						
Total Net Farm Income	$13,596	$13,154	$13,588	$13,341	$13,472	$13,088
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-3.2%	-0.1%	-1.9%	-0.9%	-3.7%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$442	-$7	-$255	-$124	-$507
Burleigh						
Total Net Farm Income	$30,488	$30,150	$30,459	$30,130	$30,494	$30,293
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-1.1%	-0.1%	-1.2%	0.0%	-0.6%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$339	-$29	-$358	$6	-$195
Morton						
Total Net Farm Income	$27,933	$27,733	$27,912	$27,679	$27,925	$27,826
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-0.7%	-0.1%	-0.9%	0.0%	-0.4%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$200	-$21	-$254	-$8	-$107
Emmons						
Total Net Farm Income	$17,039	$15,058	$17,514	$15,078	$16,862	$13,857
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-11.6%	2.8%	-11.5%	-1.0%	-18.7%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$1,981	$475	-$1,961	-$177	-$3,182
Sully						
Total Net Farm Income	$69,925	$68,221	$70,712	$65,822	$70,250	$63,792
Percent Change in Net Farm Income Relative to Alt. 1.	n/a	-2.4%	1.1%	-5.9%	0.5%	-8.8%
Change in Total Net Farm Income Relative to Alt. 1	n/a	-$1,704	$787	-$4,103	$325	-$6,133

Table 8. Average Annual Net Farm Income by MRRMP-EIS Alternative (Thousands of 2018$)

County	Scenario	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
McCone	Average Annual Net Farm Income	$1,003	$1,001	$1,004	$1,014	$1,011	$1,007
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$2	$1	$11	$8	$4
Valley	Average Annual Net Farm Income	$438	$436	$438	$443	$442	$440
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$1	$1	$6	$4	$2
Roosevelt	Average Annual Net Farm Income	$848	$843	$849	$862	$862	$859
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$5	$1	$14	$14	$11
Richland	Average Annual Net Farm Income	$1,215	$1,202	$1,214	$1,233	$1,238	$1,227
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$13	-$1	$18	$23	$12
Williams	Average Annual Net Farm Income	$558	$556	$558	$541	$554	$552
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$2	$0	-$17	-$3	-$5
McLean	Average Annual Net Farm Income	$718	$715	$718	$710	$717	$707
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$3	-$1	-$9	-$2	-$11
Mercer	Average Annual Net Farm Income	$70	$70	$70	$62	$69	$66
	Change in Average Annual Net Income Relative to Alternative 1	n/a	$0	$0	-$8	-$1	-$5
Oliver	Average Annual Net Farm Income	$166	$160	$166	$163	$164	$160
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$5	$0	-$3	-$2	-$6
Burleigh	Average Annual Net Farm Income	$372	$368	$371	$367	$372	$369
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$4	$0	-$4	$0	-$2
Morton	Average Annual Net Farm Income	$341	$338	$340	$338	$341	$339
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$2	$0	-$3	$0	-$1
Emmons	Average Annual Net Farm Income	$208	$184	$214	$184	$206	$169
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$24	$6	-$24	-$2	-$39
Sully	Average Annual Net Farm Income	$853	$832	$862	$803	$857	$778
	Change in Average Annual Net Income Relative to Alternative 1	n/a	-$21	$10	-$50	$4	-$75

In evaluating the NED results, it is important to note that when counties that have a higher proportion of high-margin crops are impacted by management actions under one of the alternatives, the change in total net farm income for all counties (Figure 3) under that alternative will also be larger. The highest-margin crops in the table above include potatoes, sugarbeets, hay, and beans. The lowest-margin crop, for the counties included in this analysis, is wheat. These margins are defined as described above, using ERS prices and crop enterprise budgets relevant to each county.

The highest variation in annual net farm income for all alternatives would be in Sully County, which would vary from -$381,000 in drought years to $1.4 million during modeled years with greater access to water for all alternatives. The least amount of variation in annual average net farm income for all alternatives would be in Morton County, North Dakota, which would range from $229,000 during drought years to $345,000 during years of high water access. Sully is one of the few counties in this analysis where all three of the county's largest crops have a positive margin, and the county also has a relatively large number of acres irrigated by the Missouri River (7,744). Though the top three crops in Morton County have a positive margin, Morton has the fewest irrigated acres of any county in the analysis (1,166), which accounts for the small variation in annual net farm income.

However, several modeled years clearly show a greater beneficial or adverse impact under the MRRMP-EIS Alternatives (Figure 4). The worst years, particularly for Alternatives 2, 4, and 6, occur between 1956 and 1968, overlapping with years of drought between 1954 and 1961 and, for those alternatives, flow events simulated in 1963. Declines in net farm income in 1988 similarly coincide with periods of drought from 1987 to 1993 and a flow event in 1988 under Alternatives 2, 4, and 6. The other noticeable decline in Figure 4 would occur as simulated in 2010, which is at the end of a drought period that concludes in 2008 and follows a partial flow event under Alternatives 2, 4, and 6 in 2009.

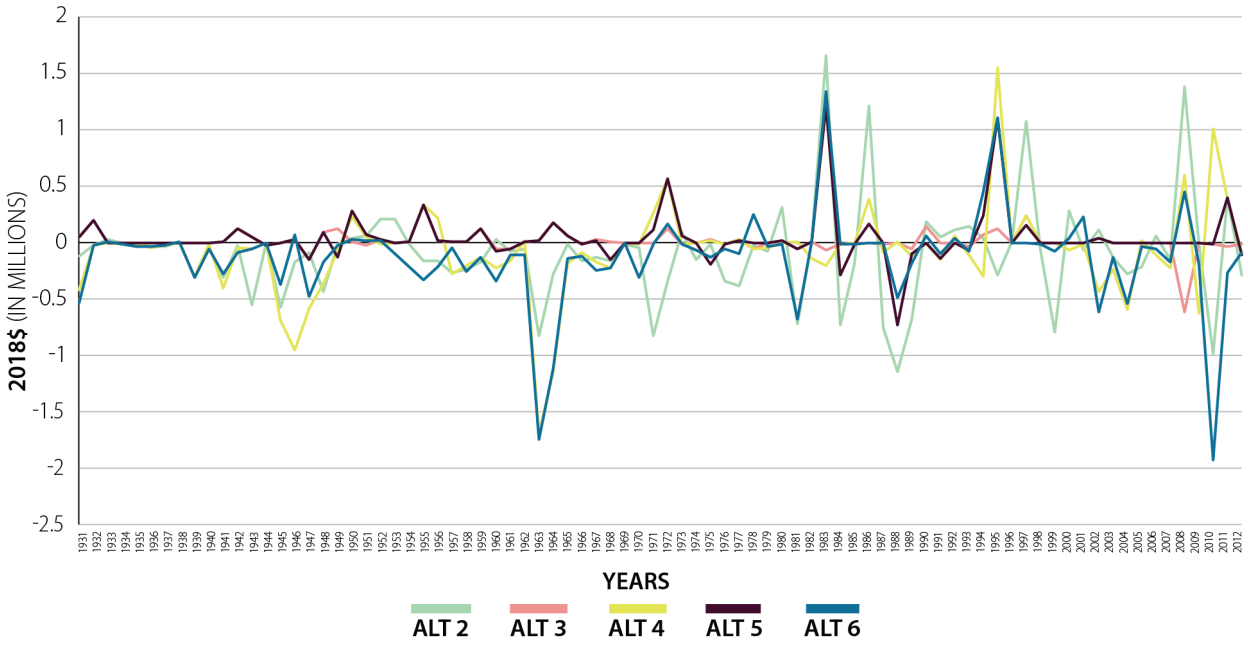

Figure 4. Change in Total Net Farm Income Relative to Alternative 1, All Counties (2018 Dollars)

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

Table 9 summarizes the NED analysis for Alternative 1. Overall, average annual net farm income for all 12 counties evaluated would be approximately $6.79 million. Under Alternative 1, a negative net farm income does not imply a negative impact as a result of MRRMP-EIS implementation, but rather lower prices for crops grown in the counties under consideration. Much of the variation in annual net farm income is a result of drought conditions. Management actions under Alternative 1, including the spring plenary pulse, would have a negligible contribution to reductions in net farm income because of the very small changes in river stages and reservoir elevations.

5.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The NED results for Alternative 2 are summarized in Table 10. On average net farm income would total $6.71 million for all twelve counties per year under Alternative 2. This represents a slight decrease from Alternative 1 of $83,000 or -1.2 percent. On average, all counties under this alternative would experience negligible adverse impacts. However, in certain years, impacts would be small especially in certain counties that border Lake Sakakawea and reducing access to water for irrigation. During the worst difference years from Alternative 1, the change in net farm income would be temporary and small across a number of counties, with Sully County experiencing a decrease of $238,000 in net farm income in the average of the eight worst difference years from Alternative 1. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to Alternative 1, many of these adverse impacts would be offset, resulting in very small changes on average to net farm income under Alternative 2 relative to Alternative 1.

The decline in annual average net income for all counties would be $83,000, with most of this decline occurring in Emmons, Sully, and Richland counties. Oliver County would experience the largest percentage decrease in net farm income, with a decline of 3.2 percent. Emmons County would experience the largest overall change in average annual net farm income relative to Alternative 1, with a decline of $24,000, equal to approximately a 12 percent decline in net farm income. Sully County would be impacted by lower reservoir elevations in Lake Oahe from late June to late August following flow events in 1963, 1988, and 2002. Emmons County, also located on Lake Oahe, would be negatively impacted in 1976, 1977, and 1948. Oliver County, located downstream of Lake Sakakawea, would be similarly impacted by flow releases. Richland County would experience less precipitous declines in net farm income as a result of full release events, but would experience persistent minor adverse impacts from early May to mid-September particularly during years of partial release in the late 1960s, 1970s, and 1980s.

Table 9. Summary of National Economic Development Analysis for Alternative 1 (2018$)

State	County	Total Net Farm Income	Average Annual Net Farm Income	Annual Maximum	Annual Minimum	Total Acres Irrigated	Top Three Crops
Montana	McCone	$82,220,000	$1,003,000	$1,093,000	$779,000	$82,220,000	Beans (32%), Hay (30%), Wheat (20%)
	Valley	$35,888,000	$438,000	$479,000	$321,000	$35,888,000	Hay (52%), Hay & Haylage (26%), Wheat (17%)
	Roosevelt	$69,526,000	$848,000	$992,000	$356,000	$69,526,000	Wheat (51%), Hay & Haylage (17%), Hay (17%)
	Richland	$99,631,000	$1,215,000	$1,432,000	$584,000	$99,631,000	Wheat (31%), Hay (21%), Sugarbeets (17%)
North Dakota	Williams	$45,721,000	$558,000	$770,000	$323,000	$45,721,000	Wheat (21%), Corn (19%), Potatoes (17%)
	McLean	$58,913,000	$718,000	$831,000	$185,000	$58,913,000	Corn (69%), Pinto Beans (16%), Potatoes (11%)
	Mercer	$5,770,000	$70,000	$163,000	-$052,000	$5,770,000	Corn (59%), Beans (22%), Barley (13%)
	Oliver	$13,596,000	$166,000	$245,000	-$168,000	$13,596,000	Corn (57%), Soybeans (33%), Alfalfa (10%)
	Burleigh	$30,488,000	$372,000	$382,000	$258,000	$30,488,000	Corn (50%), Beans (16%), Soybeans (15%)
	Morton	$27,933,000	$341,000	$345,000	$302,000	$27,933,000	Corn (49%), Soybeans (25%), Alfalfa (21%)
	Emmons	$17,039,000	$208,000	$813,000	-$539,000	$17,039,000	Corn (58%), Beans (14%), Peas (11%)
South Dakota	Sully	$69,925,000	$853,000	$1,434,000	-$388,000	$69,925,000	Corn (58%), Soybeans (38%), Hay (3%)
Total		$556,650,000	$6,788,000	$8,966,000	$3,406,000	51,248	Corn (29%), Wheat (17%), Hay (12%)

Table 10. Summary of National Economic Development Analysis for Alternative 2 (2018$)

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to No Action (average annual)	% Increase during eight greatest crop production value years compared to No Action (average annual)	Decrease during eight least crop production value years compared to No Action (average annual)	% Decrease during eight least crop production value years compared to No Action (average annual)
Montana	McCone	-0.2%	$1,001,000	-$2,000	$146,000	14.6%	-$140,000	-14.0%
	Valley	-0.3%	$436,000	-$1,000	$63,000	14.3%	-$64,000	-14.5%
	Roosevelt	-0.6%	$843,000	-$5,000	$209,000	24.6%	-$217,000	-25.6%
	Richland	-1.1%	$1,202,000	-$13,000	$287,000	23.6%	-$343,000	-28.3%
North Dakota	Williams	-0.3%	$556,000	-$2,000	$43,000	7.6%	-$52,000	-9.2%
	McLean	-0.4%	$715,000	-$3,000	$96,000	13.3%	-$108,000	-15.0%
	Mercer	-0.2%	$70,000	$,000	$33,000	46.4%	-$29,000	-40.8%
	Oliver	-3.2%	$160,000	-$5,000	$58,000	35.0%	-$102,000	-61.6%
	Burleigh	-1.1%	$368,000	-$4,000	$16,000	4.4%	-$57,000	-15.3%
	Morton	-0.7%	$338,000	-$2,000	$6,000	1.8%	-$30,000	-8.9%
	Emmons	-11.6%	$184,000	-$24,000	$72,000	34.5%	-$188,000	-90.7%
South Dakota	Sully	-2.4%	$832,000	-$21,000	$94,000	11.0%	-$238,000	-27.9%
Total		-1.2%	$6,705,000	-$83,000	$794,000	11.7%	-$817,000	-12.0%

Additional modeling results are summarized in Figure 5 which shows the difference in annual net farm income during years when there is a release action or a low summer flow. Years of full release and low summer flow correspond to the years of highest impact. The year of highest adverse impact (-$1.1 million) occurred in conditions similar to 1988, when reservoir elevations at Lake Sakakawea and Lake Oahe would decrease, and net farm income in McLean, Morton, and Emmons Counties would decrease in particular relative to Alternative 1. The one-year decrease in net farm income for the most affected county (McLean, with a decline of $467,000) in 1988 represents 0.3 percent of net cash farm income of all farming operations in that county ($149.8 million) (USDA 2012).[5]

Years with partial flow releases also correspond with lower annual net farm income. For example, the second-highest adverse impact year relative to Alternative 1 would occur in 2010, the year following a partial release when reservoir releases would be lower than under Alternative 1. In this year, adverse impacts would be more concentrated downstream of Fort Peck Lake, with reductions in net farm income occurring in Richland County (decrease of $726,000 relative to Alternative 1), neighboring Roosevelt County (decrease of $367,000), and McCone County (decrease of $230,000 relative to Alternative 1). The decrease in net farm income in Richland County would represent 1.7 percent of net cash farm income of all farm operations in the county ($41.5 million) (USDA 2012).

Increases in net farm income relative to Alternative 1 would also occur in some years, increasing by as much at $1.6 million across all counties. Roosevelt, Richland, and McCone are beneficially impacted in 1983, 1986, and 1988, which corresponds to periods of higher flow in the upper reaches of the river. In 1983, river flow at Culbertson would be as much as 110 percent higher under Alternative 2 relative to Alternative 1. Relatively higher modeled flows in 1988 for the upper reaches of the river would not, however, compensate for larger impacts downstream. In 1988, there was a full release and low summer flow modeled that would reduce reservoir elevations under Alternative 2 compared to Alternative 1 from July to September, resulting in adverse impacts in to counties in North Dakota (with Williams, McLean, and Mercer bordering Lake Sakakawea, and Emmons and Morton at least partially bordering Lake Oahe) and Sully County in South Dakota, which borders Lake Oahe.

5.3 Alternative 3 – Mechanical Construction Only

Under Alternative 3, average annual net farm income would be approximately $6.80 million (Table 11). This represents a small increase in annual average net farm income relative to Alternative 1 of $15,000 for all 12 counties, an increase of 0.2 percent. In general, the benefits of Alternative 3 would be the result of the elimination of the spring plenary pulse under Alternative 1, which results in small increases in net farm income under Alternative 3. The highest beneficial impact would occur in conditions similar to 1955, when net farm income in Sully County would increase by $197,000 relative to Alternative 1.

[5] Net cash farm income is the gross cash income—all income, such as crop value of production—minus any expenses, which would include raw materials, employees, and even payments on debt. This is a simpler estimation of net farm income as it doesn't include depreciation and amortization expenses.

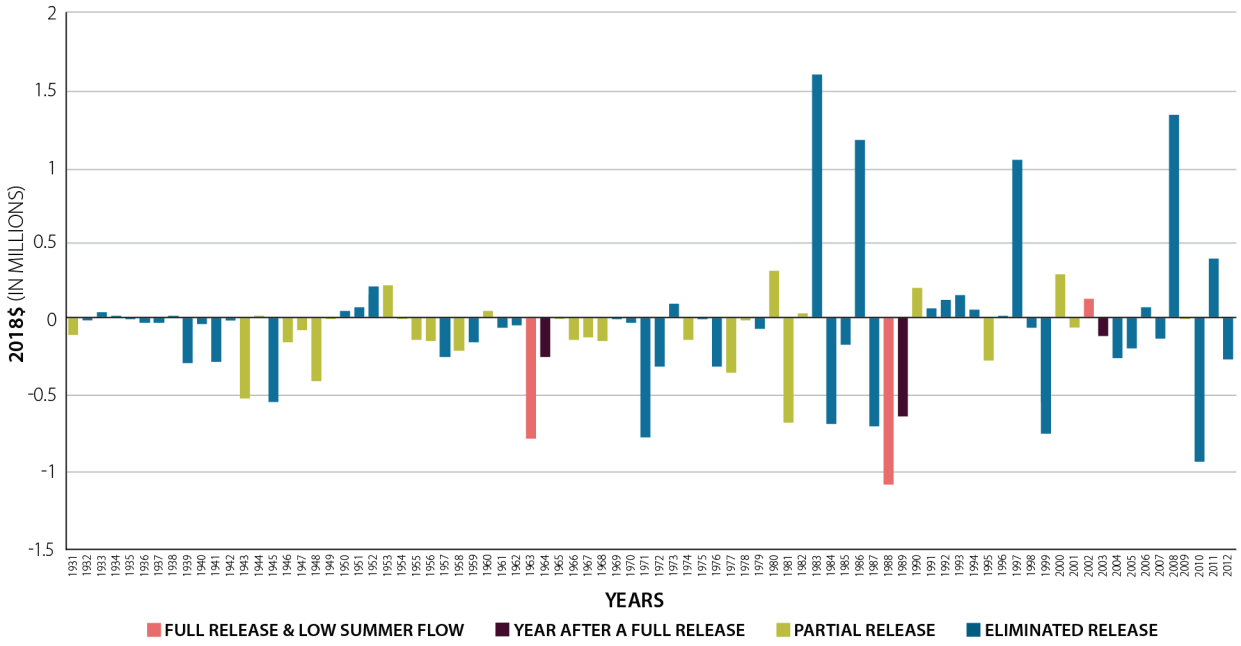

Figure 5. Annual Difference in Net Farm Income under Alternative 2 Relative to Alternative 1 (2018 Dollars)

Table 11. Summary of National Economic Development Analysis for Alternative 3 (2018$)

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to No Action (average annual)	% Increase during eight greatest crop production value years compared to No Action (average annual)	Decrease during eight least crop production value years compared to No Action (average annual)	% Decrease during eight least crop production value years compared to No Action (average annual)
Montana	McCone	0.1%	$1,004,000	$1,000	$23,000	2.3%	-$11,000	-1.1%
	Valley	0.1%	$438,000	$1,000	$11,000	2.5%	-$4,000	-0.9%
	Roosevelt	0.1%	$849,000	$1,000	$42,000	4.9%	-$29,000	-3.5%
	Richland	-0.1%	$1,214,000	-$1,000	$62,000	5.1%	-$74,000	-6.1%
North Dakota	Williams	0.0%	$558,000	$,000	$4,000	0.8%	-$3,000	-0.6%
	McLean	-0.1%	$718,000	-$1,000	$3,000	0.4%	-$10,000	-1.4%
	Mercer	0.0%	$70,000	$,000	$2,000	3.3%	-$3,000	-3.7%
	Oliver	-0.1%	$166,000	$,000	$15,000	9.1%	-$16,000	-9.5%
	Burleigh	-0.1%	$371,000	$,000	$1,000	0.3%	-$5,000	-1.2%
	Morton	-0.1%	$340,000	$,000	$1,000	0.3%	-$4,000	-1.1%
	Emmons	2.8%	$214,000	$6,000	$48,000	23.2%	-$9,000	-4.5%
South Dakota	Sully	1.1%	$862,000	$10,000	$111,000	13.0%	-$34,000	-4.0%
Total		0.2%	$6,804,000	$15,000	$183,000	2.7%	-$128,000	-1.9%

Small decreases in net farm income would occur in some years relative to Alternative 1, but would be more than offset by increases in net farm income in other years. The highest adverse impact would occur under conditions similar to those modeled in 2008. Flows out of Fort Peck Lake would very briefly decrease under Alternative 3 relative to Alternative 1 and affect access to irrigation. Overall, the changes in net farm income would be negligible and beneficial because of continued access to water for irrigation and only minor changes in annual irrigation operations and net farm income compared to Alternative 1.

Overall, farms using Missouri River water for irrigation would experience relatively small, beneficial impacts under Alternative 3 relative to Alternative 1, with the exception of two counties that experienced small adverse impacts. In the case of these two counties, the change in average annual income is caused by isolated years of adverse impact but not ongoing impacts lasting more than two years and occur drought conditions.

The increase in total net farm income for the twelve counties evaluated would apply to most of the counties in the upper reaches of the river, but the largest increase in total net farm income would occur in Sully County, with an increase of $787,000 relative to Alternative 1 ($10,000 on average).

Figure 6 shows the annual NED impacts to irrigation intakes for all counties over the entire POR. The figure shows relatively consistent increases in net farm income for irrigators throughout the POR, and isolated periods of adverse impacts. There is one year, as simulated under 2008 conditions, when there would be noticeable adverse impacts. Under conditions similar to those in 2008, total net farm income would drop by $587,000 compared to Alternative 1, almost entirely as a result of decreases in net farm income in Richland and Roosevelt counties. Very brief periods of lower river flow in the upper reaches of the river would result in large impacts to irrigators in conditions similar to 2008 under Alternative 3 relative to Alternative 1.

Similarly, very small increases in water flow relative to Alternative 1 can have small but measurable increases in net farm income under conditions similar to Alternative 3. Relatively small increases in elevation at Lake Oahe from the elimination of the spring plenary pulse, as modeled in 1955, 1959, and 1964, would result in small but measurable increases in net farm income relative to Alternative 1.

5.4 Alternative 4 – Spring ESH Creating Release

Table 12 summarizes the results for Alternative 4 which would have a small, adverse impact on irrigation relative to Alternative 1, with average annual net farm income of $6.72 million, a slight decrease of $69,000 from Alternative 1 (1.0%). Adverse impacts under Alternative 4 would occur in the counties bordering Lake Sakakawea (Williams, Mercer, and McLean) and Lake Oahe (Emmons, Sully) in the years of or following the spring release, which reduces the reservoir elevations during the irrigation seasons. On average, the counties in Montana would experience small increases in annual net farm income during the releases that would partly occur during the growing seasons, resulting in an increase in water access for irrigation in the Montana counties.

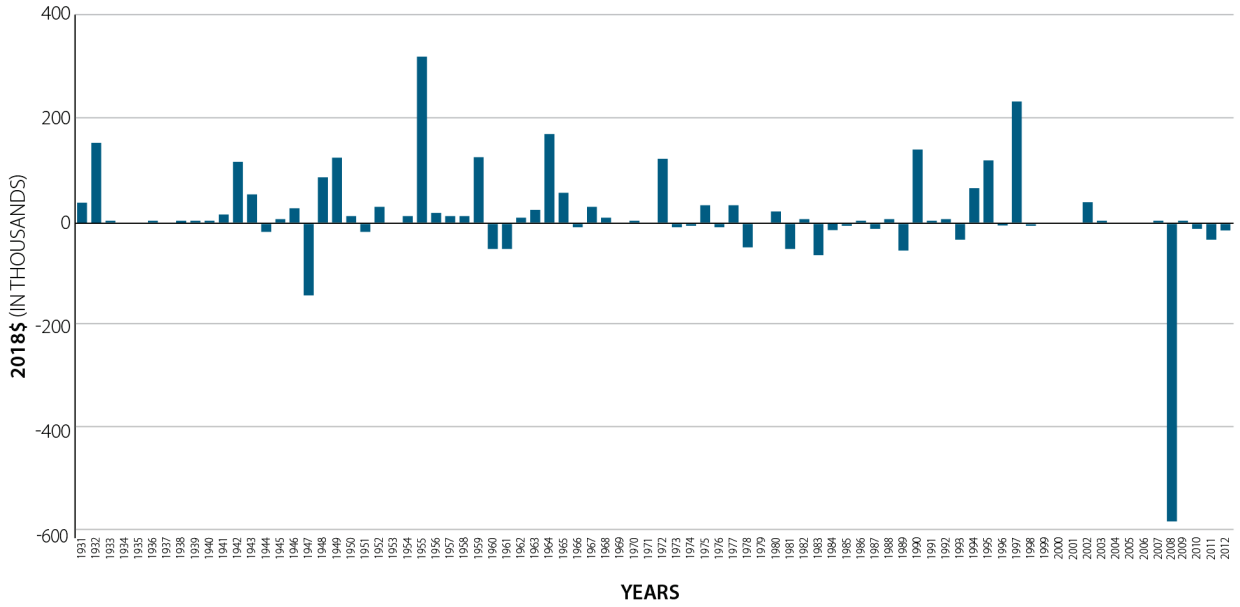

Figure 6. Annual Difference in Net Farm Income under Alternative 3 Relative to Alternative 1 (2018 Dollars)

Table 12. Summary of National Economic Development Analysis for Alternative 4 (2018$)

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to No Action (average annual)	% Increase during eight greatest crop production value years compared to No Action (average annual)	Decrease during eight least crop production value years compared to No Action (average annual)	% Decrease during eight least crop production value years compared to No Action (average annual)
Montana	McCone	1.1%	$1,014,000	$11,000	$127,000	12.7%	-$37,000	-3.7%
	Valley	1.3%	$443,000	$6,000	$65,000	14.8%	-$14,000	-3.3%
	Roosevelt	1.6%	$862,000	$14,000	$175,000	20.6%	-$76,000	-8.9%
	Richland	1.5%	$1,233,000	$18,000	$249,000	20.5%	-$119,000	-9.8%
North Dakota	Williams	-3.0%	$541,000	-$17,000	$4,000	0.7%	-$110,000	-19.7%
	McLean	-1.2%	$710,000	-$9,000	$65,000	9.0%	-$128,000	-17.8%
	Mercer	-11.9%	$62,000	-$8,000	$9,000	12.6%	-$56,000	-79.2%
	Oliver	-1.9%	$163,000	-$3,000	$45,000	26.9%	-$66,000	-40.0%
	Burleigh	-1.2%	$367,000	-$4,000	$10,000	2.6%	-$53,000	-14.2%
	Morton	-0.9%	$338,000	-$3,000	$1,000	0.4%	-$32,000	-9.4%
	Emmons	-11.5%	$184,000	-$24,000	$43,000	20.9%	-$183,000	-88.1%
South Dakota	Sully	-5.9%	$803,000	-$50,000	$41,000	4.8%	-$402,000	-47.1%
Total		-0.8%	$6,719,000	-$69,000	$621,000	9.1%	-$808,000	-11.9%

Farms on Lake Sakakawea and Lake Oahe would experience temporary, relatively small, and adverse impacts on net farm income relative to Alternative 1. However, farms upstream of Lake Sakakawea and downstream of Fort Peck Lake would experience beneficial impacts on average relative to Alternative 1. The spring release under Alternative 4 would result in adverse impacts to the counties adjacent to Lake Sakakawea (Williams, McLean, and Mercer) and Lake Oahe (Emmons and Sully County). Elevations at Lake Sakakawea and Lake Oahe would be several feet lower during and following flow releases, and counties that rely on these reservoirs would be adversely affected through decreases in access to water. Counties upstream of Lake Sakakawea in Montana would experience generally beneficial impacts relative to Alternative 1 as a result of the reservoirs rebalancing after the spring releases increasing river flows and increasing water for irrigation access.

The largest losses in total net farm income under Alternative 4 would occur in the Sully County, South Dakota and nearby counties. The largest percentage decline in total net farm income would occur in Mercer County, with a decline of 11.9 percent, with the worst change years occurring in 1994 (full release the year after a drought period), 2009 (partial release the year after a drought period), and 1946 (full release). For Sully County, annual average net farm income would be $50,000 lower under Alternative 4 relative to Alternative 1, with the worst change years occurring in 1963 (full release), 1964 (year following a full release), and 2002 (full release coinciding with a period of drought). The impacts to Sully County would be persistent across the 82-year period, and reflect low water elevations at Lake Oahe in the year and years following the spring release.

Figure 7 shows the annual NED impacts associated with different flow events compared to Alternative 1. The most adverse impacts to net farm income would occur during full release events when releases are followed by the onset of a drought or relatively drier conditions, with a decrease across all counties of $1.6 million. In conditions similar to 1963, a full release would be implemented. Low flow out of Fort Peck during the growing season would adversely impact the four counties located in Montana by as much as $277,000 for all four counties. In addition, the counties bordering Lake Oahe and Lake Sakakawea (Sully, Mercer, McLean, and Williams) would be adversely impacted in this year. The highest adverse impact would occur in Sully County, with a decrease of $896,000 due to low reservoir elevations on Lake Oahe. In Sully County, $896,000 would represent approximately 1.2 percent of net cash farm income of all operations ($76.1 million) (USDA 2012). The second-highest year of adverse impact ($1.1 million) would occur in conditions similar to 1964, when the reservoirs would be lower following the full ESH creating release in 1963.

Years with increases in net farm income compared to Alternative 1 would also occur as the reservoirs rebalance after the spring release, with the greatest increase in net farm income of $1.5 million across all counties. The counties that would experience the highest beneficial impact relative to Alternative 1 are located downstream of Fort Peck Dam in Montana (Valley, Roosevelt, Richland, and McCone counties).

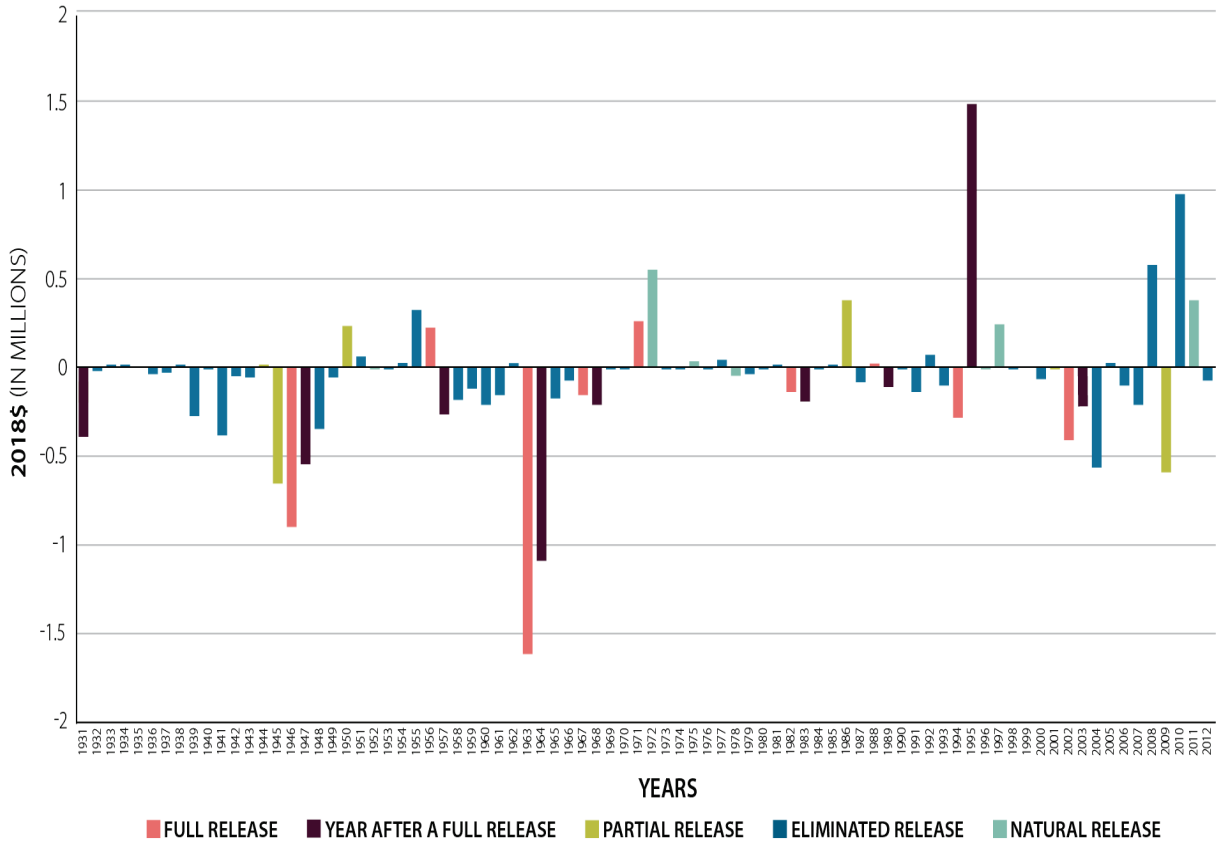

Figure 7. Annual Difference in Net Farm Income under Alternative 4 Relative to Alternative 1 (2018 Dollars)

5.5 Alternative 5 – Fall ESH Creating Release

The NED results for Alternative 5 are summarized in Table 13. Under Alternative 5, average annual net farm income would be approximately $6.83 million, an increase of $44,000 (0.6%) for all twelve counties relative to Alternative 1. In general, there would be negligible to small increases in net farm income in the Montana counties downstream of Fort Peck Dam, associated with the fall release, and there would be negligible to small decreases in net farm income in a couple of years following the fall releases for irrigation operations in counties bordering Lake Sakakawea and Lake Oahe. Releases from Fort Peck Dam associated with the implementation of the fall release would increase river stages and flows during the growing season below Fort Peck Dam, with small increases in net farm income for irrigators in the Montana counties under these conditions. However, in a few years following the fall release, reservoir elevations at Lake Oahe and Lake Sakakawea would be lower than under Alternative 1, with adverse impacts to net farm income to operations in counties that border these reservoirs.

Figure 8 summarizes changes in net farm income associated with different flow events compared to Alternative 1. The greatest increases in net farm income would occur during the years when there would be a full release simulated to occur, with most of the beneficial effects to irrigation occurring in Montana counties when river stages and flows are relatively higher under Alternative 5.

The year of highest adverse impact to net farm income relative to Alternative 1 would occur under conditions similar to 1988, in the year following a full release when reservoirs and river stages would be lower than under Alternative 1. Adverse impacts would be highest for the counties located downstream of Fort Peck Lake, ranging from a decrease of $176,000 in Richland County to a decrease of $37,000 in Williams County. In 1984, the year following a fall release, McLean County would be the most adversely impacted county, with a decrease of $129,000 in net farm income relative to Alternative 1.

The greatest increases in net farm income would occur during the full release years and the years following full releases, when releases from Fort Peck Dam would be higher than under Alternative 1, with small increases in net farm income for irrigators in the Montana counties.

5.6 Alternative 6 – Pallid Sturgeon Spawning Cue

The NED results for Alternative 6 are summarized in Table 14. Under Alternative 6, average annual net farm income would be $6.67 million, a decrease of $115,000 relative to Alternative 1 (-1.7%). Sully County would experience the greatest average annual decrease in net farm income (-$75,000) associated with reduced lake elevations at Lake Oahe following the spawning cue release. To a lesser extent, North Dakota counties bordering Lake Sakakawea would also experience small adverse reductions in net farm income from relatively lower reservoir elevation following the spawning cue release. In the average of the eight worst years, Sully County would experience a decrease in net farm income of $523,000. In specific counties, individual farms that rely on the Missouri River for irrigation could experience isolated adverse impacts in some years. However, during the best difference years, with increased net farm income compared to Alternative 1, many of these adverse impacts would be offset, resulting in very small changes on average to net farm income under Alternative 6 relative to Alternative 1.

Table 13. Summary of National Economic Development Analysis for Alternative 5 (2018$)

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to No Action (average annual)	% Increase during eight greatest crop production value years compared to No Action (average annual)	Decrease during eight least crop production value years compared to No Action (average annual)	% Decrease during eight least crop production value years compared to No Action (average annual)
Montana	McCone	0.8%	$1,011,000	$8,000	$94,000	9.4%	-$20,000	-2.0%
	Valley	1.0%	$442,000	$4,000	$46,000	10.5%	-$5,000	-1.1%
	Roosevelt	1.7%	$862,000	$14,000	$151,000	17.8%	-$29,000	-3.4%
	Richland	1.9%	$1,238,000	$23,000	$231,000	19.0%	-$38,000	-3.1%
North Dakota	Williams	-0.6%	$554,000	-$3,000	$8,000	1.5%	-$34,000	-6.1%
	McLean	-0.2%	$717,000	-$2,000	$19,000	2.6%	-$36,000	-5.0%
	Mercer	-1.7%	$69,000	-$1,000	$6,000	8.8%	-$16,000	-23.0%
	Oliver	-0.9%	$164,000	-$2,000	$25,000	15.2%	-$41,000	-24.5%
	Burleigh	0.0%	$372,000	$,000	$5,000	1.4%	-$5,000	-1.2%
	Morton	0.0%	$341,000	$,000	$2,000	0.7%	-$3,000	-1.0%
	Emmons	-1.0%	$206,000	-$2,000	$47,000	22.7%	-$83,000	-39.9%
South Dakota	Sully	0.5%	$857,000	$4,000	$96,000	11.3%	-$71,000	-8.3%
Total		0.6%	$6,833,000	$44,000	$529,000	7.8%	-$224,000	-3.3%

Table 14. Summary of National Economic Development Analysis for Alternative 6 (2018$)

State	County	Percent Change Relative to Alternative 1	Average Annual Net Farm Income	Change in Average Annual Net Farm Income Relative to Alternative 1	Increase during eight greatest crop production value years compared to No Action (average annual)	% Increase during eight greatest crop production value years compared to No Action (average annual)	Decrease during eight least crop production value years compared to No Action (average annual)	% Decrease during eight least crop production value years compared to No Action (average annual)
Montana	McCone	0.4%	$1,007,000	$4,000	$101,000	10.1%	-$67,000	-6.7%
	Valley	0.5%	$440,000	$2,000	$50,000	11.5%	-$29,000	-6.7%
	Roosevelt	1.3%	$859,000	$11,000	$178,000	21.0%	-$102,000	-12.0%
	Richland	1.0%	$1,227,000	$12,000	$251,000	20.7%	-$185,000	-15.2%
North Dakota	Williams	-0.9%	$552,000	-$5,000	$8,000	1.5%	-$34,000	-6.1%
	McLean	-1.6%	$707,000	-$11,000	$10,000	1.4%	-$107,000	-14.8%
	Mercer	-6.5%	$66,000	-$5,000	$4,000	6.3%	-$29,000	-41.6%
	Oliver	-3.7%	$160,000	-$6,000	$15,000	9.3%	-$63,000	-38.2%
	Burleigh	-0.6%	$369,000	-$2,000	$7,000	2.0%	-$29,000	-7.8%
	Morton	-0.4%	$339,000	-$1,000	$3,000	0.9%	-$15,000	-4.3%
	Emmons	-18.7%	$169,000	-$39,000	$29,000	13.9%	-$229,000	-110.3%
South Dakota	Sully	-8.8%	$778,000	-$75,000	$9,000	1.0%	-$523,000	-61.4%
Total		-1.7%	$6,674,000	-$115,000	$498,000	7.3%	-$921,000	-13.6%

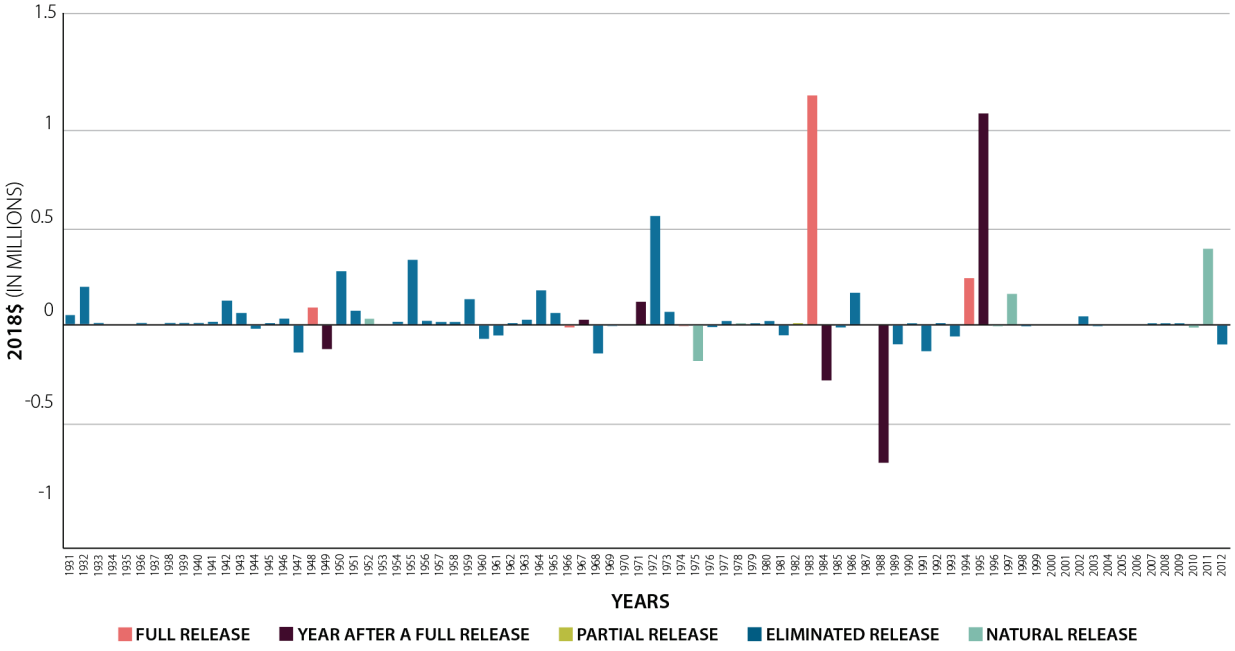

Figure 8. Annual Difference in Net Farm Income under Alternative 5 Relative to Alternative 1 (2018 Dollars)

Average annual net farm income for all counties would be $6.67 million, and would decrease by $115,000 relative to Alternative 1 (1.7 percent).

Net farm income would decrease under Alternative 6 for counties in North Dakota and South Dakota, while counties in Montana would experience a slight increase in net farm income. Sully County, which is located on Lake Oahe, would have the highest overall change in dollar value, relative to Alternative 1, with an average annual decrease of $75,000 in net farm income. Emmons County would experience the largest percentage decrease in net farm income relative to Alternative 1, with a decrease of 18.7 percent.

Figure 9 shows the annual NED impacts tied to different flow events relative to Alternative 1. Full releases would result in adverse impacts to net farm income. As simulated in 1963, a full release would occur under Alternative 6. The counties in Montana would experience adverse impacts during this year, with decreases in net income as large as $277,000 relative to Alternative 1. However, reservoir elevations at Lake Oahe would decrease by as much as 8 feet during this year relative to Alternative 1, and Sully County would experience the highest adverse impact to net farm income with a decrease of $961,000. This decrease in net income would represent 1.4 percent of net cash farm income of all farming operations in Sully County (USDA 2012).

The year of highest adverse impact to net farm income relative to Alternative 1 would occur under conditions similar to 2010, the year following a partial release, when net farm income would be $1.8 million lower than under Alternative 1. During reservoir rebalancing, the counties in Montana would be adversely impacted relative to Alternative 1 as a result of lower releases from Fort Peck Dam, with decreases in net farm income ranging from $39,000 to $574,000 relative to Alternative 1. The decrease in Richland County, the county to experience the largest

adverse impact in this year, would equal a decrease of 1.5 percent of net cash farm income of all operations in that county (USDA 2012).

Generally, the greatest increases in net farm income relative to Alternative 1 would occur in the counties in Montana. In several years over the POR river stages downstream of Fort Peck are higher as releases increase during reservoir rebalancing in the years following full and partial releases. The greatest increase in net farm income would occur in 1983, with an increase of $1.3 million in net farm income compared to Alternative 1. This is particularly true for Richland County, which would experience an increase of $638,000 in net farm income relative to Alternative 1, which would account for 1.7 percent of net cash farm income of all farming operations in that county (USDA 2012).

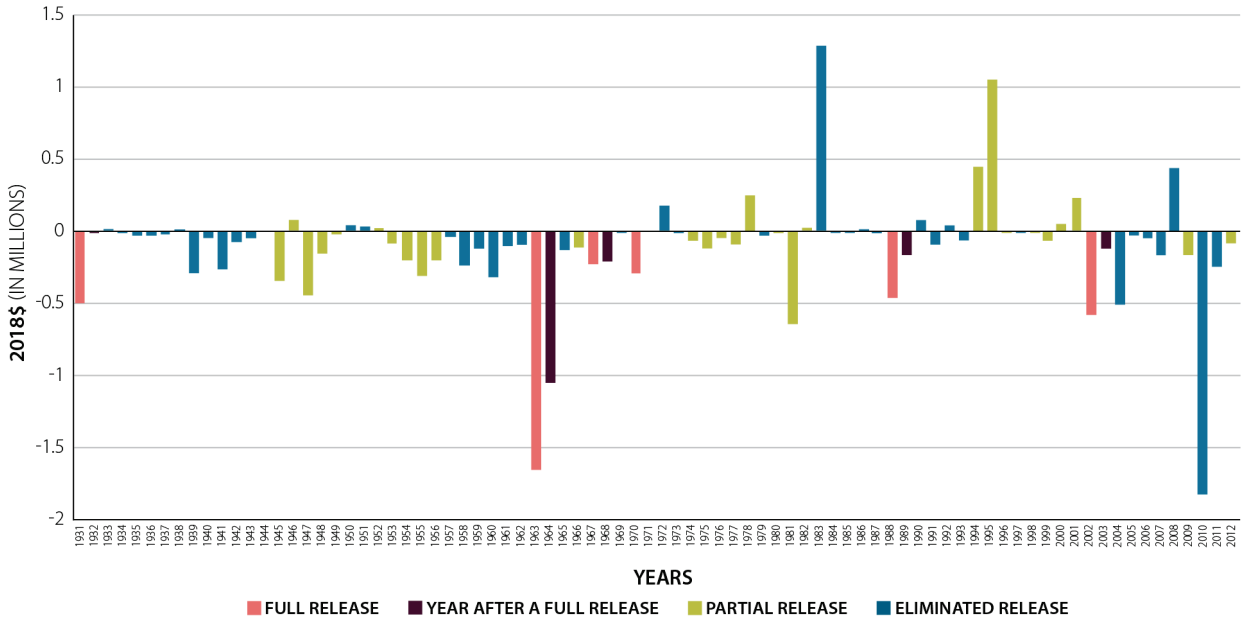

Figure 9. Annual Difference in Net Farm Income under Alternative 6 Relative to Alternative 1 (2018 Dollars)

6.0 Regional Economic Development Analysis

The RED analysis focuses on changes in the distribution of economic activity at a local and regional scale. For irrigation, the RED analysis focused on the change in employment, income, and sales that would occur at the regional level for each of the MRRMP-EIS alternatives. The RED impacts were estimated by examining changes in gross sales of crops grown using water from the Missouri River for irrigation purposes. The methodology and results are discussed in detail under this section.

The results in this section focus on changes in sales, labor income, and employment in each county associated with the MRRMP-EIS alternatives. Economic impacts estimated with IMPLAN® are reported on an annual basis. Three scenarios were developed that describe the range of RED impacts that can occur under each of the MRRMP-EIS alternatives. Each of the

scenarios was based on net sales calculated for each county under each alternative and are summarized in Table 15.

Table 15. Scenarios Considered in the Regional Economic Development Analysis

Scenario	Description
Average Annual Value of Crop Production	The average annual production value for each county for all years included in the POR by alternative.
Average of the 8 Greatest Production Value Years Compared to Alt 1	The average annual production value observed in the eight greatest crop production value years compared to No Action.
Average of the 8 Least Production Value Years Compared to Alt 1	The average annual production value observed in the eight least crop production value years compared to No Action.

6.1 Summary of Regional Economic Development Results

The RED analysis for each alternative is summarized in Table 16. The table shows the total average annual employment, labor income, and sales for all twelve counties. Across all alternatives, annual average employment varies only by 1.15 jobs. Tables 17, 18, and 19 summarize these results for each of the twelve counties analyzed. For all alternatives, the change in RED impacts relative to Alternative 1 are extremely small.

Table 16. Regional Economic Development Results for All Twelve Counties by Alternative Based on Average Annual Production Values

Type of Impact	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Employment	341	340	341	341	341	340
Labor Income	$13,555	$13,526	$13,560	$13,540	$13,577	$13,524
Output	$52,698	$52,578	$52,721	$52,604	$52,766	$52,537

Note: All dollar values are in 2018 dollars.

The location of the county plays an important role in determining the modeled level of employment, labor income, or output. Crops such as potatoes and hay require more labor than beans and soybeans, and IMPLAN® assigns a higher number of jobs per million dollars of crop production for these farming sectors. Accordingly, when counties that grow more of those high-labor crops are impacted under an alternative, the modeled impact may be greater than with counties with relatively lower labor productivity are impacted.

Table 18 summarizes the change in employment based on the change in average annual net farm income from crop production as described in Section 6.0 (‘Annual Average Production Value’). Because eight years is approximately equal to ten percent of the POR, the RED analysis also includes the change in employment during the average of the eight worst years and eight best years relative to Alternative 1 (‘Average Production Value for 8 Worst/Best Years’). Because this count is only calculated relative to Alternative 1, the eight best and eight worst years are not analyzed under Alternative 1.

Table 17. Employment Results by Alternative

County	Type of Impact	Alt 1 Total Annual Average Employment	Change in Annual Average Employment Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
McCone	Annual Average Production Value	48.6	0.0	0.0	0.1	0.1	0.1
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-1.8	-0.1	-0.5	-0.3	-0.8
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	1.8	0.3	1.6	1.2	1.3
Valley	Annual Average	22.3	0.0	0.0	0.1	0.1	0.0
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-1.1	-0.1	-0.2	-0.1	-0.5
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	1.1	0.2	1.1	0.8	0.9
Roosevelt	Annual Average	61.7	-0.1	0.0	0.2	0.2	0.1
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-2.6	-0.4	-0.9	-0.4	-1.2
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	2.5	0.5	2.1	1.8	2.1
Richland	Annual Average	70.5	-0.2	0.0	0.2	0.3	0.1
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-3.9	-0.9	-1.4	-0.4	-2.1
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	3.3	0.7	2.9	2.7	2.9
Williams	Annual Average	31.3	0.0	0.0	-0.2	0.0	-0.1
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-0.8	0.0	-1.6	-0.5	-0.5
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.6	0.1	0.1	0.1	0.1
McLean	Annual Average	30.2	0.0	0.0	-0.1	0.0	-0.1
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-26.1	-2.4	-31.0	-8.7	-25.9
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	23.3	27.7	15.7	4.6	2.4
Mercer	Annual Average	6.1	0.0	0.0	0.0	0.0	0.0
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-0.1	0.0	-0.3	-0.1	-0.1
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.2	0.0	0.0	0.0	0.0
Oliver	Annual Average	11.1	0.0	0.0	0.0	0.0	0.0
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-0.5	-0.1	-0.3	-0.2	-0.3

County	Type of Impact	Alt 1 Total Annual Average Employment	Change in Annual Average Employment Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.3	0.1	0.2	0.1	0.1
Burleigh	Annual Average	8.4	0.0	0.0	0.0	0.0	0.0
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-0.3	0.0	-0.2	0.0	-0.1
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.1	0.0	0.0	0.0	0.0
Morton	Annual Average	9.0	0.0	0.0	0.0	0.0	0.0
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-0.3	0.0	-0.3	0.0	-0.1
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.1	0.0	0.0	0.0	0.0
Emmons	Annual Average	17.7	-0.1	0.0	-0.1	0.0	-0.2
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-1.0	0.0	-0.9	-0.4	-1.2
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.4	0.2	0.2	0.2	0.1
Sully	Annual Average	23.9	-0.1	0.0	-0.2	0.0	-0.4
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-1.2	-0.2	-2.0	-0.3	-2.6
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	0.5	0.5	0.2	0.5	0.0

Table 18. Labor Income Results by Alternative (2018$)

County	Type of Impact	Alt 1	Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
McCone	Annual Average	$1,701,684	-$901	$466	$4,935	$3,681	$1,767
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$61,441	-$5,032	-$16,288	-$8,760	-$29,440
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$64,267	$10,179	$55,943	$41,151	$44,366
Valley	Annual Average	$699,230	-$629	$352	$3,105	$2,404	$1,212
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$34,206	-$2,154	-$7,673	-$2,509	-$15,689
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$33,671	$5,907	$34,937	$24,831	$27,061
Roosevelt	Annual Average	$2,171,205	-$2,150	$415	$5,907	$6,130	$4,721
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$92,371	-$12,525	-$32,234	-$12,333	-$43,268
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$88,739	$17,656	$74,317	$64,342	$75,575
Richland	Annual Average	$2,976,145	-$6,418	-$705	$8,880	$11,020	$6,006
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$166,277	-$36,054	-$57,658	-$18,247	-$89,492
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$139,141	$29,878	$120,689	$111,978	$121,641
Williams	Annual Average	$966,123	-$838	$101	-$7,577	-$1,455	-$2,328
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$23,624	-$1,542	-$50,420	-$15,495	-$15,602
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$19,530	$1,941	$1,701	$3,886	$3,833
McLean	Annual Average	$1,006,298	-$1,051	-$248	-$3,081	-$626	-$3,981
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$870,562	-$81,147	-$1,033,698	-$290,056	-$862,883
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$775,683	$924,722	$522,417	$152,894	$79,845

County	Type of Impact	Alt 1	Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Mercer	Annual Average	$275,931	-$27	$7	-$1,899	-$269	-$1,028
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$6,493	-$593	-$12,624	-$3,657	-$6,628
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$7,398	$522	$2,015	$1,402	$1,011
Oliver	Annual Average	$529,856	-$1,241	-$21	-$716	-$349	-$1,425
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$23,508	-$3,632	-$15,277	-$9,359	-$14,577
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$13,368	$3,474	$10,260	$5,794	$3,564
Burleigh	Annual Average	$444,354	-$984	-$86	-$1,040	$16	-$567
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$13,538	-$1,105	-$12,601	-$1,078	-$6,894
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$3,917	$226	$2,327	$1,243	$1,738
Morton	Annual Average	$319,793	-$777	-$80	-$989	-$33	-$418
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$9,679	-$1,169	-$10,235	-$1,076	-$4,687
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$1,959	$348	$429	$740	$942
Emmons	Annual Average	$768,084	-$5,326	$1,276	-$5,272	-$475	-$8,553
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$42,048	-$2,081	-$40,846	-$18,507	-$51,139
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$16,016	$10,771	$9,668	$10,549	$6,465
Sully	Annual Average	$1,695,978	-$7,273	$3,359	-$17,514	$1,386	-$26,176
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$83,417	-$11,951	-$140,611	-$24,738	-$183,222
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$32,962	$38,685	$14,236	$33,635	$3,091

Table 19. Sales Results by Alternative (2018$)

County	Type of Impact	Alt 1	Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
McCone	Annual Average	$5,573,635	-$2,951	$1,527	$16,163	$12,054	$5,788
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$201,246	-$16,480	-$53,344	-$28,691	-$96,424
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$210,503	$33,340	$183,212	$134,772	$145,309
Valley	Annual Average	$1,955,318	-$1,758	$983	$8,683	$6,723	$3,391
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$95,654	-$6,025	-$21,455	-$7,015	-$43,873
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$94,158	$16,519	$97,698	$69,437	$75,672
Roosevelt	Annual Average	$7,742,825	-$7,666	$1,481	$21,063	$21,860	$16,835
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$329,417	-$44,665	-$114,939	-$43,978	-$154,290
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$316,465	$62,963	$265,003	$229,433	$269,492
Richland	Annual Average	$9,427,716	-$20,334	-$2,233	$28,123	$34,901	$19,022
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$526,806	-$114,214	-$182,609	-$57,787	-$283,449
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$440,834	$94,648	$382,234	$354,629	$385,274
Williams	Annual Average	$2,950,016	-$2,558	$308	-$23,135	-$4,443	-$7,108
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$72,134	-$4,708	-$153,953	-$47,314	-$47,638
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$59,635	$5,925	$5,194	$11,864	$11,704
McLean	Annual Average	$4,072,514	-$4,255	-$1,004	-$12,471	-$2,534	-$16,114
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$3,523,415	-$328,408	-$4,184,206	-$1,173,910	-$3,492,981
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$3,139,415	$3,742,430	$2,114,642	$618,792	$323,217

County	Type of Impact	Alt 1	Relative to Alternative 1				
			Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Mercer	Annual Average	$1,738,947	-$170	$45	-$11,964	-$1,694	-$6,476
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$40,917	-$3,737	-$79,540	-$23,048	-$41,762
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$46,621	$3,288	$12,696	$8,836	$6,370
Oliver	Annual Average	$3,244,367	-$7,597	-$129	-$4,386	-$2,136	-$8,728
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$143,943	-$22,242	-$93,545	-$57,308	-$89,256
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$81,853	$21,274	$62,825	$35,476	$21,821
Burleigh	Annual Average	$2,567,968	-$5,689	-$496	-$6,012	$93	-$3,277
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$78,231	-$6,386	-$72,819	-$6,229	-$39,842
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$22,635	$1,305	$13,449	$7,185	$10,045
Morton	Annual Average	$1,412,307	-$3,431	-$354	-$4,367	-$145	-$1,845
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$42,740	-$5,165	-$45,196	-$4,753	-$20,699
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$8,651	$1,538	$1,893	$3,268	$4,162
Emmons	Annual Average	$4,953,008	-$34,351	$8,229	-$34,007	-$3,065	-$55,180
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$271,222	-$13,420	-$263,465	-$119,347	-$329,919
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$103,305	$69,450	$62,361	$68,030	$41,709
Sully	Annual Average	$7,059,734	-$30,277	$13,983	-$72,912	$5,768	-$108,977
	Average of the 8 Least Production Value Years Compared to Alt 1	n/a	-$347,244	-$49,748	-$585,361	-$102,973	-$762,783
	Average of the 8 Greatest Production Value Years Compared to Alt 1	n/a	$137,215	$161,029	$59,264	$140,009	$12,868

6.2 Alternative 1 – No Action (Current System Operation and MRRP Management Actions

The RED analysis for Alternative 1 was focused on employment, labor income, and sales associated with the value of crop production from irrigated agriculture in the twelve counties being evaluated. Table 20 summarizes the economic contribution of irrigation for all counties. Note that employment, labor income, and total sales are described here as 'contribution' because regional economic benefits are currently being supported under existing conditions and do not represent an impact of MRRMP-EIS actions.

Under Alternative 1, irrigated agriculture would support 340 jobs per year on average for all counties, $14 million in labor income, and $53 million in sales. The number of jobs supported on average annually would be highest in Richland County, with 70.5 jobs (Table 17). Average annual labor income would be highest in Richland County at $2.9 million.[6] Average annual sales would also be highest in Richland County at $9.4 million per year. Average annual labor income and sales would be lowest in Morton County at $319,793 and $1.4 million, respectively.

Table 20. Regional Economic Development Effects for Irrigated Agriculture Using Missouri River Water: Alternative 1 (2018$)

Economic Contribution	Scenario	Total
Employment	Average Annual Value of Production	340.8
Labor Income	Average Annual Value of Production	$13,555,000
Total Sales	Average Annual Value of Production	$52,698,000

6.3 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Relative to Alternative 1, average annual change in employment, labor income, and sales would be negligible under Alternative 2 (Table 21). For all twelve counties evaluated employment would decrease by 0.6 jobs per year. Sully County (SD), Richland County (MT), and Emmons County (ND) would account for much of the change in sales, employment, and labor income. The least affected county would be Mercer County, with virtually no change in jobs, employment, or sales relative to Alternative 1 (Tables 17, 18, and 19). Under the average eight worst years when the value of production would be lower than under Alternative 1 from relatively lower lake elevations and river stages affecting access for irrigation water, there would be a reduction of 40 jobs and $1.4 million in labor income. The majority of these jobs would be lost in McLean County, with a loss of 26 jobs in the average eight worst years, followed by Richland, with a loss of 4 jobs.

[6] In considering this labor income impact, it is worth noting that labor income is calculated based on sales, which do not account for the cost of production.

Table 21. Regional Economic Development Impacts of Alternative 2 Relative to Alternative 1 (2018$)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	340.2
	Change in Average Annual from Alternative 1	-0.6
	Average of the 8 Greatest Production Value Years Compared to Alt 1	34.0
	Average of the 8 Least Production Value Years Compared to Alt 1	-39.6
Labor Income	Average Annual Value of Production	$13,526,000
	Change in Average Annual from Alternative 1	-$29,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$1,174,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$1,400,000
Sales	Average Annual Value of Production	$52,578,000
	Change in Average Annual from Alternative 1	-$120,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$4,573,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$5,565,000

Note: All dollar values are reported in 2018 dollars.

6.4 Alternative 3 – Mechanical Construction Only

Alternative 3 would have negligible RED impacts relative to Alternative 1. About half of the counties in this analysis (seven) experience small, beneficial impacts in economic activity, while the other half experience small, adverse impacts. The most adversely impacted county would be Richland, where average annual labor income would be $705 lower when compared to Alternative 1 (Table 18). For the other counties, there would be a change of less than $300 dollars in labor income, on average annually. None of the counties would experience a change in average annual employment of more than one job relative to Alternative 1 (Table 17). During the average of the eight lowest value of production years compared to Alternative 1, there would be a decrease of 4 jobs and $156,000 in labor income (Table 22). The impact would be largest in McLean during the average of the eight lowest value production years, with a decrease of 2 jobs, $81,000 in labor income, and $328,000 in sales.

Table 22. Regional Economic Development Impacts of Alternative 3 Relative to Alternative 1 (2018$)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	340.9
	Change in Average Annual from Alternative 1	0.1
	Average of the 8 Greatest Production Value Years Compared to Alt 1	30.4
	Average of the 8 Least Production Value Years Compared to Alt 1	-4.3
Labor Income	Average Annual Value of Production	$13,560,000
	Change in Average Annual from Alternative 1	$5,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$1,024,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$156,000
Sales	Average Annual Value of Production	$52,721,000
	Change in Average Annual from Alternative 1	$23,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$4,134,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$604,000

Note: All dollar values are reported in 2018 dollars.

6.5 Alternative 4 – Spring ESH Creating Release

Under Alternative 4, the counties located in Montana downstream of Fort Peck Dam would experience small, beneficial impacts relative to Alternative 1, while the counties in North Dakota and South Dakota bordering Lake Sakakawea and Lake Oahe would experience small, adverse impacts relative to Alternative 1. On average, the change in economic activity would lead to a decrease in annual employment of less than one job and a reduction in annual labor income of $15,000 across all twelve counties relative to Alternative 1 (Table 23). Sully County would experience the largest impacts on average with average annual employment decreasing by less than one job, average annual labor income declining by $18,000, and average annual sales declining by $73,000. During the eight worst difference years compared to Alternative 1, average labor income would be $1.4 million lower than Alternative 1, and the number of jobs would decrease by almost 40. Effects under the eight least production years would be largest in McLean County, which would experience a loss of 31 jobs, $1.0 million in labor income, and $4.2 million in sales.

Table 23. Regional Economic Development Impacts of Alternative 4 Relative to Alternative 1 (2018$)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	340.6
	Change in Average Annual from Alternative 1	-0.2
	Average of the 8 Greatest Production Value Years Compared to Alt 1	24.1
	Average of the 8 Least Production Value Years Compared to Alt 1	-39.7
Labor Income	Average Annual Value of Production	$13,540,000
	Change in Average Annual from Alternative 1	-$15,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$833,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$1,403,000
Sales	Average Annual Value of Production	$52,604,000
	Change in Average Annual from Alternative 1	-$94,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$3,199,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$5,739,000

Note: All dollar values are reported in 2018 dollars.

6.6 Alternative 5 – Fall ESH Creating Release

The changes in RED impacts under Alternative 5 are negligible in all counties compared to Alternative 1 (Table 24). On average, annual employment would increase by less than one job for all counties. Economic activity in half of the counties (six out of twelve), including all of the counties in Montana, would improve under Alternative 5, though these changes would be small relative to Alternative 1. Richland County would experience the largest benefit relative to Alternative 1, with an increase in average annual labor income of $11,000 relative to Alternative 1 (Table 18). Emmons County would experience the largest adverse impacts compared to other counties in terms of impacts to sales, with an average annual decrease of approximately $3,000 (Table 19). Collectively, the four counties in Montana would experience an increase in average annual sales of approximately $76,000 relative to Alternative 1. During the eight worst difference years modeled relative to Alternative 1, average labor income would decrease by $398,000 with a decrease of twelve jobs. As in the other MRRMP-EIS alternatives, the impacts under the eight worst difference years would be largest in McLean County, with a decrease of 9 jobs, $290,000 in labor income, and $1.2 million in sales.

Table 24. Regional Economic Development Impacts of Alternative 5 Relative to Alternative 1 (2018$)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	341.4
	Change in Average Annual from Alternative 1	0.5
	Average of the 8 Greatest Production Value Years Compared to Alt 1	12.1
	Average of the 8 Least Production Value Years Compared to Alt 1	-11.4
Labor Income	Average Annual Value of Production	$13,577,000
	Change in Average Annual from Alternative 1	$22,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$444,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$398,000
Sales	Average Annual Value of Production	$52,766,000
	Change in Average Annual from Alternative 1	$68,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$1,650,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$1,641,000

Note: All dollar values are reported in 2018 dollars.

6.7 Alternative 6 – Pallid Sturgeon Spawning Cue

RED impacts under Alternative 6 are mixed relative to the Alternative 1, with counties in Montana experiencing slight increases in RED effects relative to Alternative 1, and all other counties experiencing adverse impacts (Table 25). On average, employment would be reduced by less than one job for any of the twelve counties under Alternative 6 relative to Alternative 1 (Table 17). The counties in North Dakota and South Dakota, bordering Lake Sakakawea and Lake Oahe would experience the largest adverse effects to jobs, labor income, and sales (Table 18, Table 19, and Table 20). The four counties in Montana would experience slight benefits relative to Alternative 1, with increases in annual average labor income ranging between $1,000 and $6,000. Sully and Emmons would experience a decline of $109,000 and $55,000 respectively, in average annual sales relative to Alternative 1. However, average employment in both counties would be reduced by less than one job relative to Alternative 1 (Table 17). During the eight worst difference years relative to Alternative 1, average annual employment would decrease by 36 jobs across all twelve counties and by $1.3 million in average annual labor income. During the eight worst difference years relative to Alternative 1, McLean County would experience the largest decline in jobs, labor income, and sales, with a decrease of 26 jobs, $863,000 in labor income, and $3.5 million in sales.

Table 25. Regional Economic Development Impacts of Alternative 6 Relative to Alternative 1 (2018$)

Economic Impact	Scenario	Total
Jobs	Average Annual Value of Production	340.4
	Change in Average Annual from Alternative 1	-0.5
	Average of the 8 Greatest Production Value Years Compared to Alt 1	10.0
	Average of the 8 Least Production Value Years Compared to Alt 1	-35.6
Labor Income	Average Annual Value of Production	$13,524,000
	Change in Average Annual from Alternative 1	-$31,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$362,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$1,298,000
Sales	Average Annual Value of Production	$52,537,000
	Change in Average Annual from Alternative 1	-$161,000
	Average of the 8 Greatest Production Value Years Compared to Alt 1	$1,283,000
	Average of the 8 Least Production Value Years Compared to Alt 1	-$5,300,000

Note: All dollar values are reported in 2018 dollars.

7.0 Other Social Effects

The OSE analysis for irrigation relied on the results of the NED and RED analysis to determine the scale of impacts that could occur to individual and community well-being, traditional ways of life, and economic vitality. A qualitative discussion of the OSE impacts on irrigation operations is provided in Chapter 3 of the MRRMP-EIS.

8.0 References

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