Missouri River Recovery Program

DRAFT

Missouri River Recovery Management Plan and Environmental Impact Statement

WATER SUPPLY ENVIRONMENTAL CONSEQUENCES ANALYSIS TECHNICAL REPORT

December 2016

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Missouri River Recovery Management Plan and Environmental Impact Statement

Water Supply
Environmental Consequences Analysis

Technical Report

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Acronyms and Abbreviations

BiOp	Biological Opinion (amended in 2003)
DSS	Data Storage System
EIS	environmental impact statement
EQ	environmental quality (account)
ER	Engineering Regulation
ESH	emergent sandbar habitat
H&H	hydrologic and hydraulic (model)
HC	human considerations
HEC	Hydrologic Engineering Center
M&I	municipal and industrial
MRRIC	Missouri River Recovery Implementation Committee
MRRMP-EIS	Missouri River Recovery Management Plan and Environmental Impact Statement
MRRP	Missouri River Recovery Program
NED	national economic development (account)
O&M	operations and maintenance
OSE	other social effects (account)
P&G	1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies
POR	period of record
RAS	River Analysis System
RED	regional economic development (account)
ResSim	Reservoir System Simulation
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

The USACE in cooperation with the USFWS are developing a Missouri River Recovery Management Plan and Draft Environmental Impact Statement (MRRMP Draft EIS). The purpose of the MRRMP Draft EIS is to develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, the interior least tern, and the pallid sturgeon using USACE authorities.

The purpose of the Water Supply Technical Report is to provide additional information on the impact analysis and results relevant to water supply that was completed for the MRRMP-EIS. Additional details on the National Economic Development (NED) methodology and results are provided in this technical report. The Regional Economic Development (RED) and Other Social Effects (OSE) are presented in the MRRMP-EIS, Chapter 3, Water Supply, Environmental Consequences section. No Environmental Quality (EQ) analysis was undertaken for water supply.

1.1 Summary of Alternatives

The MRRMP-EIS evaluates the following alternatives. Detailed description of the alternatives is provided in the Draft EIS, Chapter 2.

- **Alternative 1 – No Action.** This is the no-action alternative, in which the Missouri River Recovery Program (MRRP) would continue to be implemented as it is currently, including a number of management actions associated with the MRRP and BiOp compliance. Management actions under No Action include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse. The construction of habitat will be focused in the Garrison and Gavins reaches for ESH (an average rate of 107 acres per year) and between Ponca to the mouth near St. Louis for early life stage habitat (3,999 additional acres constructed).
- **Alternative 2 – USFWS 2003 Biological Opinion Projected Actions.** This alternative represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (USFWS, 2003). Whereas No Action only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that the USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. Considerably more early life stage habitat (10,758 additional acres constructed) and ESH (an average rate of 3,546 acres per year) would be constructed under Alternative 2 than under Alternative 1. In addition, a spring pallid sturgeon flow release would be implemented every year if specific conditions were met. Alternative 2 would also modify System operations to allow for summer flows that are sufficiently low to provide for early life stage habitat as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon.
- **Alternative 3 – Mechanical Construction.** The USACE would only create ESH through mechanical means at an average rate of 391 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from system operations. The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as

well as constructing new ESH. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 3. There would not be any reoccurring flow releases or pulses implemented under this alternative.

- **Alternative 4 – Spring ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 240 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of an ESH-creating reservoir release in the spring. Alternative 4 would be similar to Alternative 1 (current operations), with the addition of a spring release designed to create ESH for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 4.
- **Alternative 5 – Fall ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 309 acres per year across the entire system. This alternative is based on Alternative 1 (current operations), with the addition of a release in the fall designed to create sandbar habitat for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 5.
- **Alternative 6 – Pallid Sturgeon Spawning Cue.** The USACE would mechanically construct ESH annually at an average rate of 303 acres per year across the entire system. In addition, the USACE would attempt a spawning cue pulse every three years in March and May. These spawning cue pulses would not be started or would be terminated whenever flood targets are exceeded. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 6.

1.2 USACE Planning Accounts

Human considerations (HC) evaluated in the MRRMP-EIS are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to HC evaluated in the MRRMP- Draft EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR 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 the USACE is described in Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services expressed in monetary units.
- The regional economic development (RED) account registers changes in the distribution of regional economic activity (i.e., jobs and income).
- The environmental quality (EQ) displays non-monetary effect on significant natural and cultural resources.
- The other social effects (OSE) account registers plan effects from perspective that are relevant to the planning process, but are not reflected in the other three accounts. In a

general sense, OSE refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention.

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

1.3 Approach for Evaluating Environmental Consequences to Water Supply Access of the Missouri River Recovery Management Plan

There are currently 55 municipal and commercial intakes located along the Missouri River and its reservoirs. When river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to municipalities, Tribes, commercial operations and others. This in turn can drive changes in costs to access water. The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its reservoirs can lead to changes in costs of water supply access.

The evaluation of environmental consequences to water supply access by examined how water supply intake operations would be affected by changes in river and reservoir conditions as modeled by the Hydrologic Engineering Center River Analysis System (HEC-RAS) and Reservoir System Simulation (HEC-ResSim) models developed by the Institute for Water Resources, Hydrologic Engineering Center (HEC) (Figure 2). Data from these models provided a profile of river and reservoir behavior at locations that approximately corresponded to locations of water supply intakes, in the form of HEC-DSS (Data Storage System) flat files. River and reservoir behavior for each location were modeled over a period of 82 years, from 1930 to 2012. This analysis provided important inputs for the second step, the NED analysis, which calculated the change in water supply costs resulting from changes in access to water from the Missouri River. The following sections provide further details on the methodology.

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

CHANGES IN: Physical components of the Missouri River watershed (including seasonality, frequency, duration)

- Reservoir water surface elevations
- River flows and stages
- Channel morphology
- Water chemistry
- Sediment load

Lead To

CHANGES IN: Water supply conditions

- Access to water (including ice buildup)
- Intake operations, maintenance, and/or modification
- Water quality and water treatment requirements

Lead To

CHANGES IN: Water supply operations

- Intake pumping costs
- Intake Operations and Maintenance (O&M) costs
- Water treatment costs
- Capital replacement or modification costs

Lead To

CHANGES IN: Benefits

- National Economic Development (NED) – Operational and Maintenance Costs, capital investments for replacement or modification, shutdown or reduced service costs

Lead To

CHANGES IN: Benefits

- Regional Economic Development (RED) – changes in household spending used to estimate jobs, income, and sales/economic output

Lead To

CHANGES IN: Benefits

- Other Social Effects (OSE) – changes in public health, individual and community well-being

Figure 1. Flow Chart of Inputs Considered in Evaluation of Impacts to Water Supply Access

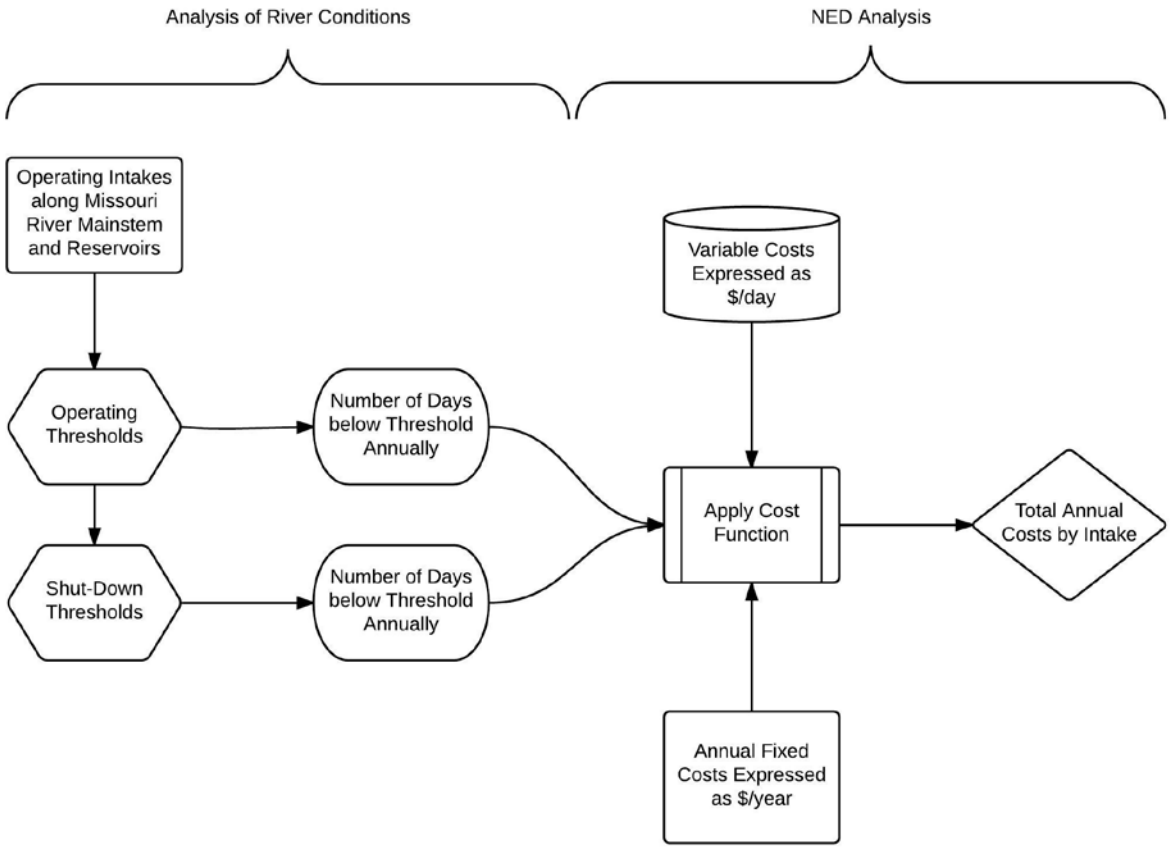


Figure 2. Approach for Evaluating Environmental Consequences to Water Supply Access

2.0 Assumptions

In modeling the environmental consequences to water supply access from the MRRMP-EIS alternatives, the project team established a set of assumptions. The important assumptions used in the modeling effort are as follows.

- The river conditions analysis and economic analysis uses data from the 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 including Alternative 1 (No Action).
- The river conditions analysis shows that impacts are expected to occur to water supply access under current system operations. Recent bed degradation is likely causing water surface elevations to fall below critical thresholds in some locations.[1] Since these conditions exist under current system management, which are modeled with a 2012

[1] For additional information on bed degradation please see section 3.2 River Infrastructure and Hydrological Processes in the MRRMP-EIS.

channel geometry, water supply managers would need to improve intakes to address these issues. The analysis presented here does not attempt to evaluate intake modifications resulting from bed degradation issues, but instead focuses on change in intake operations relative to Alternative 1 as a result of the action alternatives.

- Based on interviews with a representative sample of water supply managers it was assumed that water supply operations can adapt to small, less frequent changes in river flows and reservoir elevations under the MRRMP-EIS alternatives by using different-sized portable submersible pumps.

2.1 River Conditions Analysis

The purpose of the river conditions analysis was to link H&H modeling efforts that simulate river and reservoir operations of the Missouri River under each of the MRRMP-EIS alternatives with economic analysis necessary to determine environmental consequences. The river conditions analysis used Microsoft Excel® to evaluate potential effects of changes in river flows, river stages, and reservoir elevations to water supply operations accessing water from the Missouri River.

The analysis evaluated how access to water supply would be affected by changes in river and reservoir conditions. As river flows and reservoir elevations fall below minimum operating requirements, intakes become unavailable to provide water to municipalities, Tribes, commercial operations and others. This in turn can require changes to how water supply providers access water including extending intakes or using submersible pumps, which lead to an increase in costs for water supply providers. . The river conditions analysis used outputs from H&H models developed by the USACE using specialized software to simulate river and reservoir operations for planning studies and decision support developed by the Institute for Water Resources, Hydrologic Engineering Center (HEC). Hydrologic Engineering Center River Analysis System (HEC-RAS) and 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 water supply intakes, in the form of HEC-DSS (Data Storage System) flat files. River and reservoir behavior for each location were modeled over a POR.

The project team identified and evaluated 55 municipal and commercial intakes located along the Missouri River and its reservoirs that are expected to be operational during plan implementation for this analysis.

2.2 River Condition Metrics

Table 1 identifies the metrics that were calculated in the river conditions analysis.

Table 1. Water Supply River Conditions Analysis Metrics

Proxy	Performance Measure	Description
Metric 1 – Number of days river/reservoir levels fall below minimum access requirements for regular operation	Number of days	This measure is an estimate of the number of days in a calendar year that a water supply intake will not have access to water from either a river or reservoir. The focus of the metric is on operating conditions.

Proxy	Performance Measure	Description
Metric 2 – Number of days river/reservoir levels falls below shutdown elevation.	Number of days	This measure is an estimate of the number of days in a calendar year that a water supply intake will not have access to water from either a river or reservoir. The focus of the metric is on shutdown conditions.
Metric 3 – Average number of consecutive days river/reservoir levels falls below shutdown elevations.	Average number of consecutive days below access requirements	This metric calculates an average length of time, in days, for all occurrences of river or reservoir levels falling below minimum access requirements for one or more days in a calendar year.
Metric 4 – Frequency river/reservoir elevations fall below minimum access requirements to avoid shut down for a period of five or more days.	Number of occurrences of consecutive days exceeding five in which water surface elevations fall below access conditions	This metric measures the frequency of river or reservoir elevations falling below minimum access requirements for more than five consecutive days in a calendar year.

2.3 River Conditions Results

The primary purpose of the river conditions analysis was to better understand how each of the proposed alternatives might impact water supply access and to understand and describe the relationship between the Hydraulic and Hydrologic models and economic consequences. The NED analysis used the results of two of the river conditions metrics: number of days below operating thresholds and the number of days below shut-down thresholds for each of the 55 intakes. These results were used to estimate changes in costs to water supply operations due to changes in river and reservoir operations from the MRRMP-EIS alternatives.

2.4 Risk and Uncertainty

Risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall Management Plan is associated with the operation of the Missouri River system and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 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 HEC-RAS models or carried through in the water supply model described is this document. The project team has attempted to address risk and uncertainty in the Management Plan by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River. All of the alternatives were modeled to estimate impacts to municipal, tribal, and commercial water supplies.

Another source of uncertainty associated with the water supply analysis is predicting how water supply managers would react to long-term changes in river and reservoir conditions. The project team has utilized information from interviews with water supply managers to assess how adverse effects would affect operation of intakes. In all cases, the project assumed that submersible pumps would be used to adapt to changing conditions. However, in some cases,

water supply managers may decide that it is more cost effective to make modifications to the intake to adjust to these conditions. For consistency across all water supply intakes, a standard approach of utilizing portable, submersible pumps were used. Some of these river conditions have not occurred in the recent past and therefore represent the anticipated operational response of a water supply managers to a hypothetical situation. However, while these operational responses may be reasonable under current conditions or in the near future, unforeseen conditions may arise that may alter the operational response to the adverse conditions

3.0 National Economic Development Analysis

Water supply access is sensitive to changes in elevations of the Missouri River and reservoirs. As water flow/elevation falls below minimum access requirements, water intakes become unable to provide water for local municipalities, tribes, commercial operators, and others. Furthermore, a change in the cost of maintaining or operating intakes affects the residents and firms that rely on the intakes.

3.1 Approach

An Excel®-based economic analysis was developed that builds upon the river conditions analysis to evaluate the change in NED benefits for water supply access as a result of implementing the MRRMP-EIS alternatives. The NED analysis of water supply access was defined as changes in variable and fixed costs as a result of changing physical conditions along the Missouri River. The river conditions analysis evaluated conditions relevant to water supply intakes on riverine stretches and reservoirs. The analysis showed that water surface elevations would fall below both operating and shut-down elevations for many of the intakes evaluated under all the MRRMP-EIS alternatives, as well as Alternative 1. Several of the intakes show frequent occurrences when water surface elevations falling below operating and shut-down elevations under Alternative 1. Given the frequency of occurrences, it is likely that water supply managers would require intake improvements under Alternative 1.

The river conditions analysis showed that water surface elevations would fall below both operating and shut-down elevations for many of the intakes evaluated under all the MRRMP-EIS alternatives as well as the Alternative 1. Modeling results for Alternative 1 indicate that water supply intakes, if they were to remain at existing elevations, would experience long-term, adverse impacts under continuation of current operations. These impacts would be due to frequent and prolonged instances when water surface elevations fall below critical operating thresholds (operating and shut-down). The modeling results show that 33 of the 55 intakes would experience on average 57.1 days when water surface elevations would fall below operating thresholds. In addition, 21 of the 55 intakes would experience on average 14.7 days when water surface elevations are below shut-down elevations under Alternative 1. These impacts are occurring in both the upper and lower river and along riverine areas as well as reservoirs though the reasons for these effects vary by location.

For the MRRMP-EIS alternatives, modeling results show that the annual average number of days that water surface elevations would fall below shutdown thresholds for water supply intakes would increase by less than one day. The MRRMP-EIP alternatives would increase the annual average number of days below operating thresholds by less than two days. The project team concluded from the river conditions analysis that additional impacts would occur to water

supply intakes under the MRRMP-EIS alternatives in various degrees but these impacts are considered incremental to those that are observed under the Alternative 1. Thus, the NED analysis for water supply access focused on estimating these incremental changes in operations under the MRRMP-EIS alternatives.

Interviews with water supply managers provided some insight on how they adjust to temporary changes in river or reservoir conditions, similar to those observed under the MRRMP-EIS alternatives. Operators indicated that when water surface elevations temporarily fall below operating elevations, submersible pumps can be used to pump water to collection basins or the intake and maintain operations. The project team used this information to estimate additional costs associated with conditions occurring under the MRRMP-EIS alternatives relative to Alternative 1 including the fixed and operating costs of submersible pumps needed to maintain operations at various water supply intakes along the river and reservoirs.

The NED analysis for water supply access was focused on the change in variable and fixed costs under each of the MRRMP-EIS alternatives to municipal and commercial water facilities. The following section explains the NED analysis in detail, including data sources and assumptions.

3.1.1 Estimate Intake Capacity

In order to determine the size of the pumps that would be required at each intake location, the project team first needed to estimate the capacity of each of the 55 water supply intakes. Where possible, the project team obtained this information directly from water supply managers, especially commercial operators. For municipal intakes where this information was not available, the project team estimated daily water demand for each intake based on the population served and a daily per capita water usage rate. Per capita water usage rates were estimated for each state in the study area using data obtained from the US Geological Survey (USGS 2000). For intakes that capacity values were unknown, the daily water use estimate was multiplied by the population served for each intake resulting in a daily capacity value.

3.1.2 Estimate Pumping Requirements for each Intake

Once the capacity for each intake was estimated, the project team used that information to determine the number and size of submersible pumps that would be needed to maintain each intake if water surface elevations fall below operating or shut-down levels under any of the alternatives. The project team contacted a manufacturing representative of Gorman-Rupp for information on their S-Series Submersible Dewatering Pumps (White, 2016). These pumps come in a variety of sizes and horsepower and are routinely used for pumping water under conditions similar to those encountered by water supply managers along the Missouri River. Table 2 summarizes the pumps used for the analysis.

Table 2. Submersible Pumps Costs (2016 Dollars)

Submersible Pumps Model Number	Horse-power	Capacity (gpm)	Capital Cost [a]	Useful Life	Daily Rental Costs [b]	Operations and Maintenance Costs [c]	Environmental Permitting and Regulatory Costs [c]
S4E1-E20	20	450	$12,833	8–12 years	$5.72	$208.85	$208.85
S4B1-E50	50	750–1,000	$19,247	8–12 years	$8.58	$313.24	$313.24
S6A1-E60	60	750–2,100	$22,191	8–12 years	$9.89	$361.15	$361.15
S6E1-E60	60	750–2,100	$28,159	8–12 years	$12.56	$458.27	$458.27
S12A1-E140	140	750–7,000	$30,000	8–12 years	$40.51	$1,478.51	$1,478.51

Notes: gpm = gallons per minute

a (White 2016)

b Daily rental costs calculated for each pump based on a 10-year life and discount rate of 10 percent.

c Estimated as ten percent of annual fixed costs.

Using the information on the intake capacity and the capacity of submersible pumps, the project team determined the appropriate size of pumps that needed to extend operations for each water supply intake. For some of the larger intakes, multiple pumps would be needed to extend operations.

3.1.3 Estimate Pump Variable Costs

After estimating the number and size of pumps for each water supply intake, the project team estimated the daily energy costs for each size pump. Based on the horsepower rating for each pump size, the team used the following calculation to show the energy requirements in watts:

$$1\ horsepower = 745\ watts$$

The number of hours each pump would operate was determined from the capacity of the pump and the amount of water that would need to be pumped per day. The calculation showing daily energy requirements per pump follows:

$$\frac{Water\ Amount\ (gallons)}{Pump\ Capacity\ (\frac{gallons}{hour})} * watts = watt/hours$$

The daily energy requirements were then converted to kilowatt/hours and multiplied by the average price for electricity ($/kWh) for the West North Central region of the United States as reported by the Energy Information Agency (EIA 2015). This resulted in an average energy cost per pump per day (2016 Dollars).

3.1.4 Estimate Pump Fixed Costs

The project team estimated an annual fixed cost for each pump used at each of the intakes. This fixed cost for each pump includes three components: (1) daily rental cost; (2) operations and maintenance (O&M) costs; and (3) permitting and regulatory requirements. Because it was assumed that the pumps would be used on a temporary basis (several days at a time), a daily

rental cost was estimated for each sized pump. The daily rate was estimated by annualizing the capital cost of each pump considering an average life expectancy of ten years, and a discount rate of ten percent.[2] This annual cost was then converted to a daily rental rate by dividing the annual rate by 365. The fixed cost for each pump also includes a cost for maintenance activities and environmental permits and regulatory requirements. These additional costs were estimated as ten percent of the annualized cost of the pumps. Table 2 summarizes the fixed costs for each pump size.

3.1.5 Estimate Costs for Changing River Conditions under each Alternative

The project team used the variable and fixed costs for each pump with the river conditions analysis results to estimate the costs to access water under each alternative. As discussed above, the river conditions results indicated that several of the intakes evaluated would experience many instances when water surface elevations would fall below either operating or shut-down elevations under the Alternative 1. It is assumed that these operators would undertake some measures to modify or replace intakes that experience frequent operational impacts. However, in order to compare the MRRMP-EIS alternatives with Alternative 1, the project team applied the same assumptions of using submersible pumps when water surface elevations fall below operating conditions for Alternative 1. The costs were estimated using the following rules:

- For every day that water surface elevations fall below intake operating elevations, half of the daily energy costs per pump are applied (assumes intakes would still be operational when water surface elevations fall below operating thresholds but would not be as efficient)).
- For every day that water surface elevations fall below intake shut-down elevations, the daily energy costs per pump are applied.
- For every day that a pump is used, a daily rental cost is applied.

These assumptions were applied to all 55 water supply intakes evaluated which resulted in an annual cost per alternative over the POR.

3.2 Regional Economic Development Methodology

The RED water supply evaluation included a qualitative discussion of impacts of the MRRMP-EIS alternatives. The project team utilized the results of the NED evaluation of changes in costs of water supply access in describing potential RED effects. Because there were minimal changes in costs to access water for municipal and industrial (M&I) facilities, the analysis did not

[2] This rate is expected to reflect the private cost of capital. In August 2016, the prime rate was estimated to be between 2.5 and 3.0 percent. Because the analysis is using a higher discount rate than the current private cost of capital, the rental costs estimated are approximately 30 percent higher than expected under current conditions. However, the higher discount rate results in an overall increase in NED costs by 6 percent. Using the higher discount rate may overstate the actual costs that would be incurred by operators but it does not change the comparison of alternatives because all are affected equally.

try and quantify potential changes in rates. However, because there is likely a small impact or an uncertain impact on rates, these impacts were described qualitatively.

3.3 Other Social Effects Methodology

Changes in water supply operations have a potential to cause other types of effects on individuals and communities. For example, if an alternative reduced or eliminated a facility's ability to access the water, this could affect the local community in a number of ways, such as the community's ability to grow and attract investment without a reliable water supply and a community's sense of well-being. The water supply analysis used the results of the NED and RED analysis to determine the scale of impacts to the OSE account. The consequence evaluation for water supply for other social effects did not involve a detailed modeling effort. Data collected from water supply facilities and others was used to determine potential impacts to individual and community well-being, access to safe water sources, and economic vitality. Any changes to these areas of concern that would occur under MRRMP-EIS alternatives were examined to the extent possible. Any potential issues with water quality and treatment were considered a health and safety concern as well. Interviews with a sample of M&I water supply providers were conducted to inform the qualitative discussion of the social and public health effects possible under the MRRMP-EIS alternatives.

3.4 Environmental Quality Methodology

This account was not evaluated for water supply.

3.5 Geographic Areas

Water supply intakes are located all along the Missouri River and mainstem reservoirs. The intakes evaluated were organized into two groups depending on their location. "upper basin" includes all intakes located above Gavins Point Dam, whereas "lower basin" includes those located below Gavins Point.

4.0 National Economic Development Evaluation Results

The NED analysis for water supply focused on the changes in operational and capital costs as a result in changing physical conditions along the Missouri River. The results of the H&H modeling showed that water surface elevations would fall below both operating and shut-down elevations for many of the intakes evaluated under all the MRRMP-EIS alternatives including Alternative 1. The impact to water supply operators is an increase or decrease in costs associated with adapting to these changing conditions. Tables 3, 4, and 5 provide an overall summary of the NED analysis for each of the MRRMP-EIS alternatives. Table 3 summarizes the results for all of the water supply intakes in the basin over the POR. Total costs over this time period range from $30.5 million under Alternative 3 to $31.9 million under Alternative 4. Average annual costs range from $372,000 under Alternative 3 to $389,000 under Alternative 4. Relative to Alternative 1, Alternative 4 resulted in the largest increase in costs (3.4 percent) or $12,900 on average per year, while Alternative 3 showed a reduction in average costs (1.1 percent) of just over $4,000.

Table 3. National Economic Development Analysis of MRRMP-EIS Alternatives to Water Supply Access (2016 Dollars)

All Locations	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Variable Costs	$26,945,546	$27,238,856	$26,646,029	$27,856,450	$26,836,002	$27,492,469
Fixed Costs	$3,891,239	$3,980,956	$3,857,941	$4,037,096	$3,883,154	$3,982,842
Total Costs	$30,836,785	$31,219,811	$30,503,970	$31,893,546	$30,719,157	$31,475,311
Difference in Total Costs from Alternative 1	NA	$383,026	-$332,815	$1,056,761	-$117,628	$638,526
Percentage Difference in Costs from Alternative 1	NA	1.2%	-1.1%	3.4%	-0.4%	2.1%
Annual Average Total Costs	$376,058	$380,729	$372,000	$388,946	$374,624	$383,845
Total Difference in Annual Average Costs from Alternative 1	NA	$4,671	-$4,059	$12,887	-$1,434	$7,787
Difference in Annual Costs per Intake	$6,837*	$85	-$74	$234	-$26	$142

Note: *Represents average annual costs for Alternative 1.

Table 4 summarizes the NED analysis for intakes in the upper river including Tribal intakes. Total costs ranged from $8.3 million under Alternative 3 to $8.5 million under Alternative 4. Relative to Alternative 1, Alternative 4 resulted in the greatest increase in costs (3.6 percent) or $3,600 on average per year.

Table 4. National Economic Development Analysis MRRMP-EIS Alternatives to Water Supply Access in the Upper River (2016 Dollars)

Upper Basin	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Variable Costs	$6,896,658	$7,013,257	$6,917,315	$7,133,135	$6,921,972	$7,030,889
Fixed Costs	$1,377,150	$1,405,416	$1,380,925	$1,438,022	$1,383,792	$1,417,644
Total Costs	$8,273,808	$8,418,673	$8,298,239	$8,571,156	$8,305,764	$8,448,532
Difference in Total Costs from Alternative 1	NA	$144,865	$24,432	$297,348	$31,956	$174,725
Percentage Difference in Costs from Alternative 1	NA	1.8%	0.30%	3.6%	0.4%	2.1%
Annual Average Total Costs	$100,900	$102,667	$101,198	$104,526	$101,290	$103,031
Total Difference in Annual Average Costs from Alternative 1	NA	$1,767	$298	$3,626	$390	$2,131
Difference in Annual Costs per Intake	$2,803	$49	$8	$101	$11	$59

Note: *Represents average annual costs for Alternative 1.

Impacts of the MRRMP-EIS alternatives on intakes in the lower river varied slightly from those in the upper river as shown in Table 5. Intakes in the lower river tend to be larger in size than those in the upper river and these intakes experience higher costs when water surface elevations fall below operating thresholds. This results in overall costs being higher for intakes in the lower river. Total costs ranged from $22.2 million under Alternative 3 to $23.3 million under Alternative 4. Relative to Alternative 1, Alternative 4 resulted in the greatest increase in costs (3.4 percent) or $9,300 on average per year for intakes in the lower river. Alternatives 3 and 5 resulted in a slight beneficial impact to water supply intakes in the lower river by lowering costs relative to Alternative 1.

Table 5. National Economic Development Analysis MRRMP-EIS Alternatives on Water Supply Access in the Lower Basin (2016 Dollars)

Lower Basin	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6
Variable Costs	$20,048,888	$20,225,598	$19,728,714	$20,723,315	$19,914,031	$20,461,581
Fixed Costs	$2,514,089	$2,575,540	$2,477,017	$2,599,074	$2,499,363	$2,565,198
Total Costs	$22,562,977	$22,801,138	$22,205,731	$23,322,389	$22,413,393	$23,026,779
Difference in Total Costs from Alternative 1	NA	$238,161	-$357,246	$759,412	-$149,584	$463,802
Percentage Difference in Costs from Alternative 1	NA	1.1%	-1.6%	3.4%	-0.7%	2.1%
Annual Average Total Costs	$275,158	$278,063	$270,802	$284,419	$273,334	$280,814
Total Difference in Annual Average Costs from Alternative 1	NA	$2,904	-$4,357	$9,261	-$1,824	$5,656
Difference in Annual Costs per Intake	$14,482	$153	-$229	$487	-$96	$298

Note: *Represents average annual costs for Alternative 1.

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

Alternative 1 represents current system operations including a number of management actions associated with the MRRP and BiOp compliance. Management actions under Alternative 1 include creation of both SWH and ESH habitat and a spring plenary pulse or a bi-modal spring plenary pulse. The management actions included under Alternative 1 are focused on areas below Gavins Point Dam.

Modeling results under Alternative 1 indicate that if water supply intakes were to remain at their existing elevations they would experience long-term, adverse impacts compared to existing conditions. These impacts would be due to frequent instances when water surface elevations fall below critical operating thresholds (operating and shut-down). The river conditions analysis showed that 33 of the 55 intakes would experience on average 57.1 days when water surface elevations would fall below operating thresholds. In addition, 21 of the 55 intakes would

experience on average 14.7 days when water surface elevations are below shut-down elevations under Alternative 1. System operations under Alternative 1 would be the same as the current operations. However, as described in Section 3.1, Introduction, the impacts modeled do not account for the ability of water management to adapt to changing conditions on the system to serve authorized purposes, such as water supply. It also does not account for what activities may be implemented in the future relative to bed degradation which may be influencing model results. This is because the 2012 river geometry used in HEC-RAS modeling reflects a level of bed degradation that was not present in prior years included in the POR analysis. These impacts are discussed in more detail in Section 3.2, River Infrastructure and Hydrological Processes of the MRRMP-EIS. Given the frequency and duration of these periods where water surface elevations fall below critical operational thresholds, it is likely that water supply operators would need to make intake improvements, modifications, or relocation to adapt to changing conditions along the river.

The NED analysis for Alternative 1 is summarized in Table 6. Water supply intake operators along the Missouri River would incur an average annual cost of over $376,000 to adapt to changing conditions of the river. Average costs are higher in the lower river than in the upper river in part due to the size of the intakes which require larger pumps to move the required amount of water to the intake than for intakes in the upper river. In addition, more intakes in the lower river are showing more impacts (days below critical thresholds) than in the upper river under this alternative. Total annual costs for all 55 intakes evaluated range from a low of just under $46,000 to over $1.5 million.

Table 6. Summary of National Economic Development Analysis for Alternative 1 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$6,896,6587	$20,048,888	$26,945,546
Total Fixed Costs (82-year POR) [b]	$1,377,150	$2,514,089	$3,891,239
Total Costs (82-year POR)	$8,273,808	$22,562,977	$30,836,785
Annual Average Total Costs	$100,900	$275,158	$376,058
Annual Average Total Costs per Intake	$2,803	$14,482	$6,837
Maximum Annual Costs	$241,931	$1,336,463	$1,535,664
Minimum Annual Costs	$36,748	$0	$45,729

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

4.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

The NED Analysis for Alternative 2 is summarized in Table 7. Water supply facilities along the Missouri River would incur on average $380,000 per year to adapt to changing conditions of the river relative to Alternative 1. Total annual costs range from $51,000 to $1.5 million. This represents an overall increase in costs to water supply access of 1.2 percent over Alternative 1.

Table 7. Summary of National Economic Development Analysis for Alternative 2 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$7,013,257	$20,225,598	$27,238,856
Total Fixed Costs (82-year POR) [b]	$1,405,416	$2,575,540	$3,980,956
Total Costs (82-year POR)	$8,418,673	$22,801,138	$31,219,811
Difference in Total Costs from Alternative 1	$144,865	$238,161	$383,026
Percentage Difference from Alternative 1	1.8%	1.1%	1.2%
Annual Average Total Costs	$102,667	$278,063	$380,729
Difference in Annual Average Costs from Alternative 1	$1,767	$2,904	$4,671
Difference in Annual Costs per Intake	$49	$153	$85
Maximum Annual Costs	$244,829	$1,337,273	$1,537,929
Minimum Annual Costs	$36,976	$7,459	$51,100

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

When evaluating the impacts of each of the MRRMP-EIS alternatives, it is helpful to examine the annual impacts. Figure 3 shows the annual NED impacts to water supply intakes in the upper and lower river. The graphic clearly shows that intakes in the lower river dominate the overall NED costs for water supply access. In three of the 82 years modeled, water supply access in the lower river would experience costs greater than $100,000 above those experienced under Alternative 1. These same intakes also realized a reduction in costs relative to Alternative 1 of greater than $100,000 in five years of the 82 years modeled. Water supply access in the upper river, including Tribal intakes experienced lesser impacts under Alternative 2 than intakes in the lower river. The difference in cost from Alternative 1 for intakes in the upper river ranged from −$17,000 to $23,000.

Additional modeled results are shown in Figure 4. Here the difference in NED costs between Alternative 1 and 2 are plotted and color-coded based on the type of release occurring each year. This figure shows the results for water supply access in the lower river only. The results show that the greatest impacts to intakes in the lower river would occur in years when a release was eliminated or a natural release occurs. These impacts are occurring during the winter or fall months when flows tend to be at their lowest levels in the lower river. Alternatively, years that have a full release and a low summer flow result in the greatest beneficial impacts to water supply access relative to Alternative 1.

Figure 5 shows the same data plot for intakes in the upper river for Alternative 2. There are less conclusive results of impacts to water supply access in the upper river, with all types of releases showing impacts. However, the impacts would be much smaller than for intakes in the lower river. The increase in costs to access water in the upper river would be relatively small with the largest increase in costs of approximately $23,000 for all 36 intakes located in the upper river.

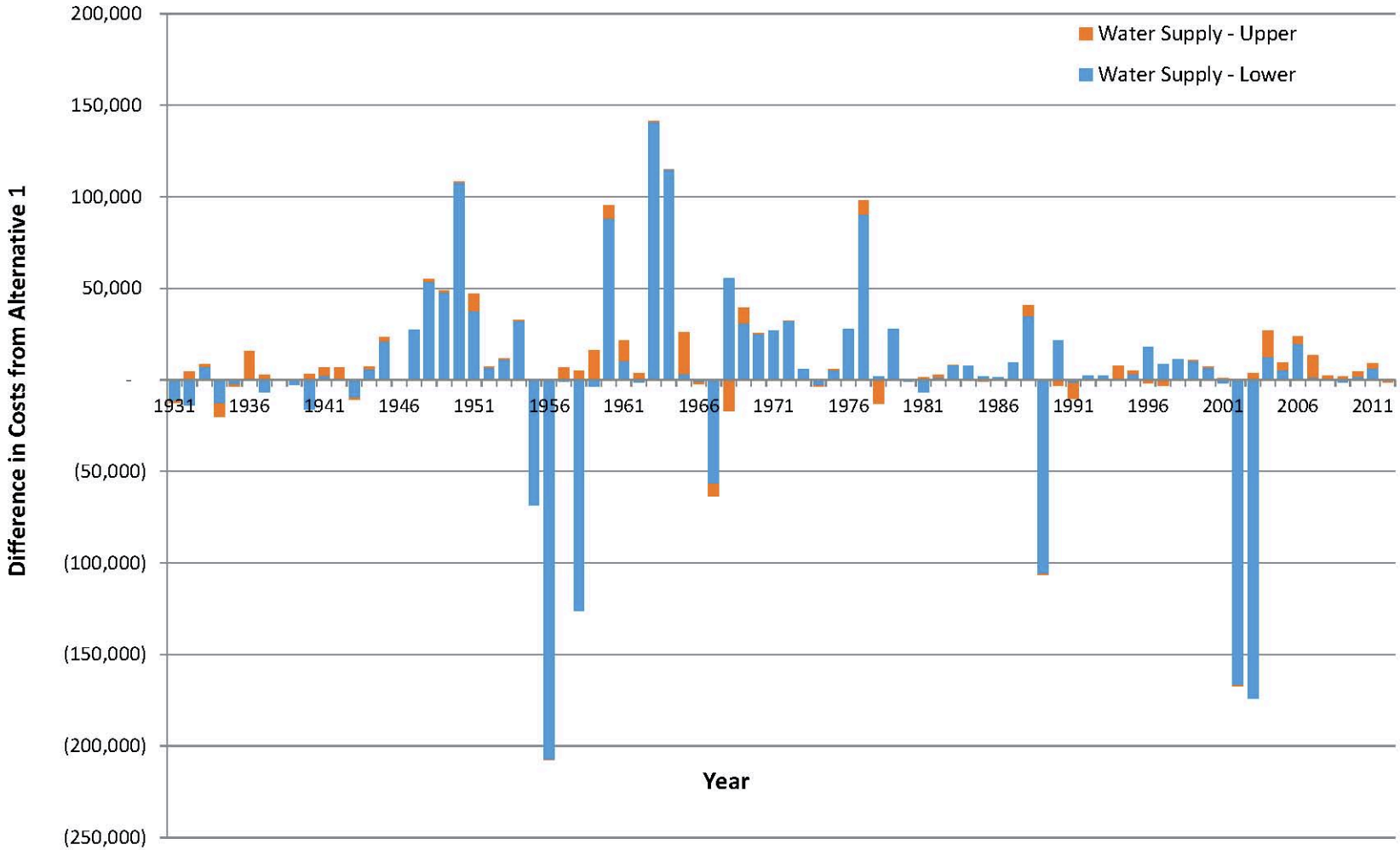
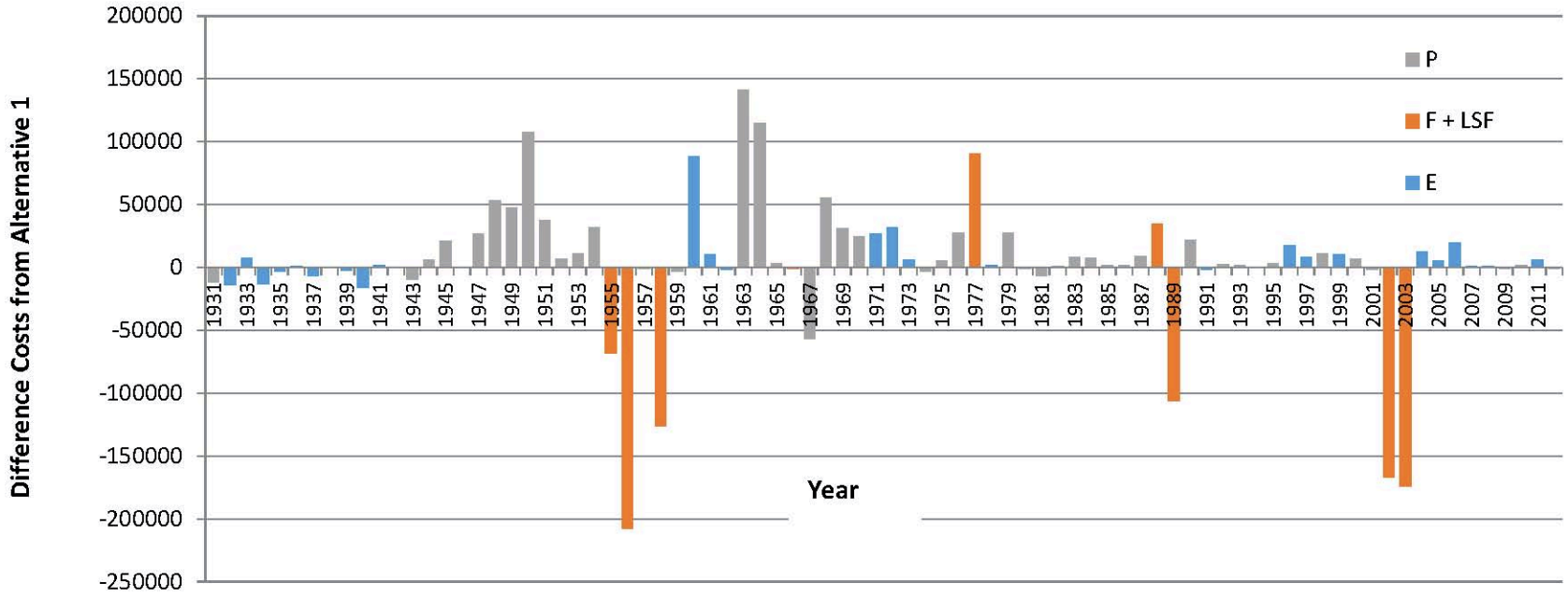
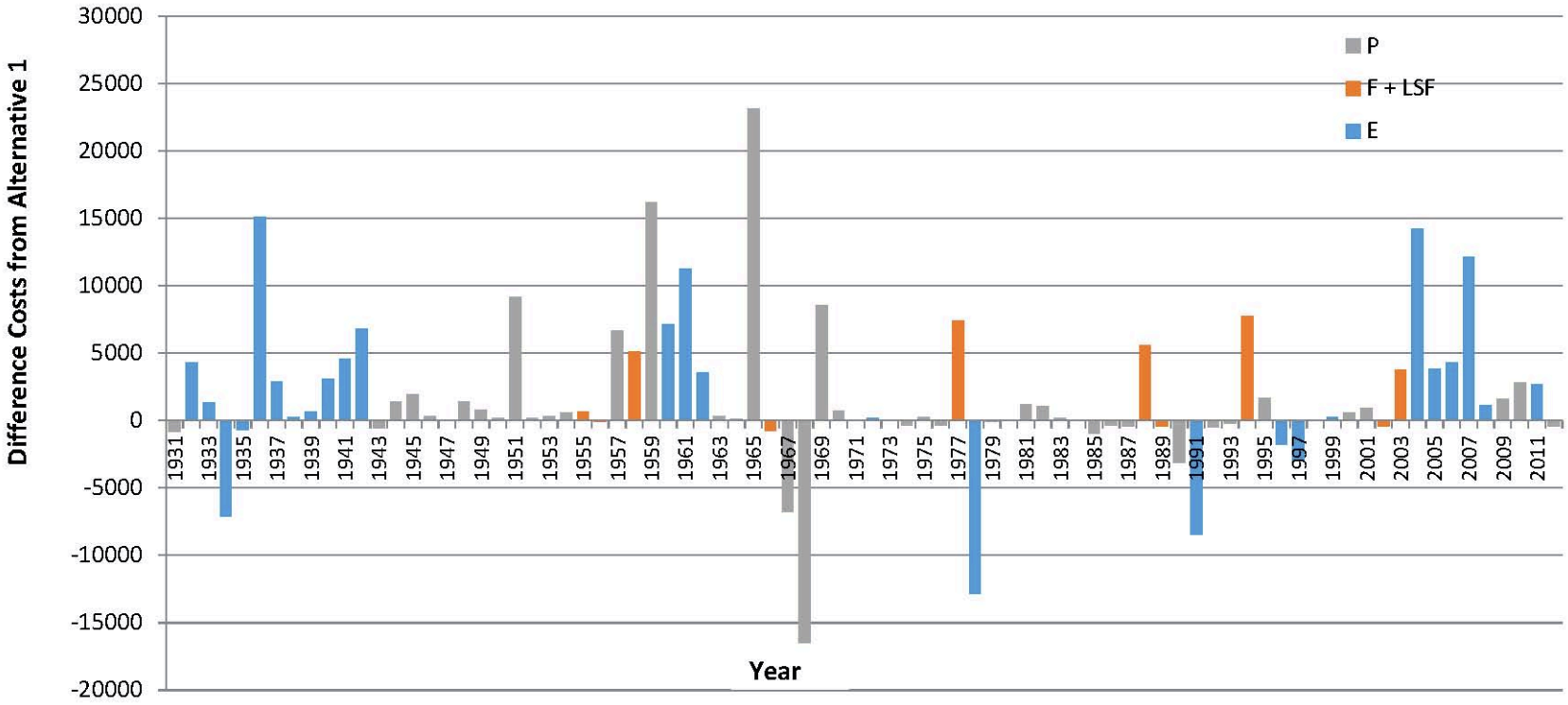


Figure 3. Annual Difference in Costs for Alternative 2 Relative to Alternative 1 for Intakes in Upper and Lower River (2016 Dollars)



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

Figure 4. Difference Costs under Alternative 2 from Alternative 1 for Water Supply Access in the Lower River (2016 Dollars)



P – Partial Release

F + LSF – Full Release + Low Summer Flow

E – Eliminated Release

Figure 5. Difference in Costs under Alternative 2 from Alternative 1 for Water Supply Access in the Upper River (20016 Dollars)

4.3 Alternative 3 – Mechanical Construction Only

Management actions included under Alternative 3 would include those that focus on the creation of ESH through mechanical means. This alternative would have a small, beneficial impact on water supply intakes. Most of the benefits would be realized in the lower river.

The NED results for Alternative 3 are summarized in Table 8. Overall, Alternative 3 would have a relatively small, beneficial impact on water supply access relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a slight decrease in the average number of days (57.0) when water surface elevations would fall below operating thresholds under Alternative 3. In addition, 22 of the 55 intakes would experience on average 14.0 days when water surface elevations are below shut-down elevations under Alternative 3. Total costs for all water supply intakes would decrease by nearly $333,000 over the 82-year POR or a decrease of 1.1 percent from Alternative 1. Most of these cost decreases would occur in the lower river with costs to water supply operations in the upper river showing a slight increase.

Table 8. Summary of National Economic Development Analysis for Alternative 3 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$6,917,315	$19,728,714	$26,646,029
Total Fixed Costs (82-year POR) [b]	$1,380,925	$2,477,017	$3,857,941
Total Costs (82-year POR)	$8,298,239	$22,205,731	$30,503,970
Difference from Alternative 1	$24,432	−$357,246	−$332,815
Percentage Difference from Alternative 1	0.3%	−1.6%	−1.1%
Annual Average Total Costs	$101,198	$270,802	$372,000
Difference in Annual Average Costs from Alternative 1	$298	−$4,357	−$4,059
Difference in Annual Costs per Intake	$8	−$229	−$74
Maximum Annual Costs	$253,182	$1,335,357	$1,557,985
Minimum Annual Costs	$36,770	$0	$46,460

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Figure 6 shows the annual NED impacts to water supply access in the upper and lower river. This graphic clearly shows that costs for water supply access in the lower river again dominate the overall NED costs for water supply and most years show a reduction in costs relative to Alternative 1. In ten of the 82 years modeled, water supply access would experience an increase in costs in the lower river however in only two years do these costs exceed $10,000 for all 19 intakes in the lower river. These same intakes also realized a reduction in costs relative to Alternative 1 of greater than $25,000 in six years of the 82 years modeled. Water supply access in the upper river, including Tribal intakes appear to experienced more impacts under Alternative 3 than intakes in the lower river. In particular, several years in the 1930s show an increase in costs for water supply access in the upper river. Intakes in the upper river also experience several years when costs decreased relative to Alternative 1.

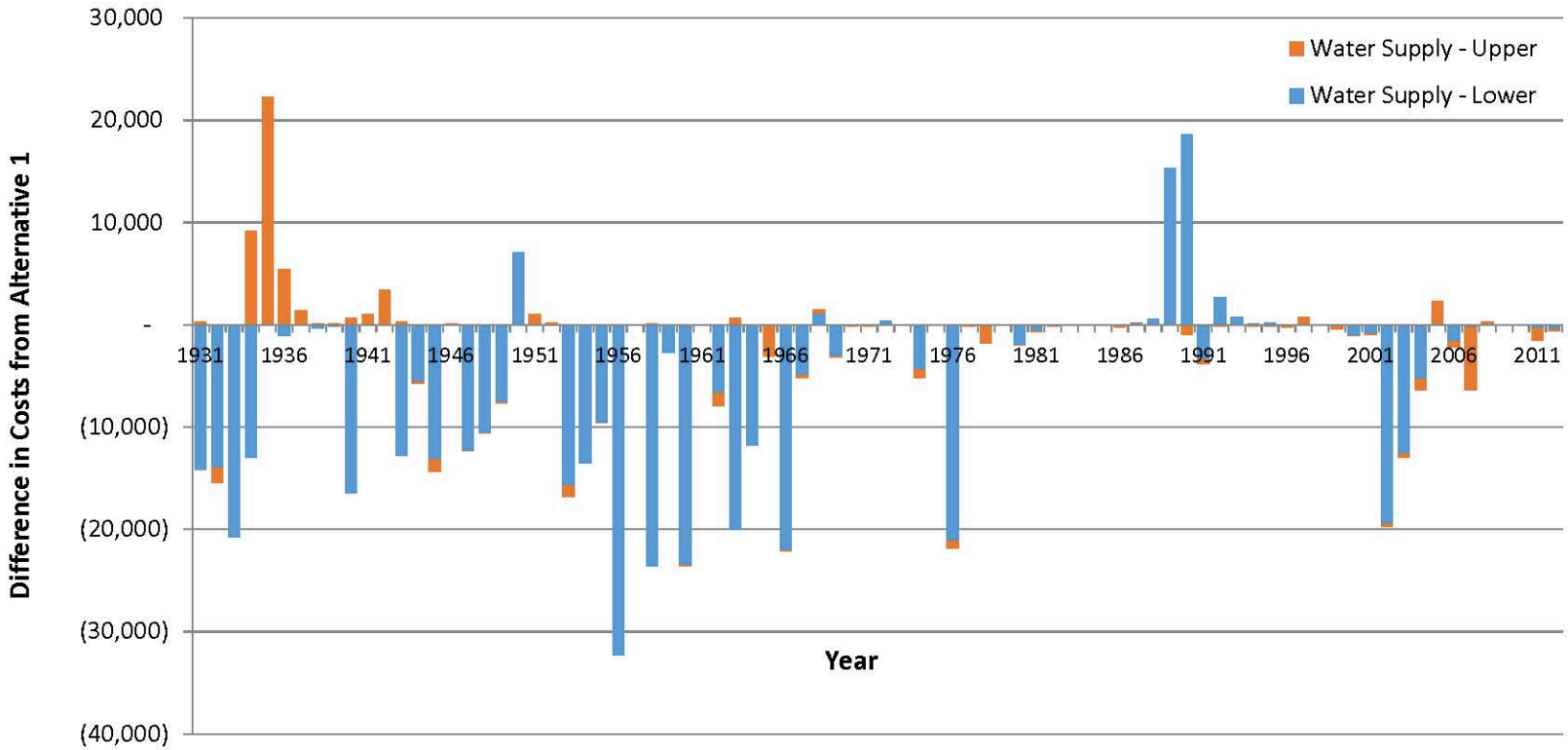


Figure 6. Annual Difference in Costs under Alterative 3 Relative to Alternative 1 for Water Supply Access in Upper and Lower River (2016 Dollars)

4.4 Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Both actions have the potential to affect water supply intakes. Alternative 4 is expected to have a small, adverse impact on water supply intakes.

The NED results for Alternative 4 are summarized in Table 9. On average, Alternative 4 has a small, adverse impacts on water supply access relative to Alternative 1. The modeling results show that one additional intake (34) would experience a slight increase in the average number of days (57.6) when water surface elevations would fall below operating thresholds under Alternative 4. In addition, 24 of the 55 intakes would experience on average 14.2 days when water surface elevations are below shut-down elevations under Alternative 2. Over all locations costs increase by slightly more than $1.0 million over the modeled POR or an increase of 3.4 percent from Alternative 1. Alternative 4 has the largest impact on water supply access relative to Alternative 1 of any of the MRRMP-EIS alternatives and these impacts are occurring across both the lower and upper river. Annual costs range from $46,500 to $1.6.

Table 9. Summary of National Economic Development Analysis for Alternative 4 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$7,133,135	$20,723,315	$27,856,450
Total Fixed Costs (82-year POR) [b]	$1,438,022	$2,599,074	$4,037,096
Total Costs (82-year POR)	$8,571,156	$23,322,389	$31,893,546
Difference from Alternative 1	$297,348	$759,412	$1,056,761
Percentage Difference from Alternative 1	3.6%	3.4%	3.4%
Annual Average Total Costs	$104,526	$284,419	$388,946
Difference in Annual Average Costs from Alternative 1	$3,626	$9,261	$12,887
Difference in Annual Costs per Intake	$101	$487	$234
Maximum Annual Costs	$253,182	$1,335,357	$1,557,985
Minimum Annual Costs	$36,770	$0	$46,460

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Figure 7 shows the annual NED impacts to water supply intakes in the upper and lower river. While the change in average annual costs to water supply access relative to Alternative 1 is small under Alternative 4, intakes experience increase in costs much more frequently under Alternative 4 than other MRRMP-EIS alternatives. In over half the years of the modeled POR, costs for water supply access in the upper river would increase under Alternative 4. These costs are relatively small (less than $20,000 in all but three years). Five of the years with the largest increase in costs occurred during the drought conditions similar to the 1930s and are not necessarily associated with a flow event. Drought conditions similar to those in the mid-2000s also attributed to cost increases were highest for water supply access in the upper river.

Differences in costs for water supply access in the upper river over the period of analysis would range from a low of −$13,800 to a high of $42,600. Water supply access in the lower river are also experiencing an increase in costs in over half the years during the POR relative to Alternative 1. Five of these years show an increase in costs greater than $60,000. Differences in costs for water supply access in the upper river over the period of analysis would range from a low of −$13,800 to a high of $42,600. Figure 8 shows the difference in NED costs between Alternative 1 and Alternative 4 for the type of release occurring each year for the lower river. The results show that full and partial releases result in both increases and decreases in costs to access water in the lower river relative to Alternative 1. However, the largest adverse impacts occur in years after an eliminated release. Years with the largest impacts occur during the winter or fall months when flows tend to be at their lowest levels in the lower river.

Figure 9 shows the same data plot for intakes in the upper river for Alternative 4. Water supply access in the upper river appear to be affected most often under Alternative 4 during drought conditions (1930s, early 1960s, and mid-2000s). Drought conditions and its effects on reservoirs appear to be exasperated by a full release in 1930s. Full and partial releases in the late 1950s and early 1960s, combined with drought conditions also appear to be driving increase in costs in the upper river. In the mid-2000s, again a full release event appears to cause adverse impacts to water supply access in the upper river. However, the adverse impacts are relatively small with the largest impact resulting in an increase in costs of approximately $46,500 for all 36 intakes located in the upper river.

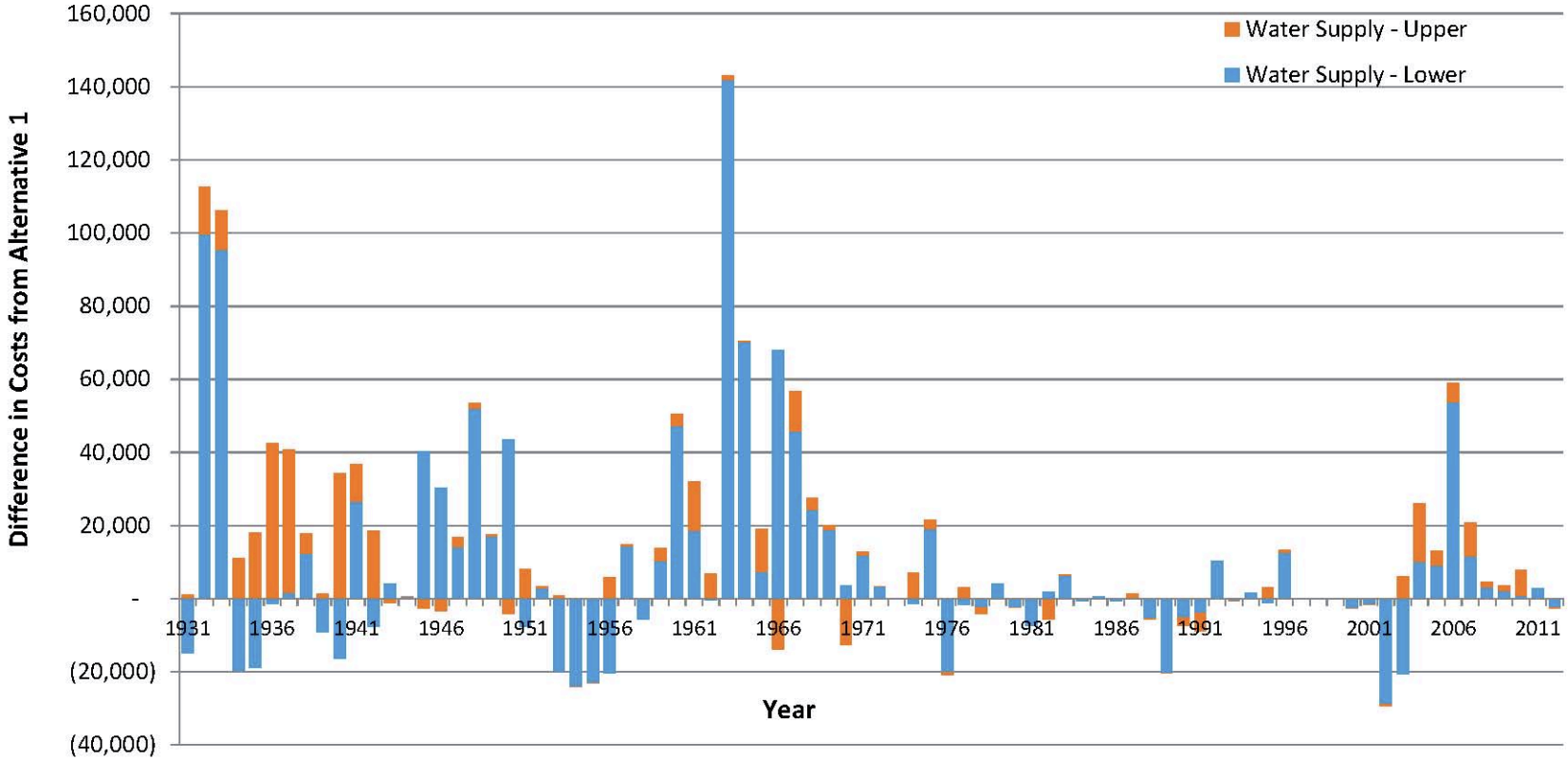
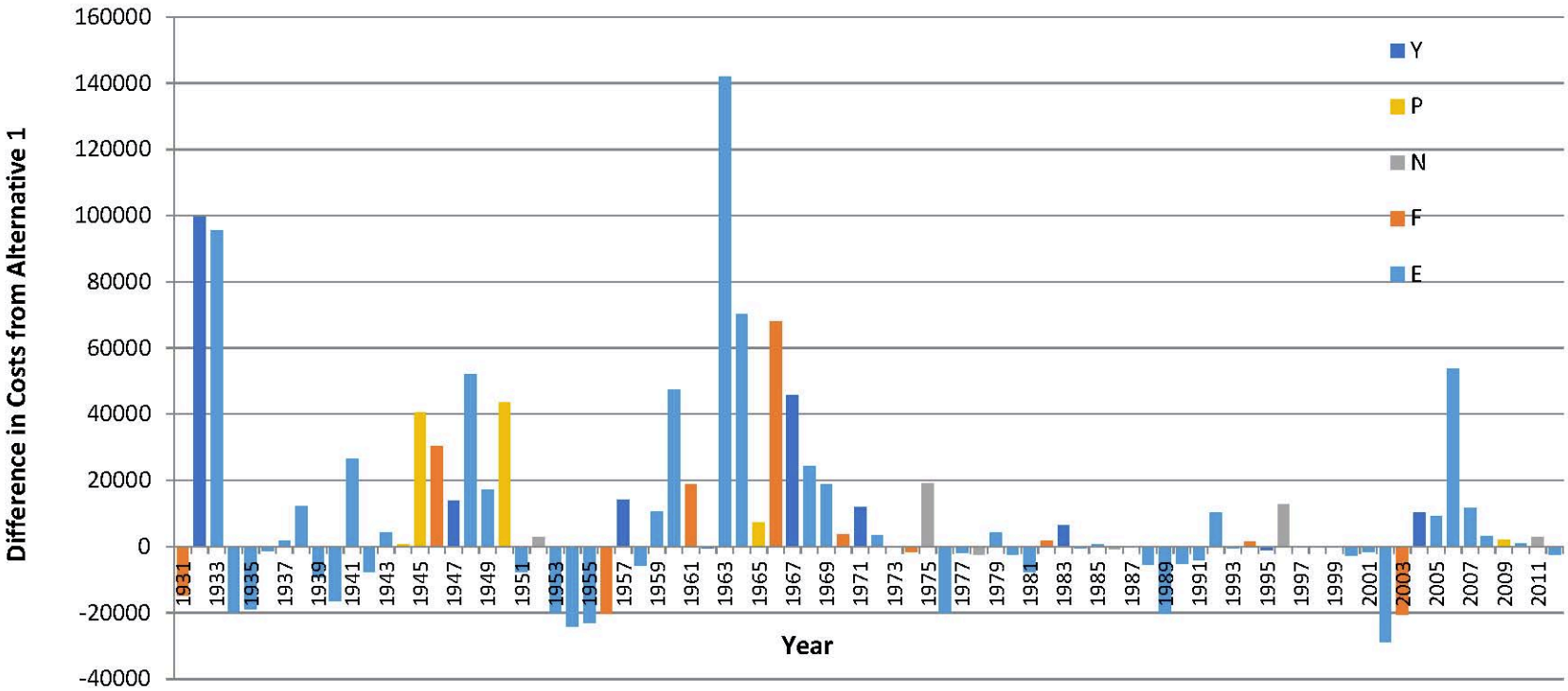
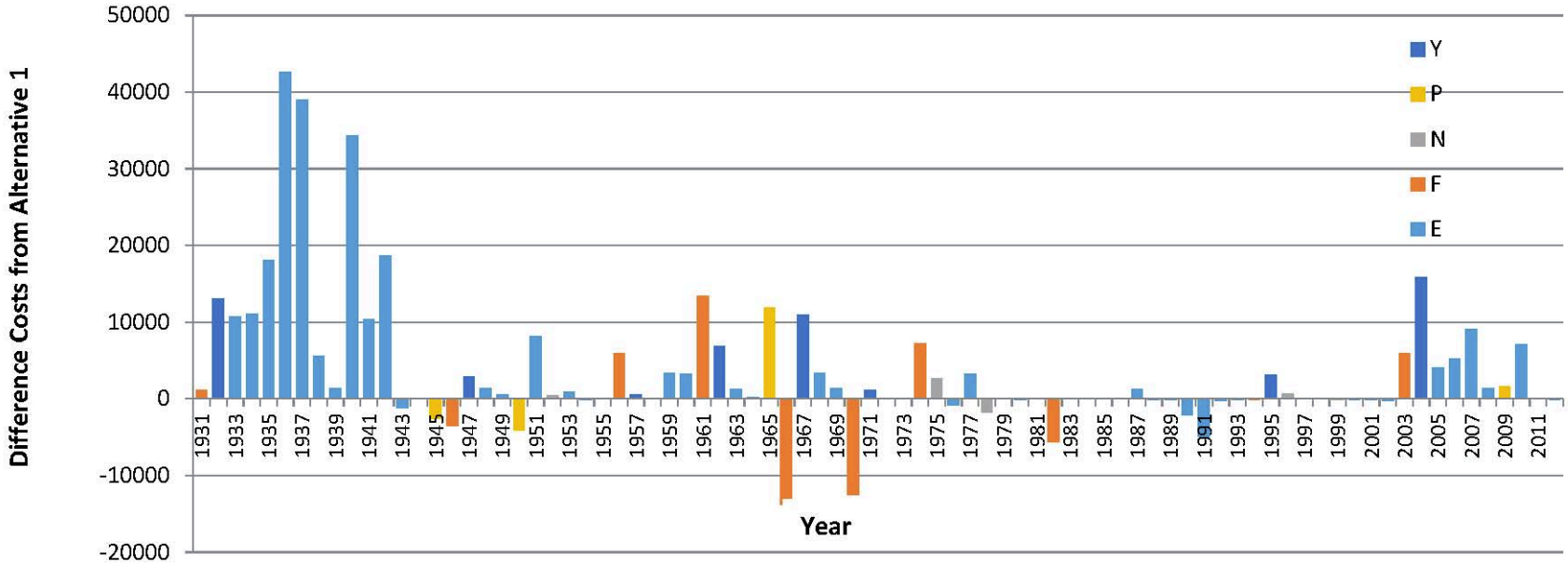


Figure 7. Annual Difference in Costs under Alternative 4 Relative to Alternative 1 for Water Supply Access in Upper and Lower River (2016 Dollars)



Y – Year after a full release
P – Partial Release
N – Natural Release
F – Full Release
E – Eliminated Release

Figure 8. Difference in Costs under Alternative 4 from Alternative 1 for Water Supply Access in the Lower River (2016 Dollars)



Y – Year after a full release
P – Partial Release
N – Natural Release
F – Full Release
E – Eliminated Release

Figure 9. Difference in Costs under Alternative 4 from Alternative 1 for Water Supply Access in the Upper River (2016 Dollars)

4.5 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Both actions have the potential to affect water supply intakes. Alternative 5 is expected to have a small, beneficial impact on water supply intakes.

The NED results for Alternative 5 are summarized in Table 10. Overall, Alternative 5 has a small, beneficial impact on water supply intakes relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a small increase in the average number of days (57.2) when water surface elevations would fall below operating thresholds under Alternative 5. In addition, 22 of the 55 intakes would experience on average 14.1 days when water surface elevations are below shut-down elevations under Alternative 2. For all locations costs decrease by $117,000 over the modeled POR or a decrease of 0.4 percent from Alternative 1. While Alternative 5 is having an overall small beneficial impact, water supply access in the upper river would experience a small adverse impact under Alternative 5. Annual costs to access water along the river range from over $48,000 to $1.6 million.

Table 10. Summary of National Economic Development Analysis for Alternative 5 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$6,921,972	$19,914,031	$26,836,002
Total Fixed Costs (82-year POR) [b]	$1,383,792	$2,499,363	$3,883,154
Total Costs (82-year POR)	$8,305,764	$22,413,393	$30,719,157
Difference in Total Costs from Alternative 1	$31,956	−$149,584	−$117,628
Percentage Difference from Alternative 1	0.4%	−0.7%	−0.4%
Annual Average Total Costs	$101,290	$273,334	$374,624
Difference in Annual Average Costs from Alternative 1	$390	−$1,824	−$1,434
Difference in Annual Costs per Intake	$11	−$96	−$26
Maximum Annual Costs	$247,699	$1,335,357	$1,557,985
Minimum Annual Costs	$36,932	$0	$47,627

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Figure 10 shows the annual NED impacts to water supply access in the upper and lower river. The graph shows that both the upper and lower river would experience more years of cost reductions under Alternative 5 relative to Alternative 1. This results in a small beneficial impact to water supply access in the lower river and a slight increase in costs in the upper river. However, three years in the POR show cost increases greater than $40,000 with the highest costs occurring in 1996 of nearly $122,000. Costs are higher in all three years (1950, 1966, 1996) due to lower flows in winter months relative to Alternative 1.

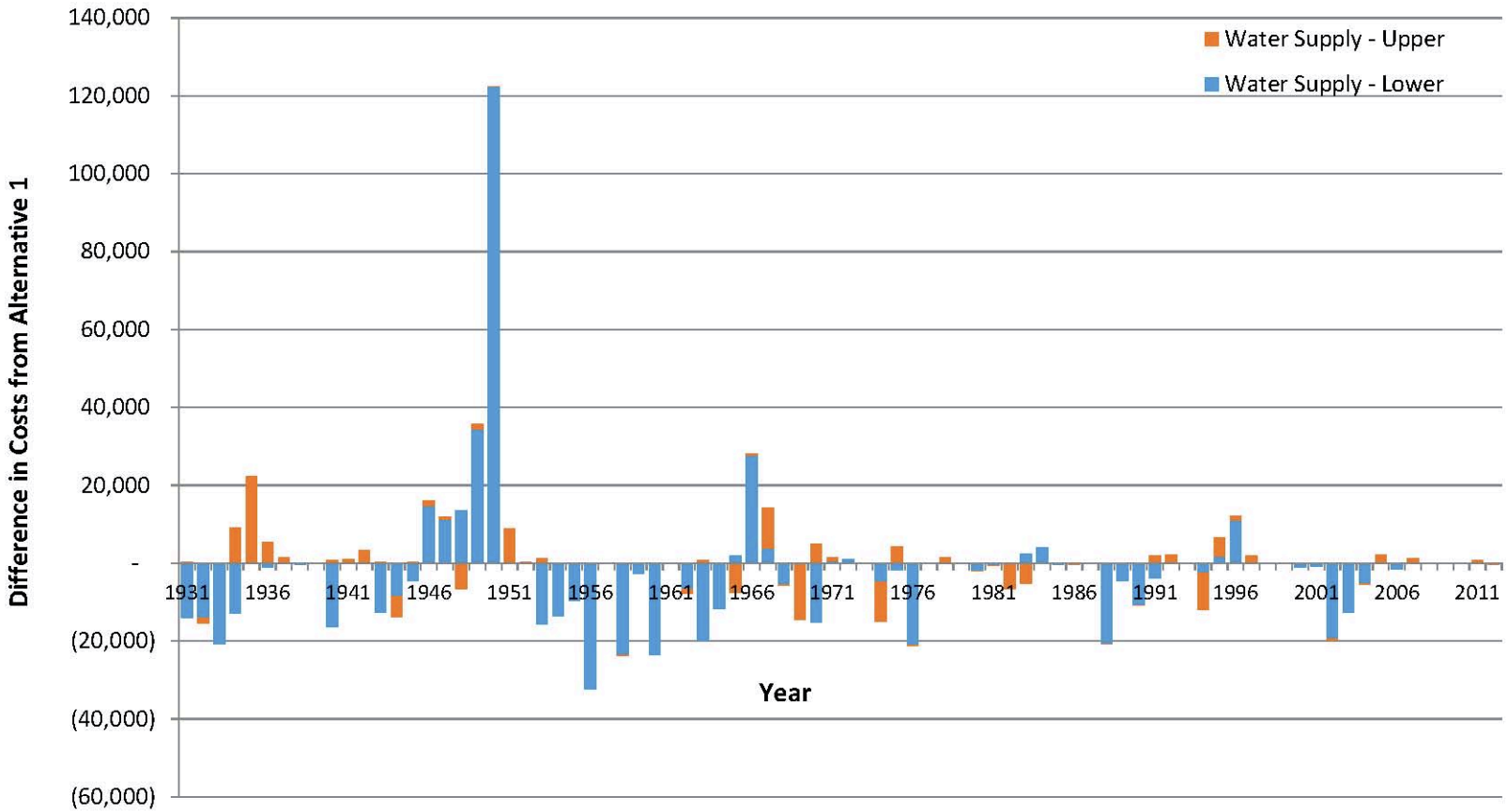
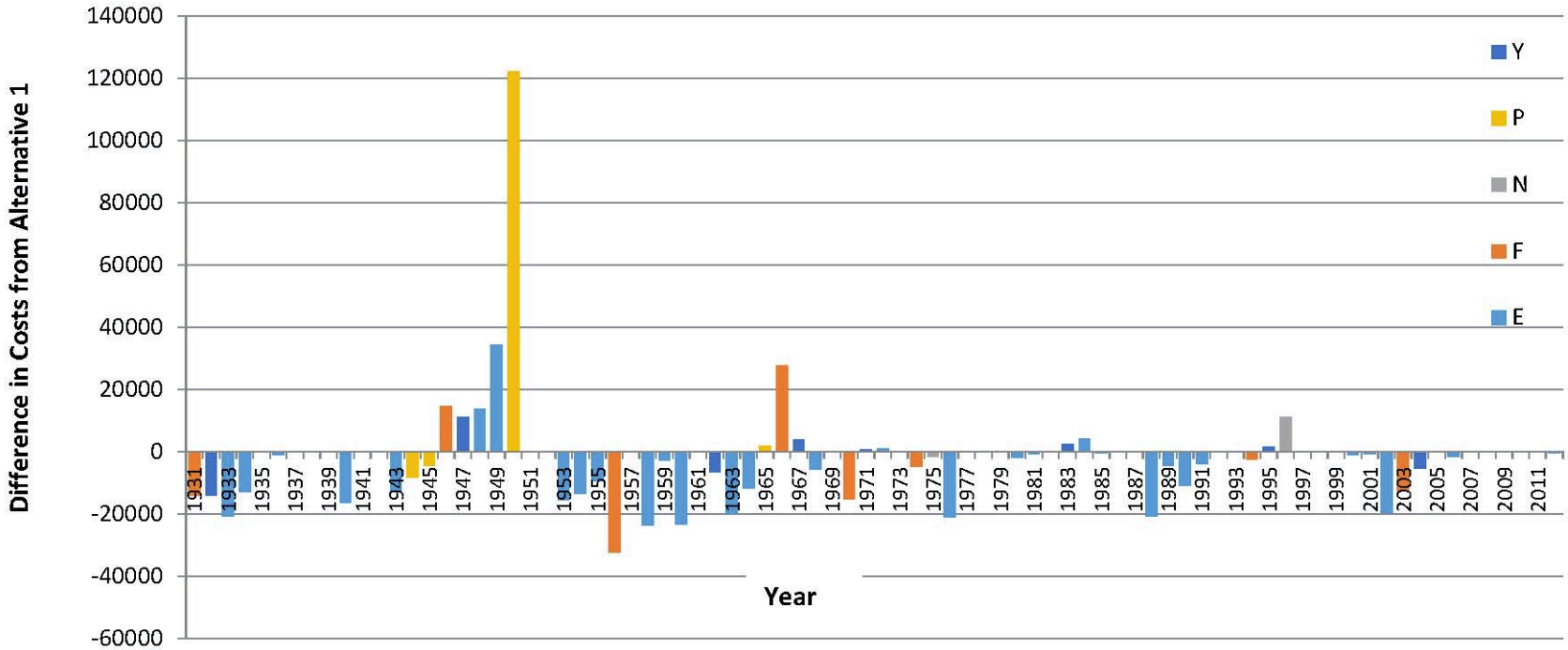


Figure 10. Annual Difference in Costs under Alternative 5 Relative to Alternative 1 for Water Supply Access in Upper and Lower River (2016 Dollars)

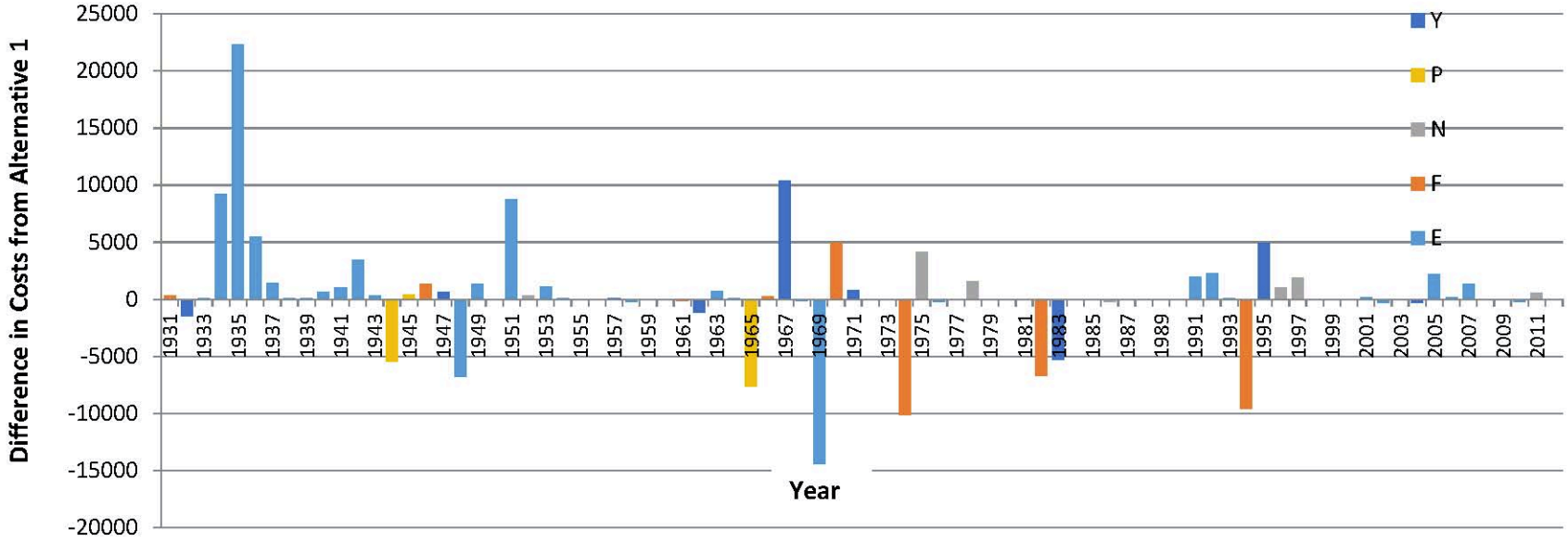
Figure 11 shows the difference in NED costs between Alternative 1 and 5 for the type of release occurring each year in the lower river. The results show that full and partial releases are not having a direct adverse impact on water supply access in the lower river. In most years when a full or partial release is occurring, water supply access in the lower river would realize cost reductions relative to Alternative 1. The exception is 1983 when a full release resulted in an increase in costs to water supply access in the lower river. However, in years when the largest adverse impacts are occurring (1950, 1966, and 1996) are likely due to the system rebalancing after events that occurred in previous years. Differences in annual costs for water supply access in the lower river ranged from a reduction in costs of $32,300 in 1974 to an increase in costs of $122,000 in 1996.

Figure 12 shows the same data plot for water supply access in the upper river for Alternative 5. Impacts to water supply access in the upper river appear to be more adverse under Alternative 5 than in the lower river. Years with the greatest increase in costs occur in the 1930s drought. Some adverse impacts are occurring in years following a release event (full or partial) and may be the result of system rebalancing and changing reservoir elevations. In many years when pulse events are occurring costs are lower for water supply access in the upper river under Alternative 5. Adverse impacts are relatively small with the largest impact resulting in an increase in costs of approximately $22,300 for all 36 intakes located in the upper river. Differences in annual costs over the POR range from a cost savings of nearly $14,500 in 1974 to $22,300 in 1935.



Y – Year after a full release
P – Partial Release
N – Natural Release
F – Full Release
E – Eliminated Release

Figure 11. Difference in Costs under Alternative 5 from Alternative 1 for Water Supply Access in the Lower River (2016 Dollars)



Y – Year after a full release
P – Partial Release
N – Natural Release
F – Full Release
E – Eliminated Release

Figure 12. Alternative 5 Difference in Costs from Alternative 1 for Water Supply Access in the Upper River (2016 Dollars)

4.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. Both of these management actions have the potential to impact water supply intakes. Alternative 6 would have a small, adverse impact on water supply intakes.

The NED results for Alternative 6 are summarized in Table 11. Overall, Alternative 6 has a small, adverse impact on water supply intakes relative to Alternative 1. The modeling results show that 33 of the 55 intakes would experience a small increase in the average number of days (58.7) when water surface elevations would fall below operating thresholds under Alternative 6. In addition, 22 of the 55 intakes would experience on average 14.7 days when water surface elevations are below shut-down elevations under Alternative 6. For all locations costs increase by $638,500 over the modeled POR or an increase of 2.1 percent from Alternative 1. Water supply access in both the upper and lower river experience increases in costs under Alternative 6. Annual costs range from over $46,000 to $1.6 million.

Table 11. Summary of National Economic Development Analysis for Alternative 6 (2016 Dollars)

Costs	Upper River	Lower River	All Locations
Total Variable Costs (82-year POR) [a]	$7,030,889	$20,461,581	$27,492,469
Total Fixed Costs (82-year POR) [b]	$1,417,644	$2,565,198	$3,982,842
Total Costs (82-year POR)	$8,448,532	$23,026,779	$31,475,311
Difference in Total Costs from Alternative 1	$174,725	$463,802	$638,526
Percentage Difference from Alternative 1	2.1%	2.1%	2.1%
Annual Average Total Costs	$103,031	$280,814	$383,845
Difference in Annual Average Costs from Alternative 1	$2,131	$5,656	$7,787
Difference in Annual Costs per Intake	$59	$298	$142
Maximum Annual Costs	$247,699	$1,335,357	$1,552,778
Minimum Annual Costs	$36,932	$0	$46,000

Notes:

a Variable costs in this context are those costs that change with amount of water that must be pumped at each intake.

b Fixed costs are those that do not change with pumping requirements and are based on the size and number of pumps being used on an annual basis at each intake.

Figure 13 shows the annual NED impacts to water supply access in the upper and lower river. The graph shows that water supply access in the upper and lower river are experiencing several years of both cost reductions and increases under Alternative 6 relative to Alternative 1. This results in a small adverse impact to water supply access in both the upper and lower river overall. Total annual costs range from a cost savings of nearly $22,000 to an increase in costs of $72,000.

Figure 14 shows the difference in NED costs between Alternative 1 and 6 for the type of release occurring each year for intakes in the lower river. The results show that in about half the years when a full or partial release is occurring, access to water supply in the lower river are realizing

an increase in costs but a decrease in costs in the other years of these releases. Two of the years with the largest adverse impacts are occurring when there is a full release though the increase in costs is relatively small. The largest decrease in annual costs from Alternative 1 occurs in a year when a release is eliminated. Differences in annual costs for water supply access in the lower river ranged from a reduction in costs of $21,000 in 1974 to an increase in costs of $72,000 in 1966 relative to Alternative 1.

Figure 15 shows that access to water supply in the upper river appear to have more adverse effects under Alternative 6 than in the lower river with many of these impacts occurring during drought conditions. Years with the greatest increase in costs occur during conditions similar to the 1930s drought but also in the late 1950s and early 1960s and the mid-2000s. In many years when pulse events are occurring costs are lower for water supply access in the upper river under Alternative 6. Adverse impacts are relatively small with the largest impact resulting in an increase in costs of less than $32,000 for all 36 intakes located in the upper river. Differences in annual costs relative to Alternative 1 over the modeled POR range from a cost savings of $14,500 to an increase of nearly $32,000.

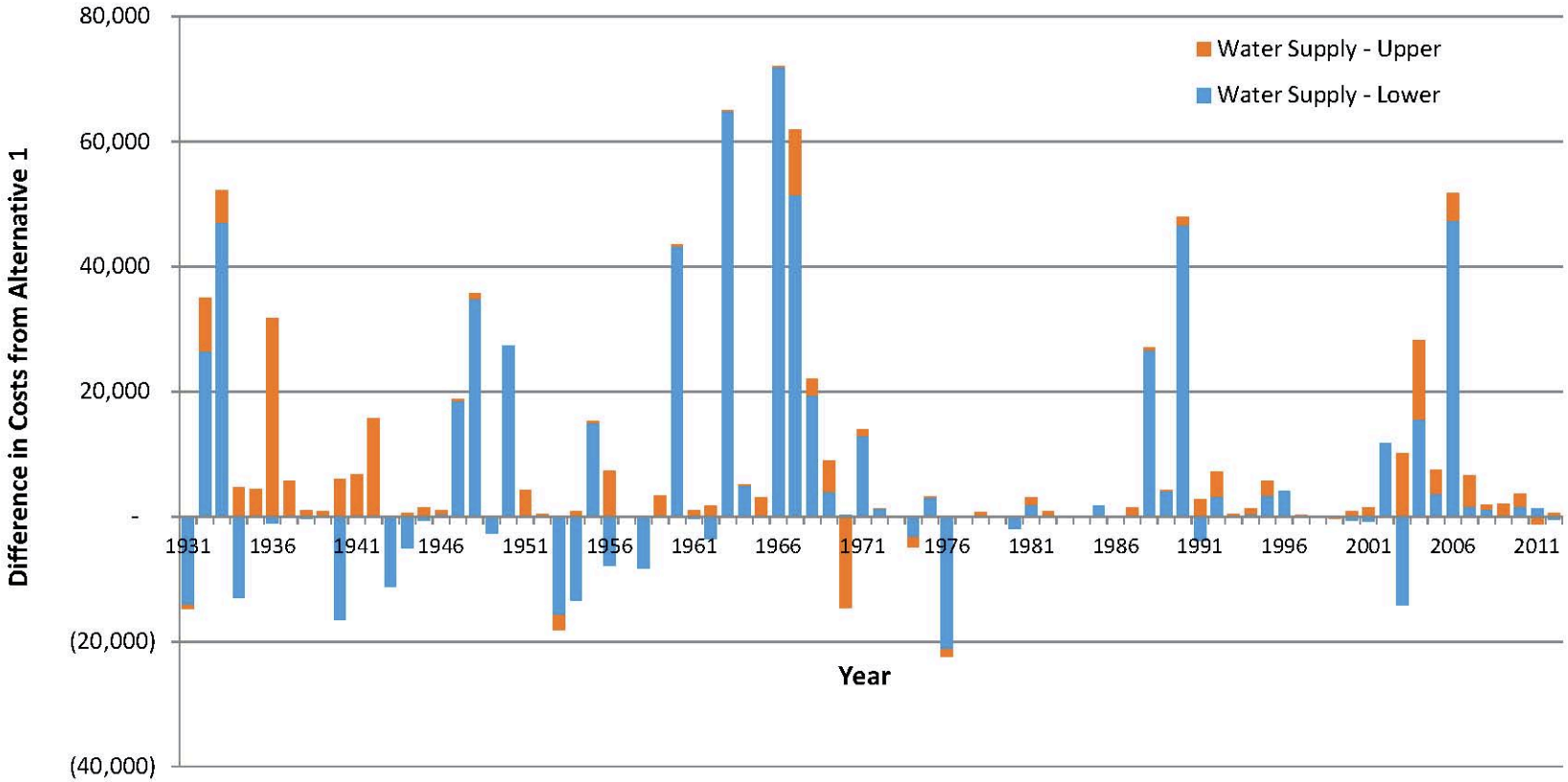
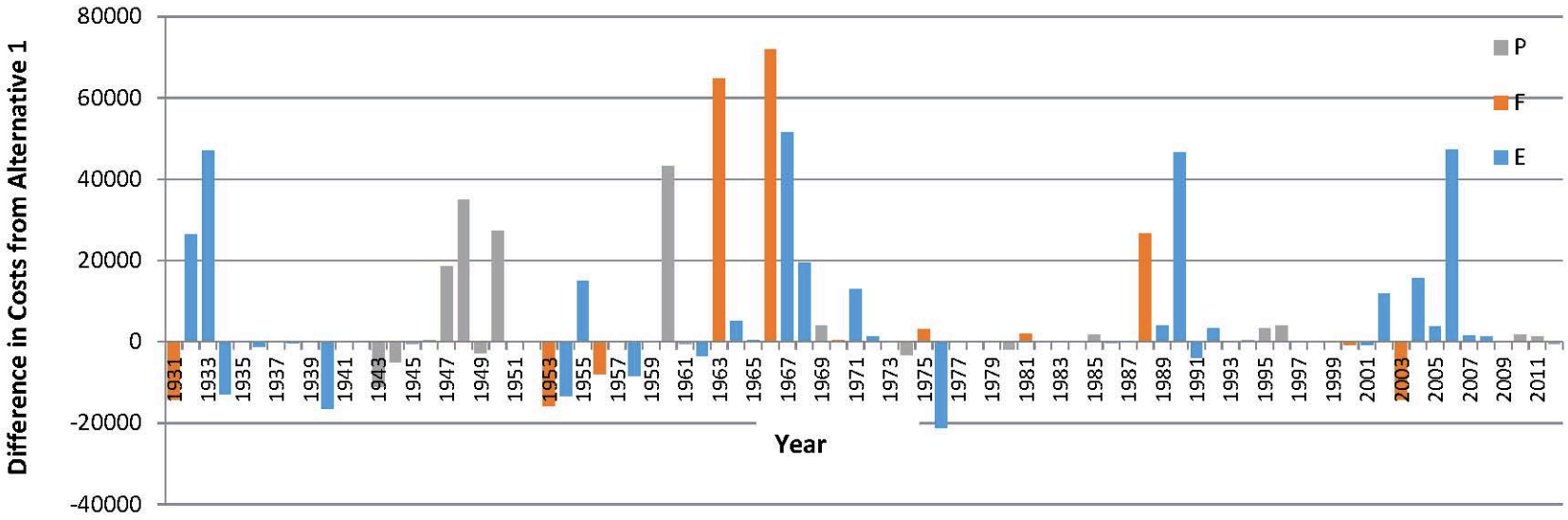
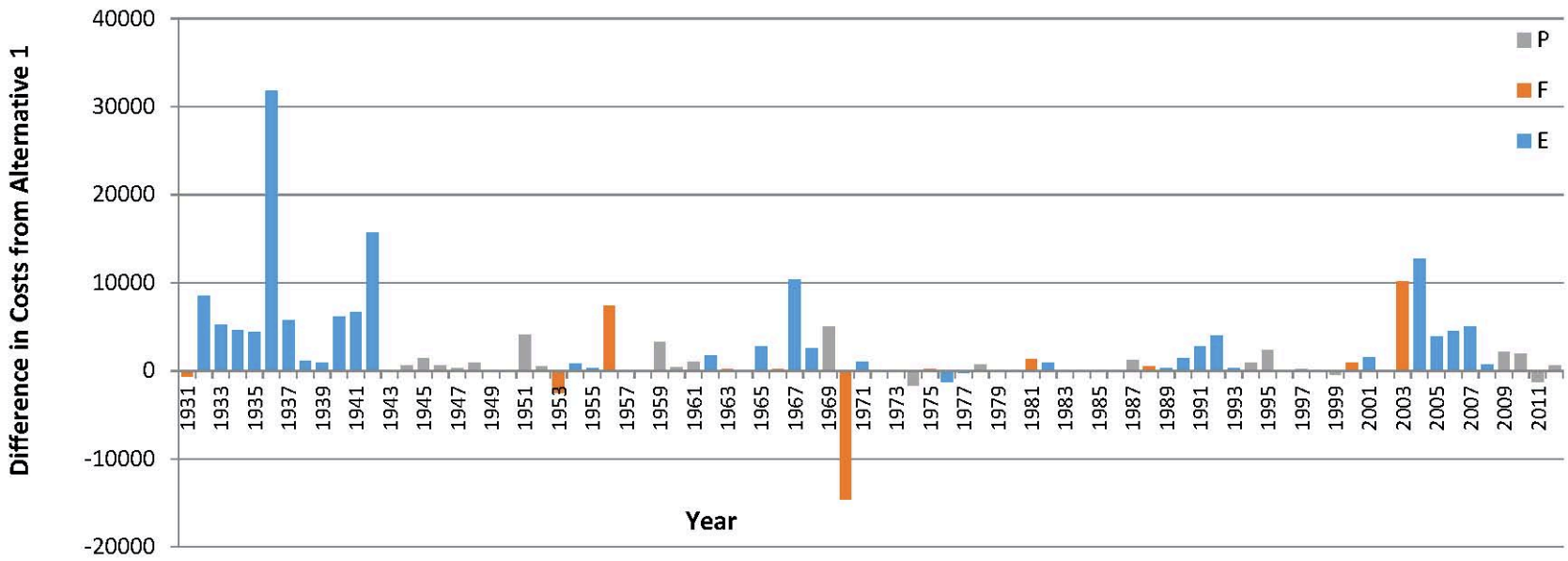


Figure 13. Annual Difference in Costs for Alternative 6 Relative to Alternative 1 for Water Supply Access in Upper and Lower River (2016 Dollars)



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

Figure 14. Difference in Costs under Alternative 6 from Alternative 1 for Water Supply Access in the Lower River (2016 Dollars)



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

Figure 15. Difference in Costs under Alternative 6 from Alternative 1 for Water Supply Access in the Upper River (2016 Dollars)

5.0 Regional Economic Development Evaluation Results

The RED analysis focused on whether changes in costs to water supply intakes due to the MRRMP-EIS alternatives would have a measurable impact on water rates to local customers. A qualitative discussion of the RED impacts on water supply intakes is provided in Chapter 3 of the MRRMP-EIS.

6.0 Other Social Effects Results

The OSE analysis for water supply 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, access to safe water sources, and economic vitality. A qualitative discussion of the OSE impacts on water supply intakes is provided in Chapter 3 of the MRRMP-EIS.

7.0 Environmental Quality Results

This account was not evaluated for water supply intakes.

8.0 References

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