Niobrara River Basin Study Appendix G — Economics Technical Report

U.S. Department of the Interior April 2015

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

On cover: Rafters shoot through Rocky Ford Rapid in the Wild and Scenic portion of the Niobrara River. Photo by National Park Service.

Niobrara River Basin Study Appendix G — Economics Technical Report

Prepared by:

Technical Service Center
Water and Environmental Resources Division (86-68200)
Economics, Planning, and Technical Communications Group (86-68270)
Todd L. Gaston, Economist
Jon Platt, Economist

Peer reviewed by:

Rob M. Davis, Ph.D, Economist

U.S. Department of the Interior **April 2015**

Executive Summary

Purpose, Scope and Objectives

The purpose of this economic analysis is to provide a comparison of the net economic benefits of the Niobrara River Basin Study's proposed alternatives under a series of climate change scenarios. The alternatives propose operational and structural modifications designed to recharge aquifers and conserve surface water in the Niobrara River Basin. This economic analysis is conducted for the U.S. Bureau of Reclamation's (Reclamation) Office of Policy and Nebraska - Kansas Area Office.

It was decided by the Niobrara River Basin Study leadership team that the scope of the economic analysis will be limited to agriculture and recreation, as these categories are expected to comprise the majority of river- and reservoir-related economic benefits associated with the Niobrara River Basin Study's alternatives. Therefore, the primary objective of the economic analysis is to estimate the net economic benefits for each proposed alternative as compared to the No Action Alternative based on benefits accruing only to agriculture and recreation. A secondary objective is to evaluate the economic effect of climate change associated the various climate change scenarios.

Benefit Cost Analysis

This economic study comprises an appraisal level benefit-cost analysis (BCA) consistent with the *Principles, Requirements, and Guidelines* (PR&Gs), which represent the main set of guidelines for Federal water management agency economic analyses (USCEQ, 2014) (DOI, 2015).

The purpose of a BCA is to compare the monetized benefits of a proposed project to its monetized costs. The total costs of the proposed project are subtracted from the total benefits to measure net benefits. If the net benefits are positive, implying benefits exceed costs, the project could be considered economically justified. In studies like this one, where multiple alternatives are being considered, the alternatives are ranked and the one with the greatest positive net benefit would be preferred from strictly an economics perspective.

The BCA in this economic study is conducted using a "with" versus "without" approach. The "with" condition reflects the situation *with* a given proposed action alternative in place, while the "without" condition reflects the situation *without* the given proposed action alternative in place. The alternative representing the "with" condition is referred to as the Action Alternative and the alternative representing the "without" condition is referred to as the No Action Alternative. A "with" versus "without" analysis compares estimates of the net benefits under the No Action Alternative to estimates of net benefits under each proposed Action Alternative. The Action Alternative with the greatest increase in net benefits in excess of those under the No Action Alternative is the preferred Action Alternative from an economics perspective.

Alternatives Analyzed

This analysis evaluates two proposed operational and/or structural modifications: (1) a groundwater recharge alternative (Mirage Flats Canal Recharge Alternative); and (2) a diversion point change alternative (Mirage Flats Pumping Station Alternative). In addition, three future climate change scenarios are analyzed for each proposed alternative: (1) hot/dry (*low* water availability); (2) central tendency (*median* water availability); and (3) warm/wet (*high* water availability). This results in six combinations of climate change scenarios and operational/ structural modifications to be modeled for the economics analysis. These six combinations are referred to as the Action Alternatives/Scenarios for the purpose of this analysis—to conform to the BCA methodology outlined above.

Two versions of the No Action Alternative are developed for comparison purposes. One based on historical climate/hydrologic conditions (without climate change) and the other based on the three future climate change scenarios. The Baseline No Action Alternative (Baseline No Action) models historical climate with no climate change and no operational modifications. The Future No Action Alternative models the following: (1) future climate change scenario 1 (hot/dry) with no operational modification (Low No Action); (2) future climate change scenario 2 (central tendency) with no operational modification (CT No Action); and (3) future climate change scenario 3 (warm/wet) with no operational modification (High No Action). Table ES-1, below, displays the three alternatives associated with each climate change scenario for a total of ten alternatives/ scenarios used for comparison purposes within this economics analysis. The designations assigned to each alternative/scenario (far right column of Table ES-1) are used throughout this report for the purposes of succinctness and clarity.

Table ES-1. Alternatives/Climate Change Scenarios Analyzed

Period	Alternative/Operational modification	Climate Change Scenario	Designation
Baseline	No Action (current operations)	Historical (no climate change)	Baseline No Action
Future	No Action (current operations)	Low water availability	Low No Action
Future	(1) Mirage Flats pumping station	Low water availability	Alt 1 Low
Future	(2) Mirage Flats canal recharge	Low water availability	Alt 2 Low
Future	No Action (current operations)	Central Tendency water availability	CT No Action
Future	(1) Mirage Flats pumping station	Central Tendency water availability	Alt 1 CT
Future	(2) Mirage Flats canal recharge	Central Tendency water availability	Alt 2 CT
Future	No Action (current operations)	High water availability	High No Action
Future	(1) Mirage Flats pumping station	High water availability	Alt 1 High
Future	(2) Mirage Flats canal recharge	High water availability	Alt 2 High

Economic Methodology

Agricultural and recreation benefits are estimated independently under the conditions specified for each of the ten alternatives/scenarios defined in Table ES-1. The sum of agricultural and recreation benefits under a given alternative/ scenario yields the *combined benefits*. The costs associated with each alternative/ scenario are then subtracted from *combined benefits* to yield *net benefits* under each alternative/scenario.

As stated above, BCAs are conducted using a “with” versus “without” approach—the “with” condition reflecting the situation with a proposed Action Alternative in place and the “without” condition reflecting the situation without the proposed Action Alternative in place. The “Comparison Alternative/ Scenario” column in Table ES-2 depicts the “with” condition, while the “Base Case Alternative/Scenario” column depicts the “without” condition. The BCA is conducted as six net benefits comparisons—calculating the difference between each Action Alternative/Scenario and its No Action variant (comparison numbers 4–9 in Table ES-2).

Three additional net benefits comparisons are made solely for the purpose of evaluating the economic effects of the three future climate change scenarios (comparison numbers 1–3 in Table ES-2). In this case, the Baseline No Action Alternative “without” climate change is compared to the Future No Action Alternative “with” climate change such that the “with” versus “without” comparison is maintained. Low No Action, CT No Action, and High No Action are compared to Baseline No Action to gauge the climate change scenario economic effects. Comparison numbers 1–3 in Table ES-2 are therefore technically not part of the BCA, as the basin cannot “choose” a future climate scenario (as opposed to choosing an operational modification), rather the basin is subjected to that future climate scenario. The nine total comparisons are displayed below in Table ES-2.

Table ES-2. Alternative/Scenario Comparisons

Comparison number	Base Case Alternative/Scenario		Comparison Alternative/Scenario
(1)	Baseline No Action	→	Low No Action
(2)	Baseline No Action	→	CT No Action
(3)	Baseline No Action	→	High No Action
(4)	Low No Action	→	Alt 1 Low
(5)	Low No Action	→	Alt 2 Low
(6)	CT No Action	→	Alt 1 CT
(7)	CT No Action	→	Alt 2 CT
(8)	High No Action	→	Alt 1 High
(9)	High No Action	→	Alt 2 High

Calculation of Net Economic Benefits

Agricultural benefits are based solely on the irrigated land falling within the boundaries of Mirage Flats Irrigation District (MFID) and results are not extrapolated to total basin irrigated acreage. This assumption was directed by the basin study leadership team to facilitate the agricultural economic analysis for this appraisal-level study. Further assumptions and modeling details concerning the agricultural benefits portion of this analysis are described in section 2.1 of this report.

Recreation benefits are based on reservoir recreation models developed for Box Butte and Merritt reservoirs and a river recreation model developed for the highest use stretch of the designated Niobrara National Scenic River. Details concerning the reservoir and river recreation models are described in section 2.2 of this report.

The only costs included in this analysis are those associated with construction activities. Annual operation, maintenance, replacement, and power (OMR&P) costs likely vary by alternative, but are not included in this appraisal-level BCA. The alternatives/scenarios that have a construction-related cost are those that include the Mirage Flats pumping station (Alt 1 Low, Alt 1 CT and Alt 1 High). These alternatives/scenarios include the estimated $4.46 million cost of constructing a new pumping plant. Since the construction period for this new pumping is less than one year, no interest during construction is added to the construction cost estimate.

Both agricultural and recreation benefits are initially estimated as annual values. The present value of the stream of annual benefits under each alternative/scenario is then calculated using a 50-year planning horizon and the FY2015 Federal discount rate of 3.375 percent (Reclamation, 2014) and reported in Table ES-3.

Summary of Benefit-Cost Analysis Results

Table ES-4 reports the results of the alternative/scenario comparisons described in Table ES-2. Under each climate change scenario, net benefits under the Future No Action Alternative (i.e., Low No Action, CT No Action, and High No Action) with climate change exceed the Baseline No Action Alternative (Baseline No Action) without climate change. The net benefits are dominated by the recreational benefits (see Table ES-3) which increase under each Future No Action climate change scenario due to increased temperatures under all three scenarios and increased water elevations under the CT and High scenarios.

With the exception of Alt 1Low, the comparisons of the proposed action alternatives/scenarios to the Future No Action alternative/scenarios result in positive net benefits ranging from $1.0 to $14.2 million. This indicates that the net benefits of the action alternatives generally exceed those of the Future No Action Alternative implying the action alternatives are economically justified. In addition to the combined agricultural and recreation benefits, Alternative Alt 1also includes the costs for constructing the new pumping plant. Under each scenario, the net benefits of Alternative Alt 2exceed those of Alternative Alt 1.

Table ES-3. Present Value of Net Benefits under Defined Alternatives/Scenarios

All benefits, costs, and net benefits reported in millions of dollars.

Alternative/ Scenario	Agricultural Benefits[a]	Recreation Benefits[a]	Combined Benefits[a,b]	Costs[c]	Net Benefits[a,d]
Baseline No Action	$15.8	$112.5	$128.3	$0.0	$128.3
Low No Action	$15.1	$136.0	$151.1	$0.0	$151.1
Alt 1 Low	$17.3	$137.0	$154.3	$4.5	$149.8
Alt 2 Low	$13.1	$139.0	$152.1	$0.0	$152.1
CT No Action	$16.5	$137.2	$153.7	$0.0	$153.7
Alt 1 CT	$18.5	$146.3	$164.8	$4.5	$160.3
Alt 2 CT	$13.6	$154.3	$167.9	$0.0	$167.9
High No Action	$17.5	$133.7	$151.2	$0.0	$151.2
Alt 1 High	$18.3	$141.3	$159.6	$4.5	$155.1
Alt 2 High	$13.9	$147.7	$161.6	$0.0	$161.6

[a] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

[b] The sum of agricultural benefits and recreation benefits.

[c] Costs are only associated with any Future Alternative/Scenario that includes the Mirage Flats Pumping Station operational modification—see section 3 of this report.

[d] Combined Benefits minus Costs.

Table ES-4. Alternative/Scenario Comparisons of Net Benefits

Net benefits reported in millions of dollars.

Base Case			Comparison		Difference (million $'s)	Percent Difference
Alternative/ Scenario	Net Benefits[a]		Alternative/ Scenario	Net Benefits[a]		
Baseline No Action	$128.3	→	Low No Action	$151.1	$22.8	17.8%
Baseline No Action	$128.3	→	CT No Action	$153.7	$25.4	19.8%
Baseline No Action	$128.3	→	High No Action	$151.2	$22.9	17.8%
Low No Action	$151.1	→	Alt 1 Low	$149.8	–$1.3	–0.9%
Low No Action	$151.1	→	Alt 2 Low	$152.1	$1.0	0.7%
CT No Action	$153.7	→	Alt 1 CT	$160.3	$6.6	4.3%
CT No Action	$153.7	→	Alt 2 CT	$167.9	$14.2	9.2%
High No Action	$151.2	→	Alt 1 High	$155.1	$3.9	2.6%
High No Action	$151.2	→	Alt 2 High	$161.6	$10.4	6.9%

[a] The sum of agricultural and recreation benefits. 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

Contents

Page

Tables

Figures

1 Introduction

The economic analyses conducted for the U.S. Bureau of Reclamation's (Reclamation) Niobrara River Basin Study focus on an appraisal level benefit-cost analysis (BCA) consistent with the *Principles, Requirements, and Guidelines* (PR&Gs).

The PR&Gs represent the main set of guidelines for Federal water management agency economic analyses. The PR&Gs replace the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (USWRC, 1983), otherwise referred to as the P&Gs. The PR&Gs are comprised of three tiers: (1) the Principles and Requirements (P&Rs)—high-level policy guidance (USCEQ, 2013); (2) the Interagency Guidelines (IGs)—guidance in somewhat more detail that applies to all agencies involved in water investment and management (USCEQ, 2014); and (3) Agency Specific Procedures (ASPs)—guidance for specific agencies (DOI, 2015).

The PR&Gs describe four economic or quasi-economic analyses – national economic benefit-cost analysis (BCA), regional economic impact analysis (RIA), cost effectiveness analysis (CEA), and breakeven analysis (BEA). However, given time and budget constraints, the economic analysis for the Niobrara Basin Study will focus entirely on an appraisal level BCA.

1.1 Overview of Benefit-Cost Analysis

The purpose of a BCA is to compare the monetized benefits of a proposed project to its monetized costs. The total costs of the project are subtracted from the total benefits to measure net benefits. If the net benefits are positive, implying benefits exceed costs, the project could be considered economically justified. Conversely, if net benefits are negative—implying costs exceed benefits—the project would not be economically justified. In studies like this one, where multiple alternatives are being considered, the alternatives are ranked and the one with the greatest positive net benefit would be preferred from strictly an economics perspective.

BCAs are conducted using a "with" versus "without" approach. The "with" condition reflects the situation *with* a given proposed action alternative in place, while the "without" condition reflects the situation *without* the given proposed action alternative in place. The alternative representing the "with" condition is referred to as the Action Alternative and the alternative representing the "without" condition is referred to as the No Action Alternative. A "with" versus "without" analysis compares estimates of the net benefits under the No Action Alternative to estimates of net benefits under each proposed Action Alternative. The Action

Alternative with the greatest increase in net benefits in excess of those under the No Action Alternative is preferred from an economics perspective.

Another option for providing this "with" versus "without" perspective is to estimate the change in benefits and costs for each proposed Action Alternative as compared to the No Action Alternative (incremental analysis) instead of measuring the benefits and costs for the No Action Alternative itself. This can be accomplished by estimating the changes in inputs to the economic analysis (e.g., changes in agricultural water deliveries, changes in reservoir water levels for recreation) under each action alternative as compared to the No Action Alternative. These changes in economic inputs are then used to estimate the change in benefits and costs associated with each proposed Action Alternative. The change in benefits and costs are used to estimate the change in net benefits and again, the Action Alternative with the greatest increase in net benefit would be preferred from an economic perspective. While this approach avoids the need to estimate economic benefits and costs for the No Action Alternative, estimating effects under both the Action Alternatives and the No Action Alternative would be required for the inputs to the economic analyses.

Before comparisons can be made between costs and benefits, they must be converted to the same dollar year and point in time. For this study, regardless of when they were expected to be incurred, all the costs and benefits are calculated in 2014 dollars; therefore no dollar year/price level adjustment was necessary. However, the costs and benefits will occur at different points in time into the future implying different time values. In addition to the construction period required to complete construction tasks (e.g., installing pumps for the Mirage Flats Pumping Station Alternative), a 50 year period of analysis is used for benefit evaluation.

The concept of the time value of money suggests that a dollar of benefits or costs incurred in the future is worth less than a dollar of benefits or costs incurred today because all benefits and costs have an opportunity cost. That is, one could put today's dollar in a bank (or some alternative investment) and earn interest over time resulting in a total value in the future greater than the original dollar. For example, if one could earn 3% interest over the year, $1.00 today would be equivalent to $1.03 a year from now, therefore $1.00 a year from now is only worth $0.97 today (1/1.03). In the analysis developed for this study, costs and benefits incurred in the future are reduced by discounting (present valuing) them back to the start of the period of analysis (equivalent to the end of the construction period) using the Fiscal Year 2015 (FY2015) Federal discount rate of 3.375 percent (Reclamation, 2014). It's standard Reclamation practice to measure all the costs and benefits as of the end of the construction period. Note that the point of reference for the benefits and costs has no bearing on the results of the benefit-cost analysis.

As decided by the Niobrara River Basin Study leadership team, the BCA conducted for this study focuses on agricultural and recreation benefits since they were expected to comprise the majority of river and reservoir related economic benefits associated with the alternatives under consideration. The benefit analysis evaluates the economic effect of changing water deliveries and groundwater pumping costs to agriculture and changing temperatures, instream flows and reservoir water levels to recreation. From a cost perspective, construction activities are being proposed for certain alternatives, but not all alternatives. Changing operations under the proposed action alternatives could result in differences in annual operation, maintenance, replacement, and power (OMR&P) costs between alternatives. However, for this appraisal level analysis, OMR&P costs were not evaluated. Therefore any cost differential between alternatives is based purely on construction costs. The BCA combines the positive and negative effects across the two benefit categories (agriculture and recreation) with any construction costs to estimate the net benefits of each alternative. The net benefits of the action alternatives are compared to those of the No Action Alternative to estimate the change in net benefits for each action alternative. The changes in net benefits are then compared across the action alternatives to determine the best alternative from an economic perspective.

1.2 Alternatives Analyzed

This analysis evaluates two proposed operational and structural modifications: (1) a groundwater recharge alternative (Mirage Flats Canal Recharge Alternative); and (2) a diversion point change alternative (Mirage Flats Pumping Station Alternative). In addition, three future climate change scenarios are analyzed for each proposed alternative: (1) hot/dry (low water availability); (2) central tendency (median water availability); and (3) warm/wet (high water availability).

The Mirage Flats Canal Recharge Alternative involves additional diversions of available natural flows outside of irrigation season in an effort to recharge groundwater in the project area. The Mirage Flats Pumping Station Alternative moves the diversion point on the Niobrara River from Dunlap Diversion Dam to a downstream point approximately 9.5 miles upstream of Pumping Plant #1 thereby eliminating the need to run water through the 12 mile stretch of high loss canal from Dunlap Diversion Dam to the point where the Mirage Flats Irrigation District begins delivering water to project acres.

The three future climate change scenarios associated with each of the two proposed operational/structural alternatives result in six combinations of alternative/climate change scenarios to be modeled for the economics analysis. These six combinations are referred to as the Action Alternatives/Scenarios for the purpose of this analysis—to conform to the BCA methodology outlined above in section 1.1.

Two versions of the No Action Alternative are developed for comparison purposes. One based on historical climate/hydrologic conditions (without climate change) and the other based on the three future climate change scenarios. The Baseline No Action Alternative (Baseline No Action) models historical climate with no climate change and no operational modifications. The Future No Action Alternative models the following: (1) future climate change scenario 1 (hot/dry) with no operational modification (Low No Action); (2) future climate change scenario 2 (central tendency) with no operational modification (CT No Action); and (3) future climate change scenario 3 (warm/wet) with no operational modification (High No Action).

Table 1, below, displays the three alternatives associated with each climate change scenario for a total of ten alternatives/scenarios used for comparison purposes within this economic analysis. The designations assigned to each alternative/scenario (far right column of Table 1) are used throughout this economics report for the purposes of succinctness and clarity.

Table 1. Alternatives/Climate Change Scenarios Analyzed

Period	Alternative/Operational modification	Climate Change Scenario	Designation
Baseline	No Action (current operations)	Historical (no climate change)	Baseline No Action
Future	No Action (current operations)	Low water availability	Low No Action
Future	(1) Mirage Flats pumping station	Low water availability	Alt 1 Low
Future	(2) Mirage Flats canal recharge	Low water availability	Alt 2 Low
Future	No Action (current operations)	Central Tendency water availability	CT No Action
Future	(1) Mirage Flats pumping station	Central Tendency water availability	Alt 1 CT
Future	(2) Mirage Flats canal recharge	Central Tendency water availability	Alt 2 CT
Future	No Action (current operations)	High water availability	High No Action
Future	(1) Mirage Flats pumping station	High water availability	Alt 1 High
Future	(2) Mirage Flats canal recharge	High water availability	Alt 2 High

1.3 Benefit-Cost Analysis Methodology

Agricultural and recreation benefits are estimated independently under the conditions specified for each of the ten alternatives/scenarios defined in Table 1. The sum of agricultural and recreation benefits under a given alternative/scenario yields the *combined benefits* under that alternative/scenario. The costs associated with each alternative/scenario are then subtracted from *combined benefits* to yield *net benefits* under each alternative/scenario.

As stated above in section 1.1, BCAs are conducted using a “with” versus “without” approach—the “with” condition reflecting the situation with a proposed Action Alternative in place and the “without” condition reflecting the situation without the proposed Action Alternative in place. The “Comparison Alternative/Scenario” column in Table 2 depicts the “with” condition, while the

“Base Case Alternative/Scenario” column depicts the “without” condition. The BCA is conducted as six net benefits comparisons—calculating the difference between each Action Alternative/Scenario and its No Action variant (comparison numbers 4–9 in Table 2).

Three additional net benefit comparisons are made solely for the purpose of evaluating climate change economic effects (comparison numbers 1–3 in Table 2). In this case, the Baseline No Action Alternative “without” climate change is compared to the Future No Action Alternative “with” climate change such that the with versus without comparison is maintained. Low No Action, CT No Action, and High No Action are compared to Baseline No Action to gauge the economic effects of the three future climate change scenarios. Comparison numbers 1–3 in Table 2 are therefore technically not part of the BCA, as the basin cannot “choose” a future climate change scenario (as opposed to choosing an operational modification), rather the basin is subjected to that future climate scenario. The nine total comparisons are displayed below in Table 2.

The nine alternative/scenario comparisons are also made independently for agricultural benefits and recreation benefits, and presented in sections 2.1.8.3 and 2.2.4.2, respectively. The benefit comparisons in sections 2.1.8.3 and 2.2.4.2 are presented solely for informative purposes, since they exclude the costs associated with each alternative, they do not represent the net benefits displayed in the BCA.

Table 2. Alternative/Scenario Comparisons

Comparison number	Base Case Alternative/Scenario		Comparison Alternative/Scenario
(1)	Baseline No Action	→	Low No Action
(2)	Baseline No Action	→	CT No Action
(3)	Baseline No Action	→	High No Action
(4)	Low No Action	→	Alt 1 Low
(5)	Low No Action	→	Alt 2 Low
(6)	CT No Action	→	Alt 1 CT
(7)	CT No Action	→	Alt 2 CT
(8)	High No Action	→	Alt 1 High
(9)	High No Action	→	Alt 2 High

2. Benefits Analyses

As noted above, the benefits analyzed for this study are limited to agriculture and recreation.

2.1 Agricultural Benefits Analysis

For the purpose of this analysis, *agricultural benefits* under a defined alternative/scenario are estimated as *irrigation benefits* accrued to the agricultural district under the hydrologic conditions specified by that alternative/scenario. *Irrigation benefits* are measured as the change in net farm income (NFI) received from the use of irrigation water to produce agricultural commodities (Reclamation, 2004a).

Due to this being an appraisal-level analysis, a number of assumptions were made to facilitate the agricultural benefits analysis. The following assumptions were directed by the basin study leadership team and are employed for this agricultural benefits analysis:

1. The agricultural benefits analysis is based solely on the irrigated land falling within the boundaries of Mirage Flats Irrigation District (MFID) and results are not extrapolated to total basin irrigated acreage;
2. Groundwater is used to supplement any surface water delivery losses under any alternative/scenario;
3. No groundwater cells within MFID are fully depleted under any alternative/scenario; and
4. Cropping pattern remains constant under all alternatives/scenarios.

2.1.1 MFID Background

MFID receives surface irrigation water from Box Butte Reservoir via the Mirage Flats Canal—diverted from the Niobrara River at a point about 8 miles downstream of Box Butte Dam (see Figure 1). Box Butte Dam and MFID are part of the Mirage Flats Project in western Nebraska. Box Butte Dam and Reservoir reside in Dawes County, while MFID resides in Sheridan County.

MFID consists of 11,662 irrigated acres. The irrigation season begins June 1 and concludes on September 30. During the four month irrigation season, about 1 acre-foot of total irrigation water is applied to MFID fields. Typically, just less than half of this water (about 5.35 acre-inches) is delivered as surface water from Box Butte Dam via the Mirage Flats Canal.[1] The difference between crop water

[1] See section 2.1.4, *Hydrology Requirements and Inputs*.

requirements and surface water deliveries from Box Butte Reservoir is made up by groundwater pumping.

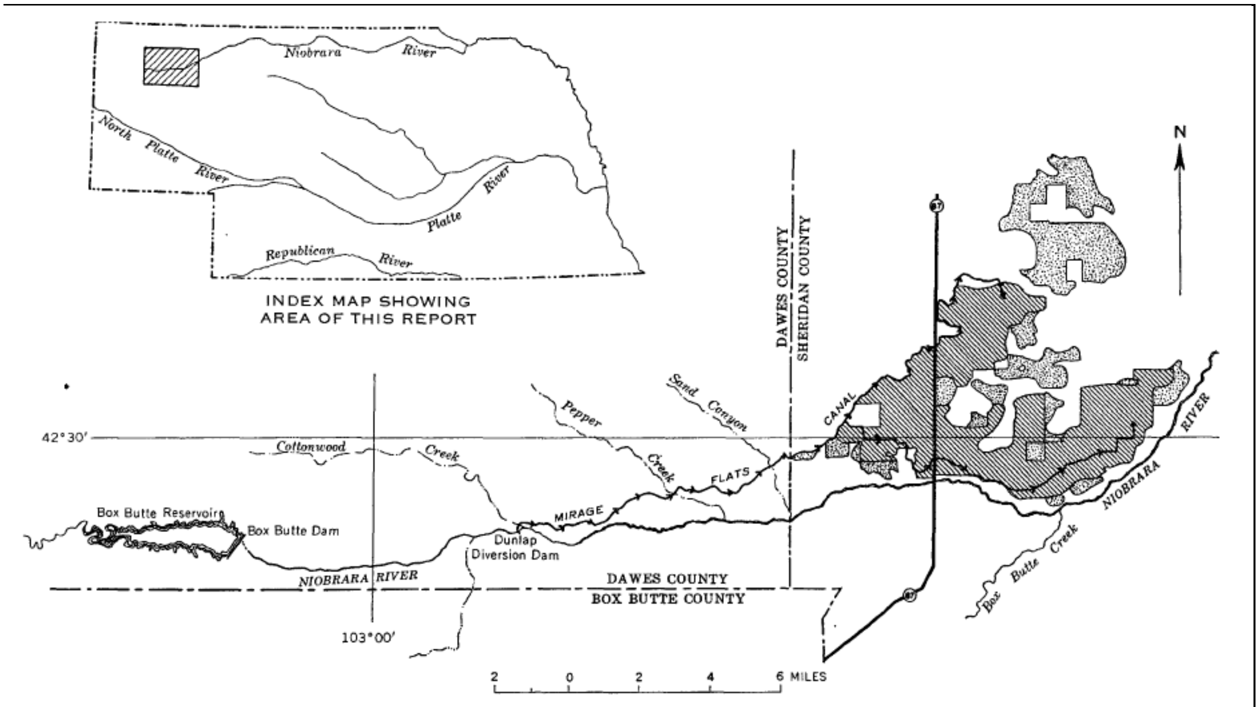

Figure 1. Map depicting Mirage Flats Irrigation District (oblique-line pattern).

Source: *Ground-water Resources of Mirage Flats, Nebraska* – Figure 1. page BB4 (Keech, 1964)

2.1.2 Agricultural Benefits Methodology

Annual agricultural benefits under a given alternative/scenario are estimated as MFID NFI subject to the hydrologic conditions specified by that alternative/scenario. The present value of annual agricultural benefits under each alternative/scenario is then calculated—using a 50-year planning horizon and the FY2015 Federal discount rate of 3.375 percent (Reclamation, 2014).

The methodology employed to calculate MFID NFI under a given alternative/ scenario is:

1. In accordance with Reclamation guidance (Reclamation, 2004b), crop-specific farm budgets are developed that depict typical full-time irrigated operations for the dominant crops grown within MFID;
2. The farm budgets are assigned a proportion of MFID irrigated acreage based on historical cropping patterns;
3. Each farm budget is modeled under the hydrologic conditions specified by the given alternative/scenario using Reclamation's Farm Budget Tool

(FBT)—a computer application developed by Reclamation—to yield *net income per acre for each crop* under the given alternative/scenario;

4. The *net income per acre for each crop* under the given alternative/scenario is multiplied by the acreage assigned to that crop to yield *district-level net income per crop* under the given alternative/scenario; and
5. The sum of the *district-level net income per crop* values under the given alternative/scenario yields *NFI* under that alternative/scenario.

This methodology is used to calculate MFID NFI under each of the 10 defined alternatives/scenarios displayed in Table 1 on page 4 of this report. The following sections describe Reclamation's Representative Farm Method; the data used to determine cropping pattern, farm size, and water requirements; and the inputs used to develop the farm budgets modeled with Reclamation's FBT.

2.1.3 Representative Farm Method

Reclamation guidance (Reclamation, 2004b) recommends that enough farm types be analyzed to reflect the kinds of farm organizations and enterprises influencing the irrigation benefits and/or payment capacity of the area as a whole. It is often not practical to complete farm budgets for all crops grown in the irrigation district. If certain crops are grown only on a small percentage of total district acres, they can be represented by a more extensively grown crop in the same general category of crops (i.e., forage, grain, orchard, vegetables, etc.). For this analysis, five single-crop farm budgets were prepared to represent the farming operations in MFID. The single-crop farm budgets are based on the major crops identified from the historical cropping pattern.

The farm budgets prepared for this analysis account for gross revenues, variable and fixed costs of operation, and allowances for returns to management and labor in the estimation of NFI.

2.1.3.1 Historical Cropping Pattern

The most comprehensive cropping pattern data for MFID was generated and compiled by the Upper Niobrara White Natural Resources District (UNWNRD)—one of 23 natural resource districts in Nebraska. UNWNRD encompasses all of Box Butte, Dawes, Sheridan and the northern 80% of Sioux county and is divided into six ground water management sub-areas based on hydrogeologic and physical conditions (see Figure 2). (UNWNRD, 2015)

UNWNRD conducts groundwater meter readings at the end of each growing season for all farms that pump groundwater for irrigation. Farms that pump groundwater constitute about 90 percent of MFID's 11,662 irrigated acres. MFID makes up about 65 percent of UNWNRD Sub-Area 6, and practices typical Sub-Area 6 cropping patterns. UNWNRD meter readers began documenting crop types for each meter read at the end of the 2008 growing season. The crop type is then associated with the number of acres served by the respective meter. (UNWNRD, 2014)

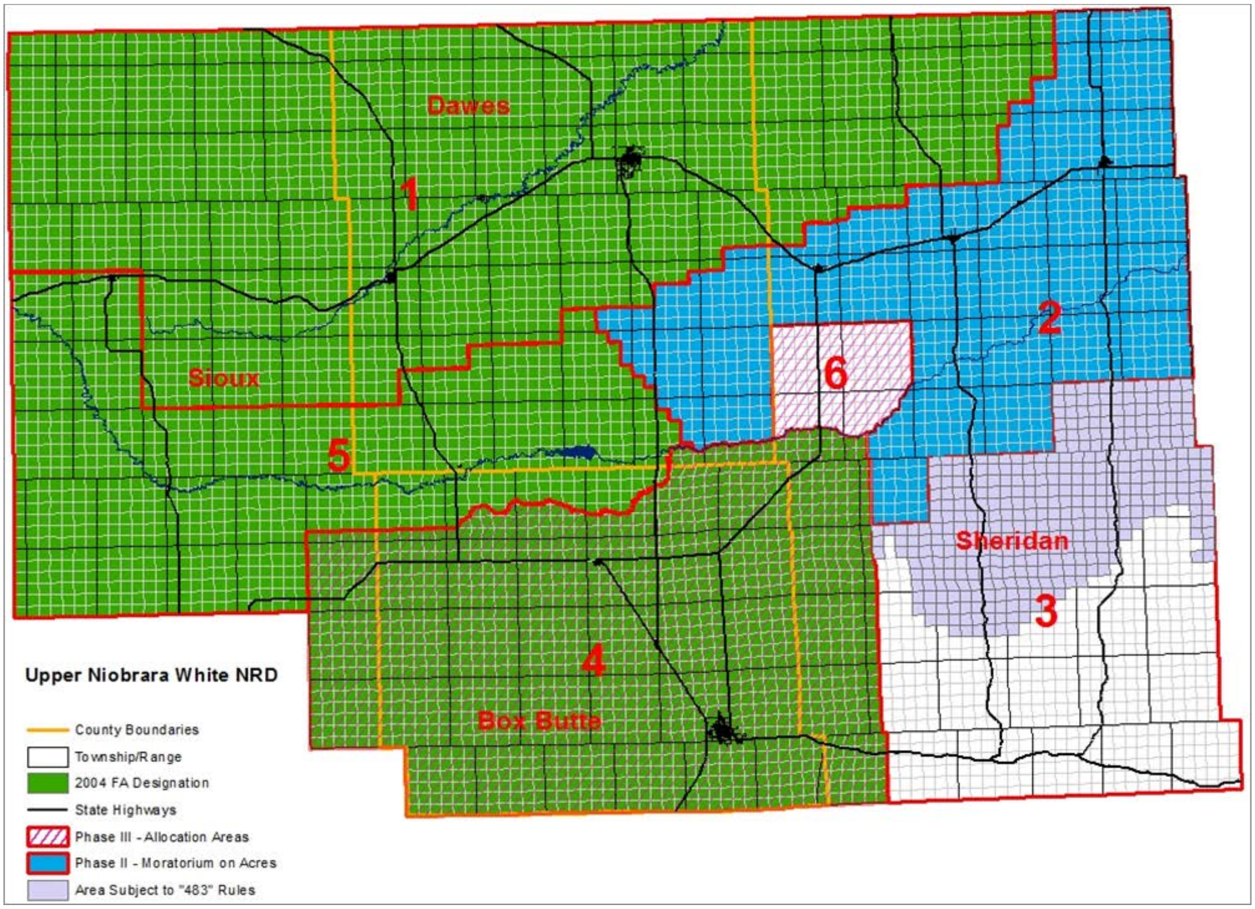

Figure 2. Upper Niobrara White Natural Resources District (source: www.unwnrd.org).

Table 3 shows the cropping pattern developed from the data provided by UNWNRD. This data was validated using USDA's CropScape – Cropland Data Layer (USDA NASS, 2009–12).

2.1.3.2 Crops Studied

The five crops that dominate MFID acreage (in order from highest to lowest historical acreage) are grain corn (corn), dry edible beans (beans), alfalfa, winter wheat (wheat), and sugar beets (beets). As displayed in Table 3, these five crops comprise about 94 percent of MFID irrigated acreage. The percent constituency for each crop is based on four years (2009-2012) of observational data reported by UNWNRD. For analytic purposes, benefits budgets are developed for these five crops and weighted proportionally to estimate the benefits for the entire district. The acreage of all other irrigated crops is subsequently dropped and the acreage of the five studied crops is extrapolated proportionally (based on the historical cropping pattern) to a sum of 11,662 acres (see Table 4).

Table 3. Historical Cropping Pattern for MFID based on Data from UNWNRD

Studied crops	Crop acreage for UNWNRD sample area[a]				4-year average	Proportion of MFID irrig. land (4-yr. avg.)[b]
	2009	2010	2011	2012		
Alfalfa	1,009	773	515	402	675	7.3%
Beans	2,131	1,499	1,793	3,002	2,106	22.7%
Corn	4,335	4,825	5,533	5,405	5,025	54.1%
Beets	332	575	295	330	383	4.1%
Wheat	312	491	877	407	522	5.6%
Other irrig. Crops[c]	211	1,696	190	209	577	6.2%
Totals	8,329	9,860	9,203	9,755	9,288	100%

[a] MFID irrigated acreage from 2009–2012 based on data provided by UNWNRD; as this is observational data based on meter-readings (see UNWNRD data description in text above), the sum of irrigated acreage in any given year is not equal to MFID's total irrigated acreage (11,662 acres).

[b] Cropping pattern as a percentage of total MFID irrigated acreage (as observed by UNWNRD); derived by dividing individual crop acreage (4-year average) by total irrigated acreage (4-year average). The total indicates that the 5 studied crops make up 93.8% of all MFID irrigated acres during the study period (2009–2012).

[c] Other irrigated crops (as observed by UNWNRD) consisted of (in order of highest to lowest acreage): unknown, sunflowers, sorghum, weeds, grasses, and sudan. Other irrigated crops are not included in our benefits analysis. The acreage of the 5 studied crops is subsequently extrapolated to represent all MFID irrigated acres (see Table 4).

Table 4. Extrapolated Cropping Pattern for Purpose of Benefits Analysis

Studied crops	Acreage (4-yr. avg.)	Studied crops extrapolated to 100% of acreage[a]	Studied crops extrapolated to full MFID acreage for analysis[b]
Alfalfa	675	(675 / 8,711*100) = 7.7%	(7.7%*11,662) = 898
Beans	2,106	(2,106 / 8,711*100) = 24.2%	(24.2%*11,662) = 2,822
Corn	5,025	(5,025 / 8,711*100) = 57.7%	(57.7%*11,662) = 6,729
Beets	383	(383 / 8,711*100 = 4.4%	(4.4%*11,662) = 513
Wheat	522	(522 / 8,711*100) = 6.0%	(6.0%*11,662) = 700
Totals	8,711[c]	100.0%	11,662

[a] For the purpose of this analysis, the 5 studied crops are extrapolated (based on historical proportions calculated from NRD-provided data) to constitute 100% of MFID irrigated acreage.

[b] Extrapolation of the 5 studied crops to constitute all 11,662 MFID irrigated acres is achieved by multiplying the extrapolated crop percentage by 11,662. The result is a more easily analyzed version of MFID made up solely of the 5 studied crops in proportions based on the historical cropping pattern shown in Table 3.

[c] 8,711 is the sum of the acreage of the 5 studied crops (4-year average, as observed by UNWNRD). The difference between this total and the 9,288 acres reported in Table 3 is the 4-year average of "other irrigated crops", which is not included in this benefits analysis.

2.1.3.3 Farm Size

Reclamation guidance (Reclamation, 2004b) recommends using a minimum farm size that provides reasonable full employment for the farm operator based on the amount of investment and management expected for the type of farm represented.

Farm size was initially derived using USDA county-level data for Sheridan County (USDA NASS, 2014). The average irrigated acres by crop (2008–2012) for Sheridan County, NE was divided by the number of Sheridan County farms growing that crop over the same time period. These farm sizes were then adjusted based on data from University of Nebraska, Lincoln (UNL) crop budgets (UNL Extension, 2013) and discussions with the MFID district manager and county extension agents.

The alfalfa budget has 160 acres in full-production and 40 acres in the establishment phase. The dry beans budget has 200 acres, the grain corn budget has 300 acres, the sugar beet budget has 400 acres, and the wheat budget has 200 acres.

Farmstead, roads, and waste acreage are assumed to be about 5 percent of irrigated acres and are included in total farm size in the enterprise budgets.

2.1.3.4 University Crop Budgets

UNL crop budgets (UNL Extension, 2013) were used to develop the farm budgets estimated with Reclamation's FBT. The UNL budgets provide the basis for machinery, seed, fertilizers, chemicals, farming operations, etc. The benefits budgets estimate the typical per-acre costs and benefits for producing crops in Nebraska. The representative enterprises are of adequate size to provide a fair return to land, labor, and capital.

The specific assumptions used in the representative farm budgets are discussed below. These sections of the report are arranged to give the reader an idea of how the gross revenues were obtained, the variable and fixed expenses that were included, and the return to management and labor.

2.1.4 Hydrology Requirements and Inputs

Reclamation's FBT requires a number of hydrology inputs for each crop budgeted. These hydrology inputs by crop include:

1. Total irrigation water requirement;
2. Surface irrigation water applied;
3. Groundwater irrigation applied; and
4. Groundwater pumping depth.

Inputs 2, 3, and 4 vary for each defined alternative/scenario, while input 1 is constant over all alternatives/scenarios.

The irrigation water requirement for each studied crop comes from UNL crop budgets (UNL Extension, 2013). Table 5 shows the water requirements for commercial yields in Nebraska for each of the five studied crops.

Table 5. Water Requirements Per Acre for Crops of Interest

Source: (UNL Extension, 2013)

Crop studied	Water requirement[a] (acre-inches)	Description
Alfalfa	15.2	16 in. on full prod. acreage and 12 in. on establishment acreage
Beans	7.0	Conventional using pumped water
Corn	13.0	Bt ECB and RW, continuous
Beets	16.0	Roundup Ready, one pass tillage
Wheat	8.0	No-till after beans

[a] All crops pivot irrigated at 800 gpm and 35 psi.

Based on the irrigation water requirements of the crops studied (see Table 5) and the cropping pattern used for this analysis (see Table 4) the total water requirement per acre for MFID is calculated to be 11.55 acre-inches. Table 6 displays the input data and results for this calculation.

Table 6. MFID Total and Per Acre Water Requirements

Crop studied	Water requirement[a] (acre-inches)	MFID acreage[b]	Water per crop[c] (acre-inches)
Alfalfa	15.2	898	13,650
Beans	7.0	2,822	19,754
Corn	13.0	6,729	87,477
Beets	16.0	513	8,208
Wheat	8.0	700	5,600
Totals		11,662	134,689
Water requirement per acre (134,689 / 11,662) = **11.55 acre-inches**			

[a] Inches of water per acre for each crop as reported in Table 5.

[b] Cropping pattern used in this analysis (see Table 4).

[c] Crop water requirement multiplied by the MFID acreage that crop constitutes.

During the irrigation season, about 1 acre-foot (11.55 acre-inches) of total irrigation water is applied to MFID's 11,662 irrigated acres. Typically, just less than half of this water (5.35 acre-inches, see Table 7) is delivered as surface water from Box Butte Dam via the Mirage Flats Canal. The difference between crop water requirements and surface water deliveries from Box Butte Reservoir is made up by groundwater pumping. The pumping costs associated with groundwater irrigation are higher than the costs associated with surface irrigation due to the additional electricity required to do so. Typical MFID farms will therefore use their entire surface water allocation (varies annually due to Niobrara flow conditions) before resorting to groundwater irrigation.

Average surface water irrigation deliveries under each defined alternative/scenario were modeled by The Flatwater Group (TFG) and supplied to Reclamation for the purpose of this analysis (TFG, 2015). Average groundwater pumping under each defined alternative/scenario was derived by subtracting the average surface water irrigation deliveries from 11.55 acre-inches—the total per acre irrigation water requirement for MFID (see Table 6). The Nebraska Department of Natural Resources (DNR) provided estimates for average MFID pumping depths under each defined alternative/scenario (DNR, 2015). Table 7 displays surface water deliveries, groundwater pumping, and pumping depths used in this analysis for each defined alternative/scenario.

Table 7. Hydrology Inputs under Defined Alternatives/Scenarios

Alternative/ Scenario	Surface water[a] (acre-inches)	Groundwater pumped[b] (acre-inches)	Groundwater pumping depth[c] (ft)
Low No Action	5.35	6.20	75.4
Alt 1 Low	4.24	7.31	79.5
Alt 2 Low	8.57	2.98	78.1
CT No Action	0.00	11.55	76.9
Alt 1 CT	6.45	5.10	72.9
Alt 2 CT	12.01	0.00	71.0
High No Action	0.00	11.55	71.6
Alt 1 High	8.59	2.96	68.5
Alt 2 High	11.15	0.40	68.2
Low No Action	0.00	11.55	68.2

[a] Projected 51-year average for surface water deliveries (TFG, 2015).

[b] MFID per acre water requirement (11.55 acre-inches) minus Surface Water[a].

[c] Projected 51-year average for MFID mean groundwater level (in feet) for all model runs (DNR, 2015).

The breakout of surface water and groundwater applied by crop and by alternative/scenario is displayed in Table 8. Note that all available surface water under a given alternative/scenario is utilized before any groundwater is pumped.

2.1.5 Gross Farm Income

Gross farm income for crops is calculated by multiplying the price times yield times the number of units sold. All crops are produced on-farm and assumed to be sold after harvest. A five-year stand life was assumed for alfalfa, while all other crops are annuals. Yields and prices are discussed in this section.

2.1.5.1 Crop Yields

The ideal crop yield data to be used in this benefits analysis are a 5-year average ending with 2013 for Sheridan County, Nebraska. Data meeting these criteria was available for beans and sugar beets. To develop average yields for alfalfa, corn, and wheat, Sheridan County data most closely meeting these criteria was used.

All county-level yield data was obtained from USDA's National Agricultural Statistics Service (USDA NASS, 2014). All average yields were confirmed with a UNL Extension agent as "representative" for MFID agriculture. Average yields per acre for each crop are detailed in Table 9.

Table 8. Irrigation Water Application by Crop Studied under the Defined Alternatives/ Scenarios

Crop studied→		Alfalfa		Beans		Corn		Beets		Wheat	
Crop water requirement[a]→		15.2		7.0		13.0		16.0		8.0	
Alternative/ Scenario	SW available[b]	SW[c]	GW[d]	SW[c]	GW[d]	SW[c]	GW[d]	SW[c]	GW[d]	SW[c]	GW[d]
Baseline No Action	5.4	5.4	9.9	5.4	1.7	5.4	7.7	5.4	10.7	5.4	2.7
Low No Action	4.2	4.2	11.0	4.2	2.8	4.2	8.8	4.2	11.8	4.2	3.8
Alt 1 Low	8.6	8.6	6.6	7.0	0.0	8.6	4.4	8.6	7.4	8.0	0.0
Alt 2 Low	0.0	0.0	15.2	0.0	7.0	0.0	13.0	0.0	16.0	0.0	8.0
CT No Action	6.5	6.5	8.8	6.5	0.6	6.5	6.6	6.5	9.6	6.5	1.6
Alt 1 CT	12.0	12.0	3.2	7.0	0.0	12.0	1.0	12.0	4.0	8.0	0.0
Alt 2 CT	0.0	0.0	15.2	0.0	7.0	0.0	13.0	0.0	16.0	0.0	8.0
High No Action	8.6	8.6	6.6	7.0	0.0	8.6	4.4	8.6	7.4	8.0	0.0
Alt 1 High	11.2	11.2	4.1	7.0	0.0	11.2	1.9	11.2	4.9	8.0	0.0
Alt 2 High	0.0	0.0	15.2	0.0	7.0	0.0	13.0	0.0	16.0	0.0	8.0

[a] Total crop water requirement in acre-inches during irrigation season (UNL Extension, 2013).

[b] Available surface water (acre-inches) under the respective alternative/scenario as modeled by TFG (see Table 7).

[c] Acre-inches of surface water applied to studied crop under the respective alternative/scenario. Surface water is applied up to the water requirement of the respective crop.

[d] Acre-inches of groundwater pumped to make up the difference between surface water availability and the irrigation water requirement of the respective crop.

Table 9. Average Yields Per Acre for Sheridan County, Nebraska

Source: USDA NASS (2014)

Crop studied	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average yield	Years used for average yield[a]
Alfalfa	Ton	4.9	4.3	3.6	4.2	4.4	--	--	--	--	4.3	2005–09
Beans	Cwt	--	--	--	22.6	22.5	18.7	21.2	30.4	24.4	23.4	2009–13
Corn	Bu	175	150	171	--	176	167.7	165	170.8	--	169.9	2009–12
Beets	Ton	--	--	--	22.1	25.4	26.4	26.9	32.1	25.4	27.2	2009–13
Wheat	Bu	68	55	68	--	--	59	79.8	88	71.4	74.6	2010–13

[a] Years used were for most recent available Sheridan County data for each crop; average yields were confirmed with UNL Extension agent as "representative" for MFID agriculture.

Alfalfa requires an establishment period of one year where production is less than full production in the establishment year. For this reason, establishment acreage is calculated independently for alfalfa and alfalfa yields were prorated over the years of production.

Alfalfa is typically grown on a 5-year rotation in this region. Each year 40 acres of alfalfa are reseeded for new growth and 160 acres are in full production. This study assumes that the average county alfalfa yield (4.3 tons per acres) is over all alfalfa acreage. The 160 acres of established alfalfa is therefore assumed to produce 4.5 tons per acre, while the 40 acres of reseeded alfalfa is assumed to produce 3.5 tons per acre. Total alfalfa yield is therefore 860 tons over 200 acres (160 acres x 4.5 tons + 40 acres x 3.5 tons), which equals an overall average of 4.3 tons per acre.

2.1.5.2 Prices Received

In an agricultural benefits analysis, the State-level USDA normalized price is used when available for prices received. ERS calculates these prices based on 5-year averages of actual market prices lagged two years (e.g., an average of 2008–12 market prices is used to calculate 2014 normalized prices). State-level normalized prices for 2014 were calculated by multiplying the national-level normalized prices by the average ratios of the State-level market prices to the national market prices for 2010–12. (USDA ERS, 2014). USDA 2014 State-level normalized prices for Nebraska were obtained for all 5 crops analyzed in this study.

Note that section 2.1.6 below specifies that all farm expenses are indexed to 2013; while the USDA 2014 normalized prices received are calculated using a 5-year average ending in 2012. Farm income is ideally estimated using an equivalent base year for expenses and prices received; however the USDA 2014 normalized prices received are the best data available at the time of this appraisal-level analysis.

Government program payments are not included in a Reclamation agricultural benefits analysis. All prices received are listed below in Table 10.

Table 10. 2014 USDA Normalized Prices Received for Nebraska

Crop studied	Unit	2014 USDA normalized price[a]	USDA description
Alfalfa	Ton	$122.50	Hay, all types, baled
Beans, dry edible	Cwt	$34.60	Dry beans
Corn for grain	Bu	$5.11	Corn for grain (does not include deficiency payments)
Sugar beets	Ton	$63.89	Sugar beets (doesn't incl. pmts. under the Sugar Act)
Wheat	Bu	$6.20	Wheat, all types (does not include deficiency pmts.)

[a] Prices based on 5-year lagged averages of actual market prices. 2014 State-level normalized prices are an average of 2008-12 market prices multiplied by the average ratios of the State-level market prices to the national market prices for 2010-12 (USDA ERS, 2014).

2.1.6 Farm Expenses

Expenses were taken from UNL Extension crop budgets (UNL Extension, 2013), discussions with the irrigation district manager, and others knowledgeable about agriculture in Sheridan County, NE. Other general farm expenses are discussed here.

All expenses except for the real estate investment are indexed to 2013 dollars within the FBT—the base year set within the FBT and the year in which all values are reported.

2.1.6.1 Real Estate Investment

Real estate investment is included in the budget to estimate interest cost on loans. Real estate investment, in this analysis, includes investment in land, buildings, and improvements. Investment in irrigated land in a benefits study is the market value of land for agricultural purposes. The average reported value of center pivot irrigated farmland for northwestern Nebraska from 2008 through 2012 was used to generate a 5-year average of $1,819 per acre (UNL, 2013).

An additional cost of $300 per acre is used for the irrigation system and irrigation infrastructure for all crops (UNL Extension, 2013). Thus, the land value is estimated to be $2,119 per acre ($1,819 + $300) for all crops.

2.1.6.2 Buildings and Improvements

Annual investment and repair costs are included for buildings and improvements in the representative farm budgets. These costs include items such as fuel tanks, wells and pumps, shop buildings, and tools, etc.

Building investments on full-time farms in the area vary widely. This study uses a machine shed valued at $60,000, and a storage shed valued at $26,000.

2.1.6.3 Machinery Costs

Information on cultural practices, machinery and equipment needed, time of use, new costs, depreciation, fuel, and repair costs were obtained from the respective enterprise budget for each crop when possible. Supplemental sources used include the University of Minnesota Extension publication *Machinery Cost Estimates: May 2011* (Lazarus, 2011).

Fuel, oil, grease, and repair costs are calculated on a per hour basis for farm equipment and on a per mile basis for vehicles, and then multiplied by the total hours or miles the equipment is used to calculate the total maintenance cost.

2.1.6.4 Depreciation

Depreciation is calculated for machinery, vehicles, buildings and improvements using the sinking fund method. Buildings, vehicles, and machinery generally have maximum useful lives of 40 years, 10 years, and 25 years, respectively, although the equipment life in the analysis is usually less than the maximum useful life and varies based on annual use. Salvage value was set at 10 percent of the investment value for equipment and 0 percent for buildings.

In accordance with Reclamation's *Economics Guidebook* (Reclamation, 2004a) sinking fund depreciation must be evaluated at the Federal discount rate for a benefits analysis. The FY2015 Federal discount rate is 3.375 percent (Reclamation, 2014).

2.1.6.5 Crop Expenses

Crop expenses include custom work, herbicides, insect control, disease control, fertilizer, seed, and miscellaneous crop expenses. Custom work includes the application of chemicals and fertilizer, and custom harvest. Chemicals are used on the representative farms to control weeds, insects, and gophers.

2.1.6.6 General Expenses

General expenses include expenses that are general and similar in nature for each budget, such as labor, utilities, and taxes.

2.1.6.6.1 Labor Distribution and Costs

Labor expense is derived from the hours of labor required to operate machinery and manual labor for irrigation. Total machinery labor is calculated by adding 10 percent to the power machinery use. The hours of power machinery use are driven by the non-power machine being pulled by the power machine. The addition of 10 percent of hours for the power machine provides an estimate of time for the operator of the machine for such things as greasing and fueling equipment, etc.

Hired labor is required if the operator and family labor is not sufficient to perform all the tasks that are required. Hired labor is estimated on a monthly basis. There is no hired labor required in this study due to the extensive use of custom work.

Wages are reported by the Bureau of Labor Statistics on a state wide basis. The 5-year average (2008-2012) farm labor wage rate for Nebraska is $13.52 per hour. This is the rate used for hired labor and family labor. Skilled labor is figured at $20.72 per hour—the 5-year average (2008-2012) for farm supervisors in Nebraska—and is used for operator labor. These rates were obtained from the U.S. Bureau of Labor Statistics website.

Labor requirements are taken from previous studies and from budgets used in those studies. The labor requirements tend to be highest in the summer months when irrigated crops place heavy requirements on the available labor supply.

Social Security expense, in a farm budget, is calculated only for hired labor. The social security rate is 15.30 percent, which is divided between the employer and employee, thus, the hired labor rate is 7.65 percent. A Worker's Compensation rate of 11.83 percent is used for all representative farms in this study.[2]

2.1.6.6.2 Telephone and Electricity

According to the U.S. Department of Labor, the average annual telephone electricity costs for self-employed workers in the United States for 2011 was about $1,265 and $1,567, respectively. Reclamation assumes 25 percent of usage is attributed to farm business, so telephone and fixed electricity expenses for the purpose of this study are calculated to be $316.25 and $391.75, respectively. Additionally, a base rate of $0.138 per kWh – obtained from UNL enterprise budgets – is used in this study to calculate electricity usage costs for irrigation pumping.

2.1.6.6.3 Pumping Costs

The pumping costs associated with groundwater irrigation are higher than the costs associated with surface irrigation due to the additional electricity required to do so. Typical MFID farms will therefore use their entire surface water allocation (varies annually due to Niobrara flow conditions) before resorting to groundwater irrigation.

Pumping costs are calculated within Reclamation's farm budgeting software based on a number of inputs. Typical MFID farms pump surface water into center pivot systems from shallow cans (6-8 feet deep) using electric pumps. When surface water is not available, farmers pump groundwater into the shallow cans to then be pumped into the center pivot system. DNR provided estimates for average MFID pumping depths under each defined alternative/scenario (DNR, 2015). The pumping depth estimates by alternative/scenario range from 68.2 to 79.5 feet and are reported in Table 7

2.1.6.6.4 Taxes

Tax rate information comes from UNL crop budgets. Average 2012 real estate tax for Nebraska is 1 percent of value. Property taxes were computed on the taxable value of land constituting the representative farm—assumed to be one-half the market value.

Agricultural buildings, equipment, and vehicles are taxed at 1 percent of the average value over their useful life.

2.1.6.6.5 Insurance Costs

Liability insurance pays for personal injury and property damage that occurs on the property or is caused by the insured while off the property. A farmer in the area is usually insured for $1,000,000, which costs $300 per year.

[2] Code 0037: Farm-field crops; Travelers, Workers Compensation and Employers Liability – Nebraska Workers Compensation Insurance Plan, Effective 02/01/2012

Wind and fire insurance can vary greatly depending on type, age, and quality of buildings or machinery, distance from the local fire department, and policy holder history. Cost of wind and fire insurance used on the budget is $6.67 per $1,000 for machinery and buildings.

Vehicle insurance is quoted in dollar amounts and can also vary depending on several factors. The average insurance cost for a new pickup would be about $1,400.

2.1.6.6.6 Interest on Debt

Interest is charged on the debt portion of assets and operating costs. In accordance with Reclamation's *Economics Guidebook* (Reclamation, 2004), this benefits analysis assumes 100 percent debt on land and equipment and the interest rates for each are set to the Federal discount rate. The FY2015 Federal discount rate is 3.375 percent (Reclamation, 2014).

2.1.6.6.7 Miscellaneous Expenses

An amount equal to 2 percent of total variable costs is included in each farm budget to cover any miscellaneous costs that the analysis may not have specifically accounted for.

2.1.7 Return to Farm Family

The farm operator and farm family are entitled to income from the farm as a result of their investment, management, and labor. The returns to the farm family include a return to labor and management.

2.1.7.1 Return-to-Equity

There is no return to equity in a benefits budget since interest is charged on 100 percent of assets.

2.1.7.2 Return-to-Management

An allowance of 6.0 percent of variable costs is made for the farm operator's management ability over and above the supervisory labor rate. The return to management is an opportunity cost to the farm operator and represents the farm operator's ability to earn income by applying his or her management skills in another management operation.

2.1.7.3 Return-to-Labor

The farm operator's labor is normally valued at the current wage rate for supervisory farm labor for the crop type in the region of analysis. Labor performed by the farm operator's family should be valued at the same wage rate as hired farm labor since they are substitutes for one another. The return to labor is calculated by adding the farm operator's wages and the farm family labor wages. The return to labor is deducted from net farm income. In this study operator wages are $20.72 per hour and family wages are $13.52 per hour.

2.1.8 Agricultural Benefits Results

This section reports the agricultural benefits estimated under each alternative/scenario and then compares alternatives/scenarios as prescribed in Table 2 of report section 1.3.

As previously stated, annual agricultural benefits under a given alternative/scenario are estimated as MFID NFI subject to the hydrologic conditions specified by that alternative/scenario.

Reiterating the methodology to calculate MFID NFI under a given alternative/scenario:

1. The FBT estimates the *net income per acre for each crop* under the hydrologic conditions specified by the given alternative/scenario;
2. *Net income per acre for each crop* under the given alternative/scenario is multiplied by the MFID acreage that crop comprises to yield *district-level net income per crop* under the given alternative/scenario; and
3. The sum of the five *district-level net income per crop* values under the given alternative/scenario yields *MFID NFI* under that alternative/scenario.

This section first shows the calculation of MFID NFI under each alternative/scenario in 2013 dollars. MFID NFI under each alternative/scenario is then indexed to 2014 dollars to estimate annual agricultural benefits in dollars equivalent to costs and recreation benefits (see section 1.1). The present value of annual agricultural benefits under each alternative/scenario is then reported—calculated using a 50-year planning horizon and the FY2015 Federal discount rate of 3.375 percent (Reclamation, 2014).

2.1.8.1 Calculation of MFID NFI

Table 11 displays Reclamation's FBT output—the net income per acre values for each studied crop under the hydrologic conditions specified by each defined alternative/scenario.

Table 12 displays the net income per crop and MFID NFI values under each defined alternative/scenario. Net income per crop for a given alternative/scenario is calculated as the net income per acre for each studied crop under the given alternative/scenario (see Table 11) multiplied by the MFID acreage that crop constitutes. MFID NFI under a given alternative/scenario is the sum of the five net income per crop values under the given alternative/scenario. Annual agricultural benefits under a given alternative/scenario are equal to MFID NFI under that alternative/scenario.

Table 11. Net Income Per Acre By Crop Under Defined Alternatives/Scenarios

Alternative/ Scenario	Net income per acre calculated by FBT[a,b]				
	Alfalfa	Beans	Corn	Beets	Wheat
Baseline No Action	$26.12	$66.87	$22.21	$722.98	–$119.36
Low No Action	$22.87	$66.49	$19.20	$719.64	–$121.86
Alt 1 Low	$31.30	$71.58	$27.54	$728.10	–$114.77
Alt 2 Low	$16.14	$59.21	$12.32	$712.97	–$129.06
CT No Action	$28.35	$70.58	$24.31	$725.26	–$117.58
Alt 1 CT	$37.95	$71.58	$33.80	$734.90	–$114.77
Alt 2 CT	$18.21	$60.16	$14.09	$715.15	–$127.97
High No Action	$32.91	$71.58	$28.62	$729.91	–$114.77
Alt 1 High	$36.88	$71.58	$32.56	$733.88	–$114.77
Alt 2 High	$19.54	$60.77	$15.23	$716.55	–$127.26

[a] The net income per acre for each studied crop under the hydrologic conditions specified by each defined alternative/scenario, as calculated by Reclamation's FBT.

[b] All net income per acre values reported in 2013 dollars.

Table 12. Annual Net Income Per Crop and Annual MFID NFI Calculations under Defined Alternatives/Scenarios

Alternative/ Scenario	Net income per crop (2013 $'s)[a]					MFID NFI[b]
	Alfalfa	Beans	Corn	Beets	Wheat	MFID Total
Acres[c]→	898	2,822	6,729	513	700	11,662
Baseline No Action	$23,456	$188,707	$149,451	$370,889	–$83,552	$648,951
Low No Action	$20,537	$187,635	$129,197	$369,175	–$85,302	$621,242
Alt 1 Low	$28,107	$201,999	$185,317	$373,515	–$80,339	$708,599
Alt 2 Low	$14,494	$167,091	$82,901	$365,754	–$90,342	$539,898
CT No Action	$25,458	$199,177	$163,582	$372,058	–$82,306	$677,969
Alt 1 CT	$34,079	$201,999	$227,440	$377,004	–$80,339	$760,183
Alt 2 CT	$16,353	$169,772	$94,812	$366,872	–$89,579	$558,230
High No Action	$29,553	$201,999	$192,584	$374,444	–$80,339	$718,241
Alt 1 High	$33,118	$201,999	$219,096	$376,480	–$80,339	$750,354
Alt 2 High	$17,547	$171,493	$102,483	$367,590	–$89,082	$570,031

[a] *Net income per crop* (in 2013 $'s) for a given alternative/scenario is calculated as the *net income per acre for each studied crop* under the given alternative/scenario (see Table 11) multiplied by the MFID acreage that crop constitutes.

[b] Net Farm Income (NFI) for a given alternative/scenario is the sum of the five *net income per crop* values under the given alternative/scenario. Reported in 2013 dollars.

[c] Cropping pattern used in this analysis (see Table 4).

2.1.8.2 Agricultural Benefits by Alternative/Scenario

Table 13 below displays the annual agricultural benefits by alternative/scenario (in 2014 dollars) and the present value of annual agricultural benefits calculated using a 50-year planning horizon and the FY2015 Federal discount rate of 3.375 percent (Reclamation, 2014).

Table 13. Agricultural Benefits under Defined Alternatives/ Scenarios

Alternative/ Scenario	Annual Agricultural Benefits[a]	Present Value of Agricultural Benefits[b]
Baseline No Action	$658,685	$15,804,000
Low No Action	$630,561	$15,130,000
Alt 1 Low	$719,228	$17,257,000
Alt 2 Low	$547,996	$13,149,000
CT No Action	$688,139	$16,511,000
Alt 1 CT	$771,586	$18,513,000
Alt 2 CT	$566,603	$13,595,000
High No Action	$729,015	$17,492,000
Alt 1 High	$761,609	$18,274,000
Alt 2 High	$578,581	$13,882,000

[a] Annual benefits calculated and reported in 2014 dollars.

[b] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

Note that Table 12 (above) reports MFID NFI in 2013 dollars—Reclamation's FBT base year. This economic analysis calls for all benefits and costs to be evaluated in equivalent dollars (see section 1.1), and 2014 is the base year chosen. Therefore, MFID NFI is indexed[3] from 2013 to 2014 to yield annual agricultural benefits in 2014 dollars. This indexing accounts for the difference in values between the far right column of Table 12 (MFID NFI) and the center column of Table 13 (Annual Agricultural Benefits).

Alternative Alt 2 Low results in the lowest annual agricultural benefits ($547,996) and subsequently the lowest present value of agricultural benefits ($13,149,000). This is an intuitive result, as the Alt 2 Low includes the lowest water availability climate change scenario—translating to less surface water to fulfill crop water requirements (Table 7 shows 0 acre-inches of surface water deliveries under Alt 2 Low) and therefore all irrigation water must be pumped from the ground. Alt 2 Low also has the third deepest pumping depth (76.9 feet, see Table 7) of the 10 analyzed alternatives/scenarios, meaning that each unit of water pumped is more expensive.

Alternative Alt 1 CT results in the highest annual agricultural benefits ($771,586) and subsequently the highest present value of agricultural benefits ($18,513,000). This is an intuitive result, as Alt 1 CT results in the highest available surface water for irrigation (12.01 acre-inches) and the 4th shallowest pumping depth (71.0 feet) of the 10 alternatives/scenarios analyzed (see Table 7). Higher surface water deliveries translates to less groundwater pumping required and shallower

[3] Agricultural benefits were indexed from 2013 to 2014 using the Consumer Price Index annual average for Midwest – Urban, as reported by the Bureau of Labor Statistics.

pumping depth means that each unit of water pumped is less expensive—both factors minimizing pumping costs.

2.1.8.3 Comparison of Agricultural Benefits

Benefit comparisons by alternative/scenario are described in section 1.3 of this report. The comparison of agricultural benefits follows the alternative/scenario comparisons prescribed in Table 2 of report section 1.3. Agricultural benefit comparisons are reported in Table 14 below.

Table 14. Comparison of Agricultural Benefits

Base Case			Comparison		Difference (millions of $'s)	Percent Difference
Alternative/ Scenario	Value[a] (millions)		Alternative/ Scenario	Value[a] (millions)		
Baseline No Action	$15.8	→	Low No Action	$15.1	–$0.7	–4.4%
Baseline No Action	$15.8	→	CT No Action	$16.5	$0.7	4.4%
Baseline No Action	$15.8	→	High No Action	$17.5	$1.7	10.8%
Low No Action	$15.1	→	Alt 1 Low	$17.3	$2.2	14.6%
Low No Action	$15.1	→	Alt 2 Low	$13.1	–$2.0	–13.2%
CT No Action	$16.5	→	Alt 1 CT	$18.5	$2.0	12.1%
CT No Action	$16.5	→	Alt 2 CT	$13.6	–$2.9	–17.6%
High No Action	$17.5	→	Alt 1 High	$18.3	$0.8	4.6%
High No Action	$17.5	→	Alt 2 High	$13.9	–$3.6	–20.6%

[a] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

The first three comparisons in Table 14 compare the baseline No Action climate scenario with the three Future No Action climate change scenarios to isolate the economic effect of climate change from operational modifications. The future climate change scenario that results in the largest *decrease* in agricultural benefits from Baseline No Action is Low No Action (a decrease of 4.4 percent). This is an expected result, as the low water availability future climate scenario results in the lowest surface water deliveries, most groundwater pumped, and deepest pumping depth of all the Future No Action climate change scenarios (see Table 7). This translates into higher pumping costs. Comparing High No Action to Baseline No Action results in the largest *increase* in agricultural benefits—also an expected result, as High No Action increases surface water deliveries, decreases groundwater pumping, and decreases pumping depth compared to Baseline No Action (see Table 7).

The last six comparisons in Table 14 compare each Future No Action climate change scenario with the two operational/structural modification alternatives within each future climate change scenario. For all three future climate change scenarios (Low, CT, and High) the first operational modification (Mirage Flats Canal Recharge, or A1) results in *increased* agricultural benefits compared to No

Action, while the second operational modification (Mirage Flats Pumping Station, or A2) results in *decreased* agricultural benefits compared to No Action.

The Mirage Flats Canal Recharge results in the largest agricultural benefits *increase* (14.6 percent) under the Low future climate change scenario. This is an intuitive result, as when surface water deliveries are lowest (Low No Action) diverting water to the Mirage Flats the irrigation canal will decrease groundwater pumping depth and help offset pumping costs to farmers. The Mirage Flats Pumping Station results in the largest agricultural benefits *decrease* (20.6 percent) under the High future climate change scenario. This result is explained by the fact that moving from High No Action to Alt 2 High results in a loss of all surface water deliveries (from 8.59 to 0 acre-inches, see Table 7). Alt 2 Low and Alt 2 CT also result in a loss of all surface water deliveries, but as they start out with less under their No Action variants (4.24 and 6.45 acre-inches, respectively—see Table 7) the difference from No Action is not as pronounced.

2.2 Recreation Benefits Analysis

For approximately 100 miles through Nebraska's Sand Hills, the Niobrara River represents "a mountain stream in a prairie state," offering outstanding scenery, plant communities, wildlife, and recreation opportunities. Congress recognized these values by designating a 76-mile reach east of Valentine as the Niobrara National Scenic River (Niobrara NSR) in 1991. The Niobrara NSR is managed by the National Park Service (NPS) and is popular with tubers, canoeists, and kayakers.

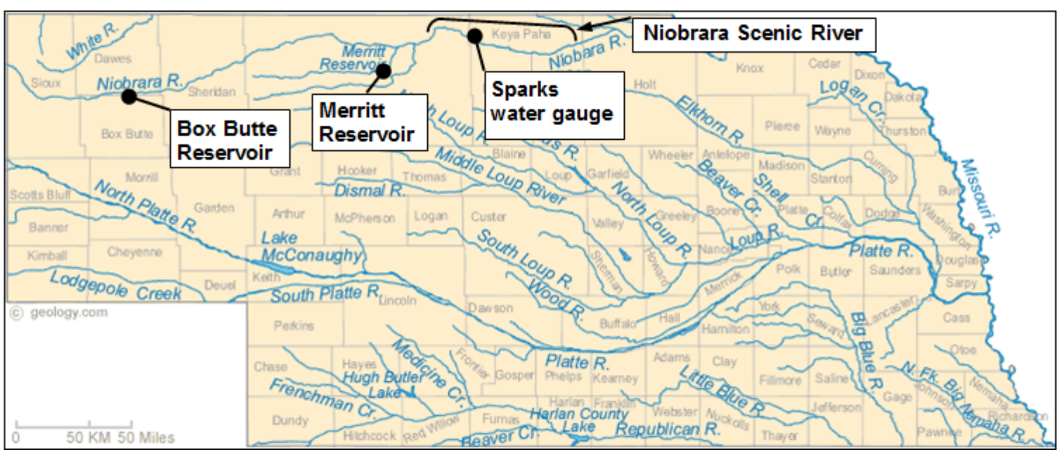

Figure 3. Niobrara River locations studied for recreation economics analysis.

The Niobrara River watershed includes two Bureau of Reclamation water development projects that affect flows of the Niobrara NSR: (1) Box Butte Dam and Reservoir provides storage for the Mirage Flats Irrigation Project (1946) in northwestern Nebraska, and (2) Merritt Dam and Reservoir (1964) on the Snake

River (a south bank tributary southwest of Valentine), provides irrigation storage for the Ainsworth Irrigation District.

The recreation economic benefits analysis developed for this study is therefore comprised of two parts – a river recreation analysis and a reservoir recreation analysis.

2.2.1 Recreation Methodology

To estimate recreation economic benefits under each alternative/scenario for the river and two reservoir settings, analytical results are developed in terms of annual visitation and value per visit. As will be discussed in detail below, average annual visitation estimates were developed by alternative/scenario based on alternative/scenario specific hydrology and climate change measures, but the value per visit is not alternative/scenario specific. Multiplying the average annual visitation estimates by alternative/scenario times the values per visit for both the river and reservoirs results in estimates of average annual recreation economic value by alternative/scenario. Discounting and summing the range of annual values estimated across each year of the 50 year period of analysis results in a present value by alternative/scenario for use in the BCA.

2.2.2 River Recreation Analysis Methodology

The majority of the river recreation analysis effort went into trying to estimate a statistically significant visitation model with explanatory variables of the expected sign. In addition, effort was expended on developing an estimate of value per visit to apply to the recreation use results obtained from the visitation model.

2.2.2.1 River Visitation Modeling

The Niobrara NSR averaged about 65,900 visits annually from 2004 to 2011 with approximately 83 percent of the visitation occurring during the June through August high use season. Approximately 30 miles of the western half of the Niobrara NSR from Cornell Dam to Norden Bridge receives the highest level of recreation use. Note that the 4.8 mile reach from Borman Bridge to Cornell Dam lying within the Fort Niobrara National Wildlife Refuge is closed to boating to protect wildlife habitat and wilderness values (Whittaker & Shelby, 2008).

Attempts were made to statistically estimate a relationship between instream flow and visitation on the Niobrara NSR. As noted above, recreation use of the Niobrara NSR focuses on water based activities particularly tubing, canoeing, and kayaking. Generally speaking, levels of use for these activities would be expected to move in unison with instream flows, at least within the typical range of flows. In other words, as river flows decline, visitation would be expected to decline since exposed and unexposed obstructions tend to become more of a problem. The opposite would be true as flows increase. However, as flows increase beyond the typical range, the current can become so fast as to make recreational activity on the river hazardous for most people.

Monthly visitation data for the Niobrara NSR from 2004-2011 was obtained from the NPS visitor use statistics website (NPS, 2015). Data on average monthly discharge (flow) for the same 2004-2011 period came from the U.S. Geological Survey's water gauge near Sparks, NE (USGS, 2015). Weather data was also used in the modeling effort. Average monthly temperatures and total monthly precipitation for the study period was obtained from the High Plains Regional Climate Center (HPRCC, 2015). Finally, annual population data for Nebraska as obtained from the U.S. Census Bureau.

2.2.2.1.1 All Month Modeling:

Using data across all months from 2004 through 2011, the following four visitation or use estimating models were proposed.

The dependent variable in each model reflects total monthly visits. The independent or explanatory variables vary by model. The positive and negative signs under each explanatory variable represent the direction of the expected relationship between the explanatory variable and the dependent variable. For example, in Equation 1, the positive sign under the average monthly flow and temperature variables reflect the expectation that average monthly flows/ temperatures and total monthly visits would move in the same direction such that an increase (decrease) in flows/temperatures is expected to result in an increase (decrease) in total monthly visits. As noted above, visitation and flows are expected to move in unison due to the effect of exposed and unexposed obstructions among other reasons. The same is true for temperature and visitation as the desire to be on the water due to the cooling effect and interest in swimming/soaking increase as temperatures rise. The opposite would be true of explanatory variables with a negative sign (e.g., an increase in total monthly precipitation is expected to result in a decrease in total monthly visits). All models were run using an ordinary least squares statistical regression approach.

Equation 1. Basic flow model for Niobrara NSR visitation

$$Visits_m = f\,(\underset{(+)}{Flow_m},\ \underset{(+)}{Temp_m},\ \underset{(-)}{Precip_m},\ \underset{(+)}{Pop_y})$$

where:

Month: $m = 1, \ldots, 12$
Year: $y = 2004, \ldots, 2011$

Dependent Variable ($Visits_m$): Total visits associated with each month.

Explanatory Variables:

$Flow_m$: Average monthly flow measured in cubic feet per second (cfs).
$Temp_m$: Average monthly air temperature in degrees Fahrenheit
$Precip_m$: Total monthly precipitation in inches
Pop_y: Annual Nebraska population

When this model was estimated, all of the explanatory variables proved to be statistically significant, but the sign on the Flow variable came in negative. In viewing the raw data, flows in the mid to late summer months (July, August, September) tended to be lower than other months, yet the visitation levels were generally higher, hence the negative sign on the flow variable.

Equation 2. Basic flow model with seasonality for Niobrara NSR visitation

$$Visits_m = f\,(Flow_m,\ Temp_m,\ Precip_m,\ Pop_y,\ Spring,\ Summer,\ Fall)$$
$$\qquad (+)\quad (+)\quad (-)\quad (+)\quad (+)\quad (+)\quad (+)$$

where:

Month: m = 1, . . . , 12
Year: y = 2004, . . . , 2011

Dependent Variable ($Visits_m$): Total visits associated with each month.

Explanatory Variables:

$Flow_m$: Average monthly flow measured in cubic feet per second (cfs)
$Temp_m$: Average monthly air temperature in degrees Fahrenheit
$Precip_m$: Total monthly precipitation in inches
Pop_y: Annual Nebraska population
Spring: Spring (March–May) qualitative (0/1) variable
Summer: Summer (June–August) qualitative (0/1) variable
Fall: Fall (September–November) qualitative (0/1) variable

The model depicted in Equation 2 is the same as that in Equation 1 with the addition of the spring, summer, and fall qualitative (or dummy) variables. If a month falls within the range of months associated with each season, it is assigned a value of 1, otherwise 0. The objective of this model was to address seasonality in the model. The spring, summer, and fall dummy variables are inherently compared to the excluded winter (December, January, and February) season and therefore the expectation would be that these non-winter seasonal variables should have positive signs since spring, summer, and fall visitation is greater than winter visitation. The assumption was that once seasonality was taken into account that perhaps a significant positive relationship with visitation would result for the Flow variable. Unfortunately, this did not occur.

Equation 3. Quadratic flow model for Niobrara NSR visitation

$$Visits_m = f\,(Flow_m,\ Flow_m^2,\ Temp_m,\ Precip_m,\ Pop_y)$$
$$\qquad (+)\quad (-)\quad (+)\quad (-)\quad (+)$$

where:

Month: m = 1, . . . , 12
Year: y = 2004, . . . , 2011

Dependent Variable ($Visits_m$): Total visits associated with each month.

Explanatory Variables:

$Flow_m$:	Average monthly flow measured in cubic feet per second (cfs).
$Flow_m^2$:	Average monthly flow squared
$Temp_m$:	Average monthly air temperature in degrees Fahrenheit
$Precip_m$:	Total monthly precipitation in inches
Pop_y:	Annual Nebraska population

A quadratic model (using Flow and Flow2 explanatory variables) was also attempted (see Equation 3). This model attempts to account for the possibility of reaching preferred peak flows. As flows increase toward the peak, visitation increases. At the peak, visitation is at its maximum. Beyond the peak, visitation declines as flows become too dangerous for some recreators. Unfortunately, the sign on the Flow variable continued to remain negative. This same model was attempted with the seasonal variables, but didn't prove any more useful.

Equation 4. Optimal/acceptable flow model for Niobrara NSR visitation

$$Visits_m = f(\underset{(+)}{Optimal\ Flow_m},\ \underset{(+)}{Temp_m},\ \underset{(-)}{Precip_m},\ \underset{(+)}{Pop_y})$$

where:

Month:	m = 1, . . . , 12
Year:	y = 2004, . . . , 2011

Dependent Variable ($Visits_m$): Total visits associated with each month.

Explanatory Variables:

Optimal $Flow_m$:	Optimal flow range (450 to 1,050 cfs) qualitative (0/1) variable.
$Temp_m$:	Average monthly air temperature in degrees Fahrenheit
$Precip_m$:	Total monthly precipitation in inches
Pop_y:	Annual Nebraska population

Whittaker et al. (2008) conducted a thorough analysis of recreational floating on the Niobrara NSR. The authors interviewed outfitters and other experienced river users during May 2006 and July 2007. As shown in Table 15 below, responses indicated a median 50th percentile optimal flow range from 600 to 900 cfs and a median 50th percentile acceptable flow range from 460 to 1,200 cfs. One model was attempted using the optimal flow range and another using the acceptable flow range (see Equation 4). If an average monthly flow fell within the optimal (or acceptable flow range) it was assigned a value of 1, otherwise 0. It was also observed that the median (50th percentile) and high (75th percentile) estimate was the same (1,200 cfs) for the high end of the acceptable flow range. So in addition to using the median values as noted above to define the acceptable flow range, the decision was made to also use the narrower lower bound (25th percentile) to define the acceptable flow range (450 to 1,050 cfs). The signs of these optimal or acceptable flow variables were expected to be positive compared to suboptimal or unacceptable flows. Unfortunately, none of these flow variable options proved useful in the full (all month) model.

Table 15. Median Flows and Interquartile Ranges for Recreation Opportunities on Niobrara NSR

Source: Whittaker & Shelby (2008) – Table 1

Specified flow for floating opportunities	Median (cfs)	25th to 75th percentile
Lowest flow that allows use of the river for transportation (minimum boatable flow)	340	319 to 336
Lowest flow that provides an acceptable quality “scenic trip”	460	450 to 500
Lowest flow that provides an optimal quality “scenic trip”	600	550 to 600
Highest flow that provides an optimal quality “scenic trip”	900	750 to 1,000
Highest flow that provides an acceptable quality “scenic trip”	1,200	1,050 to 1,200
Lowest flow that provides optimal whitewater in the three Class II-III rapids	800	740 to 1,000

2.2.2.1.2 High Season Modeling:

When the modeling efforts using data for all months proved unsuccessful, additional modeling was attempted using monthly data for only the high use recreation season. After studying the raw monthly visitation data for the 2004–2011 period (only years where visitation data was available for all months), it became apparent that the June through August months reflected the majority (averaged 83%) of the annual visitation at the Niobrara NSR. As a result, the high recreation season was defined as June through August. The dataset was adjusted to only include those three months each year before further modeling efforts were attempted. The idea was that by eliminating all the low use months that perhaps some of the complexities associated with the relationship between flow and visitation might disappear and yet the models would still be addressing the vast majority of the annual visitation. For example, by focusing only on the summer months, the need to address the seasonality issue is eliminated.

Except for the seasonality models, all of the models discussed under the all month modeling section above were also attempted using only the high season month data. Only the acceptable flow model (Equation 4) produced useful results. As shown in Table 16 below, the low end percentile acceptable flow range (450-1,050 cfs) model proved useful given it resulted in a statistically significant qualitative flow variable of the expected positive sign. The overall model proved statistically significant as indicated by the F statistic and based on the adjusted R^2, the model explained 62 percent of the variation in the dependent variable.

Table 16. Niobrara NSR Optimal/Acceptable Flow Model Visitation Estimates

Regression Statistics	
Multiple R	0.80883
R Square	0.65421
Adjusted R Square	0.62128
Standard Error	3575.50
Observations	24

ANOVA	*Df*	*SS*	*MS*	*F*	*Significance F*
Regression	2	507932549.6	253966274.8	19.8655	1.437E–05
Residual	21	268468699.7	12784223.8		
Total	23	776401249.3			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	–60645.09	12527.85	–4.840820	8.735E–05	–86698.20	–34591.99
Temp	1057.54	168.814	6.264583	3.2602E–06	706.48178	1408.61
Flows 450–1050	3603.41	1835.88	1.962772	0.063056	–214.50580	7421.33

Since the acceptable flow range variable is a qualitative 0/1 variable, it estimates additional visitation associated with those months that fall within the 450-1050 cfs acceptable flow range as an on/off condition. Given the coefficient on the variable is a positive 3603, this implies an additional 3,603 visits would be expected to occur in summer months which fall within the acceptable range as opposed to those months which do not. However, the difference between estimated visitation across summer months would not be exactly equal to 3,603 visits due to the influence of the temperature variable. Bottom line, average monthly flow and temperature estimates from the hydrology and climate change models for each proposed alternative/scenario (as well as the Baseline No Action and Future No Action Alternatives/Scenarios) were run through this model to estimate visitation during the summer months.

Since summer months reflect 83% of the average annual visitation, one might be inclined to divide the modeled summer month visitation estimate by alternative/scenario by .83 to obtain an annual visitation estimate, but that would imply non-summer month visitation would maintain the same relationship to summer month visitation and non-summer month visitation would therefore be impacted by changing flows similarly. Since this is at best a questionable assumption, the decision was made to only evaluate the differences in visitation during the high summer season and assume that visitation for the remainder of the year would not be substantially affected. Therefore, for this analysis, the difference in high season visitation between alternatives/scenarios represents the difference in annual visitation between the alternatives/scenarios. The difference in annual visitation between the proposed alternatives/scenarios and the Future No Action Alternative/Scenarios is used to help measure the recreation economic river oriented benefits associated with each proposed alternative/scenario.

2.2.2.2 River Value per Visit Estimation

Value per visit is measured in terms of recreator consumer surplus or willingness-to-pay minus the cost of accessing the site. The value per visit was selected from other existing recreation economic studies in what is referred to as a benefit transfer application. Rosenberger (2011) presents the results of an extensive literature search of outdoor recreation studies obtained from across the U.S. Four nonmotorized boating studies, which include rafting, kayaking, canoeing, and rowing, were identified in the database for the Midwestern Region which includes Nebraska. An average value of $18.09 in 2010 dollars was presented for these activities. Indexing that value up to average 2014 dollars using the Midwest Urban Consumer Price index results in a value of $19.60 for those activities. This $19.60 value was applied to the visitation estimates obtained from the high recreation season visitation model to estimate value per month and year for each alternative/scenario.

2.2.3 Reservoir Recreation Analysis Methodology

Two reservoirs can be found in the Niobrara River Basin - Box Butte and Merritt. Merritt Reservoir provides more than five times the level of recreation use at Box Butte Reservoir. Box Butte has averaged less than 20,000 visits a year recently whereas Merritt averaged nearly 105,000 visits from 2000 to 2010 (missing data precluded the use of 2011 and 2012 in the annual average).

2.2.3.1 Reservoir Visitation Modeling

As with the river recreation analysis, attempts were made to statistically estimate a relationship between end-of-month water levels, climate change variables (i.e., temperature, precipitation), and monthly visitation at both Box Butte and Merritt Reservoirs.

2.2.3.1.1 Box Butte Reservoir Visitation

Lack of data precluded attempts at estimating visitation models for Box Butte. Instead, annual visitation at Box Butte was assumed to move in tandem with reservoir surface acreage (Reclamation, 2015a). If water surface acreage increased (decreased) by 10 percent for a given alternative/scenario, then annual recreation use would also be expected to increase (decrease) by 10 percent. While simplistic, this method does provide an approach for estimating recreation visitation at Box Butte for each alternative/scenario.

Use of this ratio method requires a point of reference in terms of surface acreage and recreation visitation. Total annual visitation data was only available for years 2012 and 2013 (18,500 and 19,950 respectively, average: 19,225). Creel survey data suggest that fishing averaged approximately 6,800 visits annually during that period. That implies that non-fishing activities averaged approximately 12,425 visits annually for those two years.

As shall be discussed below, fishing and non-fishing visits are evaluated separately because different values per visit are assigned to each. The 6,800 fishing visits and 12,425 non-fishing visits were used as the visitation point of reference (Reclamation, 2015a). Since the high recreation season was determined to extend from beginning of April to the end of September, average surface acreage across these months for 2012 and 2013 was used as the surface acreage point of reference. The end of month water level (EOM WL) for these months during 2012 and 2013 averaged 3992.37 (Reclamation, 2015b) which converts to an average surface area of nearly 897 acres. Average April to September surface acreage for each alternative/scenario was compared to the surface acreage reference point and a ratio was developed to apply to the visitation reference point in order to develop estimates of visitation by alternative/scenario (including the Baseline No Action and Future No Action Alternatives/Scenarios).

2.2.3.1.2 Merritt Reservoir Visitation

Merritt Reservoir provides a wide range of recreational activities including fishing, boating/waterskiing, camping, picnicking, swimming, hunting, etc. Some of these activities are water based (boating/waterskiing, fishing, swimming) since they directly make use of the water while others are water influenced (camping, picnicking, hunting) given they make use of the water indirectly.

The relationship of visitation to water levels within the typical water level range is fairly straightforward for most water based activities – as water levels decline so does visitation. For example, boating and boat based fishing tends to decline due to limited access as boat ramps become unusable. Also, as water surface acreage declines, crowding and reduced access to certain areas of the reservoir increases, as do exposed and unexposed obstructions. In addition, shoreline fishing and swimming tends to decrease as mud flats widen making water access more difficult.

For some water influenced activities (e.g., camping, picnicking), while they do not require access to the water they are generally influenced by water levels due to aesthetic reasons – the development of “bath tub rings” and mud flats around the reservoir creates a less attractive setting. For other water influenced activities (e.g., hunting, birding/wildlife viewing), depending on the species targeted, bird/wildlife populations can vary significantly with the presence of water or the quantity of water. As a result, levels of use of most water based and water influenced recreational activities tend to move in unison with water levels. Above the typical water level range, both water based and water influenced activities often decline as recreation facilities become flooded.

Monthly visitation data for Merritt Reservoir from 2000-2012 was obtained from the Nebraska Game and Parks Commission. Data on EOM WL was obtained from Reclamation personnel. Weather data was also used in the modeling effort.

Average monthly temperatures and total monthly precipitation for the study period was obtained from the High Plains Regional Climate Center (HPRCC, 2015). Finally, annual population data for Nebraska as obtained from the U.S. Census Bureau.

All Month Modeling:

Prior to the modeling efforts, a visitation based monthly outlier analysis was conducted. Data was sorted by month and average visitation was calculated for each month. A standard deviation was calculated for each month and high and low end visitation thresholds were developed using two standard deviations from the mean (reflects 95% of the data). If a given monthly visitation observation fell outside of the two standard deviation range, either on the high or low end, that observation was dropped from the data set. Following this procedure for each month resulted in the dropping of 17 outlier observations (including all 12 of the December observations). Dropping outliers and observations with missing data resulted in a dataset with 130 observations.

Using data across all available months from 2000 through 2012, the following visitation or use estimating model was proposed:

Equation 5. Basic water level model for Merritt Reservoir visitation

$$Visits_m = f\,(\underset{(+)}{EOM\ WL_m},\ \underset{(+)}{Temp_m},\ \underset{(-)}{Precip_m},\ \underset{(+)}{Pop_y},\ \underset{(+)}{Spring},\ \underset{(+)}{Summer},\ \underset{(+)}{Fall})$$

where:

Month:	m = 1, . . . , 12
Year:	y = 2000, . . . , 2012

Dependent Variable ($Visits_m$): Total visits associated with each month.

Explanatory Variables:

EOM WL_m:	End of month water level in feet above mean sea level (msl) by month
$Temp_m$:	Average monthly air temperature in degrees Fahrenheit
$Precip_m$:	Total monthly precipitation in inches
Pop_y:	Annual Nebraska population
Spring:	Spring (March–May) qualitative (0/1) variable
Summer:	Summer (June–August) qualitative (0/1) variable
Fall:	Fall (September–November) qualitative (0/1) variable

The dependent variable in Equation 5 reflects total monthly visits. The positive and negative signs under each explanatory variable represent the direction of the expected relationship between the explanatory variable and the dependent variable (visits). For example, the positive sign under the EOM water level and temperature variables reflect the expectation that EOM water levels/temperature and total monthly visits would move in the same direction such that an increase (decrease) in water levels/temperature is expected to result in an increase (decrease) in total monthly visits. The logic of the expected relationship between Merritt Reservoir water levels and visitation was described above - for temperature, the logic may be less obvious but generally relates to the idea that recreators may want to be on the water more as temperatures rise due to the cooling effects and an increased interest in swimming.

Consideration was given to including seasonality terms (spring, summer, and fall dummy variables) until it was discovered that the average monthly temperature (Temp) variable essentially picks up the effect of both temperature and summer season on visitation since the Temp variable was highly correlated with the Summer dummy variable (correlation .7495, summer dummy equals 1 during the June-August months and 0 otherwise). Since the temp variable is also a climate change measure, it can be used to differentiate between the climate change scenarios. Explanatory variables with a negative sign suggest that visits would move in the opposite direction (e.g., an increase in total monthly precipitation is expected to result in a decrease in total monthly visits). The model was run using an ordinary least squares statistical regression approach.

High Season Modeling:

When attempting to address seasonality within the all month modeling efforts, it became apparent that the relationship between water levels and visitation during the low use months did not mirror the relationship during the high use months. Therefore, models were attempted using what was deemed to be the high recreation season. In looking at the breakdown of average visitation by month, a high recreation season extending from May through September was selected given approximately 84 percent of the average annual visitation falls within this period.

The same model as estimated above under the all month perspective (Equation 5) was also estimated from the May-September high season perspective. When this high season model was estimated (see Table 17), EOM WL and temperature variables came in significant and of the expected sign. In addition, the overall model proved statistically significant as indicated by the F statistic and based on the adjusted R^2, the model explained 52 percent of the variation in the dependent variable. This model also uses the natural log of visits as the dependent variable which has the advantage of eliminating the potential of negative visit predictions. While the adjusted R^2 is somewhat lower for this model as compared to the all month model, the decision was made to use this model to estimate visitation in this study.

Table 17. Merritt Reservoir High Season (May–September) Visitation Model Estimates

Regression Statistics	
Multiple R	0.735501
R Square	0.540961
Adjusted R Square	0.524567
Standard Error	0.328175
Observations	59

ANOVA	*Df*	*SS*	*MS*	*F*	*Significance F*
Regression	2	7.10748	3.55374	32.99701	3.4E–10
Residual	56	6.031136	0.107699		
Total	58	13.13862			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	–138.963	21.28267	–6.52941	2.07E–08	–181.598	–96.329
EOM WL	0.049566	0.007175	6.908165	4.91E–09	0.035193	0.063939
Temp	0.044766	0.006564	6.820223	6.86E–09	0.031618	0.057915

Hydrologic information on EOM WL and climate change (CC) information on temperature and precipitation was provided for historic with current operations conditions (without CC, Baseline No Action), future No Action with CC conditions (Low No Action, CT No Action, and High No Action), and the action alternatives with CC conditions (Alt 1 Low, Alt 1 CT, Alt 1 High, Alt 2 Low, Alt 2 CT, Alt 2 High). Comparisons were made between the Baseline No Action Alternative and Future No Action Alternative/Scenarios and the Future No Action Alternative/Scenarios and the action alternatives/scenarios, but not between the Baseline No Action and action alternatives. Differences between the Baseline No Action Alternative and the Future No Action Alternative/Scenarios are driven by both changes in EOM WL and temperature. However, differences between the action alternatives/scenarios and the Future No Action Alternative/Scenarios would be driven exclusively by differences in EOM WL because temperature would not vary between the Future No Action and action alternatives under the same CC scenario. However, temperatures between the CC scenarios would vary for the same alternative.

Estimation of the change in monthly visitation for each action alternative/scenario as compared to the Future No Action Alternative under each climate change scenario would be accomplished by inserting estimates of EOM WL and average monthly temperature for a given month and CC scenario for the action alternative and Future No Action Scenario into the visitation model. This results in a visitation estimate for that month and CC scenario for that alternative. Aggregating across months provides a total annual visitation estimate under both the action alternatives and the Future No Action for that CC scenario. Taking the difference provides an estimate of the average annual change in visitation for each action alternative and CC scenario. While the visitation model is only based on data from 2000-2011, computationally it can be used to estimate changes in visitation under different climate change scenarios due to the temperature variable. However, this will imply predicting visitation outside the range of the underlying data when average monthly temperature estimates for any of the alternatives fall outside the average monthly temperature range seen from 2000-2011.

2.2.3.2 Reservoir Values per Visit

As noted at the start of the recreation methodology section, to develop estimates of annual recreation value for each alternative/scenario, the estimates of recreation visitation by alternative/scenario need to be multiplied by estimates of recreation value per visit. As with the river value, the reservoir value per visit is measured in terms of recreator consumer surplus or willingness-to-pay minus the cost of accessing the site.

2.2.3.2.1 Box Butte Reservoir Visitation Values

Recreation use values per visit for Box Butte Reservoir were derived from the Recreation Use Values Database (Rosenberger, 2011). Since values from this database are reported in 2010 dollars, they were subsequently indexed to 2014 dollars for use in this study.[4] The value used for general (non-fishing) recreation is an average across several activities. The activities included in this average reflect those listed on the websites recreation.gov and outdoornebraska.ne.gov for Box Butte Reservoir. These activities include birdwatching/wildlife viewing, camping, non-powered boating, motorboating, picnicking, and swimming. The average value for these activities is $23.26 per person per visit, in 2014 dollars. The value for fishing visitation was not included in the general recreation use average value, as angling visitation is treated separately from general recreation visitation for the purposes of this study. The use value for fishing is $42.58 per visit, in 2014 dollars (Reclamation, 2015).

2.2.3.2.2 Merritt Reservoir Visitation Values

Merritt Reservoir provides a wide range of recreational activities including fishing, boating/waterskiing, camping, picnicking, swimming, hunting, etc. Based on information pulled from Reclamation's Recreation Use Data Report (Johanson, 2013), the top four recreation activities at Merritt Reservoir are fishing, boating, camping, and hunting. Without data on the percentage breakdown by activity, the assumption was made that each of the four activities are equally likely. The value per visit for Merritt Reservoir was based on information for these four activities.

The same Rosenberger (2011) nationwide database of outdoor recreation studies as described under the Niobrara NSR and Box Butte Reservoir sections was also

[4] Recreation use values were indexed from 2010 to 2014 using the Consumer Price Index annual average for Midwest – Urban, as reported by the Bureau of Labor Statistics.

used to estimate a value per visit for Merritt Reservoir. The results of 188 freshwater fishing studies, 32 motorized boating studies, 3 camping studies, and 26 waterfowl hunting studies were gathered and presented for the Midwestern Region which includes Nebraska. Rosenberger (2011) reports an average value of $39.30 for fishing, $30.84 for boating, $9.85 for camping, and $31.76 for waterfowl hunting in 2010 dollars. These four values average to $27.94 in 2010 dollars. Indexing the $27.94 value up to average 2014 dollars using the Midwest Urban Consumer Price index results in a value of $30.27 for those activities.

2.2.4 Recreation Valuation Results

This section reports the recreation benefits estimated under each alternative/ scenario and then compares alternatives/scenarios as prescribed in Table 2 of report section 1.3.

2.2.4.1 Recreation Benefits by Alternative/Scenario

The recreation valuation results are presented in Table 18. All values reflect recreation benefits over the future 50 year period of analysis discounted to a present value using the current Reclamation FY14-15 planning rate of 3.375 percent. Results are shown for each of the recreation sites (Box Butte Reservoir, Merritt Reservoir, and the Niobrara NSR), for each alternative/scenario.

Table 18. Recreation Benefits under Defined Alternatives/Scenarios

Alternative/ Scenario	Box Butte Reservoir[a]	Merritt Reservoir[a]	Niobrara National Scenic River[a]	Total[a]
Baseline No Action	$9,288,000	$81,177,000	$22,009,000	$112,474,000
Low No Action	$9,103,000	$93,997,000	$32,877,000	$135,977,000
Alt 1 Low	$10,173,000	$93,997,000	$32,877,000	$137,047,000
Alt2 Low	$12,173,000	$93,997,000	$32,877,000	$139,047,000
CT No Action	$11,936,000	$97,844,000	$27,440,000	$137,220,000
Alt 1 CT	$21,039,000	$97,844,000	$27,440,000	$146,323,000
Alt 2 CT	$29,013,000	$97,844,000	$27,440,000	$154,297,000
High No Action	$16,522,000	$95,270,000	$21,937,000	$133,729,000
Alt 1 High	$24,097,000	$95,270,000	$21,937,000	$141,304,000
Alt 2 High	$30,462,000	$95,270,000	$21,937,000	$147,669,000

[a] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

It should be noted that because the recreation visitation models for Merritt Reservoir and the Niobrara NSR include both positive water level/instream flow and temperature terms such that an increase (decrease) in water levels/instream flows or temperatures would result in an increase (decrease) in visitation, the hot/dry and warm/wet conditions work at cross purposes in terms of the effect on visitation. In other words, the hot/dry condition would result in increased visitation as temperatures increase (hot) but reduced visitation as water levels/ instream decline (dry) – the same cross purposes effect is also true of the warm/ wet climate change condition. How this effect influences the recreation value at each site across the climate change scenarios depends on the magnitude of the water levels/instream flows and temperatures between each climate change scenario.

At Merritt Reservoir, the central tendency climate change scenario generates the highest recreation value whereas at the Niobrara NSR, the Low (hot/dry) climate change scenario generates the highest value. Overall, the central tendency climate change scenario generates the highest recreation value because Merritt Reservoir is the dominant site.

2.2.4.2 Comparison of Recreation Benefits

Benefit comparisons by alternative/scenario are described in the *Alternatives Analyzed* section on page 3 of this report. The comparison of recreation benefits follows the prescribed comparisons in Table 2 on page 5 of this report. Table 19 below presents the change in discounted recreation benefits for the Future No Action Alternative/Scenarios (with climate change) as compared to the Baseline No Action Alternative/Scenario (without climate change) as well as the two proposed action alternatives by climate change scenario as compared to the Future No Action by climate change scenario.

Table 19. Comparison of Recreation Benefits

Base Case			Comparison		Difference (millions of $'s)	Percent Difference
Alternative/ Scenario	Value[a] (millions)		Alternative/ Scenario	Value[a] (millions)		
Baseline No Action	$112.5	→	Low No Action	$136.0	$23.5	20.9%
Baseline No Action	$112.5	→	CT No Action	$137.2	$24.7	22.0%
Baseline No Action	$112.5	→	High No Action	$133.7	$21.2	18.8%
Low No Action	$136.0	→	Alt 1 Low	$137.0	$1.0	0.7%
Low No Action	$136.0	→	Alt 2 Low	$139.0	$3.0	2.2%
CT No Action	$137.2	→	Alt 1 CT	$146.3	$9.1	6.6%
CT No Action	$137.2	→	Alt 2 CT	$154.3	$17.1	12.5%
High No Action	$133.7	→	Alt 1 High	$141.3	$7.6	5.7%
High No Action	$133.7	→	Alt 2 High	$147.7	$14.0	10.5%

[a] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

When comparing the with and without climate change conditions, the overall analysis shows that the Future No Action with climate change generates more recreation value than the Baseline No Action without climate change. As shown in Table 18, at Merritt, the central tendency and warm/wet scenario water levels and temperatures under the Future No Action exceed those of the Baseline No Action resulting in a higher recreation value. In addition, the increase in temperatures under the hot/dry scenario offset the decrease in water levels for the Future No Action as compared to the Baseline No Action again resulting in a higher recreation value. For the Niobrara NSR and Box Butte Reservoir, the difference between the Future No Action and the Baseline No Action is less consistent. As shown in Table 19, across all climate change scenarios and recreation sites, the recreation value for the Future No Action exceeds that of the Baseline No Action with the difference ranging from $21.3 million to $24.7 million depending on the scenario.

When evaluating the proposed action alternatives, which include climate change, the climate change scenario for each proposed action alternative is compared to the same climate change scenario under the Future No Action. As shown in Table 18, because the hydrologic and climate change analyses did not estimate a difference in water levels/instream flows and temperatures for the proposed action alternatives as compared to the Future No Action at Merritt Reservoir and the Niobrara NSR (see Climate Change, Groundwater, and Surface Water Appendices - A, B, and D respectively), there is no change in recreation values at those sites for the two proposed action alternatives. However, given the hydrologic analyses did estimate a difference in water levels for the proposed action alternatives as compared to the Future No Action at Box Butte Reservoir, differences in recreation value for the proposed action alternatives were estimated at Box Butte. Therefore, the difference in overall recreation values across all three sites was based purely on the difference in recreation value at Box Butte. As shown in Table 19, when comparing the change in recreation value for the two proposed alternatives as compared to the Future No Action, the Mirage Flats Canal Recharge Alternative generates a larger increase in recreation value than the Mirage Flats Pumping Station Alternative.

3. Cost Analyses

As noted in section 1.1, the only costs included in this analysis are those associated with construction activities. Annual operation, maintenance, replacement, and power (OMR&P) costs likely vary by alternative, but are not included in this appraisal-level BCA. The Mirage Flats Pumping Station Alternative/Scenarios (Alt 1 Low, Alt 1 CT and Alt 1 High) include construction-related costs associated with building a new pumping station. This alternative for each CC scenario includes an estimated $4.46 million construction cost. Since the construction period for this new pumping plant is less than one year, no interest during construction is added to the construction cost estimate.

As explained in section 1.1, all costs are calculated in 2014 dollars regardless of when they are expected to be incurred.

4. Benefit-Cost Analysis Results

As noted in section 1.2, a BCA compares estimates of net benefits (i.e., benefits minus costs) under the Future No Action Alternative to estimates of net benefits under the proposed Action Alternatives. The Action Alternative with the greatest increase in net benefits compared to the No Action Alternative is preferred from an economics perspective. In addition, to evaluate the economic effects of climate change, net benefits of the No Action Alternative under with and without climate change conditions are compared.

The sum of agricultural and recreation benefits under each of the 10 defined alternatives/scenarios yields the *combined benefits* under each alternative/ scenario. The costs associated with each alternative/scenario are then subtracted from *combined benefits* to yield *net benefits* under each alternative/scenario. The BCA is conducted by calculating the difference in net benefits between each Action Alternative/Scenario and its Future No Action variant.

This section first shows the calculation of net benefits by alternative/scenario. The BCA is then conducted by calculating the difference in net benefits according to the alternative/scenario comparisons prescribed in section 1.3 of this report.

4.1 Calculation of Net Benefits by Alternative/Scenario

Net benefits under a given alternative/scenario are calculated as the combined benefits minus the costs associated with that alternative/scenario. Combined benefits under a given alternative/scenario for the purpose of this basin study are the sum of agricultural benefits and recreation benefits under that alternative/scenario. Table 20 reports the combined benefits, costs, and net benefits by alternative/scenario.

Table 20. Present Value of Net Benefits Under Defined Alternatives/ Scenarios

All benefits, costs, and net benefits reported in millions of dollars

Alternative/ Scenario	Agricultural Benefits[a]	Recreation Benefits[a]	Combined Benefits[a,b]	Costs[c]	Net Benefits[a,d]
Baseline No Action	$15.8	$112.5	$128.3	$0.0	$128.3
Low No Action	$15.1	$136.0	$151.1	$0.0	$151.1
Alt 1 Low	$17.3	$137.0	$154.3	$4.5	$149.8
Alt 2 Low	$13.1	$139.0	$152.1	$0.0	$152.1
CT No Action	$16.5	$137.2	$153.7	$0.0	$153.7
Alt 1 CT	$18.5	$146.3	$164.8	$4.5	$160.3
Alt 2 CT	$13.6	$154.3	$167.9	$0.0	$167.9
High No Action	$17.5	$133.7	$151.2	$0.0	$151.2
Alt 1 High	$18.3	$141.3	$159.6	$4.5	$155.1
Alt 2 High	$13.9	$147.7	$161.6	$0.0	$161.6

[a] 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

[b] The sum of agricultural benefits and recreation benefits.

[c] Costs are only associated with any Future alternative/scenario that includes the Mirage Flats Pumping Station operational modification—see section 3 of this report.

[d] Combined Benefits minus Costs.

4.2 Summary of Benefit-Cost Analysis Results

The BCA is conducted as six net benefits comparisons—calculating the difference between each Action Alternative/Scenario and its Future No Action variant (comparison numbers 4–9 in Table 2, section 1.3 of this report). Three additional net benefits comparisons are made solely for the purpose of evaluating the economic effects of the three future climate change scenarios (comparison numbers 1–3 in Table 2, section 1.3 of this report). These three comparisons are technically not part of the BCA, as the basin cannot "choose" a future climate change scenario (as opposed to choosing an operational modification); rather the basin is *subjected* to that future climate scenario.

Alternative/scenario comparisons are described in section 1.2 of this report. The comparison of net benefits by alternative/scenario follows the prescribed comparisons listed in Table 2 of section 1.2. Comparisons of net benefits between alternatives/scenarios are reported in Table 21 below.

Under each climate change scenario, net benefits under the Future No Action Alternative (i.e., Low No Action, CT No Action, and High No Action) with climate change exceed those of the Baseline No Action Alternative (Baseline No Action) without climate change. The net benefits are dominated by the recreational benefits which increase under each Future No Action climate change scenario due to increased temperatures under all three scenarios and increased water elevations under the CT and High scenarios.

Table 21. Alternative/Scenario Comparisons of Net Benefits

Net benefits reported in millions of dollars.

Base Case			Comparison		Difference (million $'s)	Percent Difference
Alternative/ Scenario	Net Benefits[a]		Alternative/ Scenario	Net Benefits[a]		
Baseline No Action	$128.3	→	Low No Action	$151.1	$22.8	17.8%
Baseline No Action	$128.3	→	CT No Action	$153.7	$25.4	19.8%
Baseline No Action	$128.3	→	High No Action	$151.2	$22.9	17.8%
Low No Action	$151.1	→	Alt 1 Low	$149.8	–$1.3	–0.9%
Low No Action	$151.1	→	Alt 2 Low	$152.1	$1.0	0.7%
CT No Action	$153.7	→	Alt 1 CT	$160.3	$6.6	4.3%
CT No Action	$153.7	→	Alt 2 CT	$167.9	$14.2	9.2%
High No Action	$151.2	→	Alt 1 High	$155.1	$3.9	2.6%
High No Action	$151.2	→	Alt 2 High	$161.6	$10.4	6.9%

[a] The sum of agricultural and recreation benefits. 50-year stream of benefits discounted at the FY2015 Federal Discount rate of 3.375% (Reclamation, 2014).

With the exception of Alt 1 Low, the comparisons of the proposed action alternatives/scenarios to the Future No Action Alternative/Scenarios result in positive net benefits ranging from $1.0 to $14.2 million. This indicates that the net benefits of the action alternatives generally exceed those of the Future No Action implying the action alternatives are economically justified. In addition to the combined agricultural and recreation benefits, Alternative Alt 1 also includes the costs for constructing the new pumping plant. Under each scenario, the net benefits of Alternative Alt 2 exceed those of Alternative Alt 1.

5. References

DNR. (2015, March 30). Data provided in email correspondence with Mahesh Pun of Nebraska Department of Natural Resources. (T. L. Gaston, Interviewer)

DOI. (2015). *Department of the Interior Agency Specific Procedures For Implementing CEQ Principles & Requirements for Investments in Federal Water Resources Draft*. U.S. Department of the Interior.

HPRCC. (2015). *Historical Climate Data Summaries - Valentine WSO AP, Nebraska (258760)*. Retrieved February 2015, from High Plains Regional Climate Center: http://www.hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?ne8760

Johanson, N. (2013, February 26). Personal communication. (J. Platt, Interviewer)

Keech, C. F. (1964). *Ground-Water Resources of Mirage Flats, Nebraska*. Washington DC: U.S. Department of Interior, Geological Survey; U.S. Government Printing Office.

Lazarus, W. F. (2011). *Machinery Cost Estimates*. University of Minnesota, Extension.

NPS. (2015). *Visitor Use Statistics - Niobrara National Scenic River*. Retrieved January 2015, from National Park Service: https://irma.nps.gov/Stats

Reclamation. (2004a). *Bureau of Reclamation Economics Guidebook*. U.S. Bureau of Reclamation.

Reclamation. (2004b). *Technical Guidance for Irrigation Payment Capacity*. U.S. Bureau of Reclamation.

Reclamation. (2014). *Interest Rates for Fiscal Year 2015 - 11/25/2014* Memorandum from Roseann Gonzales, Director, Policy and Administration Office. U.S. Bureau of Reclamation.

Reclamation. (2015a). *Box Butte Safety of Dams – Economic Benefit Analysis and Damage Assessment, Mirage Flats Project, Nebraska*. U.S. Bureau of Reclamation.

Reclamation. (2015b). *Hydromet: RES070 Monthly Values for Period of Record*. Retrieved February 2015, from US DOI, Reclamation, Great Plains Region, Hydromet: http://www.usbr.gov/gp-bin/res070_form.pl?BBNE

Rosenberger, R. (2011). *Recreation Use Values Database, Overview – Table 1: Recreation Use Values per Person per Day by Activity and Region in 2010 USD*. Corvallis, OR: Department of Forest Ecosystems and Society, College of Forestry, Oregon State University.

TFG. (2015, February 20). Data provided in email correspondence with Isaac Mortensen of The Flatwater Group. (T. L. Gaston, Interviewer)

UNL. (2013). *Nebraska Farm Real Estate Market Highlights, 2012–2013*. University of Nebraska, Lincoln, Department of Agricultural Economics.

UNL Extension. (2013). *Crop Budgets, Nebraska – 2013*. University of Nebraska, Lincoln, Extension.

UNWNRD. (2014, February 12). Telephone conversation with Sheri Daniels, the Water Resources Manager for Upper Niobrara White Natural Resources District, regarding MFID cropping patterns and agricultural practices. (T. L. Gaston, Interviewer)

UNWNRD. (2015, March). *Welcome*. Retrieved from Upper Niobrara White Natural Resources District: http://www.unwnrd.org/

USCEQ. (2013). *Principles and Requirements for Federal Investments in Water Resources*. U.S. Council of Environmental Quality.

USCEQ. (2014). *Chapter III – Interagency Guidelines*. U.S. Council of Environmental Quality.

USDA ERS. (2014). *Table 4—State-level normalized price estimates for commodities, 2014*. U.S. Department of Agriculture, Economic Research Service.

USDA NASS. (2009–12). *CropScape* - *Cropland Data Layer*. Retrieved November 2014, from U.S. Dept. of Agriculture, National Agricultural Statistics Service: http://nassgeodata.gmu.edu/CropScape/

USDA NASS. (2014, August). *Quick Stats*. Retrieved from USDA National Agricultural Statistics Service: http://quickstats.nass.usda.gov/

USGS. (2015). *Water Resources of the United States USGS 06461500 Niobrara River near Sparks, NE*. Retrieved January 2015, from U.S. Geological Survey - National Water Information System: http://waterdata.usgs.gov/usa/nwis/uv?06461500

USWRC. (1983). *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington DC: U.S. Water Resources Council.

Whittaker, D., & Shelby, B. (2008). *Flows and Recreational Floating on the Niobrara National Scenic River, Nebraska. Prepared for: Nebraska Game and Parks Commission, Lincoln NE. Lincoln, NE*: Nebraska Game and Parks Commission.