Niobrara River Basin Study

Appendix D — Central Nebraska Surface Water Operations Modeling Report

U.S. Department of the Interior
Bureau of Reclamation
Nebraska-Kansas Area Office
McCook, Nebraska

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: Aerial view of Merritt Dam and Reservoir, near Valentine, Nebraska.

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Appendix D —
Central Nebraska Surface Water Operations Modeling Report

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Executive Summary

Purpose, Scope and Objectives

The Niobrara River Basin Study (Basin Study) is a collaborative effort by the Nebraska Department of Natural Resources (DNR) and the U.S. Bureau of Reclamation (Reclamation), which is authorized under the SECURE Water Act (Title IX, Subtitle F of Public Law 111-11). The purpose of the Basin Study is to evaluate current and projected future water supply and demand and to collaborate with stakeholders in the region on identification and evaluation of potential adaptation strategies which may reduce any identified gaps.

The purpose of this report is to summarize the analysis of the surface water operations model for the Central Nebraska (CENEB) sub-region (see Figure 1 in Section 1.2) used to evaluate the impacts of climate variability in the middle and lower portions of the basin. This study also includes the climate variability effects on future water supply and demand associated with the operations of Merritt Reservoir. Additional Basin Study technical reports supplement this analysis and contribute to the overall Basin Study report.

Data and Models Used to Evaluate Climate Change Effects on Water Supply

The modeling framework for the Basin Study consists of two modeled sub-regions, namely the Upper Niobrara White portion and the CENEB portion. For each of the sub-regions, a series of models have been developed to simulate the full water balance of the region, including soil water dynamics of agricultural areas, and surface and groundwater hydrology. A surface water operations model, including the operations of Merritt Reservoir, was developed by the Nebraska-Kansas Area Office (NKAO) for the CENEB region to simulate managed flows in the Niobrara River and to evaluate the effects of projected surface and groundwater hydrology on streamflows at three specific locations within the CENEB. Inputs to the CENEB surface water operations model primarily consist of baseflow (output from groundwater model), deliveries from surface and groundwater sources (output from watershed model), and surface runoff (output from watershed model) that correspond with each of the model nodes. Additional inputs to the model include total streamflow at the Niobrara River gage at Gordon, the model's upstream boundary location, and simulated inflows and evaporation at Merritt Reservoir.

Four different model runs were generated for the CENEB region using data from the series of models developed to simulate the full water balance of the CENEB region. A Baseline No Action run of the CENEB surface water operations model was generated from 1960 to 2010. This run includes historical climate and current land use, identified at 2010 levels. In addition, three individual climate scenarios were incorporated into the CENEB model to evaluate the impacts to future surface water supplies and the operations of Merritt Reservoir (called Future No Action scenarios). The climate scenarios represent a low projected water availability or drier climate condition (Low scenario), a median projected water availability (Central Tendency scenario), and a high projected water availability or wet climate condition (High scenario). Reclamation's Technical Service Center developed adjusted historical Merritt Reservoir inflows for the purpose of calibrating the CENEB decision support model, as well as adjusted Merritt Reservoir inflows for the Future No Action scenarios. Other model inputs were provided by DNR and its contractors.

In addition to the four model runs performed as part of the study analysis, a historical simulation was performed using historical climate and land use to calibrate the model. Calibration of the CENEB model involved comparing simulated historical flows over the historical period 1960-2010 to the United States Geological Survey (USGS) streamflow records within the basin. Historical climate data was used along with assumed current water demands to establish a Baseline No Action scenario condition. The Baseline No Action scenario provides a benchmark to evaluate the effects of climate change on future supply and assumed future demands.

Effects of Climate Variability and Change on Water Supply

Overall, the modeling results show the streamflows at the four model nodes is the lowest under the Low climate scenario and significantly higher under the High climate scenario. The Low scenario represents projected low water availability and generally corresponds with hotter and drier future climate. The Central Tendency scenario represents the normal or average condition water availability. The High scenario represents high projected water availability and generally corresponds with wetter and less warm future climate. Together, the climate change scenarios are intended to represent a range of projected future conditions. Sections 4.2 through 4.5 summarize the impacts to streamflows as a result of the Baseline No Action and Future No Action scenarios at the four node locations in the basin.

The impacts to the Merritt Reservoir operations are modest for the Central Tendency and High future scenarios as compared to the Baseline No Acton scenario. Impacts to the reservoir under the Low scenario, corresponding to the hot and dry climate, are slightly greater than the other scenarios analyzed in this report. Under the Low scenario, the reservoir levels at the end of the summer months are on average 2 feet lower as compared to three other modeled scenarios. Typically, the annual minimum reservoir levels occur at the end of the irrigation season. Further details on the modeled reservoir operations have been summarized in Section 4.1.

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1 Introduction

1.1 Purpose, Scope, and Objective of Study

The purpose of the Niobrara River Basin Study (Basin Study) is to evaluate current and projected future water supply and demand and to collaborate with stakeholders in the region on identification and evaluation of potential adaptation strategies which may reduce any identified gaps. This study is a collaborative effort by the Nebraska Department of Natural Resources (DNR) and the U.S. Bureau of Reclamation (Reclamation).

The purpose of this report is to summarize the analysis of the surface water operations model for the Central Nebraska (CENEB) sub-region used to evaluate the impacts of climate variability in the middle and lower portions of the basin as a result of the selected climate variability alternatives developed for the Basin Study. This study also includes the climate variability effects on future water supply and demand associated with the operations of Merritt Reservoir.

1.2 Location and Description of Study Area

The Niobrara River Basin begins in eastern Wyoming and extends across much of northern Nebraska (extending into a small portion of South Dakota), emptying into the Missouri River. The Niobrara River provides extensive water supplies for agriculture uses as well as significant benefits for recreation and fish and wildlife. This report focuses on the modeled area known as the CENEB sub-region in the Basin Study modeling framework. The western edge of this region begins near the Niobrara River near Gordon, Nebraska and extends eastward to Spencer, Nebraska. There are three select runoff zones in this study area illustrated in Figure 1. Spencer Hydropower is the single (private) hydropower facility in the basin, located near USGS gage ID 06465000. In addition, a reach of the lower Niobrara River was designated as a National Wild and Scenic River. This Wild and Scenic River is located near the Fort Niobrara National Wildlife Refuge downstream of USGS gage ID 06461500 (see Figure 1).

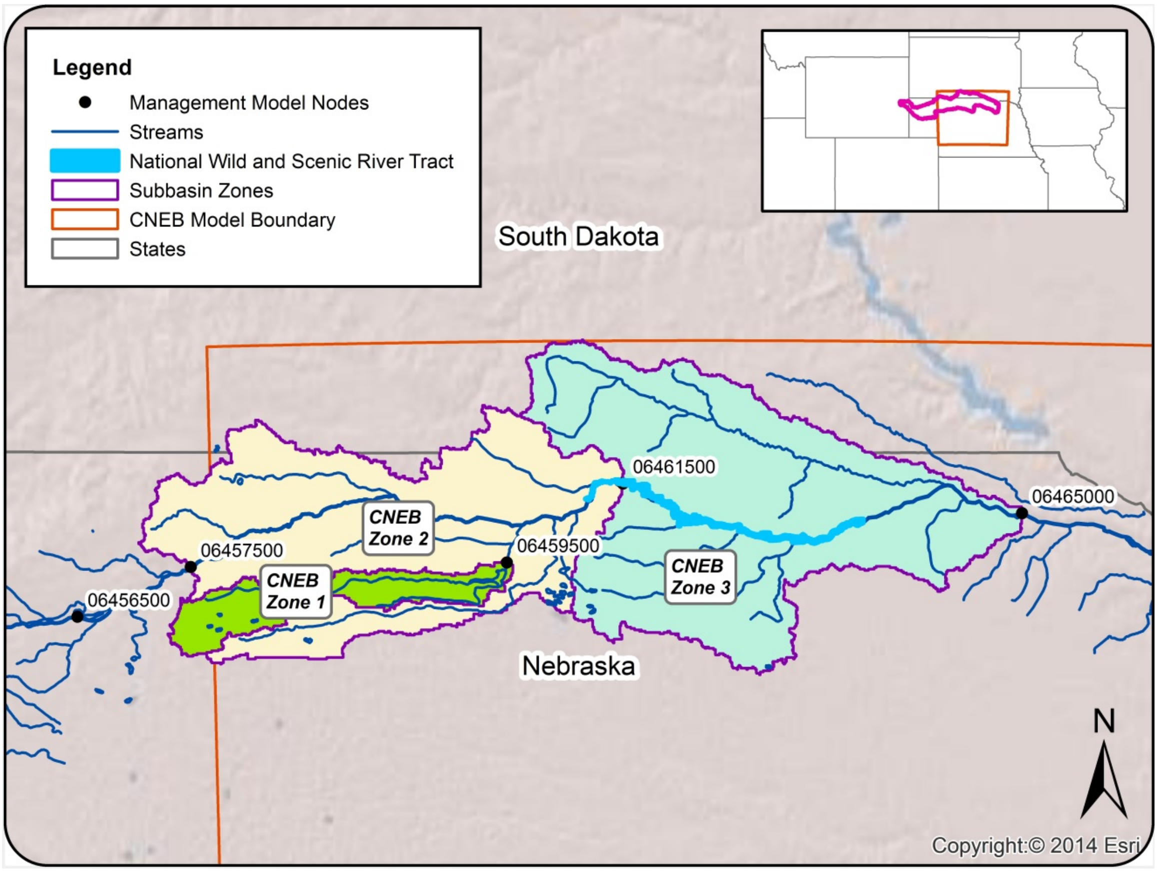

Figure 1. CENEB sub-region showing model zones and nodes.

2 Historical Surface Water Availability

2.1 Data and Models Used

A surface water operations model was developed for the CENEB region to incorporate the effects of surface and groundwater hydrology on Merritt Reservoir elevations and streamflows at three locations within the region. Similar to the Upper Niobrara - White (UNW) model region, inputs into the surface water operations model for the CENEB region were taken from the CENEB groundwater model and CENEB watershed model. Figure 2 illustrates the model interactions for the CENEB region. Together, the model components comprise an integrated model for the CENEB region. It should be noted that the data exchanged between the models is slightly different from the data exchange in the UNW integrated model. Description of the framework of the integrated models may be found in Appendix F, the Integrated Water Management Modeling Report. However, section 2.2 describes the data linkages in the CENEB integrated model and, specifically, inputs to the CENEB surface water operations model which are generated from the groundwater and watershed models.

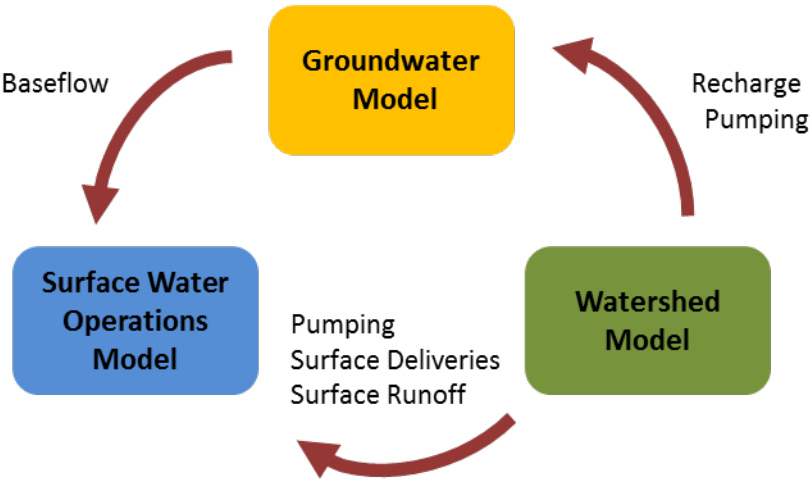

Figure 2. Model interactions for the CENEB sub-region of the study area.

Four different model runs were generated for the CENEB region using data from the series of models developed to simulate the full water balance of the CENEB region, including both surface and groundwater hydrology (Figure 2). A Baseline No Action run of the CENEB surface water operations model was generated from 1960 to 2010. This run includes historical climate and current land use, identified at 2010 levels. In addition, three individual climate scenarios were incorporated into the CENEB model to evaluate the impacts to future surface water supplies and the operations of Merritt Reservoir. The climate scenarios represent a low projected water availability or drier climate condition (Low scenario), a median projected water availability (Central Tendency scenario), and a high projected water availability or wet climate condition (High scenario). Each scenario used a monthly timestep with the 2010 level of development of land use data.

In addition to the four model runs performed as part of the study analysis, a historical simulation was performed using historical climate and land use to calibrate the model. Calibration of the CENEB model involved comparing simulated historical flows over the historical period 1960-2010 to the USGS streamflow records at three locations:

- ID 06461500 Niobrara River near Sparks, Nebraska
- ID 06459500 Snake River near Burge, Nebraska
- ID 06465000 Niobrara River near Spencer, Nebraska

Historical climate data was used along with assumed current water demands to establish a Baseline No Action scenario condition. The Baseline No Action scenario provides a benchmark to evaluate the effects of climate change on future supply and assumed future demands. Hydrologic inputs used to implement the Merritt Reservoir operations for each scenario, such as reservoir inflow and reservoir evaporation and impacts from climate variability, were developed by Reclamation's Technical Service Center. All other inputs, such as irrigation water demand and baseflow and surface water components, used in this study were developed by DNR and its contractors. Detailed descriptions of the modeling framework and descriptions of the climate scenarios developed for this study may be found in separate technical reports included within the Basin Study Report (Appendix F and A, respectively).

The CENEB surface water operations model, including the operations model of Merritt Reservoir, was developed by the Nebraska Kansas Area Office (NKAO) to simulate reservoir elevations and streamflow throughout the Lower Niobrara watershed. The operations criteria of Merritt Reservoir are described in detail below in Section 3.

2.2 Historical Model Inputs

Inputs to the CENEB surface water operations model primarily consist of baseflow (output from groundwater model), deliveries from surface and groundwater sources (output from watershed model), and surface runoff (output from watershed model) that correspond with each of the model nodes. Additional inputs to the model include total streamflow at the Niobrara River gage at Gordon, Nebraska, the model's upstream boundary location, and simulated inflows and evaporation at Merritt Reservoir. Each of these inputs is further described below.

It should be noted that CENEB watershed and groundwater model simulations were not available for Baseline No Action and Future No Action scenarios. Due to Basin Study time constraints, a historical simulation for each model was not performed. However, it was assumed that Baseline No Action results represent historical conditions because, based on our analysis, there is little variability in crop acreage from year to year. Small variability suggests little sensitivity of model results to the assumption that 2010 cropping patterns are representative of historical conditions. Therefore, in the following discussion of model inputs, we focus the discussion on Baseline No Action and Future No Action scenarios, unless otherwise noted. Further discussion of this assumption and supporting information may be found in Appendix A, Climate Change Analysis Report.

2.2.1 Baseflow

Groundwater generated baseflow is the dominant component of total flow in the Niobrara River Basin. Baseflow inputs to the CENEB surface water operations model come directly from the CENEB groundwater model. Baseflow values represent the contributing flow upstream of the CENEB surface water operations model nodes. Further details on the simulated baseflow coming from the CENEB groundwater model can be found in Appendix B, Groundwater Modeling Report.

2.2.2 Deliveries from Surface and Groundwater, and Surface Runoff

Surface water deliveries, groundwater pumping, and natural surface runoff come directly from the CENEB watershed model. Similar to baseflow, these values represent the contributing flow upstream of the CENEB surface water operations model nodes. Surface water deliveries and groundwater pumping are at levels to meet irrigation demands in the modeled zones. The CENEB surface water operations model does not curtail deliveries based on operating criteria as in the UNW surface water operations model. The reasoning for this is, sufficient water has been available to meet water demands, resulting in no need to adjust model operations to meet those demands. Additionally, the simple approach to modeling surface water operations in the CENEB region does not warrant iterative model runs due to the lack of detailed representation of canals and other infrastructure that would increase the sensitivity of total managed flow to differences in operations. Further details on the simulated deliveries, pumping, and surface runoff may be found in Appendix E, Watershed Modeling Report.

2.2.3 Total Flow at Niobrara River at Gordon

The Niobrara River at the Gordon gage location serves as the downstream most node in the UNW surface water operations model as well as the upstream most node in the CENEB surface water operations model. As such, this location also serves as the linkage between UNW and CENEB integrated models. The total streamflow simulated by the UNW model is used as input to the CENEB model at Gordon for the corresponding scenarios (Baseline No Action and Future No Action Low, Central Tendency, and High). Future with Alternative scenarios, including the Mirage Flats pumping plant alternative and the Mirage Flats canal recharge alternative, were not simulated by the CENEB surface water operations model. The reasoning for not simulating these scenarios in the CENEB model is the lack of sensitivity of managed flows in the CENEB region to changes in flow in the UNW region. Sensitivity analyses were performed both with respect to groundwater and managed surface water and the lack of sensitivity is summarized in Appendix B and Appendix C, respectively.

2.2.4 Merritt Reservoir Inflows and Evaporation

Historical inflows to Merritt Reservoir are computed based on historical storage, computed evaporation, and releases. Historical inflows were provided by the NKAO for comparison with Baseline No Action simulated inflows, computed as the sum of baseflow from the CENEB groundwater and surface runoff from the CENEB watershed model. As previously discussed, for the CENEB surface water operations modeling, we assume historical simulated data (which were not developed) are equal to the Baseline No Action scenario data.

Due to inherent biases in the Baseline No Action simulated Merritt inflows, a bias correction procedure was used to adjust the simulated inflows to match the statistics of the historical computed inflows over a common time period. A percentile-based map of adjustment factors is developed for each month (January through December) based on historical data. The same map is used to adjust

Future No Action scenario data. Details of the bias correction procedure may be found in Appendix A, Climate Change Analysis Report.

Evaporation for Merritt Reservoir was calculated using available data in combination with results from the Complementary Relationship Lake Evaporation (CRLE) model (Morton et al., 1985). Evaporation for Baseline No Action and Future No Action scenarios was developed as input to the CENEB surface water operations model. Further details on development of evaporation at Merritt Reservoir may be found in Appendix A, Climate Change Analysis Report.

2.3 Model Inputs and Mass Balance Equations

Table 1 illustrates the inputs and mass balance equations used to compute the flows at each of model nodes in the CENEB surface water operations model and the inputs used in the Merritt Reservoir Operations model. Data provided by the Technical Services Center (TSC) for the Merritt Reservoir operations model included reservoir inflow and evaporation inputs. DNR provided baseflow inputs for the surface water operations model generated directly from the CENEB groundwater model and The Flatwater Group (TFG) provided surface water deliveries, groundwater pumping, and natural surface runoff directly from the CENEB watershed model. Section 4 of this technical report discusses the details of mass balance equations at each node.

Table 1. Inputs and Mass Balance Equations - CENEB Surface Water Operations Model

Parameter	Mass Balance	Source
Node 1: Flow at Gordon	Not applicable, provided by UNW surface water operations model	HDR
Node 2: Flow at Burge	Flow @ Burge = [Merritt Inflow] – [Surface Deliveries to Canal] – [Merritt Evap] + [Merritt Reservoir Operational Spills to River] Where, Merritt Inflow = [CENEB "base flow" for Burge] + [CENEB surface flow for Burge]	TSC, TFG
Node 3: Flow at Sparks	Flow @ Sparks = ([Flow @ Burge] – [CENEB "base flow" for Burge]) + [Flow @ Gordon] + [“base flow” btw Gordon and Stateline] + [CENEB "base flow" for Sparks (from DNR)] + [CENEB surface flow for Sparks (from TFG)] – [Surface Deliveries (from TFG)] + [return flows from Surface Deliveries and GW pumping]	DNR, TFG
Node 4: Flow at Spencer	Flow @ Spencer = ([Flow @ Sparks] – [CENEB "base flow" for Sparks]) + [CENEB "base flow" for Spencer] + [CENEB surface flow for Spencer] – [Surface Deliveries] + [return flows from Surface Deliveries and GW pumping]	DNR, TFG

3 Merritt Reservoir Operations

3.1 Data and Models Used

As part of the CENEB surface water operations model, Reclamation's NKAO incorporated operating criteria for Merritt Reservoir to simulate surface water operations using the CENEB input data developed by TSC, DNR and its contractors. Operating criteria consistent with Reclamation's contract and operating agreements with the Ainsworth Irrigation District were employed for each scenario. Typically, Merritt Reservoir is filled to elevation 2944.0 each fall after the irrigation season. This level is approximately two feet below the top of conservation capacity and within the repaired area of the soil cement on the upstream face of the dam. To help avoid ice damage to the older existing soil cement on the face of the dam, the reservoir is regulated to maintain this level until the ice clears each spring. Upon ice-out, the reservoir is rapidly filled to elevation 2946.0 (full pool) to reduce shoreline erosion and minimize the sand accumulations on the face of the dam. The filling process generally takes place in April. The reservoir level is maintained until irrigation demands begin to draw on the pool.

Modeled data including monthly inflows, evaporation and irrigation demands developed by TSC, DNR and DNR's contractors were used as inputs to develop the historic calibration as well as to simulate managed flows for the Baseline No Action and the three Future No Action climate scenarios (see Table 1). Figures 3 and 4 summarize the modeled end of month reservoir elevations for the study period.

4 Effects of Variable Climate on the Surface Water Components within the CENEB Region

The modeling components for this study consists of four nodes located at selected USGS gaging locations and three runoff zones or sub-basins located throughout the CENEB region. Node 1, or the upstream segment of the CENEB model, is located at the Niobrara River gage near Gordon, NE, corresponding to the surface water inflow into the modeled region; Node 2 is located at the Snake River gage near Burge, Nebraska, corresponding to river releases from Merritt Reservoir; Node 3 is located at the Niobrara River gage near Sparks, Nebraska, representing streamflows along the National Wild and Scenic River area of the basin; and Node 4 is located at the Niobrara River gage near Spencer, Nebraska, corresponding to the streamflows at the eastern edge of the modeled region and water supplies available to the Spencer hydropower facility.

The zones in the region correspond with the modeled runoff zones by the watershed and groundwater models (for UNW and CENEB regions). Runoff zones represent the upstream contributing area to each of the surface water operations model nodes for the CENEB region, subtracting any upstream zone areas. Zone 1 represents the Snake River drainage area above the Snake River gage near Burge, Nebraska (ID 064615000); the Zone 2 drainage area extends upstream from the Niobrara River gage near Sparks, Nebraska (ID 06461500) to the Niobrara River gage near Gordon, NE (ID 06467500); and the Zone 3 drainage area extends upstream from the Niobrara River gage near Spencer, Nebraska (ID 06465000) to the Niobrara River gage near Sparks, Nebraska.

4.1 Merritt Reservoir Operations

This section analyzes the impacts to the reservoir operations based on the three Future No Action climate scenarios as compared to the Baseline No Action scenario. Figures 3 and 4 illustrate the comparison of the annual end of month reservoir elevations and the reservoir elevation at the end of September, respectively. In each scenario, the projected inflows are sufficient to refill the reservoir each year to the desired reservoir level in the fall following the irrigation season. Each spring, the reservoir is allowed to fill to the top of conservation prior to the irrigation season. For the purposes of this study, the maximum reservoir level is capped at the top of the conservation pool (elevation 2646.0 ft). The end of September elevations were selected for comparison of the reservoir drawdown as a result of the changes in irrigation demands. The end of September elevations illustrate the annual minimum reservoir levels for each scenario. For the Central Tendency and the High climate scenarios, the change in reservoir elevations at the end of the irrigation season is modest as compared to the Baseline No Action scenario. For the Low scenario (corresponding to the hot and dry climate), the average reservoir elevations at the end of the irrigation season are approximately 2 feet lower as compared to the Baseline No Action scenario (see Table 2). The projected reservoir elevations at the end of September for the Low scenario range from approximately 2 feet below the top of conservation to 14 feet below the top of conservation.

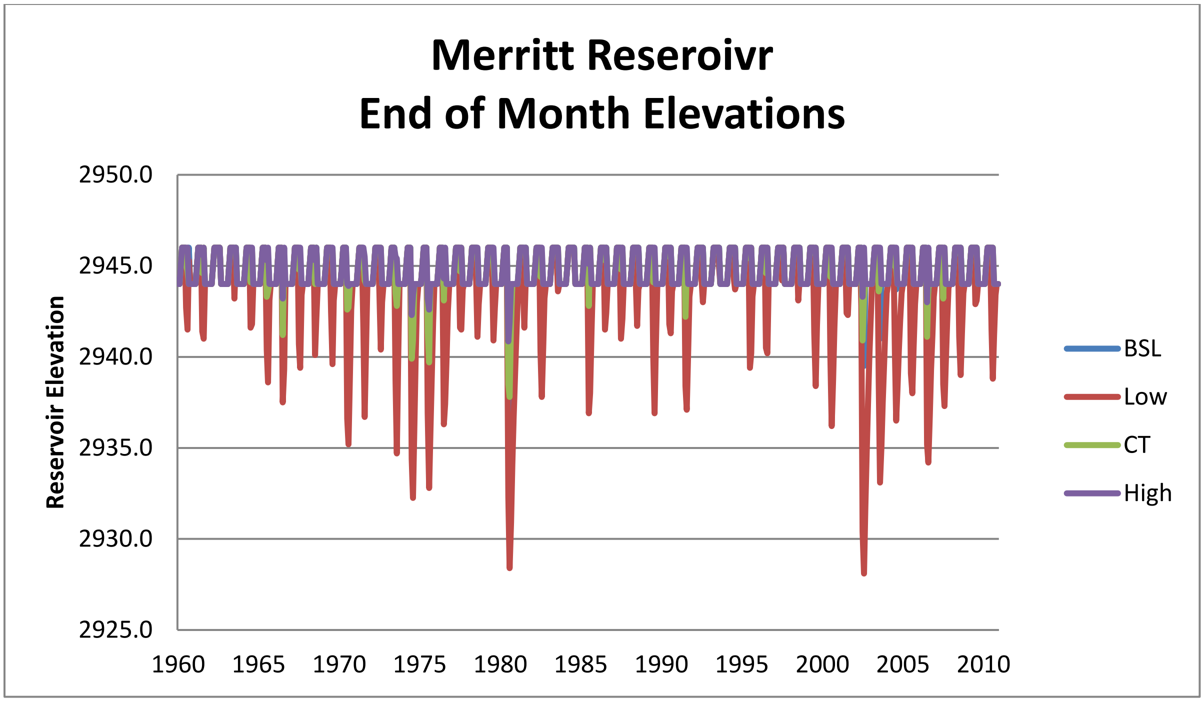

Figure 3. Comparison of the end of month reservoir elevations for the study period.

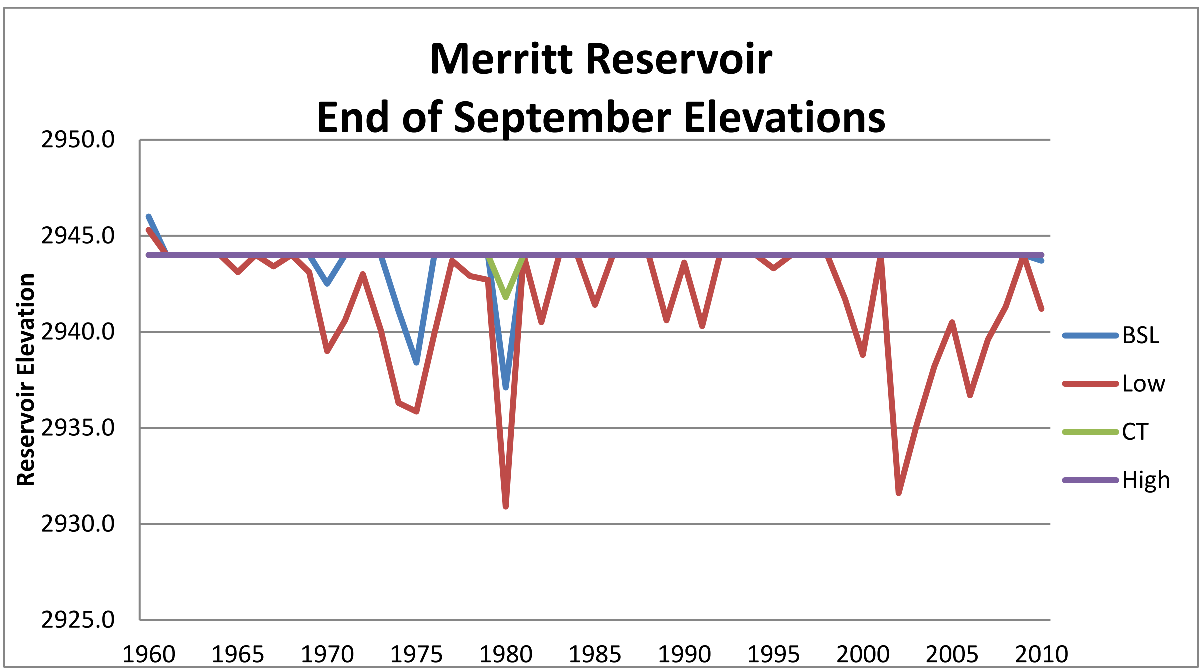

Figure 4. Comparison of the end of September reservoir elevations.

Table 2. Merritt Reservoir Level Elevations (feet)

Scenario	BSL	Low	CT	High
Minimum Reservoir Level	2934.5	2929.1	2937.8	2940.85
Mean End of September Levels	2943.7	2941.7	2944.0	2944.0

4.2 Snake River below Merritt Dam (Near Burge, NE – ID 06459500)

The Snake River gage near Burge is located approximately two miles downstream of Merritt Dam. For the purposes of this model, this gage primarily reflects the releases to the river and seepage flows from Merritt Reservoir. Return flows and natural river gains between the dam and the river gage are minimal. Releases to the river generally peak in May and June. Once the irrigation season begins the majority of the releases from the dam are made directly to the canal. Consistent releases to the river resume once the reservoir level reaches the desired elevation following the irrigation season, which generally occurs in September of each year.

Overall, a comparison of the Baseline No Action scenario to the projected climate scenarios shows the mean annual flows at Burge vary from 54 percent for the Low scenario to 187 percent for the High Scenario. For the Central Tendency scenario, mean annual flows showed an increase of 32 percent. Figure 5 illustrates Baseline No Action and future climate mean annual flows at the Snake River gage near Burge, Nebraska.

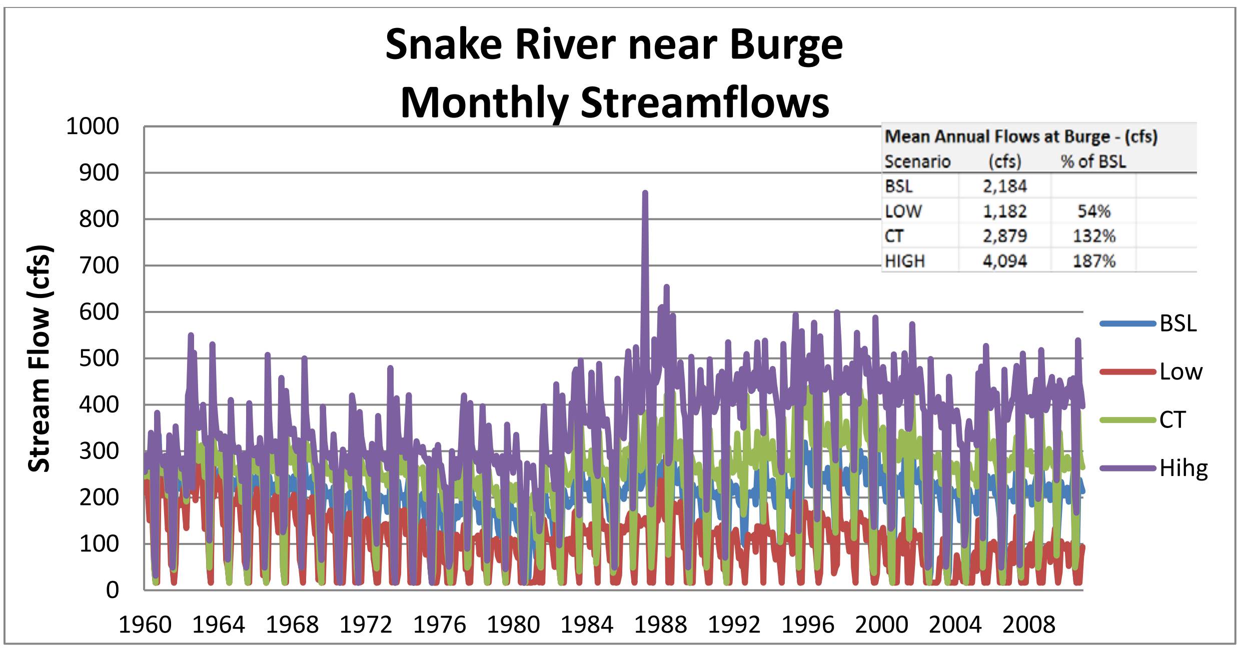

Figure 5. Snake River Flows at Burge Comparison – CENEB Model Scenarios.

4.3 Niobrara River at Sparks, NE (ID 06461500)

The Niobrara River gage near Sparks is located near the upstream edge of the Niobrara National Scenic River area and as a result this site was selected to provide an evaluation of climate change impacts to the river flows in the scenic river area. The Sparks gage also represents the downstream edge of the Zone 2 drainage area. For the purposes of this study, it was assumed that 15 percent of the surface water deliveries in Zone 2 return to the river and are incorporated into the computed river flows at Sparks.

Historical flows in the National Scenic River area typically peak during May and June which correspond closely with seasonal surface runoff patterns related to precipitation in the basin. For the Central Tendency scenario, mean annual flows showed an increase of 11percent, compared to the Baseline No Action scenario. Increases in monthly flows during the wetter years for the Central Tendency, such as the mid-90's or late 2000's, ranged from approximately 10 percent to 30 percent. While increases in monthly flows during the dry periods of the mid-70's or early 90's ranged from zero percent to about 12 percent.

The projected mean annual flows for the Low scenario decreased by an average of 17 percent over the study period. The mean monthly flows also showed corresponding decreases in nearly every month of the year. Projected decreases in mean monthly flows varied from about 10 to 30 percent. Further details of the projected changes in streamflows at the Sparks gage is illustrated in Figure 6. For the High scenario, the mean annual flows increased by an average of 36 percent.

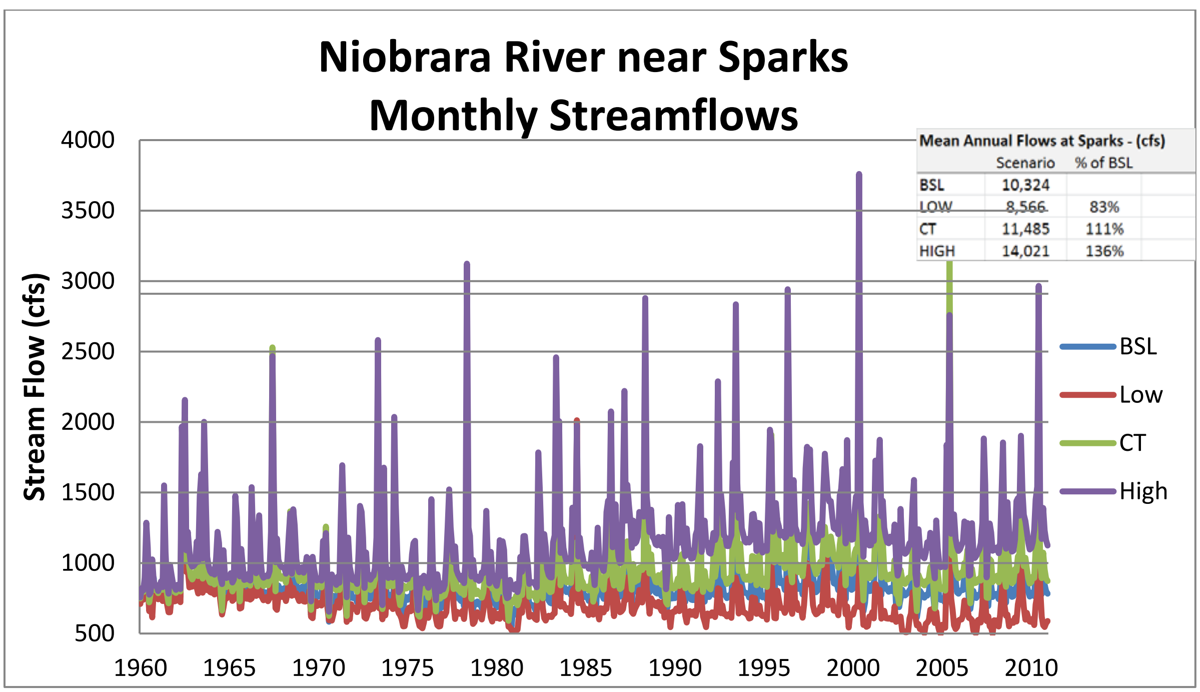

Figure 6. Niobrara River Flows at Sparks Comparison - CENEB Model Scenarios.

4.4 Niobrara River near Spencer, NE (ID 06465000)

The Niobrara River near Spencer gage location serves as the downstream most node of the CENEB model area. The Spencer gage also represents the downstream edge of the Zone 3 drainage area. It was estimated that approximately 65 percent of the surface water deliveries occurring in Zone 3 are deliveries occurring to the Ainsworth Irrigation District. Ainsworth Irrigation District water supply originates from releases from Merritt Reservoir and not from the flows of the Niobrara River within Zone 3. For the purposes of this study, it was assumed that 15 percent of the surface water deliveries in Zone 3 return to the river and are incorporated into the computed river flows at Spencer. The Spencer Hydropower, the single hydropower facility in the basin, is located near the Spencer gage location as well. As a result, the projected flows at Spencer provide a better understanding of the potential effects of future climate impacts on the water supplies available for the hydropower facility.

The mean annual flows for the Central Tendency scenario increased by an average of 15 percent as compared to the Baseline No Action. Increases in mean monthly varied from zero to 70 percent. For the Low scenario, the mean annual flows decreased by an average of 8 percent while the mean annual flows for the High scenario increased by an average of 34 percent. Figure 7 summarizes the streamflow simulations at the river gage near Spencer.

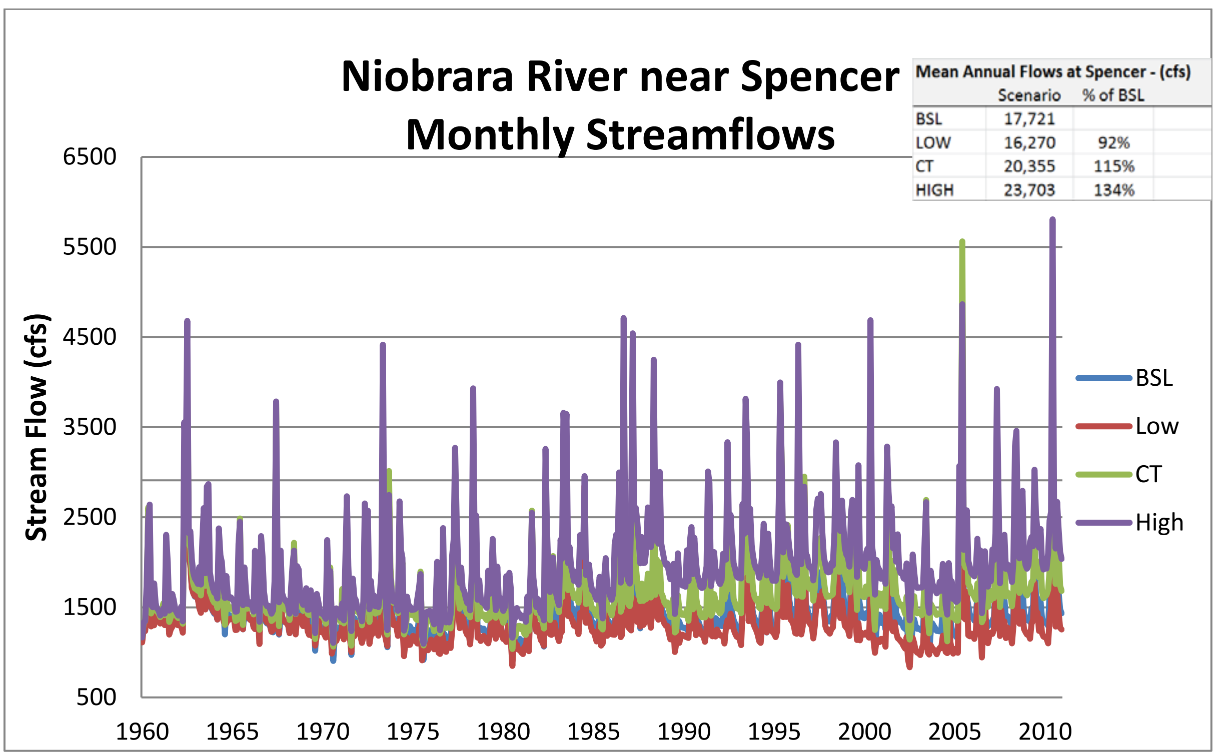

Figure 7. Niobrara River Flows at Spencer – CENEB Model Scenarios.

5 Summary

The modeling results show streamflows at the four model nodes is the lowest under the Low climate scenario and significantly higher under the High climate scenario. Under the Central Tendency scenario, streamflows are projected to increase moderately as compared to the Baseline scenario. The Low scenario represents projected low water availability and generally corresponds with hotter and drier future climate. The Central Tendency scenario represents the normal or average condition water availability. The High scenario represents high projected water availability and generally corresponds with wetter and less warm future climate. Streamflows at each of the four nodes are projected to decrease moderately under the Low scenario and increase under the Central Tendency and High scenarios.

The impacts to the Merritt Reservoir operations, such as end of month reservoir elevations and reservoir outflows, are modest for the Central Tendency and High future scenarios as compared to the Baseline No Acton scenario. Impacts to the reservoir under the Low scenario, corresponding to the hot and dry climate, are slightly greater than the other scenarios analyzed in this report. Under the Low scenario, which represents a hotter and dryer climate, the reservoir levels at the end of the summer months are on average 2 feet lower as compared to the three other modeled scenarios. This is directly related to the increase in irrigation demands and diversions to the Ainsworth Canal.