Nevada Irrigation District

Staff Report

for the Special Meeting of the Board of Directors, November 18, 2020

TO: Board of Directors

FROM: Doug Roderick, P.E., Interim Engineering Manager
Greg Jones, M.B.A., Interim General Manager

DATE: November 10, 2020

SUBJECT: **Water Planning Projections (FATR #1041)**

ENGINEERING

RECOMMENDED ACTION:

Receive a presentation from staff and HDR consultants regarding the Water Planning Projections presented in the supply and demand technical memoranda and file associated TM's.

BACKGROUND:

It is a best practice and good stewardship for NID to plan ahead for future supply and demand conditions. Projecting these conditions is a dynamic process and should be updated on a regular basis to reflect trends, constraints, and needs as it relates to the District's service area, infrastructure, and policies.

NID hired HDR to update a 50-year outlook for hydrology, supply, and demand technical memoranda projections, identified as Water Planning Projections. These Projections are flexible, "what-if" scenarios to be used as reference points in a number of NID planning documents and other management and policy-setting efforts, including the Plan for Water (a.k.a. Raw Water Master Plan), 5-year Capital Improvement Planning, annual capital project planning, annual operational budgets, strategic planning, and the Agriculture and Urban Water Management Planning process. The Projections consist of three studies that analyze the hydrology, water supply, and water demand that help NID anticipate if its water storage and delivery system will provide sufficient water to meet customer demands over time and under variable conditions. The resulting methodology, assumptions, and findings are presented in a suite of technical memorandums prepared by HDR and were released to the public for review and comment on August 27, 2020.

The need to update the Projections is driven by changes in system-wide supply and demand characteristics, including regulatory flow directives, natural system losses, demand growth rates, carryover storage potential, and climate change impacts, to name a few. Changes to supply and demand projections are anticipated to modify over time, and NID will update and revise the Projections as necessary. NID's last update to the Projections were within the 2011 Raw Water Master Plan Update.

It is important to note that alternative management strategies, specific projects, individual policies, and/or other mitigating factors that may derive from the Projections are not a part of the Technical Memoranda. Any and all future mitigating projects and alternatives which may derive from these Projections will be addressed separately through various Board-directed planning and policy actions.

A brief overview of the make-up of the Projections are briefly described below:

Hydrologic Analysis Technical Memorandum

The goal of the Hydrologic Analysis is to understand a range of outcomes based on various greenhouse gas emissions reduction scenarios and to determine the unimpaired flow, the amount of water available in the natural watershed without influence (i.e., regulation of stream flow by man-made structures such as dams or diversions). The State of California anticipates conditions under climate change to include warmer temperatures, declining snowpack, more intense precipitation events, more droughts, and more area burned by wildfire. These factors, among others, will ultimately impact the amount of water available in a watershed in any given year.

The result of this analysis is the unimpaired runoff in NID's watersheds under various climate change scenarios.

Water Supply Analysis Technical Memorandum

The Water Supply Analysis uses the unimpaired runoff results from the Hydrologic Analysis to determine available water supply to NID over time and under certain conditions. NID's four main sources of water are: natural snowmelt and resulting runoff, reservoir storage carryover (unused from prior year), contract water purchases, and recycled water released by treatment plants and later diverted to NID irrigation canals.

The Water Supply Analysis has been updated to consider the impact of drought, climate change, contract purchases, and new FERC license conditions for environmental flows on its water supply system. An additional carryover storage model is also used to determine what NID reservoir storage carryover will be from year to year.

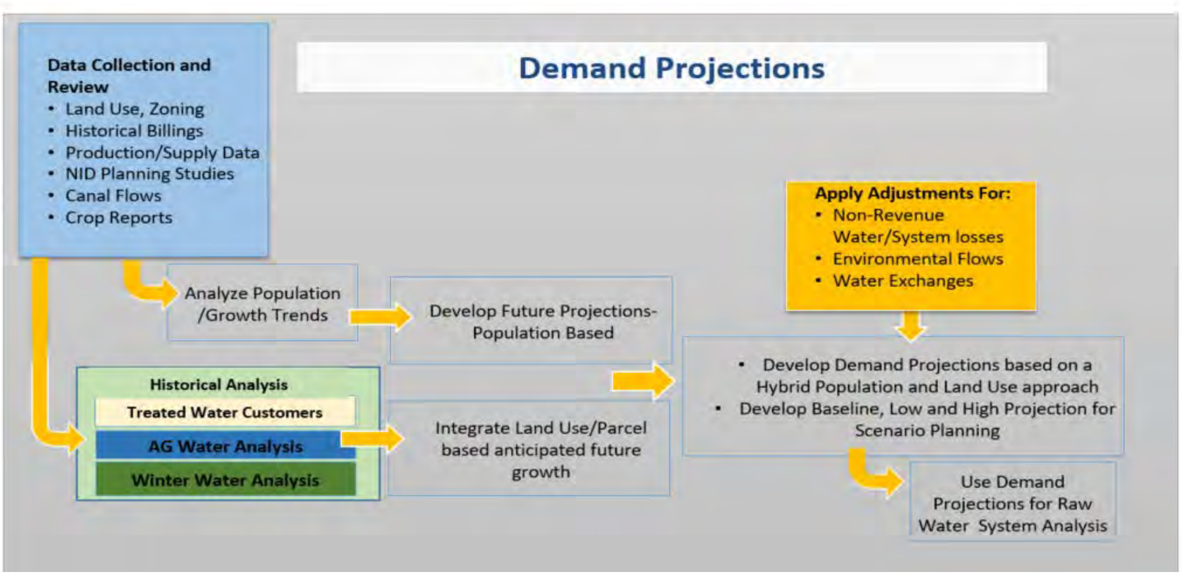
The result of this analysis is the amount of water available to NID during average and wet years, as well as during a 5-year drought scenario. It is the amount available to meet regulatory required environmental flows, customer demand for raw or irrigation water, customer demand for treated or drinking water, municipal purchases, and to cover system losses.

Water Demand Projection Model Update Technical Memorandum

The Water Demand model used in this projection has been used to assess future water demands on NID's water storage and delivery system since the models development in 2005. The assumptions in the model have been updated to reflect current trends, constraints and needs. The five components of total water demand are: the demand for raw or irrigation water, the demand for treated or drinking water, required environmental flows, system losses, and municipal purchases.

Calculating demand in the model is a simple process of multiplying the projected water demand factor by the number of customers or parcel size in order to effectively assume a state of the NID community in 50 years. Assumptions incorporated in the model include demand growth rates, soft service area saturation and system conveyance losses. The model is primarily used as a "what-if" / "point-in-time" assessment and has the ability to be updated as conditions or policy directives change.

The original Demand Model, reviewed and adopted by the NID Board of Directors, was built by Kleinschmidt Associates as part of the Raw Water Master Plan in 2005 and updated in 2011. The revised and updated model is consistent with previous model methodology and approach. This model was chosen to update as it maximizes the previous efforts rather than adopting a new analysis approach.



Timeline for Public Input and Overview

Date	Activity
8/27/2020	Release Technical Memoranda (Hydrology/Supply/Demand)
8/24/2020	Public Technical Clarifications Zoom Conference
10/12/2020	Final Day for Public Comments
10/12 – 11/18/20	Updates to Website FAQ's, Comment Collection
11/18/2020	BOD Presentation

How NID Uses Water Planning Projections

The need to update NIDs Water Planning Projections at this time is driven by upcoming state-required Urban and Raw Water Master Plans, a long-range Plan for Water planning effort, new Yuba-Bear System Federal Energy Regulatory Commission requirements, and climate change impacts. Below is a summary of these required and other planning efforts.

Urban Water Management Plan

The Urban Water Management Plan (UWMP) requires all municipal water providers to project its supplies and demands over the next 20 years, describe its conservation efforts and impacts, consider drought impacts, describe its water shortage contingency plan, consider indoor and outdoor water budgets, as well as other elements to report progress. The plan is due to the state every five years, with the next plan due June 30, 2021.

The plan is functionally a summary of NID's key performance indicators for the next 20 years to support its capabilities to meet its customer's demands. However, in order for there to be common reporting across all water agencies, the plan requirements have been standardized. Its pre-formatted tables and data entry forms do not allow for NID to fully investigate and present its unique situation. Therefore, many agencies conduct their detailed planning efforts in a customized manner that best fits their needs and uses the UWMP as a method to report out findings and status.

Agricultural Water Management Plan

The Agricultural Water Management Plan (AWMP) is similar to the Urban Water Management Plan, as both are state-mandated reports due every five years. The AWMP requires an agricultural water provider to present information about its agricultural water customers, water usage, conservation efforts, and other management elements. However, the AWMP is a backward-looking document, only reporting on past data and results. The report does not have a forward-looking supply and demand projection element. The AWMP is also due to the state every five years, with the next plan due in April 2021.

Raw Water Master Plan

In the past, NID conducted its analyses of supply and demand needs through the Raw Water Master Plan process. However, NID is now facing a much broader scope of issues and impacts that range beyond any previous internal or state-mandated planning efforts. For this reason, NID is creating the Plan for Water to customize the efforts directly to NID's specific needs. The Nevada Irrigation District's Raw Water Master Plan was last updated in 2005 and adopted in 2013. The Plan for Water is scheduled to be updated beginning in 2021.

Plan for Water: A Long-Range Decision Tool to Guide NID's Water Management
This process is an open and comprehensive look by NID and the community at the potential limitations of its available water resources and the impacts of new regulations, changes in land use, climate change, and community vision. Though science will play a part in understanding NID's long-term risks and projected impacts, the Plan for Water will not identify individual programs or projects needed to meet future demand. Rather, it will identify solution-based strategies which are consistent with the values of the community while meeting the needs of the District.

The Plan for Water is born of the FERC relicensing effort, climate change impacts, financial requirements, and new regulatory requirements. The Plan for Water does not re-analyze or revisit any new requirements set by FERC or the State. Instead, it sets these requirements as the new normal and looks ahead 50 years to anticipate potential supply/demand scenarios and identify alternative solutions through public input, community engagement, and Board direction.

NID began the Plan for Water process in 2018. To meet the regulatory requirements to submit the UWMP and AWMP in April of 2021, NID must begin the UWMP and AWMP development process ahead of the Plan for Water process. NID plans to re-engage in the Plan for Water effort in Q3, 2021.

Public Questions, Comments & Requests
Staff has been encouraged by the amount of interest these Projections have garnered from the public. NID has received numerous questions from the public which have since been answered in writing and are currently uploaded for review on the NID website at: https://nidwater.com/2020/08/water-planning-projections/.

In addition to the questions, NID has received a number of comments and requests which require an additional level of review and analysis which have not been budgeted for this process. The additional comments and requests all merit Board input, as much of the answers the public seeks are related to Board policy and direction. As such, staff has compiled all the comments and questions in this packet for public record and review. Staff anticipates these comments and requests will be incorporated into the early stages of the Plan for Water process.

It is not the intent of this presentation today to review all of the questions, nor is it the intent today to evaluate and discuss the additional comments and requests from the public. Although staff is extremely respectful of the degree of interest and public involvement, staff believes that these comments and requests will be better discussed, answered, and addressed during the Plan for Water, and to a limited extent during the development of the AWMP and UWMP.

The Projections are dynamic and are intended to be updated on a regular basis to reflect trends, constraints, and District needs. Long-range planning ultimately involves forecasting & projecting future conditions based on realistic, valid, and supportive assumptions. Regardless of the technology, science, or process used, assumptions still must be made to produce a forecast and can be changed. These assumptions assume what the community will be and look like throughout the planning horizon of 50 years. There is a wide range of assumptions that can be made for any particular data point, all of which may be equally valid. The purpose of the updated Water Planning Projections is to delineate a point-in-time, forward-looking, and possible assumption of NID’s 50-year supply and demand characteristics supported by industry standards and reasonable methodology.

This item supports Goal No. 3 of the District’s Strategic Plan by developing and managing our resources that protects and provides for local control of our community's most valuable assets – a fairly priced and available water supply.

BUDGETARY IMPACT:
None

ATTACHMENTS: (5)
- Hydrology TM
- Demand TM
- Supply TM
- Public Questions & Answers
- Public Input Received

DR

Hydrologic Analysis Technical Memorandum – Final Report

Nevada Irrigation District

November 12, 2020

Megan Lionberger

Date:_11/12/2020_______________________________

Megan Lionberger, P.E.

HDR Engineering, Inc.

Civil Engineer, C74543

Expiration Date: December 31, 2020

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1 Introduction

Nevada Irrigation District (NID) is an independent public agency that is governed by a five-member elected Board of Directors and employs approximately 200 full- and part-time employees. The District supplies water to nearly 25,000 homes, farms, and businesses in portions of Nevada, Placer and Yuba counties in the foothills of Northern California's Sierra Nevada. Water is collected from mountain watersheds and stored in a system of reservoirs. As water flows to its customers in the foothills, it is used to generate clean, hydroelectric energy in excess of 354 gigawatts per year, to maintain environmental flows, and to provide public recreation opportunities. NID supplies both treated drinking water and crop irrigation water. Approximately 90 percent of NID's annual demand is made up of raw water/agricultural demand during the irrigation season.

NID's water supply system is a "store and release" system, in that reservoirs store snow melt and seasonal rains for release during the typically dry irrigation seasons. Based on the timing of seasonal precipitation events, NID's water supply management is dependent on a combination of springtime snowmelt and winter period rains to fill its storage reservoirs. While there is some natural runoff during the summer months, much of this water is required to meet necessary environmental flows in the rivers; therefore, the irrigation season demand is met primarily with withdrawals from storage reservoirs. Careful management and operation of storage reservoirs is essential to capture the maximum amount of runoff, minimize spillage from reservoirs, and ensure there is sufficient volume available in reservoirs to accommodate runoff during the spring snow melt and storm events.

1.1 Raw Water Master Plan Update

A key planning document for NID is its Raw Water Master Plan (RWMP), originally developed in 1985. The primary purpose of the RWMP is to assess the adequacy of the existing water storage and conveyance system to accommodate current and future water demand. Since 1985, the RWMP has been updated in two phases. The phase I update was completed in 2005 (Kleinschmidt et al. 2005), and the phase II update was completed in 2011 (Kleinschmidt Associates 2011). The RWMP provides information to NID's Board of Directors to make decisions about how NID will operate within the RWMP planning horizon.

NID's water supply comes from four main sources: natural runoff (including snowmelt) from the contributing watershed areas, reservoir carryover storage, contract water purchases, and recycled water. Events such as drought and climate change create imminent challenges for NID in maintaining a sustainable water supply system. According to NID's RWMP (Kleinschmidt Associates 2011), the margin between average watershed runoff volume and NID customer demand is diminishing. Increased future demands within NID's service area will result in increased demand on water storage and greater drawdown of NID's reservoirs, especially during summer months when there is little natural runoff.

The 2011 RWMP was based on projected 2032 water management practices. The following updates are needed to reflect current standards and anticipated operations:

- Expand the planning horizon to 50 years, to be consistent with other regional planning studies (Sustainable Groundwater Management Act and the 2018 California Water Plan Update)[1].
- Update customer demand projections to reflect the new planning horizon.
- Consider hydrologic impacts from climate change, which is expected to change the volume and timing of watershed runoff relative to existing conditions.
- Include new Federal Energy Regulatory Commission (FERC) license conditions, which will generally increase flow in rivers downstream of NID reservoirs for environmental benefit, resulting in less available water to meet NID customer demand.
- Include new long-term water purchase agreement with Pacific Gas and Electric (PG&E).
- Expand the extreme drought water supply analysis from 3 years to 5 years, per Executive Order SB-37-16(8).

1.2 Projections of Climate Change Impacts on Watershed Runoff

The State of California recently published its Fourth Climate Change Assessment (Thorne 2018) to proactively address the current and future impacts of climate change and to make California more climate-resilient. California anticipates conditions under climate change to include:

- Warmer temperatures;
- Rising sea levels;
- Declining snowpack;
- More intense precipitation events;
- More droughts; and
- More area burned by wildfire.

In recent years, California has experienced increased temperatures, more frequent heat waves, and highly variable precipitation including a severe drought from 2012 through 2017.

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[1] There is not a strict rule on planning horizons, although Integrated Regional Water Management Plans and Urban Water Management need “at least” 20 years. The Sustainable Groundwater Management Act (SGMA) stipulates that the planning and implementation horizon is a **50-year time period** over which (groundwater sustainability) plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield. Other related plans have followed suit, such as the 2018 California Water Plan Update. The new 2020 guidelines for UWMPs may require a 50-year planning horizon.

Climate in California is exceptionally variable, ranging from extremely wet in some years to extremely dry in others. While total precipitation is not expected to change substantially on average, future climate projections all tend towards more extreme conditions, meaning wetter wet years and drier dry years (Thorne 2018). With a warmer climate, more precipitation will fall as rain rather than snow (Thorne 2018). By 2050, average water supply from snowpack is projected to decline by one-third. If greenhouse gas emissions are not reduced, average water supply from snowpack is projected to decline by two-thirds by 2100 (Thorne 2018).

In the Sierra Nevada, where NID's water supply network is located, air temperatures are projected to increase on average by 6 to 10°F by the year 2100, resulting in an increase in the rain to snow transitional elevation by 1,500 to 3,000 ft during winter snow storms (Dettinger et al 2018). Snowpack is projected to be eliminated below about 6,000 feet, and snowmelt runoff will occur earlier than it has historically (Dettinger et al 2018).

Climate change will impact NID's water supply. NID's Mountain Division storage reservoirs rely heavily on snowmelt runoff capture in the spring for use throughout the summer and fall dry season to meet customer demands and to maintain reservoir carryover storage to protect against future drought. The loss of snowpack in watersheds in the northern Sierra Nevada region of California will result in increased winter runoff, and reductions in spring runoff (Dettinger et al 2018). Changes to timing in watershed runoff to reservoirs north of the American River basin are expected to decrease end-of-year reservoir carryover storage as a result of reservoirs filling earlier (Dettinger et al 2018). A decline in carryover storage will limit the capability of NID to maintain water deliveries in dry years, and particularly during multi-year droughts. Severe droughts are projected to increase under climate change (Thorne 2018).

1.3 Study Goals and Objectives

The goal of this study is to assemble hydrologic data sets representative of historic and projected climate change conditions for the year 2070 to support the RWMP update. These data sets will cover a range of projected likely outcomes based on various scenarios of greenhouse gas emissions reductions. Hydrologic data sets will be used to develop a supply analysis to quantify how much of the projected runoff is available for water supply. Projected demands in 2070 are currently under development and will be presented in a separate technical memorandum. NID will use information from the water supply analysis and demand analysis technical memorandums to determine if projected supply will be able to meet projected demands in support of its RWMP update.

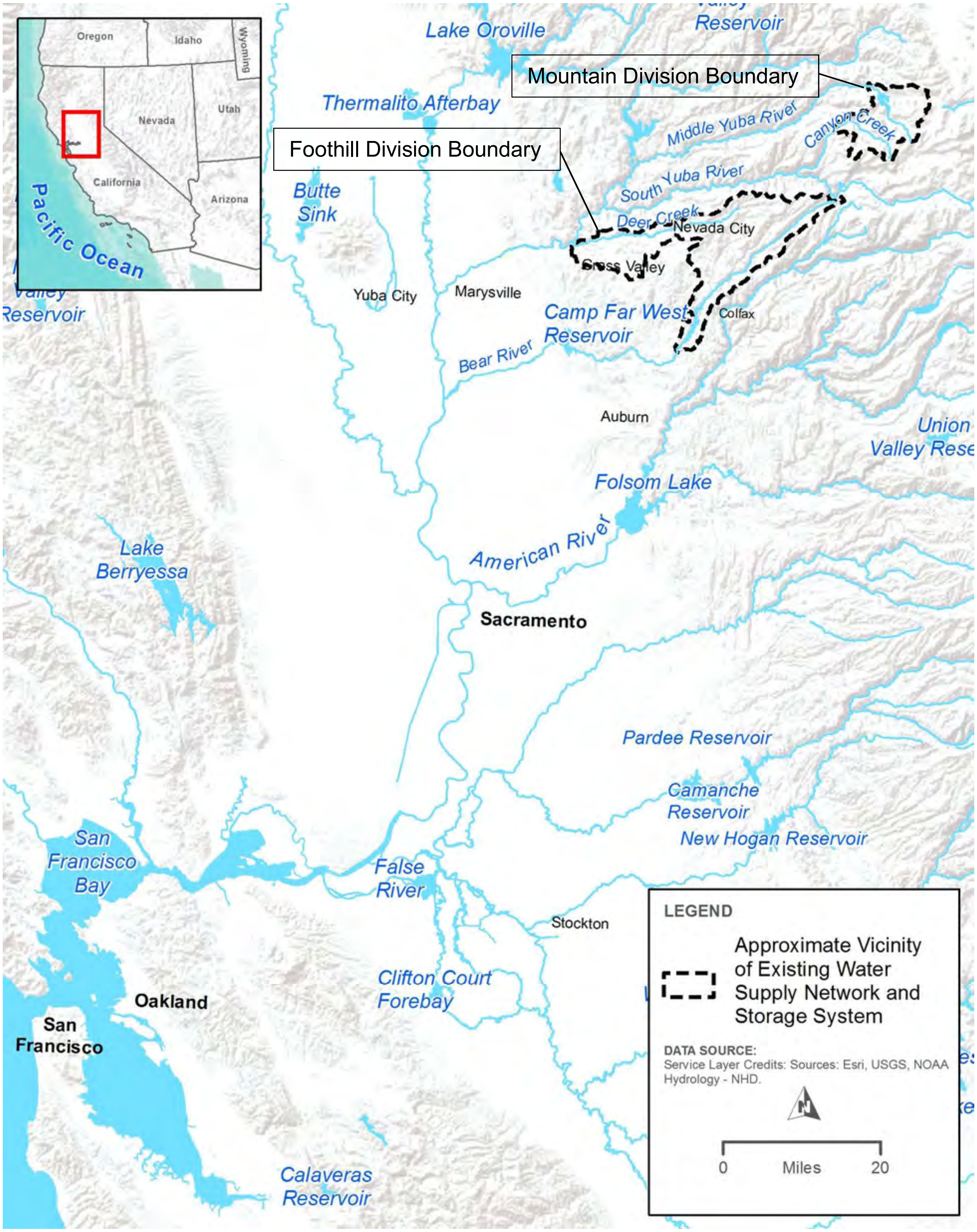
If projected water supply is not able to meet projected demand, it is necessary to analyze various reasonable, practical, and feasible demand-side and supply-side alternatives to bridge the gap between supply and demand. A system operations model approach will be used to evaluate potential alternatives to assess the relative benefit of each to create a resilient and sustainable water system for NID and its customers. An existing reservoir operations model has been expanded to include additional raw water delivery points within NID's service area. Unimpaired hydrology, fundamental input to the reservoir operations model, will utilize the projected 2070 unimpaired hydrology data sets described in this report.

This study builds upon existing unimpaired hydrology data and modeling tools developed for the joint FERC relicensing of NID’s Yuba-Bear Hydroelectric Project (FERC Project Number 2266) and PG&E’s Drum-Spaulding Hydroelectric Project (FERC Project Number 2310). These data and tools were accepted by FERC and other state and federal agencies to adequately represent conditions within the two hydroelectric project areas and were used to evaluate impacts to water resources as a result of potential operations and facilities modifications during the relicensing process.

2 NID’s Water Supply Network

NID currently has a water supply network and storage facilities located in four major watersheds: 1) the Middle Yuba River; 2) tributaries of the South Yuba River; 3) Deer Creek; and 4) the Bear River. All four of these watersheds ultimately flow into the Feather River, and are part of the Sacramento River basin, which drains into the Sacramento-San Joaquin Delta, and then into San Francisco Bay. Figure 2-1 illustrates the general regional location of NID’s existing water supply network and storage system.

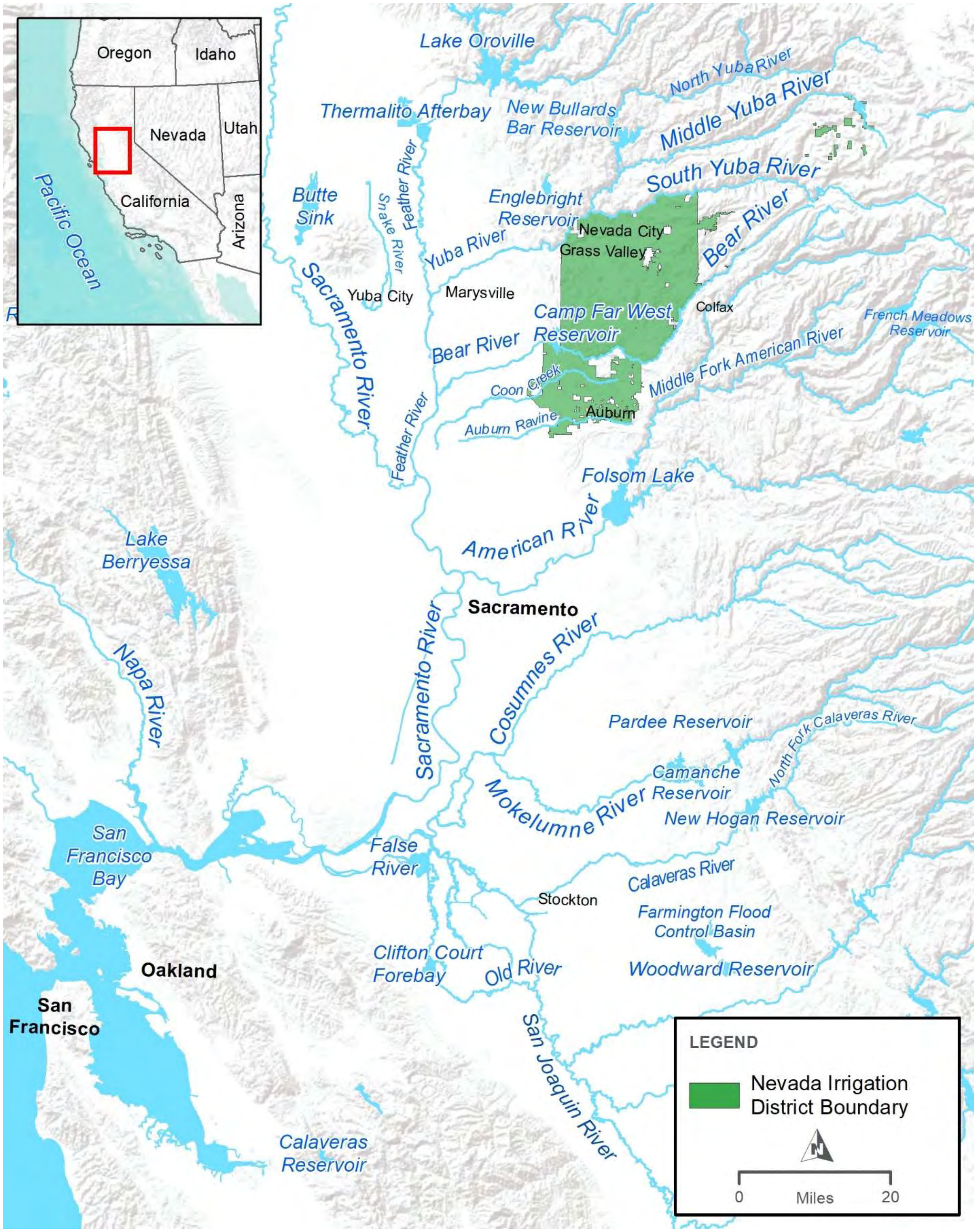
Figure 2-1. Area of NID's existing water supply network and storage system in relation to San Francisco Bay, California, and tributary watersheds.



DATA SOURCE:
Service Layer Credits: Sources: Esri, USGS, NOAA Hydrology - NHD.

Facilities located in the Middle Yuba and South Yuba river watersheds belong to NID's Mountain Division. These facilities include Jackson Meadows Reservoir, Bowman Lake, French Lake, Faucherie Lake, Sawmill Lake, Jackson Lake, and Milton Diversion Impoundment. Facilities located in the Deer Creek and Bear River watersheds belong to NID's Foothill Division. These facilities include Rollins Reservoir, Scotts Flat Reservoir, and Lake Combie. Watershed runoff is collected in Mountain Division reservoirs and then is diverted through the Bowman-Spaulding Canal to PG&E's Lake Spaulding. From Lake Spaulding, water is routed to the Foothills Division down either the South Yuba Canal to the Deer Creek watershed, where water is then supplied to NID customers in the Nevada City-Grass Valley area, or down the Drum Canal along the Bear River, where the water is used to generate power before supplying NID customers in southern Nevada County and Placer County. NID's service area is shown in Figure 2-2. Mountain Division and Foothill Division facilities are described in more detail in Appendix A.

Figure 2-2. Map of NID's service area.



3 Unimpaired Hydrology Data Sets

Unimpaired flow is defined as the hydrologic response of watershed basins with no influence (i.e., regulation) of stream flow by man-made structures such as dams or diversions. Quantification of unimpaired flow is important because it is used to estimate watershed runoff. Watershed runoff is the largest contributor to NID's water supply (Kleinschmidt Associates 2011). Climate change is projected to change the quantity and timing of runoff in mountain division watersheds that contribute to NID's water supply. Comparisons between historical and 2070 projections of unimpaired hydrology developed for this study will help quantify how climate change is going to impact NID's watershed runoff and reservoir carryover storage within the planning horizon of the RWMP. Unimpaired hydrology will be used in the RWMP:

1. To quantify the volume of runoff available to NID, relative to historical conditions, based on water rights;
2. To assess NID's ability to meet projected customer demand (separate technical memorandum; and
3. As input to an operations model (described in Section 4) to quantify the cumulative effects of projected changes in the watershed (e.g., hydrologic changes, increased demand, increased environmental flow requirements).

Watersheds that contribute runoff to NID's water supply are either ungaged (flow is not measured by a stream gage) or highly regulated, or both. Because it is not possible to directly measure runoff in these watersheds it is necessary to synthesize unimpaired hydrology to quantify how much water is available to NID, both historically and under projected climate change conditions. Unimpaired hydrology data sets were developed for Water Years[2] 1976 through 2011. The lower bound of 1976 was chosen based on availability of stream gage data. The upper bound of 2011 is based on the available period of record of projected hydrologic data provided by the California Water Commission (CWC 2016) for climate change assessments.

This section of the report describes the existing unimpaired hydrology data set developed in 2008 during FERC relicensing, updates that have been made to this data set post-FERC relicensing, and the methodology used to transform the historical unimpaired hydrology data set to represent projected conditions in 50 years (2070) as a result of three climate change scenarios.

3.1 Historical Unimpaired Hydrology

Historical unimpaired hydrology data sets were developed for Water Years 1976 through 2008 for a total of 59 sub-basins in portions of the Middle Yuba, South Yuba, and Bear rivers (NID 2012) as part of joint FERC relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project. Appendix B details the gage-proration methodology used to develop these data. Unimpaired hydrology data were used as the basis of numerous environmental assessment studies and as input to a reservoir

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[2] Water years are defined as October 1 of the previous year through September 30 of the year documented.

operations model (described in Section 4) to simulate joint operating conditions of the two hydroelectric projects. The reservoir operations model was validated using the unimpaired hydrology for three different hydrologic years, wet, normal and dry, and a continuous period of ten Water Years representative of recent historical operations. Validation results showed very good correlation of modeled versus historic regulated hydrology with respect to the timing, magnitude and duration of flows, demonstrating that the unimpaired hydrology closely simulates actual historic discharge volumes (Devine Tarbell & Associates 2008).

Historical synthetic unimpaired hydrology data were developed using a gage proration method (Mann et al 2004) to estimate flows for each sub-basin. Gage proration assumes that runoff is proportional to the drainage area and average annual precipitation depth. Flows were calculated for the sub-basin of interest by scaling the hydrograph of a nearby gaged, unimpaired reference basin with similar elevation and physiography using the following equation:

$$Q_{target} = \left(\frac{A_{target}}{A_{reference}}\right)\left(\frac{P_{target}}{P_{reference}}\right)Q_{reference}$$

Where: Q_{target} is the flow (cubic feet per second) for the sub-basin of interest
$Q_{reference}$ is the flow (cubic feet per second) for the reference basin
A_{target} is the drainage area (square miles) for the sub-basin of interest
$A_{reference}$ is the drainage area (square miles) for the reference basin
P_{target} is the mean annual precipitation (inches) for the sub-basin of interest
$P_{reference}$ is the mean annual precipitation (inches) for the reference basin

USGS Gage South Yuba River at Cisco (USGS 11421000) was used as the reference gage for sub-basins above 5,000 feet in elevation and Pilot Creek above Stumpy Meadows Reservoir (USGS 11431800) was used for lower elevation sub-basins.

The original FERC unimpaired hydrology data set ended in Water Year 2008 and did not cover all areas of the watershed where NID stores water, diverts water, or has water rights, as it only addressed sub-basins within the FERC project boundary. As part of this study, daily average unimpaired hydrology data have been redeveloped for the Bear River lower basin and sub-basins were added for Deer Creek, Coon Creek, and Auburn Ravine. As a result, the total number of sub-basins included in the historical unimpaired hydrology dataset has increased from 59 to 68. The period of record has also been extended to include Water Years 2009 through 2011.

The additional watersheds include areas that are lower in elevation than sub-basins in the existing FERC unimpaired hydrology data set. For example, sub-basins in Auburn Ravine range in elevation from approximately 200 ft to 1,700 ft. Pilot Creek, the original reference gage for low-elevation sub-basins, is representative of mid-elevation watersheds (4,250 feet to 6,250 feet), but is not applicable to lower elevation watersheds because of differences in quantity and timing of snowmelt runoff contributions. Therefore, four additional reference gages were compiled to better represent the extended elevation ranges. A combined gage proration technique was used to incorporate available data for Water Years 1976 through 2011. The method subdivided sub-basin areas into elevation bands and prorated area-weighted gage data associated with each elevation range. For consistency, unimpaired hydrology was redeveloped for all Bear River sub-basins in the FERC relicensing dataset using the updated methodology. Unimpaired hydrology for all other sub-basins from the original FERC relicensing dataset were extended to 2011 using the same methodology as used for the FERC relicensing, as described in Appendix B. Historical unimpaired hydrology for all 68 sub-basins is provided in Appendix E.

3.2 Projected 2070 Unimpaired Hydrology

Hydrologic projections for future conditions representative of year 2070 were developed using simulated historical and projected runoff from the Variable Infiltration Capacity (VIC) model (Liang et al. 1994) to translate gage-proration historical unimpaired hydrology (described in Section 3.1) into projected unimpaired hydrology. The analysis employed daily historical and 2070 future conditions VIC model runoff predictions for water years 1976 through 2011 provided by the California Water Commission (CWC 2016).

The VIC model is a gridded hydrologic model that simulates land-surface-atmosphere exchanges of moisture and energy at each model grid cell. The CWC provided VIC model data for the state of California on a grid spatial resolution of approximately 14 square miles. Recommendations and guidance for using the climatological input and model results were provided for Water Storage Investment Program (WISP) grant applicants (CWC 2016) and for other water supply climate studies, such as the Sustainable Groundwater Management Program overseen by the California Department of Water Resources (DWR 2018). Data are provided for three climate change scenarios:

- Median climate change conditions, based on 20 global climate models (GCMs) and representative concentration pathway (RCP) combinations[3];
- Drier/extreme-warming (DEW) conditions, representing a pessimistic trajectory of greenhouse gas emissions throughout this century[4]; and
- Wetter/moderate-warming (WMW) conditions, representing an optimistic trajectory of greenhouse gas emissions throughout this century[5].

CWC developed meteorology for the three climate projections by applying perturbations to the historical precipitation and temperature time series, a method known as “climate period analysis” (CWC 2016, DWR 2018). The modeled future inter-annual variability is based on the reference period from which change is being measured, so all differences between the future and historical simulations are a result of the climate change signal alone (DWR 2018). Therefore, each future scenario exhibits a similar temporal pattern and the relative distribution of water year types remains the same as the historical record. This methodology does not account for potential changes in inter-annual variability, such as prolonged drought sequences, although the frequency of dry years is expected to increase along with an overall increase in year-to-year variability (Pierce 2018).

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[3] The 20 climate model and RCP combinations were composed of 10 general circulation models, each run with two RCPs: one optimistic (RCP 4.5) and one pessimistic (RCP 8.5).

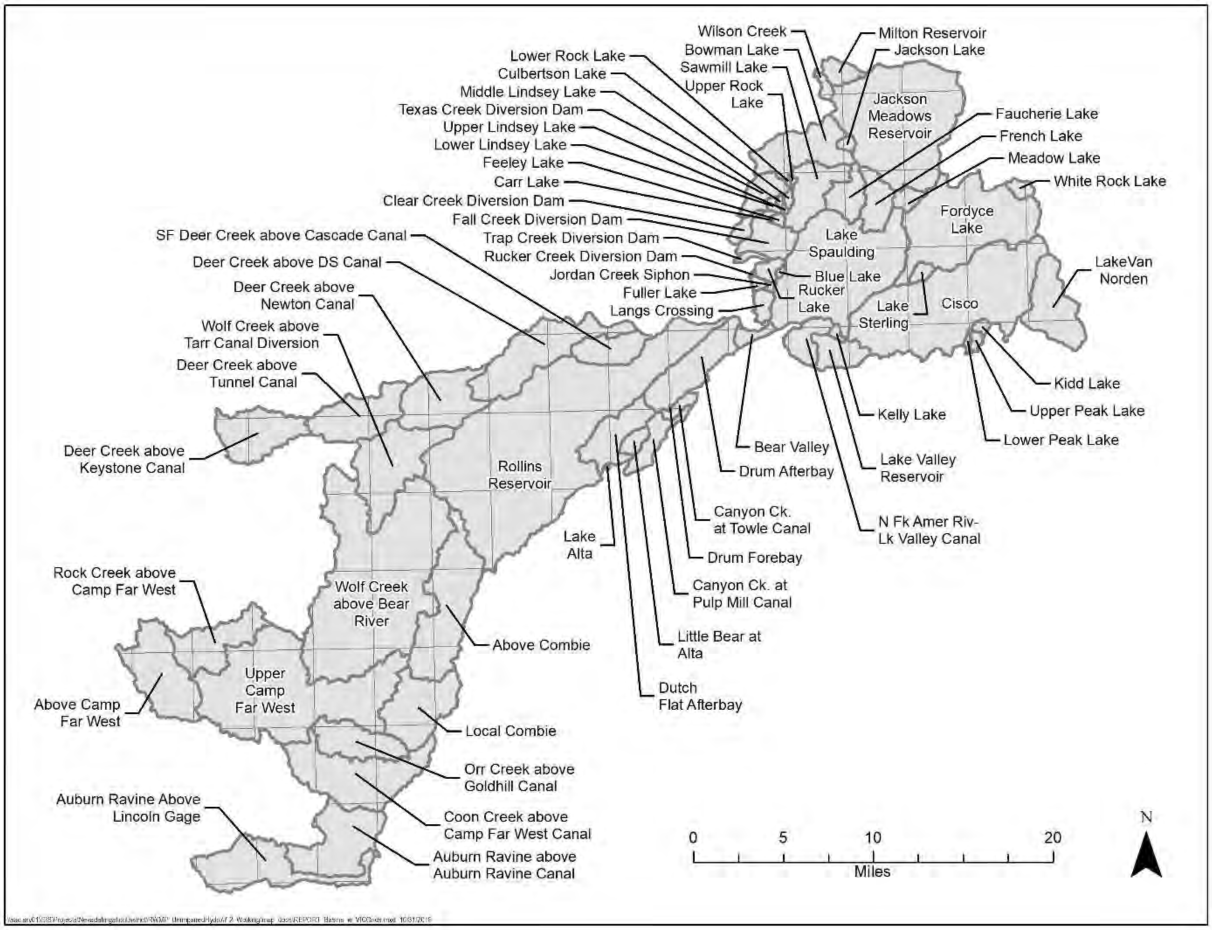
[4] Based on GCM HadGEM2-ES and emission scenario RCP 8.5.

[5] Based on GCM CNRM-CM5 and emission scenario RCP 4.5.

3.2.1 Methods

A geographic information system (GIS) was used to overlay the unimpaired hydrology sub-basin boundaries on the VIC model grid (Figure 3-1). Total VIC model daily runoff (in millimeters) was calculated for each basin as the sum of surface runoff and baseflow from grid cells completely contained within the basin and the values from grid cells weighted by the fractional area intersected by the basin boundary. Daily basin-averaged VIC results were generated for each unimpaired hydrology basin for all three 2070 climate projection scenarios and the historical scenario provided by the CWC.

Figure 3-1. Unimpaired hydrology sub-basins divided by VIC model grid cells.



A comparison of gage-proration historical hydrology to VIC model runoff for water years 1976 to 2011 indicates significant differences in timing and magnitude of flow. Figure 3-2 demonstrates the scattered correlation between VIC model and gage-proration daily runoff in the 41.3 square mile Cisco basin. VIC model flows were calculated by multiplying runoff depth by basin area and converting to cubic feet per second (cfs). Figure 3-3 demonstrates a much tighter correlation on an annual time scale, although VIC model volumes are approximately 28 percent greater. The exceedance diagram in Figure 3-4 further illustrates the significant differences in annual volume. The monthly temporal distribution of flows is shown in Figure 3-5. Both gage-proration flows and VIC model flows peak in May as a result of snowmelt in the higher elevation basin. VIC model flows are slightly higher than gage-proration flows from January through March and slightly lower from April through December.

Figure 3-2. Comparison of gage-proration and VIC model historical mean-daily runoff at Cisco Basin.

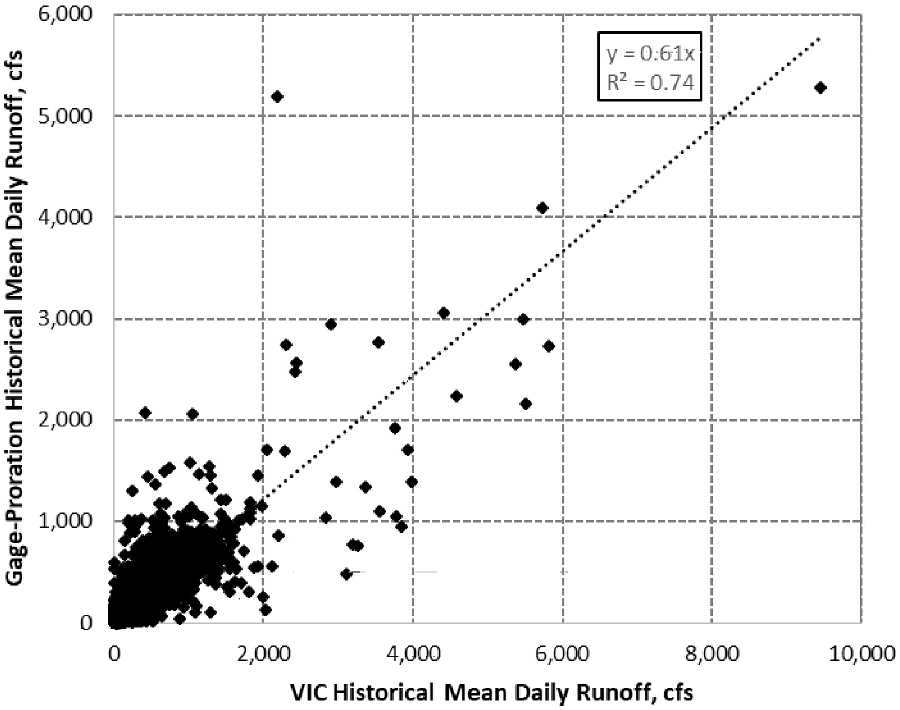


Figure 3-3. Comparison of gage-proration and VIC model historical mean-annual runoff at Cisco Basin.

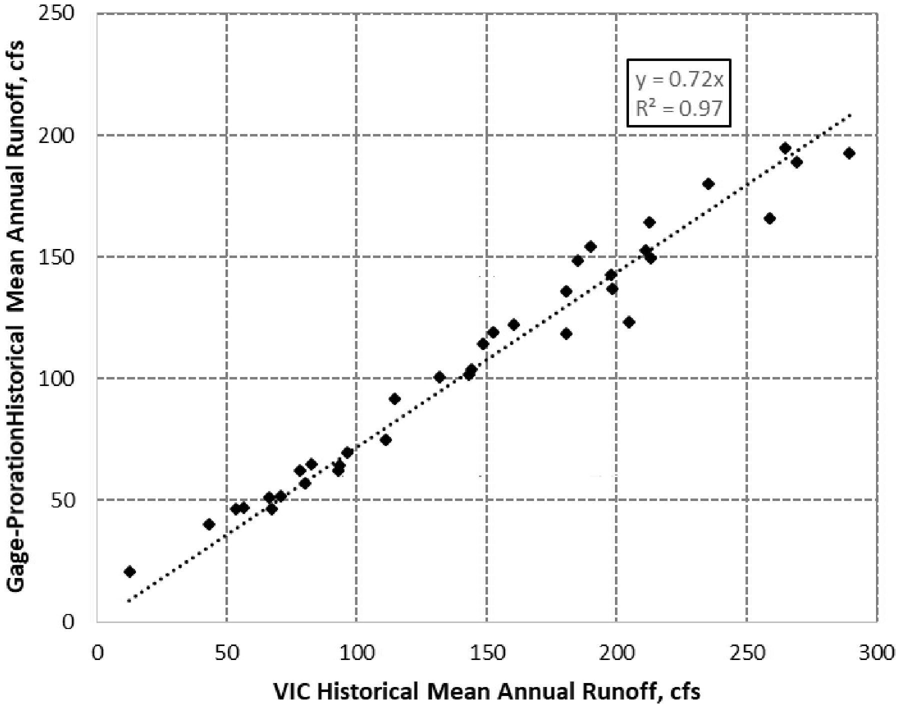


Figure 3-4. Comparison of gage-proration and VIC model historical mean-annual runoff probability of exceedance at Cisco Basin.

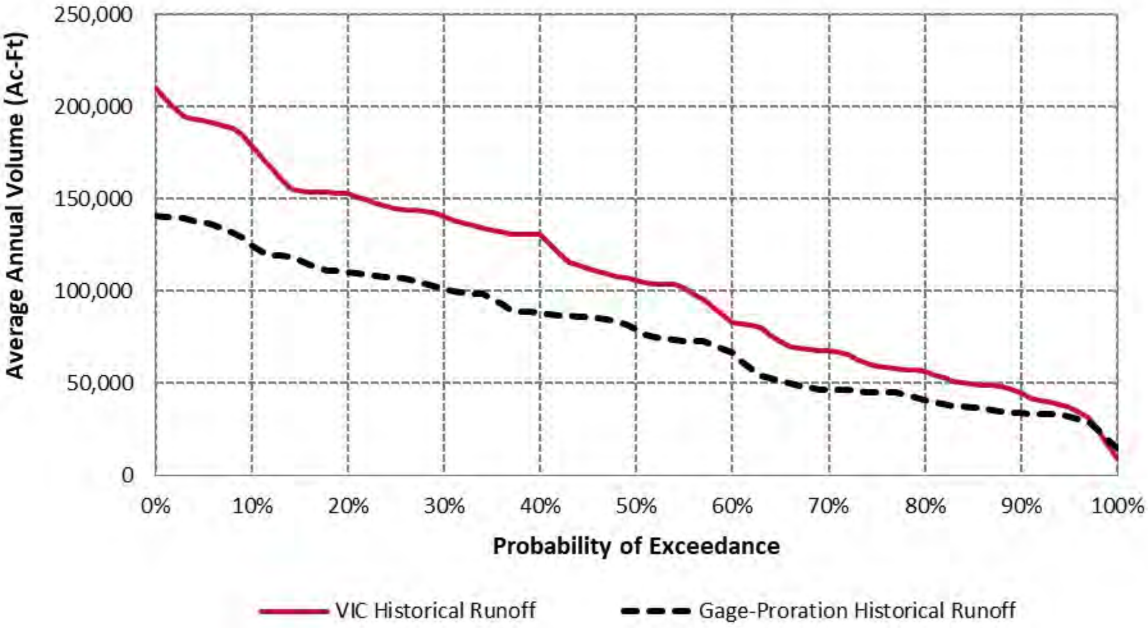
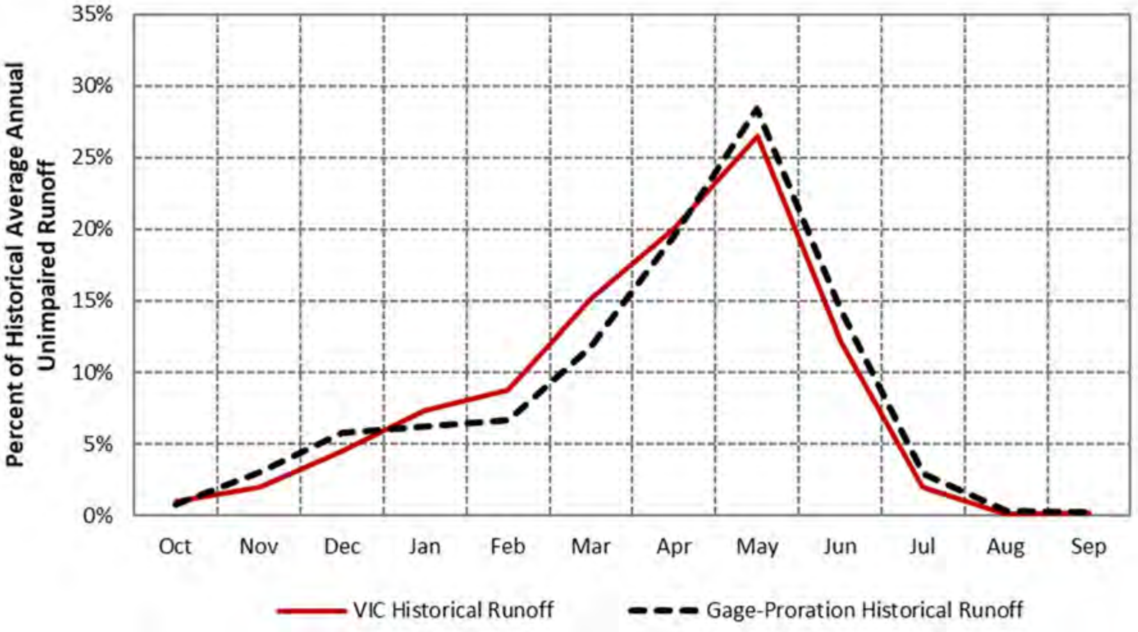


Figure 3-5. Comparison of gage-proration and VIC model historical monthly runoff at Cisco Basin.



Although the VIC Model was recalibrated for 12 large upper watersheds in the Sacramento and San Joaquin River Basins for water years 1970 through 2003 (CWC 2016), model bias can impact results at the smaller scale of the unimpaired hydrology sub-basins. The study sub-basins range in size from less than a square mile to 82 square miles, with an average size of less than 10 square miles. VIC model bias results from multiple factors, including the coarse spatial model resolution, spatial and temporal errors in gridded climate input, complexities of snowmelt simulation, base flow and groundwater interactions, and other model uncertainties. The gage-proration historical hydrology can also be considered a model with its own inherent uncertainties; however, for the purposes of this study it is considered to be the more accurate data set based on successful verification using the FERC relicensing operations model (Devine Tarbell & Associates 2008) and gage–summation (Appendix B). The existing gage-proration hydrology has been used extensively for FERC relicensing and other NID operations studies and is considered to be the historical unimpaired baseline hydrology for this study.

The differences in timing and volume between VIC model historical and future flows are used to develop a transformation of the gage-proration historical hydrology to represent potential future flows. Therefore, a bias correction approach is needed to address the model differences in volume and timing of historical gage-proration and VIC model flows to effectively use the VIC model results for prediction of future flow conditions.

There is no standardized method for bias correction and different approaches can yield significantly different results (Pierce et al. 2015). We chose an approach based on the variable perturbation method used in California's fourth climate change assessment to estimate impacts on the State Water Project (Wang et al. 2018). The method was developed for monthly flows, so required some modification to be applied to daily flows, as described in the following paragraphs.

The variable perturbation method applied by Wang (2018) is similar to the cumulative distribution function transform (CDF-t) bias correction described by Pierce (2015). The VIC model projected results were bias-corrected using CDF-t applied first to daily flows using a month-long time window, and subsequently to annual flows. The CDF-t method assumes that the historical mapping between the model and observed cumulative distribution functions applies to the future period (Pierce et al. 2015). The methodology used to develop future hydrology is described in detail in Appendix C and a summary of the steps is provided below:

1. Evaluate the correlation between daily gage-proration hydrology and VIC model historical runoff depths across all basins. In general the best correlation did not occur between the exact geographically corresponding basins due to various bias errors as described above, with the large VIC model grid scale relative to basin size and lack of calibration at the basin scale likely being significant factors. In addition, the gage-proration method is a function of a small number of reference basins which results in some self-similarity of constructed flows in different basins. The best correlated VIC model results were chosen to be used as the reference hydrology for each basin.
2. Develop linear regressions between each best correlated basin pair and apply to the VIC model historical and projected runoff depths to create the baseline VIC model flows for each unimpaired hydrology sub-basin and each emissions scenario. Because flow volumes differ so significantly between gage-proration flows and VIC model flows when using basin area proration to transform VIC model depths to flows, as shown in Figure 3-2, linear regression was chosen as a reasonable alternative method.
3. Calculate cumulative distribution functions (CDF) of the VIC model historical flows and the VIC model projected flows for each calendar month. Determine the ratio of projected to historical flows for each quantile.
4. Map each gage-proration historical daily flow to the corresponding VIC model historical quantile associated with that flow in the corresponding month. The ratio of VIC model projected flow to VIC model historical flow for that CDF quantile is used as the perturbation ratio for that daily historical flow. A perturbation ratio was determined and applied to each day in the historical record.
5. Calculate CDFs of VIC model historical and projected annual volumes to determine perturbation ratios using the same method as for monthly flows described in Step 3.
6. Map each gage-proration historical annual flow to the corresponding VIC model historical quantile associated with that annual flow to determine the annual perturbation ratios. Apply the annual perturbation ratios to the daily flows calculated in Step 4 for each year in the historical record.
7. Multiply the results of Step 6 by the ratio of the annual volume of gage-proration historical flows to the annual volume of perturbed flows from Step 4 so that the

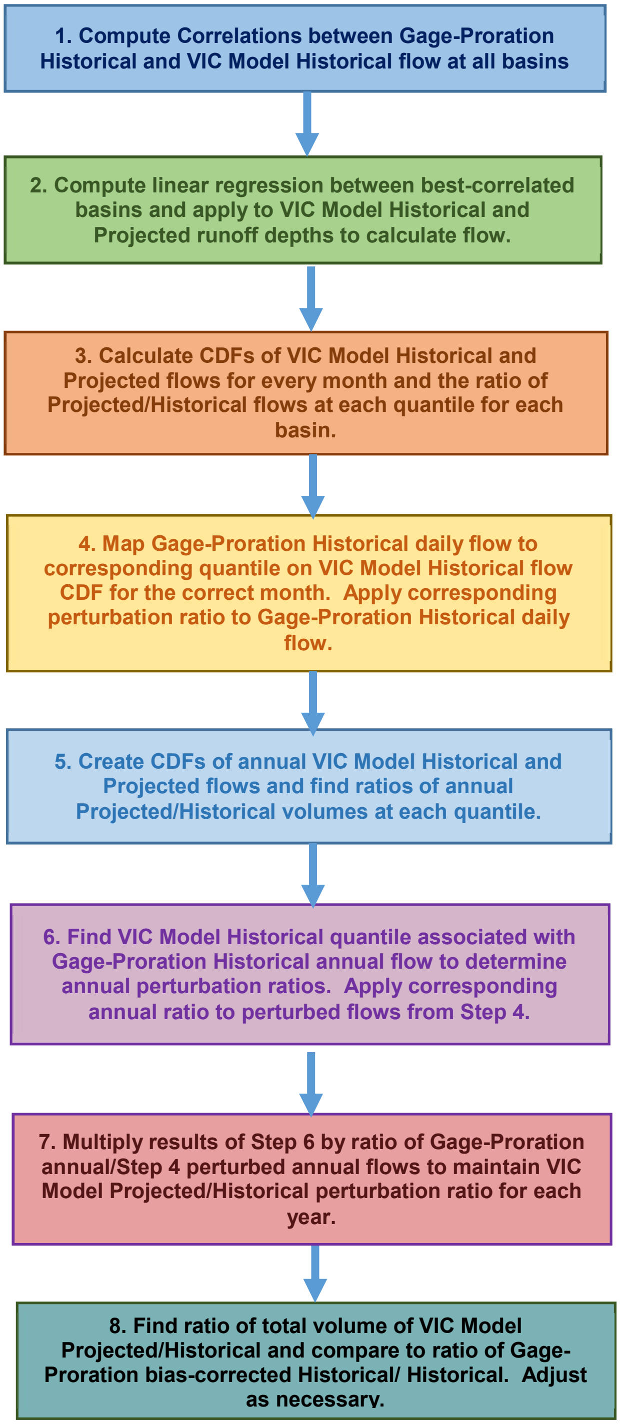
final volume ratio of projected to historical annual flows is equivalent to the VIC model annual ratio at that quantile.

8. A final adjustment was made if needed to correct discrepancies from the total period of record volume ratio of VIC model projected to VIC model historical flows.

A schematic of the transformation steps is given in Figure 3-6.

The transformed gage-proration historical flows are intended to represent potential future hydrology for each emissions scenario. Different methods of developing future flows may result in differences in temporal distributions and magnitudes of individual peak flows on a daily basis. However, general trends demonstrating changes in annual distributions are expected to be similar between methods.

Figure 3-6. Schematic of methodology used to develop projected flows.



3.2.2 Results

Projected unimpaired hydrology data were developed for all three 2070 climate change scenarios for the 68 unimpaired hydrology sub-basins by applying the methodologies described in Section 3.2.1 and is provided in Appendix E. Hydrologic basins were aggregated into four larger basins to compare projected hydrology to historical gage-proration hydrology. The four locations, Middle Yuba at Milton Diversion Dam, Canyon

Creek at Bowman Dam, Bear River at Rollins Dam, and Deer Creek at Scotts Flat Dam, represent approximately 32 percent of the total area covered by the 68 basins. They were selected as example locations because of their significance within NID’s overall water supply network and because they represent a mix of watersheds from the Mountain Division and Foothills Division, demonstrating the variations in climate change impacts from higher- to lower-elevation watersheds.

Middle Yuba at Milton Diversion Dam and Canyon Creek at Bowman Dam represent two higher-elevation watersheds, located in the Middle and South Yuba watersheds, respectively. Middle Yuba at Milton Diversion Dam comprises two sub-basins (Jackson Meadows Reservoir and Milton Reservoir) with a total watershed area of 39.7 square miles. The watershed ranges in elevation from approximately 5,690 feet to over 8,000 feet. Canyon Creek at Bowman Dam comprises five sub-basins (French Lake, Faucherie Lake, Sawmill Lake, Jackson Lake and Bowman Lake) with a total watershed area of 23.7 square miles and an elevation range from 5,390 feet to over 8,000 feet.

Bear River at Rollins Dam, and Deer Creek at Scotts Flat Dam represent two lower-elevation watersheds. Bear River at Rollins Dam comprises five sub-basins (Bear Valley, Drum Afterbay, Dutch Flat Afterbay, Little Bear at Alta, and Rollins Reservoir) with a total watershed area of 103.5 square miles and an elevation range from 1,927 feet to approximately 5,750 feet. Deer Creek at Scotts Flat Dam comprises two sub-basins (SF Deer Creek above Cascade and Deer Creek above DS Canal) with a total area of 22.0 square miles and ranging in elevation from 2,940 feet to approximately 5,000 feet.

Figures 3-7 through 3-10 show monthly percent of historical annual average unimpaired runoff for all three 2070 climate change scenarios along with historical unimpaired flow at these four locations. Monthly comparisons for the full period of record are included in Appendix D.

Figure 3-7. Monthly percent of historical annual average unimpaired runoff (Water Years 1976 through 2011) at Milton Diversion Dam on the Middle Yuba River under historical conditions and under projected 2070 climate change conditions.

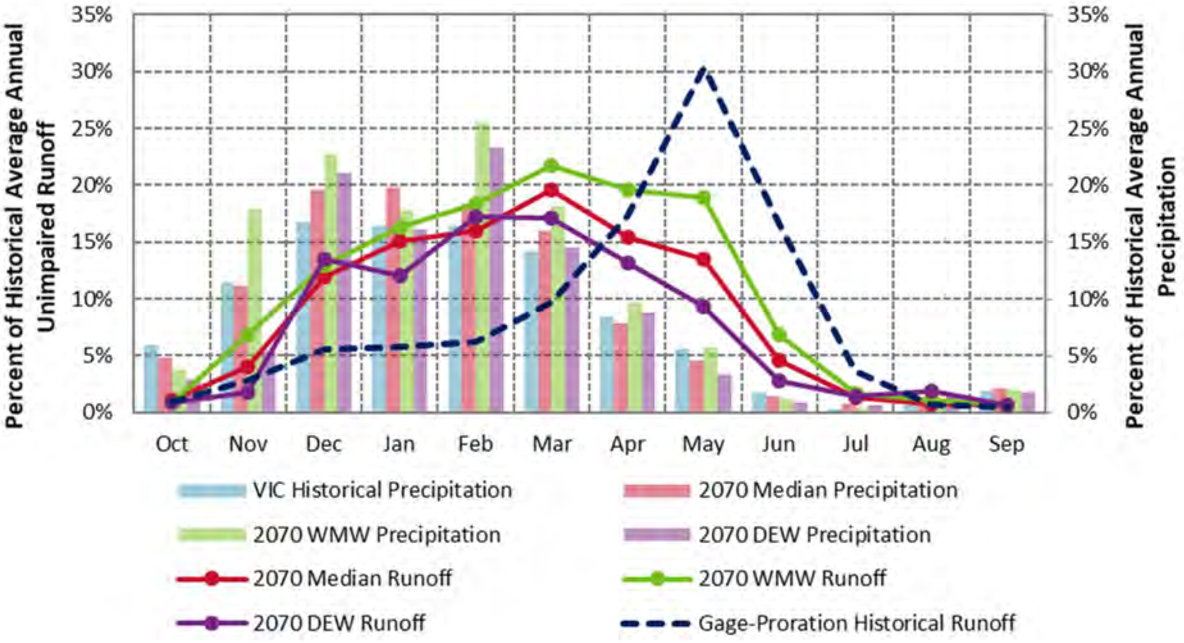


Figure 3-8. Monthly percent of historical annual average unimpaired runoff (Water Years 1976 through 2011) at Bowman Dam on Canyon Creek under historical conditions and under projected 2070 climate change conditions.

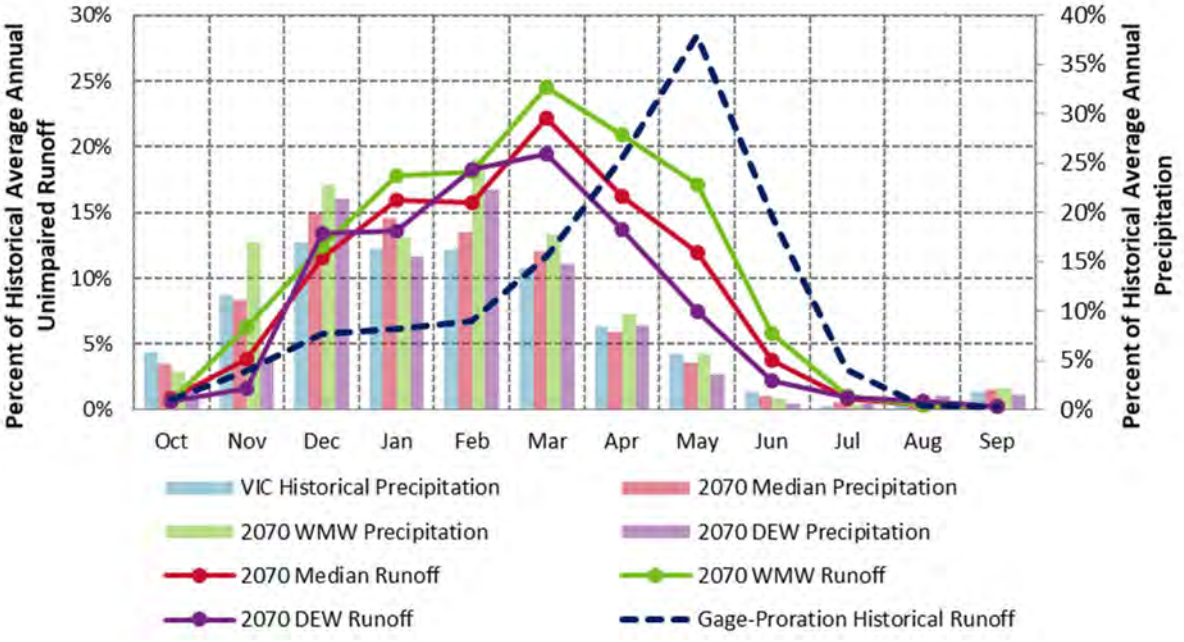


Figure 3-9. Monthly percent of historical annual average unimpaired runoff (Water Years 1976 through 2011) at Rollins Dam on the Bear River under historical conditions and under projected 2070 climate change conditions.

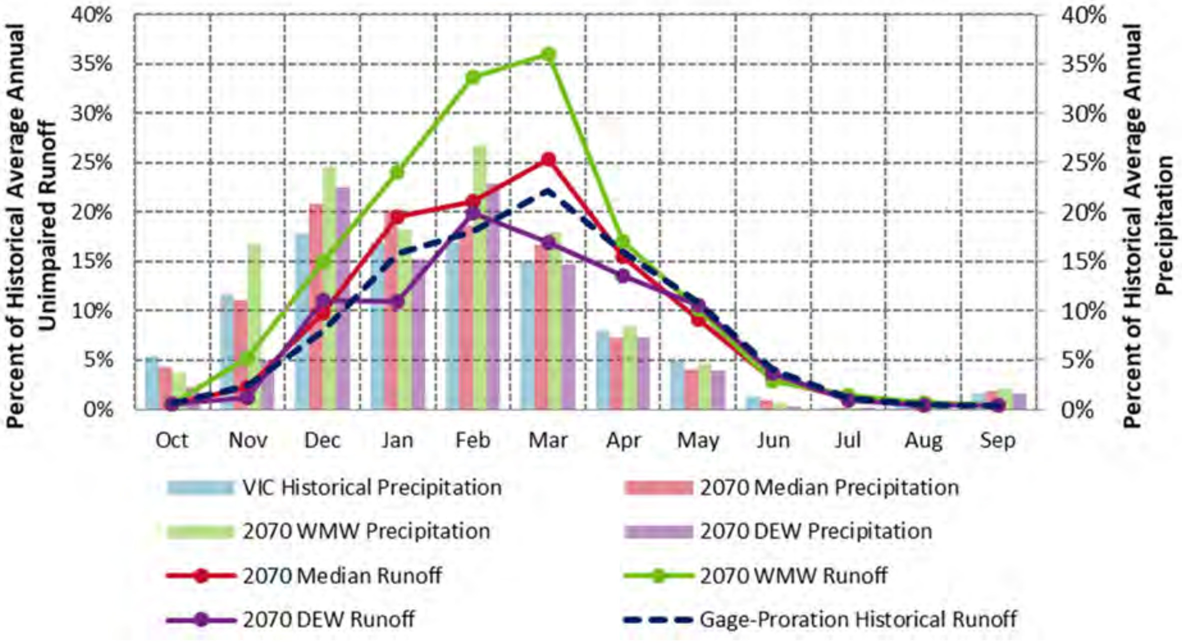
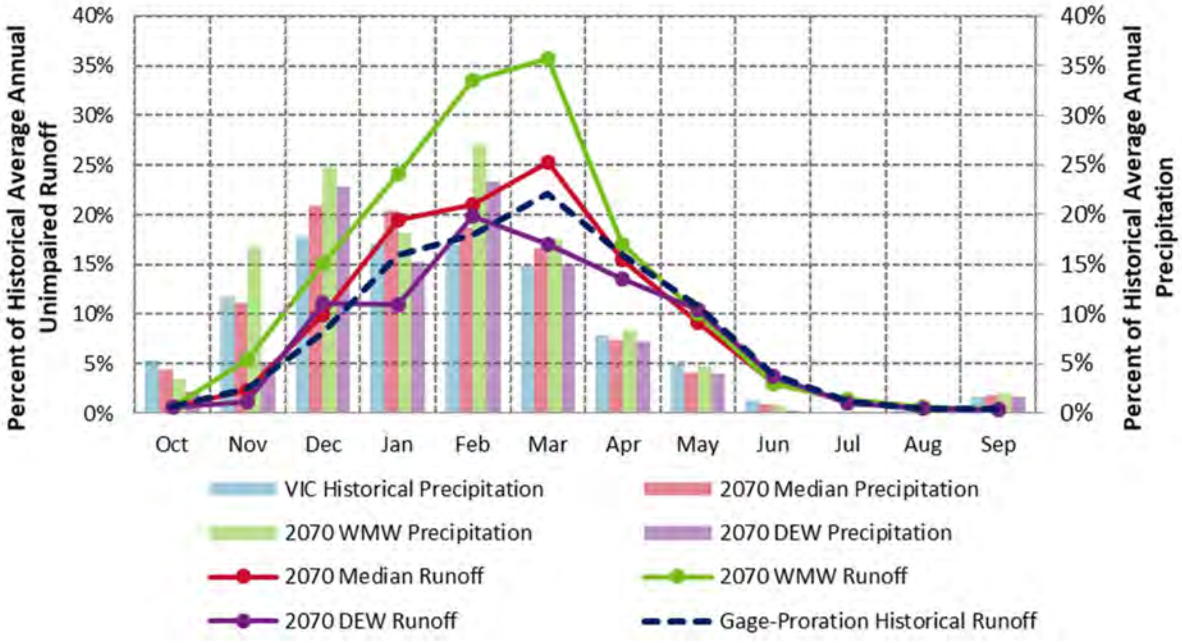


Figure 3-10. Monthly percent of historical annual average unimpaired runoff (Water Years 1976 through 2011) at Scotts Flat Dam on Deer Creek under historical conditions and under projected 2070 climate change conditions.



In the high-elevation watersheds that are historically snowfall dominant during the wet season, the 2070 peak runoff months occur earlier in the Water Year and are more distributed during the rainy season relative to historical conditions as a result of the shift in precipitation from snowfall to rainfall (Figures 3-7 and 3-8). The 2070 scenarios generally exhibit higher percentages of flows from December through March, and lower percentages from May through July. The prominent historical May snowmelt peak is no longer evident at Milton Diversion Dam and is broader and shifted to March at Bowman Dam, which has greater runoff contributions from higher elevation watersheds.

In the low-elevation watersheds that are historically rainfall dominant in the wet season, the shifts in runoff pattern are not as pronounced. This is because the largest contribution to runoff occurs as direct runoff of rainfall during the rainy season and future scenario changes in the snowmelt contribution are small relative to the total annual runoff volume. The Median and colder, wetter WMW scenarios indicate higher flows in December through March and flows slightly less than historical in the drier months (Figures 3-9 and 3-10).

Changes in runoff volume are not directly proportional to changes in precipitation volume between scenarios. Variation of temperature, and rainfall intensity and duration impact hydrologic processes and parameters simulated by the VIC model, such as rainfall losses to interception, detention and groundwater storage, evapotranspiration and sublimation, and changes in infiltration parameters under different degrees of soil saturation. A comparison of VIC model historical and future precipitation and flow indicates that losses are reduced relative to historical for the WMW scenario, with a larger percentage of precipitation transformed to runoff, likely due to more saturated conditions, more intense precipitation, and reduction of snow pack. Losses are higher for the warmer, drier DEW scenario, likely due to drier soils and increases in evapotranspiration.

Table 3-1 summarizes the percent of average annual historical runoff at the four locations. Table 3-2 summarizes annual volumes at each location. The 2070 WMW scenario is approximately 25 percent wetter than historical conditions in the higher elevation example watersheds and nearly 50 percent wetter in the lower elevation watersheds. The 2070 DEW scenario is about 8 to 10 percent drier, and the Median scenario is 6 to 9 percent wetter. The results indicate that there is potential for significantly higher runoff volume during wet years and lower runoff volume during dry years than experienced under historical climate conditions.

Table 3-1. Percent of average annual historical runoff.

Location	Percent of Average Annual Historical Runoff		
	2070 DEW[1]	2070 Median[2]	2070 WMW[3]
Middle Yuba River at Milton Diversion Dam	92%	104%	126%
Canyon Creek at Bowman Dam	92%	104%	125%
Bear River at Rollins Dam	90%	109%	148%
Deer Creek at Scotts Flat Dam	90%	108%	147%

[1] Drier, extreme warming scenario based on GCM HadGEM2-ES and emission scenario RCP 8.5.

[2] Median scenario based on 10 general circulation models, each run with two emission scenarios: one optimistic (RCP 4.5) and one pessimistic (RCP 8.5).

[3] Wetter, moderate warming scenario based on GCM CNRM-CM5 and emission scenario RCP 4.5.

Table 3-2. Annual Flow Volumes for four location under historical conditions and under projected 2070 climate change conditions.

Scenario		Annual Flow Volumes in Acre-Feet			
		Middle Yuba River at Milton Diversion Dam	Canyon Creek at Bowman Dam	Bear River at Rollins Dam	Deer Creek at Scotts Flat Dam
Historical	Average	89,004	91,068	156,830	30,983
	Maximum	192,731	165,289	488,342	102,800
	Minimum	12,557	17,362	8,262	1,747
2070 DEW[1]	Average	81,748	83,976	142,322	31,677
	Maximum	197,825	169,670	416,588	92,156
	Minimum	11,817	16,381	7,633	1,753
2070 Median[2]	Average	92,632	94,258	170,217	37,191
	Maximum	208,767	179,314	535,430	115,882
	Minimum	11,865	16,628	8,176	1,830
2070 WMW[3]	Average	112,013	113,861	231,518	50,457
	Maximum	248,617	212,318	697,622	150,901
	Minimum	15,950	19,873	8,888	1,984

[1] Drier, extreme warming scenario based on GCM HadGEM2-ES and emission scenario RCP 8.5.

[2] Median scenario based on 10 general circulation models, each run with two emission scenarios: one optimistic (RCP 4.5) and one pessimistic (RCP 8.5).

[3] Wetter, moderate warming scenario based on GCM CNRM-CM5 and emission scenario RCP 4.5.

The three 2070 scenarios represent different projections of greenhouse gas emission trajectories (CWC 2016). The WMW and DEW scenarios represent bookend estimates of runoff under optimistic and pessimistic trajectories, respectively. The median scenario represents a moderate trajectory of greenhouse gas emissions. The annual exceedance probabilities demonstrate the bracketing of potential outcomes as shown in Figures 3-11 through 3-14. These figures indicate that the WMW scenario is significantly wetter than historical conditions with differences increasing in higher volume years. The Median scenario has wetter wet years, but generally shows a similar pattern of annual average flow over an exceedance probability of about 40 percent. The DEW scenario shows drier dry years for exceedance probabilities greater than 40 percent, slightly more so for the higher elevation watersheds, and variable higher flows in comparison to historical conditions.

Figure 3-11. Average Annual Runoff Volume Exceedance Probabilities (Water Years 1976 through 2011) at Milton Diversion Dam on the Middle Yuba River under historical conditions and under projected 2070 climate change conditions.

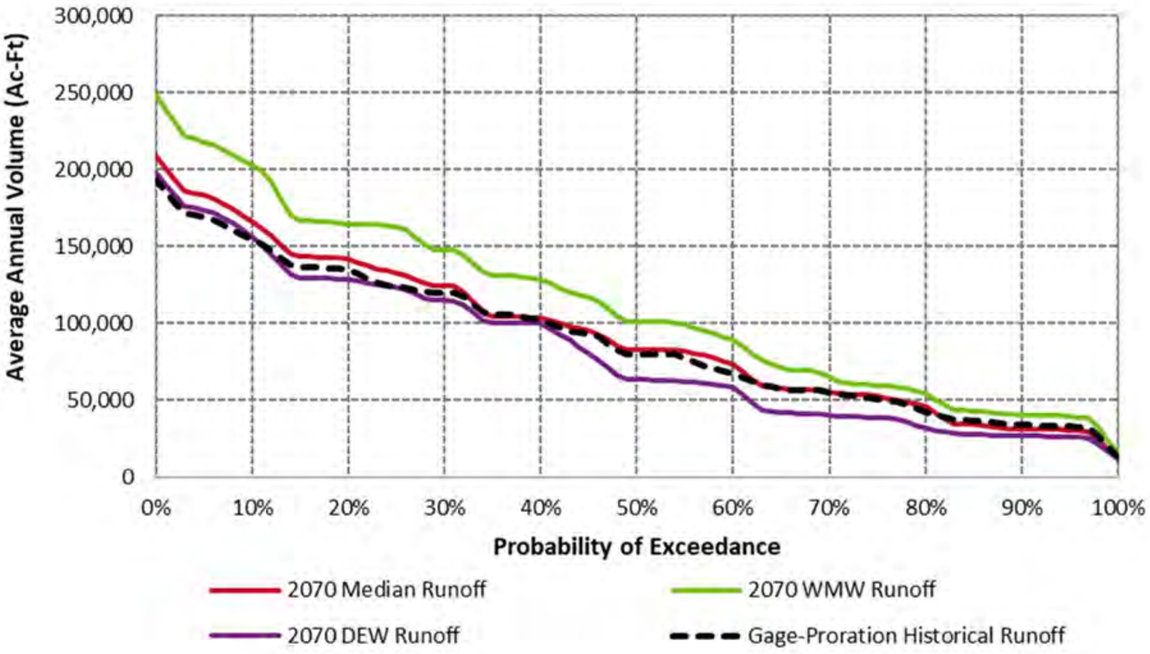


Figure 3-12. Average Annual Runoff Volume Exceedance Probabilities (Water Years 1976 through 2011) at Bowman Dam on Canyon Creek under historical conditions and under projected 2070 climate change conditions.

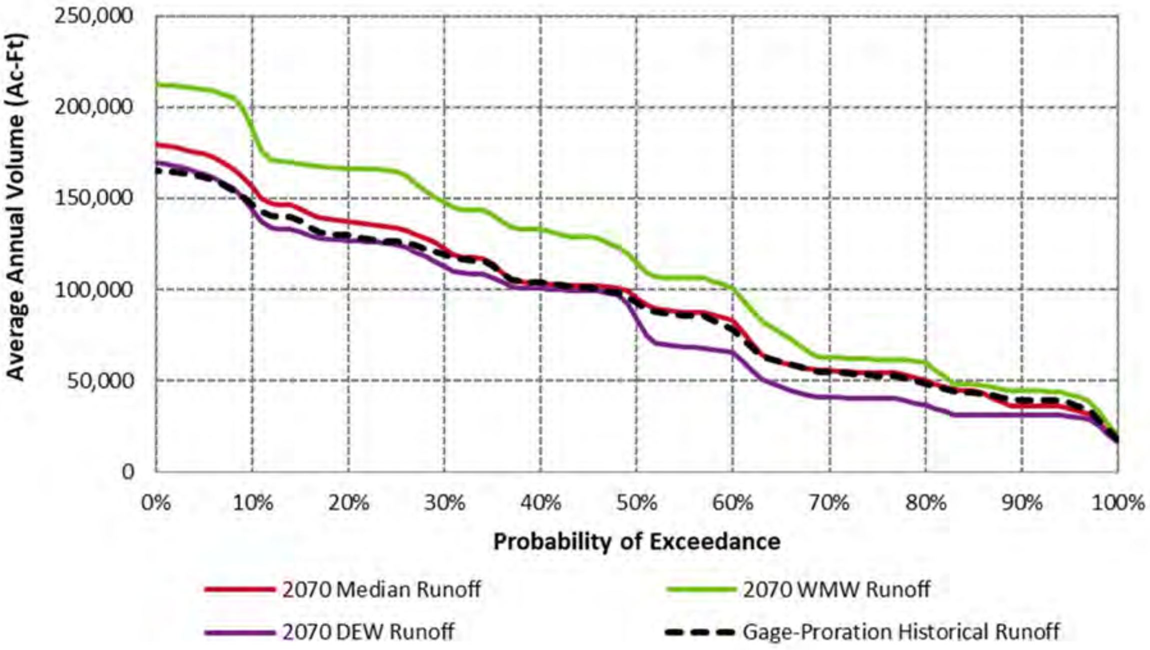


Figure 3-13. Average Annual Runoff Volume Exceedance Probabilities (Water Years 1976 through 2011) at Rollins Dam on the Bear River under historical conditions and under projected 2070 climate change conditions.

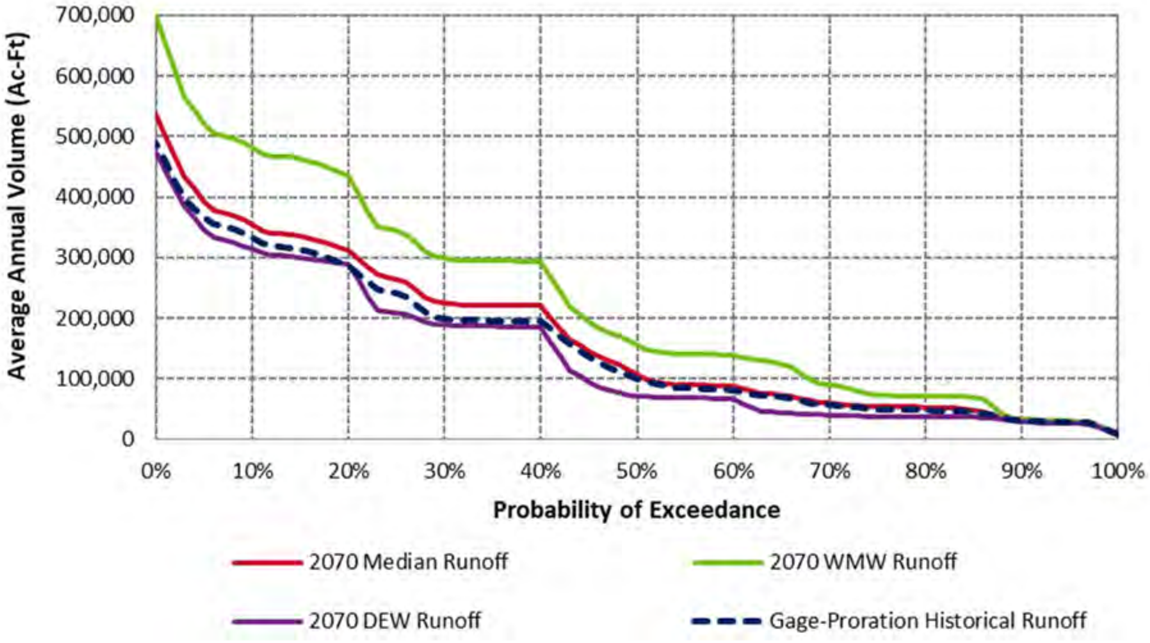
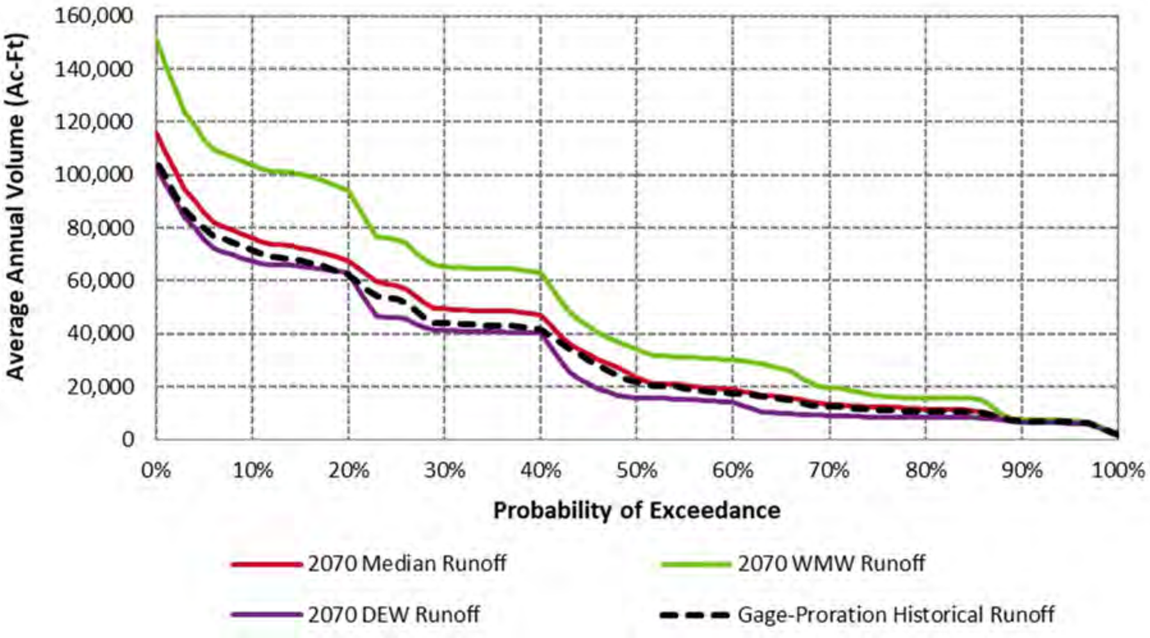


Figure 3-14. Average Annual Runoff Volume Exceedance Probabilities (Water Years 1976 through 2011) at Scotts Flat Dam on Deer Creek under historical conditions and under projected 2070 climate change conditions.

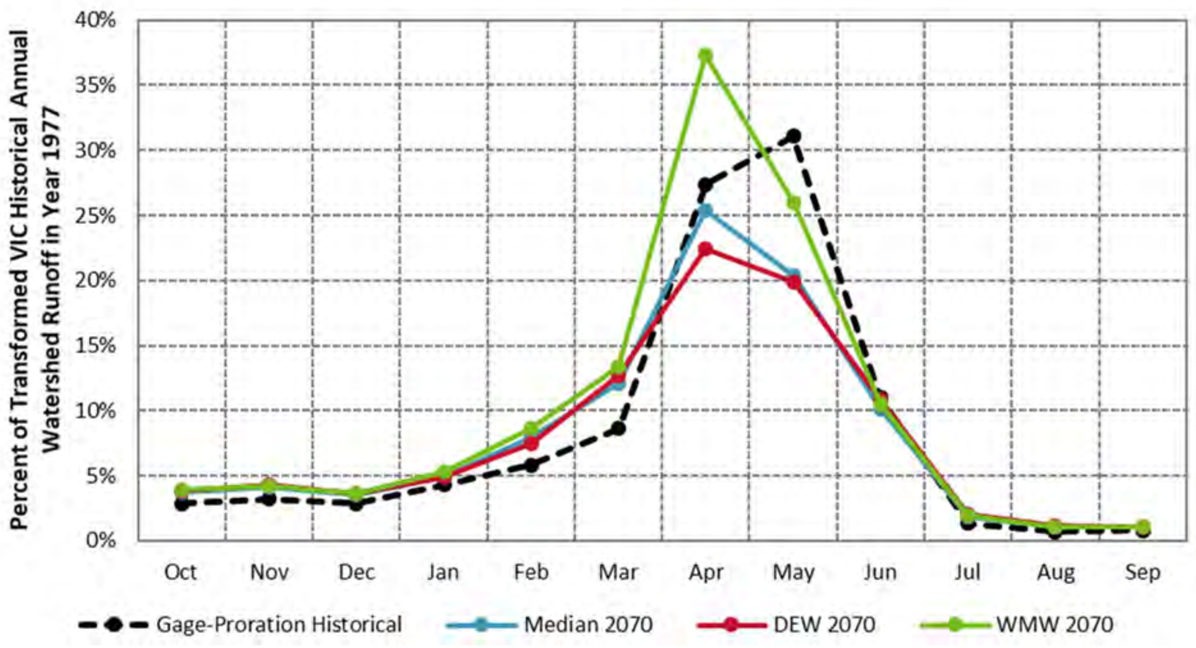


3.3 2070 Drought Projections

The prevalence of droughts in California is expected to increase under climate change (Thorne 2018). The 2070 unimpaired hydrologic data sets (median, DEW, and WMW) provided by the CWC (2016) do not include additional years of drought relative to historical conditions as a result of the climate period analysis method used to estimate the future meteorology driving the VIC model (DWR 2018). The relative distribution of wet, normal and dry years are the same as for the modeled historical period of record because the data sets are perturbations of historical conditions representative of 50 years into the future. Nonetheless, it is possible to draw conclusions on what drought conditions might look like in the future under climate change. While the hydrologic datasets do not include the recent multi-year drought, from 2012 to 2016, there are dry years in the 1976 through 2011 period of record, including 1977, which was considerably drier than any one single year in the recent drought.

Unimpaired runoff in sub-basins where NID has water rights was summed for each water year in the period of record, Water Years 1976 through 2011, to rank the Water Years from wettest to driest. The driest year in the period of record was consistently Water Year 1977 in all of the 2070 hydrologic data sets, and in the historical data set (Appendix E). Because watershed runoff is the largest contributor to NID's water supply, 1977 is assumed to be the Water Year with the lowest water supply available to NID in the hydrologic period of record (DWR 2016). A comparison of Water Year 1977 runoff under 2070 conditions relative to historical runoff is shown in Figure 3-15. Peak runoff occurred earlier (April) in the 2070 scenarios as compared to historical (May). Dry month base flows (October through December, and July through September) in the 2070 scenarios were similar to historical base flows. Both the Median and DEW 2070 scenarios were approximately 5 percent drier than historical, while the WMW 2070 scenario was 17 percent wetter than historical, as summarized in Table 3-3. WY 1977 was slightly drier relative to the period of record average for both the Median and WMW 2070 scenarios, as compared to historical unimpaired.

Figure 3-15. Monthly percent of average sum of runoff in sub-basins with NID water rights for the driest year in the hydrologic period of record, Water Year 1977, under 2070 conditions relative transformed VIC historical conditions.



3-3. Runoff statistics for WY 1977 under historical conditions and under projected 2070 climate change conditions based on sum of runoff in sub-basins with NID water rights.

Scenario	Percent of Historical Annual WY 1977 Runoff	Percent of Scenario Average Annual Runoff
Gage-Proration Historical	**100%**	**10%**
Median 2070[1]	**96%**	**9%**
DEW 2070[2]	**94%**	**10%**
WMW 2070[3]	**117%**	**9%**

[1] Drier, extreme warming scenario based on GCM HadGEM2-ES and emission scenario RCP 8.5.

[2] Median scenario based on 10 general circulation models, each run with two emission scenarios: one optimistic (RCP 4.5) and one pessimistic (RCP 8.5).

[3] Wetter, moderate warming scenario based on GCM CNRM-CM5 and emission scenario RCP 4.5.

4 Reservoir Operations Model

Future increases in water demand within NID's service area, coupled with anticipated periods of drought and ongoing climate change, create imminent challenges for NID in maintaining a sustainable water system for its service area. NID will perform an accounting of water supply and demand for average conditions and for drought conditions within the planning horizon of the RWMP. If the analysis indicates that projected supply will not be able to meet projected demand it may be necessary to analyze various reasonable, practical, and feasible ways (alternatives) to bridge the gap between supply and demand. A reservoir operations model (Ops Model) will be used to evaluate potential alternatives to assess the relative benefit of each to create a resilient and sustainable water system for NID and its customers.

A HEC-ResSim (US Army Corps of Engineers 2013) reservoir operations model (Ops Model) was previously developed in support of the Yuba-Bear/Drum-Spaulding hydroelectric project FERC relicensings (Devine Tarbell & Associates 2008). The Ops Model was accepted by FERC and other state and federal agencies to adequately simulate conditions within the two hydroelectric project areas and was used to evaluate impacts to water resources as a result of potential operations and facilities modifications during the relicensing process.

The Ops Model simulates operating conditions of the two hydroelectric projects, which include a complex network of reservoirs, diversions, canals, and a combined 16 powerhouses. It is a tool that can be used to determine potential sensitivity of the system to changed constraints, including future projections of climate change, customer demand and environmental flow requirements. Unimpaired hydrology is a fundamental input to the Ops Model. The unimpaired hydrology data sets described in Section 3 were developed to be compatible with the Ops Model's physical and temporal input requirements.

4.1 Modifications to the Reservoir Operations Model

Since the end of the FERC relicensing process, several updates have been made to the Ops Model, including an extension of the period of record hydrology, extensions of the watershed simulation area to include more of the Bear River and Deer Creek basins, and 2070 projections of customer demand and climate change. Each of these changes are described below.

4.1.1 Simulation Period of Record

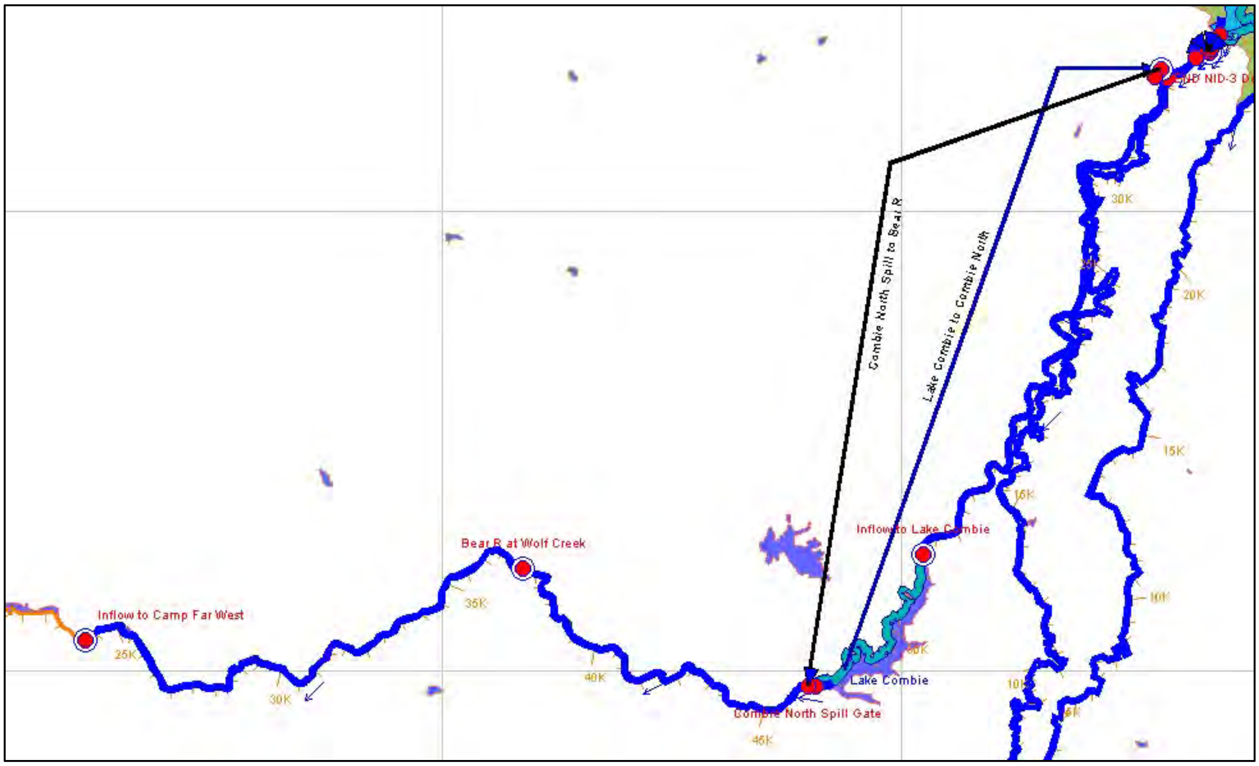
The FERC relicensing simulation period of record included water years 1976 through 2008. The simulation period of record has been extended through 2011, to coincide with the historical unimpaired hydrology period of record extension, described in Section 3.1, and the projected 2070 unimpaired hydrology period of record, described in Section 3.2. In addition to extending the inflow hydrology time series, other input time series were extended in order for the Ops Model to simulate the longer period of record. These include minimum instream flow requirements at multiple locations throughout the watershed, Smartsville Index based Water Year types (FERC 2014) that affect reservoir operations, and aggregated NID and Placer County Water Agency (PCWA) raw water demands.

4.1.2 Bear River Watershed Extension

The Ops Model developed for FERC relicensing simulated the Bear River from the headwaters down to the Bear River Canal Diversion Dam. NID also owns and operates Lake Combie, located approximately 13 river miles downstream of the Bear River Canal Diversion Dam. NID makes releases to Combie Phase I Canal from Lake Combie and maintains a minimum instream flow of 5 cfs in the Bear River below Lake Combie, per California Department of Fish and Wildlife's minimum flow requirement (Water Rights Permit Number 5803). The Ops Model was modified to include additional reaches of the

Bear River from the Bear River Canal Diversion Dam to the inflow to South Sutter Water District's Camp Far West Reservoir, located approximately 19 river miles downstream of Lake Combie (Figure 4-1).

Figure 4-1. Screen-shot of the Ops Model Bear River extension, from the Bear River Canal Diversion Dam to the inflow to Camp Far West Reservoir.



The Ops Model was originally configured to make deliveries to the Combie Phase I Canal (Ops Model demand node NID-3) without explicit simulation of Lake Combie. A representation of Lake Combie was added to the Ops Model, with a storage capacity of approximately 5,555 ac-ft at normal-maximum water-surface elevation. Historically, reservoir storage in Lake Combie is drawn down each fall to allow for collection to storage under NID's Bear River water rights.

The Bear River watershed extension was validated by comparing simulated and historical Lake Combie storage (BR-900) and Bear River flow below Lake Combie (BR-300) for water years 2001 through 2011. Figure 4-2 shows the comparison of Lake Combie storage, and Figure 4-3 shows the comparison of Bear River flow below Lake Combie. Simulated results correlate very well to observed data. The model and calibration analysis are provided in Appendix F.

Figure 4-2. Comparison of historical and simulated Lake Combie Storage, Water Years 2001 through 2011.

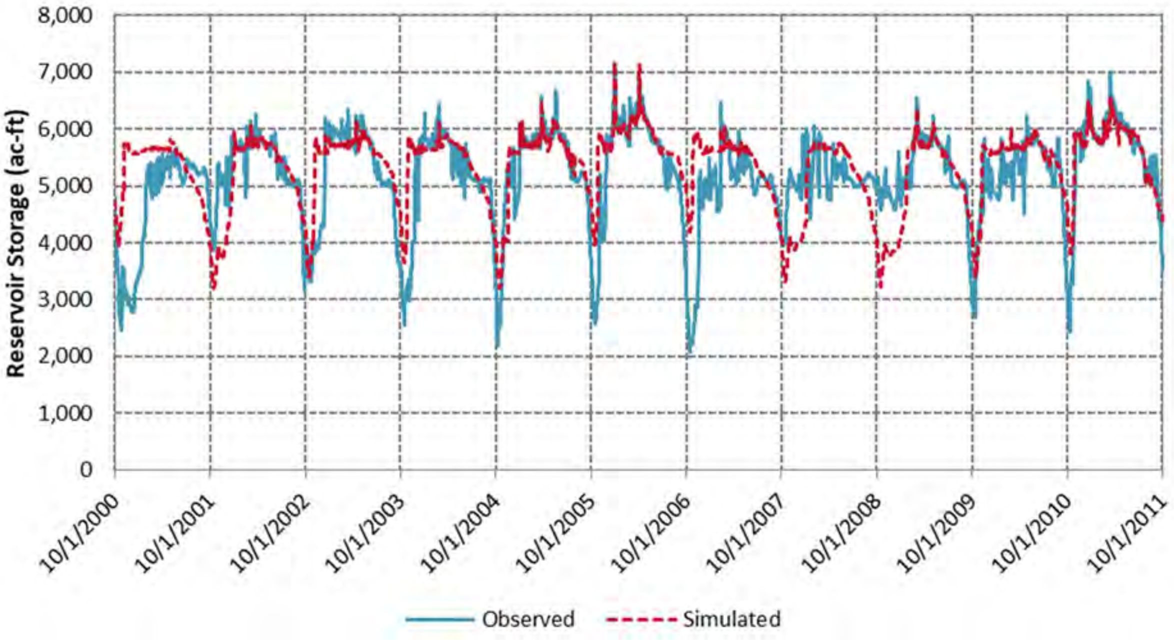
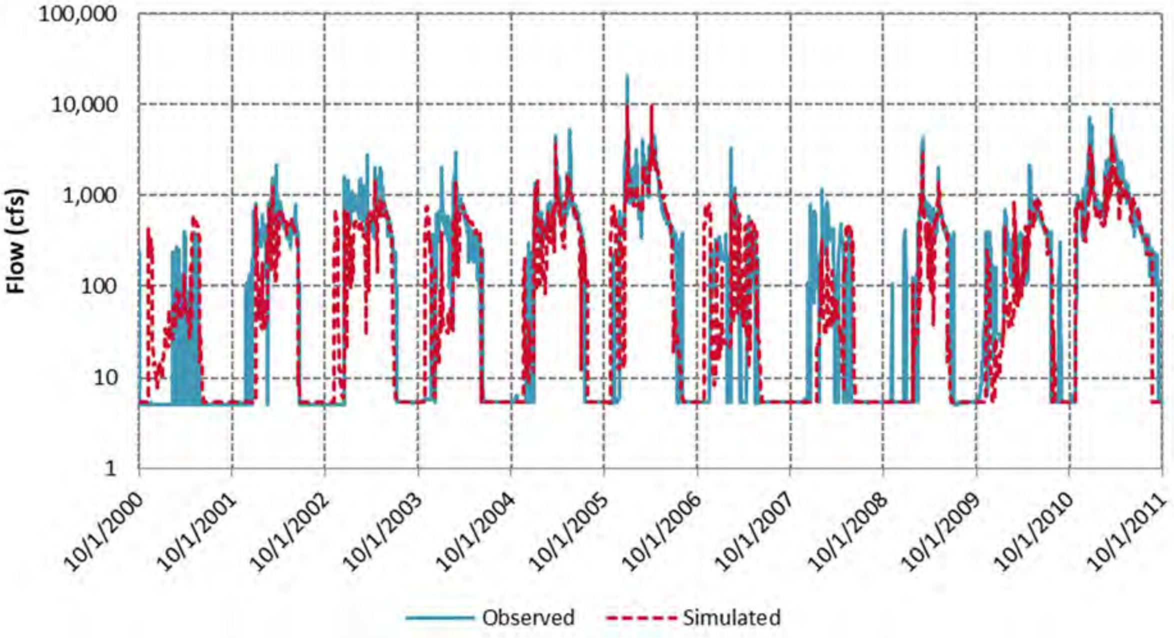


Figure 4-3. Comparison of historical and simulated flow in the Bear River below Lake Combie, Water Years 2001 through 2011.



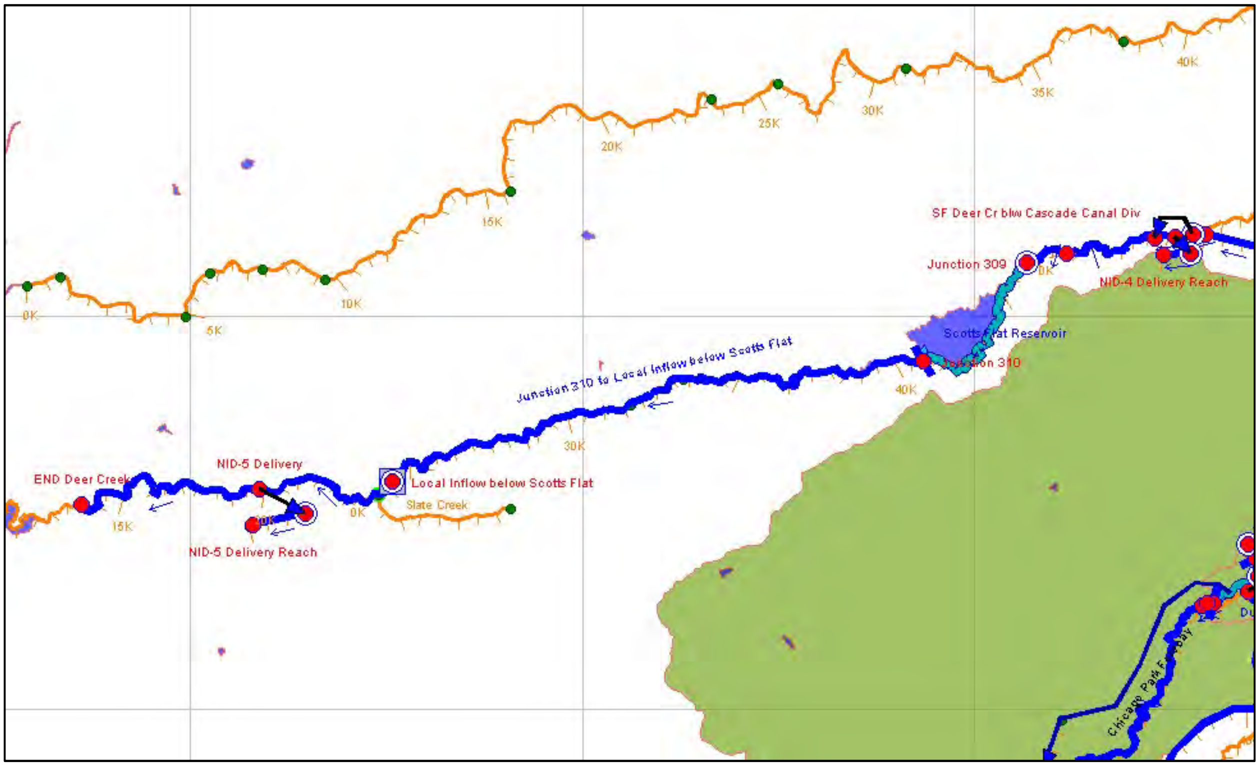
4.1.3 Deer Creek Watershed Extension

The Ops Model developed for FERC relicensing did not explicitly simulate Deer Creek. The model simulated flow through the Deer Creek Powerhouse, which was delivered to a demand node (NID-4) to assess delivery shortages to Deer Creek from NID's Mountain

Division storage via the South Yuba Canal. It did not include local inflow contribution from the Deer Creek watershed or the simulation of Scotts Flat Reservoir. NID owns and operates Scotts Flat Reservoir as a storage reservoir and diverts water from Deer Creek at multiple locations.

The Ops model was modified to simulate Scotts Flat Reservoir, diversions from Deer Creek, and a minimum instream flow below Cascade Canal Diversion (Figure 4-4). Diversions from Deer Creek are represented as two demand nodes, one representing diversions upstream of Scotts Flat Reservoir (demand node NID-4, Cascade Canal) and diversions downstream of Scotts Flat Reservoir (aggregated demand node NID-5, D-S Canal, Newtown Canal, Tunnel Canal, and Keystone Canal). Simulated inflows to Deer Creek include imported water from NID's Mountain Division storage through the South Yuba Canal, local watershed accretion, and wastewater effluent from the Nevada City wastewater treatment plant.

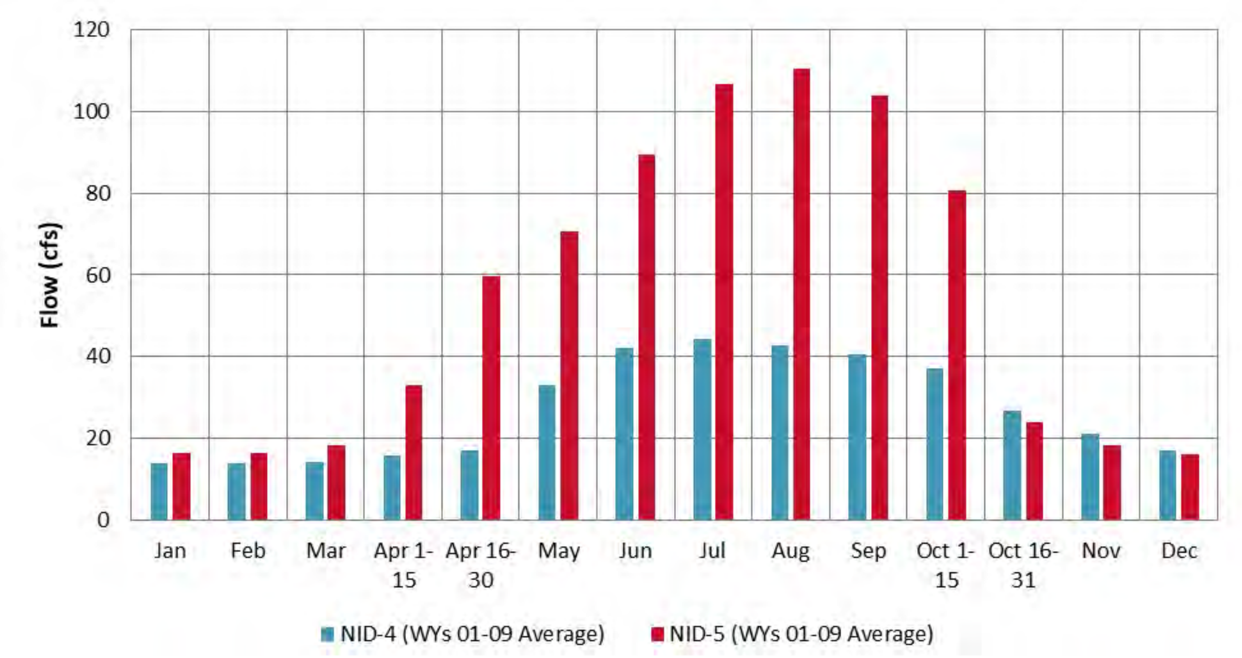
Figure 4-4. Screenshot of the Ops Model Deer Creek extension.



For FERC relicensing, existing water delivery demands in the Ops Model for NID and Placer County Water Agency (PCWA) were based on the average of historical gage data for Water Years 2001 through 2009. For consistency, the same methodology was applied here to develop the revised NID-4 and new NID-5 demand patterns, which were used to validate the model. The irrigation season typically runs from mid-April through mid-October. Therefore, April and October demand patterns were split between the first half of the month and the second half of the month. NID-4 demand pattern (Figure 4-5) is based on historical flow data at the head of the Cascade Canal (DC-102). NID-5 demand pattern (Figure 4-5) is based on the summation of historical D-S Canal, Newtown Canal, Tunnel Canal, and Keystone Canal flow data (DC-145, DC-131, DC-

140, and DC-127). These demand patterns were converted into a daily demand time series for the simulation period of record. The Ops Model removes up to this amount of flow from Deer Creek, if available, after meeting all minimum instream flow requirements. If there is inadequate supply to meet demand, it is accounted for as a delivery deficit, or an unmet demand.

Figure 4-5. Simulated Deer Creek existing water demand at Ops Model node NID-4 (above Scotts Flat Reservoir) and NID-5 (below Scotts Flat Reservoir).



The Deer Creek watershed extension was validated by comparing simulated historical Scotts Flat Reservoir storage (DC-900) and Deer Creek flow below Scotts Flat Reservoir (DC-125) for water years 2001 through 2011. Figure 4-6 shows the comparison of Scotts Flat Reservoir storage, and Figure 4-7 shows the comparison of Deer Creek flow for controlled releases below Scotts Flat Reservoir.

Figure 4-6. Comparison of historical and simulated Scotts Flat Reservoir storage, Water Years 2001 through 2011.

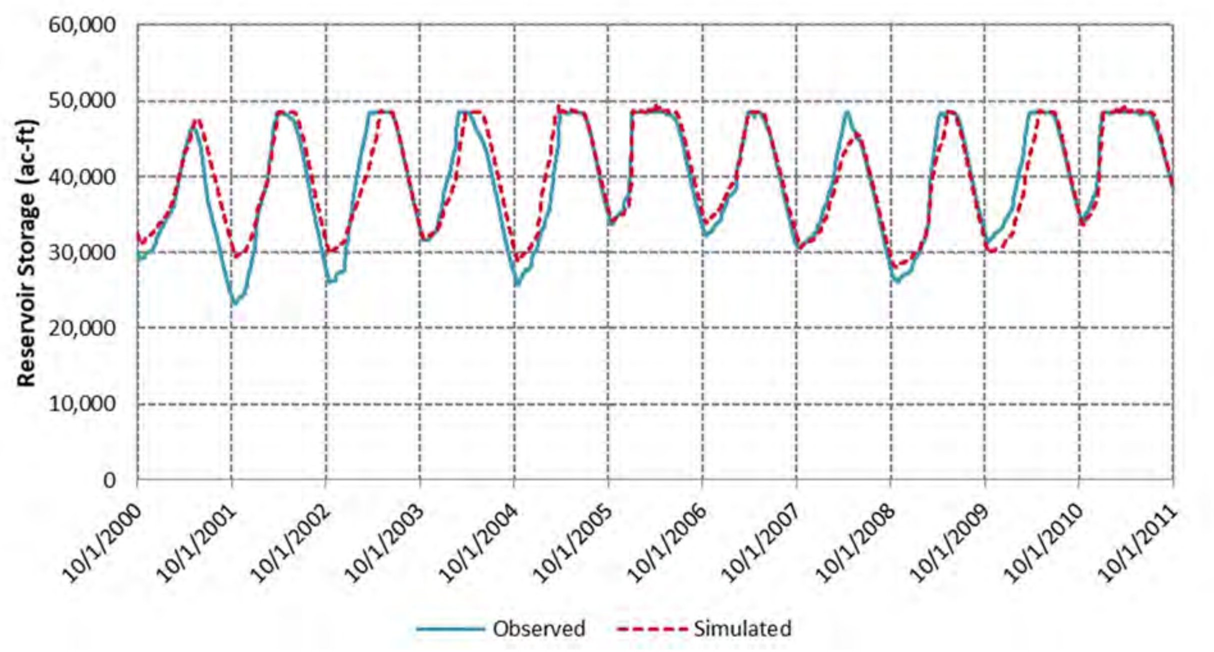
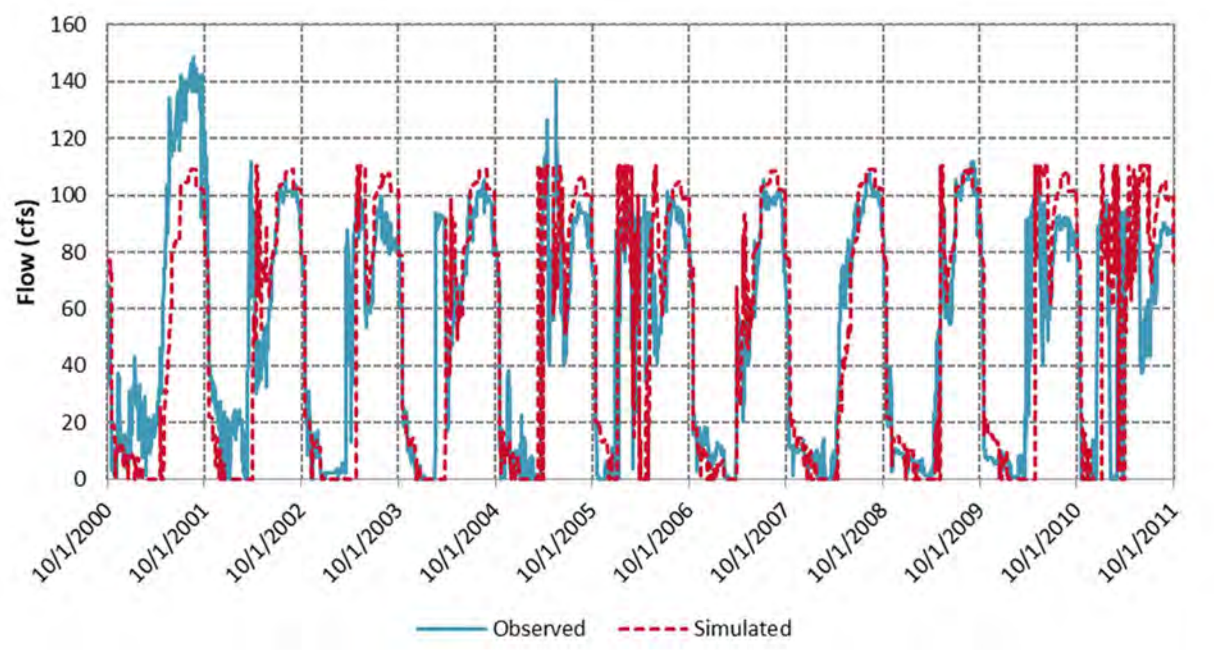


Figure 4-7. Comparison of historical and simulated controlled releases (excludes spill) in Deer Creek below Scotts Flat Reservoir, Water Years 2001 through 2011.



4.1.4 Projected 2070 Conditions

For FERC relicensing, the Ops Model was configured to simulate existing conditions and projected conditions. Projected conditions were representative of historical hydrology and projected 2062 NID and PCWA customer demand. NID's 2062 projected demand was based on extrapolation of 2032 projected demand from the RWMP Phase II update (Kleinschmidt Associates 2011). This projection included NID's soft service areas assuming historical demands. PCWA's 2062 projected demand was based on data received from PCWA. FERC projected conditions did not include hydrologic changes resulting from climate change.

For this study, the Ops Model has been updated to represent projected conditions in 50 years (2070), including climate-changed input hydrology data (described in Section 3.2), and updated projections of NID customer water demand (HDR 2020). PCWA demands were not modified, assuming that 2062 projected demands adequately represent 2070 projected demands. All projected model runs will include anticipated FERC license conditions (FERC 2014). A copy of the Ops Model is provided in Appendix F.

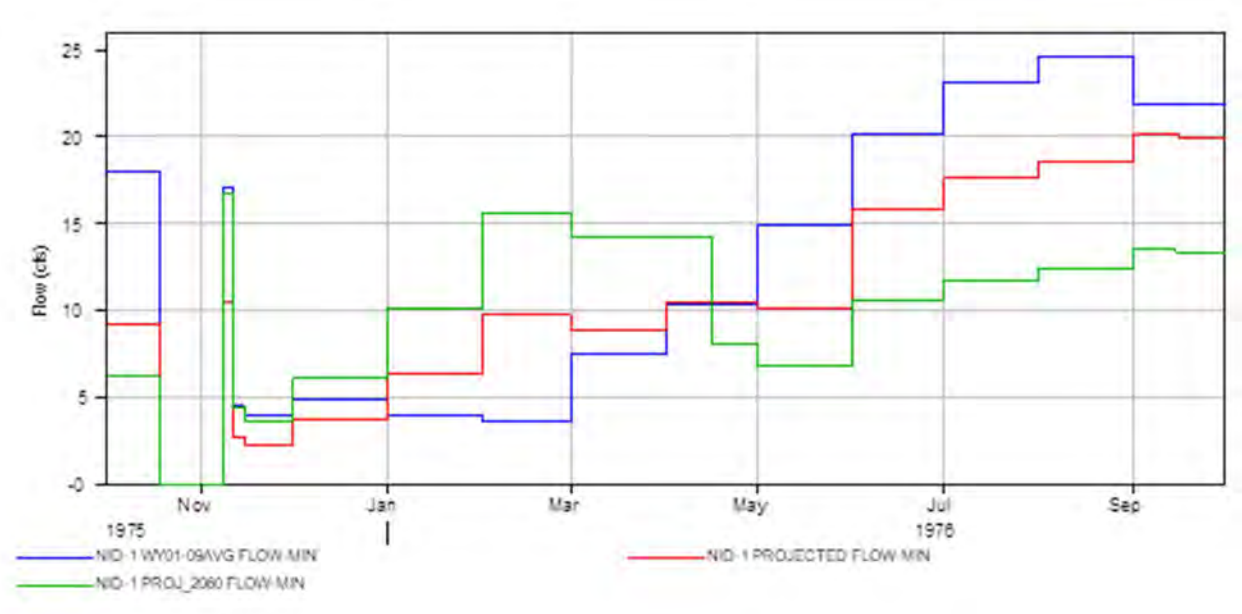
NID water demands in the Ops Model are represented by 5 delivery nodes. Table 4-1 summarizes the areas represented by each node.

Table 4-1. Summary of water delivery nodes included in the Ops Model.

Ops Model Node	Diversion Location	NID Gages Represented by Demand Node
NID-1	Rock Creek	YB64+YB86+YB108+YB255
NID-2	Auburn Ravine	YB132+YB259
NID-3	Combie Phase I Canal	BR301
NID-4	Cascade Canal	DC-102
NID-5	Deer Creek downstream of Scotts Flat Reservoir	DDC145+DC131+DC140+DC127

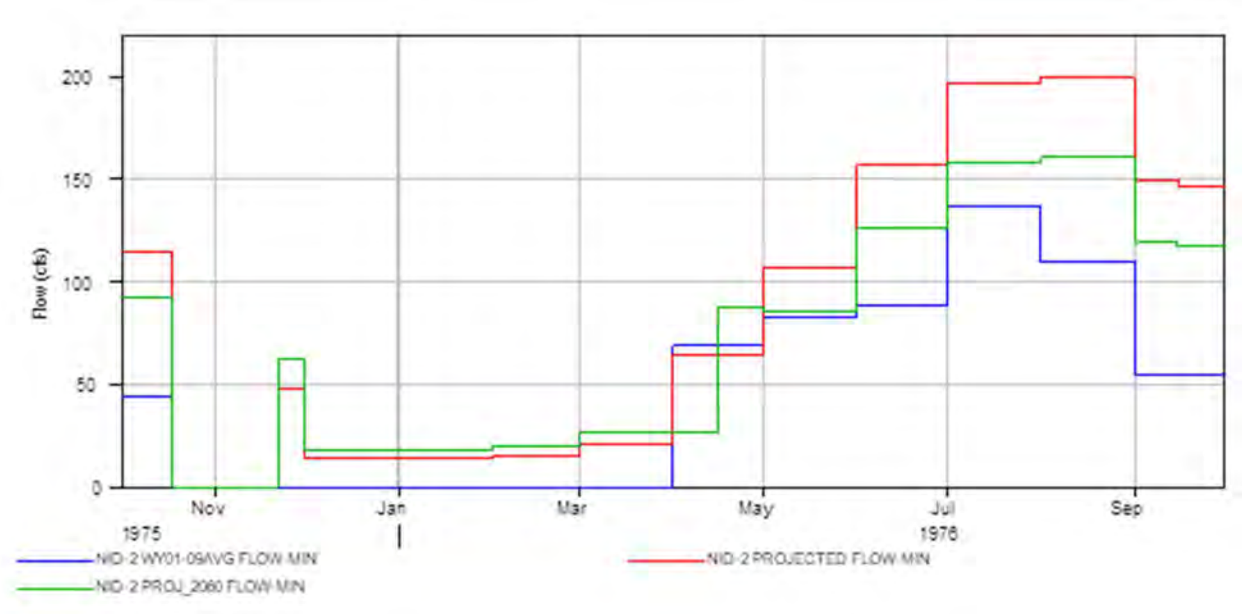
Output from the demand model (HDR 2020) was not an exact match for the NID-1 Ops Model node. Output for Fiddler Green from the 2011 RWMP and from the updated demand model were used to scale irrigation season deliveries developed for FERC relicensing for 2062. Figure 4-8 shows a comparison of NID-1 demand inputs to the Ops Model for historical 2001-2009 average demands, the old 2062 projected demands and the updated 2060 demands.

Figure 4-8. Demand time series for Ops Model node NID-1, historical 2001-2009 average (blue), old 2062 projection (red), new 2060 projection (green).



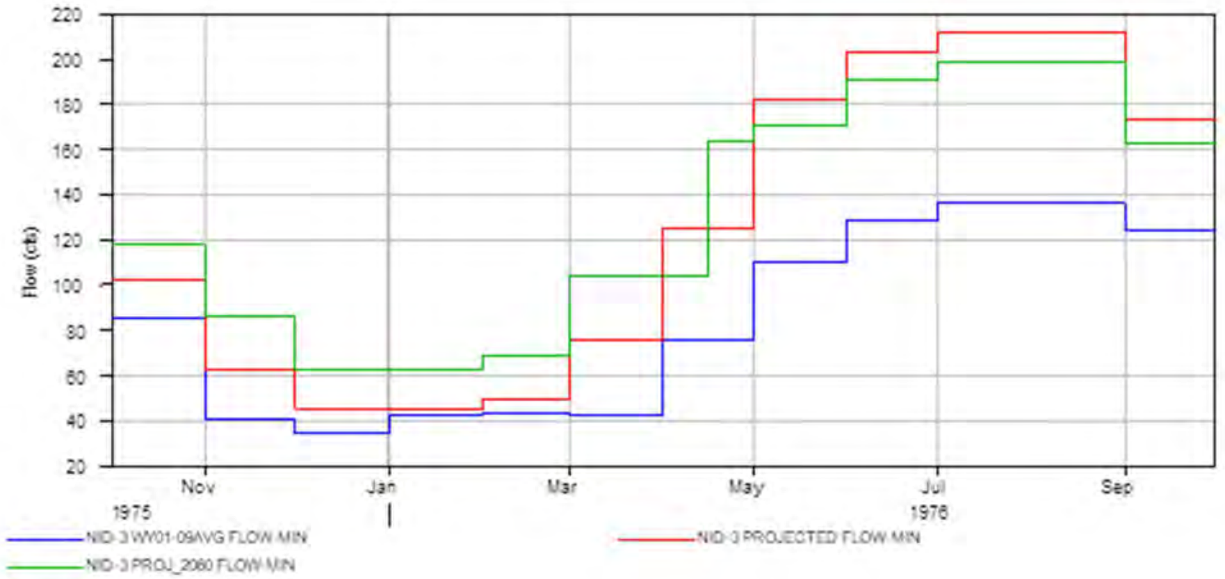
Output from the demand model (HDR 2020) was not an exact match for the NID-2 Ops Model node. Output for Auburn Ravine Natural (Wise P.H. to Hwy 65) from the 2011 RWMP and from the updated demand model were used to scale irrigation season deliveries developed for FERC relicensing for 2062. Figure 4-9 shows a comparison of NID-2 demand inputs to the Ops Model for historical 2001-2009 average demands, the old 2062 projected demands and the updated 2060 demands.

Figure 4-9. Demand time series for Ops Model node NID-2, historical 2001-2009 average (blue), old 2062 projection (red), new 2060 projection (green).



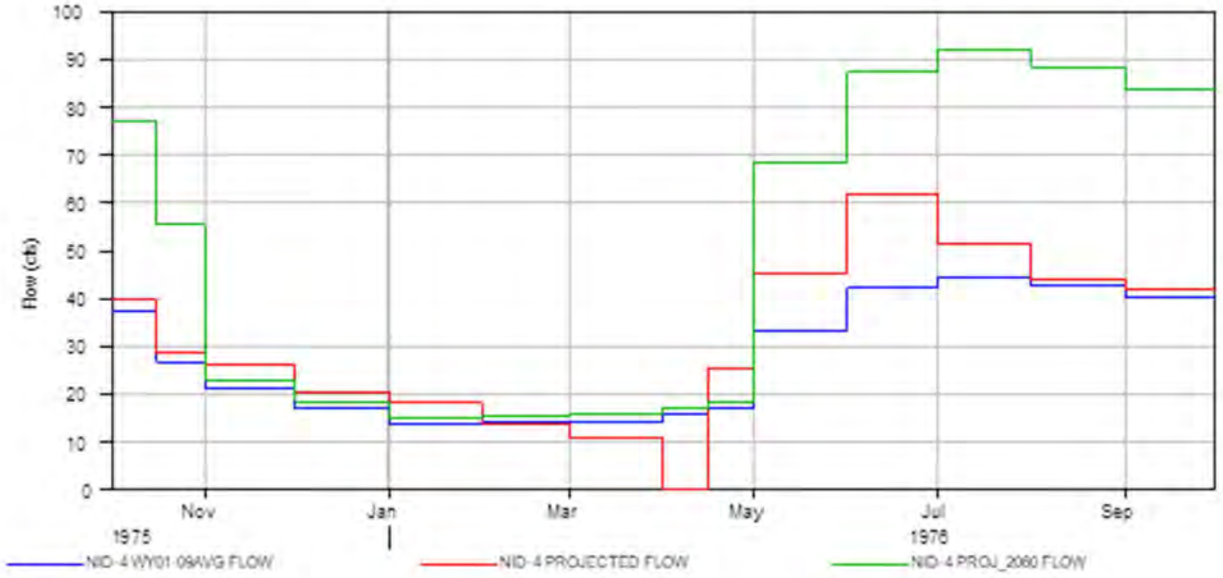
Output from the demand model (HDR 2020) is an exact match for the NID-3 Ops Model node. Output for Combie Phase I (Dam to Bear River Siphon) from the 2011 RWMP and from the updated demand model were used to scale irrigation season deliveries developed for FERC relicensing for 2062. Figure 4-10 shows a comparison of NID-3 demand inputs to the Ops Model for historical 2001-2009 average demands, the old 2062 projected demands and the updated 2060 demands.

Figure 4-10. Demand time series for Ops Model node NID-3, historical 2001-2009 average (blue), old 2062 projection (red), new 2060 projection (green).



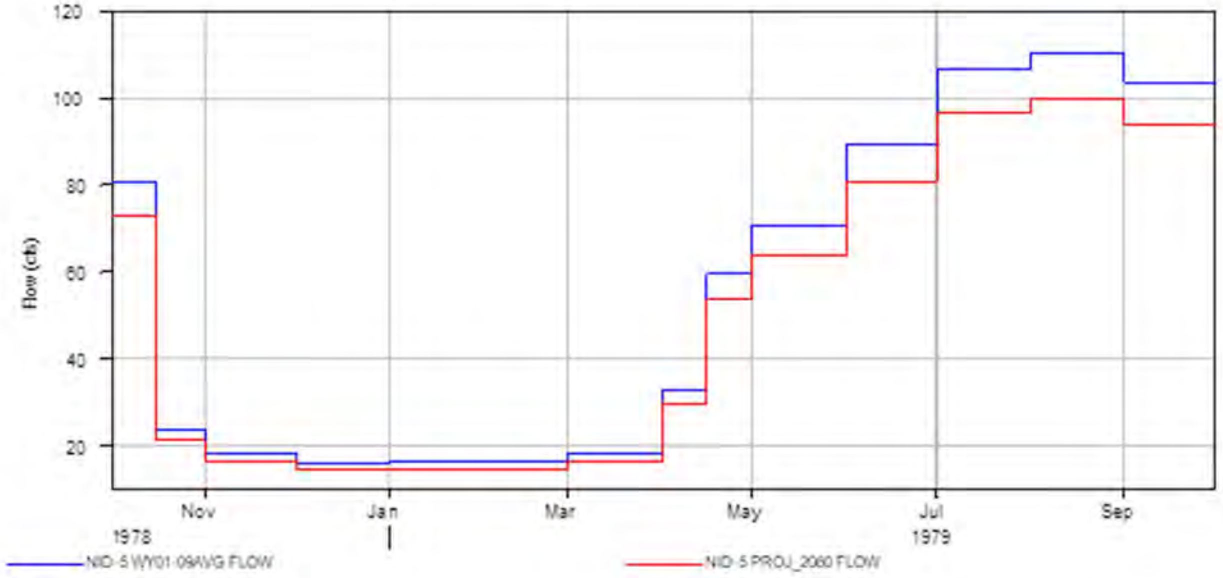
Output from the demand model (HDR 2020) is an exact match for the NID-4 Ops Model node. Historical 2001-2009 diversions were scaled to updated demand model output for Cascade System. Figure 4-11 shows a comparison of NID-4 demand inputs to the Ops Model for historical 2001-2009 average demands, the old 2062 projected demands and the updated 2060 demands.

Figure 4-11. Demand time series for Ops Model node NID-4, historical 2001-2009 average (blue), old 2062 projection (red), new 2060 projection (green).



Output from the demand model (HDR 2020) is an exact match for the NID-5 Ops Model node. Historical 2001-2009 diversions were scaled to updated demand model output for D/S (Deer Creek South Canal to D.S. Ext Pumps) plus Deer Creek Natural. Figure 4-12 shows a comparison of NID-5 demand inputs to the Ops Model for historical 2001-2009 average demands and the updated 2060 demands (NID-5 was not included in the original FERC Relicensing Ops Model).

Figure 4-12. Demand time series for Ops Model node NID-5, historical 2001-2009 average (blue) and new 2060 projection (blue).



5 Conclusion

Environmental and energy policies in California (Senate bills 100 and 350) and worldwide (Paris Agreement) aim to reduce greenhouse gas emissions. How much greenhouse gas emissions are reduced is expected to dictate to what extent climate change will affect our environment. Acknowledging this as a source of uncertainty, three projections of 2070 climate-changed hydrology data were developed representing a median greenhouse gas emissions trajectory, a pessimistic greenhouse gas emissions trajectory, and an optimistic greenhouse gas emissions trajectory.

The projected unimpaired hydrology developed for each scenario was investigated in detail for two higher-elevation and two lower-elevation watersheds. The study indicates that the effects of climate change will significantly impact the timing and volume of watershed runoff, NID's primary source of water supply, especially in NID's Mountain Division watersheds.

The prominent May peak of snowmelt runoff is no longer apparent in the projected hydrology on the Middle Yuba at Milton Diversion Dam and shifted from May to March at Bowman Dam on Canyon Creek. The rainy season runoff distribution shifts to a broader peak from December through May, with significantly lower flows than current conditions from May through July.

The lower watersheds do not exhibit as extreme a shift in the runoff temporal distribution; however, the winter months (December through March) are generally wetter under the Median and WMW projections. The three potential future scenarios investigated demonstrate the uncertainty with respect to impacts on magnitude of changes in runoff volume. The optimistic WMW scenario indicates up to 148 percent of historical runoff volume in lower watersheds and the pessimistic DEW scenario reduces runoff volumes to approximately 90 percent of historical and indicates the potential for drier dry years. The median scenario indicates a slight increase over historical runoff volumes, with wetter wet years. NID is proactively updating its RWMP to assess the possible impacts of climate change and other projected changes within its service area on its ability to maintain a sustainable water system in the future.

The hydrologic projections presented here are intended to be used by NID to assess the adequacy of existing water storage and conveyance systems to provide a reliable water supply throughout the RWMP planning horizon. Projected unimpaired hydrology will be used to assess water supply availability in a subsequent tech memo. Projected unimpaired hydrology will be used:

- To quantify watershed runoff under climate change.
- To quantify carryover storage using the Ops Model with projected demands and anticipated FERC license minimum instream flow requirements.

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Appendix A. Water Supply Network Description

Appendix A – Water Supply Network Description

Introduction

The purpose of this appendix is to describe Nevada Irrigation District's (NID) water supply network. Statistics based on historical gage data are presented to quantify regulated flow within watersheds that contribute runoff to NID's water supply.

Network Overview

NID's water supply network is characterized by high elevation storage and low elevation power generation via a network of natural and man-made conveyances. Water is stored and released from the high-elevation reservoirs based on NID's consumptive needs and reservoir carryover storage targets. Discretionary releases for water supply are made from Jackson Meadows Reservoir and Jackson, French, Faucherie, and Sawmill reservoirs during the spring runoff season through late fall. Releases from Jackson Meadows Reservoir are conveyed to Bowman Lake via the Milton-Bowman Tunnel. Releases from Jackson, French, Faucherie, and Sawmill lakes are stored and released by Bowman Dam through Bowman Powerhouse into the Bowman-Spaulding Conduit Diversion Impoundment.

While the majority of the Bowman-Spaulding Conduit flow is provided by releases at Bowman Lake, five small diversion structures (known as "feeders") on creeks that run perpendicular to the alignment of the Bowman-Spaulding Conduit also provide water to the conduit. These feeders augment flows in the conduit up to its capacity, and spill the remainder into their respective natural drainages downstream of the conduit. Flows upstream of the Bowman-Spaulding Conduit in Texas, Fall, and Rucker creeks are regulated by upstream reservoirs owned and operated by PG&E.

Flows from the Bowman-Spaulding Conduit are then passed through PG&E's Lake Spaulding into PG&E's Drum and South Yuba canals. Water transported into the South Yuba Canal is diverted into South Fork Deer Creek to supply NID customers in the Nevada City-Grass Valley area. This water is largely diverted at the Cascade Canal Diversion Dam located immediately downstream, but is also used to manage Scotts Flat Reservoir storage. Releases from Scotts Flat Reservoir provide water to four other downstream diversions downstream along Deer Creek.

Water transported into the Drum Canal is passed through PG&E's Drum Forebay into the Bear River at PG&E's Drum Afterbay. Water is diverted and returned several times along the Bear River reach upstream of Rollins Reservoir by NID and PG&E for power generation. Daily volumes are scheduled by NID and PG&E for downstream consumptive demand.

Rollins Reservoir is NID’s major low-elevation storage reservoir on the Bear River. Rollins Reservoir is a multipurpose facility that meets municipal, irrigation, domestic water supply, recreation, and power generation needs. From Rollins, water supplies NID customers in southern Nevada County and Placer County.

The following sections summarize historical flows within NID’s water supply network by watershed, from the Middle and South Yuba rivers, the primary source of watershed runoff, and from Bear River and Deer Creek, where NID’s customer demand is concentrated. There is also an overview of historical reservoir carryover storage.

Middle Yuba River

Middle Yuba River is a predominantly snowmelt-fed stream, with peak runoff occurring from March through June. Runoff is stored in Jackson Meadows Reservoir, which has a usable storage capacity[1] of 64,641 ac-ft (NID 2012). Discretionary releases are made from Jackson Meadows Reservoir during the spring runoff season through late fall. These releases are conveyed to Bowman Lake via the Milton-Bowman Tunnel. The FERC license of NID’s Yuba-Bear Hydroelectric Project (FERC Project Number 2266) includes minimum instream flow requirements below Jackson Meadows Reservoir and Milton Diversion Dam. Releases to the Middle Yuba River below Milton Diversion Dam are unrecoverable to NID. Figure A-1 shows a map of these facilities.

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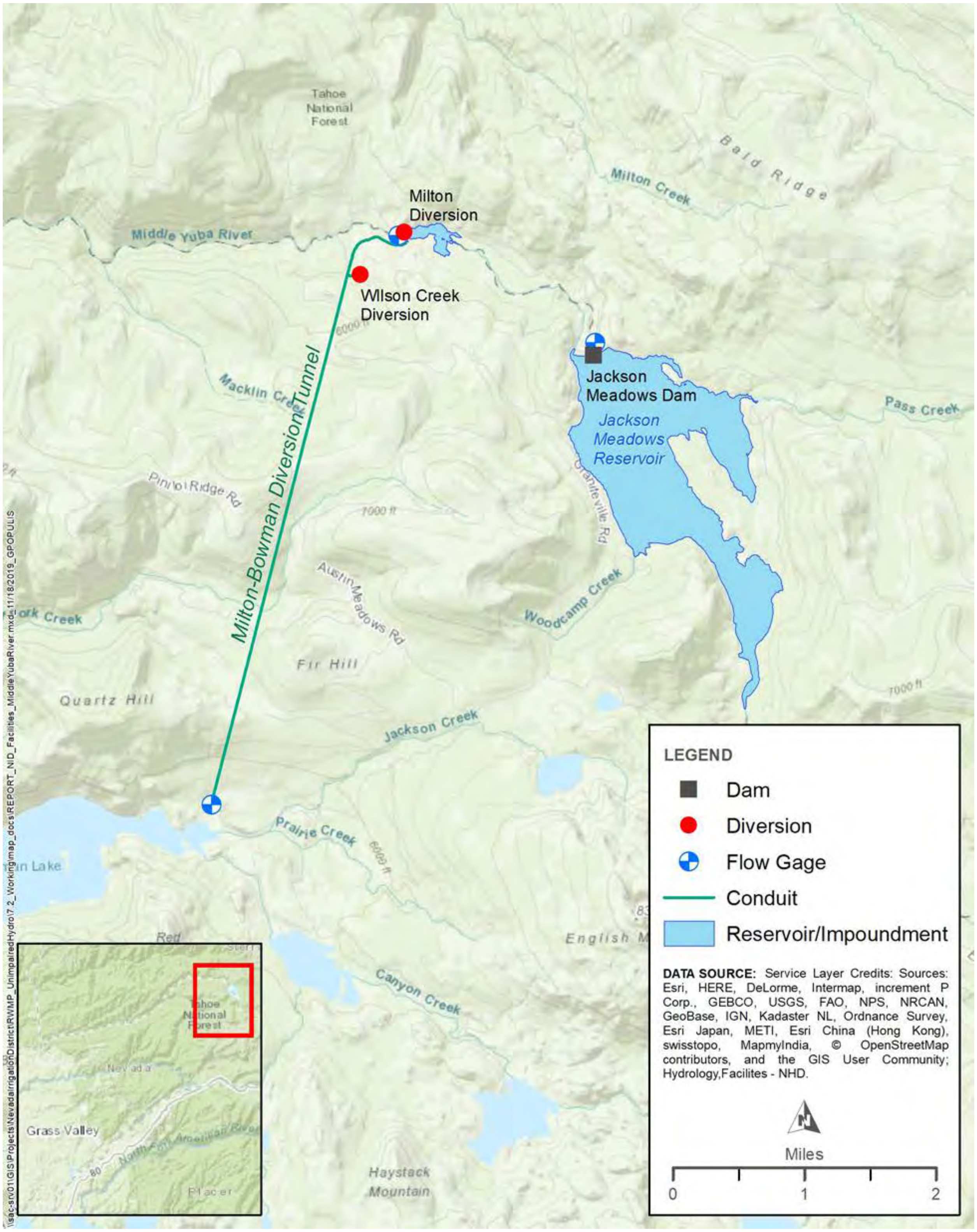
[1] Not all reservoir storage is usable. Unusable storage is made up of either dead storage or minimum-pool storage. Dead storage is storage volume within a reservoir that is located below the lowest reservoir outlet. Minimum-pool storage is a regulatory requirement to maintain reservoir storage above a certain level.

Figure A-1. Map of NID facilities located within the Middle Yuba River watershed.



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Hydrology,Facilites - NHD.

Average historical monthly flows in the Middle Yuba River Watershed are shown in Table A-1. There is approximately 2.5 square miles of contributing watershed area between Jackson Meadows Dam and Milton Dam.

Table A-1. Historical Average Monthly Flows in the Middle Yuba River Watershed.

Location	Average Monthly Inflow[1] (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Middle Yuba River Below Jackson Meadows Dam[2]	156.4	98.0	50.2	35.4	67.2	97.9	118.2	154.6	153.5	104.1	82.5	140.8	76.0
Milton-Bowman Tunnel Outlet[3]	153.1	84.8	40.8	32.2	45.5	75.9	68.9	94.8	88.2	90.0	90.1	126.0	59.9
Middle Yuba River Below Milton Dam[4]	5.7	6.0	19.9	30.3	27.0	18.6	47.7	113.4	87.4	16.8	3.8	4.4	23.0

[1] Common period of record for all gages 10/01/1975 – 9/30/1987, 7/17/1994 – 9/30/2004, 10/01/2008 – 9/30/2009
[2] Middle Yuba River below Jackson Meadows Dam flow from USGS Gage 11407900
[3] Milton-Bowman Tunnel outlet flow from USGS Gage 11408000
[4] Middle Yuba River below Milton Dam flow from USGS Gage 11408550
Key: cfs = cubic feet per second TAF = thousand acre-feet

South Yuba River Tributaries

Canyon Creek is a tributary to the South Yuba River. It is a predominantly snowmelt-fed stream, with peak runoff occurring from March through June. The combined usable storage capacity[2] in the Canyon Creek watershed is 90,048 ac-ft. The largest storage reservoir is Bowman Lake, with a usable storage capacity of 68,363 ac-ft, followed by French Lake with a usable storage of capacity of 13,940 ac-ft, Faucherie Lake with a usable storage of capacity of 3,740 ac-ft, Sawmill Lake with a usable storage of capacity of 3,030 ac-ft, and Jackson Lake with a usable storage of capacity of 975 ac-ft (NID 2012) Discretionary releases are made from Jackson, French, Faucherie, Sawmill, and Bowman lakes during the spring runoff season through late fall. Bowman Lake also receives inflow from the Middle Yuba River through the Milton-Bowman Tunnel. Water is released from Bowman Lake and is either diverted to the Bowman-Spaulding Canal or released to Canyon Creek below the Bowman-Spaulding Canal Diversion Dam. NID's FERC license includes minimum instream flow requirements below Bowman-Spaulding Diversion Dam, which are unrecoverable to NID. Feeder creeks that run perpendicular to the alignment of the canal augment flows up to its capacity.

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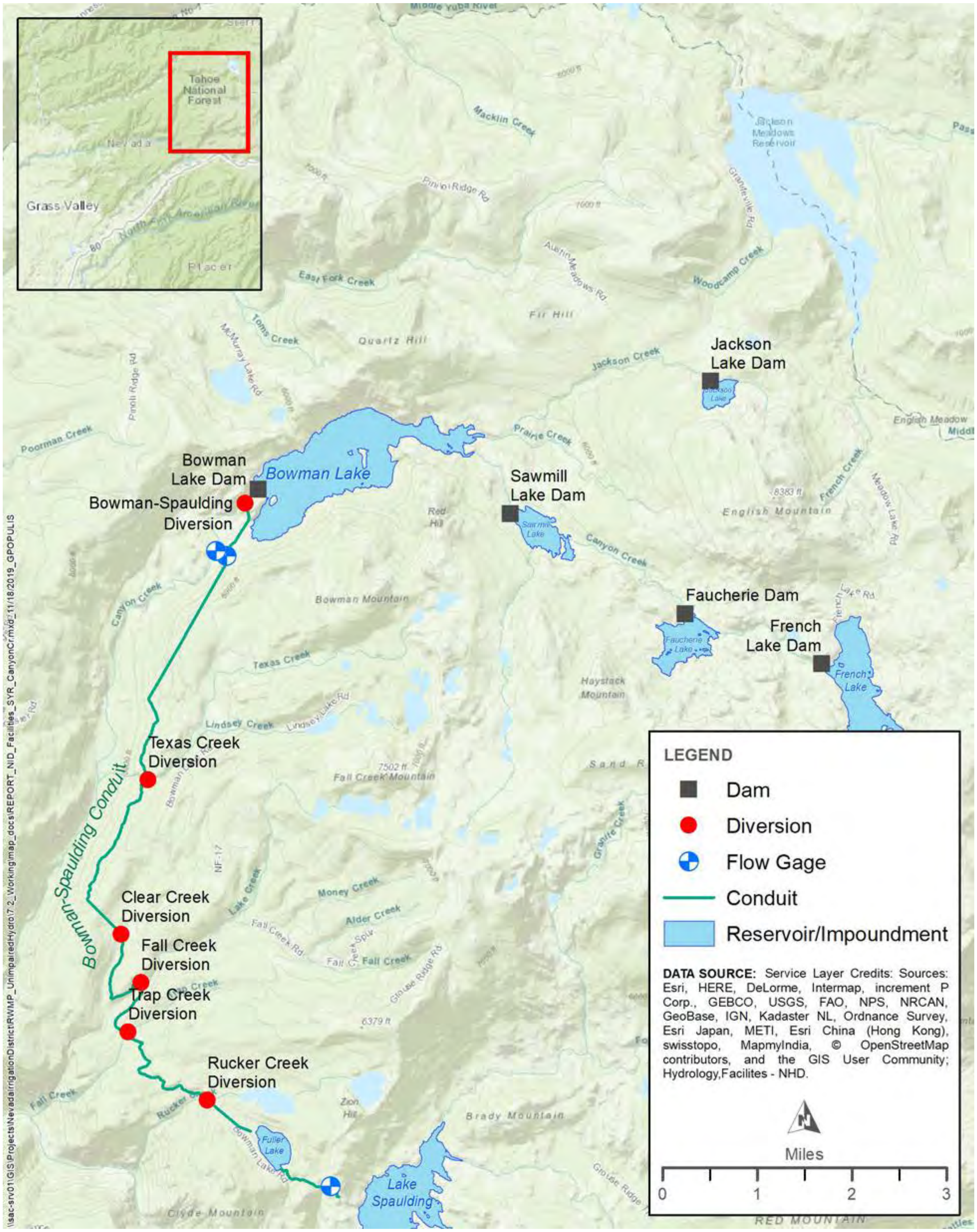
[2] Not all reservoir storage is usable. Unusable storage is made up of either dead storage or minimum-pool storage. Dead storage is storage volume within a reservoir that is located below the lowest reservoir outlet. Minimum-pool storage is a regulatory requirement to maintain reservoir storage above a certain level.

Figure A-2 shows a map of NID's facilities in the South Yuba River watershed. Average monthly flows from gages in the South Yuba River watershed are shown in Table A-2.

Figure A-2. Map of NID facilities located within the South Yuba River watershed.



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Hydrology,Facilites - NHD.

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Table A-2. Historical Average Monthly Flows in the South Yuba Watershed.

Location	Average Monthly Inflow[1] (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Canyon Creek Below Bowman Lake[2]	4.9	9.4	26.0	24.3	32.3	47.0	55.3	107.2	85.5	14.9	4.7	5.1	25.1
Bowman-Spaulding Canal Intake[3]	194.2	154.8	139.2	90.2	127.5	129.6	116.4	134.6	168.4	199.1	247.2	243.9	117.5
Bowman-Spaulding Canal above Lake Spaulding[4]	202.1	169.9	164.4	110.5	170.4	196.9	206.7	232.1	211.2	209.5	248.0	249.4	143.1

[1] Common period of record of all gages is 10/01/1975- 9/30/2003, 10/01/2005 – 9/30/2017
[2] Canyon Creek below Bowman Lake flow from USGS Gage 11416500
[3] Bowman-Spaulding Canal Intake flow from USGS Gage 11416000
[4] Bowman-Spaulding Canal above Lake Spaulding from USGS Gage 11416100
Key: cfs = cubic feet per second TAF = thousand acre-feet

Bear River

The Bear River is a predominantly rainfall-fed stream, with peak runoff occurring from December through May. Both NID and PG&E use the Bear River as a conveyance reach for water originating in the Yuba River and American River watersheds, and both have water rights to natural runoff in the Bear River. Water is diverted by NID and PG&E from Lake Spaulding to the Bear River through the Drum Canal. Both imported and natural water in the Bear River pass through a series of powerhouses before entering Rollins Reservoir, the primary storage reservoir on the Bear River, with a usable storage capacity[3] of 54,453 ac-ft (NID 2012). A portion of the releases from Rollins Reservoir are diverted immediately downstream to the Bear River Canal by NID and PG&E. NID also diverts water from the Bear River to the Combie Phase I Canal, located approximately 13 miles downstream of Rollins Reservoir at Lake Combie. Figure A-3 shows a map of facilities located in the Bear River watershed. Average monthly flows for gages in the Bear River watershed are shown in Table A-3. Flows in Table A-3 represent a blend of imported and natural water. Not all of the flows reported in Table A-3 are available to NID for use as water supply.

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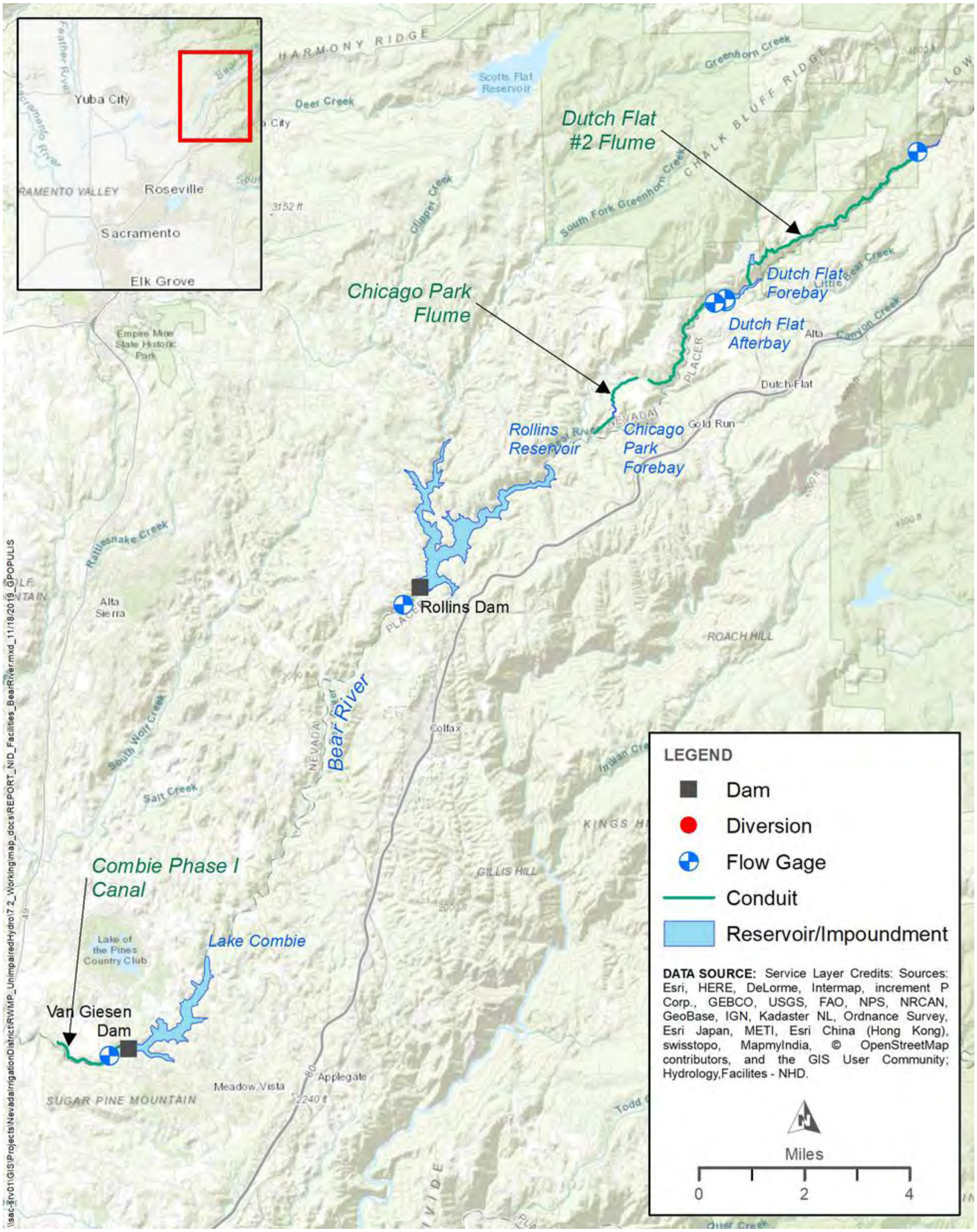
[3] Not all reservoir storage is usable. Unusable storage is made up of either dead storage or minimum-pool storage. Dead storage is storage volume within a reservoir that is located below the lowest reservoir outlet. Minimum-pool storage is a regulatory requirement to maintain reservoir storage above a certain level.

Figure A-3. Map of NID facilities located within the Bear River watershed.



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Hydrology,Facilites - NHD.

Table A-3. Historical Average Monthly Flows in the Bear River Watershed.

Location	Average Monthly Inflow[1] (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Bear River near Emigrant Gap[2]	8.3	11.8	24.8	25.0	36.1	73.3	81.5	100.0	61.0	24.6	15.6	12.1	28.6
Drum Canal[3]	314.4	381.0	431.0	428.2	449.4	509.1	600.2	668.0	649.6	623.2	579.6	328.4	360.0
Bear River below Drum Afterbay[4]	6.8	8.9	15.4	16.7	28.0	32.6	39.8	32.8	15.8	12.2	13.5	11.6	14.1
Dutch Flat No 2 Flume[5]	147.8	191.6	234.9	243.5	300.6	359.8	351.1	378.2	346.2	332.5	302.5	162.3	202.2
Bear River below Dutch Flat Afterbay[6]	18.0	14.1	30.0	21.1	40.9	31.1	54.7	32.5	33.5	28.7	25.9	26.1	21.4
Chicago Park Flume[7]	302.9	417.6	518.4	555.5	599.6	668.9	697.7	749.4	683.3	621.9	567.2	323.4	404.6
Bear River below Rollins[8]	115.4	177.1	439.1	568.4	743.5	758.7	680.1	542.2	364.4	248.3	186.2	150.6	298.7
Bear River below Lake Combie[9]	36.7	160.3	447.8	558.3	745.0	845.4	704.9	478.7	276.3	139.7	68.8	54.8	270.9

[1] Common period of record of all gages is 12/18/1978 – 9/30/2017
[2] Bear River near Emigrant Gap flow from USGS Gage 11421710
[3] Drum Canal flow from USGS Gage 11414170
[4] Bear River below Drum Afterbay flow from USGS Gage 11421770
[5] Dutch Flat No 2 Flume flow from USGS Gage 11421760
[6] Bear River below Dutch Flat Afterbay flow from USGS Gage 11421790
[7] Chicago Park Flume flow from USGS Gage 11421780
[8] Bear River below Rollins Dam flow from USGS Gage 11422500
[9] Bear River below Lake Combie flow from NID Gage BR300
Key: cfs = cubic feet per second TAF = thousand acre-feet

Deer Creek

Deer Creek is a predominantly rainfall-fed stream, with peak runoff occurring from December through May. Water is also imported into Deer Creek by NID from the Bowman-Spaulding Conduit through the South Yuba Canal. Local watershed runoff and imported water are stored in Scotts Flat Reservoir, which has a usable storage capacity[4] of 43,547 ac-ft (Kleinschmidt Associates 2011). Figure A-4 shows a map of NID facilities located in Deer Creek. Water is released from Scotts Flat Reservoir from mid-April through mid-October to meet seasonal NID customer demand. Average monthly flows for gages in the Deer Creek watershed are shown in Table A-4.

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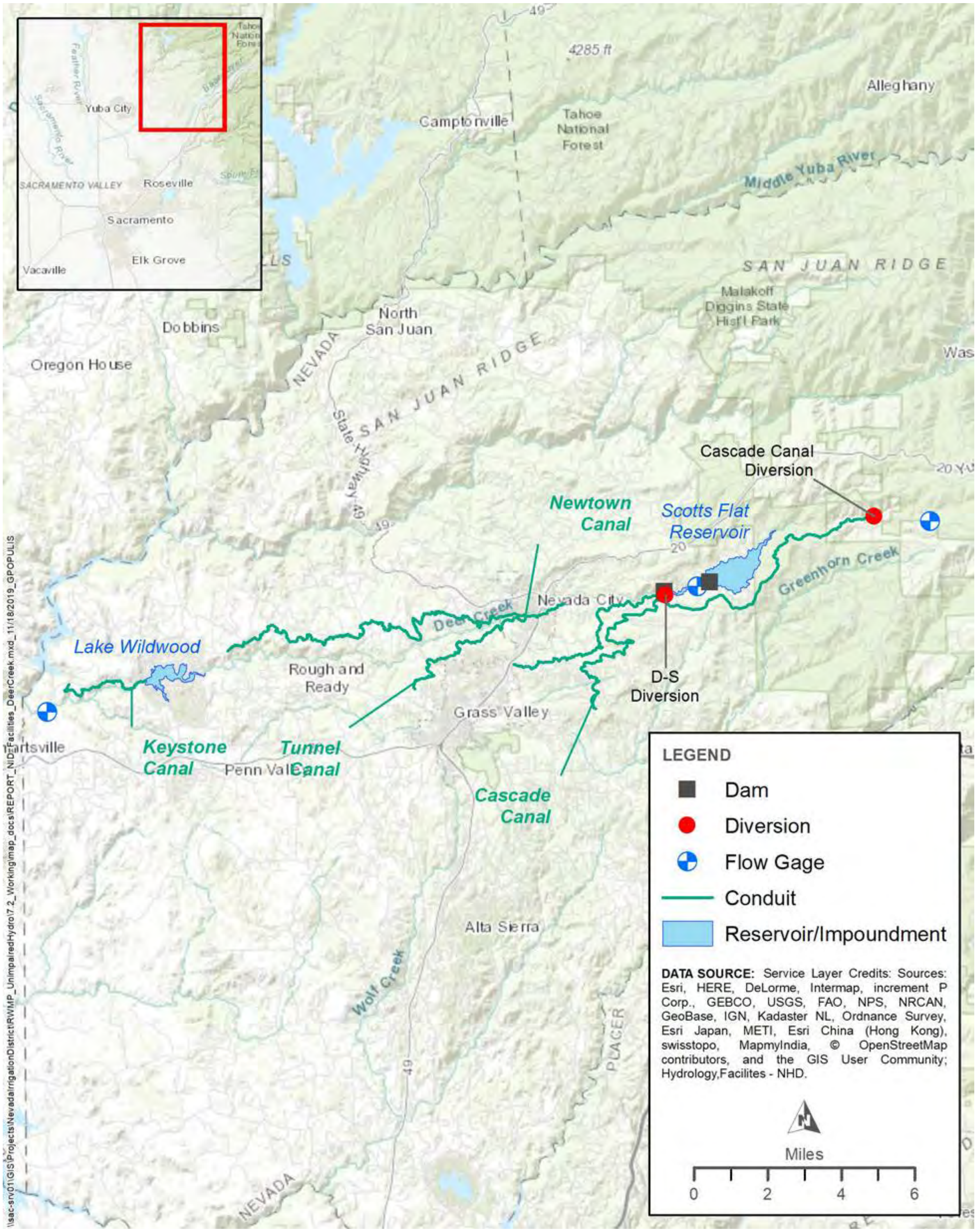
[4] Not all reservoir storage is usable. Unusable storage is made up of either dead storage or minimum-pool storage. Dead storage is storage volume within a reservoir that is located below the lowest reservoir outlet. Minimum-pool storage is a regulatory requirement to maintain reservoir storage above a certain level.

Figure A-4. Map of NID facilities located within the Deer Creek watershed.



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Hydrology,Facilites - NHD.

Table A-4. Historical Average Monthly Flows in the Deer Creek Watershed.

Location	Average Monthly Inflow[1] (cfs)												Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Chalk Bluff Canal[2]	53.7	41.1	38.3	39.3	39.7	41.6	23.6	51.3	63.2	61.9	61.7	60.2	34.8
Deer Creek below Scotts Flat Reservoir[3]	42.8	12.1	11.1	17.9	24.5	40.5	56.2	62.8	69.8	83.9	89.2	83.6	36.0
Deer Creek near Smartsville[4]	38.2	42.2	144.7	250.1	315.9	304.7	163.0	65.6	16.0	5.1	3.9	5.3	106.1

[1] Common period of record of all gages is 10/1/1975-9/30/2018
[2] Chalk Bluff Canal flow from Gage YB-34
[3] Deer Creek below Scotts Flat Reservoir flow from NID Gage DC-125
[4] Deer Creek near Smartsville flow from USGS Gage 11418500
Key: cfs = cubic feet per second TAF = thousand acre-feet

Reservoir Storage

Reservoir (carryover) storage is the second largest source of water supply available to NID to meet customer demand. Historical reservoir storage is summarized in Table A-5 for Water Years 1976 through 2017. April 15 is the approximate starting date of the irrigation season, June 15 is the approximate end date of rainfall and snowmelt runoff, and October 14 is the approximate end data of the irrigation season. Any storage left in reservoirs at the end of the irrigation season is considered carryover storage. Carryover storage is stored water held in reserve for droughts or for emergency supply to avoid water shortages, and to meet environmental flow requirements.

Table A-5. Historical average reservoir storage on April 15, June 15, and October 14, for Water Years 1976 through 2017.

Location	Average Reservoir Storage (ac-ft)		
	April 15	June 15	October 14
Jackson Meadows[1]	41,056	57,973	36,974
Jackson Lake	941	1,230	845
French Lake	10,334	12,384	7,131
Faucherie Lake	3,840	3,955	2,865
Sawmill Lake	3,019	3,006	2,153
Bowman Lake[2]	43,463	60,896	42,517
Total Mountain Division Storage	**102,653**	**139,445**	**92,485**
Rollins Reservoir[3]	55,256	54,405	34,625
Lake Combie	5,528	5,115	3,057
Scotts Flat Reservoir	46,343	44,588	29,647
Foothill Division Storage	**107,127**	**104,108**	**67,329**
Total Storage[4]	***209,780***	***243,553***	***159,814***
Total Usable Storage[5]	***200,562***	***234,335***	***150,596***

[1, 2] Based on 2009 bathymetric survey storage capacity curve (Devine Tarbell & Associates 2009).
[3] Based on 2007/2008 bathymetric survey storage capacity curve (Devine Tarbell & Associates 2009).
[4] Sum of the total Mountain Division storage and the Foothill Division storage.
[5] Total storage minus 9,218 ac-ft of dead storage and/or minimum pool storage.
Key: ac-ft = acre-feet

Not all reservoir storage is usable. System-wide, a total of 9, 218 ac-ft of reservoir storage is considered either dead storage or minimum-pool storage, as summarized in Table A-6, and is not available for use. Dead storage is storage volume within a reservoir that is located below the lowest reservoir outlet. Minimum-pool storage is a regulatory requirement to maintain reservoir storage above a certain level. The estimate of system-wide amount of usable storage has increased from previous studies (Kleinschmidt et al 2005, Kleinschmidt Associates 2011) primarily because of changes to regulatory requirements for Jackson Meadows Reservoir. Previous values included a 21,000 ac-ft regulatory minimum-pool, which is no longer required. Dead storage values have also been updated based on new bathymetric surveys for Jackson Meadows and Rollins reservoirs. The usable storage reported in Table A-5 is the total storage minus 9,218 ac-ft.

Table A-6. Unusable reservoir volume in NID's storage reservoirs.

Reservoir	Unusable Storage (ac-ft)
Jackson Meadows	2,486[1]
Jackson Lake	0
French Lake	0
Fauchierie Lake	249[2]
Sawmill Lake	0
Bowman Lake	0[2]
Rollins Reservoir	270[3]
Lake Combie	1,213[4]
Scotts Flat Reservoir	5,000[5]
Total	***9,218***

[1] Reservoir storage at elevation 5,933 ft, the low-level outlet invert. Based on 2009 bathymetric survey storage capacity curve (Devine Tarbell & Associates 2009).

[2] California State Water Resources Control Board regulatory minimum-pool requirement.

[2] Reservoir storage at elevation 5,401 ft, the low-level outlet invert. Based on 2009 bathymetric survey storage capacity curve (Devine Tarbell & Associates 2009).

[3] Reservoir storage at elevation 1,970 ft, the low-level outlet invert. Based on 2007/2008 bathymetric survey storage capacity curve (Devine Tarbell & Associates 2009).

[4] Reservoir storage at elevation 1,580 ft, practical level to avoid souring accumulated sediment causing extreme water quality issues.

[5] California Department of Fish and Wildlife regulatory minimum-pool requirement.

Key: ac-ft = acre-feet

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Appendix B. Development of Historical Gage-Proration Unimpaired Hydrology

Appendix B – Development of Historical Gage-Proration Unimpaired Hydrology

Introduction

The purpose of this appendix is to document the methods used to develop historical unimpaired hydrology. Unimpaired flow is defined as the hydrologic response of watershed basins with no influence (i.e., regulation) of stream flow by man-made structures such as dams or diversions. Quantification of unimpaired flow is important because it is used to estimate watershed runoff, required for understanding the timing and volume of water supply available to NID. Watersheds that contribute runoff to NID's water supply are either ungaged or highly regulated, or both. Because it is not possible to directly measure runoff in these watersheds it is necessary to synthesize unimpaired hydrology to quantify how much water is available to NID from runoff.

HDR first developed an unimpaired hydrology data set for Water Years[1] 1976 to 2008 during the joint FERC relicensing of NID's Yuba-Bear Hydroelectric Project and PG&E's Drum-Spaulding Project (Nevada Irrigation District 2012). These data sets have been updated and extended to include additional sub-basins and cover a longer period of record from Water Year 1976 through 2011. The lower bound of 1976 was chosen based on availability of stream gage data. The upper bound of 2011 is based on the available period of record of VIC model hydrologic data provided by the California Water Commission (CWC 2016) used for climate change assessments.

Gage Summation versus Gage Proration Methodology

This study applied two common approaches used to derive unimpaired hydrology in regulated watersheds: (1) gage summation using relevant stream and reservoir gages within the basin of interest, and (2) gage proration using data from nearby gaged reference basins with similar rainfall-runoff response to construct synthetic unimpaired hydrographs for the basin of interest.

The gage-summation method directly uses observed (i.e., gage) data to calculate unimpaired flow based on the regulated flow and storage data associated with man-made structures. For example, a reservoir will typically accumulate inflows during winter months and release outflows during summer months. This buffering of basin through-flow can be removed from the hydrograph using the daily change in reservoir storage in conjunction with reservoir discharge data to back calculate the unimpaired flow (Q_{inflow}) using the hydrologic water budget equation:

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[1] Water years are defined as October 1 of the previous year through September 30 of the year documented.

$$\Delta S = Q_{inflow} - Q_{outflow} - Q_{losses}$$

Where: ΔS is the change in storage (cfs);
Q_{inflow} is the inflow (cfs);
$Q_{outflow}$ is the outflow (cfs); and
Q_{losses} is the sum of all losses, e.g. evaporation (cfs).

The gage-summation method also incorporates stream flow gage data from contributing drainage areas and accounts for losses from diversion flows.

The gage-summation method is subject to inaccuracies typically found in reservoir storage and stream flow gage data. A small error in reservoir elevation can result in a large error in calculated flow. Errors are evident in the summation data as negative inflows, as well as random or atypical hydrologic fluctuations. Accumulation of error from the gage data can render a significant portion of the synthesized daily unimpaired flow data to be unreliable. Also, data gaps in the gage record present a significant problem for use of the summation method.

A second approach, the gage-proration method (Mann et al 2004), characterizes unimpaired flows throughout a region of interest by utilizing flow data from a nearby unimpaired reference basin that has good gage data. The gage-proration method applied in this study gives an estimate of unimpaired flows for a given watershed of interest by scaling the reference basin's hydrograph as follows:

$$Q_{target} = \left(\frac{A_{target}}{A_{reference}}\right)\left(\frac{P_{target}}{P_{reference}}\right) Q_{reference}$$

Where: Q_{target} is the flow (cubic feet per second) for the sub-basin of interest;
$Q_{reference}$ is the flow (cubic feet per second) for the reference basin;
A_{target} is the drainage area (square miles) for the sub-basin of interest;
$A_{reference}$ is the drainage area (square miles) for the reference basin;
P_{target} is the mean annual precipitation (inches) for the sub-basin of interest; and
$P_{reference}$ is the mean annual precipitation (inches) for the reference basin.

Drainage areas were taken directly from USGS records where available, or by using Geographic Information System (GIS) data to delineate watersheds. Mean annual precipitation values were calculated using GIS to sum gridded mean-annual precipitation data published by the PRISM Climate Group (http://www.prism.oregonstate.edu/) for each basin.

Development of the FERC Relicensing Unimpaired Hydrology Dataset

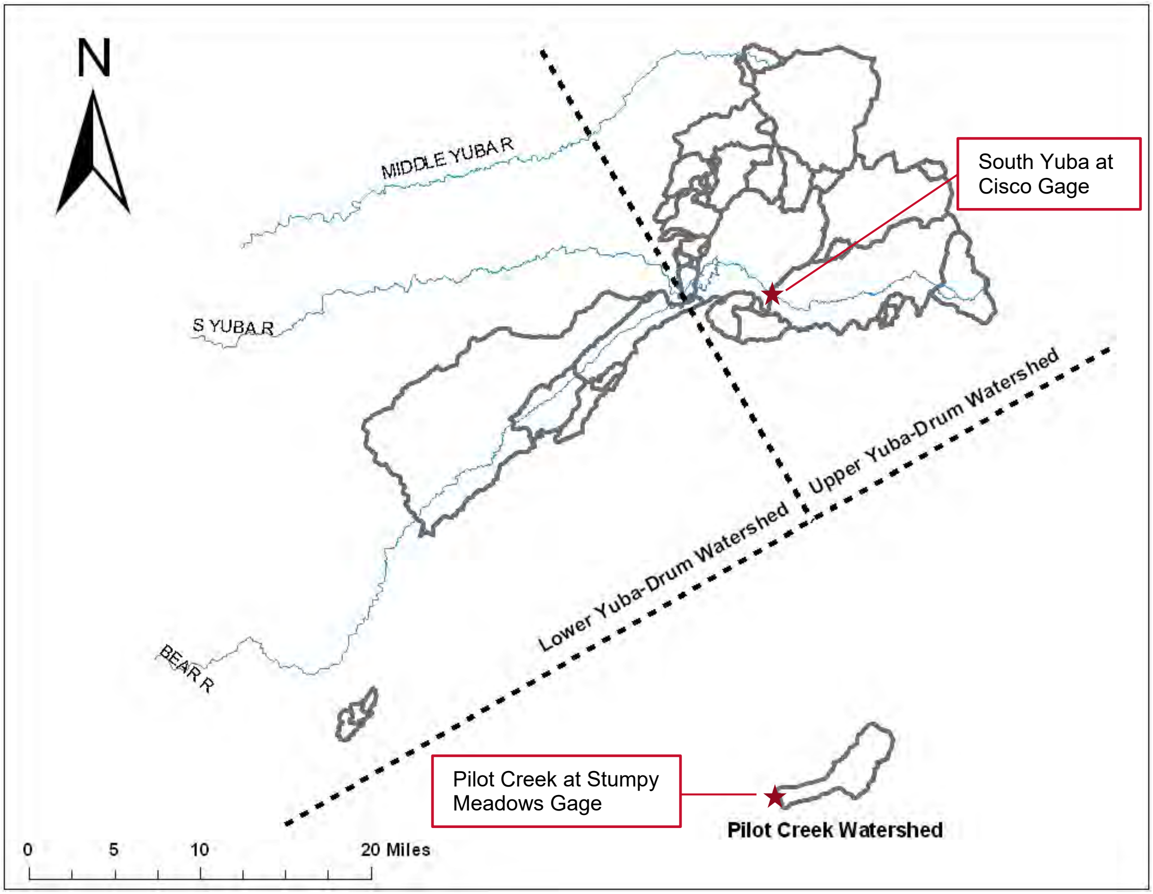
Unimpaired hydrology data were developed for the joint FERC relicensing of NID's Yuba-Bear Hydroelectric Project (FERC Project Number 2266) and PG&E's Drum-Spaulding Hydroelectric Project (FERC Project Number 2310). A report detailing the development of the unimpaired flow data can be found in Appendix E12 of Exhibit E of NID's application for a new FERC license (Devine Tarbell & Associates 2008). These data were accepted by FERC and other state and federal agencies to adequately represent historical unimpaired hydrology within the two hydroelectric project areas and were used during the relicensing process to evaluate impacts of potential operations and facilities modifications.

Gage summation was used as the initial approach for calculating unimpaired hydrology, However, during the development process it was determined that this method was not feasible for most of the sub-basins, primarily due to a lack of data for the full Period of Record (Water Years 1976 through 2008) at many locations (Devine Tarbell and Associates 2008). Therefore, two suitable reference basins were identified, one for basins with elevation greater than 5,000 feet and one for basins with elevation less than 5,000 feet, so that gage-proration could be utilized as a first step for synthesizing unimpaired flow data.

The South Yuba watershed above the stream gage at Cisco (USGS gage 11414000) was used as the gage-proration reference basin for high-elevation sub-basins (Upper Yuba-Drum Watershed) and the Pilot Creek watershed above Stumpy Meadows Reservoir stream gage (USGS gage 11431800) was used as the reference basin for low-elevation sub-basins (Lower Yuba-Drum Watershed). The distribution of high-elevation and low-elevation sub-basins is shown in Figure B-1. The South Yuba above Cisco location was selected as the reference basin because: 1) it is located within the Upper Yuba-Drum Watershed and is hydrologically similar to the other high-elevation sub-basins of interest; 2) it has very good data quality for the entire POR; and 3) its hydrology is largely unimpaired. The Pilot Creek watershed has good gage data with a full POR and its hydrology is completely unimpaired. Although the Pilot Creek sub-basin is located outside (to the south of) the Lower Yuba-Drum Watershed, it is representative of the lower-elevation sub-basins in terms of watershed setting, elevation, and shape.

The South Yuba at Cisco gage measures runoff from its entire watershed, which ranges in elevation from approximately 5,600 ft-msl at the gage to over 9,000 ft-msl at Castle Peak. To account for differences in elevation between other sub-basins in the Upper Yuba-Drum Watershed and the Cisco basin (both in range of elevations and percent of basin with a certain range of elevations), historical Cisco unit-area flow was parsed into discrete 1,000 ft elevation bands to be used as runoff spectrum for the other sub-basins based on their relative elevation ranges. Unique monthly average elevation corrections by elevation band were developed for each water year in the period of record using historical Cisco flow to distribute the relative runoff within each elevation band. Monthly flow errors were limited to no more than 2 percent for the entire Cisco basin within any given month. Utilization of unit-area flows by elevation band created more realistic seasonal unimpaired hydrographs, accounting for impacts of differing sub-basin elevation ranges on temporal runoff patterns from snowmelt.

Figure B-1. Map of the upper and lower basins, and the Pilot Creek reference basin.



Adequate gage data were available to calculate gage-summation unimpaired hydrology at 3 locations in the Upper Yuba-Drum watershed: the Middle Yuba at Milton Diversion Dam (Figure B-2), Canyon Creek at Bowman Dam (Figure B-3), and Fordyce Creek at Fordyce Dam (Figure B-4). The gage-summation hydrology was used to validate the gage-proration methodology using the Cisco watershed as a reference basin. Unimpaired flow data at Bowman Dam and Fordyce Dam compared well between methods. The comparison for Milton Diversion Dam, however, showed a distinct difference between the two methodologies. The difference was thought to be caused either by a faulty gage (or gages) in the Milton Diversion Dam sub-basin, or a poor matchup between the Cisco reference basin and the Middle Yuba River sub-basins being modeled. With input from FERC relicensing participants, monthly scaling factors were developed to adjust the gage-proration unimpaired hydrology based on comparison to gage-summation unimpaired hydrology. The average scaling factor for Water Years 1976 through 1986 is 0.75, and for Water Years 1987 through 2008 is 0.70.

Figure B-2. Comparison of Gage summation and gage proration unimpaired hydrology for the Middle Yuba River at Milton.

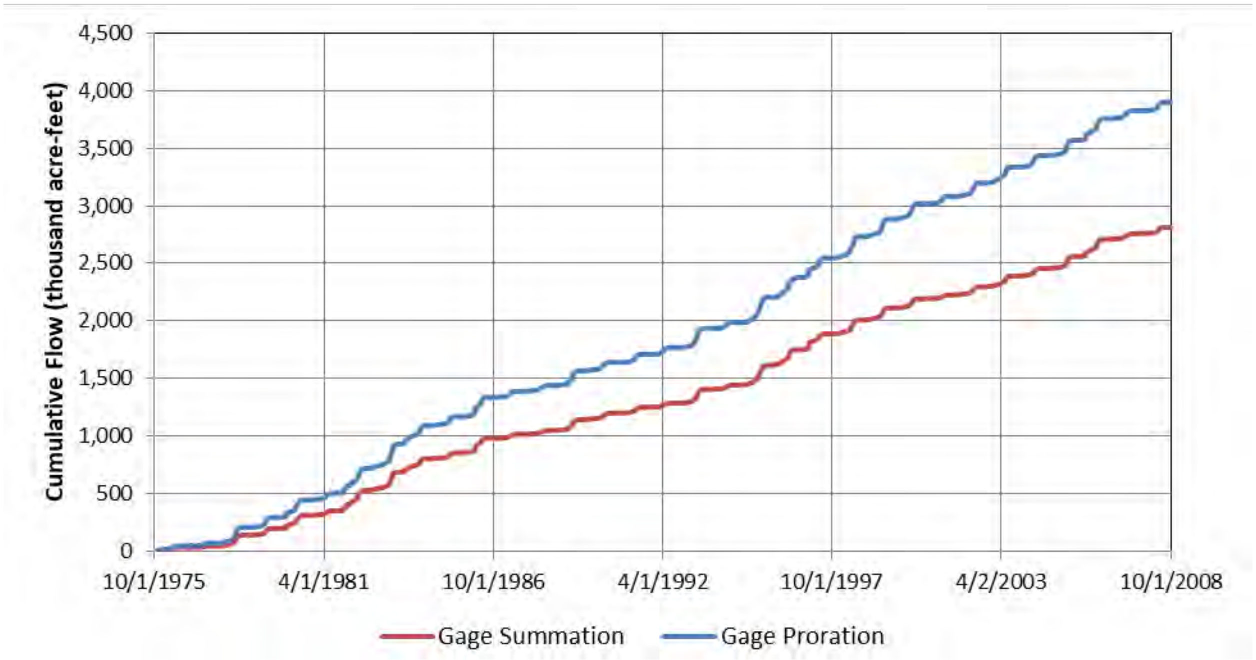


Figure B-3. Comparison of Gage summation and gage proration unimpaired hydrology for Canyon Creek at Bowman Dam.

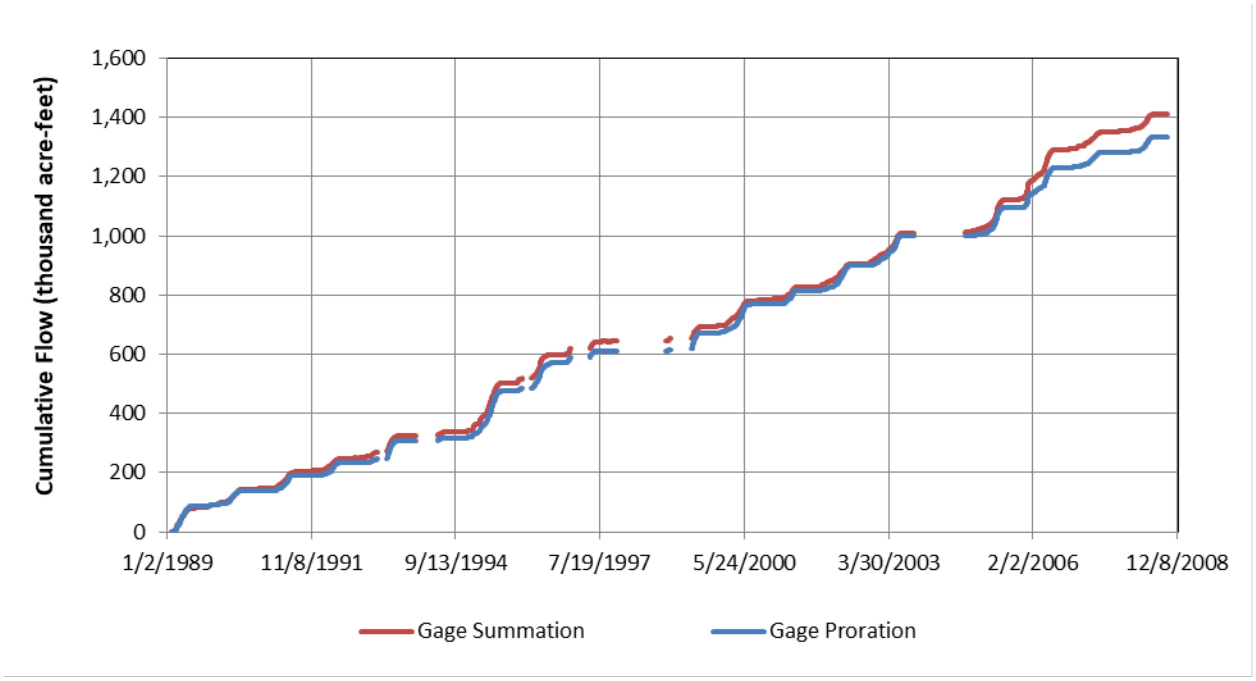
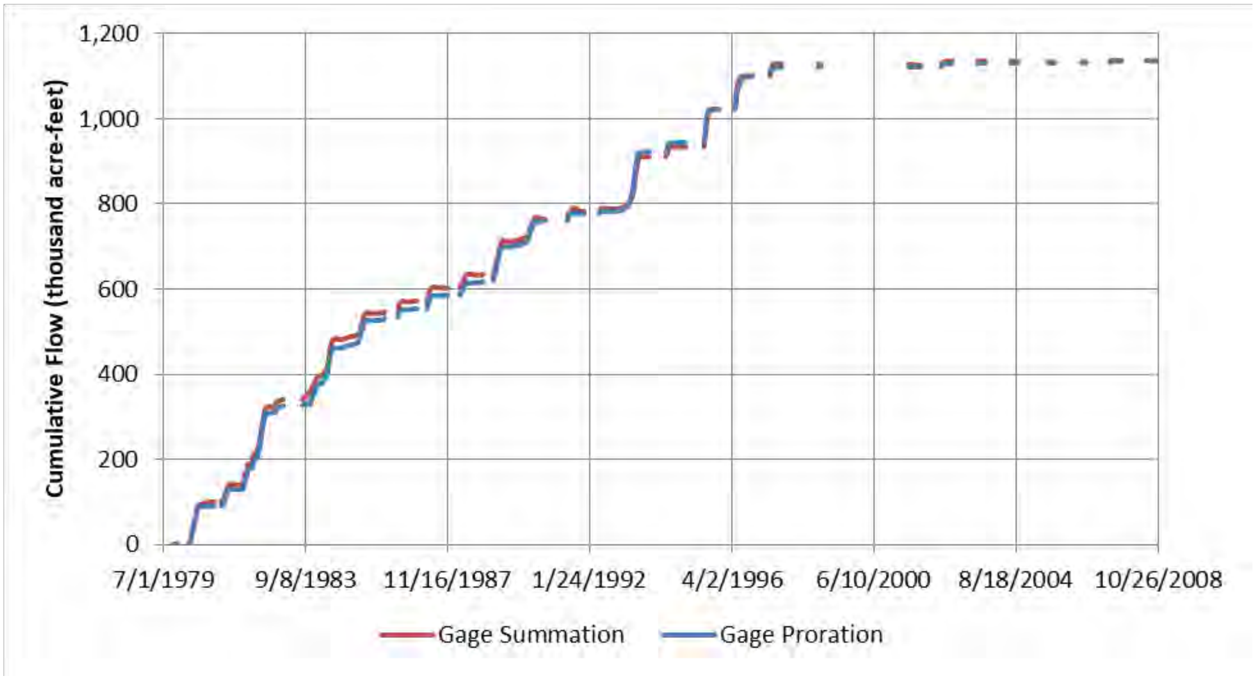


Figure B-4. Comparison of Gage summation and gage proration unimpaired hydrology for Fordyce Creek at Fordyce Dam.



Combined Gage-Proration Technique to Redevelop Low-Elevation Unimpaired Hydrology

The original FERC unimpaired hydrology data set does not cover all areas of the watershed where NID stores water, diverts water, or has water rights, as it only addressed sub-basins within the FERC project boundary. As part of this study, additional daily average unimpaired hydrology data were developed for sub-basins in:

- The Bear River downstream of the Bear River Canal and upstream of Camp Far West Dam;
- Deer Creek above Lake Wildwood Dam;
- Coon Creek downstream of Halsey Afterbay and Rock Creek Reservoir and above Camp Far West Canal; and
- Auburn Ravine above Hemphill Canal.

The additional watersheds include areas that are lower in elevation than sub-basins in the existing FERC unimpaired hydrology data set. For example, sub-basins in Auburn Ravine range in elevation from approximately 200 ft to 1,700 ft. Pilot Creek, the original reference gage for low-elevation sub-basins, is representative of mid-elevation watersheds (4,250 feet to 6,250 feet), but is not applicable to lower elevation watersheds because of differences in quantity and timing of snowmelt runoff contributions. Therefore, additional reference gages were compiled to better represent the extended elevation ranges, summarized in Table B-1. Figure B-5 is a location map showing the reference basins used.

Table B-1. Reference gages used to develop unimpaired hydrology for low-elevation sub-basins.

Gage Name	USGS Gage Number	Start Date	End Date	Elevation Range (ft)	Drainage Area (mi^2)
Cosumnes River at Michigan Bar	11335000	10/1/1975	9/30/2011	250 – 7,500	534.6
Oregon Creek above Log Cabin Diversion	11409300	10/1/1975	9/30/2000	2,000 – 6,000	23.0
South Honcut Creek near Bangor	11407500 A05775 (DWR)	10/1/1975 7/6/2006	9/30/1986 9/30/2011	500 – 3,500	30.6
Pilot Creek above Stumpy Meadows	11431800	10/1/1975	9/30/2011	4,250 – 6,250	11.6
Deadwood Creek (sum)[1]	11413320[2] + 11413323[3] + 11413326[4]	10/1/1994	9/30/2011	3,000 – 4,000	5.0

[1] Water Years 2005 and 2006 are missing.

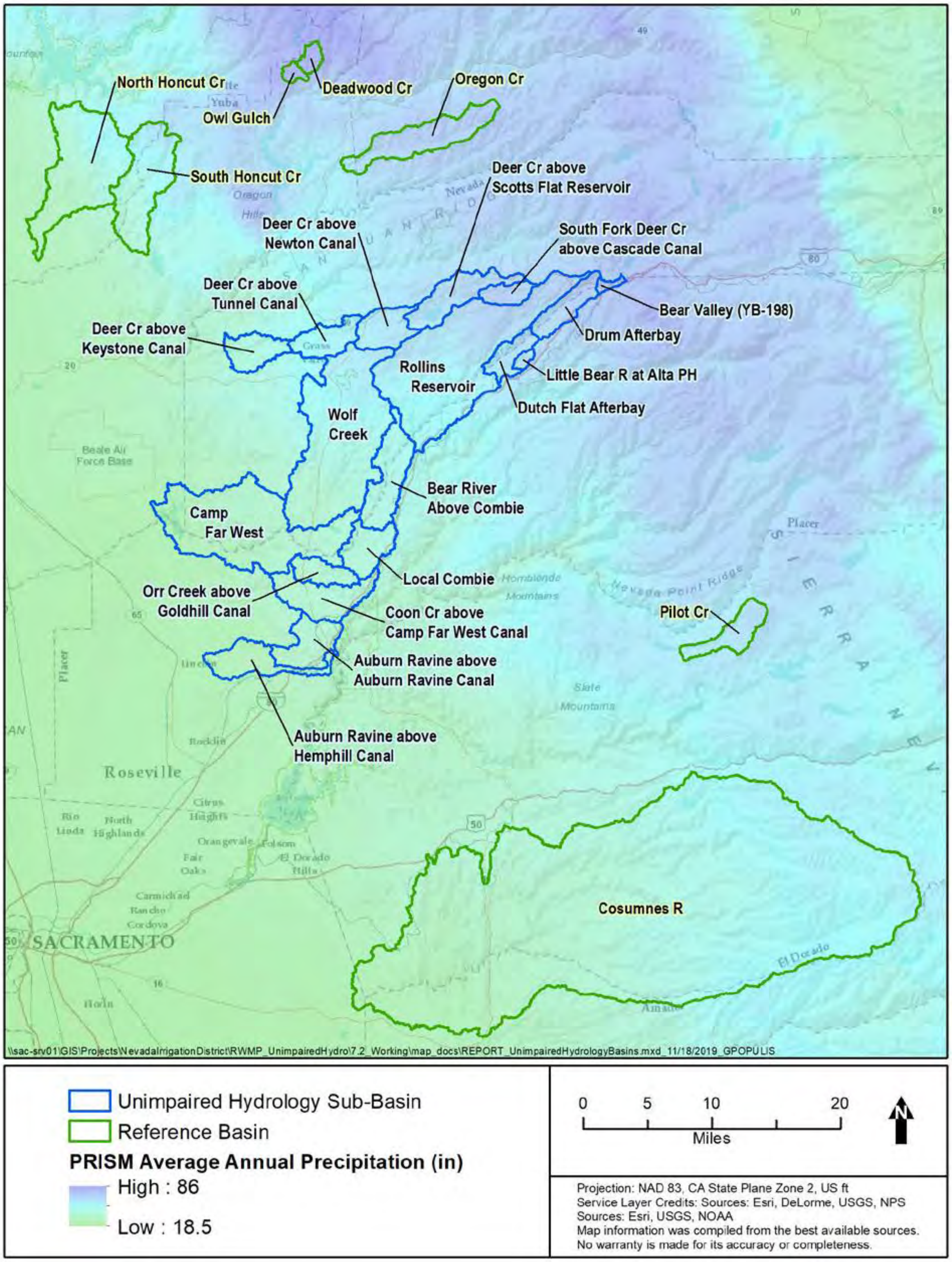
[2] Deadwood Creek near Strawberry Valley, CA.

[3] Owl Gulch near Strawberry Valley, CA.

[4] Deadwood Creek Power Plant near Strawberry Valley, CA.

Key: ft = feet mi^2 = square miles

Figure B-5. Map of reference basins used in unimpaired hydrology development and sub-basins (center of figure) where the reference basin data were applied.



The combined gage proration method subdivides both reference and target sub-basin areas into elevation bands and prorates the reference gage data by area and precipitation associated with each elevation band.

$$Q_{target} = \sum\nolimits_{j}\left[\sum\nolimits_{i}\left[Q_i\left(\frac{A_{ij}P_{ij}}{\sum_j A_{ij}P_{ij}}\right)\left(\frac{A_{tj}P_{tj}}{\sum_i A_{ij}P_{ij}}\right)\right]\right]$$

Where: Q_{target} is the flow (cubic feet per second) for the sub-basin of interest;
j refers to the elevation band
i refers to the reference basin
Q_i is the flow (cubic feet per second) for a reference basin;
A_{ij} is the drainage area (square miles) for the reference basin (i) and the elevation band (j);
P_{ij} is the mean annual precipitation (inches) for the reference basin (i) and the elevation band (j);
A_{tj} is the drainage area (square miles) for the elevation band (j) of sub-basin of interest; and
P_{tj} is the mean annual precipitation (inches) for the sub-basin of interest and the elevation band (j).

The combined gage proration method prorates gage data from multiple reference basins based on drainage area and average annual precipitation by 250 ft elevation bands. The benefits of using multiple reference gages to develop unimpaired hydrology include:

- Duplicate records allow coverage of reference gage data gaps.
- Inclusion of reference gages to the north and south of the target basins removes regional biases of individual reference basins.
- Reference gages can be selected based on similarities in watershed elevation ranges to the target sub-basin elevation range.
- Errors from individual gages are muted.

This method was used to develop unimpaired hydrology for the new sub-basins listed above, as well as to redevelop the unimpaired hydrology for all previous sub-basins in the Bear River watershed for consistency.

This combined gage proration approach was also used to develop unimpaired hydrology for Don Pedro Hydroelectric Project (FERC Project Number 2299) relicensing (Turlock Irrigation District and Modesto Irrigation District 2017).

Validation of the Combined Gage Proration Method

While the shape of a daily hydrograph is important for sub-daily operations decisions, reservoirs buffer their inflow making the shape less important than the overall inflow volume for studies of water supply in regulated watersheds. In the Bear River, Rollins Reservoir buffers both natural and imported flow. Combined gage-proration monthly inflow volumes to Rollins Reservoir were compared to reconstructed natural monthly inflow volumes to validate the combined gage proration technique.

Reconstruction of Rollins Reservoir Natural Inflow

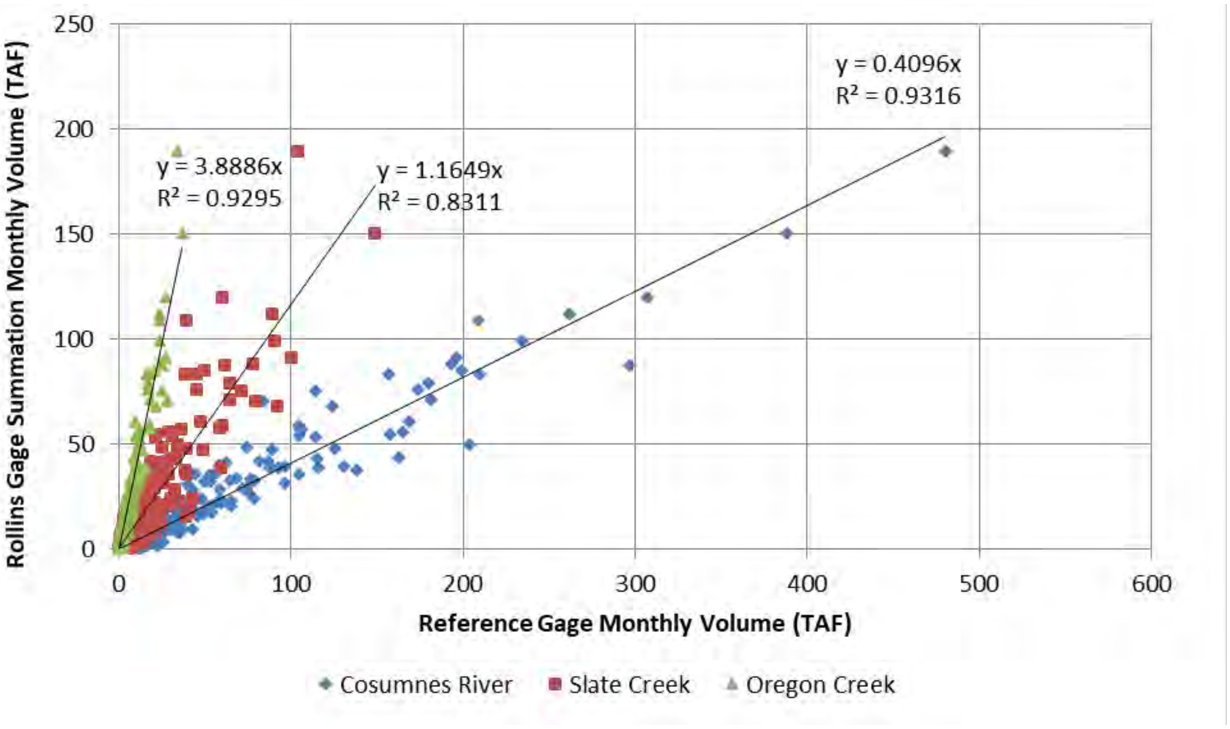
On a short-term (daily, weekly) basis, gage summation hydrographs are prone to error due to a number of factors, including missing data, poor data, intermittent data collection, measurement rounding, ungaged evaporation, canal leakage, and canal spillage. On a monthly basis, these errors are averaged out, but can still result in a poor representation of natural inflow.

Rollins Reservoir gage summation includes twelve gages in the Bear River basin. All twelve gages have a limited overlapping period of record, from October 1, 1992 to September 30, 2005. The Towle Diversion gage (PG&E gage YB-93), a critical gage used in the summation, had the shortest period of record. The following updates were made to minimize some of the known shortfalls of the historical gage record to improve and expand the gage summation period of record:

1. Towle Diversion (YB-93) flow was synthesized to estimate missing gage data. A regression equation was developed to estimate flow at YB-93 using gage records from January 2, 1993 through September 30, 2005 of inflow to Alta Forebay (YB-117), Canyon Creek below Towle Diversion (YB-282), and Canyon Creek above Towle Diversion (YB-280).
2. Gage records of imports to the Bear River from Drum Canal (YB-137) and South Yuba Canal (YB-139) waste gates are very poor. As an alternative, drainage-area-proration of Pilot Creek above Stumpy Meadows was used to synthesize the natural flow in the Bear River at Emigrant Gap (YB-198). Waste gate imports were calculated by subtracting the synthetic natural flow from YB-198 gaged flow.

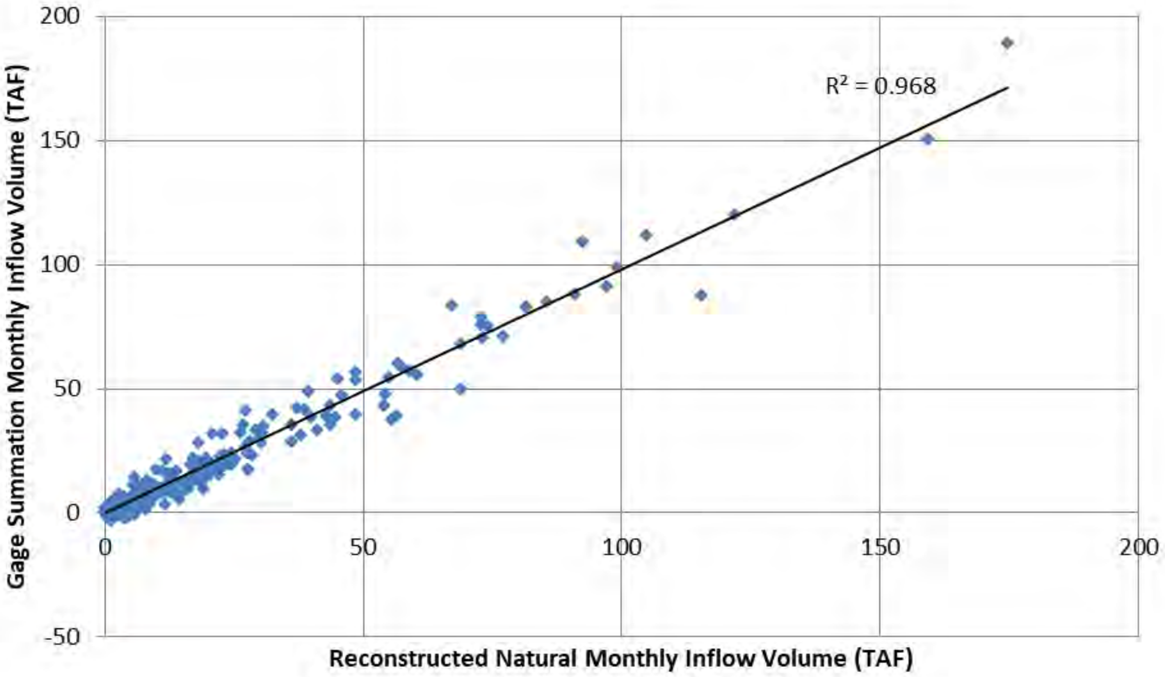
Gage summations were calculated daily and then averaged monthly. Even with the adjustments described above, there are some months when the calculated natural inflow to Rollins Reservoir was negative or unusually high. To smooth these data, a reconstruction of monthly Rollins Reservoir inflow volumes was created using linear regression of monthly volumes from three unimpaired USGS gages: Cosumnes River at Michigan Bar (USGS 11335000), Oregon Creek above Log Cabin (USGS 11409300), and Slate Creek above Diversion Dam (USGS 11413300+11413250). The Cosumnes River and Slate Creek basins both have a larger snowmelt component than the Bear River, so monthly multipliers were developed to reshape the gaged volumetric record. Figure B-6 shows the regressions used to reconstruct monthly natural inflow to Rollins Reservoir.

Figure B-6. Linear regressions of natural inflow to Rollins Reservoir from three unimpaired USGS gages.



There is some geographic variability in the amount of precipitation received during large storm events. This is why three gages were selected for this analysis, including one gage to the north (Slate Creek) and one to the south (Cosumnes River), relative to the low-elevation sub-basins for which unimpaired hydrology was being developed. An average of monthly volumes from the north and the south result in a better fit to Rollins Reservoir inflow than either the north or the south alone. Averages using the Cosumnes River and Oregon Creek regressions were used to reconstruct unimpaired inflow to Rollins Reservoir for Water Years 1976 through 2000. Averages using the Cosumnes River and Slate Creek regressions were used to reconstruct unimpaired inflow to Rollins Reservoir for Water Years 2001 through 2011. A comparison of the final reconstructed natural inflow to Rollins Reservoir compared to gage-summation inflow is shown in Figure B-7.

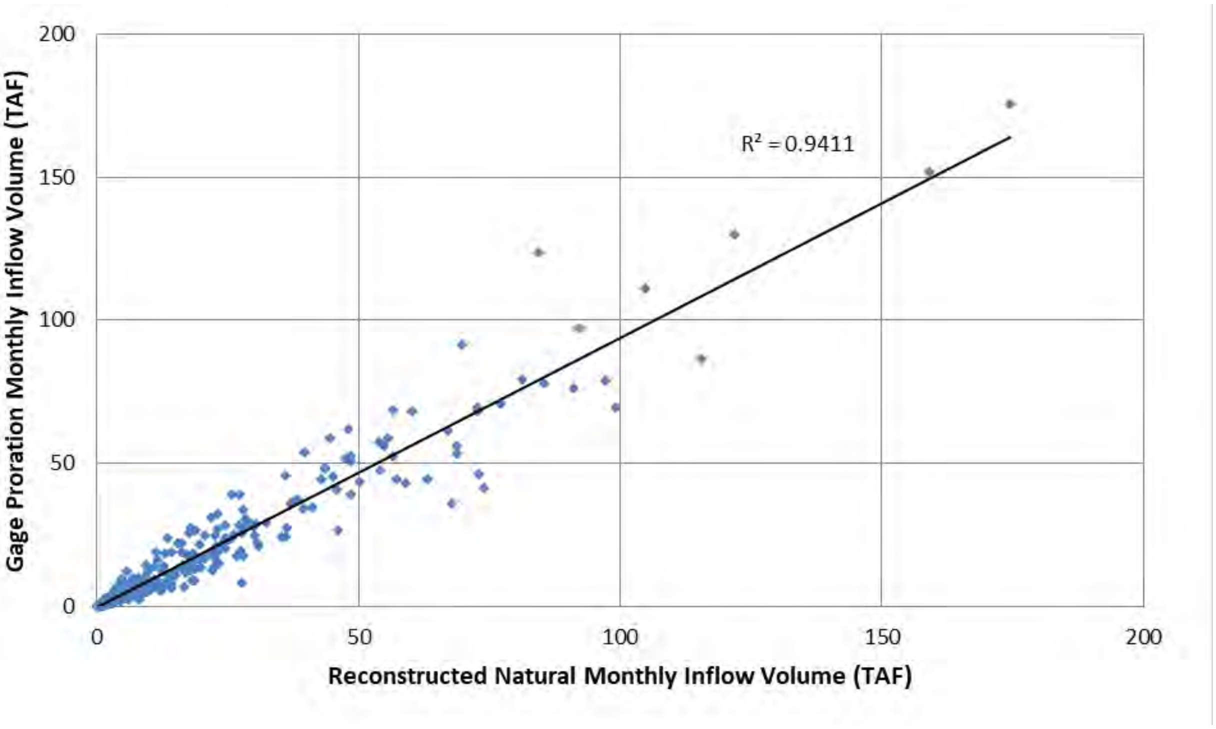
Figure B-7. Final reconstruction of monthly average natural inflow to Rollins Reservoir compared to monthly average gage summation inflow.



Validation Results

Gage-proration unimpaired hydrology for the Bear River above Rollins Reservoir was compared to the reconstructed natural monthly inflow to Rollins Reservoir to validate the combined gage proration technique, as shown in Figure B-8. Validation results show that unimpaired hydrology developed using the combined gage proration technique is able to reasonably represent reconstructed natural inflow to Rollins Reservoir. The combined gage proration technique was used to develop daily average unimpaired hydrology for all sub-basins in the Bear River, Deer Creek, Coon Creek, and Auburn Ravine watersheds.

Figure B-8. Results of gage proration monthly inflow volumes compared to reconstructed natural inflow to Rollins Reservoir.



Summary

Unimpaired hydrology is a fundamental input to NID's Operations Model, described in Section 4 of the Hydrologic Analysis Technical Memorandum. The historical unimpaired hydrology data set was developed to be compatible with the Operations Model's physical and temporal input requirements. Historical unimpaired hydrology was developed for 68 sub-basins in the Middle Yuba, South Yuba, Deer Creek, Bear River, Coon Creek, and Auburn Ravine watersheds for Water Years 1976 through 2011 using several methods.

A precipitation-weighted gage-proration method, using the South Yuba River at Cisco as a reference basin, was used to develop historical unimpaired hydrology for sub-basins in the Middle Yuba and South Yuba rivers, building on previously developed methods for FERC relicensing (Devine Tarbell & Associates 2008). The previous period of record (Water Years 1976 through 2008) for sub-basins in these watersheds was extended through Water Year 2011.

Combined gage proration, using a mix of low-elevation stream gages, was used to develop historical unimpaired hydrology for the remaining watersheds. Previously developed unimpaired hydrology for the Lower Yuba-Drum Watershed from the FERC relicensing was replaced with newly developed combined gage-proration unimpaired hydrology.

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PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, August 2016.

Turlock Irrigation District and Modesto Irrigation District. 2017. Don Pedro Hydroelectric Project FERC No. 2299 Amendment of Application.

Appendix C. Development of Future 2070 Unimpaired Hydrology

Appendix D. Comparisons of Projected and Historical Hydrology at Select Locations

Middle Yuba River at Milton Diversion Dam - Historical Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	24.1	36.5	21.0	17.0	25.8	53.4	118.7	181.7	26.4	3.5	3.9	17.1	44.1	0.2	332.8
1977	9.7	4.7	3.6	3.0	8.4	9.5	57.5	65.2	38.8	4.5	2.3	1.3	17.3	0.6	116.9
1978	1.0	5.6	54.1	82.4	53.9	178.1	238.1	576.6	447.8	80.2	11.7	16.4	145.9	0.4	871.9
1979	1.4	6.5	9.3	32.2	33.1	53.9	173.5	516.1	129.1	17.9	5.8	3.9	82.3	1.0	779.1
1980	14.5	4.4	26.4	424.6	199.9	95.6	305.7	521.9	333.1	91.1	9.7	7.8	169.5	0.7	4,563.7
1981	8.9	14.3	20.5	22.2	64.1	64.9	228.1	226.6	42.4	8.8	3.7	3.6	58.8	1.0	535.3
1982	13.4	466.4	483.6	88.7	381.0	176.3	374.7	743.7	369.6	80.0	11.8	21.9	266.2	2.7	4,484.7
1983	82.7	69.7	81.3	67.5	77.6	205.0	138.4	661.3	1,008.0	322.9	46.8	18.6	232.1	6.1	1,460.3
1984	29.9	351.9	319.8	144.5	87.9	147.4	213.5	534.7	212.5	29.1	8.4	6.4	174.1	2.9	1,743.0
1985	12.8	62.3	20.8	23.3	23.8	47.2	332.1	320.8	71.2	9.1	4.6	11.6	78.3	2.8	606.7
1986	8.4	16.7	31.2	114.2	603.3	474.7	382.4	445.5	186.5	13.5	4.8	7.8	187.8	1.6	3,932.2
1987	8.6	1.9	1.7	10.6	42.3	67.1	239.1	146.5	22.9	9.4	3.7	0.5	46.0	0.4	390.8
1988	2.4	5.4	38.7	28.0	32.0	89.1	159.8	128.3	51.3	10.8	4.7	1.4	46.0	0.7	252.3
1989	1.9	43.5	24.6	21.3	45.5	363.2	488.4	384.3	158.9	15.6	12.4	13.5	131.3	1.5	1,501.1
1990	33.8	29.8	23.1	52.2	37.0	107.1	319.2	195.7	99.5	15.8	12.3	10.9	78.0	2.0	515.3
1991	7.1	4.0	6.3	7.7	13.7	110.9	147.8	332.0	174.9	26.3	8.1	6.9	70.8	3.3	1,390.7
1992	11.3	13.9	13.4	9.7	51.1	90.1	270.5	100.6	22.2	14.3	6.5	3.0	50.2	2.7	501.4
1993	8.8	11.7	30.5	79.0	44.3	228.5	343.1	767.2	384.1	63.3	11.7	8.8	165.8	2.6	1,235.4
1994	11.2	2.0	18.3	13.7	20.6	73.4	198.4	228.6	37.8	6.4	5.2	4.6	51.8	0.7	528.3
1995	4.2	26.8	14.6	159.8	112.7	370.5	290.9	742.8	818.5	276.6	23.4	2.8	237.5	2.2	2,232.7
1996	8.3	6.3	105.3	110.0	384.9	182.1	368.9	822.2	200.6	34.8	4.5	8.5	185.7	2.8	2,257.9
1997	4.1	65.8	419.0	608.9	106.4	166.9	371.1	362.7	103.3	16.2	8.6	12.6	188.3	1.5	7,411.1
1998	7.2	21.5	22.0	103.2	89.7	184.9	221.0	454.1	699.6	158.1	16.0	12.6	165.7	2.8	1,067.3
1999	8.9	38.2	47.7	75.2	110.9	111.7	227.6	662.4	394.4	45.7	12.3	6.1	145.1	3.6	1,310.6
2000	10.0	11.8	21.4	70.4	124.3	117.6	368.4	460.2	108.9	15.6	5.8	9.8	110.1	2.4	1,034.1
2001	7.5	8.3	11.2	10.7	17.8	69.0	154.6	246.7	20.3	5.9	7.5	4.7	47.3	2.8	463.2
2002	4.8	26.7	36.8	67.1	55.5	102.5	360.6	389.8	129.8	13.1	4.1	3.3	99.5	2.9	671.4
2003	6.3	35.1	85.0	117.2	98.6	177.8	199.2	499.5	268.4	22.3	9.6	6.4	127.3	1.2	917.0
2004	4.1	6.8	49.6	31.9	67.0	180.7	315.3	343.1	88.0	16.2	4.9	2.2	92.5	1.2	602.8
2005	15.7	9.6	28.2	34.9	38.6	107.7	208.4	837.2	338.7	45.5	10.3	4.1	140.7	2.7	3,382.8
2006	4.0	17.9	606.5	201.4	245.0	155.1	324.8	767.8	266.7	25.0	7.6	5.8	219.5	1.9	6,824.5
2007	4.9	20.0	30.1	25.1	84.3	132.0	218.7	226.3	39.2	12.5	8.2	6.5	67.1	4.0	407.3
2008	16.7	8.4	15.4	34.0	23.1	54.2	203.4	415.9	86.0	14.7	6.3	5.3	73.9	4.9	798.0
2009	19.5	49.7	16.9	27.2	81.6	149.6	272.3	574.1	98.5	11.5	6.7	3.0	109.5	2.4	1,778.7
2010	9.5	8.6	16.0	26.1	24.5	58.8	162.5	390.0	564.9	54.6	6.3	3.0	110.3	1.5	1,295.9
2011	49.1	45.3	168.0	74.8	72.0	107.5	279.0	520.1	847.5	283.0	23.8	9.6	206.8	1.0	1,262.0
Average	13.2	43.3	81.2	83.9	99.6	140.7	257.7	438.7	246.9	52.0	9.6	7.6	122.9	0.2	7,411.1
10% Exc.	19.6	65.2	138.0	157.5	153.8	276.5	468.4	815.1	675.1	136.1	15.0	14.3	365.5	--	--
20% Exc.	11.7	34.4	61.0	90.2	102.2	193.9	383.9	666.0	436.3	57.1	11.7	10.3	182.8	--	--
50% Exc.	5.8	10.4	20.0	32.9	49.3	91.8	217.7	387.8	130.4	14.1	6.7	5.6	27.9	--	--
80% Exc.	3.0	4.6	10.2	14.4	21.1	49.7	118.6	186.6	28.3	6.5	4.7	2.9	6.7	--	--
90% Exc.	1.9	2.5	6.7	9.4	15.1	35.6	81.5	110.9	17.7	5.2	3.7	1.6	4.1	--	--

Middle Yuba River at Milton Diversion Dam - Historical Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,482	2,174	1,289	1,046	1,486	3,284	7,060	11,172	1,570	213	238	1,016	32,031
1977	595	277	223	183	466	581	3,421	4,012	2,310	275	139	75	12,557
1978	60	333	3,327	5,065	2,994	10,953	14,170	35,454	26,643	4,934	719	977	105,629
1979	89	387	574	1,978	1,837	3,315	10,327	31,736	7,683	1,104	358	229	59,616
1980	894	262	1,625	26,105	11,499	5,878	18,189	32,092	19,819	5,605	599	462	123,029
1981	544	848	1,263	1,366	3,560	3,990	13,572	13,935	2,524	538	225	217	42,582
1982	825	27,751	29,737	5,457	21,158	10,839	22,298	45,731	21,992	4,916	726	1,301	192,731
1983	5,085	4,149	4,997	4,149	4,308	12,604	8,235	40,660	59,979	19,855	2,878	1,107	168,006
1984	1,836	20,937	19,663	8,887	5,059	9,064	12,703	32,876	12,645	1,789	516	379	126,354
1985	787	3,707	1,281	1,430	1,323	2,902	19,764	19,728	4,234	557	284	691	56,688
1986	515	996	1,916	7,022	33,508	29,185	22,753	27,394	11,098	830	292	464	135,974
1987	531	116	105	654	2,348	4,127	14,228	9,007	1,360	579	227	33	33,315
1988	146	321	2,383	1,720	1,842	5,476	9,509	7,890	3,053	663	292	83	33,378
1989	116	2,591	1,513	1,308	2,530	22,335	29,064	23,629	9,453	961	765	802	95,066
1990	2,077	1,770	1,418	3,208	2,057	6,586	18,994	12,031	5,921	971	756	650	56,439
1991	437	237	387	474	760	6,821	8,792	20,411	10,406	1,617	501	408	51,250
1992	692	825	824	593	2,941	5,543	16,093	6,187	1,320	879	401	178	36,477
1993	541	694	1,873	4,858	2,461	14,049	20,414	47,171	22,858	3,894	718	522	120,052
1994	691	117	1,125	841	1,145	4,514	11,807	14,056	2,246	394	322	274	37,533
1995	258	1,593	900	9,824	6,257	22,781	17,312	45,674	48,706	17,007	1,440	164	171,916
1996	512	373	6,473	6,764	22,138	11,196	21,954	50,554	11,935	2,138	279	503	134,818
1997	252	3,917	25,765	37,438	5,909	10,261	22,079	22,300	6,145	994	530	752	136,343
1998	440	1,281	1,350	6,348	4,982	11,370	13,152	27,924	41,626	9,724	983	749	119,931
1999	546	2,271	2,935	4,627	6,158	6,870	13,544	40,729	23,469	2,811	757	365	105,082
2000	616	699	1,316	4,332	7,148	7,233	21,919	28,299	6,481	960	357	583	79,943
2001	460	496	687	660	989	4,246	9,199	15,171	1,208	366	464	278	34,224
2002	295	1,586	2,260	4,127	3,083	6,300	21,457	23,966	7,725	803	250	199	72,052
2003	385	2,089	5,223	7,207	5,474	10,931	11,850	30,716	15,971	1,369	589	380	92,184
2004	253	402	3,049	1,960	3,856	11,109	18,764	21,095	5,234	995	302	131	67,150
2005	965	574	1,736	2,145	2,142	6,622	12,402	51,476	20,153	2,799	635	246	101,895
2006	248	1,064	37,294	12,381	13,605	9,536	19,324	47,207	15,867	1,538	466	348	158,878
2007	303	1,191	1,851	1,543	4,684	8,116	13,011	13,916	2,335	767	506	388	48,611
2008	1,030	500	944	2,089	1,327	3,334	12,100	25,570	5,118	907	385	318	53,621
2009	1,202	2,957	1,038	1,672	4,531	9,200	16,202	35,297	5,861	706	413	181	79,261
2010	582	512	984	1,603	1,358	3,613	9,667	23,983	33,612	3,356	384	179	79,834
2011	3,019	2,694	10,329	4,600	3,999	6,611	16,604	31,982	50,428	17,398	1,461	573	149,698
Average	814	2,575	4,991	5,157	5,581	8,649	15,332	26,973	14,694	3,200	588	450	89,004
Maximum	5,085	27,751	37,294	37,438	33,508	29,185	29,064	51,476	59,979	19,855	2,878	1,301	192,731
Minimum	60	116	105	183	466	581	3,421	4,012	1,208	213	139	33	12,557
10% Exc.	1,659	3,812	14,996	9,355	12,552	13,327	22,017	46,451	37,619	7,664	874	889	154,288
20% Exc.	965	2,591	4,997	6,764	6,158	11,109	20,414	40,660	22,858	3,894	726	691	134,818
50% Exc.	543	922	1,569	2,676	3,322	6,846	14,199	26,482	8,589	995	465	380	79,888
80% Exc.	258	373	944	1,308	1,486	4,127	10,327	13,935	2,524	663	292	181	42,582
90% Exc.	197	269	630	657	1,234	3,325	8,996	10,089	1,908	466	244	147	33,801

Middle Yuba River at Milton Diversion Dam - 2070 Median Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	25.8	51.8	27.7	20.7	61.4	130.2	75.5	45.3	22.6	4.0	4.5	19.9	40.7	0.3	298.9
1977	15.0	7.4	5.8	4.7	16.5	15.5	48.0	42.4	29.9	7.0	3.6	2.0	16.4	1.0	121.5
1978	1.3	7.3	162.2	294.9	206.7	363.7	225.7	287.1	85.6	28.1	15.2	23.5	141.9	0.5	1,717.2
1979	2.3	10.1	14.6	118.2	123.0	168.2	176.0	295.9	37.6	23.8	9.0	6.0	82.0	1.5	1,788.6
1980	14.2	4.6	43.6	919.6	502.5	188.0	243.0	198.3	38.7	21.9	10.2	8.1	182.2	0.8	6,641.8
1981	10.4	18.3	38.4	52.6	183.4	162.6	199.9	60.9	22.2	10.9	4.6	4.6	63.1	1.2	645.9
1982	11.6	605.0	854.0	230.5	792.7	270.3	356.2	289.2	40.9	20.3	11.0	33.6	289.2	2.5	5,651.2
1983	104.6	155.3	318.7	339.4	350.6	593.4	120.0	458.2	430.6	58.7	64.1	32.5	252.1	10.2	4,111.7
1984	23.0	444.5	703.6	319.8	191.8	204.5	121.7	167.1	23.9	14.4	7.1	5.4	185.9	2.4	3,025.6
1985	16.6	116.8	34.2	46.0	69.3	138.6	354.1	106.2	28.0	12.3	6.3	16.3	78.2	3.9	653.1
1986	7.2	15.2	48.1	284.2	1,040.0	607.3	265.1	128.0	25.6	9.4	4.1	6.7	197.9	1.4	3,889.5
1987	8.9	2.0	1.8	11.6	109.9	135.7	180.5	34.8	17.4	9.6	3.8	0.6	42.4	0.5	1,072.7
1988	2.2	5.0	71.8	53.4	74.4	154.3	82.4	29.6	19.8	9.9	4.4	1.3	42.4	0.6	632.4
1989	2.2	67.7	41.8	34.0	116.3	716.0	457.7	128.3	28.9	13.2	13.5	16.9	136.5	1.8	2,958.9
1990	30.9	36.5	32.7	156.5	103.5	196.9	270.8	46.2	25.2	15.4	12.9	11.4	77.9	2.1	1,448.7
1991	13.1	7.3	11.6	14.2	28.1	380.7	145.5	159.1	50.5	25.0	15.0	12.7	72.5	6.0	4,591.2
1992	10.2	13.7	12.8	9.2	100.4	155.0	195.4	27.6	17.9	12.7	6.2	2.8	46.6	2.6	378.5
1993	11.7	18.0	75.2	311.3	184.9	499.2	385.8	457.0	67.6	28.8	16.5	12.4	172.8	3.7	2,226.8
1994	14.6	2.6	29.7	19.5	39.9	189.3	178.5	75.0	23.2	8.5	7.0	6.1	49.5	1.0	483.6
1995	6.2	46.7	27.9	698.2	371.7	832.8	327.8	440.2	270.1	44.7	23.9	4.1	258.0	3.3	4,431.5
1996	8.1	6.1	237.0	274.7	892.2	273.3	282.2	342.5	30.7	19.8	4.4	8.2	195.8	2.8	3,904.0
1997	3.1	71.4	741.0	802.8	193.9	186.5	248.9	76.5	18.5	9.1	6.6	9.6	198.6	1.1	5,819.6
1998	10.1	38.2	42.6	476.0	349.2	473.3	230.5	212.3	177.2	32.4	20.6	17.8	172.5	4.0	3,133.2
1999	11.2	58.2	141.6	234.9	348.5	241.6	222.0	340.6	67.2	23.6	15.8	7.9	141.7	4.7	1,747.9
2000	10.5	13.8	44.3	183.1	352.7	217.8	326.2	162.7	25.4	14.7	6.3	10.7	112.9	2.7	2,369.1
2001	10.4	11.7	15.7	15.1	35.4	156.9	145.5	84.0	22.3	8.3	10.6	6.6	43.6	3.9	460.5
2002	6.2	43.4	81.7	230.6	180.0	223.6	359.3	142.3	31.3	15.6	5.2	4.3	109.7	3.7	700.5
2003	6.5	46.1	228.6	347.8	250.6	288.6	132.7	193.6	42.0	15.2	10.0	6.6	130.5	1.2	2,413.1
2004	5.0	8.1	132.4	94.3	207.6	311.3	296.8	107.4	27.3	16.4	5.9	2.6	100.9	1.5	1,537.9
2005	22.9	15.8	84.5	138.2	181.6	309.2	234.7	569.8	71.5	29.8	17.0	6.8	140.4	4.4	2,653.5
2006	3.6	18.4	1,064.1	478.9	475.7	234.4	239.8	288.0	33.3	12.3	6.8	5.3	238.2	1.7	8,319.7
2007	5.2	24.8	51.9	49.0	230.2	228.7	159.7	50.7	19.0	12.9	8.6	6.8	69.5	4.2	1,337.2
2008	24.0	12.6	29.1	101.2	63.1	164.2	206.9	200.3	34.1	20.8	9.4	8.0	72.9	7.4	529.4
2009	22.6	84.9	31.4	74.7	283.3	305.9	248.5	264.0	28.9	13.5	8.4	3.8	113.0	3.0	1,850.8
2010	20.2	19.7	43.1	118.4	116.7	233.9	242.8	264.4	239.7	40.3	14.4	6.9	113.2	3.5	887.5
2011	56.1	85.0	680.3	314.1	297.8	270.3	304.1	269.8	296.0	50.4	24.3	14.1	221.8	1.4	3,303.9
Average	15.5	61.0	172.4	218.7	253.7	283.9	230.3	195.7	68.6	19.8	11.6	9.8	127.9	0.3	8,319.7
10% Exc.	24.1	105.3	322.8	373.4	370.0	450.4	463.7	450.2	168.9	34.5	19.9	17.0	327.2	--	--
20% Exc.	15.6	49.1	171.8	293.3	298.4	346.9	379.6	330.1	68.3	29.5	14.5	12.7	209.8	--	--
50% Exc.	6.5	13.1	27.0	110.7	181.7	208.0	175.0	115.1	29.3	16.8	8.3	6.7	29.7	--	--
80% Exc.	3.5	5.5	12.9	18.6	36.5	130.9	68.6	42.6	21.4	7.8	4.8	3.6	8.3	--	--
90% Exc.	2.2	2.8	9.1	12.6	23.1	104.6	49.1	33.8	18.3	5.7	4.2	1.5	5.0	--	--

Middle Yuba River at Milton Diversion Dam - 2070 Median Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,589	3,081	1,704	1,273	3,532	8,007	4,494	2,784	1,342	246	277	1,182	29,512
1977	924	441	356	292	919	954	2,857	2,606	1,780	432	222	119	11,900
1978	78	437	9,973	18,135	11,482	22,366	13,429	17,656	5,092	1,728	935	1,396	102,707
1979	138	600	898	7,267	6,831	10,340	10,475	18,195	2,239	1,466	556	357	59,362
1980	872	274	2,680	56,542	28,903	11,560	14,457	12,195	2,305	1,345	629	484	132,247
1981	640	1,091	2,363	3,234	10,187	9,997	11,896	3,747	1,323	672	284	274	45,708
1982	714	35,998	52,511	14,171	44,025	16,620	21,196	17,783	2,436	1,250	677	1,997	209,377
1983	6,432	9,244	19,598	20,870	19,473	36,488	7,138	28,172	25,621	3,610	3,939	1,932	182,517
1984	1,412	26,452	43,264	19,664	11,031	12,572	7,243	10,275	1,422	886	437	321	134,979
1985	1,019	6,949	2,105	2,827	3,847	8,521	21,068	6,530	1,667	755	389	969	56,647
1986	442	904	2,957	17,474	57,758	37,342	15,776	7,873	1,526	577	253	401	143,281
1987	544	119	108	715	6,104	8,343	10,739	2,141	1,033	589	234	34	30,702
1988	136	299	4,412	3,282	4,282	9,489	4,902	1,822	1,177	609	273	78	30,761
1989	135	4,029	2,569	2,091	6,458	44,024	27,237	7,890	1,722	812	829	1,004	98,799
1990	1,898	2,173	2,010	9,622	5,745	12,106	16,112	2,838	1,500	944	791	680	56,420
1991	805	436	710	871	1,558	23,409	8,660	9,784	3,003	1,540	924	753	52,455
1992	625	816	788	563	5,776	9,532	11,627	1,695	1,065	781	381	169	33,819
1993	721	1,071	4,622	19,140	10,271	30,696	22,959	28,099	4,020	1,774	1,016	739	125,128
1994	895	155	1,828	1,199	2,214	11,639	10,620	4,610	1,381	520	429	366	35,856
1995	380	2,778	1,718	42,933	20,641	51,208	19,503	27,067	16,074	2,750	1,471	242	186,764
1996	498	363	14,575	16,893	51,321	16,805	16,792	21,057	1,825	1,216	272	490	142,106
1997	192	4,248	45,560	49,360	10,770	11,468	14,811	4,706	1,102	562	405	574	143,759
1998	623	2,275	2,620	29,266	19,394	29,099	13,718	13,055	10,545	1,995	1,266	1,060	124,917
1999	691	3,464	8,709	14,442	19,354	14,858	13,213	20,943	3,996	1,450	973	468	102,561
2000	647	819	2,726	11,258	20,290	13,390	19,409	10,002	1,510	905	390	638	81,983
2001	638	698	967	931	1,967	9,645	8,657	5,163	1,329	509	654	392	31,549
2002	378	2,584	5,026	14,182	9,998	13,746	21,378	8,751	1,865	960	321	256	79,445
2003	401	2,745	14,055	21,388	13,917	17,746	7,895	11,904	2,500	936	613	396	94,495
2004	304	483	8,144	5,801	11,942	19,139	17,663	6,606	1,627	1,008	364	157	73,238
2005	1,410	942	5,193	8,497	10,085	19,013	13,965	35,033	4,254	1,830	1,046	405	101,672
2006	223	1,094	65,429	29,447	26,421	14,415	14,271	17,711	1,979	759	421	314	172,484
2007	317	1,476	3,190	3,011	12,785	14,062	9,502	3,119	1,130	794	530	406	50,321
2008	1,479	748	1,788	6,225	3,628	10,094	12,310	12,314	2,030	1,282	578	478	52,954
2009	1,388	5,053	1,929	4,594	15,735	18,812	14,789	16,235	1,719	827	517	227	81,825
2010	1,244	1,169	2,650	7,280	6,482	14,384	14,448	16,258	14,264	2,480	885	412	81,958
2011	3,451	5,057	41,831	19,316	16,540	16,618	18,095	16,588	17,614	3,100	1,497	842	160,548
Average	952	3,627	10,599	13,446	14,213	17,458	13,703	12,033	4,084	1,219	713	584	92,632
Maximum	6,432	35,998	65,429	56,542	57,758	51,208	27,237	35,033	25,621	3,610	3,939	1,997	209,377
Minimum	78	119	108	292	919	954	2,857	1,695	1,033	246	222	34	11,900
10% Exc.	1,534	6,003	42,548	29,357	27,662	33,592	21,132	24,062	12,405	2,238	1,156	1,121	166,516
20% Exc.	1,388	4,029	14,055	19,664	19,473	22,366	18,095	17,783	4,020	1,728	935	842	142,106
50% Exc.	644	1,093	2,703	9,059	10,521	14,223	13,842	10,139	1,803	940	543	409	81,970
80% Exc.	317	441	1,718	2,091	4,282	9,997	8,660	3,747	1,342	609	321	256	45,708
90% Exc.	165	331	843	901	2,873	9,005	7,190	2,695	1,154	541	272	163	31,155

Middle Yuba River at Milton Diversion Dam - 2070 Median Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	106	907	415	227	2,047	4,723	-2,567	-8,387	-228	33	39	166	-2,519
1977	329	164	132	109	452	372	-563	-1,406	-531	157	83	44	-657
1978	18	104	6,646	13,070	8,488	11,413	-740	-17,798	-21,551	-3,207	216	419	-2,922
1979	49	213	324	5,290	4,995	7,024	149	-13,541	-5,444	362	199	127	-254
1980	-22	12	1,054	30,436	17,404	5,682	-3,732	-19,897	-17,515	-4,259	30	23	9,217
1981	96	243	1,101	1,869	6,627	6,007	-1,676	-10,188	-1,201	133	59	56	3,126
1982	-111	8,247	22,775	8,714	22,867	5,781	-1,102	-27,948	-19,557	-3,667	-49	696	16,646
1983	1,347	5,094	14,601	16,721	15,166	23,883	-1,097	-12,489	-34,358	-16,245	1,061	826	14,511
1984	-423	5,516	23,600	10,777	5,972	3,507	-5,460	-22,601	-11,222	-903	-79	-58	8,625
1985	232	3,242	824	1,397	2,524	5,619	1,304	-13,198	-2,567	198	105	278	-41
1986	-73	-92	1,041	10,452	24,250	8,156	-6,978	-19,521	-9,572	-253	-39	-63	7,307
1987	13	3	3	61	3,756	4,216	-3,489	-6,866	-327	9	7	1	-2,613
1988	-10	-22	2,030	1,562	2,439	4,013	-4,608	-6,069	-1,876	-54	-19	-5	-2,617
1989	20	1,438	1,057	783	3,929	21,689	-1,827	-15,739	-7,732	-149	64	202	3,734
1990	-179	403	592	6,414	3,688	5,520	-2,883	-9,193	-4,420	-27	35	30	-20
1991	368	199	324	397	799	16,588	-131	-10,627	-7,403	-76	424	345	1,205
1992	-67	-8	-37	-30	2,835	3,989	-4,466	-4,491	-255	-98	-20	-9	-2,658
1993	180	377	2,749	14,281	7,811	16,647	2,545	-19,071	-18,838	-2,120	298	217	5,076
1994	204	38	703	358	1,068	7,125	-1,187	-9,446	-865	125	107	91	-1,678
1995	122	1,185	818	33,110	14,384	28,427	2,191	-18,608	-32,632	-14,257	31	78	14,848
1996	-14	-11	8,102	10,129	29,184	5,608	-5,162	-29,497	-10,109	-921	-7	-13	7,288
1997	-60	331	19,795	11,922	4,862	1,207	-7,269	-17,594	-5,043	-433	-125	-178	7,416
1998	183	994	1,270	22,918	14,412	17,729	566	-14,869	-31,082	-7,729	283	311	4,986
1999	145	1,193	5,774	9,816	13,196	7,988	-331	-19,786	-19,474	-1,361	216	104	-2,521
2000	31	119	1,410	6,926	13,142	6,157	-2,511	-18,297	-4,971	-55	34	55	2,040
2001	178	201	281	271	977	5,400	-543	-10,008	121	144	190	114	-2,675
2002	83	998	2,766	10,055	6,914	7,446	-79	-15,215	-5,859	157	71	56	7,393
2003	16	656	8,831	14,180	8,444	6,815	-3,955	-18,812	-13,471	-433	25	16	2,311
2004	51	81	5,095	3,841	8,086	8,030	-1,100	-14,489	-3,607	13	61	26	6,088
2005	445	368	3,457	6,352	7,943	12,390	1,563	-16,443	-15,899	-969	412	159	-223
2006	-24	30	28,135	17,067	12,816	4,879	-5,053	-29,496	-13,888	-779	-45	-34	13,606
2007	14	285	1,339	1,468	8,100	5,946	-3,509	-10,797	-1,205	27	24	18	1,710
2008	449	249	844	4,137	2,301	6,759	209	-13,256	-3,088	375	194	160	-668
2009	186	2,096	892	2,922	11,204	9,612	-1,413	-19,062	-4,142	121	104	46	2,565
2010	662	657	1,666	5,677	5,124	10,771	4,781	-7,725	-19,348	-876	501	233	2,124
2011	433	2,363	31,502	14,716	12,541	10,007	1,491	-15,394	-32,815	-14,299	36	268	10,850
Average	138	1,052	5,609	8,289	8,632	8,809	-1,629	-14,940	-10,610	-1,981	126	133	3,628

Middle Yuba River at Milton Diversion Dam - 2070 WMW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	22.4	68.4	32.3	22.6	63.7	160.0	122.5	86.8	24.5	4.3	4.8	21.2	52.7	0.3	451.2
1977	16.8	8.4	6.7	5.4	18.0	18.7	80.2	62.2	35.5	8.0	4.1	2.3	22.1	1.1	125.3
1978	1.3	7.9	197.3	339.6	229.1	436.7	314.3	405.2	157.7	30.5	16.2	25.7	180.3	0.5	2,218.1
1979	2.4	10.9	16.0	138.5	132.9	208.1	260.8	426.8	47.9	25.7	9.7	6.4	107.3	1.7	2,151.6
1980	12.6	4.8	51.0	1,074.0	640.1	219.9	317.3	276.4	62.2	24.0	10.6	8.4	224.2	0.8	7,020.3
1981	10.1	18.6	40.2	54.0	195.5	178.4	265.3	106.7	22.8	10.6	4.5	4.5	74.9	1.2	835.3
1982	9.2	1,131.6	864.4	221.0	928.2	263.4	343.9	320.2	58.7	18.2	9.7	29.1	344.6	2.2	5,942.4
1983	61.9	210.3	314.6	331.8	342.4	613.3	170.7	541.5	675.0	108.7	205.1	29.7	300.4	9.2	4,489.4
1984	14.8	907.1	687.9	313.4	185.4	198.1	148.7	202.8	27.8	12.8	6.3	4.8	225.5	2.1	2,925.8
1985	16.1	160.5	38.1	47.4	66.4	161.5	448.5	189.5	30.1	12.2	6.3	16.2	99.0	3.9	823.0
1986	6.5	14.6	45.7	283.7	1,273.5	662.3	299.3	176.4	31.1	8.5	3.7	6.1	227.3	1.3	4,353.4
1987	9.3	2.1	1.9	12.5	136.6	160.3	248.9	60.7	18.5	10.0	4.0	0.6	54.6	0.5	1,726.5
1988	2.4	5.4	88.8	62.6	79.5	185.9	140.4	50.5	22.6	10.7	4.8	1.4	54.6	0.7	835.8
1989	2.2	142.2	48.0	34.9	120.9	834.4	542.4	204.5	34.5	13.0	13.2	17.2	167.5	1.8	3,580.8
1990	22.9	46.1	41.4	185.5	107.2	235.2	369.9	89.9	32.7	16.9	14.1	12.5	97.6	2.4	1,738.7
1991	11.0	6.2	9.9	11.9	23.5	386.3	189.9	237.3	55.2	21.1	12.6	10.6	81.9	5.1	4,699.5
1992	9.9	15.2	14.0	9.8	116.7	184.3	275.1	43.5	19.4	13.6	6.6	3.0	58.7	2.7	518.2
1993	10.5	19.5	83.3	339.6	186.1	575.9	489.5	579.4	113.5	29.6	16.7	12.5	205.3	3.7	2,706.9
1994	14.0	2.5	31.0	19.2	37.1	204.9	232.6	126.2	23.4	8.1	6.7	5.9	59.4	0.9	594.7
1995	5.8	54.0	29.3	743.7	388.4	928.3	406.5	585.0	436.1	80.0	24.8	3.8	307.4	3.1	4,787.5
1996	7.6	5.7	246.9	281.2	1,122.2	280.2	335.3	411.6	39.9	18.5	4.1	7.7	226.7	2.6	4,139.5
1997	3.0	144.7	814.4	890.2	204.5	205.4	273.9	129.5	21.2	8.9	6.4	9.3	227.4	1.1	6,870.4
1998	9.7	46.6	45.5	504.7	388.3	521.4	277.5	300.8	302.6	36.8	19.6	17.0	204.9	3.8	3,613.9
1999	11.6	104.5	172.9	269.8	415.1	279.9	294.4	459.6	116.2	24.6	16.3	8.1	179.7	4.8	2,195.2
2000	9.8	14.8	51.0	203.6	430.0	238.4	409.3	250.5	28.5	14.9	6.4	10.8	137.7	2.7	3,333.2
2001	10.5	11.9	16.2	15.3	35.3	175.3	198.8	157.5	23.0	8.4	10.8	6.7	55.9	4.0	560.9
2002	6.1	62.3	93.7	243.5	181.2	245.4	451.5	245.0	36.8	15.4	5.1	4.2	132.1	3.7	786.2
2003	6.7	63.6	262.8	398.7	282.6	346.6	194.9	268.0	67.1	15.8	10.3	6.9	160.2	1.3	2,761.0
2004	4.9	8.0	148.9	96.9	239.5	341.4	372.5	180.6	29.6	16.2	5.8	2.6	120.1	1.4	2,261.7
2005	21.8	15.9	96.5	149.0	175.1	342.2	319.6	816.5	115.4	30.1	17.0	6.8	176.2	4.4	4,637.0
2006	3.7	22.2	1,239.6	540.8	623.9	265.4	301.2	374.3	50.5	12.7	7.0	5.4	286.6	1.8	10,165.7
2007	5.0	27.5	54.5	50.1	264.5	239.5	209.7	91.4	19.3	12.5	8.3	6.6	81.1	4.1	1,929.4
2008	21.5	11.4	28.5	100.5	54.7	175.3	256.4	277.2	33.9	18.9	8.5	7.3	83.1	6.7	607.7
2009	19.2	160.8	33.3	74.4	325.8	319.4	313.7	369.5	30.6	12.8	8.0	3.6	137.8	2.8	3,016.2
2010	15.5	17.8	42.8	114.1	98.2	253.3	301.1	377.8	380.3	36.9	13.0	6.3	138.0	3.1	1,355.8
2011	35.4	106.0	770.2	342.9	322.5	301.9	393.7	375.9	496.1	104.3	26.8	14.1	274.0	1.4	3,665.3
Average	12.6	101.7	187.8	236.9	290.2	315.2	293.6	273.8	103.3	23.7	15.5	9.6	154.6	0.3	10,165.7
10% Exc.	23.6	134.0	331.9	405.4	394.5	472.7	568.6	547.6	307.7	35.4	19.7	16.2	374.6	--	--
20% Exc.	15.5	58.6	191.4	308.6	324.4	369.0	457.7	427.1	112.5	29.6	14.5	12.7	245.9	--	--
50% Exc.	6.5	13.0	28.4	112.4	182.8	224.1	247.4	210.6	32.5	16.1	8.2	6.2	31.4	--	--
80% Exc.	3.4	5.3	13.4	18.4	35.3	149.2	108.3	75.2	23.1	7.7	4.9	3.4	8.2	--	--
90% Exc.	2.2	3.0	8.8	11.1	22.8	128.9	76.1	52.2	18.8	5.9	4.0	1.6	4.9	--	--

Middle Yuba River at Milton Diversion Dam - 2070 WMW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,379	4,071	1,987	1,388	3,666	9,840	7,287	5,338	1,457	262	296	1,264	38,234
1977	1,033	500	410	331	1,000	1,148	4,774	3,824	2,110	489	252	135	16,005
1978	83	473	12,133	20,882	12,723	26,852	18,701	24,914	9,382	1,875	994	1,531	130,544
1979	149	646	985	8,515	7,383	12,796	15,517	26,244	2,853	1,583	598	384	77,654
1980	778	284	3,135	66,036	36,817	13,519	18,881	16,997	3,702	1,477	650	501	162,776
1981	623	1,104	2,473	3,321	10,859	10,968	15,789	6,563	1,357	652	276	266	54,250
1982	568	67,332	53,147	13,591	51,552	16,195	20,466	19,686	3,494	1,120	594	1,732	249,478
1983	3,806	12,515	19,344	20,405	19,015	37,711	10,157	33,295	40,163	6,686	12,609	1,766	217,472
1984	912	53,976	42,296	19,268	10,667	12,184	8,846	12,469	1,657	786	386	283	163,729
1985	990	9,552	2,342	2,913	3,687	9,928	26,687	11,653	1,791	747	385	967	71,644
1986	399	866	2,809	17,442	70,725	40,726	17,810	10,847	1,850	524	229	363	164,591
1987	569	124	114	766	7,585	9,859	14,814	3,732	1,100	615	244	35	39,559
1988	147	324	5,458	3,852	4,570	11,430	8,354	3,105	1,344	661	295	84	39,624
1989	133	8,462	2,954	2,144	6,712	51,303	32,274	12,573	2,055	802	809	1,025	121,245
1990	1,408	2,742	2,544	11,405	5,951	14,463	22,009	5,526	1,947	1,039	868	746	70,650
1991	676	367	606	732	1,307	23,752	11,298	14,594	3,284	1,300	776	632	59,322
1992	607	903	858	602	6,711	11,330	16,372	2,675	1,154	837	407	181	42,637
1993	647	1,160	5,124	20,880	10,336	35,412	29,129	35,629	6,754	1,820	1,025	746	148,661
1994	860	149	1,905	1,180	2,058	12,597	13,840	7,763	1,395	501	413	352	43,012
1995	359	3,213	1,801	45,727	21,572	57,081	24,188	35,969	25,948	4,916	1,528	228	222,531
1996	464	338	15,182	17,292	64,551	17,227	19,953	25,306	2,374	1,140	253	457	164,539
1997	186	8,608	50,075	54,735	11,360	12,631	16,296	7,960	1,263	546	392	556	164,607
1998	594	2,772	2,801	31,034	21,563	32,057	16,515	18,497	18,006	2,262	1,202	1,012	148,315
1999	714	6,216	10,630	16,590	23,056	17,212	17,518	28,257	6,912	1,514	1,004	484	130,106
2000	602	879	3,135	12,519	24,733	14,656	24,357	15,404	1,697	915	393	641	99,930
2001	646	707	997	943	1,961	10,776	11,831	9,682	1,370	515	662	397	40,485
2002	373	3,709	5,763	14,973	10,063	15,090	26,867	15,067	2,189	950	316	252	95,610
2003	414	3,787	16,158	24,515	15,696	21,312	11,598	16,478	3,992	971	633	408	115,963
2004	300	477	9,156	5,961	13,776	20,994	22,164	11,106	1,759	998	359	155	87,205
2005	1,343	944	5,936	9,163	9,723	21,039	19,019	50,204	6,868	1,849	1,047	405	127,540
2006	228	1,323	76,217	33,255	34,651	16,316	17,922	23,014	3,003	778	429	320	207,457
2007	307	1,638	3,353	3,080	14,689	14,726	12,480	5,621	1,147	769	513	393	58,715
2008	1,320	677	1,755	6,182	3,144	10,781	15,255	17,047	2,019	1,160	522	432	60,294
2009	1,178	9,568	2,050	4,572	18,093	19,638	18,668	22,720	1,819	788	490	215	99,798
2010	956	1,061	2,634	7,013	5,454	15,575	17,916	23,230	22,630	2,270	799	372	99,909
2011	2,178	6,305	47,359	21,083	17,913	18,564	23,427	23,116	29,518	6,412	1,649	839	198,362
Average	776	6,049	11,545	14,564	16,259	19,380	17,472	16,836	6,149	1,459	953	571	112,013
Maximum	3,806	67,332	76,217	66,036	70,725	57,081	32,274	50,204	40,163	6,686	12,609	1,766	249,478
Minimum	83	124	114	331	1,000	1,148	4,774	2,675	1,100	262	229	35	16,005
10% Exc.	1,361	9,560	44,827	32,144	35,734	36,561	25,522	30,776	20,318	2,266	1,125	1,144	202,909
20% Exc.	1,033	6,305	15,182	20,882	21,572	23,752	22,164	24,914	6,868	1,820	994	839	164,539
50% Exc.	615	1,132	3,045	10,284	10,763	15,332	17,664	15,235	2,083	960	518	407	99,920
80% Exc.	307	477	1,801	2,144	4,570	11,330	11,831	6,563	1,395	652	316	252	54,250
90% Exc.	168	331	922	854	2,601	10,352	9,502	4,581	1,303	519	265	168	40,054

Middle Yuba River at Milton Diversion Dam - 2070 WMW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-103	1,897	698	342	2,181	6,556	227	-5,834	-114	49	58	248	6,204
1977	438	224	187	148	533	566	1,353	-188	-200	215	112	60	3,448
1978	23	140	8,806	15,817	9,729	15,900	4,531	-10,540	-17,261	-3,059	275	554	24,915
1979	60	259	411	6,537	5,547	9,481	5,191	-5,491	-4,830	480	241	154	18,039
1980	-117	22	1,510	39,931	25,318	7,640	692	-15,095	-16,117	-4,127	51	39	39,747
1981	79	255	1,211	1,955	7,299	6,978	2,217	-7,372	-1,167	114	51	49	11,668
1982	-257	39,581	23,411	8,134	30,394	5,356	-1,832	-26,045	-18,498	-3,796	-131	431	56,747
1983	-1,279	8,366	14,347	16,256	14,708	25,106	1,922	-7,365	-19,816	-13,169	9,731	659	49,466
1984	-924	33,040	22,632	10,381	5,608	3,119	-3,857	-20,407	-10,988	-1,003	-131	-96	37,375
1985	204	5,845	1,061	1,483	2,364	7,026	6,923	-8,075	-2,443	190	101	276	14,956
1986	-115	-130	893	10,420	37,217	11,541	-4,943	-16,548	-9,247	-306	-63	-101	28,617
1987	38	9	9	112	5,237	5,732	586	-5,275	-260	35	17	2	6,244
1988	2	3	3,075	2,132	2,728	5,954	-1,156	-4,786	-1,709	-2	3	1	6,246
1989	18	5,871	1,442	836	4,182	28,968	3,210	-11,056	-7,399	-159	44	223	26,179
1990	-669	971	1,126	8,197	3,894	7,878	3,015	-6,504	-3,973	68	112	96	14,211
1991	239	129	220	258	547	16,930	2,506	-5,818	-7,122	-317	275	224	8,072
1992	-85	79	34	8	3,770	5,787	279	-3,511	-166	-42	6	3	6,160
1993	106	466	3,251	16,021	7,876	21,363	8,715	-11,542	-16,104	-2,074	308	223	28,609
1994	169	32	780	339	912	8,083	2,033	-6,293	-851	106	91	77	5,479
1995	101	1,620	901	35,903	15,315	34,300	6,875	-9,705	-22,758	-12,090	88	64	50,616
1996	-47	-35	8,709	10,528	42,414	6,031	-2,001	-25,248	-9,560	-997	-25	-46	29,721
1997	-66	4,691	24,310	17,297	5,451	2,370	-5,784	-14,340	-4,882	-449	-138	-196	28,265
1998	154	1,491	1,450	24,686	16,581	20,686	3,363	-9,426	-23,620	-7,462	219	263	28,384
1999	168	3,945	7,695	11,963	16,899	10,342	3,974	-12,472	-16,557	-1,298	247	119	25,025
2000	-14	179	1,819	8,188	17,585	7,424	2,438	-12,895	-4,785	-45	36	58	19,988
2001	186	211	310	283	972	6,531	2,632	-5,489	162	149	198	118	6,260
2002	78	2,123	3,503	10,846	6,980	8,790	5,410	-8,900	-5,536	146	66	52	23,559
2003	29	1,699	10,934	17,308	10,223	10,381	-252	-14,238	-11,979	-398	45	29	23,779
2004	47	74	6,107	4,001	9,920	9,885	3,400	-9,989	-3,475	3	57	24	20,055
2005	378	370	4,200	7,019	7,581	14,416	6,616	-1,273	-13,286	-950	413	160	25,645
2006	-20	259	38,923	20,874	21,046	6,781	-1,402	-24,194	-12,864	-760	-37	-28	48,579
2007	4	447	1,503	1,537	10,004	6,610	-531	-8,295	-1,188	2	7	5	10,105
2008	291	177	811	4,093	1,817	7,446	3,154	-8,523	-3,099	254	138	114	6,673
2009	-24	6,611	1,012	2,901	13,562	10,437	2,466	-12,578	-4,042	81	77	34	20,538
2010	374	548	1,650	5,410	4,096	11,962	8,249	-753	-10,982	-1,086	414	193	20,075
2011	-841	3,611	37,030	16,483	13,914	11,953	6,823	-8,866	-20,911	-10,986	188	265	48,664
Average	-38	3,475	6,555	9,406	10,678	10,731	2,140	-10,137	-8,545	-1,741	365	121	23,009

Middle Yuba River at Milton Diversion Dam - 2070 DEW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	21.4	34.5	27.8	22.5	41.4	114.7	60.1	36.5	25.4	4.6	5.2	22.7	34.7	0.3	179.9
1977	15.4	7.8	6.1	5.0	14.5	16.2	48.6	39.1	30.8	7.4	3.8	2.1	16.4	1.0	61.2
1978	1.5	8.5	211.6	293.9	179.3	378.0	218.5	201.8	51.0	33.4	18.4	25.5	135.4	0.6	3,321.5
1979	2.4	10.6	15.2	87.1	86.7	137.5	140.6	174.6	35.8	24.9	9.5	6.3	60.9	1.6	1,152.1
1980	11.7	4.8	44.5	739.3	666.3	158.4	219.2	130.0	26.8	22.6	10.8	8.6	168.7	0.8	4,875.7
1981	8.6	14.5	26.0	27.7	146.6	108.0	130.6	34.2	18.6	9.4	4.0	4.0	43.5	1.0	738.5
1982	9.4	128.1	1,040.3	191.4	1,112.5	222.1	391.3	180.4	23.0	19.2	10.6	21.9	273.9	2.4	7,240.6
1983	59.2	78.0	242.2	319.4	334.6	528.3	92.2	373.6	183.9	59.0	550.7	34.7	238.7	11.7	4,082.2
1984	15.6	120.8	972.3	288.1	186.2	199.6	100.5	102.2	21.4	16.0	7.9	6.0	170.8	2.7	4,666.6
1985	15.7	50.8	28.5	30.7	45.2	107.9	296.9	59.3	26.6	12.3	6.3	15.6	57.7	3.9	603.9
1986	6.0	11.0	33.0	185.1	1,327.9	403.7	187.1	56.9	16.7	7.8	3.5	5.7	179.1	1.2	4,733.9
1987	8.9	2.0	1.8	10.9	118.9	109.5	126.6	26.7	17.2	9.7	3.8	0.6	35.7	0.5	1,886.4
1988	2.5	5.7	70.3	28.6	54.4	141.0	58.4	26.7	21.7	11.2	5.0	1.5	35.6	0.7	923.9
1989	2.7	30.8	36.7	30.8	119.2	655.0	497.4	84.5	31.4	16.0	18.3	18.4	128.3	2.2	2,263.9
1990	16.8	23.6	24.3	99.2	58.9	165.8	208.5	30.6	22.1	15.0	12.7	11.3	57.3	2.1	908.2
1991	13.1	7.3	11.5	14.2	25.3	281.0	96.0	86.5	41.3	24.8	15.0	12.6	52.8	6.0	2,842.1
1992	8.8	12.4	12.8	9.2	94.8	125.3	130.2	23.0	17.8	12.8	6.2	2.9	37.7	2.6	363.6
1993	11.9	18.3	70.6	274.1	148.5	524.9	381.9	373.0	46.8	35.3	20.5	15.4	160.7	4.6	1,703.7
1994	13.8	2.5	24.3	17.5	29.1	144.5	138.0	45.5	22.0	8.2	6.8	6.0	38.2	0.9	435.2
1995	7.6	37.2	27.5	651.1	428.8	826.8	339.0	387.7	123.9	49.7	49.8	5.0	244.3	4.1	4,128.4
1996	6.7	5.0	227.0	191.8	1,111.5	201.8	192.9	187.8	18.8	16.1	3.7	6.8	177.1	2.3	4,461.9
1997	2.9	22.3	907.7	566.0	166.1	152.6	250.1	38.0	15.1	8.4	6.1	8.9	179.9	1.0	4,082.7
1998	12.4	25.5	39.5	423.1	425.9	437.7	249.1	152.0	85.0	38.3	28.6	21.8	160.1	4.8	3,740.3
1999	13.0	38.1	167.1	216.4	412.1	231.8	219.4	249.0	41.4	27.1	18.4	9.2	135.3	5.4	3,252.1
2000	7.9	10.0	36.7	121.0	339.6	161.3	241.7	82.7	20.4	12.6	5.5	9.2	86.2	2.3	3,132.1
2001	10.4	11.9	15.9	15.3	26.8	141.1	115.8	49.9	22.3	8.4	10.8	6.7	36.3	4.0	433.7
2002	6.2	21.9	59.3	169.9	135.2	187.1	308.3	75.0	28.5	15.7	5.3	4.3	84.2	3.8	633.1
2003	6.6	24.6	246.9	277.3	227.6	244.1	97.9	125.6	26.8	15.2	10.1	6.7	108.9	1.2	3,212.4
2004	4.8	7.9	93.0	35.2	203.1	277.8	242.0	57.8	25.0	15.7	5.7	2.6	80.3	1.4	2,532.6
2005	26.0	20.7	73.0	103.9	136.5	342.0	226.4	554.4	56.4	38.6	22.3	8.9	134.7	5.8	3,782.4
2006	3.2	11.4	1,236.6	334.1	548.6	177.3	191.8	171.2	19.3	10.7	6.0	4.6	225.4	1.5	9,716.6
2007	4.5	15.2	37.2	29.3	210.8	174.5	99.9	27.8	16.0	11.2	7.5	5.9	52.2	3.6	1,967.9
2008	23.2	12.7	24.1	70.7	38.3	129.7	153.2	110.7	32.3	20.8	9.5	8.1	52.9	7.4	498.0
2009	17.3	32.5	21.6	51.3	307.5	249.1	172.0	150.4	25.6	12.7	8.0	3.6	86.1	2.8	2,931.5
2010	17.5	22.3	42.3	81.6	78.2	225.0	212.9	165.8	121.2	45.3	16.4	7.9	86.4	4.0	911.9
2011	27.0	50.1	907.0	286.1	271.3	249.4	252.2	187.9	124.1	49.9	47.4	15.9	206.2	1.6	4,941.2
Average	12.3	26.1	196.2	175.0	274.1	248.1	196.9	135.0	41.2	20.7	27.2	9.9	112.8	0.3	9,716.6
10% Exc.	24.2	53.5	277.9	353.0	382.7	481.8	450.8	315.0	82.4	39.6	24.4	17.8	266.1	--	--
20% Exc.	16.6	34.0	104.2	262.0	285.3	328.8	322.8	201.8	45.2	34.1	16.3	13.5	142.6	--	--
50% Exc.	6.8	12.9	25.9	46.6	135.5	170.1	101.1	62.7	26.7	16.0	8.1	7.3	27.6	--	--
80% Exc.	3.5	5.8	12.8	17.1	31.0	98.2	52.3	31.2	19.6	7.7	5.1	3.4	8.2	--	--
90% Exc.	2.2	2.9	8.6	12.6	21.0	83.7	44.1	26.6	15.8	5.9	3.8	1.6	5.0	--	--

Middle Yuba River at Milton Diversion Dam - 2070 DEW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,315	2,051	1,709	1,381	2,382	7,055	3,577	2,246	1,509	281	318	1,350	25,175
1977	948	466	376	309	807	996	2,889	2,406	1,830	456	235	126	11,843
1978	94	506	13,009	18,073	9,956	23,239	13,002	12,411	3,033	2,055	1,132	1,516	98,028
1979	146	631	934	5,353	4,813	8,456	8,368	10,737	2,131	1,529	586	375	44,060
1980	717	288	2,736	45,457	38,327	9,739	13,041	7,994	1,594	1,389	664	511	122,456
1981	529	863	1,602	1,701	8,143	6,643	7,773	2,102	1,105	579	244	236	31,520
1982	578	7,623	63,968	11,771	61,787	13,659	23,284	11,091	1,370	1,178	651	1,302	198,263
1983	3,639	4,639	14,892	19,640	18,585	32,485	5,486	22,972	10,942	3,625	33,859	2,064	172,828
1984	961	7,187	59,783	17,712	10,712	12,272	5,980	6,283	1,276	983	489	359	123,997
1985	966	3,022	1,754	1,886	2,509	6,633	17,664	3,645	1,586	755	390	931	41,741
1986	371	656	2,030	11,380	73,749	24,824	11,132	3,500	997	482	213	339	129,672
1987	548	120	108	669	6,601	6,736	7,531	1,643	1,024	593	236	34	25,843
1988	154	340	4,325	1,761	3,129	8,667	3,476	1,644	1,294	688	310	88	25,876
1989	166	1,830	2,256	1,893	6,618	40,272	29,600	5,198	1,871	984	1,122	1,093	92,902
1990	1,033	1,404	1,497	6,100	3,268	10,195	12,409	1,880	1,315	925	782	671	41,478
1991	803	436	710	870	1,406	17,276	5,714	5,318	2,460	1,524	924	752	38,193
1992	541	740	786	567	5,455	7,703	7,746	1,415	1,059	787	384	171	27,354
1993	734	1,087	4,341	16,854	8,247	32,272	22,723	22,933	2,784	2,173	1,262	917	116,328
1994	851	151	1,494	1,077	1,614	8,886	8,214	2,799	1,309	506	418	356	27,674
1995	469	2,215	1,689	40,033	23,815	50,836	20,170	23,837	7,374	3,054	3,062	298	176,850
1996	412	300	13,959	11,792	63,936	12,409	11,478	11,549	1,119	992	225	406	128,575
1997	178	1,328	55,810	34,800	9,225	9,385	14,880	2,336	898	515	375	532	130,262
1998	763	1,519	2,426	26,014	23,654	26,912	14,821	9,343	5,056	2,353	1,761	1,298	115,920
1999	800	2,265	10,272	13,305	22,889	14,255	13,058	15,309	2,463	1,663	1,134	546	97,958
2000	488	597	2,259	7,438	19,535	9,919	14,384	5,085	1,211	774	336	549	62,575
2001	643	707	978	941	1,490	8,676	6,893	3,070	1,326	517	663	398	26,302
2002	383	1,302	3,644	10,449	7,508	11,505	18,344	4,610	1,693	964	325	259	60,986
2003	405	1,464	15,181	17,053	12,640	15,012	5,823	7,726	1,594	937	620	400	78,855
2004	295	467	5,716	2,163	11,684	17,082	14,399	3,555	1,487	965	352	152	58,316
2005	1,597	1,233	4,486	6,391	7,583	21,029	13,472	34,087	3,356	2,372	1,373	531	97,511
2006	196	679	76,034	20,540	30,470	10,904	11,410	10,525	1,151	658	369	275	163,212
2007	274	906	2,289	1,800	11,705	10,732	5,944	1,708	953	688	459	351	37,810
2008	1,425	753	1,484	4,347	2,206	7,973	9,115	6,806	1,925	1,278	582	482	38,375
2009	1,066	1,934	1,325	3,153	17,077	15,317	10,238	9,250	1,523	778	489	214	62,364
2010	1,078	1,325	2,603	5,015	4,342	13,834	12,671	10,197	7,212	2,786	1,008	470	62,542
2011	1,661	2,980	55,771	17,593	15,069	15,337	15,010	11,556	7,387	3,066	2,913	946	149,288
Average	756	1,556	12,062	10,758	15,359	15,253	11,714	8,299	2,450	1,274	1,674	592	81,748
Maximum	3,639	7,623	76,034	45,457	73,749	50,836	29,600	34,087	10,942	3,625	33,859	2,064	198,263
Minimum	94	120	108	309	807	996	2,889	1,415	898	281	213	34	11,843
10% Exc.	1,370	3,001	55,791	23,277	34,399	29,592	19,257	19,121	6,134	2,579	1,567	1,300	156,250
20% Exc.	1,033	2,051	13,959	17,712	22,889	21,029	14,880	11,549	2,784	2,055	1,132	931	128,575
50% Exc.	610	997	2,358	6,246	8,736	11,888	11,444	5,801	1,554	965	536	438	62,559
80% Exc.	295	467	1,484	1,701	3,129	8,456	5,980	2,336	1,151	593	325	259	31,520
90% Exc.	172	320	860	905	1,910	6,896	5,600	1,794	1,042	511	240	161	26,089

Middle Yuba River at Milton Diversion Dam - 2070 DEW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-167	-122	420	335	897	3,771	-3,483	-8,925	-62	68	79	334	-6,856
1977	353	190	153	126	341	415	-531	-1,606	-480	181	95	51	-713
1978	35	174	9,682	13,008	6,962	12,287	-1,167	-23,043	-23,610	-2,880	413	539	-7,601
1979	57	244	361	3,376	2,976	5,141	-1,958	-20,999	-5,552	426	228	146	-15,556
1980	-177	26	1,111	19,352	26,828	3,860	-5,148	-24,098	-18,226	-4,216	65	50	-573
1981	-16	15	339	336	4,583	2,653	-5,799	-11,833	-1,419	40	19	18	-11,063
1982	-247	-20,128	34,231	6,314	40,630	2,820	986	-34,639	-20,623	-3,738	-75	1	5,533
1983	-1,446	490	9,895	15,491	14,277	19,881	-2,749	-17,688	-49,037	-16,229	30,981	958	4,822
1984	-874	-13,750	40,120	8,825	5,653	3,208	-6,722	-26,592	-11,369	-806	-28	-20	-2,357
1985	179	-685	473	456	1,186	3,731	-2,100	-16,083	-2,648	198	106	240	-14,948
1986	-144	-340	114	4,358	40,241	-4,361	-11,621	-23,894	-10,101	-348	-79	-126	-6,302
1987	16	4	3	15	4,253	2,609	-6,696	-7,364	-336	14	8	1	-7,471
1988	9	18	1,943	41	1,286	3,191	-6,034	-6,246	-1,758	25	18	5	-7,502
1989	50	-761	743	585	4,089	17,937	536	-18,431	-7,582	22	357	291	-2,164
1990	-1,044	-367	78	2,892	1,211	3,609	-6,585	-10,151	-4,606	-46	25	21	-14,961
1991	367	199	323	396	647	10,454	-3,078	-15,094	-7,946	-92	423	344	-13,057
1992	-151	-84	-38	-26	2,514	2,160	-8,347	-4,772	-261	-92	-17	-8	-9,123
1993	193	393	2,468	11,996	5,787	18,224	2,309	-24,238	-20,075	-1,721	544	395	-3,724
1994	160	34	369	236	469	4,372	-3,593	-11,257	-938	112	96	81	-9,860
1995	211	622	788	30,209	17,557	28,055	2,858	-21,837	-41,332	-13,953	1,622	134	4,934
1996	-99	-73	7,486	5,027	41,798	1,213	-10,476	-39,005	-10,815	-1,145	-54	-98	-6,243
1997	-74	-2,590	30,045	-2,638	3,316	-876	-7,199	-19,963	-5,247	-479	-155	-220	-6,081
1998	322	238	1,076	19,666	18,672	15,542	1,668	-18,581	-36,571	-7,370	778	549	-4,011
1999	254	-6	7,337	8,678	16,732	7,385	-486	-25,420	-21,007	-1,148	377	181	-7,123
2000	-127	-103	942	3,107	12,387	2,686	-7,535	-23,214	-5,270	-186	-21	-34	-17,367
2001	183	211	292	281	501	4,431	-2,306	-12,102	118	151	199	119	-7,922
2002	88	-284	1,384	6,322	4,425	5,205	-3,113	-19,357	-6,031	161	75	60	-11,066
2003	20	-625	9,958	9,845	7,166	4,081	-6,027	-22,990	-14,377	-432	32	20	-13,329
2004	42	65	2,667	203	7,827	5,973	-4,365	-17,541	-3,747	-30	50	21	-8,834
2005	632	659	2,750	4,246	5,441	14,407	1,070	-17,389	-16,797	-427	738	286	-4,383
2006	-52	-385	38,740	8,159	16,865	1,368	-7,914	-36,683	-14,716	-880	-97	-73	4,334
2007	-29	-285	439	257	7,020	2,616	-7,066	-12,208	-1,382	-79	-47	-37	-10,801
2008	395	253	539	2,258	879	4,638	-2,985	-18,764	-3,193	372	198	163	-15,247
2009	-136	-1,022	287	1,481	12,546	6,117	-5,964	-26,048	-4,338	72	76	33	-16,897
2010	496	813	1,619	3,413	2,984	10,221	3,004	-13,786	-26,400	-570	624	290	-17,292
2011	-1,358	286	45,442	12,993	11,070	8,726	-1,594	-20,426	-43,041	-14,332	1,452	372	-410
Average	-58	-1,019	7,072	5,601	9,778	6,604	-3,617	-18,674	-12,244	-1,927	1,086	141	-7,256

Canyon Creek at Bowman Dam - Historical Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	39.5	56.0	32.2	30.4	33.7	71.7	111.4	144.9	13.0	3.3	12.4	12.2	46.8	1.0	431.0
1977	2.1	4.7	3.4	3.3	8.4	15.6	106.9	106.6	31.9	2.4	1.4	1.3	24.0	0.4	189.3
1978	1.0	3.2	69.4	87.4	69.6	214.8	241.4	563.9	414.7	50.6	4.6	6.0	144.2	0.4	858.5
1979	1.6	3.4	5.5	34.7	26.7	114.6	220.7	518.7	115.9	5.0	1.4	0.6	87.9	0.3	771.8
1980	14.5	37.1	43.8	446.8	163.6	77.3	322.8	454.2	301.1	61.5	3.7	2.5	160.7	0.7	4,778.8
1981	4.7	3.7	11.1	17.4	97.8	79.3	276.7	206.9	21.2	1.3	1.1	4.0	59.9	0.9	659.6
1982	11.8	460.5	385.3	62.7	355.1	126.8	339.1	583.0	336.7	53.1	4.5	15.4	226.1	2.3	3,574.0
1983	143.8	89.6	75.9	64.4	77.5	195.3	142.0	621.4	872.4	322.2	43.2	11.1	222.1	4.2	1,342.1
1984	33.6	396.2	292.3	121.9	82.8	161.2	206.6	503.4	188.8	13.9	2.3	3.2	167.3	1.6	1,718.9
1985	8.1	80.0	33.9	26.2	41.7	73.1	368.1	301.4	42.1	2.0	1.9	3.8	81.7	1.2	671.5
1986	3.4	6.0	41.2	173.1	540.1	419.2	326.1	438.8	168.8	6.8	1.7	8.6	175.4	1.5	3,504.1
1987	15.9	5.7	4.8	8.4	55.0	88.1	322.5	138.0	10.8	1.9	1.6	1.2	54.1	0.9	495.0
1988	3.1	4.0	36.7	31.9	65.0	140.4	198.7	129.9	38.2	2.6	1.1	1.4	54.3	1.0	305.5
1989	1.2	46.2	32.6	28.1	63.8	406.3	490.8	387.9	142.5	3.5	2.0	4.5	134.3	1.0	1,697.4
1990	20.8	25.7	22.7	59.4	37.1	161.0	341.5	172.4	66.8	2.6	1.1	1.3	76.0	0.9	539.6
1991	2.0	1.5	1.7	2.0	6.1	109.3	220.8	345.9	168.5	13.8	1.4	1.2	73.1	1.1	1,214.6
1992	2.4	6.6	11.2	12.8	92.1	154.0	346.2	95.6	5.0	4.1	2.4	1.2	60.7	1.1	640.2
1993	4.4	9.8	33.1	108.7	68.8	287.4	408.7	757.0	356.9	42.0	2.8	1.8	174.1	1.1	1,183.4
1994	3.8	3.1	9.7	15.0	16.4	125.2	245.9	216.3	16.4	1.0	1.1	1.5	54.8	0.8	553.3
1995	2.7	14.3	23.5	205.9	132.2	359.9	324.9	665.2	700.6	281.7	21.1	2.5	228.3	1.4	2,221.2
1996	2.5	3.4	111.3	96.4	420.6	223.7	381.8	597.6	206.0	123.3	6.5	5.5	180.6	2.2	2,427.8
1997	4.4	91.5	414.4	480.2	100.4	211.8	388.7	352.3	82.2	3.6	2.4	3.0	179.0	1.3	6,190.5
1998	4.8	18.4	36.0	171.5	93.9	265.5	270.2	486.6	762.7	188.7	6.6	3.9	192.4	2.2	1,537.4
1999	6.1	39.8	82.7	111.3	89.0	138.8	325.3	743.6	340.7	25.2	4.2	3.1	159.5	1.8	1,427.1
2000	3.8	11.7	81.9	107.3	138.2	171.0	437.7	619.3	98.3	4.2	1.7	2.1	139.8	1.6	1,394.7
2001	4.2	8.2	12.4	13.3	23.7	168.0	244.2	305.4	11.7	2.5	1.2	1.8	66.8	1.1	586.2
2002	1.7	23.9	47.2	100.8	94.7	140.7	445.6	453.6	143.9	4.8	1.2	1.2	121.5	1.1	824.7
2003	1.2	40.1	120.6	180.6	115.7	238.3	199.6	520.1	286.2	8.7	3.3	2.7	143.4	1.2	951.0
2004	2.0	7.8	49.3	38.5	85.9	310.0	389.7	346.7	49.8	2.3	1.2	1.9	107.2	1.0	644.5
2005	5.6	15.8	43.6	53.4	70.8	155.2	258.0	728.3	301.9	28.9	1.9	1.4	139.2	1.2	2,904.2
2006	3.4	11.8	615.2	143.5	241.2	116.7	302.8	601.5	270.7	17.5	2.4	2.5	194.2	1.7	6,065.1
2007	3.1	12.4	48.3	36.7	113.8	188.4	240.5	212.0	18.9	1.2	1.1	1.4	72.9	0.9	525.2
2008	5.5	7.2	10.7	27.2	33.1	121.5	271.6	353.8	65.2	2.1	1.1	1.2	75.1	1.0	668.8
2009	2.9	23.7	10.9	63.7	119.1	190.2	333.2	574.6	88.9	2.5	1.2	1.2	117.7	0.9	1,810.2
2010	6.7	4.5	12.1	35.7	45.7	112.3	222.8	418.9	533.2	35.5	1.4	1.2	119.0	1.1	1,265.3
2011	64.6	67.2	202.9	103.1	91.7	103.7	319.3	507.2	785.5	273.9	15.0	2.5	211.5	1.2	1,175.8
Average	12.3	45.7	85.3	91.8	108.8	173.2	294.2	421.5	223.8	44.5	4.6	3.4	125.7	0.3	6,190.5
10% Exc.	15.2	76.5	135.5	153.6	185.9	353.4	525.2	757.5	649.4	126.6	6.9	7.1	389.8	--	--
20% Exc.	7.9	38.8	73.0	103.8	111.3	237.7	434.6	624.3	409.8	47.2	4.0	3.5	198.5	--	--
50% Exc.	2.6	7.9	27.5	42.3	66.3	117.3	255.7	387.1	108.8	4.6	1.7	1.7	30.8	--	--
80% Exc.	1.3	3.3	9.7	16.3	28.6	68.8	139.7	181.9	15.4	1.5	1.2	1.2	2.5	--	--
90% Exc.	1.2	2.2	4.8	10.7	16.7	55.4	107.3	106.5	7.4	1.1	1.1	1.2	1.3	--	--

Canyon Creek at Bowman Dam - Historical Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	2,427	3,330	1,981	1,868	1,938	4,411	6,629	8,907	774	204	762	728	33,959
1977	131	278	210	202	464	958	6,359	6,556	1,899	146	84	75	17,362
1978	65	191	4,265	5,377	3,863	13,207	14,364	34,670	24,674	3,109	284	357	104,425
1979	96	202	339	2,131	1,484	7,044	13,132	31,896	6,896	305	87	34	63,646
1980	892	2,210	2,696	27,474	9,408	4,755	19,209	27,927	17,918	3,780	226	148	116,641
1981	289	219	681	1,072	5,431	4,875	16,463	12,722	1,260	77	69	235	43,394
1982	728	27,403	23,693	3,856	19,720	7,794	20,181	35,850	20,037	3,267	278	914	163,720
1983	8,841	5,333	4,669	3,960	4,305	12,009	8,448	38,211	51,911	19,814	2,658	660	160,818
1984	2,067	23,577	17,973	7,497	4,761	9,909	12,291	30,955	11,234	853	144	193	121,456
1985	498	4,758	2,087	1,610	2,314	4,493	21,903	18,535	2,505	123	114	228	59,167
1986	212	356	2,532	10,645	29,998	25,776	19,407	26,982	10,045	421	103	514	126,990
1987	976	336	295	518	3,055	5,415	19,192	8,487	645	114	100	69	39,202
1988	193	239	2,256	1,961	3,740	8,634	11,823	7,989	2,275	160	69	80	39,420
1989	74	2,752	2,006	1,726	3,544	24,985	29,206	23,851	8,478	215	126	269	97,231
1990	1,278	1,529	1,395	3,652	2,058	9,898	20,320	10,600	3,976	159	70	76	55,009
1991	120	89	103	120	341	6,723	13,137	21,266	10,027	850	88	72	52,936
1992	147	395	688	789	5,296	9,471	20,601	5,878	297	253	145	71	44,029
1993	270	581	2,035	6,682	3,820	17,672	24,317	46,543	21,236	2,582	173	105	126,014
1994	234	187	596	923	913	7,697	14,633	13,299	974	62	69	87	39,673
1995	168	853	1,442	12,659	7,341	22,129	19,335	40,904	41,689	17,323	1,297	148	165,289
1996	156	204	6,842	5,928	24,192	13,757	22,717	36,747	12,257	7,583	402	328	131,113
1997	269	5,445	25,482	29,529	5,574	13,020	23,132	21,665	4,891	223	149	180	129,559
1998	292	1,095	2,212	10,545	5,218	16,322	16,078	29,923	45,384	11,601	408	232	139,310
1999	377	2,368	5,085	6,845	4,943	8,536	19,356	45,720	20,272	1,548	261	183	115,493
2000	234	695	5,037	6,596	7,951	10,512	26,046	38,079	5,851	257	104	124	101,487
2001	261	491	760	815	1,317	10,333	14,531	18,781	698	155	77	108	48,326
2002	105	1,423	2,905	6,201	5,260	8,651	26,516	27,890	8,561	294	77	72	87,956
2003	76	2,388	7,416	11,102	6,427	14,651	11,874	31,980	17,028	535	201	162	103,839
2004	121	466	3,032	2,366	4,942	19,060	23,190	21,321	2,963	144	72	112	77,789
2005	347	940	2,682	3,282	3,932	9,544	15,354	44,784	17,963	1,777	120	85	100,810
2006	207	702	37,825	8,822	13,397	7,175	18,016	36,985	16,111	1,075	148	148	140,612
2007	193	740	2,969	2,255	6,318	11,586	14,313	13,037	1,124	76	69	81	52,760
2008	341	431	659	1,672	1,904	7,468	16,162	21,752	3,880	132	69	69	54,539
2009	180	1,411	672	3,915	6,612	11,695	19,824	35,332	5,291	156	72	72	85,232
2010	411	266	744	2,192	2,537	6,904	13,258	25,759	31,725	2,182	85	72	86,136
2011	3,972	3,997	12,477	6,341	5,092	6,377	19,002	31,185	46,742	16,840	924	148	153,099
Average	757	2,719	5,243	5,642	6,095	10,651	17,509	25,916	13,319	2,733	283	201	91,068
Maximum	8,841	27,403	37,825	29,529	29,998	25,776	29,206	46,543	51,911	19,814	2,658	914	165,289
Minimum	65	89	103	120	341	958	6,359	5,878	297	62	69	34	17,362
10% Exc.	1,672	5,046	15,225	10,873	11,403	18,366	23,754	39,558	36,707	9,592	585	436	146,855
20% Exc.	728	2,752	5,085	7,497	6,612	13,757	21,903	36,747	20,272	3,109	278	235	129,559
50% Exc.	248	721	2,234	3,754	4,852	9,508	18,509	27,436	8,519	300	117	136	92,594
80% Exc.	131	266	681	1,610	2,058	6,723	13,137	13,037	1,899	146	72	72	48,326
90% Exc.	101	203	467	802	1,401	4,815	11,849	8,697	874	119	69	72	39,547

Canyon Creek at Bowman Dam - 2070 Median Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	31.9	62.7	43.5	45.8	66.4	139.1	60.1	32.1	11.4	2.9	10.9	11.0	43.1	0.9	320.9
1977	3.8	8.3	6.0	5.8	16.4	31.6	105.4	58.3	32.8	4.2	2.4	2.2	23.0	0.6	221.0
1978	1.2	3.6	204.1	273.7	224.3	432.6	207.9	262.0	66.0	24.6	5.2	6.8	142.8	0.5	2,034.5
1979	2.2	4.8	7.7	125.8	71.1	292.1	227.7	292.4	38.1	6.9	2.0	0.8	89.7	0.4	2,153.1
1980	12.1	41.6	78.9	843.6	388.2	145.5	238.3	154.0	31.1	19.4	3.3	2.2	162.9	0.6	5,652.8
1981	4.9	3.9	13.6	26.2	230.6	173.0	227.6	51.2	14.9	1.3	1.2	4.1	61.3	0.9	1,439.1
1982	10.2	580.0	652.7	168.3	744.2	215.4	307.8	224.2	33.8	20.6	4.0	24.4	244.9	2.1	4,323.7
1983	187.2	185.6	268.8	288.5	319.4	565.3	125.7	452.9	359.7	53.6	51.3	16.8	239.7	6.4	3,883.1
1984	23.9	462.1	629.0	264.6	184.2	225.6	118.1	157.4	24.7	9.5	1.9	2.6	175.5	1.3	2,735.4
1985	9.1	120.2	62.0	34.8	114.6	177.7	344.9	85.4	22.2	2.2	2.1	4.3	80.9	1.4	673.1
1986	2.7	4.7	59.3	430.0	899.1	536.3	206.0	117.1	24.2	5.0	1.3	6.7	186.6	1.2	3,912.7
1987	13.9	5.2	4.4	7.7	128.5	156.8	243.3	32.5	9.6	1.6	1.5	1.1	49.7	0.8	1,302.1
1988	2.5	3.2	53.5	51.9	137.7	199.5	106.4	27.3	16.4	2.0	0.9	1.1	49.9	0.8	476.5
1989	1.2	65.2	53.5	43.2	143.9	773.9	427.6	120.3	28.6	3.4	2.1	4.6	139.0	1.0	2,757.7
1990	18.4	26.4	25.1	173.6	79.5	251.1	285.1	39.3	21.0	2.5	1.1	1.3	77.0	0.9	1,773.7
1991	3.2	2.5	2.8	3.2	10.2	375.5	261.9	158.3	49.9	16.6	2.3	2.0	74.5	1.9	4,184.0
1992	2.2	6.1	10.3	11.8	175.8	247.7	271.2	26.8	4.5	3.7	2.2	1.1	62.9	1.0	1,151.1
1993	4.9	11.5	65.0	379.6	231.8	608.0	411.5	419.0	49.1	22.4	3.3	2.1	184.3	1.3	2,608.9
1994	4.3	3.5	10.9	17.2	23.6	259.1	204.9	63.0	14.1	1.1	1.2	1.6	50.5	0.9	529.9
1995	3.4	19.1	36.6	829.3	369.0	764.0	336.1	360.2	193.5	38.2	20.4	3.1	247.9	1.7	4,800.4
1996	2.3	3.1	218.3	230.2	960.2	326.1	286.4	229.3	29.7	24.8	5.8	4.9	190.5	1.9	3,738.6
1997	3.1	94.3	705.9	656.7	183.6	267.7	253.7	72.5	16.9	2.5	1.7	2.1	189.5	0.9	4,943.3
1998	5.6	26.3	74.2	691.4	310.3	604.4	261.4	215.1	201.4	33.5	7.8	4.6	203.0	2.6	3,942.7
1999	6.5	59.6	236.2	391.6	250.2	266.6	285.1	376.5	43.6	16.1	4.5	3.3	161.6	1.9	2,525.3
2000	3.3	10.8	195.6	316.5	319.1	242.6	331.5	236.4	22.6	3.6	1.5	1.8	140.0	1.4	2,117.7
2001	5.2	10.2	15.2	16.4	45.6	364.3	226.0	117.9	13.6	3.0	1.5	2.2	68.7	1.4	1,465.0
2002	1.8	31.1	97.6	281.0	237.6	259.3	388.4	167.0	29.6	4.9	1.3	1.2	124.3	1.2	808.9
2003	1.0	39.7	250.7	492.8	217.7	360.9	108.6	177.4	35.4	6.5	2.6	2.2	141.7	1.0	2,064.7
2004	1.8	7.4	95.7	97.0	201.3	540.4	303.6	93.1	19.8	2.1	1.1	1.8	113.6	0.9	1,444.0
2005	7.3	20.4	112.0	182.5	262.5	339.9	254.7	430.5	50.7	21.5	2.5	1.8	140.2	1.5	2,145.5
2006	2.8	11.0	1,013.8	349.2	446.5	183.8	203.3	214.5	30.5	10.3	2.0	2.0	205.4	1.4	6,612.7
2007	2.7	11.5	91.9	65.5	261.5	256.0	160.5	42.0	12.5	1.1	1.0	1.2	74.4	0.8	1,397.2
2008	7.1	9.3	14.5	58.8	94.4	287.7	273.1	133.3	29.3	2.7	1.4	1.5	76.0	1.3	569.9
2009	3.0	28.8	13.0	183.8	333.4	340.4	284.4	240.3	26.4	2.6	1.2	1.3	120.2	0.9	2,019.8
2010	10.4	7.5	21.2	136.6	199.8	367.5	277.8	232.1	181.0	29.3	2.3	2.1	121.7	1.8	1,594.5
2011	67.0	114.2	733.3	350.7	305.1	251.3	331.3	245.1	269.9	42.9	16.7	3.2	227.4	1.5	3,139.6
Average	13.2	58.5	171.6	236.8	255.4	328.6	248.5	176.6	57.2	12.5	4.9	3.8	130.1	0.4	6,612.7
10% Exc.	16.9	114.2	320.4	377.9	371.8	510.4	480.9	414.0	125.6	35.0	7.7	7.9	326.3	--	--
20% Exc.	7.8	44.9	188.5	282.1	293.5	378.3	386.6	286.3	49.1	24.9	4.1	3.3	216.3	--	--
50% Exc.	2.8	8.9	30.5	124.0	191.3	237.9	204.8	105.7	27.8	4.6	1.9	2.0	28.2	--	--
80% Exc.	1.6	3.3	10.1	19.4	48.1	151.7	85.3	38.0	14.8	1.6	1.2	1.2	2.7	--	--
90% Exc.	1.2	2.5	6.3	11.2	21.8	122.6	59.0	30.9	7.0	1.0	1.1	1.1	1.5	--	--

Canyon Creek at Bowman Dam - 2070 Median Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,959	3,730	2,675	2,815	3,817	8,555	3,576	1,976	681	181	673	652	31,290
1977	231	492	371	358	909	1,944	6,271	3,583	1,950	256	149	133	16,646
1978	73	217	12,550	16,827	12,455	26,599	12,373	16,112	3,927	1,515	321	405	103,373
1979	135	284	474	7,736	3,951	17,962	13,551	17,977	2,269	425	122	47	64,932
1980	742	2,478	4,852	51,874	22,328	8,945	14,180	9,472	1,852	1,190	203	133	118,247
1981	301	229	835	1,612	12,806	10,637	13,541	3,150	884	79	71	245	44,391
1982	629	34,511	40,133	10,349	41,332	13,242	18,313	13,787	2,012	1,268	248	1,454	177,278
1983	11,509	11,045	16,526	17,740	17,740	34,762	7,483	27,846	21,404	3,294	3,157	997	173,502
1984	1,468	27,499	38,677	16,269	10,596	13,869	7,027	9,676	1,473	584	117	156	127,411
1985	556	7,153	3,814	2,138	6,364	10,927	20,523	5,252	1,322	137	129	256	58,571
1986	165	277	3,644	26,441	49,932	32,973	12,260	7,202	1,439	310	80	399	135,122
1987	858	306	269	472	7,138	9,643	14,479	1,997	569	101	90	63	35,985
1988	153	190	3,292	3,194	7,921	12,265	6,330	1,680	974	125	54	64	36,243
1989	75	3,877	3,287	2,653	7,994	47,583	25,446	7,398	1,699	211	127	272	100,623
1990	1,131	1,573	1,544	10,676	4,418	15,442	16,965	2,418	1,250	154	68	74	55,712
1991	197	146	170	198	569	23,086	15,585	9,734	2,968	1,020	144	118	53,934
1992	135	363	634	726	10,110	15,228	16,137	1,648	266	227	133	65	45,671
1993	302	682	3,995	23,339	12,871	37,385	24,485	25,765	2,923	1,380	201	122	133,452
1994	262	210	669	1,059	1,312	15,933	12,191	3,872	838	67	76	97	36,587
1995	210	1,135	2,250	50,990	20,496	46,975	19,998	22,149	11,513	2,349	1,256	185	179,505
1996	140	183	13,425	14,152	55,234	20,048	17,043	14,098	1,770	1,524	359	294	138,269
1997	191	5,613	43,404	40,377	10,197	16,457	15,094	4,457	1,003	154	106	128	137,181
1998	347	1,567	4,563	42,514	17,232	37,164	15,557	13,223	11,983	2,062	483	275	146,969
1999	403	3,544	14,521	24,076	13,896	16,393	16,963	23,147	2,593	991	278	195	117,001
2000	201	643	12,029	19,463	18,356	14,916	19,724	14,533	1,345	222	92	110	101,634
2001	320	605	938	1,006	2,533	22,402	13,450	7,251	808	182	93	132	49,719
2002	108	1,849	6,001	17,277	13,195	15,943	23,112	10,270	1,759	300	79	74	89,966
2003	60	2,365	15,416	30,302	12,092	22,188	6,464	10,909	2,106	401	159	128	102,591
2004	113	440	5,882	5,965	11,581	33,228	18,068	5,725	1,176	130	67	105	82,481
2005	447	1,213	6,888	11,221	14,577	20,901	15,157	26,469	3,019	1,319	154	110	101,474
2006	170	653	62,336	21,471	24,795	11,299	12,095	13,187	1,815	634	122	122	148,697
2007	169	687	5,650	4,026	14,524	15,744	9,548	2,584	742	65	60	70	53,868
2008	439	554	889	3,616	5,432	17,691	16,251	8,197	1,742	167	89	89	55,157
2009	186	1,714	799	11,300	18,517	20,928	16,925	14,776	1,573	159	74	75	87,025
2010	641	448	1,301	8,397	11,097	22,595	16,530	14,274	10,768	1,799	144	123	88,119
2011	4,119	6,798	45,087	21,562	16,942	15,450	19,715	15,072	16,061	2,640	1,028	188	164,663
Average	810	3,480	10,550	14,561	14,313	20,203	14,789	10,857	3,402	767	300	227	94,258
Maximum	11,509	34,511	62,336	51,874	55,234	47,583	25,446	27,846	21,404	3,294	3,157	1,454	179,505
Minimum	60	146	170	198	569	1,944	3,576	1,648	266	65	54	47	16,646
10% Exc.	1,300	6,976	39,405	35,339	23,561	35,963	20,261	22,648	11,140	1,931	578	402	156,680
20% Exc.	641	3,730	14,521	23,339	18,356	26,599	18,313	15,072	2,968	1,380	278	272	137,181
50% Exc.	246	684	3,905	10,949	12,273	16,425	15,357	9,705	1,751	305	128	128	95,295
80% Exc.	140	284	835	2,138	5,432	12,265	12,095	3,583	974	154	79	75	49,719
90% Exc.	111	213	554	866	3,175	10,140	6,746	2,208	775	113	70	68	36,415

Canyon Creek at Bowman Dam - 2070 Median Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-469	400	694	947	1,879	4,144	-3,053	-6,931	-93	-23	-89	-76	-2,670
1977	100	214	161	155	445	986	-88	-2,973	51	110	65	58	-716
1978	9	25	8,285	11,450	8,591	13,392	-1,990	-18,558	-20,747	-1,594	38	47	-1,052
1979	39	81	136	5,605	2,466	10,918	419	-13,919	-4,627	120	35	14	1,286
1980	-150	268	2,156	24,400	12,920	4,190	-5,029	-18,455	-16,066	-2,590	-23	-15	1,607
1981	13	10	154	540	7,375	5,762	-2,922	-9,572	-377	2	3	10	997
1982	-99	7,108	16,440	6,493	21,612	5,448	-1,867	-22,062	-18,025	-1,999	-30	541	13,558
1983	2,668	5,712	11,856	13,780	13,435	22,753	-966	-10,365	-30,507	-16,520	499	338	12,684
1984	-599	3,922	20,703	8,771	5,835	3,959	-5,265	-21,279	-9,761	-268	-27	-37	5,955
1985	58	2,395	1,727	528	4,050	6,434	-1,380	-13,283	-1,183	14	14	29	-595
1986	-47	-78	1,112	15,797	19,935	7,197	-7,147	-19,780	-8,607	-110	-23	-115	8,132
1987	-118	-30	-26	-46	4,083	4,228	-4,713	-6,490	-77	-13	-9	-6	-3,217
1988	-40	-49	1,035	1,232	4,182	3,631	-5,493	-6,309	-1,301	-36	-14	-17	-3,177
1989	1	1,126	1,281	927	4,451	22,597	-3,760	-16,453	-6,779	-4	1	3	3,392
1990	-147	44	149	7,025	2,359	5,544	-3,355	-8,182	-2,726	-5	-2	-2	703
1991	77	57	67	78	227	16,363	2,448	-11,532	-7,059	170	56	46	998
1992	-12	-32	-55	-63	4,814	5,757	-4,464	-4,230	-31	-25	-12	-6	1,642
1993	32	101	1,960	16,657	9,051	19,714	169	-20,778	-18,313	-1,202	29	18	7,437
1994	27	23	74	136	399	8,236	-2,442	-9,427	-136	5	8	10	-3,086
1995	42	282	808	38,331	13,155	24,846	663	-18,755	-30,177	-14,973	-41	37	14,217
1996	-16	-21	6,583	8,224	31,042	6,291	-5,674	-22,649	-10,488	-6,059	-43	-34	7,156
1997	-78	168	17,922	10,848	4,623	3,437	-8,038	-17,208	-3,888	-69	-43	-52	7,622
1998	55	472	2,351	31,969	12,014	20,842	-521	-16,700	-33,401	-9,539	75	43	7,660
1999	25	1,177	9,437	17,231	8,954	7,856	-2,392	-22,572	-17,679	-558	17	12	1,508
2000	-33	-53	6,993	12,866	10,404	4,404	-6,322	-23,546	-4,506	-35	-12	-14	147
2001	59	114	178	191	1,215	12,069	-1,080	-11,530	111	27	17	24	1,393
2002	3	426	3,096	11,077	7,934	7,292	-3,405	-17,620	-6,802	5	2	2	2,010
2003	-16	-23	8,000	19,200	5,665	7,537	-5,410	-21,070	-14,921	-134	-42	-34	-1,249
2004	-7	-26	2,850	3,599	6,639	14,168	-5,123	-15,596	-1,787	-14	-5	-7	4,691
2005	100	273	4,206	7,939	10,646	11,357	-197	-18,314	-14,945	-458	34	24	665
2006	-37	-50	24,511	12,649	11,398	4,123	-5,921	-23,798	-14,296	-441	-27	-26	8,085
2007	-24	-53	2,681	1,771	8,206	4,158	-4,765	-10,454	-383	-11	-9	-10	1,108
2008	97	124	230	1,944	3,528	10,222	89	-13,555	-2,138	35	20	20	617
2009	6	304	127	7,386	11,905	9,232	-2,899	-20,556	-3,718	3	2	2	1,793
2010	230	182	557	6,205	8,560	15,691	3,272	-11,485	-20,957	-382	59	50	1,983
2011	147	2,800	32,610	15,220	11,850	9,073	713	-16,113	-30,681	-14,200	104	40	11,565
Average	53	761	5,307	8,918	8,218	9,552	-2,720	-15,058	-9,917	-1,966	17	25	3,190

Canyon Creek at Bowman Dam - 2070 WMW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	26.5	91.1	52.3	51.3	66.6	159.1	100.6	52.9	12.0	3.0	11.5	11.5	53.1	0.9	691.3
1977	3.4	7.5	5.5	5.3	14.7	32.4	154.2	72.2	29.5	3.6	2.1	2.0	27.6	0.6	307.8
1978	1.3	3.9	240.2	319.3	255.6	516.3	298.7	396.7	129.7	26.4	5.6	7.2	183.6	0.5	2,414.0
1979	2.3	5.0	8.2	150.9	74.3	329.0	332.4	430.7	44.6	7.1	2.1	0.8	116.2	0.4	2,708.6
1980	11.0	54.5	91.5	984.2	478.4	161.4	315.5	225.8	46.3	19.8	3.3	2.3	199.0	0.6	6,182.5
1981	4.3	3.4	12.4	23.7	239.0	165.6	269.2	77.0	13.3	1.1	1.0	3.6	66.4	0.8	1,776.9
1982	8.3	1,040.4	640.6	160.4	841.2	206.9	313.3	276.3	48.1	18.2	3.5	18.2	292.9	1.8	4,982.1
1983	103.7	288.0	272.2	302.9	334.3	628.9	200.8	550.0	608.9	95.8	81.0	16.2	290.0	6.2	4,745.5
1984	14.9	901.2	580.9	258.3	173.0	209.6	145.8	205.6	26.3	8.2	1.6	2.3	210.2	1.1	2,760.8
1985	8.9	181.4	69.8	36.7	118.1	192.2	445.0	157.2	22.7	2.2	2.1	4.3	102.6	1.3	1,304.9
1986	2.6	4.5	62.9	485.0	1,141.3	621.6	263.4	184.8	29.7	4.9	1.3	6.5	228.3	1.1	4,342.2
1987	14.2	5.3	4.5	7.9	153.3	174.8	320.0	51.3	9.8	1.7	1.5	1.1	61.1	0.8	1,876.6
1988	2.6	3.4	61.6	57.5	154.2	226.9	168.1	42.5	17.7	2.1	0.9	1.1	61.2	0.8	583.9
1989	1.2	126.5	59.9	44.9	144.5	906.9	519.3	196.6	31.7	3.3	2.0	4.5	170.3	1.0	3,428.4
1990	14.3	27.7	26.4	190.7	77.0	269.3	350.6	65.5	22.3	2.5	1.1	1.2	87.3	0.9	2,113.5
1991	2.7	2.1	2.4	2.7	8.6	371.9	312.7	241.7	52.6	14.0	2.0	1.7	85.1	1.6	4,465.0
1992	2.0	5.6	9.5	10.8	194.8	244.1	310.6	34.3	4.1	3.4	2.0	1.0	67.7	1.0	1,493.0
1993	4.7	11.9	71.0	440.0	255.5	729.0	532.9	560.1	83.4	23.1	3.4	2.1	226.9	1.4	3,387.8
1994	4.2	3.5	10.8	17.2	22.7	272.7	280.2	108.6	14.0	1.1	1.2	1.6	61.7	0.9	670.1
1995	3.2	20.1	37.5	917.2	394.7	850.7	418.2	487.1	329.5	50.7	19.9	3.0	294.6	1.6	5,645.7
1996	2.1	2.9	227.5	241.3	1,244.5	339.9	354.1	312.4	38.3	23.9	5.5	4.7	229.0	1.8	4,096.0
1997	3.1	206.2	785.7	766.8	201.0	309.3	305.7	132.8	19.0	2.5	1.7	2.2	229.3	0.9	5,949.1
1998	5.1	29.7	76.0	711.2	326.0	650.0	307.4	287.1	329.0	34.5	7.0	4.2	230.5	2.4	4,183.1
1999	6.7	110.7	257.7	455.7	282.0	297.4	377.0	499.8	76.0	16.4	4.6	3.3	198.9	2.0	2,779.5
2000	3.5	11.8	223.0	381.4	406.7	282.7	456.3	348.8	26.0	3.9	1.6	2.0	178.3	1.5	3,068.7
2001	4.9	9.6	14.5	15.5	41.6	398.4	293.8	187.5	12.9	2.8	1.4	2.1	82.4	1.3	1,594.1
2002	1.7	41.7	108.3	306.0	253.0	281.0	494.5	260.4	35.4	4.8	1.3	1.2	148.3	1.1	1,008.5
2003	1.1	59.1	295.9	612.0	258.6	455.9	170.6	260.2	62.9	7.1	2.8	2.3	182.9	1.0	2,606.5
2004	1.8	7.4	105.5	101.7	237.1	626.3	399.3	155.9	20.5	2.1	1.1	1.8	138.2	0.9	2,041.4
2005	7.6	21.3	125.7	203.7	298.0	387.5	360.0	622.8	82.2	22.5	2.6	1.9	177.7	1.6	3,411.2
2006	2.6	11.3	1,086.1	371.9	520.0	190.6	254.9	280.3	43.1	9.8	1.9	1.9	230.5	1.4	7,548.2
2007	2.6	12.1	96.7	65.9	299.4	266.0	205.6	74.3	12.0	1.0	0.9	1.1	85.0	0.7	1,877.5
2008	6.5	8.5	13.6	56.0	83.3	282.1	336.5	216.4	28.1	2.5	1.3	1.4	86.3	1.2	688.5
2009	3.0	33.5	13.3	204.1	406.1	372.0	356.4	347.7	27.9	2.5	1.2	1.2	145.8	0.9	2,867.0
2010	8.9	7.0	20.2	135.0	191.6	366.8	360.1	341.9	304.3	27.0	2.2	1.9	146.6	1.7	1,674.2
2011	39.6	149.3	819.7	385.0	340.7	280.2	437.9	366.4	485.1	75.0	16.9	3.2	282.9	1.6	3,498.5
Average	9.4	97.5	183.0	263.3	292.9	362.6	320.0	253.1	88.3	14.7	5.6	3.6	157.2	0.4	7,548.2
10% Exc.	16.0	148.2	313.3	406.7	395.6	556.1	613.3	538.6	253.3	35.7	7.2	7.1	378.7	--	--
20% Exc.	7.4	50.2	187.4	301.8	317.3	401.2	484.6	395.3	78.4	24.4	4.1	3.3	250.0	--	--
50% Exc.	2.7	8.5	32.8	129.3	205.0	247.5	271.2	201.9	30.1	4.4	1.7	1.9	30.1	--	--
80% Exc.	1.6	3.2	9.7	18.6	45.6	159.6	140.2	63.5	15.0	1.5	1.2	1.2	2.6	--	--
90% Exc.	1.2	2.4	6.1	10.4	21.0	134.0	99.4	44.7	7.0	1.0	1.1	1.1	1.5	--	--

Canyon Creek at Bowman Dam - 2070 WMW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,627	5,421	3,216	3,152	3,832	9,783	5,985	3,253	715	187	705	685	38,560
1977	206	447	340	326	816	1,991	9,174	4,441	1,756	218	132	119	19,966
1978	78	230	14,768	19,631	14,193	31,743	17,776	24,391	7,719	1,622	341	430	132,921
1979	142	300	506	9,276	4,125	20,232	19,776	26,480	2,656	438	128	49	84,109
1980	676	3,243	5,629	60,514	27,521	9,924	18,771	13,883	2,755	1,219	205	135	144,474
1981	264	201	765	1,460	13,272	10,185	16,017	4,736	789	69	63	215	48,036
1982	507	61,910	39,389	9,860	46,717	12,723	18,643	16,990	2,864	1,121	217	1,086	212,027
1983	6,374	17,138	16,735	18,625	18,564	38,667	11,946	33,819	36,231	5,893	4,980	961	209,932
1984	916	53,623	35,720	15,883	9,949	12,885	8,677	12,641	1,567	506	101	134	152,603
1985	549	10,793	4,292	2,259	6,558	11,819	26,477	9,666	1,348	135	127	253	74,277
1986	160	269	3,866	29,821	63,387	38,219	15,672	11,361	1,766	303	77	388	165,290
1987	874	313	277	484	8,516	10,748	19,041	3,155	582	102	92	64	44,249
1988	162	201	3,788	3,536	8,871	13,954	10,005	2,616	1,055	131	58	68	44,445
1989	73	7,530	3,685	2,760	8,024	55,764	30,903	12,089	1,888	206	124	266	123,313
1990	881	1,650	1,621	11,727	4,275	16,559	20,863	4,028	1,327	151	67	73	63,225
1991	166	124	145	168	480	22,864	18,606	14,860	3,129	861	122	100	61,625
1992	124	332	585	666	11,208	15,007	18,480	2,107	246	209	122	59	49,144
1993	290	707	4,368	27,056	14,190	44,825	31,707	34,440	4,961	1,421	206	126	164,296
1994	257	206	665	1,058	1,262	16,770	16,672	6,681	831	65	75	96	44,638
1995	200	1,199	2,305	56,396	21,919	52,308	24,886	29,948	19,606	3,120	1,223	176	213,285
1996	132	173	13,988	14,837	71,585	20,900	21,069	19,210	2,280	1,469	339	278	166,259
1997	193	12,268	48,309	47,149	11,164	19,017	18,191	8,166	1,128	156	107	129	165,977
1998	312	1,766	4,676	43,728	18,107	39,964	18,290	17,653	19,578	2,122	433	247	166,876
1999	410	6,590	15,848	28,023	15,659	18,285	22,431	30,729	4,523	1,009	283	198	143,987
2000	213	705	13,712	23,451	23,394	17,381	27,151	21,446	1,544	237	98	117	129,450
2001	302	571	893	952	2,310	24,494	17,482	11,531	769	172	88	125	59,690
2002	107	2,479	6,661	18,816	14,051	17,276	29,425	16,011	2,105	296	78	73	107,377
2003	65	3,516	18,193	37,631	14,361	28,030	10,154	15,998	3,741	435	171	138	132,434
2004	113	440	6,489	6,252	13,639	38,507	23,760	9,585	1,220	130	67	105	100,306
2005	465	1,266	7,727	12,526	16,552	23,824	21,419	38,295	4,894	1,382	160	114	128,625
2006	160	675	66,779	22,866	28,879	11,720	15,165	17,236	2,567	600	115	115	166,875
2007	160	721	5,946	4,052	16,629	16,359	12,234	4,568	713	62	57	67	61,567
2008	400	506	837	3,444	4,789	17,348	20,025	13,308	1,670	151	81	81	62,640
2009	182	1,993	816	12,551	22,555	22,873	21,208	21,380	1,658	156	73	73	105,519
2010	546	416	1,240	8,300	10,641	22,551	21,430	21,026	18,106	1,659	133	113	106,160
2011	2,434	8,882	50,399	23,671	18,923	17,230	26,055	22,530	28,864	4,614	1,042	191	204,833
Average	576	5,800	11,255	16,192	16,414	22,298	19,043	15,563	5,254	906	347	212	113,861
Maximum	6,374	61,910	66,779	60,514	71,585	55,764	31,707	38,295	36,231	5,893	4,980	1,086	213,285
Minimum	65	124	145	168	480	1,991	5,985	2,107	246	62	57	49	19,966
10% Exc.	899	11,530	37,555	40,680	28,200	39,316	26,814	30,338	18,842	1,891	569	409	185,855
20% Exc.	549	6,590	15,848	27,056	21,919	31,743	23,760	22,530	4,894	1,421	283	253	165,977
50% Exc.	235	714	4,330	12,127	13,845	17,833	18,707	14,371	1,827	299	123	125	115,345
80% Exc.	142	300	816	2,259	4,789	12,723	15,165	4,736	1,055	151	77	73	59,690
90% Exc.	110	204	545	809	3,071	10,467	10,079	3,641	742	116	67	67	44,542

Canyon Creek at Bowman Dam - 2070 WMW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-800	2,090	1,235	1,284	1,895	5,372	-644	-5,655	-59	-17	-57	-43	4,601
1977	76	168	131	124	352	1,034	2,815	-2,116	-143	73	48	43	2,604
1978	13	39	10,503	14,254	10,330	18,536	3,412	-10,279	-16,955	-1,487	58	72	28,496
1979	46	97	167	7,145	2,641	13,188	6,645	-5,415	-4,240	133	41	16	20,462
1980	-216	1,032	2,934	33,040	18,112	5,170	-438	-14,044	-15,163	-2,561	-21	-13	27,833
1981	-24	-18	84	388	7,841	5,310	-446	-7,986	-471	-8	-6	-20	4,642
1982	-221	34,506	15,697	6,004	26,997	4,929	-1,538	-18,860	-17,173	-2,145	-61	172	48,307
1983	-2,467	11,805	12,065	14,665	14,259	26,658	3,497	-4,391	-15,681	-13,920	2,322	301	49,114
1984	-1,151	30,046	17,747	8,386	5,187	2,976	-3,614	-18,314	-9,667	-347	-44	-59	31,147
1985	51	6,035	2,206	649	4,244	7,326	4,574	-8,869	-1,157	12	13	25	15,110
1986	-52	-86	1,334	19,176	33,389	12,443	-3,735	-15,621	-8,279	-117	-26	-127	38,300
1987	-102	-23	-18	-34	5,462	5,333	-151	-5,332	-63	-12	-8	-5	5,047
1988	-31	-38	1,532	1,575	5,132	5,320	-1,819	-5,373	-1,220	-29	-11	-13	5,025
1989	-1	4,778	1,678	1,034	4,481	30,779	1,697	-11,762	-6,590	-9	-2	-2	26,082
1990	-396	122	226	8,076	2,217	6,661	543	-6,572	-2,649	-8	-3	-3	8,215
1991	46	35	42	48	139	16,142	5,470	-6,406	-6,898	11	33	28	8,689
1992	-23	-62	-104	-122	5,911	5,536	-2,120	-3,771	-51	-43	-23	-11	5,115
1993	20	125	2,333	20,374	10,370	27,153	7,391	-12,104	-16,275	-1,160	34	21	38,282
1994	23	20	69	135	349	9,073	2,040	-6,619	-143	3	6	8	4,965
1995	32	345	863	43,736	14,578	30,180	5,551	-10,956	-22,083	-14,203	-75	28	47,996
1996	-24	-31	7,146	8,908	47,393	7,143	-1,648	-17,537	-9,977	-6,114	-63	-50	35,146
1997	-76	6,823	22,827	17,620	5,590	5,997	-4,941	-13,499	-3,763	-67	-42	-51	36,418
1998	20	671	2,464	33,183	12,890	23,642	2,212	-12,270	-25,806	-9,480	25	15	27,567
1999	33	4,222	10,763	21,178	10,716	9,748	3,075	-14,991	-15,749	-539	22	16	28,494
2000	-20	9	8,676	16,854	15,443	6,869	1,105	-16,632	-4,307	-20	-6	-7	27,962
2001	41	80	133	137	993	14,161	2,951	-7,250	72	17	11	17	11,364
2002	1	1,056	3,756	12,615	8,791	8,625	2,908	-11,878	-6,456	1	1	1	19,421
2003	-11	1,128	10,778	26,529	7,934	13,379	-1,720	-15,981	-13,287	-100	-30	-24	28,595
2004	-7	-26	3,457	3,886	8,697	19,447	569	-11,736	-1,743	-14	-5	-7	22,517
2005	118	326	5,045	9,244	12,620	14,280	6,064	-6,489	-13,069	-395	41	29	27,815
2006	-47	-27	28,954	14,044	15,481	4,545	-2,851	-19,750	-13,544	-476	-34	-34	26,263
2007	-33	-19	2,977	1,797	10,312	4,773	-2,078	-8,469	-412	-14	-12	-14	8,807
2008	59	75	177	1,772	2,885	9,879	3,863	-8,443	-2,210	19	12	12	8,101
2009	2	582	144	8,637	15,943	11,178	1,383	-13,952	-3,633	0	1	1	20,286
2010	135	150	496	6,108	8,104	15,646	8,172	-4,734	-13,619	-522	48	41	20,025
2011	-1,538	4,884	37,922	17,329	13,831	10,853	7,052	-8,656	-17,878	-12,227	118	43	51,735
Average	-181	3,081	6,012	10,549	10,320	11,647	1,535	-10,353	-8,065	-1,827	64	11	22,793

Canyon Creek at Bowman Dam - 2070 DEW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	27.7	42.1	38.1	33.6	51.9	135.8	49.0	32.6	13.8	3.6	13.6	13.5	38.0	1.1	238.4
1977	4.4	9.6	7.0	6.7	17.2	35.7	84.8	60.0	37.6	4.9	2.8	2.6	22.7	0.7	145.2
1978	1.4	4.2	283.8	276.2	229.3	427.5	182.0	160.5	43.0	28.3	6.1	7.9	137.6	0.6	3,462.5
1979	2.3	5.0	8.2	108.5	55.6	276.4	182.5	163.5	38.9	7.5	2.1	0.8	71.2	0.4	1,792.4
1980	10.6	25.6	86.9	696.1	527.3	120.8	214.2	85.6	26.6	20.1	3.5	2.4	150.5	0.7	4,117.4
1981	3.8	3.0	9.3	14.8	219.7	106.5	132.0	27.5	11.2	1.0	0.9	3.2	43.0	0.7	1,987.7
1982	8.7	126.5	779.7	132.1	1,107.6	177.8	335.0	110.6	24.6	19.7	3.9	16.9	231.0	2.0	5,620.1
1983	94.5	107.1	248.3	321.3	385.4	601.3	103.7	382.5	148.2	65.2	217.0	22.2	224.8	8.5	3,299.0
1984	17.4	130.8	894.2	256.6	192.8	229.0	92.3	87.0	25.3	10.7	2.2	3.0	162.7	1.5	4,418.6
1985	9.3	56.2	43.5	29.3	96.2	146.4	289.7	49.2	22.5	2.3	2.2	4.4	62.0	1.4	631.6
1986	2.3	4.0	50.5	301.7	1,222.8	370.8	136.2	48.2	18.2	4.3	1.1	5.7	173.5	1.0	4,950.0
1987	12.6	4.7	4.0	7.1	138.2	120.2	183.9	24.7	8.7	1.5	1.4	1.0	41.5	0.7	2,136.7
1988	2.6	3.3	51.8	29.4	124.2	182.7	61.5	24.2	16.5	2.1	0.9	1.1	41.5	0.8	675.4
1989	1.5	30.8	45.9	40.0	156.6	737.8	482.4	77.8	33.8	4.3	2.6	5.7	134.7	1.3	2,269.8
1990	11.7	20.4	20.4	117.9	51.4	204.6	206.3	27.5	18.4	2.3	1.0	1.1	56.9	0.8	1,281.9
1991	3.4	2.6	2.9	3.4	10.7	299.5	178.2	87.4	47.3	17.6	2.5	2.1	55.1	2.0	2,830.3
1992	1.6	4.4	7.4	8.5	167.8	159.4	154.6	16.9	3.1	2.6	1.5	0.8	43.4	0.8	1,504.1
1993	5.2	13.3	63.6	354.5	240.7	589.5	422.1	295.1	40.7	26.5	3.9	2.4	171.5	1.6	2,174.8
1994	4.3	3.5	10.9	16.8	20.0	229.1	155.7	40.6	14.0	1.1	1.2	1.6	41.7	0.9	471.7
1995	4.1	19.2	36.5	791.8	471.5	741.9	335.7	269.8	78.6	43.3	30.6	3.7	235.0	2.0	4,583.7
1996	1.8	2.4	218.5	152.4	1,228.2	227.2	178.7	94.5	19.3	18.8	4.5	3.8	174.8	1.5	4,257.3
1997	2.9	27.9	880.0	484.6	164.4	209.1	260.8	33.1	14.8	2.3	1.6	2.0	174.8	0.8	3,535.9
1998	6.6	19.6	58.4	633.9	408.7	538.5	286.8	141.3	78.7	38.2	9.2	5.4	184.6	3.1	3,580.2
1999	7.7	34.5	244.3	348.7	282.5	270.0	295.6	259.9	35.9	18.7	5.3	3.8	150.1	2.3	3,820.4
2000	3.6	11.0	193.2	268.1	428.3	242.3	324.6	150.1	24.3	4.1	1.7	2.1	136.7	1.6	3,639.9
2001	4.9	9.5	14.2	15.2	31.8	284.7	167.6	58.3	12.6	2.8	1.4	2.1	50.6	1.3	1,028.1
2002	1.7	16.1	86.1	224.0	219.3	213.7	323.1	75.2	25.7	4.6	1.2	1.2	98.4	1.1	1,215.0
2003	1.1	25.2	348.4	452.7	251.7	326.6	85.9	116.7	26.9	7.4	2.9	2.4	137.5	1.1	3,034.5
2004	1.8	7.0	75.1	42.5	225.6	414.5	242.0	47.6	18.4	2.0	1.0	1.7	89.4	0.9	2,409.4
2005	9.3	25.7	101.7	174.6	297.0	385.8	238.0	337.8	47.9	27.3	3.2	2.4	136.9	2.0	2,466.8
2006	2.2	6.8	1,114.8	242.4	495.8	125.3	151.4	91.0	18.9	8.2	1.6	1.6	187.4	1.2	7,350.0
2007	2.1	7.5	81.4	36.4	253.0	175.5	87.3	21.9	9.3	0.8	0.7	0.9	55.1	0.6	1,858.4
2008	6.8	8.9	13.2	47.8	60.7	240.7	197.0	65.1	27.2	2.6	1.4	1.4	56.0	1.3	477.8
2009	2.7	17.6	10.5	129.3	380.7	267.7	200.5	120.7	22.9	2.3	1.1	1.1	94.5	0.8	2,974.8
2010	10.0	8.4	22.7	99.1	173.7	345.9	232.6	136.8	87.6	32.1	2.6	2.3	95.7	2.0	1,334.7
2011	27.1	59.9	998.9	339.5	310.0	223.7	280.3	149.0	91.5	42.4	19.9	3.4	212.5	1.6	4,289.4
Average	8.9	25.1	198.7	201.0	297.5	288.4	209.3	110.3	34.2	13.4	10.0	3.9	115.9	0.4	7,350.0
10% Exc.	18.6	62.7	280.8	375.0	427.4	493.6	455.7	254.9	59.8	38.5	8.5	8.0	284.1	--	--
20% Exc.	8.0	33.8	142.8	273.0	302.8	387.3	340.3	154.6	45.2	25.3	4.5	3.8	160.2	--	--
50% Exc.	2.8	8.8	30.6	62.0	173.1	200.2	114.8	59.2	25.2	4.9	1.8	2.1	25.6	--	--
80% Exc.	1.5	3.4	8.8	16.5	30.7	120.0	55.1	28.2	15.1	1.5	1.1	1.1	2.7	--	--
90% Exc.	1.1	2.3	6.6	8.6	18.4	91.9	42.3	23.9	6.7	1.0	1.0	0.9	1.5	--	--

Canyon Creek at Bowman Dam - 2070 DEW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,702	2,503	2,343	2,067	2,987	8,347	2,917	2,008	822	220	838	803	27,559
1977	268	569	429	414	954	2,197	5,044	3,688	2,234	300	173	154	16,426
1978	85	250	17,451	16,983	12,736	26,289	10,830	9,866	2,556	1,738	372	468	99,624
1979	144	300	502	6,673	3,089	16,997	10,857	10,054	2,312	463	131	50	51,573
1980	652	1,525	5,344	42,800	30,332	7,425	12,745	5,266	1,585	1,236	213	140	109,264
1981	232	177	570	909	12,201	6,547	7,855	1,689	668	60	55	189	31,153
1982	537	7,530	47,944	8,125	61,514	10,934	19,936	6,799	1,465	1,214	240	1,003	167,240
1983	5,809	6,373	15,269	19,755	21,405	36,974	6,173	23,518	8,818	4,007	13,345	1,321	162,768
1984	1,069	7,781	54,983	15,780	11,092	14,084	5,495	5,349	1,504	656	132	177	118,101
1985	570	3,342	2,675	1,801	5,343	8,999	17,238	3,024	1,336	141	132	264	44,867
1986	141	238	3,103	18,551	67,912	22,802	8,106	2,965	1,083	265	68	342	125,575
1987	772	282	247	434	7,677	7,393	10,944	1,520	518	93	83	57	30,020
1988	158	196	3,186	1,808	7,143	11,236	3,660	1,487	984	128	56	66	30,107
1989	94	1,834	2,822	2,460	8,694	45,365	28,703	4,784	2,010	266	159	341	97,532
1990	718	1,211	1,254	7,252	2,854	12,579	12,278	1,690	1,095	139	62	68	41,201
1991	209	155	181	210	596	18,417	10,603	5,374	2,812	1,082	154	126	39,919
1992	97	262	457	523	9,654	9,804	9,200	1,038	187	161	95	47	31,525
1993	320	794	3,910	21,797	13,367	36,245	25,119	18,148	2,422	1,628	240	146	124,137
1994	262	209	668	1,033	1,112	14,084	9,265	2,494	832	68	77	98	30,203
1995	250	1,142	2,241	48,689	26,188	45,617	19,973	16,592	4,678	2,664	1,879	221	170,134
1996	108	141	13,433	9,373	70,647	13,969	10,632	5,812	1,148	1,159	277	227	126,925
1997	177	1,661	54,110	29,797	9,131	12,856	15,521	2,037	882	143	98	118	126,530
1998	408	1,165	3,593	38,975	22,701	33,110	17,064	8,687	4,684	2,348	568	323	133,625
1999	471	2,051	15,020	21,443	15,690	16,603	17,592	15,979	2,135	1,151	325	228	108,687
2000	220	654	11,880	16,483	24,633	14,898	19,315	9,227	1,449	250	103	123	99,236
2001	299	563	873	936	1,767	17,508	9,970	3,582	751	172	87	123	36,632
2002	103	956	5,292	13,774	12,180	13,139	19,228	4,623	1,528	282	75	71	71,251
2003	68	1,500	21,422	27,836	13,978	20,085	5,113	7,178	1,603	455	180	146	99,564
2004	108	418	4,615	2,612	12,974	25,490	14,400	2,926	1,093	124	64	100	64,923
2005	572	1,530	6,251	10,735	16,493	23,725	14,162	20,773	2,851	1,681	197	140	99,110
2006	137	404	68,545	14,905	27,533	7,705	9,009	5,598	1,124	507	98	98	135,663
2007	129	447	5,002	2,240	14,050	10,789	5,195	1,345	555	49	46	54	39,902
2008	419	529	812	2,938	3,491	14,797	11,720	4,006	1,619	160	85	85	40,662
2009	167	1,046	644	7,950	21,144	16,461	11,933	7,421	1,364	142	67	67	68,407
2010	615	498	1,398	6,095	9,648	21,270	13,842	8,412	5,214	1,976	160	136	69,264
2011	1,669	3,566	61,418	20,874	17,218	13,752	16,680	9,163	5,444	2,606	1,225	200	153,816
Average	549	1,495	12,219	12,362	16,670	17,736	12,453	6,781	2,038	826	616	231	83,976
Maximum	5,809	7,781	68,545	48,689	70,647	45,617	28,703	23,518	8,818	4,007	13,345	1,321	170,134
Minimum	68	141	181	210	596	2,197	2,917	1,038	187	49	46	47	16,426
10% Exc.	920	3,454	51,027	28,817	28,933	34,678	19,625	16,285	4,681	2,162	703	405	144,739
20% Exc.	615	1,834	15,269	20,874	22,701	23,725	17,238	9,227	2,556	1,628	277	264	126,530
50% Exc.	256	724	3,390	8,038	12,469	14,441	11,332	5,308	1,484	291	132	140	84,391
80% Exc.	129	262	668	1,801	3,491	9,804	7,855	2,037	882	141	75	71	36,632
90% Exc.	100	203	479	716	2,310	7,565	5,154	1,605	710	109	63	62	30,155

Canyon Creek at Bowman Dam - 2070 DEW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-725	-827	362	199	1,050	3,936	-3,712	-6,900	48	16	77	75	-6,401
1977	137	291	219	211	490	1,239	-1,315	-2,868	335	154	89	79	-936
1978	20	58	13,186	11,606	8,873	13,082	-3,533	-24,803	-22,118	-1,371	89	111	-4,801
1979	48	98	163	4,542	1,605	9,953	-2,274	-21,842	-4,584	158	44	17	-12,073
1980	-239	-685	2,649	15,326	20,924	2,671	-6,464	-22,661	-16,333	-2,544	-12	-8	-7,377
1981	-56	-42	-111	-163	6,770	1,672	-8,608	-11,033	-592	-17	-14	-46	-12,241
1982	-191	-19,874	24,251	4,269	41,793	3,140	-245	-29,050	-18,572	-2,053	-38	90	3,520
1983	-3,031	1,039	10,599	15,795	17,100	24,966	-2,275	-14,693	-43,093	-15,806	10,688	661	1,950
1984	-998	-15,796	37,010	8,282	6,331	4,174	-6,797	-25,606	-9,730	-197	-12	-16	-3,355
1985	72	-1,416	589	191	3,030	4,506	-4,664	-15,511	-1,169	18	18	36	-14,300
1986	-71	-118	571	7,907	37,914	-2,974	-11,301	-24,017	-8,962	-156	-35	-172	-1,415
1987	-204	-55	-48	-84	4,623	1,977	-8,248	-6,966	-128	-21	-17	-11	-9,181
1988	-35	-43	930	-153	3,403	2,602	-8,163	-6,502	-1,291	-33	-13	-15	-9,313
1989	20	-917	815	734	5,151	20,380	-503	-19,067	-6,468	50	33	73	301
1990	-559	-318	-141	3,600	795	2,681	-8,041	-8,910	-2,881	-20	-8	-8	-13,809
1991	89	66	77	90	255	11,695	-2,534	-15,892	-7,214	232	66	54	-13,017
1992	-50	-133	-232	-266	4,358	333	-11,400	-4,839	-110	-92	-50	-24	-12,505
1993	51	213	1,875	15,116	9,547	18,574	802	-28,395	-18,814	-954	67	41	-1,877
1994	28	23	73	110	199	6,388	-5,367	-10,806	-142	6	8	10	-9,471
1995	82	289	799	36,029	18,847	23,488	638	-24,312	-37,012	-14,659	582	73	4,845
1996	-48	-63	6,591	3,444	46,455	212	-12,085	-30,935	-11,109	-6,424	-125	-101	-4,189
1997	-92	-3,784	28,628	268	3,557	-164	-7,611	-19,629	-4,010	-80	-51	-61	-3,028
1998	116	71	1,381	28,430	17,483	16,788	986	-21,235	-40,700	-9,253	160	91	-5,684
1999	93	-317	9,935	14,599	10,747	8,067	-1,764	-29,741	-18,137	-397	64	45	-6,805
2000	-14	-41	6,844	9,887	16,682	4,386	-6,731	-28,852	-4,402	-7	-1	-1	-2,251
2001	37	72	113	121	450	7,176	-4,561	-15,199	53	17	11	15	-11,694
2002	-2	-467	2,387	7,573	6,920	4,488	-7,288	-23,267	-7,033	-13	-2	-2	-16,705
2003	-8	-888	14,007	16,734	7,551	5,434	-6,761	-24,801	-15,425	-80	-21	-17	-4,275
2004	-13	-49	1,582	246	8,032	6,430	-8,790	-18,395	-1,870	-20	-8	-12	-12,867
2005	224	590	3,569	7,453	12,562	14,180	-1,192	-24,011	-15,112	-96	77	55	-1,700
2006	-70	-298	30,720	6,083	14,136	530	-9,007	-31,388	-14,987	-569	-50	-50	-4,949
2007	-64	-293	2,033	-15	7,732	-796	-9,117	-11,692	-569	-27	-23	-27	-12,859
2008	78	99	153	1,266	1,587	7,329	-4,442	-17,746	-2,261	28	16	16	-13,878
2009	-13	-365	-27	4,036	14,532	4,766	-7,891	-27,911	-3,927	-14	-5	-5	-16,826
2010	204	232	654	3,902	7,111	14,366	584	-17,347	-26,511	-206	75	64	-16,872
2011	-2,302	-432	48,941	14,533	12,127	7,375	-2,323	-22,022	-41,298	-14,235	301	52	717
Average	-208	-1,224	6,976	6,719	10,576	7,085	-5,056	-19,135	-11,281	-1,907	333	30	-7,092

Bear River at Rollins Dam - Historical Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	36.5	45.1	40.9	33.7	55.4	86.7	75.1	42.6	12.3	3.3	8.6	6.2	37.1	1.6	199.1
1977	6.5	9.4	8.6	16.0	19.0	22.5	16.4	27.7	7.4	1.5	0.8	1.6	11.4	0.3	59.0
1978	1.1	10.7	115.8	725.7	443.6	666.1	748.6	355.7	123.8	33.6	8.6	17.9	270.0	0.8	2,634.4
1979	10.0	20.2	27.0	196.4	390.5	564.9	431.1	404.3	75.8	25.5	9.6	8.2	179.1	5.5	1,527.0
1980	21.0	45.6	92.8	1,283.7	1,210.2	606.9	312.0	226.2	102.1	44.6	15.9	11.3	328.6	5.9	7,501.3
1981	13.2	18.1	33.8	113.9	108.4	331.2	181.7	79.9	21.2	6.1	4.5	2.7	76.2	0.9	1,301.3
1982	20.8	298.1	672.5	912.3	1,272.1	1,106.2	1,634.8	501.2	130.5	52.7	22.8	31.2	549.0	8.1	9,998.1
1983	80.6	322.2	910.5	931.6	1,407.5	2,112.7	879.4	877.4	400.5	128.9	45.0	34.9	674.5	24.8	7,519.8
1984	35.9	655.4	1,403.2	469.7	437.0	475.2	300.3	194.9	70.2	27.6	16.3	12.9	341.9	12.0	5,738.2
1985	28.3	145.5	105.0	64.5	204.1	238.7	277.4	103.7	28.8	10.0	5.8	11.3	100.9	5.0	1,420.0
1986	12.7	53.6	126.8	301.5	2,734.1	1,115.4	319.9	163.9	58.9	22.5	11.5	18.0	395.7	7.9	14,516.3
1987	17.8	16.9	21.8	35.7	116.8	211.6	79.4	37.7	11.8	4.0	1.6	1.5	46.0	0.9	626.2
1988	4.8	13.2	51.8	122.3	61.5	77.0	67.8	49.0	17.7	3.6	0.7	0.6	39.2	0.5	382.7
1989	0.9	39.5	26.3	46.1	99.7	750.6	284.5	101.9	32.2	10.0	4.2	8.5	117.5	0.7	2,514.1
1990	26.8	32.7	24.7	72.2	97.7	215.1	124.6	71.2	61.8	12.1	3.8	3.1	61.9	2.2	405.5
1991	4.4	8.9	9.5	10.6	17.2	318.6	227.3	154.5	56.0	14.9	5.0	2.3	69.5	1.7	1,295.7
1992	9.7	14.8	18.9	30.2	291.8	257.8	126.8	35.4	10.4	7.0	1.4	1.1	66.2	1.0	1,160.5
1993	4.3	10.9	93.9	776.8	663.8	855.4	517.5	262.2	153.2	30.3	11.6	6.4	280.3	1.1	2,967.5
1994	10.3	13.2	38.9	35.6	118.5	123.0	73.9	66.0	15.1	3.7	1.2	1.2	41.3	1.0	338.3
1995	4.5	27.7	111.9	1,237.2	420.2	1,805.8	848.8	956.9	319.2	98.4	27.2	14.8	492.0	1.3	7,064.2
1996	13.4	15.6	79.9	356.9	928.9	740.7	489.8	455.2	117.4	40.6	17.2	14.0	270.1	11.8	3,003.6
1997	15.8	80.6	1,132.9	2,852.9	514.0	231.6	165.9	97.3	47.5	22.1	13.1	10.0	435.2	8.9	23,656.3
1998	19.6	40.2	70.3	703.7	1,429.7	956.7	805.2	741.5	446.2	110.5	37.2	27.7	442.3	9.6	5,630.0
1999	27.4	57.7	115.0	397.9	1,224.3	585.3	455.1	298.5	108.6	32.9	19.2	13.0	271.4	11.5	5,357.5
2000	13.5	32.0	32.1	337.1	1,070.9	556.8	285.0	215.2	61.8	23.3	11.3	15.0	217.9	9.4	4,178.1
2001	25.8	28.2	34.5	58.4	139.5	190.1	188.6	108.7	21.9	9.2	4.6	4.7	67.3	3.8	387.2
2002	6.4	26.6	127.3	219.9	229.8	347.7	231.6	129.7	45.1	13.0	6.3	5.0	115.2	4.0	1,014.2
2003	6.2	27.1	108.6	130.5	115.7	148.5	416.5	444.9	91.8	21.5	13.2	7.6	127.7	5.1	1,140.2
2004	6.9	17.2	89.4	123.2	309.4	313.4	169.0	73.5	23.9	10.4	5.7	5.2	94.9	4.3	1,507.3
2005	19.1	30.0	111.7	458.6	340.3	786.6	567.9	635.4	207.8	49.3	17.7	12.0	269.8	3.4	3,849.3
2006	13.1	17.6	582.4	708.1	439.6	1,008.9	2,076.7	632.2	164.1	48.0	24.6	17.4	477.0	11.6	9,257.0
2007	24.6	35.3	62.3	64.9	270.0	230.6	142.1	89.4	28.5	12.2	6.9	7.0	79.9	5.4	1,097.1
2008	13.3	14.6	29.4	138.0	175.4	148.2	131.3	96.7	29.4	8.9	4.0	3.1	65.6	2.7	513.3
2009	7.4	17.2	24.3	62.2	230.1	445.6	191.3	306.2	42.7	13.0	6.1	4.7	112.1	3.4	2,189.3
2010	12.4	11.3	36.5	148.3	198.0	268.9	400.1	416.2	243.5	36.1	12.1	8.5	148.8	4.4	1,203.6
2011	33.4	73.2	722.2	387.5	397.9	1,490.0	869.8	527.0	370.6	112.5	32.9	20.0	420.9	7.2	4,083.1
Average	16.9	64.6	202.6	404.5	505.1	566.4	419.8	277.2	104.4	30.7	12.2	10.3	216.5	0.3	23,656.3
10% Exc.	31.2	98.0	389.1	900.0	1,132.6	1,303.5	884.2	662.2	286.2	71.2	27.5	21.1	556.8	--	--
20% Exc.	23.8	46.4	162.6	478.8	667.1	805.6	606.8	472.6	165.1	44.1	18.9	15.0	285.3	--	--
50% Exc.	11.2	19.4	42.1	115.3	219.8	338.6	266.5	160.6	52.2	18.3	9.1	8.4	43.2	--	--
80% Exc.	5.4	12.1	21.2	32.6	68.4	162.2	128.6	63.2	18.9	6.7	3.7	2.6	11.0	--	--
90% Exc.	2.0	9.4	13.6	23.6	48.0	96.6	79.8	43.0	11.7	3.6	1.3	1.2	5.8	--	--

Bear River at Rollins Dam - Historical Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	2,242	2,683	2,514	2,072	3,188	5,329	4,471	2,621	731	202	529	367	26,952
1977	400	556	527	985	1,054	1,381	979	1,706	440	93	47	95	8,262
1978	70	640	7,123	44,623	24,638	40,957	44,545	21,873	7,364	2,064	532	1,064	195,492
1979	618	1,205	1,663	12,074	21,687	34,734	25,649	24,859	4,509	1,566	590	488	129,641
1980	1,293	2,713	5,706	78,931	69,610	37,316	18,565	13,910	6,078	2,740	978	674	238,515
1981	810	1,074	2,076	7,006	6,018	20,367	10,811	4,912	1,263	378	279	162	55,157
1982	1,278	17,736	41,351	56,094	70,649	68,018	97,277	30,820	7,765	3,238	1,399	1,854	397,478
1983	4,954	19,170	55,985	57,279	78,166	129,903	52,329	53,950	23,833	7,927	2,768	2,077	488,342
1984	2,208	39,002	86,282	28,883	25,136	29,216	17,867	11,984	4,177	1,697	1,004	769	248,224
1985	1,739	8,656	6,456	3,969	11,336	14,680	16,507	6,376	1,714	615	359	674	73,082
1986	780	3,190	7,795	18,536	151,843	68,582	19,036	10,076	3,506	1,381	707	1,069	286,500
1987	1,098	1,005	1,340	2,194	6,486	13,008	4,725	2,316	702	246	100	91	33,311
1988	296	787	3,182	7,521	3,535	4,737	4,034	3,016	1,050	218	45	38	28,459
1989	57	2,348	1,619	2,837	5,537	46,153	16,929	6,265	1,915	614	258	507	85,039
1990	1,650	1,944	1,521	4,441	5,428	13,227	7,412	4,379	3,677	747	235	182	44,845
1991	272	529	582	652	955	19,589	13,525	9,497	3,332	916	306	136	50,293
1992	598	878	1,163	1,860	16,786	15,853	7,545	2,174	616	432	84	63	48,051
1993	267	646	5,774	47,761	36,863	52,598	30,796	16,124	9,116	1,864	714	383	202,908
1994	635	783	2,395	2,187	6,581	7,566	4,398	4,058	899	230	72	69	29,873
1995	275	1,648	6,880	76,071	23,338	111,037	50,505	58,835	18,991	6,053	1,673	881	356,188
1996	823	931	4,914	21,942	53,433	45,541	29,145	27,987	6,985	2,495	1,058	836	196,090
1997	970	4,798	69,658	175,421	28,547	14,238	9,872	5,983	2,826	1,360	807	593	315,072
1998	1,204	2,392	4,325	43,267	79,399	58,828	47,913	45,595	26,550	6,793	2,287	1,647	320,198
1999	1,687	3,432	7,073	24,463	67,992	35,989	27,080	18,354	6,461	2,021	1,180	772	196,505
2000	828	1,905	1,975	20,725	61,599	34,239	16,958	13,234	3,675	1,432	692	894	158,157
2001	1,589	1,678	2,122	3,593	7,748	11,688	11,221	6,681	1,301	566	281	278	48,748
2002	394	1,585	7,829	13,523	12,761	21,381	13,778	7,972	2,684	798	386	295	83,385
2003	378	1,611	6,676	8,021	6,428	9,130	24,782	27,358	5,465	1,323	810	452	92,435
2004	427	1,023	5,499	7,576	17,795	19,268	10,055	4,519	1,422	638	352	311	68,885
2005	1,172	1,786	6,869	28,196	18,900	48,366	33,795	39,069	12,366	3,031	1,087	714	195,350
2006	808	1,049	35,812	43,539	24,413	62,034	123,569	38,871	9,767	2,949	1,510	1,037	345,359
2007	1,514	2,098	3,828	3,993	14,997	14,178	8,458	5,495	1,697	750	426	414	57,847
2008	817	866	1,807	8,485	10,087	9,111	7,814	5,946	1,749	546	245	185	47,658
2009	455	1,026	1,495	3,824	12,781	27,399	11,384	18,826	2,540	797	374	277	81,177
2010	764	674	2,245	9,121	10,994	16,535	23,806	25,594	14,491	2,220	742	507	107,694
2011	2,056	4,358	44,406	23,827	22,098	91,615	51,757	32,405	22,053	6,920	2,024	1,191	304,707
Average	1,040	3,845	12,457	24,875	28,300	34,828	24,980	17,046	6,214	1,885	748	612	156,830
Maximum	4,954	39,002	86,282	175,421	151,843	129,903	123,569	58,835	26,550	7,927	2,768	2,077	488,342
Minimum	57	529	527	652	955	1,381	979	1,706	440	93	45	38	8,262
10% Exc.	1,897	6,727	42,878	56,687	70,129	68,300	51,131	38,970	16,741	4,645	1,592	1,130	332,779
20% Exc.	1,589	3,190	7,795	43,539	53,433	52,598	33,795	27,987	9,116	2,740	1,087	894	286,500
50% Exc.	814	1,630	4,619	10,598	17,290	24,390	16,943	11,030	3,591	1,342	561	498	100,064
80% Exc.	394	866	1,663	3,593	6,428	13,008	7,814	4,519	1,301	546	258	182	48,051
90% Exc.	273	660	1,417	2,130	4,482	8,338	4,598	2,818	815	238	92	93	31,592

Bear River at Rollins Dam - 2070 Median Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	30.8	41.2	38.7	32.2	57.2	101.4	73.9	38.1	11.8	3.2	8.2	5.9	36.8	1.6	213.9
1977	6.5	9.3	8.5	15.9	19.0	22.3	16.3	27.3	7.3	1.5	0.8	1.6	11.3	0.3	64.9
1978	1.2	11.0	137.7	951.2	552.7	791.8	770.5	300.0	92.5	36.3	9.3	19.2	305.0	0.8	3,707.9
1979	10.9	21.5	29.1	252.3	488.8	658.9	436.9	344.5	63.8	27.6	10.4	8.9	194.4	5.9	1,761.5
1980	18.4	39.3	94.2	1,636.2	1,399.9	614.6	275.5	160.4	69.1	42.1	14.9	10.6	361.8	5.5	9,943.4
1981	13.3	18.2	34.7	135.0	115.9	370.2	172.1	69.2	21.4	6.2	4.6	2.8	80.3	0.9	1,433.4
1982	20.0	283.9	893.6	1,186.6	1,522.0	1,241.0	1,552.8	408.2	92.4	54.1	23.1	33.8	603.1	8.2	10,869.0
1983	66.0	297.6	1,201.9	1,193.0	1,613.2	2,472.3	836.4	747.6	290.7	130.5	43.6	34.9	741.0	24.7	9,543.0
1984	34.2	590.8	1,815.8	544.2	495.8	495.9	276.1	145.7	54.0	26.9	15.9	12.6	376.6	11.7	7,890.5
1985	29.0	130.6	113.8	71.5	227.0	265.6	271.3	89.5	28.8	10.4	6.0	11.7	103.5	5.1	1,589.7
1986	12.4	47.4	133.1	362.9	3,064.0	1,231.1	294.1	126.9	48.1	22.0	11.2	17.9	429.9	7.8	15,581.5
1987	16.6	15.7	20.3	35.2	122.7	215.4	75.1	33.7	11.0	3.7	1.5	1.4	45.6	0.9	695.3
1988	4.3	11.7	46.2	140.6	59.4	83.5	59.7	40.1	15.6	3.1	0.7	0.6	38.9	0.4	408.7
1989	1.0	37.2	26.9	48.3	112.5	847.6	275.3	87.3	32.3	10.3	4.3	8.8	124.8	0.7	3,100.4
1990	24.8	32.5	26.2	91.2	111.9	244.6	126.3	65.3	52.9	12.9	4.1	3.3	66.1	2.3	463.7
1991	4.9	9.9	10.6	11.9	19.2	389.4	239.5	137.4	51.8	16.6	5.6	2.6	75.4	1.9	1,590.0
1992	9.0	15.3	19.7	31.9	355.3	286.9	126.4	35.0	10.8	7.3	1.4	1.1	73.9	1.0	1,416.9
1993	4.5	11.4	108.0	991.5	794.1	984.4	515.5	209.8	112.8	32.0	12.2	6.8	313.0	1.1	4,423.4
1994	9.7	12.3	37.0	35.6	120.0	136.4	71.3	54.5	14.1	3.5	1.1	1.1	40.9	0.9	376.5
1995	4.4	26.5	117.0	1,536.6	487.8	2,117.2	807.6	811.4	226.7	98.9	26.8	14.6	526.0	1.2	8,895.3
1996	14.3	16.7	90.6	467.3	1,154.4	892.0	492.9	396.6	88.6	43.7	18.4	15.0	304.6	12.6	4,450.4
1997	13.5	61.1	1,357.8	3,089.2	515.6	208.6	133.7	70.6	36.7	18.9	11.2	8.5	464.4	7.6	22,844.9
1998	19.7	38.3	73.6	874.8	1,706.0	1,115.7	788.0	626.1	329.1	113.4	37.0	27.9	471.1	9.7	7,943.0
1999	29.1	56.2	129.6	494.7	1,552.2	670.8	451.5	240.6	82.4	34.9	20.3	13.7	306.3	12.1	8,115.3
2000	12.9	29.7	30.7	412.2	1,196.8	578.9	257.8	160.8	48.7	22.4	10.8	14.5	227.6	9.1	5,003.5
2001	26.2	30.3	36.8	74.6	168.6	224.0	191.6	96.9	23.5	9.9	4.9	5.0	73.7	4.0	396.9
2002	6.5	25.6	138.8	281.9	262.3	374.9	219.7	108.0	40.0	13.1	6.3	5.0	122.9	4.1	1,115.8
2003	6.6	27.2	126.4	191.2	127.0	177.1	424.9	374.6	72.8	23.0	14.1	8.1	131.1	5.5	1,221.7
2004	6.8	16.9	92.5	161.3	343.1	322.3	156.3	63.7	23.4	10.2	5.6	5.1	99.8	4.2	1,568.8
2005	19.7	32.5	136.6	609.8	442.0	987.2	598.7	580.5	161.9	55.3	19.7	13.3	304.8	3.8	5,913.4
2006	13.6	18.2	753.4	926.3	526.3	1,132.9	1,991.5	540.1	117.7	50.1	25.4	18.0	509.0	12.0	13,095.5
2007	25.4	35.9	64.5	75.0	319.0	252.4	139.0	79.0	29.4	12.6	7.2	7.2	85.7	5.6	1,330.4
2008	13.7	15.0	30.3	176.1	206.4	176.0	128.0	85.3	29.4	9.2	4.1	3.2	72.7	2.7	651.1
2009	8.0	18.4	26.4	79.1	284.2	518.7	194.3	265.5	41.8	14.0	6.6	5.0	121.1	3.6	2,673.0
2010	14.3	13.4	43.5	211.7	257.5	338.7	444.9	390.3	206.0	43.1	14.3	10.1	164.9	5.2	1,649.7
2011	28.6	65.6	962.6	466.0	460.6	1,715.9	847.5	418.2	271.4	114.9	32.8	20.0	451.9	7.2	5,372.2
Average	16.1	60.1	250.2	497.1	590.5	646.0	409.2	234.1	80.9	31.6	12.3	10.6	235.0	0.3	22,844.9
10% Exc.	31.5	84.7	452.1	1,071.9	1,347.9	1,446.3	891.2	532.7	213.6	73.7	28.0	21.2	577.2	--	--
20% Exc.	24.2	44.9	173.3	592.7	791.3	911.1	610.2	400.4	118.3	45.9	19.3	15.3	285.7	--	--
50% Exc.	11.1	19.5	42.0	170.9	268.6	364.6	252.9	131.6	47.5	18.7	9.3	8.4	42.5	--	--
80% Exc.	5.6	12.3	21.4	33.0	78.9	186.5	122.7	54.1	19.1	7.0	3.9	2.7	11.1	--	--
90% Exc.	2.1	9.1	14.6	23.8	46.9	121.4	78.1	40.9	11.4	3.5	1.3	1.2	6.0	--	--

Bear River at Rollins Dam - 2070 Median Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,893	2,453	2,377	1,980	3,292	6,235	4,400	2,340	700	194	507	352	26,722
1977	397	552	522	979	1,056	1,369	970	1,679	436	92	46	94	8,192
1978	75	655	8,465	58,488	30,698	48,683	45,847	18,449	5,506	2,229	570	1,141	220,806
1979	669	1,279	1,789	15,512	27,144	40,511	25,997	21,185	3,794	1,696	639	529	140,744
1980	1,133	2,336	5,793	100,605	80,521	37,790	16,392	9,865	4,114	2,586	917	631	262,682
1981	817	1,083	2,134	8,301	6,439	22,764	10,240	4,256	1,271	381	281	164	58,132
1982	1,231	16,896	54,948	72,962	84,528	76,307	92,399	25,099	5,496	3,326	1,419	2,014	436,625
1983	4,057	17,707	73,902	73,356	89,590	152,016	49,768	45,968	17,296	8,023	2,678	2,079	536,439
1984	2,105	35,158	111,647	33,459	28,517	30,491	16,431	8,958	3,214	1,653	977	749	273,358
1985	1,783	7,772	7,000	4,398	12,608	16,330	16,141	5,506	1,713	637	372	697	74,956
1986	763	2,822	8,183	22,314	170,168	75,695	17,502	7,806	2,862	1,352	692	1,067	311,225
1987	1,023	936	1,249	2,162	6,812	13,246	4,468	2,069	654	229	93	85	33,027
1988	262	697	2,843	8,645	3,419	5,131	3,553	2,468	931	194	40	34	28,217
1989	59	2,216	1,652	2,972	6,247	52,115	16,381	5,371	1,922	630	265	523	90,352
1990	1,524	1,932	1,612	5,606	6,213	15,040	7,517	4,018	3,147	792	250	194	47,844
1991	303	592	651	729	1,068	23,942	14,251	8,448	3,081	1,023	342	152	54,582
1992	555	913	1,210	1,964	20,438	17,641	7,519	2,150	641	449	88	66	53,633
1993	279	676	6,643	60,967	44,103	60,527	30,674	12,897	6,712	1,967	750	402	226,597
1994	595	730	2,277	2,187	6,662	8,385	4,241	3,352	841	216	67	64	29,618
1995	271	1,579	7,195	94,480	27,089	130,184	48,057	49,892	13,492	6,082	1,646	868	380,834
1996	881	996	5,570	28,730	66,400	54,847	29,331	24,385	5,270	2,686	1,132	894	221,121
1997	831	3,633	83,486	189,948	28,636	12,826	7,953	4,342	2,186	1,164	690	508	336,203
1998	1,214	2,280	4,523	53,787	94,747	68,602	46,891	38,496	19,581	6,976	2,278	1,661	341,036
1999	1,788	3,343	7,966	30,421	86,207	41,249	26,868	14,791	4,902	2,146	1,250	818	221,749
2000	796	1,768	1,889	25,348	68,838	35,592	15,339	9,887	2,895	1,379	666	861	165,259
2001	1,612	1,806	2,263	4,589	9,363	13,771	11,398	5,958	1,401	610	303	300	53,373
2002	398	1,521	8,533	17,332	14,566	23,051	13,075	6,640	2,382	806	390	298	88,992
2003	404	1,617	7,775	11,758	7,055	10,891	25,285	23,032	4,333	1,413	866	483	94,912
2004	418	1,004	5,690	9,915	19,735	19,820	9,301	3,916	1,392	626	345	305	72,466
2005	1,213	1,932	8,397	37,493	24,547	60,700	35,627	35,694	9,633	3,398	1,209	794	220,637
2006	835	1,082	46,327	56,955	29,227	69,657	118,502	33,212	7,005	3,083	1,561	1,073	368,519
2007	1,564	2,134	3,964	4,613	17,714	15,519	8,273	4,856	1,749	775	440	428	62,029
2008	844	894	1,866	10,828	11,873	10,823	7,616	5,243	1,748	563	253	191	52,743
2009	490	1,092	1,621	4,864	15,785	31,894	11,564	16,323	2,486	859	404	299	87,680
2010	882	797	2,676	13,016	14,303	20,825	26,474	23,998	12,255	2,649	877	600	119,352
2011	1,757	3,904	59,188	28,651	25,581	105,509	50,427	25,715	16,150	7,066	2,017	1,193	327,157
Average	992	3,577	15,384	30,564	33,089	39,722	24,352	14,396	4,811	1,943	759	628	170,217
Maximum	4,057	35,158	111,647	189,948	170,168	152,016	118,502	49,892	19,581	8,023	2,678	2,079	536,439
Minimum	59	552	522	729	1,056	1,369	970	1,679	436	92	40	34	8,192
10% Exc.	1,786	5,838	57,068	73,159	85,367	76,001	48,913	34,453	12,874	4,740	1,604	1,167	354,777
20% Exc.	1,564	2,822	8,465	56,955	66,400	60,700	35,627	24,385	6,712	2,686	1,209	894	311,225
50% Exc.	833	1,598	5,047	14,264	20,086	27,216	16,261	8,703	2,988	1,258	604	515	107,132
80% Exc.	398	894	1,789	4,398	6,662	13,246	7,616	4,018	1,392	563	265	191	53,373
90% Exc.	275	687	1,430	2,071	4,816	9,604	4,434	2,404	771	223	90	89	31,322

Bear River at Rollins Dam - 2070 Median Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-349	-230	-137	-92	103	905	-71	-281	-31	-9	-23	-16	-230
1977	-4	-5	-5	-6	2	-12	-9	-27	-4	-1	0	-1	-70
1978	5	15	1,342	13,865	6,060	7,726	1,302	-3,425	-1,857	165	39	78	25,314
1979	51	75	126	3,438	5,457	5,777	348	-3,674	-715	130	49	40	11,102
1980	-160	-377	87	21,673	10,911	474	-2,173	-4,045	-1,964	-154	-62	-42	24,168
1981	7	9	59	1,295	420	2,397	-571	-656	8	3	2	2	2,975
1982	-47	-840	13,597	16,868	13,880	8,289	-4,877	-5,721	-2,269	88	21	160	39,148
1983	-897	-1,463	17,917	16,077	11,424	22,113	-2,561	-7,982	-6,537	96	-90	1	48,098
1984	-103	-3,844	25,365	4,577	3,381	1,275	-1,436	-3,026	-963	-45	-26	-20	25,134
1985	44	-884	543	429	1,272	1,650	-367	-870	0	21	12	23	1,874
1986	-16	-368	387	3,778	18,325	7,113	-1,534	-2,271	-644	-29	-15	-2	24,725
1987	-75	-68	-91	-32	326	238	-257	-247	-48	-17	-7	-6	-284
1988	-34	-90	-340	1,124	-116	395	-481	-548	-120	-25	-5	-4	-243
1989	1	-132	33	135	710	5,962	-548	-895	8	16	6	15	5,313
1990	-126	-12	91	1,164	784	1,812	105	-361	-530	46	15	12	2,999
1991	32	62	69	77	112	4,353	726	-1,050	-251	107	36	16	4,289
1992	-43	35	47	104	3,652	1,788	-26	-23	25	17	3	2	5,582
1993	12	30	869	13,205	7,240	7,930	-122	-3,227	-2,404	103	35	19	23,689
1994	-40	-53	-118	0	81	819	-157	-706	-57	-15	-4	-4	-255
1995	-4	-70	315	18,408	3,751	19,147	-2,448	-8,943	-5,499	29	-27	-13	24,647
1996	57	65	656	6,788	12,967	9,306	186	-3,601	-1,715	191	74	58	25,031
1997	-140	-1,165	13,829	14,527	89	-1,412	-1,919	-1,641	-640	-196	-116	-85	21,131
1998	10	-111	198	10,520	15,348	9,774	-1,022	-7,098	-6,969	183	-9	15	20,838
1999	101	-89	893	5,957	18,215	5,260	-213	-3,563	-1,559	125	71	46	25,244
2000	-31	-136	-86	4,623	7,239	1,353	-1,619	-3,347	-780	-54	-26	-34	7,102
2001	22	127	140	996	1,615	2,083	178	-723	100	44	22	21	4,625
2002	4	-64	704	3,809	1,805	1,670	-703	-1,332	-301	8	4	3	5,607
2003	26	6	1,099	3,737	627	1,761	503	-4,326	-1,132	90	56	32	2,478
2004	-8	-19	191	2,339	1,940	552	-755	-603	-30	-12	-7	-6	3,581
2005	41	147	1,527	9,297	5,648	12,334	1,832	-3,376	-2,733	368	122	80	25,287
2006	27	33	10,515	13,416	4,813	7,623	-5,068	-5,659	-2,762	135	51	35	23,159
2007	51	36	135	620	2,717	1,341	-185	-639	52	25	14	14	4,182
2008	26	28	59	2,343	1,786	1,712	-198	-703	-1	18	8	6	5,084
2009	35	66	126	1,040	3,005	4,495	180	-2,503	-54	62	29	22	6,502
2010	118	123	431	3,895	3,309	4,290	2,668	-1,596	-2,236	429	135	92	11,658
2011	-299	-454	14,783	4,824	3,483	13,894	-1,330	-6,690	-5,903	147	-7	2	22,450
Average	-47	-267	2,927	5,689	4,788	4,894	-628	-2,649	-1,403	58	11	16	13,387

Bear River at Rollins Dam - 2070 WMW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	25.5	39.3	38.1	27.6	71.5	140.2	79.1	36.5	10.5	2.7	7.1	5.1	40.2	1.3	311.7
1977	6.7	9.7	8.9	17.5	22.3	24.2	17.7	29.7	8.0	1.6	0.8	1.7	12.3	0.3	95.0
1978	1.3	13.2	277.3	1,174.6	894.8	1,179.2	850.9	346.1	102.9	40.6	9.9	20.6	407.1	0.9	7,057.4
1979	11.8	24.6	35.7	350.0	756.8	936.7	497.3	393.7	72.4	30.0	11.3	9.7	258.0	6.5	2,358.9
1980	16.8	45.5	145.5	1,929.7	2,258.1	728.4	275.6	171.8	67.4	43.4	13.8	9.8	469.9	5.1	13,029.6
1981	15.3	20.9	54.6	185.0	233.2	577.9	243.9	93.7	25.5	7.1	5.3	3.2	121.7	1.0	1,852.6
1982	19.2	888.9	1,373.5	1,409.1	2,296.0	1,515.0	1,451.8	421.6	92.9	60.8	22.5	34.8	788.5	8.0	13,536.7
1983	50.9	943.1	1,604.7	1,300.4	2,551.2	3,204.2	775.4	688.8	213.1	161.2	191.5	32.2	968.8	22.4	14,886.1
1984	24.9	1,829.5	2,003.1	465.5	554.3	487.5	219.5	124.3	41.6	19.7	11.7	9.2	481.7	8.6	9,385.0
1985	34.2	283.0	283.9	150.5	433.0	463.4	355.2	124.7	35.2	12.3	7.2	13.9	181.1	6.1	2,448.3
1986	12.4	73.3	264.1	448.0	4,448.8	1,739.9	321.0	148.7	50.3	22.0	11.3	18.5	604.1	7.8	19,067.0
1987	13.3	12.6	16.2	36.9	152.4	254.0	74.8	29.0	9.2	3.0	1.2	1.1	49.8	0.7	883.1
1988	3.3	9.0	60.8	158.4	68.2	101.3	55.7	34.9	12.6	2.4	0.5	0.4	42.4	0.3	366.1
1989	1.1	66.6	37.2	79.5	221.3	1,362.4	363.3	121.9	39.3	12.1	5.1	10.4	193.9	0.8	7,196.0
1990	25.5	42.0	27.5	144.0	199.5	389.1	169.1	78.6	57.2	13.5	4.2	3.4	95.6	2.4	666.9
1991	5.4	11.0	11.7	13.1	23.5	594.3	309.1	178.0	59.6	18.3	6.1	2.8	103.5	2.1	1,975.7
1992	8.5	14.9	19.0	38.9	503.0	406.1	155.7	37.0	10.8	7.1	1.4	1.1	98.7	1.0	1,573.4
1993	4.8	11.9	198.5	1,180.0	1,237.0	1,405.5	563.8	247.4	116.1	33.8	12.8	7.1	414.1	1.2	5,919.1
1994	7.3	9.3	42.6	34.0	152.3	167.1	67.6	47.6	11.0	2.6	0.8	0.8	44.6	0.7	455.1
1995	4.6	30.0	244.3	1,916.9	809.5	3,253.6	883.3	851.2	200.4	137.2	28.9	15.3	701.6	1.3	16,053.3
1996	14.0	16.3	161.8	544.4	1,983.1	1,148.8	502.1	405.3	89.6	44.4	18.0	14.7	406.1	12.3	8,222.6
1997	13.6	102.1	2,108.3	3,946.4	784.0	312.1	169.6	83.3	38.1	19.1	11.3	8.6	637.9	7.7	29,623.4
1998	21.0	51.0	133.4	1,073.6	2,895.3	1,625.5	869.3	674.7	278.4	161.1	94.5	29.6	644.4	10.2	13,156.2
1999	27.3	70.1	248.8	538.2	2,528.9	820.1	442.1	252.7	80.7	32.9	19.1	12.9	408.5	11.4	12,019.5
2000	11.7	29.3	32.5	442.3	2,037.6	690.1	257.5	165.4	46.1	20.3	9.8	13.1	306.0	8.2	9,031.0
2001	25.7	30.2	44.5	103.5	276.7	345.1	230.5	112.5	24.4	9.9	4.9	5.0	99.9	4.0	650.5
2002	7.2	32.4	308.9	413.5	485.0	582.5	284.3	141.1	46.7	14.7	7.1	5.6	192.8	4.6	1,605.4
2003	7.6	36.8	282.9	321.5	265.6	320.1	530.1	456.1	87.4	26.6	16.3	9.4	196.5	6.3	1,484.7
2004	8.1	20.0	215.0	285.2	623.8	533.3	231.7	86.9	28.9	12.1	6.7	6.1	170.1	5.0	2,566.1
2005	21.2	38.0	237.7	793.9	771.9	1,422.5	682.6	653.0	166.4	69.6	21.6	14.7	406.8	4.2	9,175.7
2006	15.8	21.1	1,318.6	1,240.8	956.1	1,604.0	2,170.0	642.2	135.7	63.9	29.5	21.0	683.7	14.0	21,759.7
2007	27.4	39.8	134.8	120.2	500.7	405.3	190.9	98.8	32.8	13.6	7.7	7.7	129.3	6.0	1,696.0
2008	13.1	14.4	39.9	221.5	324.7	271.7	159.7	95.3	29.0	8.8	3.9	3.1	98.0	2.6	872.7
2009	9.5	22.4	44.7	122.8	532.4	883.5	283.7	343.0	51.4	16.6	7.8	6.0	192.0	4.3	4,930.9
2010	16.6	15.7	74.1	313.2	481.3	574.1	554.3	472.6	210.5	53.7	16.7	11.8	231.2	6.1	2,201.8
2011	27.5	102.0	1,606.0	579.9	715.7	2,632.1	919.3	447.8	226.0	158.2	44.4	20.8	625.9	7.5	7,885.1
Average	15.6	139.4	381.6	614.5	945.7	919.5	450.2	259.3	78.0	37.7	18.7	10.9	319.6	0.3	29,623.4
10% Exc.	29.8	132.0	798.1	1,232.5	1,648.7	1,754.0	965.2	609.2	195.7	97.7	29.4	22.5	757.2	--	--
20% Exc.	22.8	47.5	389.1	693.4	1,268.4	1,210.0	648.3	444.5	127.4	49.6	20.2	15.5	399.4	--	--
50% Exc.	11.5	21.2	46.5	267.7	457.3	532.3	290.7	160.0	50.9	19.0	9.3	8.7	45.1	--	--
80% Exc.	5.7	12.1	21.5	31.4	125.9	297.5	161.1	63.4	19.6	7.3	4.0	2.8	11.4	--	--
90% Exc.	2.0	9.0	14.5	22.2	53.0	180.5	77.8	36.9	11.0	3.0	1.2	1.1	6.4	--	--

Bear River at Rollins Dam - 2070 WMW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	1,567	2,339	2,341	1,698	4,111	8,620	4,706	2,242	624	166	434	301	29,148
1977	415	576	546	1,074	1,239	1,486	1,053	1,829	474	96	48	98	8,935
1978	80	788	17,048	72,223	49,694	72,507	50,631	21,280	6,124	2,494	611	1,226	294,708
1979	729	1,462	2,192	21,521	42,030	57,593	29,590	24,206	4,308	1,847	696	576	186,750
1980	1,033	2,710	8,947	118,652	129,890	44,785	16,398	10,562	4,012	2,671	850	585	341,095
1981	938	1,244	3,355	11,375	12,950	35,531	14,511	5,761	1,515	437	323	188	88,127
1982	1,181	52,895	84,453	86,643	127,514	93,151	86,386	25,923	5,527	3,737	1,381	2,070	570,860
1983	3,133	56,116	98,668	79,959	141,688	197,017	46,142	42,353	12,680	9,910	11,775	1,919	701,360
1984	1,533	108,865	123,166	28,624	31,883	29,973	13,062	7,643	2,476	1,214	718	550	349,708
1985	2,105	16,837	17,457	9,257	24,049	28,495	21,138	7,665	2,097	754	440	826	131,121
1986	765	4,362	16,241	27,545	247,076	106,984	19,103	9,141	2,992	1,355	693	1,100	437,357
1987	818	749	999	2,269	8,465	15,616	4,452	1,786	545	184	75	68	36,026
1988	203	538	3,736	9,739	3,922	6,230	3,312	2,143	748	149	31	26	30,777
1989	69	3,964	2,287	4,885	12,288	83,772	21,620	7,494	2,339	747	313	621	140,400
1990	1,570	2,500	1,688	8,855	11,078	23,922	10,063	4,834	3,403	828	261	202	69,204
1991	335	652	717	803	1,304	36,541	18,396	10,947	3,544	1,127	378	168	74,912
1992	525	884	1,171	2,393	28,933	24,968	9,265	2,274	646	434	85	63	71,640
1993	292	708	12,207	72,553	68,699	86,418	33,547	15,211	6,911	2,077	785	421	299,830
1994	447	552	2,619	2,090	8,459	10,273	4,024	2,924	657	162	51	49	32,307
1995	285	1,785	15,023	117,864	44,955	200,056	52,560	52,341	11,927	8,435	1,779	913	507,923
1996	860	972	9,948	33,472	114,070	70,637	29,874	24,920	5,331	2,731	1,105	873	294,794
1997	836	6,075	129,632	242,653	43,544	19,191	10,089	5,125	2,268	1,171	695	511	461,791
1998	1,288	3,033	8,202	66,011	160,796	99,950	51,726	41,486	16,568	9,905	5,812	1,763	466,539
1999	1,681	4,174	15,296	33,093	140,449	50,423	26,309	15,537	4,800	2,025	1,176	769	295,733
2000	720	1,744	1,999	27,198	117,204	42,430	15,323	10,171	2,742	1,246	602	778	222,155
2001	1,578	1,797	2,734	6,363	15,368	21,219	13,714	6,919	1,451	607	302	298	72,349
2002	445	1,927	18,991	25,426	26,936	35,818	16,916	8,676	2,781	903	436	334	139,589
2003	467	2,188	17,394	19,769	14,749	19,681	31,543	28,044	5,199	1,633	1,000	557	142,225
2004	496	1,192	13,220	17,535	35,879	32,792	13,786	5,346	1,720	743	409	362	123,478
2005	1,305	2,260	14,618	48,817	42,869	87,465	40,618	40,149	9,904	4,277	1,328	872	294,482
2006	971	1,258	81,076	76,295	53,097	98,628	129,126	39,486	8,077	3,932	1,814	1,247	495,008
2007	1,683	2,370	8,289	7,392	27,809	24,920	11,361	6,072	1,955	834	474	460	93,619
2008	807	855	2,454	13,621	18,675	16,709	9,503	5,857	1,725	538	242	183	71,168
2009	583	1,333	2,748	7,551	29,567	54,321	16,883	21,088	3,059	1,022	480	356	138,993
2010	1,023	932	4,554	19,261	26,731	35,302	32,981	29,060	12,526	3,299	1,025	701	167,395
2011	1,691	6,072	98,750	35,658	39,747	161,840	54,701	27,536	13,445	9,727	2,729	1,240	453,134
Average	957	8,298	23,466	37,782	52,992	56,535	26,789	15,945	4,642	2,317	1,149	646	231,518
Maximum	3,133	108,865	129,632	242,653	247,076	200,056	129,126	52,341	16,568	9,910	11,775	2,070	701,360
Minimum	69	538	546	803	1,239	1,486	1,053	1,786	474	96	31	26	8,935
10% Exc.	1,682	11,456	91,561	83,301	135,170	103,467	52,143	39,818	12,226	6,356	1,797	1,243	480,774
20% Exc.	1,567	4,174	17,457	72,223	114,070	87,465	40,618	27,536	6,911	3,299	1,176	913	437,357
50% Exc.	827	1,791	8,618	20,645	30,725	36,179	17,656	9,656	3,025	1,193	607	554	154,810
80% Exc.	445	855	2,287	6,363	12,288	19,681	10,063	5,125	1,515	538	302	188	71,640
90% Exc.	289	680	1,429	2,180	6,285	12,944	4,579	2,258	651	175	80	83	34,167

Bear River at Rollins Dam - 2070 WMW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-675	-344	-174	-374	923	3,290	235	-380	-108	-37	-95	-66	2,196
1977	14	20	19	89	185	105	75	123	34	3	2	3	673
1978	10	149	9,926	27,600	25,056	31,550	6,087	-593	-1,240	429	80	162	99,216
1979	111	257	530	9,447	20,343	22,858	3,940	-653	-201	281	106	88	57,108
1980	-260	-3	3,241	39,721	60,280	7,469	-2,167	-3,348	-2,067	-69	-128	-88	102,581
1981	128	169	1,280	4,368	6,931	15,164	3,700	849	253	60	44	26	32,971
1982	-97	35,159	43,102	30,549	56,865	25,133	-10,891	-4,897	-2,238	499	-17	216	173,383
1983	-1,821	36,946	42,683	22,680	63,522	67,114	-6,187	-11,597	-11,153	1,983	9,007	-159	213,019
1984	-675	69,863	36,884	-258	6,747	757	-4,805	-4,340	-1,701	-483	-286	-219	101,484
1985	366	8,181	11,001	5,288	12,713	13,815	4,631	1,289	384	138	81	152	58,039
1986	-15	1,172	8,446	9,009	95,234	38,402	68	-936	-515	-26	-13	31	150,857
1987	-279	-256	-341	75	1,980	2,607	-273	-530	-157	-63	-25	-23	2,715
1988	-93	-248	553	2,218	387	1,494	-722	-872	-302	-69	-14	-12	2,318
1989	12	1,616	668	2,049	6,751	37,618	4,692	1,229	424	133	55	114	55,361
1990	-80	556	167	4,413	5,649	10,695	2,651	455	-274	82	25	20	24,359
1991	63	123	135	151	349	16,953	4,870	1,450	212	211	71	32	24,620
1992	-73	6	8	533	12,147	9,115	1,720	101	29	3	0	0	23,589
1993	25	62	6,433	24,792	31,836	33,820	2,751	-913	-2,205	212	71	38	96,922
1994	-188	-231	224	-97	1,878	2,707	-374	-1,134	-241	-68	-21	-20	2,434
1995	10	137	8,143	41,793	21,618	89,019	2,054	-6,494	-7,064	2,383	105	32	151,735
1996	36	41	5,034	11,530	60,637	25,096	729	-3,066	-1,653	236	47	37	98,703
1997	-135	1,277	59,975	67,233	14,997	4,954	218	-859	-558	-189	-112	-82	146,718
1998	84	641	3,877	22,744	81,396	41,122	3,813	-4,108	-9,982	3,113	3,525	116	146,341
1999	-6	742	8,224	8,629	72,458	14,435	-771	-2,817	-1,661	4	-4	-3	99,229
2000	-108	-161	24	6,474	55,604	8,191	-1,635	-3,062	-934	-187	-90	-116	63,999
2001	-11	119	612	2,770	7,620	9,531	2,493	237	150	41	20	20	23,602
2002	51	343	11,162	11,904	14,175	14,437	3,137	704	97	105	50	39	56,204
2003	89	578	10,718	11,748	8,321	10,551	6,761	686	-266	310	190	106	49,790
2004	70	168	7,721	9,959	18,083	13,523	3,730	827	298	105	58	51	54,593
2005	134	475	7,748	20,621	23,969	39,099	6,823	1,080	-2,462	1,247	241	158	99,131
2006	163	209	45,264	32,757	28,684	36,594	5,557	615	-1,690	983	305	209	149,649
2007	169	272	4,461	3,399	12,813	10,742	2,903	577	257	84	48	46	35,772
2008	-11	-11	647	5,136	8,588	7,598	1,689	-89	-24	-7	-3	-2	23,510
2009	129	307	1,253	3,728	16,786	26,923	5,499	2,261	519	225	106	78	57,815
2010	259	257	2,309	10,139	15,738	18,767	9,175	3,466	-1,965	1,079	283	194	59,701
2011	-365	1,714	54,344	11,832	17,649	70,224	2,944	-4,869	-8,607	2,807	705	49	148,427
Average	-82	4,453	11,008	12,907	24,692	21,708	1,809	-1,100	-1,572	432	400	34	74,688

Bear River at Rollins Dam - 2070 DEW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	33.6	47.2	47.6	40.9	50.1	63.1	59.0	44.8	15.0	4.0	10.5	7.5	35.2	2.0	150.9
1977	6.2	9.0	8.2	15.2	17.3	21.5	15.8	26.3	7.1	1.4	0.7	1.5	10.8	0.3	42.6
1978	1.3	10.8	89.1	612.5	419.9	623.7	771.8	390.4	105.4	36.9	10.0	20.7	256.7	0.9	2,327.3
1979	8.1	15.3	21.0	104.9	282.4	370.8	269.0	309.3	47.3	20.4	7.7	6.6	121.0	4.4	1,217.2
1980	15.6	28.3	57.7	858.2	1,621.8	423.4	195.6	162.7	63.4	33.4	13.6	9.7	285.4	5.0	9,492.7
1981	12.9	17.7	29.7	75.8	51.7	249.2	122.7	56.0	20.8	6.0	4.4	2.7	54.3	0.9	1,132.2
1982	17.7	93.8	1,077.8	635.3	1,653.4	857.2	1,548.1	465.3	96.3	42.1	21.7	30.5	537.0	7.7	13,589.2
1983	42.6	99.5	1,458.0	632.6	1,923.1	1,573.8	772.9	927.5	409.3	77.4	46.3	32.9	659.7	23.5	10,485.9
1984	27.6	154.3	2,060.3	226.5	293.3	303.2	176.2	126.5	42.2	22.3	13.2	10.4	290.1	9.7	8,927.1
1985	25.8	53.1	66.3	43.0	134.1	148.6	188.0	69.0	25.9	9.4	5.5	10.6	64.3	4.6	1,425.7
1986	11.5	26.7	78.6	154.3	3,554.6	800.5	213.8	112.8	42.4	20.4	10.4	16.1	398.2	7.2	18,130.9
1987	22.4	21.2	27.3	39.5	108.5	177.9	64.5	43.3	14.8	5.0	2.0	1.9	43.7	1.2	703.7
1988	6.3	17.4	56.0	90.9	58.6	66.3	67.3	54.2	23.2	4.7	1.0	0.8	37.2	0.7	267.2
1989	0.9	24.3	25.8	40.7	57.7	628.8	211.0	74.1	31.7	10.1	4.2	8.6	93.7	0.7	1,970.3
1990	23.3	28.3	28.8	56.0	60.0	160.6	100.6	65.6	59.4	14.1	4.4	3.6	50.3	2.5	391.7
1991	4.5	9.0	9.6	10.8	17.1	238.0	158.8	114.4	45.3	15.1	5.1	2.3	52.8	1.7	1,172.0
1992	7.7	14.9	19.1	28.1	241.5	176.7	88.1	32.1	10.4	7.1	1.4	1.1	51.6	1.0	1,121.4
1993	4.8	12.1	75.2	600.7	727.4	800.7	479.9	258.7	150.7	33.7	13.0	7.2	261.0	1.2	2,677.7
1994	14.5	18.2	47.0	44.2	92.4	90.2	67.9	69.6	21.2	5.3	1.6	1.6	39.2	1.3	378.0
1995	4.9	27.4	83.8	973.3	376.5	1,508.6	846.4	1,248.5	365.8	72.6	29.8	16.2	465.2	1.4	6,192.3
1996	13.0	15.2	57.2	226.6	1,216.0	582.2	384.2	472.4	87.4	37.5	16.7	13.6	256.4	11.5	6,123.9
1997	13.7	33.2	2,074.1	2,045.3	387.6	129.1	100.3	60.0	36.3	19.3	11.4	8.7	414.1	7.8	17,773.9
1998	18.5	28.4	51.7	480.2	1,851.9	684.9	680.5	760.5	452.6	68.1	36.7	26.2	418.1	9.1	10,034.5
1999	25.3	36.2	71.9	257.1	1,640.9	447.1	334.0	255.4	74.2	30.1	17.7	12.0	257.2	10.6	9,424.6
2000	9.5	20.0	21.9	166.6	1,102.0	319.1	143.9	126.5	33.4	16.4	8.0	10.6	160.9	6.7	6,006.3
2001	24.7	30.6	35.8	46.4	95.2	124.0	143.9	86.7	23.7	10.0	5.0	5.1	52.3	4.1	318.6
2002	7.4	26.5	100.1	143.4	182.5	296.4	186.5	108.1	44.1	15.0	7.3	5.7	93.2	4.7	1,006.6
2003	5.9	20.6	70.7	67.5	48.1	85.7	323.4	411.8	67.7	20.5	12.6	7.2	95.4	4.9	1,071.5
2004	6.1	15.1	55.3	61.3	212.3	193.1	102.8	48.9	20.9	9.1	5.0	4.6	60.6	3.7	1,456.2
2005	18.2	30.8	131.4	330.0	291.2	694.1	532.4	745.5	222.2	46.7	19.8	13.4	256.6	3.8	2,344.1
2006	12.9	17.3	704.5	464.7	361.3	856.0	2,090.7	672.1	142.0	42.3	24.2	17.2	449.9	11.4	13,778.5
2007	23.2	31.7	44.8	45.1	203.5	140.3	94.1	61.8	26.8	11.5	6.5	6.6	57.0	5.1	984.8
2008	15.6	17.0	31.4	95.3	131.2	89.3	110.0	80.1	33.0	10.4	4.7	3.6	51.5	3.1	502.8
2009	7.7	17.2	22.8	44.1	184.6	347.9	134.5	290.0	39.0	13.5	6.3	4.8	92.4	3.5	1,855.3
2010	9.9	9.6	27.1	72.7	105.9	158.2	265.0	342.6	201.1	28.5	10.2	7.2	103.0	3.8	998.1
2011	21.6	40.4	1,257.1	217.4	325.4	1,182.7	793.7	517.3	396.8	75.0	33.2	20.0	408.4	7.2	9,328.0
Average	14.6	31.1	281.2	279.1	557.7	433.7	356.6	269.2	97.2	24.9	12.0	10.0	195.4	0.3	18,130.9
10% Exc.	28.7	47.7	252.2	633.3	995.8	1,144.8	772.9	662.4	313.8	52.1	27.0	20.8	447.1	--	--
20% Exc.	23.5	38.7	102.9	262.9	577.4	667.2	537.9	447.3	127.6	41.9	18.8	15.4	184.5	--	--
50% Exc.	10.9	19.9	40.5	67.3	123.7	229.3	165.5	114.4	41.8	17.1	8.2	7.5	40.1	--	--
80% Exc.	5.3	12.4	21.5	35.7	46.1	98.2	93.8	51.7	20.3	7.3	4.2	2.7	10.6	--	--
90% Exc.	2.1	8.9	13.9	23.7	40.3	59.7	62.8	41.6	13.6	4.5	1.6	1.4	6.0	--	--

Bear River at Rollins Dam - 2070 DEW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	2,064	2,810	2,929	2,518	2,883	3,881	3,513	2,754	894	247	647	449	25,589
1977	384	534	505	934	961	1,324	939	1,616	422	89	45	91	7,844
1978	81	643	5,478	37,662	23,320	38,348	45,925	24,003	6,269	2,271	615	1,231	185,846
1979	495	911	1,291	6,449	15,685	22,802	16,007	19,019	2,812	1,255	473	391	87,591
1980	957	1,686	3,546	52,770	93,287	26,032	11,637	10,001	3,773	2,055	835	575	207,154
1981	794	1,052	1,823	4,662	2,870	15,325	7,303	3,446	1,235	370	273	159	39,312
1982	1,087	5,579	66,271	39,065	91,828	52,710	92,117	28,609	5,728	2,592	1,336	1,817	388,739
1983	2,620	5,921	89,651	38,899	106,803	96,772	45,989	57,028	24,355	4,759	2,847	1,959	477,603
1984	1,698	9,179	126,680	13,924	16,870	18,641	10,487	7,778	2,513	1,369	810	620	210,570
1985	1,589	3,161	4,074	2,645	7,445	9,139	11,188	4,242	1,539	576	336	630	46,564
1986	707	1,590	4,833	9,488	197,415	49,223	12,722	6,933	2,524	1,252	640	956	288,283
1987	1,376	1,259	1,680	2,427	6,025	10,936	3,836	2,661	879	308	125	114	31,626
1988	389	1,034	3,443	5,592	3,369	4,076	4,003	3,336	1,381	288	60	50	27,021
1989	57	1,445	1,584	2,501	3,207	38,663	12,555	4,557	1,884	621	261	514	67,847
1990	1,433	1,683	1,770	3,444	3,334	9,878	5,984	4,032	3,535	868	273	211	36,446
1991	276	538	592	663	950	14,634	9,448	7,033	2,697	930	311	138	38,210
1992	476	884	1,172	1,726	13,890	10,866	5,245	1,976	621	435	85	64	37,439
1993	298	723	4,624	36,934	40,399	49,231	28,559	15,904	8,969	2,070	801	430	188,942
1994	892	1,085	2,890	2,718	5,130	5,549	4,038	4,279	1,262	323	100	96	28,363
1995	301	1,630	5,150	59,847	20,912	92,761	50,366	76,768	21,766	4,463	1,834	965	336,763
1996	799	903	3,519	13,935	69,942	35,799	22,864	29,047	5,201	2,305	1,026	811	186,151
1997	845	1,977	127,534	125,759	21,528	7,936	5,967	3,686	2,161	1,185	703	516	299,797
1998	1,138	1,691	3,181	29,525	102,848	42,113	40,491	46,759	26,930	4,190	2,257	1,557	302,681
1999	1,556	2,154	4,421	15,807	91,133	27,492	19,877	15,707	4,418	1,850	1,088	712	186,215
2000	584	1,193	1,345	10,241	63,388	19,623	8,560	7,779	1,990	1,011	489	631	116,835
2001	1,516	1,818	2,202	2,856	5,286	7,622	8,565	5,329	1,413	615	305	302	37,829
2002	456	1,579	6,155	8,820	10,135	18,227	11,096	6,647	2,622	924	447	342	67,450
2003	361	1,228	4,350	4,148	2,674	5,272	19,243	25,321	4,030	1,261	772	430	69,089
2004	374	897	3,399	3,767	12,212	11,875	6,115	3,006	1,244	559	308	272	44,027
2005	1,119	1,830	8,081	20,289	16,174	42,678	31,680	45,840	13,222	2,871	1,218	800	185,801
2006	796	1,031	43,318	28,571	20,067	52,631	124,406	41,323	8,449	2,603	1,487	1,022	325,704
2007	1,429	1,886	2,757	2,776	11,303	8,628	5,597	3,800	1,597	708	402	391	41,273
2008	956	1,014	1,933	5,863	7,546	5,493	6,545	4,924	1,966	638	287	216	37,382
2009	472	1,025	1,402	2,713	10,251	21,390	8,003	17,829	2,319	827	389	288	66,908
2010	612	572	1,668	4,469	5,883	9,725	15,770	21,064	11,965	1,751	629	430	74,537
2011	1,330	2,403	77,294	13,365	18,074	72,718	47,226	31,807	23,612	4,609	2,039	1,189	295,665
Average	898	1,849	17,293	17,160	31,251	26,667	21,218	16,551	5,783	1,529	738	594	141,530
Maximum	2,620	9,179	127,534	125,759	197,415	96,772	124,406	76,768	26,930	4,759	2,847	1,959	477,603
Minimum	57	534	505	663	950	1,324	939	1,616	422	89	45	50	7,844
10% Exc.	1,573	2,985	71,783	38,982	92,558	52,671	46,608	43,582	17,494	3,531	1,661	1,210	314,192
20% Exc.	1,429	1,977	6,155	29,525	63,388	42,678	31,680	28,609	8,449	2,305	1,088	956	288,283
50% Exc.	797	1,352	3,421	6,156	13,051	18,434	11,142	7,405	2,573	1,098	552	440	71,813
80% Exc.	384	903	1,668	2,713	3,369	7,936	5,967	3,686	1,381	559	273	211	37,439
90% Exc.	299	683	1,318	2,464	2,876	5,383	4,020	2,880	1,065	316	113	105	29,994

Bear River at Rollins Dam - 2070 DEW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-177	127	415	445	-306	-1,448	-958	133	163	45	118	82	-1,363
1977	-16	-23	-21	-51	-92	-56	-40	-90	-18	-4	-2	-4	-418
1978	11	4	-1,644	-6,961	-1,318	-2,609	1,380	2,130	-1,095	206	83	167	-9,646
1979	-122	-294	-372	-5,625	-6,002	-11,933	-9,643	-5,839	-1,696	-311	-117	-97	-42,051
1980	-336	-1,026	-2,160	-26,162	23,677	-11,284	-6,928	-3,909	-2,305	-685	-144	-99	-31,360
1981	-17	-22	-252	-2,345	-3,149	-5,043	-3,508	-1,466	-28	-8	-6	-3	-15,845
1982	-191	-12,157	24,920	-17,029	21,179	-15,308	-5,160	-2,211	-2,037	-646	-63	-37	-8,738
1983	-2,334	-13,250	33,666	-18,380	28,638	-33,131	-6,340	3,078	522	-3,167	79	-118	-10,738
1984	-510	-29,823	40,398	-14,958	-8,266	-10,575	-7,380	-4,206	-1,664	-328	-194	-149	-37,654
1985	-150	-5,496	-2,382	-1,323	-3,891	-5,541	-5,319	-2,134	-175	-40	-23	-44	-26,518
1986	-73	-1,600	-2,962	-9,048	45,572	-19,359	-6,314	-3,144	-982	-129	-66	-113	1,783
1987	278	255	340	233	-461	-2,072	-889	344	178	62	25	23	-1,685
1988	93	248	260	-1,929	-166	-661	-31	320	331	69	14	12	-1,438
1989	0	-904	-35	-336	-2,330	-7,491	-4,374	-1,709	-31	7	2	6	-17,192
1990	-217	-261	249	-998	-2,094	-3,350	-1,428	-347	-143	121	38	29	-8,399
1991	4	9	10	11	-6	-4,955	-4,078	-2,465	-635	14	5	2	-12,083
1992	-122	5	9	-134	-2,895	-4,987	-2,300	-198	5	4	1	0	-10,612
1993	31	77	-1,150	-10,827	3,536	-3,367	-2,238	-220	-147	205	87	47	-13,966
1994	257	302	495	531	-1,451	-2,017	-360	221	364	93	29	27	-1,510
1995	26	-18	-1,730	-16,225	-2,426	-18,276	-139	17,933	2,775	-1,590	161	84	-19,425
1996	-25	-28	-1,395	-8,008	16,509	-9,742	-6,281	1,061	-1,784	-190	-32	-25	-9,939
1997	-125	-2,821	57,876	-49,662	-7,019	-6,301	-3,905	-2,297	-665	-176	-104	-77	-15,275
1998	-66	-700	-1,144	-13,741	23,448	-16,714	-7,421	1,165	381	-2,602	-31	-90	-17,517
1999	-131	-1,278	-2,652	-8,657	23,142	-8,497	-7,203	-2,648	-2,044	-171	-91	-60	-10,290
2000	-243	-712	-630	-10,484	1,789	-14,616	-8,398	-5,454	-1,686	-421	-203	-263	-41,322
2001	-74	140	79	-737	-2,462	-4,066	-2,655	-1,353	112	49	24	24	-10,919
2002	62	-5	-1,674	-4,702	-2,626	-3,154	-2,682	-1,325	-62	126	61	47	-15,935
2003	-18	-383	-2,326	-3,874	-3,754	-3,858	-5,539	-2,037	-1,434	-62	-38	-21	-23,345
2004	-53	-127	-2,100	-3,808	-5,583	-7,394	-3,941	-1,513	-178	-79	-44	-38	-24,858
2005	-53	44	1,211	-7,907	-2,726	-5,688	-2,115	6,770	856	-159	131	86	-9,549
2006	-12	-18	7,506	-14,968	-4,346	-9,403	837	2,452	-1,318	-346	-23	-16	-19,656
2007	-85	-212	-1,071	-1,217	-3,694	-5,550	-2,861	-1,694	-100	-42	-24	-23	-16,574
2008	139	147	126	-2,622	-2,541	-3,617	-1,269	-1,022	217	93	42	31	-10,276
2009	17	-1	-93	-1,111	-2,529	-6,009	-3,382	-997	-221	30	14	11	-14,269
2010	-153	-102	-577	-4,652	-5,110	-6,811	-8,037	-4,530	-2,527	-469	-113	-77	-33,157
2011	-726	-1,955	32,888	-10,461	-4,025	-18,897	-4,531	-597	1,559	-2,311	15	-2	-9,042
Average	-142	-1,996	4,835	-7,714	2,951	-8,161	-3,762	-494	-431	-356	-11	-19	-15,300

Deer Creek at Scotts Flat Dam - Historical Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	8.1	10.4	9.3	7.7	13.1	21.0	17.6	9.7	2.8	0.8	1.8	1.4	8.6	0.4	55.1
1977	1.4	2.1	1.8	3.5	4.3	5.0	3.8	6.6	1.6	0.2	0.1	0.2	2.6	0.1	13.0
1978	0.3	2.6	26.5	159.9	98.1	146.5	164.1	77.7	26.5	7.2	1.9	3.9	59.4	0.2	576.2
1979	2.2	4.4	5.9	41.6	80.3	126.8	96.7	90.6	16.7	5.6	2.1	1.8	39.3	1.2	320.8
1980	4.7	10.5	20.2	287.2	262.1	133.7	69.2	49.8	22.3	9.7	3.4	2.4	72.4	1.3	1,645.4
1981	2.8	3.9	7.2	23.4	26.0	73.7	42.2	17.6	4.8	1.3	1.0	0.7	17.0	0.2	290.7
1982	5.0	66.6	156.6	195.4	280.4	237.7	354.6	109.2	28.1	11.3	4.8	6.6	120.1	2.1	2,182.3
1983	17.4	69.0	196.8	199.0	307.6	455.8	191.9	191.0	86.1	27.4	9.6	7.7	145.9	5.3	1,614.0
1984	8.0	142.2	307.3	102.6	94.4	104.2	66.1	43.0	15.3	5.9	3.5	2.8	74.7	2.6	1,260.4
1985	6.1	33.2	23.7	14.6	44.9	52.8	63.6	22.9	6.4	2.3	1.3	2.5	22.6	1.1	290.9
1986	2.8	11.5	28.2	66.2	596.6	236.9	69.5	35.6	12.9	4.9	2.5	4.0	85.8	1.7	3,114.8
1987	3.8	3.6	4.7	8.0	27.1	47.5	17.6	8.2	2.6	0.9	0.4	0.4	10.3	0.2	152.5
1988	1.1	2.9	13.6	29.9	14.9	18.1	15.3	11.1	4.1	0.9	0.2	0.2	9.4	0.1	83.0
1989	0.2	10.6	6.1	11.4	25.5	178.1	64.3	22.6	7.2	2.3	1.0	1.9	27.7	0.2	573.3
1990	6.0	7.4	5.4	17.3	22.2	49.9	28.0	17.0	15.0	2.9	0.9	0.7	14.3	0.5	91.4
1991	1.0	2.0	2.1	2.4	3.8	70.8	53.3	35.3	12.6	3.4	1.2	0.6	15.8	0.4	269.0
1992	2.3	3.5	4.3	7.0	66.3	57.6	28.6	7.9	2.4	1.6	0.4	0.3	15.0	0.3	268.6
1993	1.1	2.4	21.4	170.3	143.5	188.3	112.1	56.1	33.7	6.7	2.6	1.4	61.2	0.3	654.3
1994	2.3	2.9	8.8	8.0	26.6	29.3	16.8	14.7	3.4	0.9	0.3	0.3	9.4	0.2	72.3
1995	1.0	6.1	25.9	274.1	91.7	389.2	184.6	205.9	67.5	20.8	5.8	3.2	106.9	0.3	1,502.4
1996	2.9	3.3	18.6	81.5	209.5	160.9	109.0	102.4	25.9	8.8	3.7	3.0	60.3	2.6	634.6
1997	3.4	17.5	252.3	611.9	109.9	49.6	35.2	20.6	10.1	4.7	2.8	2.1	94.1	1.9	4,989.6
1998	4.2	8.9	15.7	159.8	308.9	206.2	173.7	160.3	96.0	23.5	7.9	5.9	96.1	2.0	1,192.7
1999	5.8	13.5	27.3	92.0	266.6	127.9	97.3	63.8	22.9	7.0	4.1	2.8	59.5	2.4	1,164.6
2000	2.9	7.0	7.1	74.3	233.9	124.0	62.9	46.4	13.4	5.0	2.4	3.2	47.8	2.0	924.3
2001	5.9	6.4	7.8	12.8	30.0	41.5	40.6	23.4	5.0	2.3	1.2	1.2	14.7	1.0	82.6
2002	1.6	6.0	28.2	48.1	49.7	75.1	49.8	28.0	10.0	3.1	1.6	1.3	25.1	1.1	216.7
2003	1.5	6.1	24.5	30.2	26.0	32.9	89.7	96.1	20.5	5.2	3.3	2.0	28.2	1.3	241.9
2004	1.8	4.1	20.1	27.3	67.9	68.3	36.7	16.3	5.6	2.6	1.5	1.4	21.0	1.2	323.4
2005	4.1	6.4	23.8	97.9	72.6	167.8	121.2	135.6	44.3	10.5	3.8	2.6	57.6	0.7	821.7
2006	2.8	3.8	124.2	151.1	93.8	215.4	443.2	134.9	35.0	10.4	5.3	3.8	101.8	2.5	1,974.6
2007	5.8	8.2	13.7	14.6	56.7	50.8	31.5	20.0	6.7	3.0	1.8	1.8	17.6	1.5	230.6
2008	3.2	3.4	6.5	28.9	37.1	33.2	29.0	21.3	6.7	2.2	1.1	0.9	14.4	0.8	109.0
2009	1.8	4.0	5.3	13.7	47.5	96.6	42.2	66.5	9.7	3.2	1.6	1.2	24.4	0.9	470.2
2010	3.0	2.7	8.1	30.4	43.0	58.0	86.2	90.8	53.3	8.3	3.0	2.2	32.3	1.2	258.8
2011	7.3	15.8	153.5	84.6	83.9	317.3	191.4	116.2	81.7	25.4	7.9	4.9	91.1	1.9	873.3
Average	3.8	14.3	44.8	88.6	110.2	123.6	91.7	60.4	22.7	6.7	2.7	2.3	47.3	0.1	4,989.6
10% Exc.	6.9	22.6	87.3	193.8	242.5	283.8	190.7	144.7	61.1	15.3	6.1	4.9	121.7	--	--
20% Exc.	5.3	10.4	36.2	104.1	145.1	176.8	132.6	103.8	35.9	9.5	4.0	3.2	62.2	--	--
50% Exc.	2.5	4.3	9.6	26.2	49.2	74.2	58.3	35.8	11.5	4.1	2.0	2.0	9.7	--	--
80% Exc.	1.3	2.8	4.7	7.3	15.7	36.7	28.3	14.2	4.3	1.6	0.9	0.6	2.5	--	--
90% Exc.	0.5	2.1	3.2	5.2	10.8	22.7	18.5	9.7	2.7	0.9	0.3	0.3	1.4	--	--

Deer Creek at Scotts Flat Dam - Historical Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	496	616	570	471	754	1,289	1,047	595	169	47	109	83	6,246
1977	89	124	113	216	238	310	225	403	94	14	7	15	1,848
1978	16	154	1,629	9,829	5,446	9,010	9,763	4,778	1,577	444	116	233	42,997
1979	133	261	362	2,558	4,462	7,796	5,757	5,569	992	343	130	107	28,470
1980	288	624	1,242	17,659	15,074	8,221	4,116	3,064	1,326	595	211	145	52,565
1981	173	231	444	1,438	1,441	4,531	2,511	1,082	283	83	61	43	12,321
1982	305	3,961	9,627	12,016	15,572	14,615	21,098	6,715	1,675	696	297	390	86,966
1983	1,069	4,107	12,101	12,235	17,084	28,023	11,418	11,742	5,124	1,688	593	459	105,641
1984	491	8,460	18,895	6,308	5,428	6,405	3,935	2,642	908	363	216	166	54,219
1985	372	1,978	1,458	896	2,492	3,244	3,785	1,411	380	141	82	150	16,389
1986	172	684	1,732	4,070	33,131	14,568	4,135	2,187	768	303	156	240	62,146
1987	236	216	289	494	1,504	2,918	1,047	504	155	55	24	22	7,463
1988	65	171	836	1,837	855	1,116	913	684	241	53	12	10	6,792
1989	14	630	377	702	1,414	10,949	3,829	1,391	426	140	60	111	20,043
1990	369	439	335	1,062	1,233	3,070	1,664	1,042	893	176	57	44	10,385
1991	62	118	129	146	214	4,353	3,172	2,168	751	209	72	33	11,427
1992	140	206	267	430	3,812	3,541	1,700	488	143	99	22	16	10,867
1993	67	144	1,314	10,472	7,969	11,581	6,669	3,447	2,005	410	159	86	44,323
1994	142	174	544	493	1,479	1,803	1,000	905	204	55	18	17	6,834
1995	62	363	1,590	16,851	5,092	23,929	10,986	12,660	4,019	1,277	357	188	77,375
1996	176	199	1,141	5,010	12,053	9,892	6,487	6,297	1,540	542	228	180	43,746
1997	209	1,044	15,513	37,627	6,103	3,048	2,094	1,265	600	288	172	127	68,092
1998	258	530	963	9,826	17,154	12,680	10,335	9,854	5,713	1,444	487	349	69,593
1999	357	802	1,680	5,658	14,805	7,861	5,792	3,924	1,362	430	251	165	43,087
2000	179	415	439	4,568	13,456	7,622	3,740	2,853	795	309	149	191	34,716
2001	362	378	479	787	1,667	2,550	2,415	1,439	300	140	75	72	10,662
2002	98	359	1,733	2,958	2,759	4,617	2,965	1,721	595	193	100	78	18,175
2003	94	362	1,506	1,858	1,447	2,025	5,335	5,909	1,217	318	202	119	20,394
2004	111	243	1,233	1,681	3,907	4,200	2,185	1,000	334	163	95	84	15,236
2005	250	381	1,466	6,019	4,032	10,321	7,210	8,336	2,639	646	231	152	41,683
2006	172	223	7,639	9,290	5,209	13,243	26,374	8,292	2,084	639	328	225	73,718
2007	355	485	844	900	3,150	3,126	1,875	1,231	398	187	111	106	12,767
2008	196	205	398	1,779	2,137	2,043	1,726	1,310	399	135	66	51	10,443
2009	111	241	327	840	2,638	5,938	2,510	4,092	579	198	96	73	17,643
2010	183	163	497	1,872	2,387	3,565	5,129	5,581	3,174	511	184	130	23,377
2011	448	938	9,438	5,201	4,660	19,507	11,388	7,147	4,862	1,559	484	292	65,923
Average	231	851	2,754	5,446	6,174	7,598	5,454	3,715	1,353	414	167	138	34,294
Maximum	1,069	8,460	18,895	37,627	33,131	28,023	26,374	12,660	5,713	1,688	593	459	105,641
Minimum	14	118	113	146	214	310	225	403	94	14	7	10	1,848
10% Exc.	410	1,511	9,532	12,125	15,323	14,591	11,187	8,314	3,597	986	343	266	71,656
20% Exc.	357	684	1,732	9,826	12,053	11,581	7,210	6,297	2,005	595	231	191	62,146
50% Exc.	178	363	1,052	2,215	3,860	5,278	3,807	2,415	781	295	123	115	21,885
80% Exc.	94	199	377	787	1,447	2,918	1,726	1,042	300	135	61	44	10,662
90% Exc.	64	159	308	482	1,044	1,914	1,047	640	186	55	23	19	7,149

Deer Creek at Scotts Flat Dam - 2070 Median Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	6.8	9.4	8.8	7.3	13.6	24.5	17.1	8.6	2.7	0.7	1.7	1.3	8.5	0.4	61.5
1977	1.4	2.1	1.8	3.5	4.3	5.0	3.8	6.4	1.6	0.2	0.1	0.2	2.5	0.1	14.2
1978	0.3	2.6	31.5	207.8	122.0	173.9	168.2	65.4	20.0	7.8	2.0	4.2	66.9	0.2	821.4
1979	2.3	4.7	6.4	53.1	101.3	148.8	98.1	77.5	14.2	6.1	2.3	2.0	42.7	1.3	358.4
1980	4.1	9.1	20.5	366.2	300.7	135.7	61.4	35.5	15.3	9.2	3.2	2.3	79.7	1.2	2,165.7
1981	2.9	3.9	7.4	27.8	28.0	82.4	40.2	15.4	4.8	1.4	1.0	0.7	18.0	0.2	321.0
1982	4.8	63.5	207.4	252.7	334.2	267.2	337.0	88.8	20.0	11.6	4.9	7.0	131.9	2.1	2,359.5
1983	14.2	63.2	259.7	255.6	351.9	533.7	182.4	162.6	62.5	27.7	9.4	7.7	160.2	5.3	2,046.5
1984	7.6	127.7	397.3	118.4	107.1	108.8	60.9	32.2	11.9	5.7	3.4	2.7	82.2	2.5	1,731.6
1985	6.2	29.8	25.7	16.2	50.6	58.5	62.1	19.8	6.4	2.4	1.4	2.6	23.2	1.2	338.3
1986	2.7	10.3	29.7	79.6	668.6	261.0	64.0	27.7	10.7	4.8	2.5	4.0	93.3	1.7	3,334.7
1987	3.6	3.4	4.4	7.9	28.3	48.2	16.6	7.4	2.4	0.8	0.4	0.3	10.2	0.2	164.6
1988	0.9	2.5	12.3	34.1	14.6	19.5	13.4	9.1	3.6	0.8	0.2	0.1	9.3	0.1	88.3
1989	0.2	9.8	6.1	12.2	28.7	198.2	61.0	19.1	7.1	2.3	1.0	1.9	29.1	0.2	758.2
1990	5.7	7.5	5.9	22.1	26.1	57.6	29.0	15.8	13.0	3.1	1.0	0.8	15.6	0.6	107.4
1991	1.1	2.2	2.3	2.6	4.3	85.6	55.8	31.0	11.7	3.8	1.3	0.6	17.0	0.5	325.4
1992	2.1	3.6	4.5	7.3	79.6	63.4	28.2	7.8	2.5	1.7	0.4	0.3	16.5	0.3	317.8
1993	1.1	2.5	24.6	216.7	171.3	216.0	111.4	44.9	24.9	7.0	2.7	1.5	68.3	0.3	972.8
1994	2.2	2.7	8.5	8.0	27.1	31.9	16.3	12.3	3.2	0.8	0.3	0.3	9.4	0.2	80.7
1995	1.0	5.8	27.2	340.3	106.0	455.3	175.6	173.9	47.8	20.8	5.7	3.1	114.2	0.3	1,888.1
1996	3.0	3.6	21.0	106.0	257.7	191.6	109.0	89.3	19.6	9.4	3.9	3.2	67.5	2.7	922.2
1997	2.9	13.3	302.4	662.3	109.9	44.7	28.3	15.0	7.9	4.0	2.4	1.8	100.4	1.6	4,806.3
1998	4.2	8.5	16.3	199.5	367.6	240.0	169.5	134.6	70.6	24.0	7.9	5.9	102.3	2.1	1,693.4
1999	6.1	13.0	31.1	114.1	336.0	145.7	96.2	51.1	17.6	7.4	4.3	2.9	67.0	2.6	1,752.4
2000	2.8	6.5	6.8	90.6	260.5	128.8	56.9	34.8	10.6	4.8	2.3	3.1	49.9	2.0	1,106.2
2001	6.0	6.8	8.3	16.2	36.1	48.7	41.2	20.9	5.4	2.4	1.3	1.3	16.1	1.1	85.6
2002	1.6	5.8	30.7	61.5	56.8	81.1	47.4	23.5	9.0	3.2	1.6	1.3	26.8	1.1	238.7
2003	1.6	6.2	28.8	43.8	28.7	39.5	92.1	81.6	16.4	5.6	3.5	2.1	29.2	1.4	258.6
2004	1.8	4.0	20.7	35.7	75.0	70.3	34.0	14.1	5.5	2.6	1.5	1.4	22.1	1.2	337.5
2005	4.3	7.0	29.1	130.4	94.1	211.3	128.1	123.8	34.7	11.8	4.2	2.8	65.1	0.8	1,281.0
2006	2.9	3.9	160.3	197.0	112.2	241.4	424.7	115.0	25.3	10.8	5.5	3.9	108.5	2.6	2,788.9
2007	6.0	8.3	14.1	16.9	66.7	55.4	30.7	17.7	6.9	3.1	1.9	1.8	18.8	1.5	279.9
2008	3.3	3.6	6.6	36.9	43.3	39.2	28.3	18.8	6.7	2.3	1.1	0.9	15.8	0.8	139.1
2009	2.0	4.3	5.7	17.4	58.7	112.9	43.2	57.5	9.6	3.5	1.7	1.3	26.4	1.0	575.7
2010	3.5	3.3	9.7	43.5	56.3	73.6	96.9	85.9	45.7	10.0	3.6	2.6	36.0	1.4	359.1
2011	6.2	14.3	205.8	102.1	97.8	364.9	187.4	92.6	60.3	26.0	7.9	4.9	97.8	1.9	1,166.0
Average	3.6	13.3	55.3	108.7	128.5	140.7	89.3	51.0	17.7	6.9	2.8	2.4	51.3	0.1	4,806.3
10% Exc.	6.9	19.5	103.3	231.7	290.7	317.9	194.2	115.8	44.5	15.8	6.1	5.0	126.4	--	--
20% Exc.	5.4	10.0	38.4	128.3	173.0	197.3	131.7	86.9	25.7	10.0	4.2	3.3	62.7	--	--
50% Exc.	2.5	4.4	9.4	37.9	59.2	80.4	55.4	29.0	10.7	4.2	2.1	1.9	9.5	--	--
80% Exc.	1.3	2.9	4.8	7.5	18.3	41.4	27.1	12.1	4.3	1.7	1.0	0.7	2.5	--	--
90% Exc.	0.5	2.1	3.3	5.3	11.3	27.6	17.8	9.2	2.6	0.8	0.3	0.3	1.4	--	--

Deer Creek at Scotts Flat Dam - 2070 Median Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	418	560	539	450	782	1,505	1,017	531	161	45	104	79	6,193
1977	88	123	113	214	239	308	223	395	94	14	7	15	1,833
1978	17	157	1,938	12,780	6,773	10,693	10,010	4,021	1,190	478	124	249	48,430
1979	144	278	391	3,264	5,625	9,147	5,839	4,767	846	373	141	117	30,933
1980	255	539	1,260	22,519	17,294	8,344	3,652	2,180	909	563	198	136	57,849
1981	175	234	456	1,709	1,555	5,070	2,392	944	286	84	61	44	13,009
1982	296	3,778	12,752	15,535	18,559	16,431	20,053	5,460	1,193	711	301	419	95,488
1983	875	3,760	15,971	15,717	19,546	32,816	10,852	9,999	3,719	1,705	577	458	115,994
1984	469	7,601	24,429	7,282	6,160	6,687	3,621	1,982	710	354	210	162	59,668
1985	382	1,773	1,579	998	2,812	3,598	3,693	1,220	383	146	85	155	16,824
1986	169	611	1,824	4,892	37,132	16,049	3,809	1,704	635	297	153	241	67,514
1987	220	202	269	487	1,572	2,965	990	456	144	51	22	20	7,399
1988	57	151	756	2,096	840	1,196	799	560	214	47	11	9	6,735
1989	15	582	378	751	1,594	12,186	3,631	1,173	421	141	61	112	21,044
1990	350	445	363	1,357	1,449	3,542	1,726	969	776	191	62	47	11,277
1991	69	131	144	162	237	5,265	3,318	1,905	693	231	80	37	12,272
1992	129	212	276	452	4,580	3,900	1,678	482	148	102	23	17	11,998
1993	69	151	1,512	13,325	9,512	13,284	6,631	2,762	1,484	431	167	90	49,417
1994	134	163	520	493	1,504	1,959	968	757	192	52	17	16	6,776
1995	60	348	1,674	20,927	5,888	27,997	10,448	10,695	2,843	1,278	351	185	82,695
1996	187	211	1,291	6,520	14,825	11,784	6,485	5,492	1,163	579	242	191	48,971
1997	179	789	18,595	40,723	6,103	2,748	1,684	924	472	246	147	109	72,720
1998	260	504	1,004	12,264	20,418	14,758	10,085	8,278	4,203	1,478	484	351	74,086
1999	377	771	1,911	7,017	18,658	8,961	5,725	3,144	1,046	452	265	174	48,501
2000	172	386	419	5,573	14,986	7,921	3,386	2,139	634	296	143	183	36,238
2001	369	406	511	995	2,006	2,997	2,450	1,288	322	151	81	78	11,653
2002	99	347	1,889	3,782	3,152	4,984	2,822	1,446	535	195	101	78	19,432
2003	101	368	1,773	2,691	1,591	2,429	5,479	5,018	978	342	217	128	21,114
2004	109	238	1,273	2,197	4,314	4,322	2,026	870	328	159	93	82	16,011
2005	263	416	1,789	8,021	5,228	12,994	7,624	7,610	2,066	727	258	169	47,165
2006	178	231	9,857	12,116	6,229	14,845	25,274	7,069	1,503	666	339	232	78,537
2007	366	493	867	1,038	3,703	3,406	1,828	1,087	409	193	115	109	13,615
2008	203	212	407	2,269	2,492	2,408	1,681	1,159	400	139	68	53	11,492
2009	121	259	353	1,067	3,259	6,944	2,570	3,536	573	214	104	79	19,080
2010	214	194	598	2,672	3,129	4,524	5,763	5,283	2,717	615	219	155	26,084
2011	379	848	12,652	6,279	5,432	22,434	11,149	5,691	3,587	1,598	483	293	70,826
Average	221	791	3,398	6,684	7,199	8,650	5,316	3,139	1,055	426	170	141	37,191
Maximum	875	7,601	24,429	40,723	37,132	32,816	25,274	10,695	4,203	1,705	577	458	115,994
Minimum	15	123	113	162	237	308	223	395	94	14	7	9	1,833
10% Exc.	381	1,311	12,702	15,626	18,608	16,240	10,650	7,339	2,780	1,003	345	271	76,312
20% Exc.	366	611	1,911	12,264	14,825	13,284	7,624	5,460	1,484	615	258	191	67,514
50% Exc.	178	358	1,132	2,977	4,447	5,976	3,626	1,944	664	271	133	115	23,599
80% Exc.	99	202	391	995	1,572	2,965	1,684	924	322	139	62	47	11,653
90% Exc.	65	154	314	469	1,145	2,184	1,004	545	177	52	22	18	7,088

Deer Creek at Scotts Flat Dam - 2070 Median Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-78	-56	-30	-21	27	217	-29	-64	-7	-2	-5	-4	-53
1977	-1	-1	-1	-1	1	-2	-2	-8	-1	0	0	0	-16
1978	1	2	309	2,951	1,327	1,683	247	-757	-388	34	8	16	5,433
1979	11	18	29	706	1,163	1,351	82	-803	-145	30	11	9	2,462
1980	-33	-85	18	4,860	2,220	122	-464	-884	-417	-32	-13	-9	5,285
1981	2	3	13	271	114	538	-119	-138	3	1	1	1	688
1982	-9	-183	3,125	3,519	2,987	1,817	-1,046	-1,255	-482	16	4	29	8,523
1983	-194	-347	3,870	3,482	2,462	4,793	-566	-1,744	-1,404	18	-16	-1	10,353
1984	-23	-858	5,534	975	732	282	-314	-660	-198	-10	-6	-4	5,450
1985	10	-205	121	102	321	354	-92	-191	3	5	3	5	435
1986	-3	-73	92	822	4,000	1,481	-326	-483	-133	-6	-3	0	5,368
1987	-16	-14	-19	-7	68	47	-58	-48	-10	-4	-2	-1	-63
1988	-7	-20	-80	259	-14	80	-114	-124	-28	-6	-1	-1	-58
1989	0	-48	1	48	180	1,237	-198	-219	-5	1	1	1	1,000
1990	-19	6	27	295	216	473	62	-73	-117	15	5	4	892
1991	7	13	14	16	24	912	147	-263	-58	22	8	4	845
1992	-11	6	8	21	768	358	-22	-7	5	3	1	0	1,132
1993	3	7	198	2,852	1,543	1,704	-38	-685	-521	20	7	4	5,094
1994	-8	-11	-24	0	25	156	-32	-148	-12	-3	-1	-1	-58
1995	-1	-16	84	4,075	797	4,068	-539	-1,965	-1,176	2	-6	-3	5,321
1996	11	12	150	1,510	2,771	1,891	-2	-805	-376	37	14	11	5,225
1997	-31	-255	3,082	3,096	0	-300	-410	-341	-128	-42	-25	-19	4,628
1998	1	-26	41	2,438	3,264	2,078	-250	-1,577	-1,510	34	-2	2	4,493
1999	20	-30	231	1,359	3,852	1,100	-67	-780	-316	22	14	9	5,414
2000	-7	-30	-20	1,005	1,530	299	-354	-714	-161	-12	-6	-7	1,522
2001	6	29	32	209	339	447	35	-151	23	11	6	6	991
2002	1	-12	157	824	393	366	-142	-275	-59	2	1	1	1,256
2003	7	5	266	833	145	404	144	-890	-239	23	15	9	721
2004	-2	-5	40	516	407	122	-159	-130	-7	-3	-2	-2	775
2005	13	35	324	2,002	1,195	2,673	413	-727	-573	81	27	17	5,482
2006	6	7	2,218	2,826	1,020	1,601	-1,100	-1,223	-581	27	11	7	4,818
2007	11	8	23	138	553	281	-47	-143	11	6	4	3	847
2008	7	7	9	490	356	366	-45	-151	1	5	2	2	1,048
2009	10	18	26	227	621	1,006	60	-556	-6	17	8	6	1,437
2010	31	31	101	801	742	959	634	-297	-457	104	35	25	2,708
2011	-69	-90	3,214	1,078	772	2,927	-239	-1,455	-1,275	39	-1	2	4,902
Average	-10	-60	644	1,238	1,026	1,053	-138	-576	-298	13	3	3	2,897

Deer Creek at Scotts Flat Dam - 2070 WMW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	5.6	9.0	8.5	6.2	17.0	33.8	17.9	8.2	2.4	0.6	1.4	1.1	9.3	0.3	85.8
1977	1.5	2.2	1.9	3.7	5.1	5.4	4.1	7.1	1.7	0.2	0.1	0.3	2.8	0.1	20.4
1978	0.3	3.2	62.7	255.8	196.6	256.9	186.3	75.6	22.3	8.6	2.2	4.5	89.1	0.2	1,529.9
1979	2.6	5.3	7.7	73.3	157.8	210.5	111.7	88.8	16.2	6.6	2.5	2.1	56.5	1.5	460.3
1980	3.8	10.6	31.4	430.0	487.1	159.9	60.7	37.7	14.8	9.3	3.0	2.1	103.0	1.1	2,820.3
1981	3.2	4.5	11.3	37.6	55.4	127.0	55.5	20.5	5.7	1.5	1.1	0.8	26.9	0.3	408.7
1982	4.6	202.6	317.9	296.9	500.6	323.4	315.1	91.1	20.1	12.7	4.7	7.2	172.5	2.1	2,872.2
1983	11.0	201.9	349.3	279.9	563.0	693.5	169.7	150.3	46.2	34.0	29.1	7.1	209.5	4.8	3,203.2
1984	5.6	397.1	438.6	101.2	119.5	106.8	48.3	27.4	9.2	4.2	2.5	2.0	105.0	1.9	2,019.8
1985	7.3	65.2	63.0	33.3	94.0	100.8	80.2	27.3	7.8	2.8	1.6	3.1	40.1	1.4	475.5
1986	2.8	15.6	58.2	98.1	975.1	364.4	70.2	32.5	11.2	4.9	2.5	4.2	131.0	1.7	4,073.2
1987	2.9	2.7	3.5	8.2	35.3	56.4	16.5	6.3	2.0	0.7	0.3	0.3	11.1	0.2	212.2
1988	0.7	2.0	16.3	37.5	17.2	23.4	12.4	7.8	2.9	0.6	0.1	0.1	10.1	0.1	80.3
1989	0.3	18.8	7.9	20.5	54.0	299.6	77.1	25.5	8.3	2.6	1.1	2.2	43.3	0.2	1,530.8
1990	5.7	9.4	6.0	33.1	44.6	87.1	37.2	18.2	13.5	3.1	1.0	0.8	21.5	0.6	147.7
1991	1.3	2.5	2.6	3.0	5.4	133.2	72.2	40.9	13.7	4.2	1.5	0.7	23.6	0.5	418.6
1992	2.0	3.5	4.3	8.9	113.1	89.2	34.6	8.2	2.5	1.6	0.4	0.3	22.0	0.3	354.6
1993	1.2	2.7	44.8	258.6	265.4	307.4	122.0	53.3	25.6	7.4	2.8	1.6	90.2	0.3	1,242.6
1994	1.6	2.1	9.9	7.6	34.3	38.7	15.4	10.7	2.5	0.6	0.2	0.2	10.2	0.2	98.4
1995	1.0	6.6	55.8	426.8	175.1	700.1	191.4	182.0	42.6	28.3	6.0	3.3	152.4	0.3	3,397.6
1996	2.9	3.4	36.8	122.1	441.4	245.7	110.1	90.4	19.6	9.4	3.8	3.1	89.4	2.6	1,795.4
1997	2.9	22.2	467.5	847.7	167.7	67.0	36.1	17.7	8.2	4.0	2.4	1.8	138.2	1.6	6,244.2
1998	4.5	11.3	29.3	247.5	626.4	348.3	187.9	146.4	60.4	33.9	15.5	6.3	140.0	2.2	2,829.8
1999	5.8	16.8	58.3	124.1	545.2	177.8	94.4	53.7	17.3	6.9	4.0	2.7	89.2	2.4	2,594.9
2000	2.5	6.4	7.2	97.2	441.7	153.2	56.7	35.8	10.1	4.4	2.1	2.8	66.9	1.8	1,976.4
2001	5.9	6.8	9.9	22.3	59.0	75.0	49.7	24.3	5.6	2.4	1.3	1.3	21.7	1.1	139.4
2002	1.8	7.3	67.9	90.2	104.9	126.2	61.6	30.7	10.5	3.6	1.8	1.5	42.1	1.2	344.3
2003	1.9	8.2	62.9	71.9	59.1	70.4	114.0	98.5	19.6	6.4	4.0	2.5	43.2	1.6	314.2
2004	2.1	4.6	46.8	60.9	132.8	112.7	48.9	18.7	6.6	3.0	1.8	1.6	36.4	1.4	531.0
2005	4.6	8.1	50.2	170.3	165.2	304.6	146.3	140.2	36.1	14.7	4.6	3.1	87.1	0.9	1,994.5
2006	3.4	4.5	281.1	265.0	203.9	344.3	465.8	137.2	29.4	13.6	6.4	4.6	146.4	3.0	4,651.9
2007	6.4	9.1	28.9	26.5	105.1	87.9	41.7	21.9	7.6	3.4	2.0	2.0	28.1	1.6	363.5
2008	3.2	3.5	8.3	47.3	69.3	61.1	35.8	21.4	6.7	2.2	1.1	0.9	21.6	0.8	174.5
2009	2.4	5.3	9.3	27.0	109.4	192.6	63.3	75.5	11.9	4.2	2.0	1.6	41.7	1.2	1,055.8
2010	4.0	3.8	16.0	64.7	104.5	124.2	119.9	103.5	46.5	12.4	4.1	3.0	50.2	1.6	476.3
2011	6.2	21.8	344.4	127.8	154.0	557.4	204.5	100.1	50.6	35.8	13.5	5.2	135.7	2.0	1,721.4
Average	3.5	30.8	84.1	134.2	205.7	199.1	98.2	56.5	17.2	8.2	3.7	2.4	69.6	0.1	6,244.2
10% Exc.	6.6	28.8	175.3	273.7	358.1	375.8	212.1	134.1	42.6	20.4	6.4	5.2	163.8	--	--
20% Exc.	5.0	10.6	87.4	150.1	273.3	264.0	142.8	96.6	27.7	10.5	4.4	3.3	87.6	--	--
50% Exc.	2.5	4.6	10.2	58.8	100.9	114.7	64.0	35.2	11.3	4.3	2.2	1.9	10.0	--	--
80% Exc.	1.3	2.8	4.8	7.3	28.8	64.8	35.8	13.8	4.6	1.7	1.0	0.7	2.6	--	--
90% Exc.	0.5	2.0	3.3	4.9	12.3	40.3	17.5	8.3	2.4	0.7	0.3	0.3	1.6	--	--

Deer Creek at Scotts Flat Dam - 2070 WMW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	343	535	520	382	975	2,078	1,068	502	142	38	88	67	6,739
1977	92	129	118	226	280	334	242	434	102	14	8	15	1,994
1978	18	192	3,853	15,729	10,918	15,798	11,088	4,649	1,327	529	134	268	64,502
1979	158	316	472	4,507	8,763	12,944	6,647	5,463	961	407	154	127	40,920
1980	231	629	1,933	26,437	28,017	9,830	3,614	2,318	881	573	183	126	74,772
1981	200	266	694	2,310	3,076	7,809	3,304	1,261	337	95	70	50	19,472
1982	283	12,057	19,544	18,255	27,803	19,883	18,749	5,599	1,194	783	291	426	124,867
1983	679	12,013	21,476	17,210	31,270	42,639	10,097	9,242	2,752	2,091	1,790	423	151,681
1984	342	23,629	26,971	6,225	6,876	6,565	2,872	1,684	546	260	155	119	76,244
1985	449	3,882	3,876	2,045	5,219	6,200	4,773	1,681	465	172	100	182	29,044
1986	170	926	3,579	6,032	54,155	22,406	4,176	1,998	665	298	154	249	94,809
1987	176	161	215	506	1,962	3,469	980	388	120	41	18	16	8,052
1988	44	116	1,000	2,307	987	1,437	736	481	170	36	8	7	7,329
1989	17	1,120	487	1,262	3,000	18,424	4,587	1,567	492	160	69	128	31,312
1990	348	561	367	2,038	2,479	5,355	2,211	1,121	806	192	63	48	15,589
1991	78	147	162	182	297	8,188	4,297	2,517	812	260	91	42	17,073
1992	121	206	267	549	6,507	5,482	2,062	506	149	99	22	16	15,986
1993	73	158	2,753	15,900	14,742	18,904	7,261	3,276	1,524	454	175	95	65,314
1994	101	124	608	470	1,905	2,380	914	658	150	39	13	12	7,374
1995	63	390	3,431	26,242	9,725	43,049	11,388	11,189	2,532	1,743	368	194	110,317
1996	181	205	2,261	7,508	25,389	15,107	6,549	5,559	1,166	580	235	186	64,926
1997	180	1,318	28,744	52,123	9,312	4,122	2,148	1,088	490	248	148	109	100,031
1998	277	673	1,799	15,219	34,790	21,416	11,179	9,000	3,592	2,082	951	374	101,352
1999	355	999	3,585	7,628	30,280	10,934	5,618	3,302	1,027	425	249	163	64,565
2000	156	378	445	5,978	25,409	9,423	3,374	2,204	601	269	130	166	48,534
2001	361	405	608	1,369	3,278	4,614	2,959	1,491	333	150	80	77	15,725
2002	111	434	4,175	5,549	5,828	7,761	3,668	1,888	625	219	113	88	30,458
2003	116	489	3,865	4,420	3,282	4,332	6,786	6,059	1,164	392	249	146	31,301
2004	126	275	2,875	3,745	7,640	6,931	2,908	1,150	394	185	108	95	26,433
2005	284	483	3,088	10,469	9,175	18,730	8,705	8,620	2,149	903	284	186	63,077
2006	207	269	17,282	16,294	11,326	21,169	27,714	8,438	1,750	838	395	271	105,953
2007	391	544	1,779	1,629	5,834	5,404	2,484	1,345	451	207	123	117	20,308
2008	197	205	509	2,911	3,986	3,754	2,131	1,313	402	135	66	51	15,660
2009	145	317	574	1,663	6,074	11,840	3,764	4,641	708	257	125	95	30,203
2010	247	226	982	3,977	5,805	7,637	7,134	6,365	2,770	761	255	181	36,339
2011	379	1,298	21,179	7,856	8,551	34,274	12,171	6,157	3,008	2,204	829	307	98,212
Average	214	1,836	5,169	8,254	11,525	12,239	5,843	3,476	1,021	504	230	145	50,457
Maximum	679	23,629	28,744	52,123	54,155	43,049	27,714	11,189	3,592	2,204	1,790	426	151,681
Minimum	17	116	118	182	280	334	242	388	102	14	8	7	1,994
10% Exc.	370	2,600	20,361	17,732	29,149	21,911	11,284	8,529	2,642	1,323	382	289	103,653
20% Exc.	343	999	3,876	15,729	25,389	18,904	8,705	6,059	1,524	761	255	194	94,809
50% Exc.	181	398	1,866	4,464	6,692	7,999	3,970	2,101	687	260	132	122	33,825
80% Exc.	101	205	487	1,369	3,000	4,332	2,148	1,121	337	135	69	50	15,725
90% Exc.	68	153	317	488	1,446	2,924	1,024	504	149	40	20	16	7,713

Deer Creek at Scotts Flat Dam - 2070 WMW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-153	-82	-50	-89	221	790	21	-93	-27	-9	-21	-16	493
1977	3	5	4	10	42	24	17	31	7	1	0	1	146
1978	2	38	2,223	5,900	5,471	6,788	1,325	-129	-250	86	17	35	21,506
1979	25	55	111	1,949	4,301	5,148	890	-107	-30	64	24	20	12,450
1980	-57	5	691	8,778	12,943	1,609	-502	-746	-445	-22	-28	-19	22,207
1981	26	35	251	872	1,635	3,278	793	179	54	12	9	7	7,151
1982	-22	8,096	9,917	6,239	12,232	5,269	-2,350	-1,115	-481	87	-6	36	37,902
1983	-390	7,906	9,375	4,975	14,186	14,616	-1,321	-2,500	-2,372	403	1,197	-36	46,040
1984	-149	15,169	8,076	-83	1,448	160	-1,063	-958	-362	-103	-62	-47	22,025
1985	77	1,904	2,418	1,150	2,727	2,956	988	270	84	31	18	32	12,655
1986	-2	242	1,847	1,962	21,023	7,838	41	-189	-102	-4	-2	8	32,663
1987	-60	-55	-73	12	458	551	-68	-115	-35	-14	-6	-5	589
1988	-21	-55	164	470	133	321	-177	-203	-71	-17	-4	-3	537
1989	2	491	109	559	1,586	7,476	758	175	66	21	9	17	11,269
1990	-21	122	32	976	1,246	2,285	547	79	-87	16	5	4	5,204
1991	16	29	32	36	83	3,835	1,126	349	61	51	18	8	5,646
1992	-19	0	0	118	2,694	1,941	361	18	5	0	0	0	5,119
1993	6	14	1,439	5,428	6,773	7,323	592	-171	-480	44	16	8	20,991
1994	-41	-50	65	-23	426	577	-86	-248	-54	-16	-5	-5	540
1995	2	27	1,841	9,391	4,634	19,120	402	-1,471	-1,487	466	11	6	32,942
1996	5	6	1,120	2,498	13,336	5,215	62	-738	-374	38	7	5	21,180
1997	-29	274	13,231	14,496	3,209	1,074	54	-177	-110	-40	-24	-18	31,939
1998	19	143	836	5,393	17,636	8,736	844	-854	-2,121	638	464	25	31,759
1999	-3	198	1,905	1,970	15,475	3,073	-175	-622	-335	-5	-2	-1	21,478
2000	-23	-37	6	1,410	11,953	1,801	-366	-649	-194	-40	-19	-25	13,818
2001	-1	27	129	583	1,611	2,064	544	53	34	10	5	5	5,063
2002	13	75	2,442	2,591	3,068	3,143	703	167	30	26	13	10	12,283
2003	22	127	2,359	2,561	1,836	2,307	1,451	150	-53	74	47	27	10,907
2004	15	33	1,642	2,064	3,732	2,731	723	150	59	22	13	12	11,197
2005	34	103	1,623	4,449	5,142	8,410	1,494	284	-490	257	53	35	21,394
2006	35	46	9,643	7,004	6,117	7,926	1,340	146	-334	199	67	46	32,235
2007	36	59	935	730	2,684	2,278	609	114	53	19	12	11	7,541
2008	1	1	111	1,132	1,850	1,711	404	4	3	0	0	0	5,217
2009	33	76	247	823	3,436	5,902	1,253	549	130	59	29	22	12,559
2010	64	63	484	2,105	3,418	4,072	2,005	785	-405	250	71	50	12,962
2011	-69	360	11,742	2,655	3,891	14,767	783	-990	-1,854	644	345	15	32,289
Average	-17	985	2,415	2,808	5,352	4,642	390	-238	-332	90	63	7	16,164

Deer Creek at Scotts Flat Dam - 2070 DEW Unimpaired Flow in cfs (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Average	Minimum	Maximum
1976	7.5	10.9	11.0	9.4	11.8	15.2	13.8	10.3	3.5	0.9	2.2	1.7	8.2	0.5	41.2
1977	1.4	2.0	1.8	3.4	3.9	4.9	3.6	6.2	1.5	0.2	0.1	0.2	2.4	0.1	9.8
1978	0.3	2.5	20.4	132.6	93.6	137.2	169.1	85.0	22.7	8.0	2.2	4.5	56.3	0.2	511.9
1979	1.7	3.4	4.6	21.6	58.3	83.8	61.4	69.8	10.6	4.5	1.7	1.5	26.7	1.0	251.2
1980	3.5	6.4	12.6	191.8	350.8	93.1	43.5	35.8	13.9	7.3	2.9	2.1	62.6	1.1	2,027.4
1981	2.8	3.9	6.5	15.4	13.0	56.3	29.0	12.7	4.7	1.3	1.0	0.7	12.3	0.2	256.0
1982	4.3	20.9	254.1	133.8	362.9	183.4	332.5	100.2	20.5	9.1	4.6	6.3	117.6	2.0	2,909.6
1983	9.2	21.6	316.5	135.0	420.5	339.1	168.1	201.4	87.4	16.8	9.6	7.3	142.9	5.0	2,258.4
1984	6.1	33.6	450.6	49.6	63.0	66.4	38.9	28.0	9.3	4.7	2.8	2.2	63.4	2.1	1,923.0
1985	5.7	12.5	15.4	10.0	30.5	33.7	44.4	15.8	5.9	2.2	1.3	2.4	14.8	1.1	307.3
1986	2.5	5.9	17.7	34.0	776.4	169.9	46.6	24.5	9.4	4.5	2.3	3.6	86.6	1.6	3,849.4
1987	4.8	4.5	5.9	8.8	25.2	40.0	14.6	9.5	3.2	1.1	0.5	0.5	9.8	0.3	174.7
1988	1.4	3.9	14.5	22.3	13.6	15.7	15.6	12.6	5.4	1.2	0.3	0.2	8.9	0.2	59.4
1989	0.2	5.7	5.8	9.1	14.0	143.3	46.2	15.9	6.7	2.2	0.9	1.8	21.1	0.2	414.1
1990	5.1	6.2	6.2	12.8	13.5	37.5	22.1	15.5	14.5	3.2	1.1	0.8	11.5	0.6	86.5
1991	1.0	2.0	2.1	2.4	3.8	52.5	37.2	26.1	10.2	3.4	1.2	0.6	11.9	0.4	239.3
1992	1.8	3.4	4.3	6.4	55.6	39.6	19.8	7.2	2.4	1.6	0.4	0.3	11.7	0.3	270.2
1993	1.2	2.7	17.2	132.2	156.2	177.1	104.2	55.4	33.4	7.4	2.9	1.6	57.1	0.3	562.7
1994	3.2	4.0	10.6	9.9	20.7	22.5	15.4	15.5	4.8	1.2	0.4	0.4	9.0	0.3	78.9
1995	1.1	6.1	19.6	217.7	82.4	326.5	184.9	267.6	76.7	15.8	6.4	3.5	101.2	0.3	1,320.1
1996	2.7	3.2	13.0	51.1	271.3	124.5	84.3	105.3	19.1	8.1	3.5	2.9	56.6	2.4	1,310.1
1997	3.0	7.3	459.0	438.5	82.5	27.7	21.5	12.8	7.9	4.1	2.4	1.9	90.0	1.7	3,748.7
1998	4.0	6.3	11.6	111.7	400.5	148.5	146.6	163.8	97.2	14.9	7.7	5.6	91.0	1.9	2,138.8
1999	5.4	8.2	17.2	61.7	356.7	97.9	71.4	54.0	15.8	6.4	3.8	2.6	56.3	2.3	2,048.4
2000	2.1	4.5	4.9	37.0	241.6	71.9	32.3	27.5	7.4	3.6	1.7	2.3	35.6	1.5	1,337.3
2001	5.7	7.0	8.2	10.5	20.8	27.6	31.5	19.1	5.5	2.5	1.3	1.3	11.7	1.1	68.4
2002	1.9	6.1	22.3	31.6	39.5	64.1	40.3	23.5	9.9	3.6	1.9	1.5	20.4	1.2	216.0
2003	1.5	4.8	16.2	15.8	11.1	19.3	69.9	89.6	15.3	5.0	3.1	1.9	21.2	1.3	224.4
2004	1.6	3.6	12.6	14.0	47.1	42.8	22.8	11.1	5.0	2.3	1.4	1.2	13.7	1.1	314.6
2005	4.0	6.8	28.1	71.8	63.0	150.7	115.4	161.6	47.7	10.4	4.3	2.9	55.6	0.8	514.9
2006	2.8	3.7	149.7	99.4	76.9	182.7	446.7	143.2	30.2	9.4	5.3	3.7	96.0	2.4	2,944.7
2007	5.5	7.3	10.1	10.3	42.6	31.3	21.0	14.0	6.3	2.9	1.7	1.7	12.7	1.4	208.3
2008	3.8	4.0	7.1	20.5	27.5	20.7	24.6	17.9	7.6	2.6	1.3	1.0	11.5	0.9	101.4
2009	1.9	4.1	5.1	9.8	38.0	75.6	29.9	62.6	9.0	3.3	1.6	1.3	20.1	0.9	399.5
2010	2.4	2.3	6.1	15.2	23.1	34.3	57.4	75.1	44.3	6.6	2.5	1.9	22.6	1.0	215.3
2011	5.0	9.2	263.1	48.2	68.0	256.3	176.8	115.4	88.5	17.2	8.1	4.9	88.8	1.9	1,982.3
Average	3.3	7.0	62.0	61.3	121.7	94.8	77.9	58.7	21.2	5.6	2.7	2.2	42.8	0.1	3,849.4
10% Exc.	6.3	10.9	56.0	142.0	216.5	248.1	168.2	144.3	68.2	11.6	6.0	4.9	98.2	--	--
20% Exc.	5.2	8.6	23.2	56.7	125.9	144.3	118.0	97.1	27.6	9.2	4.1	3.3	40.9	--	--
50% Exc.	2.4	4.4	9.2	15.3	27.6	50.9	36.9	25.2	9.4	3.9	1.9	1.8	9.0	--	--
80% Exc.	1.2	2.8	4.8	8.1	10.4	23.1	20.7	11.6	4.7	1.8	1.0	0.7	2.4	--	--
90% Exc.	0.5	2.0	3.2	5.4	9.2	14.3	14.3	9.5	3.1	1.1	0.4	0.3	1.4	--	--

Deer Creek at Scotts Flat Dam - 2070 DEW Unimpaired Volume in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	463	646	673	581	681	935	822	634	209	58	135	103	5,941
1977	85	119	109	206	218	299	216	379	91	13	7	14	1,758
1978	18	151	1,257	8,151	5,200	8,434	10,063	5,227	1,349	494	134	269	40,748
1979	107	200	285	1,326	3,239	5,153	3,652	4,291	630	277	105	87	19,353
1980	214	380	775	11,793	20,181	5,725	2,591	2,203	825	451	179	123	45,442
1981	172	230	400	948	720	3,460	1,726	781	281	82	60	43	8,903
1982	263	1,245	15,624	8,225	20,153	11,277	19,786	6,160	1,220	563	281	376	85,173
1983	567	1,287	19,458	8,302	23,355	20,849	10,003	12,384	5,203	1,033	592	431	103,463
1984	378	2,000	27,704	3,052	3,624	4,083	2,313	1,721	554	292	174	133	46,026
1985	350	741	948	616	1,696	2,071	2,644	971	352	135	79	143	10,746
1986	156	351	1,085	2,092	43,117	10,447	2,772	1,508	560	274	142	215	62,719
1987	294	270	360	540	1,398	2,460	871	587	193	69	30	27	7,098
1988	87	229	892	1,372	783	967	931	775	324	71	16	13	6,460
1989	14	342	355	561	779	8,811	2,749	975	401	135	58	108	15,287
1990	315	366	379	787	749	2,303	1,313	956	860	199	65	49	8,341
1991	62	118	130	146	209	3,228	2,211	1,606	606	209	72	33	8,633
1992	109	205	267	394	3,196	2,432	1,178	443	143	99	22	16	8,505
1993	74	162	1,058	8,127	8,675	10,892	6,202	3,404	1,990	457	179	97	41,319
1994	197	237	649	611	1,147	1,382	914	953	283	77	25	24	6,500
1995	67	364	1,207	13,386	4,574	20,075	11,001	16,455	4,564	970	392	207	73,263
1996	167	189	802	3,144	15,605	7,655	5,018	6,473	1,139	496	217	172	41,079
1997	182	437	28,226	26,963	4,580	1,705	1,279	789	469	251	150	111	65,144
1998	245	376	714	6,870	22,242	9,128	8,726	10,070	5,785	917	471	330	65,873
1999	330	488	1,060	3,794	19,811	6,021	4,248	3,320	937	395	232	152	40,787
2000	128	266	301	2,278	13,898	4,420	1,920	1,693	441	220	106	136	25,808
2001	353	415	503	646	1,156	1,697	1,877	1,172	329	154	82	79	8,463
2002	114	363	1,372	1,941	2,195	3,941	2,397	1,443	590	223	116	90	14,786
2003	90	283	993	970	616	1,188	4,162	5,510	908	305	194	114	15,334
2004	98	215	777	859	2,707	2,630	1,356	681	297	144	84	74	9,923
2005	249	403	1,727	4,418	3,501	9,264	6,866	9,935	2,838	638	264	173	40,276
2006	170	220	9,205	6,110	4,272	11,234	26,583	8,807	1,798	577	324	222	69,524
2007	336	437	618	632	2,365	1,922	1,251	859	375	177	105	100	9,178
2008	231	241	436	1,261	1,583	1,270	1,464	1,103	454	158	77	59	8,338
2009	116	242	313	605	2,108	4,648	1,777	3,851	533	206	100	76	14,575
2010	149	139	376	935	1,283	2,110	3,417	4,619	2,637	406	157	111	16,338
2011	305	546	16,179	2,966	3,779	15,761	10,519	7,099	5,268	1,060	498	294	64,273
Average	202	414	3,812	3,767	6,817	5,830	4,634	3,607	1,262	341	165	133	30,983
Maximum	567	2,000	28,226	26,963	43,117	20,849	26,583	16,455	5,785	1,060	592	431	103,463
Minimum	14	118	109	146	209	299	216	379	91	13	7	13	1,758
10% Exc.	352	694	15,902	8,264	20,167	11,255	10,291	9,371	3,701	777	358	282	67,699
20% Exc.	315	437	1,372	6,870	13,898	9,264	6,866	6,160	1,798	496	232	207	62,719
50% Exc.	171	312	776	1,349	2,952	4,012	2,494	1,650	575	237	125	109	15,836
80% Exc.	90	205	360	611	783	1,705	1,279	789	324	135	65	49	8,463
90% Exc.	71	157	293	551	701	1,229	922	657	245	74	27	25	6,799

Deer Creek at Scotts Flat Dam - 2070 DEW Change in Volume Relative to Historical in ac-ft (Water Years begin October 1st of previous year)

Water Year	October	November	December	January	February	March	April	May	June	July	August	September	Total
1976	-34	30	104	109	-73	-353	-224	39	40	11	26	20	-305
1977	-3	-5	-4	-10	-20	-11	-8	-24	-3	-1	0	-1	-90
1978	2	-3	-372	-1,678	-246	-576	299	449	-228	51	18	36	-2,249
1979	-26	-60	-76	-1,232	-1,223	-2,643	-2,105	-1,278	-362	-66	-25	-21	-9,118
1980	-73	-244	-467	-5,866	5,107	-2,497	-1,525	-860	-501	-144	-32	-22	-7,123
1981	-1	-1	-44	-490	-721	-1,071	-785	-301	-2	0	0	0	-3,418
1982	-42	-2,716	5,998	-3,791	4,581	-3,338	-1,312	-555	-455	-133	-16	-14	-1,793
1983	-502	-2,820	7,357	-3,933	6,271	-7,174	-1,415	642	79	-655	-1	-27	-2,178
1984	-114	-6,460	8,808	-3,256	-1,804	-2,323	-1,623	-921	-354	-72	-43	-33	-8,192
1985	-22	-1,237	-510	-280	-796	-1,173	-1,142	-440	-28	-6	-3	-6	-5,643
1986	-16	-333	-646	-1,978	9,986	-4,121	-1,363	-679	-208	-28	-15	-26	573
1987	58	53	71	46	-106	-458	-177	83	38	14	6	5	-365
1988	22	58	56	-465	-71	-149	18	91	82	18	4	3	-332
1989	-1	-288	-22	-141	-635	-2,137	-1,080	-416	-25	-5	-2	-4	-4,756
1990	-55	-73	44	-275	-485	-767	-351	-86	-32	23	7	6	-2,044
1991	0	0	0	0	-4	-1,125	-960	-562	-145	0	0	0	-2,795
1992	-31	-1	-1	-36	-616	-1,109	-522	-45	0	0	0	0	-2,362
1993	8	18	-256	-2,345	706	-688	-467	-43	-15	47	20	11	-3,004
1994	55	63	105	118	-332	-421	-86	48	79	21	7	7	-334
1995	6	1	-383	-3,465	-518	-3,854	15	3,796	545	-307	35	18	-4,111
1996	-9	-10	-339	-1,866	3,552	-2,237	-1,469	176	-400	-46	-11	-9	-2,667
1997	-27	-607	12,713	-10,664	-1,523	-1,343	-815	-476	-131	-37	-22	-16	-2,948
1998	-14	-153	-249	-2,956	5,088	-3,551	-1,609	215	71	-528	-16	-19	-3,720
1999	-27	-314	-620	-1,863	5,006	-1,841	-1,545	-604	-425	-35	-19	-13	-2,300
2000	-52	-150	-138	-2,290	442	-3,201	-1,820	-1,159	-354	-89	-43	-55	-8,908
2001	-9	37	24	-141	-510	-854	-539	-267	30	14	7	7	-2,200
2002	16	4	-361	-1,017	-564	-676	-568	-278	-4	31	16	12	-3,389
2003	-4	-79	-513	-889	-831	-837	-1,174	-398	-309	-13	-8	-5	-5,060
2004	-13	-27	-455	-822	-1,200	-1,570	-829	-320	-38	-18	-11	-9	-5,313
2005	-1	22	261	-1,601	-531	-1,056	-344	1,598	199	-8	32	21	-1,407
2006	-2	-3	1,566	-3,180	-937	-2,010	209	516	-286	-62	-4	-3	-4,194
2007	-19	-48	-226	-268	-785	-1,204	-624	-371	-23	-10	-6	-6	-3,590
2008	35	36	39	-518	-554	-773	-263	-206	55	24	11	9	-2,106
2009	5	1	-14	-235	-530	-1,290	-734	-241	-46	8	4	3	-3,068
2010	-35	-24	-122	-936	-1,104	-1,456	-1,712	-962	-537	-105	-27	-19	-7,039
2011	-143	-392	6,742	-2,235	-881	-3,746	-869	-48	406	-500	13	3	-1,650
Average	-30	-437	1,057	-1,679	643	-1,768	-820	-108	-91	-72	-3	-4	-3,311

Appendix E. Unimpaired Hydrology Raw Data – Historical Gage Proration, 2070 Median, 2070 DEW, 2070 WMW

Appendix F. Reservoir Operations Model

Water Demand Projection Model Update – Final Report

Nevada Irrigation District (NID)

November 12, 2020

Date: 11/12/2020

Sergio Jimenez, P.E.
HDR Engineering, Inc.
Civil Engineer, C55698
Expiration Date: December 31, 2020

Contents

Figures

Tables

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1 Introduction

The Water Demand Projection Model (DM) is revised and updated for Nevada Irrigation District (NID). The DM will provide an assessment of NID's historic and future water demands to help NID identify future water management strategies.

The DM provides the analysis of the existing and historical demands and future demand projections for NID. The development of this DM is based on update and revision of the water demand model developed in the Raw Water Master Plan (RWMP) Phase 1 (Kleinschmidt et al. 2005) and Phase 2 (Kleinschmidt Associates 2011) by Kleinschmidt Associates, recent data from the District to reflect current conditions, and meetings held with NID staff to determine the basis of demand projections. The outline for the Demand Model TM includes the following:

- Project Goals and Objectives
- NID Setting and Area Description
- Overview of previous Water Models
- Water Model Update
- Model Results

2 Project Goals and Objectives

The demand analysis includes preparing projections for current and future water use within the service areas for NID. The companion supply projections encompass a 50-year planning horizon[1], however, the demand projections extend to 2060. This is to be consistent with U.S Census Bureau and California Department of Finance population (DOF) projections. To address uncertainties in projection assumptions, multiple demand scenarios are provided which capture the expected range and provide sensitivity comparison for the various assumptions in each scenario. Demand assumptions, such as climate change impacts, are based on best available data and estimates from several sources.

3 NID Setting and Area Description

This section describes the local setting, climate, land use, and growth trends within NID's raw water service areas.

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[1] There is not a strict rule on planning horizons, although Integrated Regional Water Management Plans and Urban Water Management need "at least" 20 years. The Sustainable Groundwater Management Act (SGMA) stipulates that the planning and implementation horizon is a **50-year time period** over which (groundwater sustainability) plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield. Other related plans have followed suit, such as the 2018 California Water Plan Update.

3.1 Regional Setting

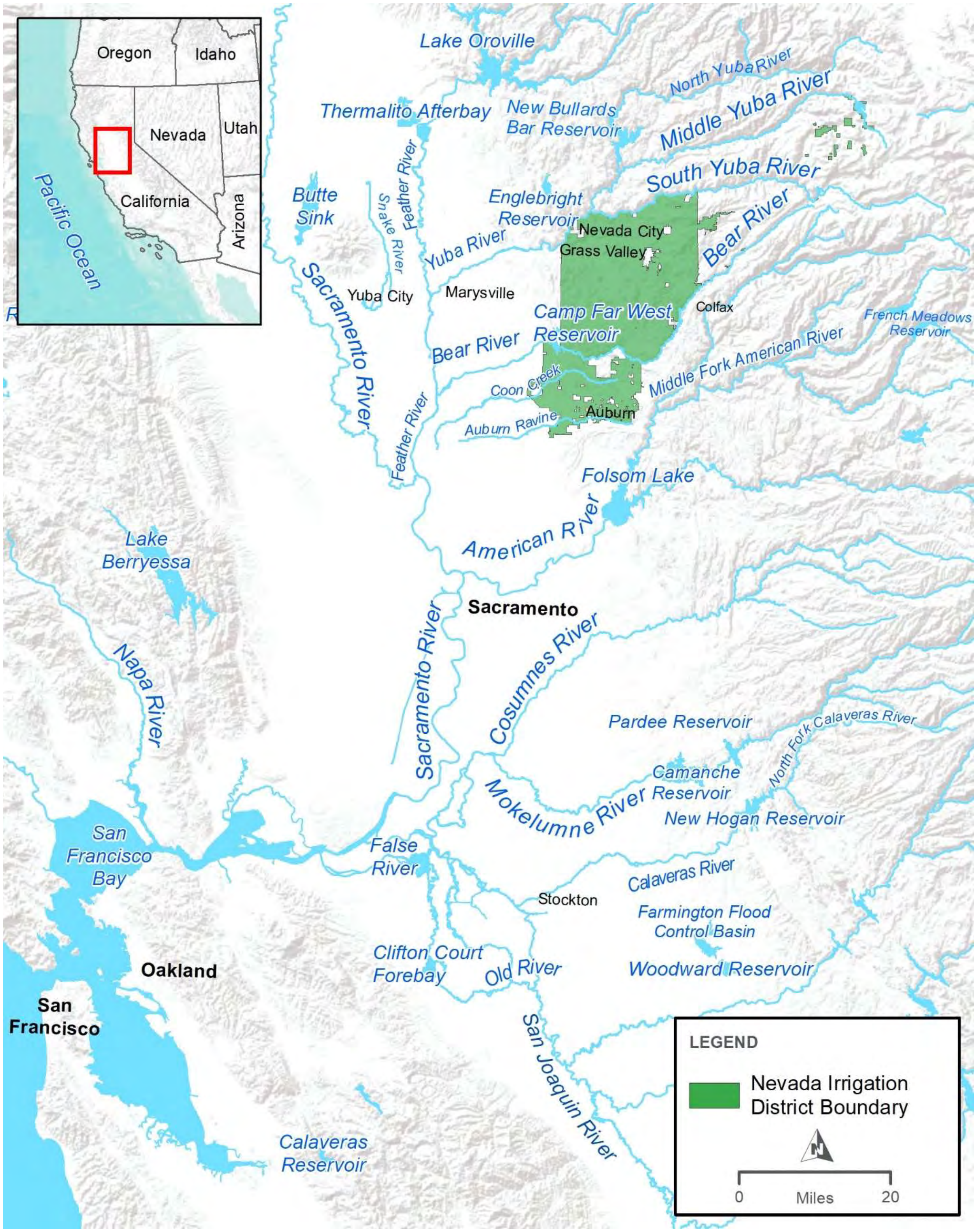
NID is an independent public agency that is governed by a five-member elected Board of Directors and employs approximately 190 full- and part-time employees. Its mission includes providing a dependable, safe, sustainable and resilient water supply while being good stewards of the watersheds

NID was established in 1921 under the California Irrigation District Act of 1897. The District operates as a nonprofit water agency under Division 11 of the State Water Code. The District services approximately 287,000 acres in Placer, Nevada, and Yuba counties in Northern California, supplying both treated and raw water for irrigation, municipal, domestic, and institutional purposes. While seasonally dependent, in recent years, NID has an average combined annual total demand (treated and raw) of approximately 165,000 acre-feet of water.

The District supplies water to nearly 25,000 homes, farms, and businesses in portions of Nevada, Placer and Yuba counties in the foothills of Northern California's Sierra Nevada. Water is collected from mountain watersheds and stored in a system of reservoirs. As water flows to its customers in the foothills, it is used to generate hydroelectric energy in excess of 354 gigawatt-hours per year, to maintain environmental flows, and to provide public recreation opportunities. NID supplies treated drinking water, crop irrigation water and environmental water. Approximately 80 percent of NID's annual demand is made up of raw water/agricultural demand during the irrigation season.

A location map is provided in Figure 3-1.

Figure 3-1. Nevada Irrigation District Location Map



3.2 Climate

Summers in the study area are generally dry with mild to hot temperatures. Winters are relatively wet, especially in the upper elevations around Nevada City and Grass Valley, with snow levels usually above 5,000 ft. Based on historical data obtained from the Western Region Climate Center (WRCC), the District's service area's average and minimum and maximum temperatures are 26 and 93 degrees Fahrenheit, respectively. Table 3-1 illustrates monthly average high and low temperatures and precipitation at key locations and Figure 3-2 shows the monthly average high and low temperatures and precipitation in Nevada City

Table 3-1. Historical Average Climate Characteristics

	Nevada City			Grass Valley		
Month	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**
January	51	30	10.22	54	32	9.69
February	53	32	9.29	55	34	8.58
March	57	34	8.20	58	36	8.32
April	63	37	4.34	62	39	4.02
May	71	43	2.21	71	45	1.97
June	80	48	0.65	80	51	0.68
July	88	53	0.05	87	56	0.12
August	87	51	0.14	87	55	0.21
September	82	47	0.76	82	51	0.79
October	71	41	2.86	72	43	2.70
November	59	35	6.22	60	36	6.73
December	51	31	9.37	53	32	9.46

WRCC # 046136
Period of record: 02/01/1893 to 06/10/2016

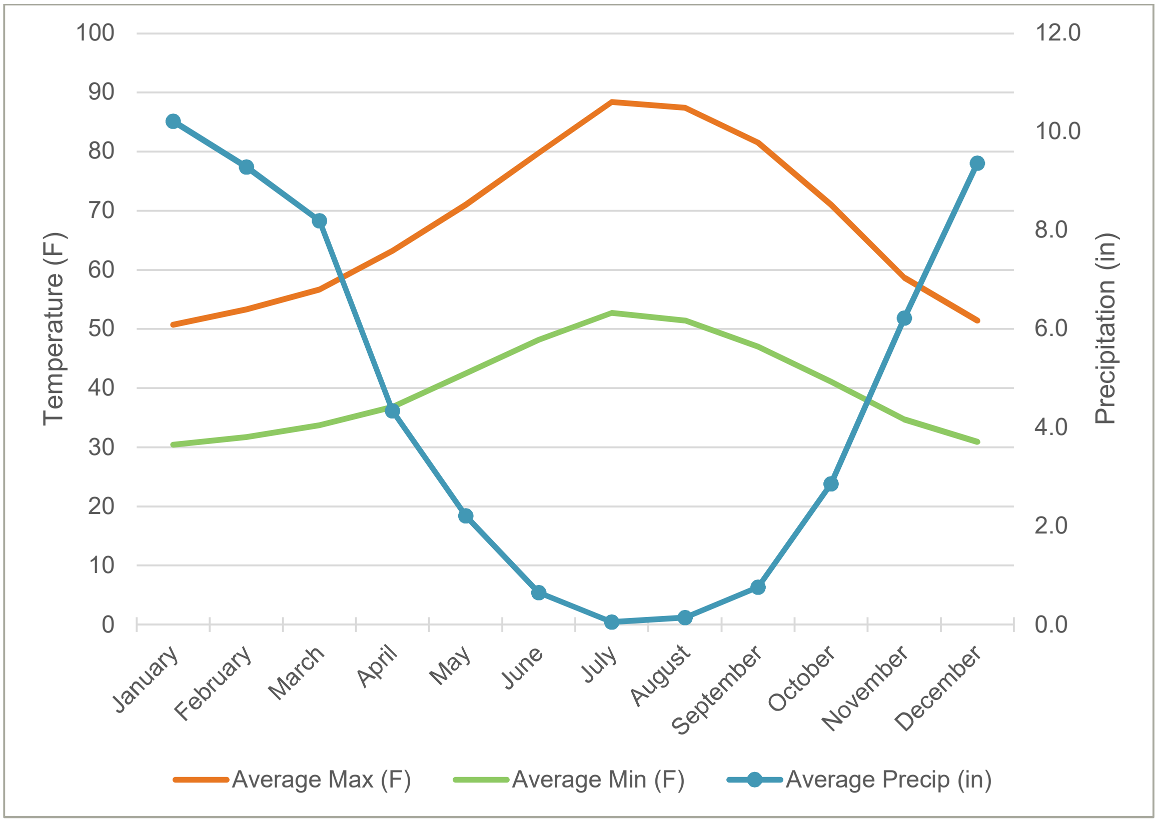
WRCC # 043573
Period of record: 10/01/1996 to 06/10/2016

	Auburn			Bowman Dam		
Month	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**
January	54	37	6.71	45	26	11.74
February	58	39	5.96	46	27	10.06
March	62	41	5.35	50	29	9.09
April	68	45	2.70	55	33	4.56
May	76	50	1.26	64	39	3.49
June	85	57	0.38	72	47	1.24
July	93	62	0.05	80	53	0.20
August	92	61	0.07	80	53	0.40
September	86	57	0.42	74	48	0.90
October	77	51	1.78	64	41	4.14
November	63	43	4.01	53	33	8.14
December	55	37	5.71	46	28	10.83

WRCC # 040383
Period of record: 01/01/1905 to 06/10/2016

WRCC # 041018
Period of record: 06/01/1896 to 05/31/2016

Figure 3-2. Historical Monthly Average Temperature and Precipitation in Nevada City



3.3 Land Use

Land use considerations and guidance are at the core of any comprehensive water management plan. Effective land use planning contributes to many aspects of a community's ultimate success and livability, including the integrity and appeal of its neighborhoods; the proximity of schools and recreation opportunities; the appropriate location and design of commercial development for convenience and compatibility with residential areas; and the provision of adequate acreage and protections for areas meant to accommodate the community's key economic drivers. Efficient provision and extension of municipal services also depends upon a sound strategy for future use of land in both fringe areas and previously developed areas that offer redevelopment and infill opportunities.

Current land uses within the service area are primarily agricultural and residential with a mix of light industrial and commercial. Future land use is dictated by the General Plans of the Counties. Land use information for the service area was based on the existing General plan land use categories. This was an important component to classify District's billing data based on type of use for carrying out the historical analysis (Section 5).

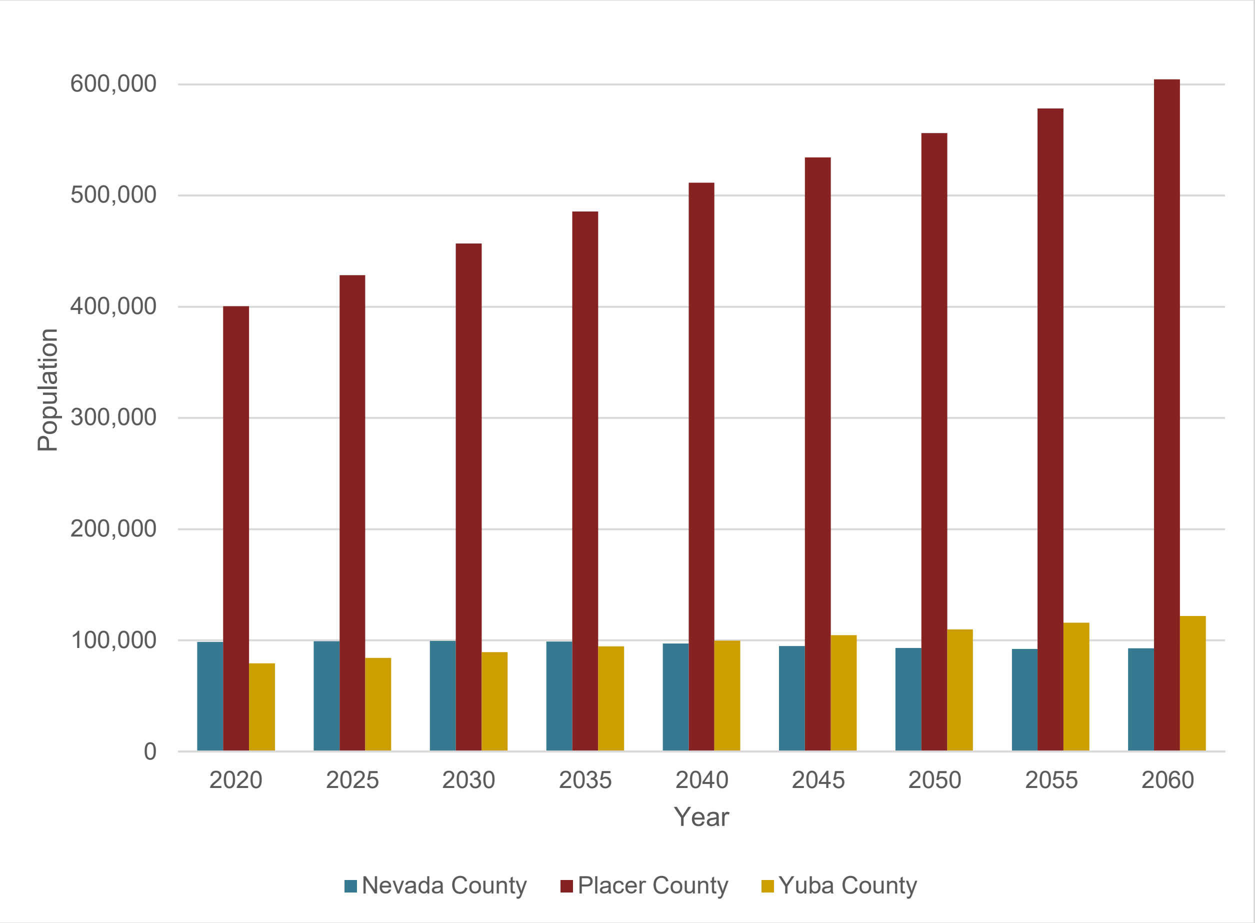
3.4 Population and Growth Trends

Growth patterns and trends are an important component of the long-range planning process. They help determine and quantify the demands that will be placed on services based on the spatial spread of additional people and potential pace and scale of the community's physical growth. Growth trends reflect local and regional trends and offer a basis to prepare for the future.

Figure 3-3 shows population projections for Nevada, Placer and Yuba Counties at five year intervals through 2060. There is a consistent projected growth trend for both Placer and Yuba Counties (5% average annual increase) while the population in Nevada County is projected to decrease slightly after 2030.

It should be noted that preparing demand projections is based on overall growth and is challenging, particularly for the long term, because it is often difficult to account for all circumstances that may arise. It is therefore important for NID to monitor population and economic growth continually to account for both short- and longer-term shifts that can influence development activity and trends in NID. The demand model described in Section 5 includes the ability to adjust the growth rate to evaluate the impacts of growth on water demand.

Figure 3-3. Population Projections to 2060



Source: California Department of Finance, State Population Projections (2010-2060)

4 Overview of Previous Water Demand Projection Models

4.1 Water Demand Projection Model developed in 2005 (Phase 1 Raw Water Master Plan)

Kleinschmidt Associates developed NID’s first water demand projection model in 2005 based on data through 2002. This Phase 1 model consisted of the technical analyses to evaluate expected future demand in a tabular/spreadsheet-based format.

4.2 Water Demand Projection Model Update developed in 2011 (Phase 2 Raw Water Master Plan)

The Phase 2 demand projection model prepared by Kleinschmidt Associates consisted of updating the water demand projection model developed as part of Phase 1. The update included a verification and adjustment of the methods and assumptions used in the Phase 1 model and included five years of additional data from system flows and NID’s customer billing database. The Phase 2 demand model used the same approach in establishing NID demands that was employed in Phase 1, but utilized a database model rather than a spreadsheet model.

The basic concept of the model developed in the Phase 2 evaluation was that demand or canal flow for each canal segment was computed by applying the respective water duty rate (acre-feet/acre) to the anticipated, or future, gross land area receiving water and then adding back in the appropriate canal conveyance losses. This approach was adopted because use of the gross acre parcel approach is based on finite, quantifiable data. The gross acre parcel approach accounts for each acre within the NID service area, regardless of if it is receiving water.

The Phase 2 model compared computed results for each canal segment for 2007 against the gaged 2007 flow data and found the two data sets to match very closely, indicating the resulting model would be a good predictor of future demand. Similar results were found when the model was compared to the 2002 data in the Phase 1 analysis.

5 Water Demand Projection Model Update (2020)

Over the past 8 years, the economic recession combined with a multi-year drought resulted in changes in water demands and usage trends throughout western United States. As the economy has rebounded and extreme drought conditions recede, there is a need to adjust and update the previously developed models to correspond with NID’s current reality, vision and future planning efforts, to reflect a “new normal” in raw water trends, and to account for historical changes in the water usage.

HDR’s current (2020) Water Demand Projection Model approach is based in the following key objectives:

- Consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts;
- Derived an updated analyses using the model previously developed;
- Maximize the use of available data;
- Build upon the District's previous efforts and approach for a land-use based model (as opposed to adopt a new analysis approach).

5.1 Demand Model Approach

Water usage within NID's system consists of several components: raw water demand (both for the irrigation season customers and winter service water customers), treated water demand, environmental flows, system losses, and municipal purchases. The sum of these components equals the total water demand for the NID system. The methodology and analysis described herein was used to develop the Raw Water Model for current and estimated future demands on the NID system.

To create a more accurate accounting of both current and future water demands, a methodology was developed that relies on a parcel-based GIS approach and canal flows provided by the District. The parcel-based approach provides the District with a means to integrate current and future land development into water use projections and more precisely assess use within its service area. Using the parcel-based GIS technique also provides a framework for easily updating the demand analysis to reflect new information, such as demand from proposed new developments or mutual water companies, which can affect NID's overall demand and demands within specific service areas that are supported by specific canals and other infrastructure.

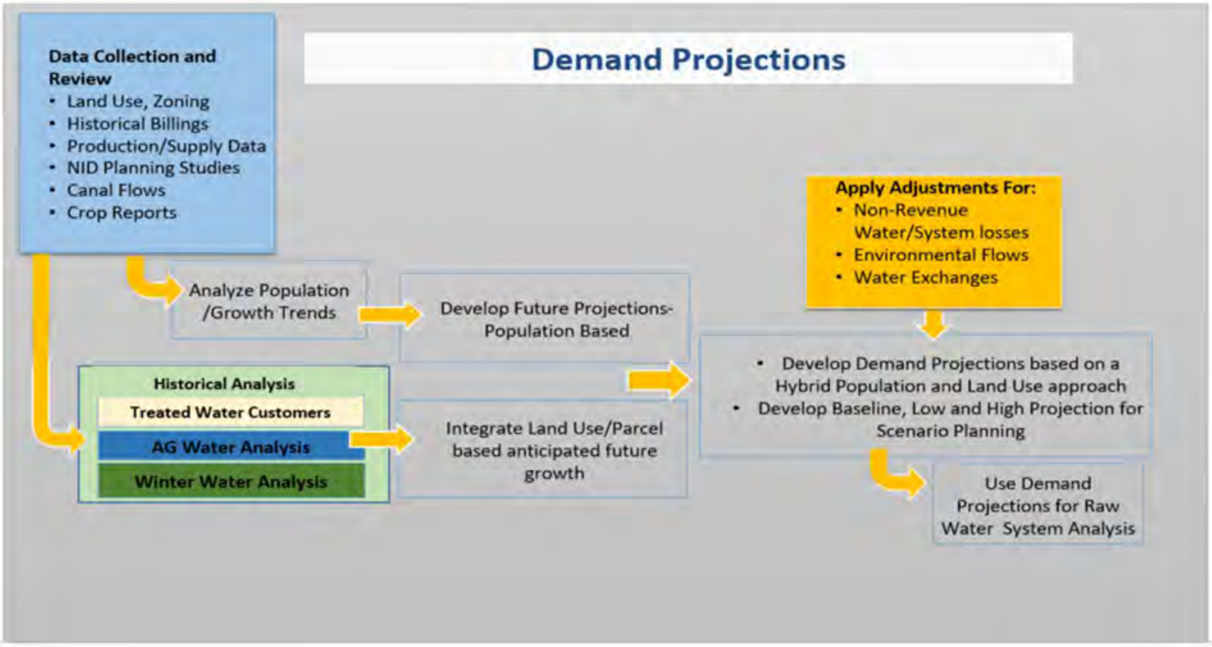
The following sections outline the data updates, sources and assumptions used for the demand analysis, and details the methodology employed with respect to data preparation and water demand forecast modeling. Three specific demands are estimated:

- Irrigation season raw water
- Winter service (non-irrigation season raw water)
- Treated water (year round)

Total future demands are estimated for the NID system from 2018 through 2060 in ten-year increments. Raw water flows vary significantly from year to year in both volume and location. Several factors affect the variability of these flows within a particular canal segment. These include weather conditions, crop rotations, land use changes, condition of canals, etc. As such, the model should be considered a planning tool for conceptual-level long-range planning only.

Figure 5-1 provides an overview of the approach and methodology for NID Raw Water Demand Model.

Figure 5-1. Overview of the Approach and Methodology for NID Demand Model



5.2 Data Sources

Because of the many factors that contribute to or affect the demand for raw water, numerous data sources were reviewed and used in the analysis. The following sections describe data sources used for the analysis.

GIS Parcel Data

County Tax Assessor's Parcel data (2017 and 2018) for Nevada, Placer, and Yuba Counties in GIS format was obtained. The parcel data is the corner stone of the spatial methodology and is the data linkage layer for other data received by the District. Other parcel related data used in the identification of District infrastructure, topography, land use, and other factors potentially affecting existing and future demands are described in the following sections.

Raw Water Customer Data

The NID Raw Water Customer Database is confidential and contains customer information including physical and billing address, service information, and account status. This dataset also included county parcel number, parcel size, and service size, location, and type for each property (parcel) supplied raw water by NID. The billing data was geo-coded using the assessor parcel number (APN) and physical address to provide a spatial location for each of the water customers.

Treated Water Customer Data

NID provided its treated water customer data from 2009-2018 as part of this project. These data were geo-coded to create a GIS data layer to establish a spatial location for each of the customers. These data were also further classified to provide information pertaining to customers receiving water from each of the six water treatment plants servicing the District: Loma Rica, Elizabeth George, Lake of Pines, Lake Wildwood, North Auburn, and Smartville. In addition to the above, Grass Valley and Nevada City (non-NID) treatment plant data was also included.

Agriculture Water Customer Data

NID provided its agriculture water customer sales data from 2009-2018 as part of this project. Similar to the above datasets, these data were geo-coded to create a GIS data layer to establish a spatial location for each of the agriculture customers.

Treatment Plant Data

In addition to the above, historical water treatment plant flow records were also obtained for the six NID operated treatment plants. These records included average and peak production flows for the various treatment plants.

Canal Flow Data

The canal flow data for 2013 through 2018 from NID's gaging network within the Deer Creek and Bear River canal systems was obtained from NID for use in the water demand analysis. In addition, US Geological Survey (USGS) flow data from two gages within the District boundary was used in the analysis:

- Gage # 11418500 – Deer Creek near Smartville
- Gage # 11422500 – Bear River below Rollins Dam

Crop Report Data

Crop Report survey forms are distributed annually to District raw water customers to solicit information regarding the type of crops grown and the total acres irrigated by crop type for each service. NID provided customer crop data compiled annually from raw water customer surveys for the period 2017-2018. Crop report data including service connections in miner's inches and net acres of irrigated crop land by crop type, were employed in this analysis.

Land Use and Zoning Data

General Plan existing land use and future zoning data for Nevada, Placer and Yuba Counties was obtained and used to contrast the changes in the growth patterns for the service area. The growth projections as noted in the respective county general plans were used for these counties.

Population Data

DOF and Regional census data (www.dof.ca.gov/Forecasting/Demographics/) was reviewed for Nevada, Placer, and Yuba Counties. Population changes, changes in housing units, employment data and building permits issued were used as indicators of growth and were used to corroborate the growth projections. These data sets were used to study growth patterns and future trends.

Water Contracts

NID has entered into contract with PG&E and CDFW. Deliveries to SSWD, however, are comprised of surplus water. NID is required, based on an agreement under the Federal Energy Regulatory Commission (FERC) licensing, to provide approximately 27,900 acre-feet for a dry year and 59,800 acre-feet for a wet year as minimum flows for fish and aquatic resources. These minimum flows are not recovered and, therefore, factored into demand estimations.

Mutual Water Companies and Water Associations Data

A growing development trend within the District, which is having an impact on water demand and the water conveyance system, is the development of mutual water companies and water associations. Based on NID data, there are 39 active mutual water companies as of 2019. These mutual water companies have a total demand of approximately 14,668 acre-feet per year or 21.12 cubic-feet per second (cfs). Details regarding these water mutual companies can be found in the sections that follow.

Other Data

Other relevant data provided by NID and used in the development of the Demand Model included:

- Currently irrigated and non-irrigated arable lands within the District’s canals and service areas
- Interviews with District staff
- Other GIS data layers (service area boundaries, canals, parcel data etc.)
- Previous planning effort carried out by the District:
    - Urban Water Management Plan, 2016
    - Agriculture Water Management Plan, 2015
    - Regional studies for population and growth trends
    - District’s water recap reports
    - Previous demand model reports
    - Raw Water Master Plan, 2011

5.3 Demand Model Updates and Model Framework

An integral part of the 2020 Raw Water Demand Model Update consisted of updating the raw water demand model developed as part of Phase 1 and Phase 2 of the 2011 RWMP. This update allowed for a check and adjustment of the assumptions used in the previous studies. HDR used the same approach in estimating District’s demands as was employed in the earlier phases of the model development in 2005 and 2011. NID 2020 Demand Model, framework, model parameters, modifications to the model design and inputs, updated features and modules developed by HDR, model analysis and results are presented in the following sections.

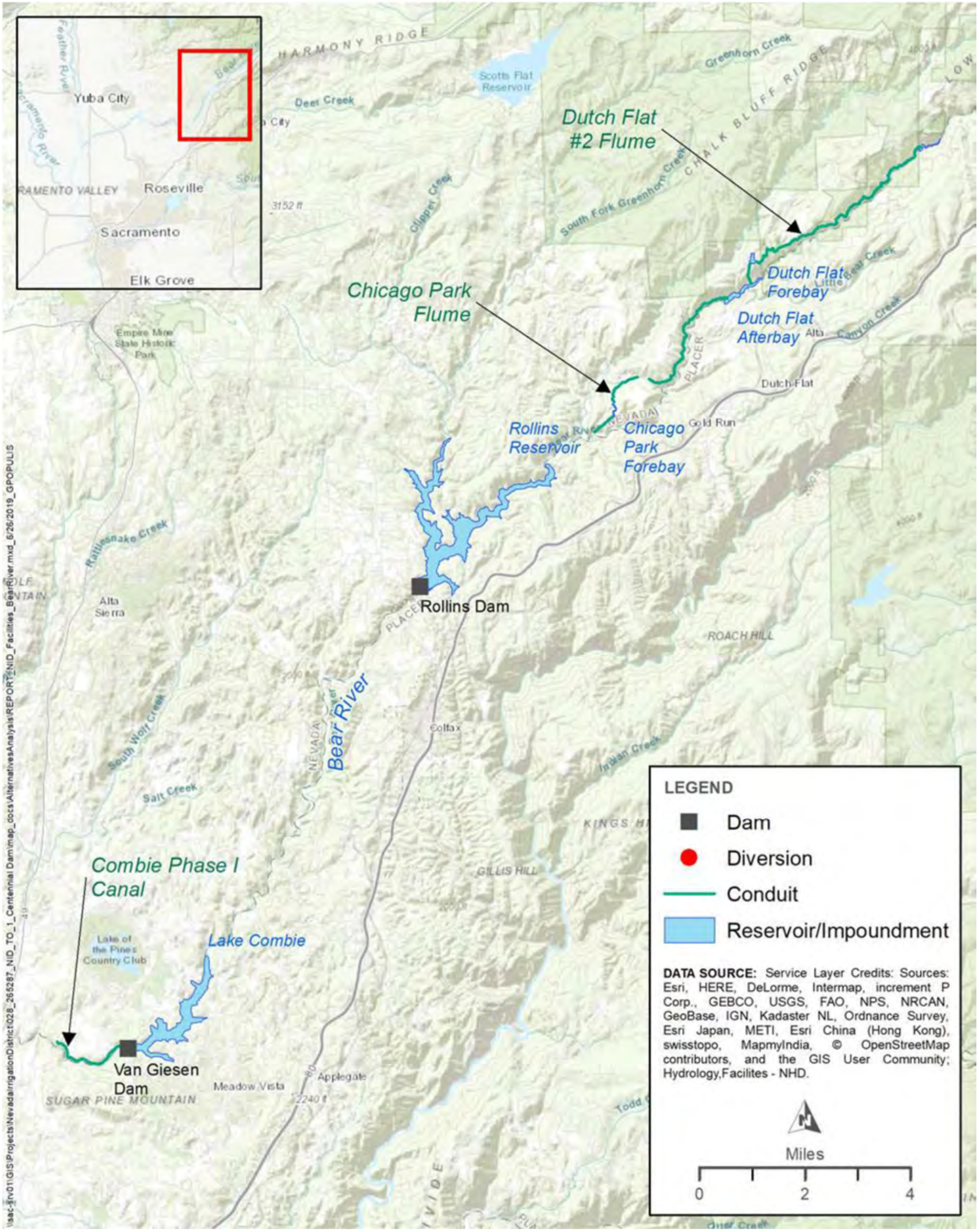
A summary of the model updates is provided below:

- Migration of the previous model to MS Access for better functionality and GIS data integration
- Update of model baseline year to 2018
- Update model parameters based on recent historical growth patterns
- Development of a HDR's Canal Flow Importer module that helps import canal flows from the District's 198 flow gages
- Incorporate updated canal flows from gaging network for Deer Creek and Bear River systems
- Model validation based on baseline year 2018
- Treated water demand analysis
- Customer land use analysis
- Spatial analysis for District's treated, raw water and agriculture analysis
- Treatment facility delineation analysis
- Development and update of Sphere of Influence (SOI) or soft service boundaries
- Incorporation of growth and land use patterns
- Incorporation of new model parameters (conservation potential, system losses and climate change) for users to provide additional flexibility in analysis
- Update of Mutual Water Company components to incorporate current customer flows
- Model interface update to incorporate changes in environmental flows based on new FERC licensing agreement
- Incorporate ability of the model to analyze demand variability.

2020 Demand Model Framework: Systems Modeled

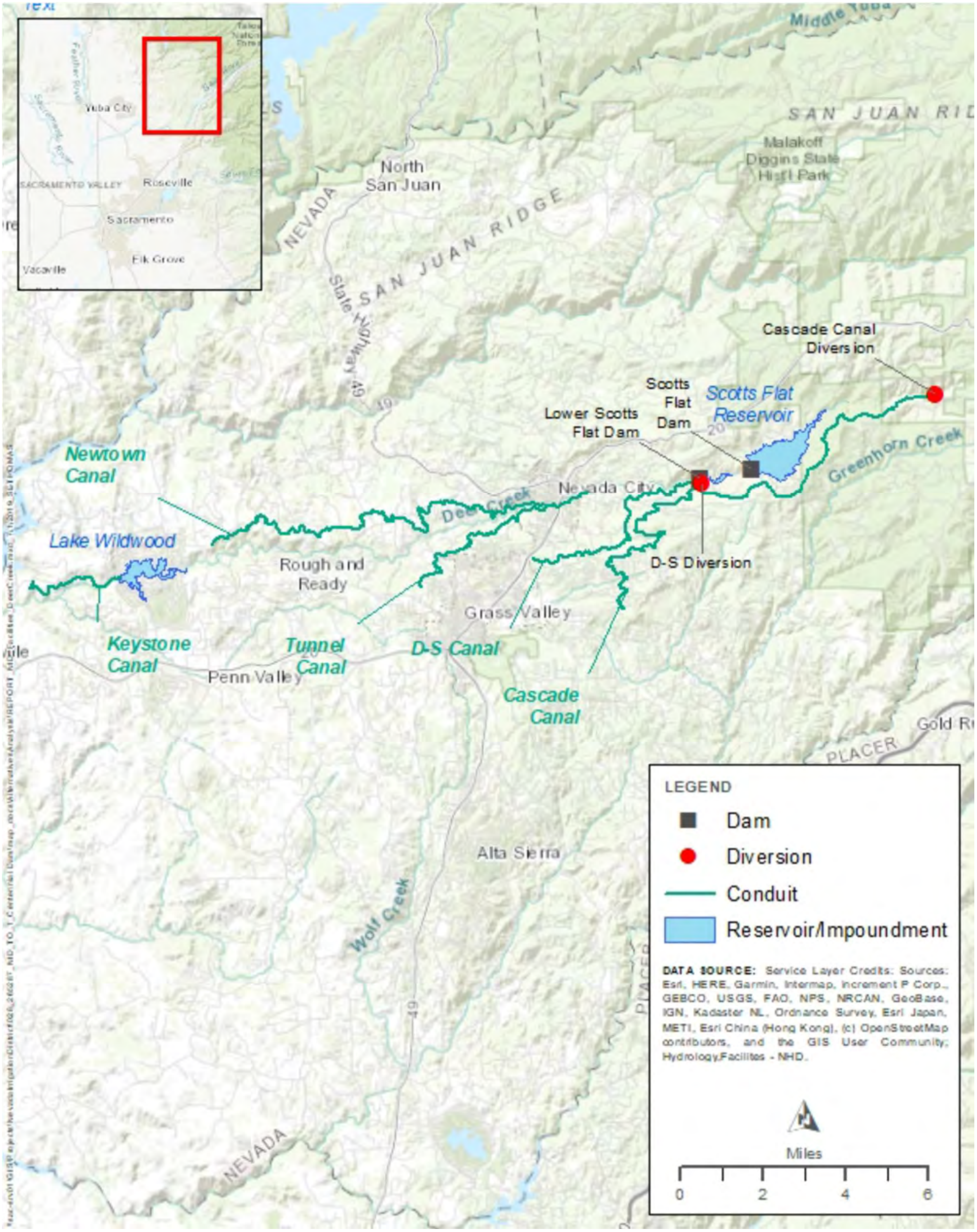
NID operates and maintains a total of nine water supply reservoirs. The District also maintains a delivery network of approximately 475 miles of mostly open canals. There are two major distribution and storage systems within the NID system: Bear River (Figure 5-2) and Deer Creek (Figure 5-3). These systems are comprised of a mixture of canals, siphons, pipelines, and other water conveyance structures, as well as reservoirs and water treatment plants. The conveyance structures, reservoirs, and treatment plants contained within each of these systems are identified in Table 5-1 and Table 5-2 for the Bear River and Deer Creek systems, respectively.

Figure 5-2. Overview of the Bear River System



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Hydrology,Facilites - NHD.

Figure 5-3. Overview of the Deer Creek System



DATA SOURCE: Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community; Hydrology.Facilities - NHD.

Table 5-1. Bear River System Facilities

Combie Reservoir

Combie Phase I Canal

Magnolia III Canal
Magnolia III Reservoir
Magnolia III Canal Extension
Lake of the Pines Treatment Plant

Combie Ophir I Canal
Lone Star Canal
Ruud Canal
Rainey Canals
Oest Canal
Willits Canal

Orr/Coon Creek Natural
Orr Creek Reservoir
Gold Hill I

Camp Far West Canal
Lateral 5 Canal
Lateral 4 Canal
Lateral 2 Canal
Lateral I Canal
Wiswell Gladding Canal
Church Canal
Forbes Canal
Renken Lateral
Bogdanoff Canal
Camp Far West Canal Extension

Combie Ophir III Canal
Columbia East
Columbia West

Combie Ophir II Canal
Pickett Canal
Beck Canal
Pickett Reservoir
Pickett North Canal
Pickett South Canal
North Auburn Treatment Plant
Rock Creek/Gold Hill I Bypass Canal

Combie Ophir IV Canal
Vernon Canal
Rohr-Shanley Pipe
Herkomer Pipe
Dudley Canal
Gold Blossom Canal
St. Patrick's Canal
Little Ophir Canal
Hymas Canal

Gold Hill II Canal
Deadman's Ravine Natural
Whiskey Diggins Canal
Old Whiskey Diggins Canal
Valley View Canal
Files Canal
Valley View Reservoir
Kilaga Springs Canal
Nicklas Canal
Livingston Canal
Reilli Canal
Iron Canyon Canal
Thomas Canal
Stringham Canal

Ophir Canal
Kemper Canal
Kemper East Canal
Kemper West Canal
Bean Cullers Canal

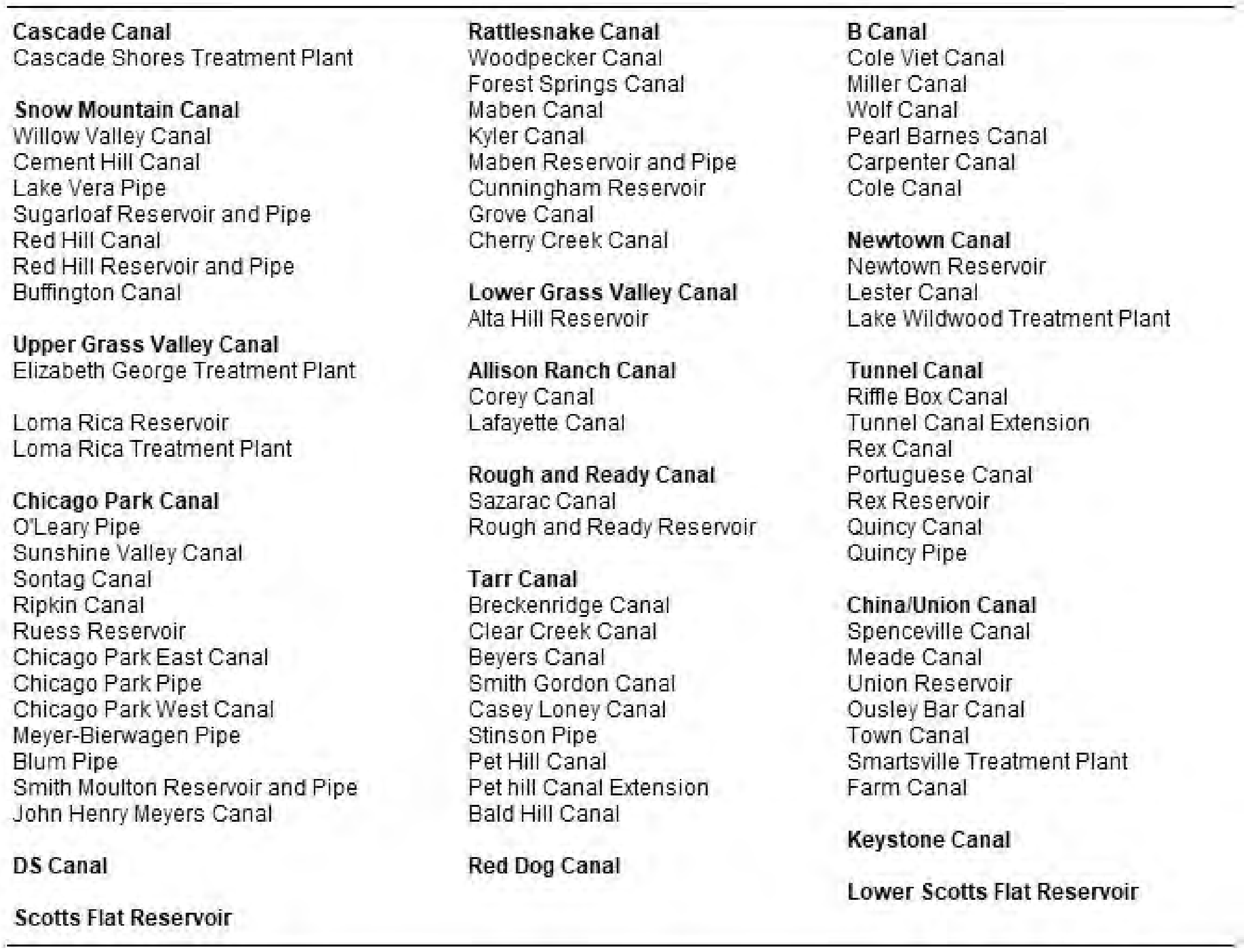
Edgewood Canal
Edgewood Reservoir
Edgewood Canal

Auburn Ravine Canal II
Chevalier Pipe
Auburn Ravine Canal II
Lincoln Canal
Musser Canal
Markell Canal
Fruitvale Canal
Sohier Ahart Canal
Hayt Canal Extension
Doty Canal
Doty South Canal
Doty North Canal
Comstock Gladding Canal
Clark Jorstad

Hemphill Canal

Combie Phase II and III Canal
Magnolia I Canal
Weeks Canal
Magnolia II South Canal
Magnolia II North Canal
Markwell Canal
Woll Hannaman Canal
Sanford Struckman Canal

Table 5-2. Deer Creek System Facilities



Cascade Canal
Cascade Shores Treatment Plant

Snow Mountain Canal
Willow Valley Canal
Cement Hill Canal
Lake Vera Pipe
Sugarloaf Reservoir and Pipe
Red Hill Canal
Red Hill Reservoir and Pipe
Buffington Canal

Upper Grass Valley Canal
Elizabeth George Treatment Plant

Loma Rica Reservoir
Loma Rica Treatment Plant

Chicago Park Canal
O'Leary Pipe
Sunshine Valley Canal
Sontag Canal
Ripkin Canal
Ruess Reservoir
Chicago Park East Canal
Chicago Park Pipe
Chicago Park West Canal
Meyer-Bierwagen Pipe
Blum Pipe
Smith Moulton Reservoir and Pipe
John Henry Meyers Canal

DS Canal

Scotts Flat Reservoir

Rattlesnake Canal
Woodpecker Canal
Forest Springs Canal
Maben Canal
Kyler Canal
Maben Reservoir and Pipe
Cunningham Reservoir
Grove Canal
Cherry Creek Canal

Lower Grass Valley Canal
Alta Hill Reservoir

Allison Ranch Canal
Corey Canal
Lafayette Canal

Rough and Ready Canal
Sazarac Canal
Rough and Ready Reservoir

Tarr Canal
Breckenridge Canal
Clear Creek Canal
Beyers Canal
Smith Gordon Canal
Casey Loney Canal
Stinson Pipe
Pet Hill Canal
Pet hill Canal Extension
Bald Hill Canal

Red Dog Canal

B Canal
Cole Viet Canal
Miller Canal
Wolf Canal
Pearl Barnes Canal
Carpenter Canal
Cole Canal

Newtown Canal
Newtown Reservoir
Lester Canal
Lake Wildwood Treatment Plant

Tunnel Canal
Riffle Box Canal
Tunnel Canal Extension
Rex Canal
Portuguese Canal
Rex Reservoir
Quincy Canal
Quincy Pipe

China/Union Canal
Spenceville Canal
Meade Canal
Union Reservoir
Ousley Bar Canal
Town Canal
Smartsville Treatment Plant
Farm Canal

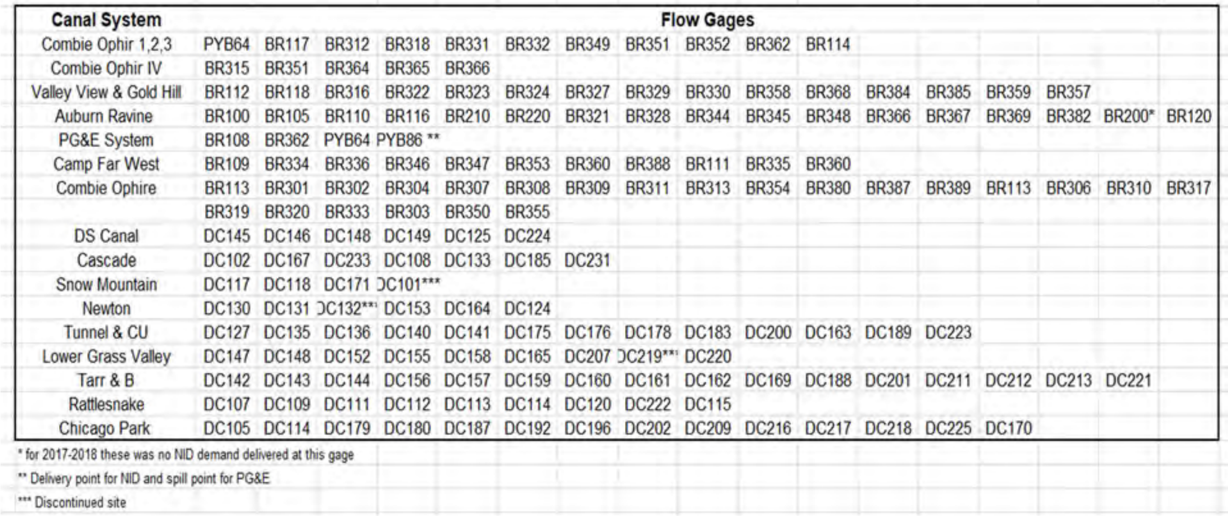
Keystone Canal

Lower Scotts Flat Reservoir

Canal Segments

The model analyzes historical demands and evaluate future demand on a Canal System (sub-system) level. Table 5-3 lists the canal segments/systems that were included in the raw water model update in 2019 along with their associated flow gages.

Table 5-3. Canal System Flow Gages by Sub-system



Canal System	Flow Gages																
Combie Ophir 1,2,3	PYB64	BR117	BR312	BR318	BR331	BR332	BR349	BR351	BR352	BR362	BR114						
Combie Ophir IV	BR315	BR351	BR364	BR365	BR366												
Valley View & Gold Hill	BR112	BR118	BR316	BR322	BR323	BR324	BR327	BR329	BR330	BR358	BR368	BR384	BR385	BR359	BR357		
Auburn Ravine	BR100	BR105	BR110	BR116	BR210	BR220	BR321	BR328	BR344	BR345	BR348	BR366	BR367	BR369	BR382	BR200*	BR120
PG&E System	BR108	BR362	PYB64	PYB86 **													
Camp Far West	BR109	BR334	BR336	BR346	BR347	BR353	BR360	BR388	BR111	BR335	BR360						
Combie Ophire	BR113	BR301	BR302	BR304	BR307	BR308	BR309	BR311	BR313	BR354	BR380	BR387	BR389	BR113	BR306	BR310	BR317
	BR319	BR320	BR333	BR303	BR350	BR355											
DS Canal	DC145	DC146	DC148	DC149	DC125	DC224											
Cascade	DC102	DC167	DC233	DC108	DC133	DC185	DC231										
Snow Mountain	DC117	DC118	DC171	C101***													
Newton	DC130	DC131	C132**	DC153	DC164	DC124											
Tunnel & CU	DC127	DC135	DC136	DC140	DC141	DC175	DC176	DC178	DC183	DC200	DC163	DC189	DC223				
Lower Grass Valley	DC147	DC148	DC152	DC155	DC158	DC165	DC207	C219**	DC220								
Tarr & B	DC142	DC143	DC144	DC156	DC157	DC159	DC160	DC161	DC162	DC169	DC188	DC201	DC211	DC212	DC213	DC221	
Rattlesnake	DC107	DC109	DC111	DC112	DC113	DC114	DC120	DC222	DC115								
Chicago Park	DC105	DC114	DC179	DC180	DC187	DC192	DC196	DC202	DC209	DC216	DC217	DC218	DC225	DC170			

* for 2017-2018 these was no NID demand delivered at this gage

** Delivery point for NID and spill point for PG&E

*** Discontinued site

Data Collection and Review

The data provided by NID were reviewed for applicability, reformatted, spatially referenced (where necessary), and aligned with the County Assessor Parcel database to create a comprehensive GIS database employed in the raw water demand modeling. This approach then allowed for the display of the inter-relationships of spatial data allowing the user to visually interpret the non-geographic data, such as water demand by a particular customer. Another key feature of the GIS methodology was the ability to query the data for specific information. For example, the customer data could be segregated by service area, treatment plant, county or any desired combination. Further, the database could compute a variety of statistical analyses ranging from calculating the area of a specific raw water parcel to calculating the total area for any selected parcels or region.

Raw and treated water customer information, as well as potential treated water service areas, were displayed with respect to the parcel data layer. The result was a spatially referenced GIS database which showed parcels, raw and treated water services, and conveyance (canal) segments, as well as major topographic and infrastructure features which noted where raw and treated water was being delivered within the District. Using the combined databases and resulting mapping, the following was developed and analyzed in the raw water demand analysis:

- Customer land use analysis – Parcel level classification of NID customers based on land use information
- Geo-coding of current customers – Allocation of spatial coordinated to each of its customers
- Facility delineation – Spatial allocation of treatment facilities and classification of customers based on Treatment Facility and service boundary
- Development and update of Sphere of Influence/soft service boundaries

Performing the analyses listed above allows the model to calculate location and gross acreage of customer parcels receiving raw water, and District facility or Canal segment from which the customer/parcel is receiving water. The model also evaluates location and gross acreage of customer parcels receiving treated water. Identification of treatment plant facility from which each parcel was receiving treated water was performed.

Model Structure and Parameters

Canal Service Boundaries

Service area boundaries and associated acreages were updated based on 2018 canal flows and customer data. Canal soft service boundaries, the approximate service area for each canal segment, were developed as a part of the Phase 1 and Phase 2 efforts and updated as part of this analysis. The boundary delineation was based on the parcels most likely to receive water within the period of this analysis, considering topography, distance from canal, and/or other obstacles to development of parcels. The District's 2017-2018 customer data was overlaid on the parcel database in conjunction with respective soft service area boundaries. Using GIS queries, necessary modifications to the soft service area boundaries were delineated. The service area soft boundaries indicate that the Deer Creek System could reasonably serve a collective (raw water and treated water) service area of 99,121 acres.

The canal service area soft boundaries for the Bear River System were updated using the same methodology as the Deer Creek. The results of this update indicated that the Bear River System could reasonably serve a collective (raw water and treated water) service area of 92,143 acres.

In general, soft service area boundaries serve as a guide to the likely limits of service for each canal segment and represent the current best estimate as to which parcels might request water service for each canal segment. If future raw water demands occur or are expected to occur beyond the existing service area soft boundaries, the soft boundaries should be adjusted to accommodate the anticipated service areas.

Canal Flow Data

NID operates an extensive network of flow gages on their canal system. For updating the previous raw water model, canal flow data from the gages provided by NID for 2013-2018 was used. These data are used to evaluate historic demands and trends in water usage. Since the previous model did not allow for the gage data to be imported as a group, HDR developed the Canal Flow Importer module as an extension to the demand model that can help with the import of the canal data automatically.

The Canal Flow Importer uses a spreadsheet in a specific format to update historic flows and assist with model calibration. Specific instructions on using the Canal Flow Importer module are included with the model.

Raw Water Customers

Raw water customers included in the NID customer database are comprised of individuals receiving service directly from the District's canal system, including sub-laterals, customers receiving raw water from private pipelines used by more than one customer, or customers receiving raw water as part of a mutual water company. For the purposes of the demand analysis, it was not considered necessary to distinguish between individual raw water customers and private pipeline customers, as factors affecting demand are expected to impact these two groups equally. Table 5-4 shows the total raw water demand based on updated data, and Table 5-5 shows the raw water demand per customer.

Figure 5-4. Total Raw Water Demand – 2012 through 2017

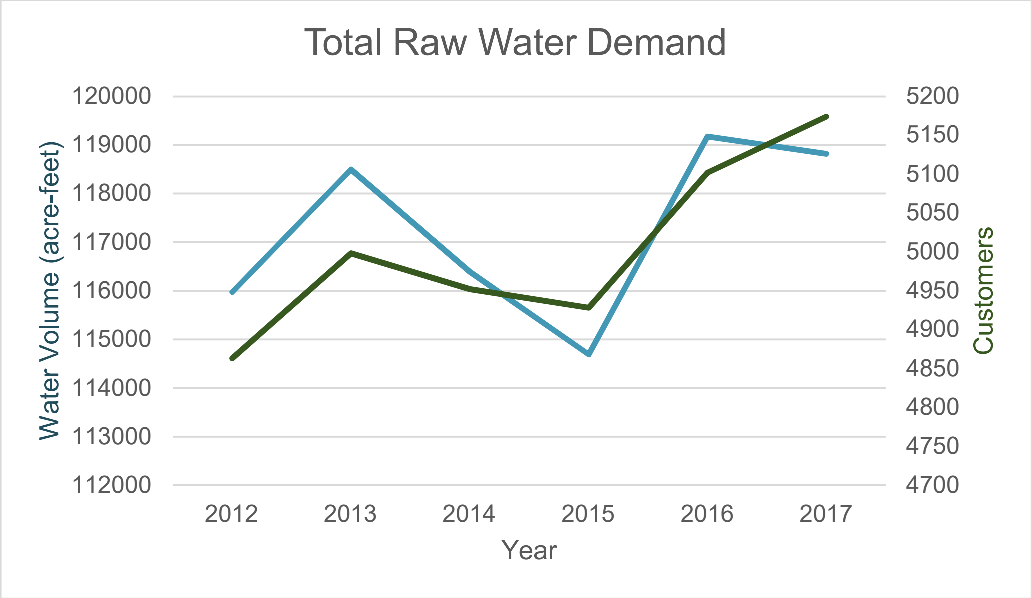
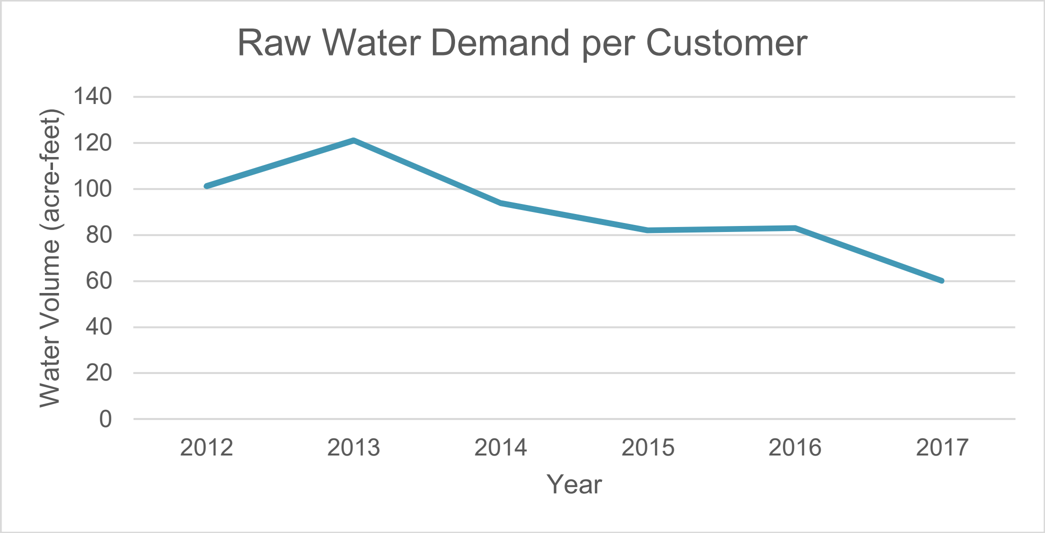


Figure 5-5. Raw Water Demand per Customer – 2012 through 2017

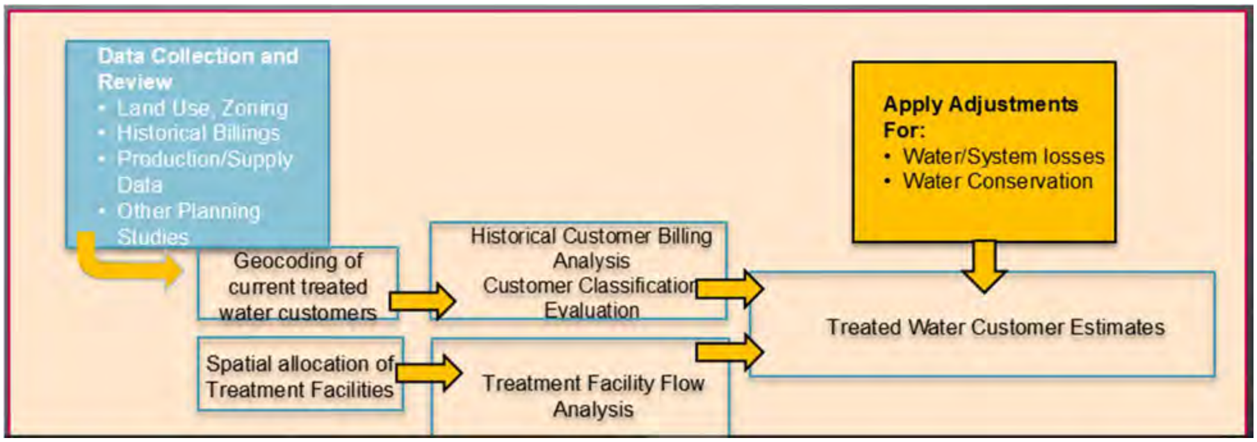


Treated Water Customers and Analysis

There are a total of eight water treatment plants provided water by the NID system. Six of these plants are currently owned and operated by NID and based on 2017 data serve approximately 19,280 connections.

Figure 5-6 shows the workflow and approach for the analysis of the historical meter data for the NID.

Figure 5-6. Workflow and Approach for the Analysis of the Historical Meter Data for the NID



An analysis of the historical quantity of water used by NID's treated water customers based on historical data from 2006 to 2017 is presented in Table 5-4 and the graphical representation is shown in Figure 5-7. Annual fluctuations in treated water demands are typically found to be primarily associated with various changes in response to weather conditions, economy and unemployment, number of customers, water usage behavior, state mandates, etc.

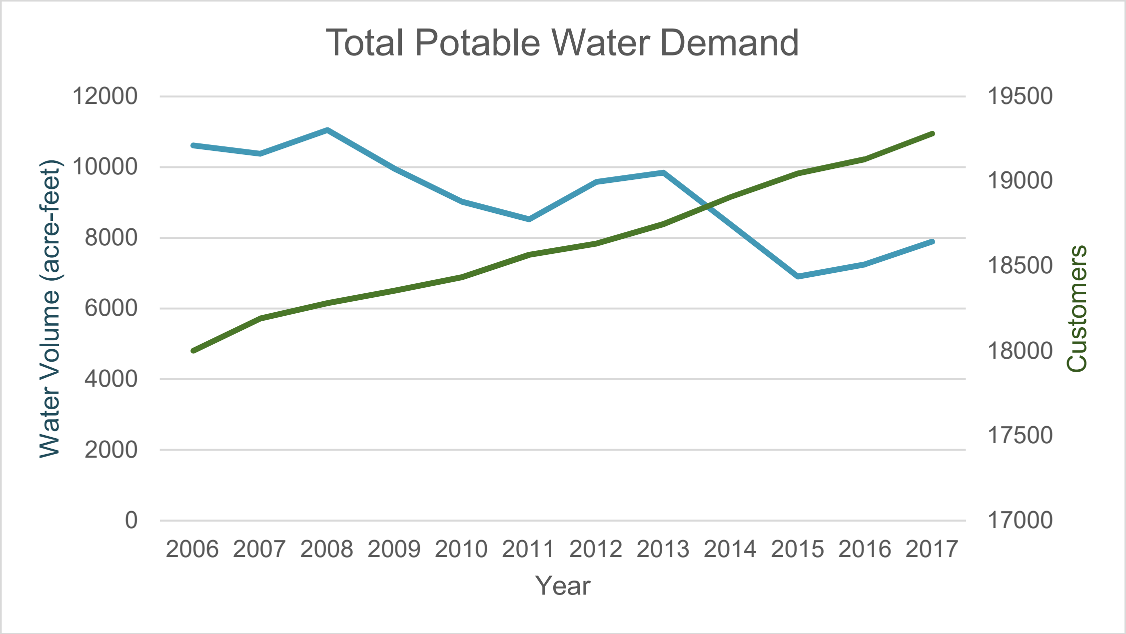
Table 5-4. Summary of Potable Customer Demand

Year	Total Demand (MG)	Number of Customers	Demand per Customer (MG)	GPCD
2006	3,458	18,002	0.19	185
2007	3,381	18,191	0.19	179
2008	3,600	18,283	0.20	190
2009	3,244	18,356	0.18	170
2010	2,939	18,435	0.16	154
2011	2,777	18,567	0.15	144
2012	3,123	18,633	0.17	162
2013	3,208	18,747	0.17	165
2014	2,729	18,908	0.14	139
2015	2,249	19,045	0.12	114
2016	2,362	19,131	0.12	119
2017	2,572	19,281	0.13	129

MG: Million Gallons

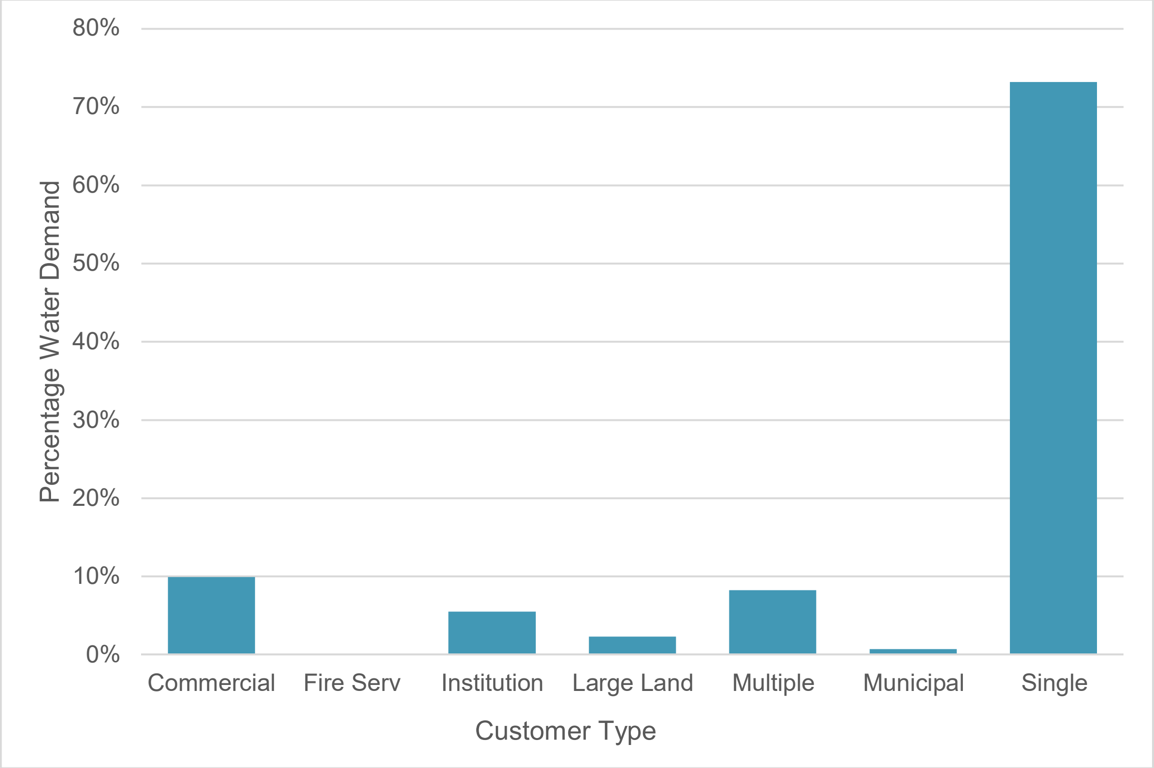
GPCD: Gallons per capita per day

Figure 5-7. Summary of Potable Customer Demand



NID's metered service connections serve a variety of different customer types, including residential, institutional, commercial customers, and large land users as shown graphically in Figure 5-8. The figure shows annual average water use from 2006 through 2017 as a percentage of the total.

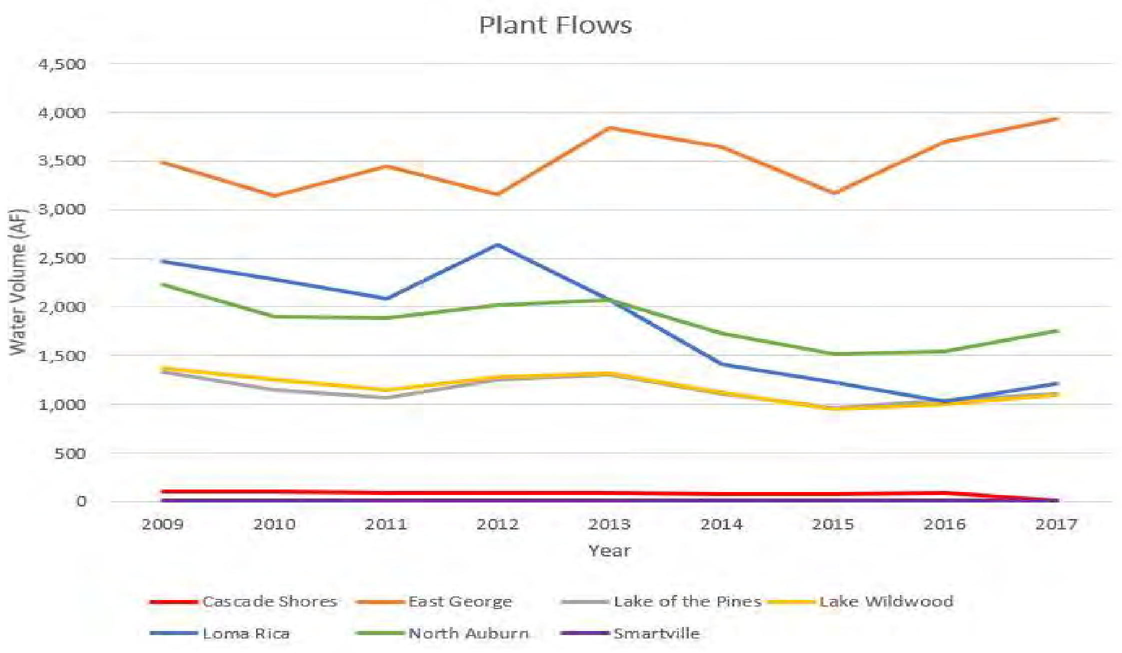
Figure 5-8. Treated Water Demand by Customer Type from 2006 to 2017.



Treatment Plant Analysis

There are a total of eight water treatment plants that provide water by the NID system. Six of these plants are currently owned and operated by NID. Two of them, Grass Valley and Nevada city plants are non-NID facilities but for which NID provides water. Figure 5-9 provides a summary of the historical flows from 2009 to 2017.

Figure 5-9. Water Treatment Plant Flows from 2009 to 2017.



Crop Report Data

In the past, the District has utilized the annual raw water customer crop reports to estimate the water use (in miner's inches) per crop for each canal and sublateral within NID's canal system. The previous raw water studies and RWMP update based many of the District's future water demand projections on trends from these data. As per the previous raw water model approach, the crop reports describe only areas currently under irrigation and not the total potential demand. It was very likely that some irrigated acreage was not reported. Further, the crop report data represents only acreages and services for customers responding to the seasonal use survey, and therefore, use of these data alone can greatly underestimate existing annual and future demand estimates. For this reason, this analysis utilized the annual crop report data only as a comparison of raw water during the irrigation season, rather than a direct application. Crop report data were also used to assess growth trends for some canal service areas.

Canal Losses

Canal losses consider two types of water loss: conveyance (seepage) losses and exit (end) losses. These losses were subtracted from the measured reach calculations.

Conveyance losses occur from leakage, seepage into the soil, evapotranspiration, and evaporation. Conveyance losses are a derived value rather than a direct measurement. Conveyance losses were updated wherever necessary based on recent data received from NID to validate the model. These are dependent on canal types (lined and unlined), segment configuration, piped or siphoned segments, and soil types for canal segments. The loss estimate for individual canal segments was lowered if the canal segment was partially lined, piped, or siphoned. The updated model has the ability to vary the percentage of the conveyance losses as desired.

Exit losses consisted of water flowing from the end of a facility segment that cannot be recaptured within that service area and, therefore, flows downstream to neighboring jurisdictions or downstream service areas. Exit loses for various canals within the NID system can and do vary and are a function of customer uses, flow demands through the canal, and District operation practices. Estimates of canal exit losses were based on a review of the canal outlet configurations and previous model estimates.

As used in the Phase 1 effort, an overall conveyance loss of 15 percent was used for the updated model. The loss estimate for individual canal segments was adjusted proportionately if the canal segment was noted to be partially lined, piped, or siphoned. Review of the canals flow data and comparison to historical data, adjustment were made to these as appropriate during the model validation stage. In the past, the District has undertaken several capital improvement projects designed to reduce both conveyance and exit losses. The reduction in system losses are a result of these efforts to manage supply in a more efficient manner. As these conservation measures have been effective, it is assumed that, in the future, NID will continue to implement additional water conservation measures. The model can define these losses, as appropriate, to include future conservation measures that can be deducted from the future total demand equation when such measures are implemented.

Mutual Water Companies and Water Associations

A growing development trend within the District, which is having a significant impact on water demand and the water conveyance system, is the development of mutual water companies and water associations. The impact of these types of development is significant because they tend to result in concentrated water demand which occurs very quickly. In some instances, the water demand in a particular canal segment can more than double within a single year as a result of the demand from these companies. Based on NID data, there are 39 active mutual water companies as of 2019. These mutual water companies have a total demand of approximately 14,668 acre-feet per year or 21.12 cfs. Table 5-5 summarizes the data listing of the 2019 Mutual Water Companies and Water Associations

Table 5-5. Mutual Water Companies and Water Associations.

Name	2019 Purchase (miners inch)	2019 Purchase (ac-ft/yr)
6 B Estates Water Association	22	398
Ali Lane	7	127
Bog Oak Valley	16	290
Blackford Ranch	28	507

Name	2019 Purchase (miners inch)	2019 Purchase (ac-ft/yr)
Carmody	10	181
Chicago Park Water Association	27	489
Chili Hill Farms	21	380
Clear Creek	11	199
Cole Country Water Users	34	615
Countryside Ranch	17	308
Fawn Hill Drive	4.5	81
Flying R Ranch	12.5	226
Foorehold Estates	4	72
Gold Blossom-Rivera	36	652
Greenpeace Water Association	10	181
HDA Association	10	181
Iron Mtn. Mutual Water Company	50	905
Little Greenhorn Creek	9	163
Meadow Hill Water Association	7	127
Melody Oaks Mutual Irrigation Company	41	742
Moonshine Water Company	21	380
Mount Vernon Estates Mutual Water Company	12	217
Mustang Valley Mutual Water	61	1,104
Oakcreek Water Association	13	235
Ophir Prison Est. Mutual Water	16	290
Perimeter Road Pipeline	28	507
Quail Hill Acres Road	54	977
Rainbow Pond Water Association	0	0
Redbud Water Association	21	380
Ridge View Woodlands Mutual Water	14	253
Rough & Ready Ranches Est. MWC *	3	54
Rudd Road Pipeline Association	17	308
Running Water Inc.	16	290
Saddleback North Water Group**	2.5	45
Saddleback Water Association	10	181
Sierra Foothills Water Association	31	561
Sky Pines Mutual Water Association	12	217
Streeter Road Water Association	35	633
Vian Water Association	20	362
Wilkes Pipeline Association	47	851
Total	**810.5**	**14,668**

* Formed in 2008; first water purchase in 2012

** Formed in 2009; first water purchase in 2010

External Deliveries

The principal raw water delivery to outside District agencies has been to South Sutter Water District (SSWD). NID purchased water for this delivery from PG&E through the

1963 Consolidated Contract, and conveyed purchased water flows through Auburn Ravine. The purchase and delivery to SSWD stopped in 2013 due to price changes when the Consolidated Contract was renewed. Because these exchanges no longer take place it does not impact the demand analysis, nor is it included in the impact to system infrastructure.

Environmental Flows

NID has several in-stream flow and minimum pool requirements. These are non-recoverable flows by downstream NID facilities. The minimum in-stream flow is not available for other uses and results in a system pass through. It must be considered in the demand calculation and as part of the infrastructure assessment.

The FERC Final Environmental Impact Statement for Hydropower License includes the minimum flow requirements, which have been classified depending upon the type of year. The following are the latest minimum flow requirements:

Table 5-6. Environmental Flow Requirements by Water Year Type.

Water Year Type	Environmental Flow requirement (acre-feet/year)
Wet	59,800
Above Normal	51,800
Below Normal	42,000
Dry	27,900
Critically Dry	22,700
Extremely Critical	16,400

Model Analysis Methodology

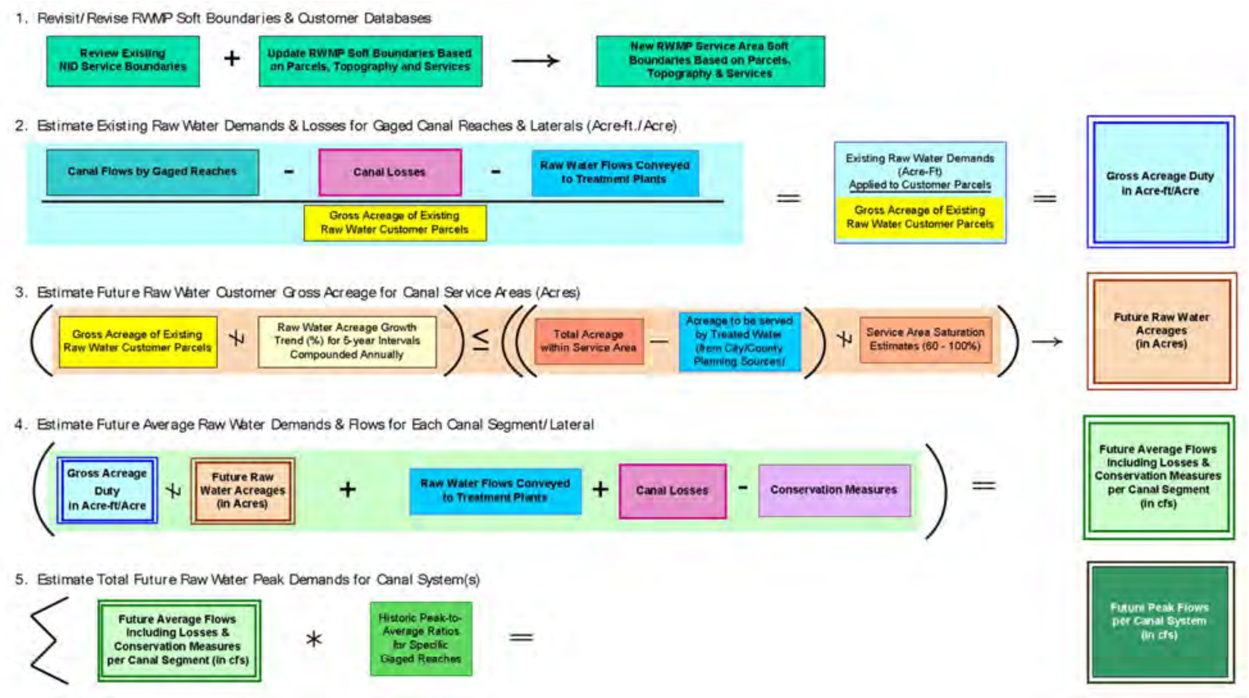
The total system demand is equal to the sum of irrigation season demand, winter service (non-irrigation season) demand, treated water demand, environmental flows, and conveyance losses. Irrigation and winter service demands are estimated independently. Treated water demands, environmental flows, and conveyance losses are embedded in the demand calculations discussed below. Export flows are made from contract water and the ability to provide export water is evaluated annually.

The irrigation season flow demand (in cfs) represents the largest portion of the total system demand. It is during this period when the peak canal flows typically occur. The peak flow values are utilized in the future planning and design of the District’s extensive raw water conveyance systems. The average flow values are used to derive the total system demand which are then used to evaluate the adequacy of existing supply.

NID’s existing Raw Water Demand Model was updated to reflect current conditions for the analysis of the water demands. The computer model facilitates the computations of irrigation season demand estimates. The model computed average and peak flow values for each canal segment, sub-systems as well as the total NID water demands. Flow values for each canal segment, summed in the appropriate sequence, are used to determine the total system raw water irrigation season demand. Model calibration was an important consideration. The 2020 raw water model was developed to the baseline year of 2018 and calibrated to data for that year. The water recap reports, gage flow data, customer data were key components in the process. The resulting average flow values computed under current conditions for each canal segment were compared to the actual gaged values as a means to confirm the methodology.

Figure 5-10 provides a model analytical workflow schematic as developed in the prior model development under Phase 1, Phase 2 and approved by the District. It includes data inputs and methodology used to calculate existing and future raw water irrigation season demands.

Figure 5-10. Raw Water Model Phase 1 and Phase 2 Demand Development.



Source: Raw Water Model Phase 1 and Phase 2

6 Model Results

Application of the outlined procedures, assumptions and methodologies were used to derive the average and peak flow demand for each canal segment. Peak demand flows are useful estimates that can help in assessing conveyance infrastructure. Average demand flows can be used to derive total demand.

6.1 Deer Creek System

Table 6-1 shows the estimated irrigation season demand for the Deer Creek system from 2020 through 2060 as well as the average irrigation system flow rate and total system demand. Summer irrigation season represents the majority of NID’s water demand, and demand during the winter is relatively constant. Consistent with the 2011 RWMP, the winter demand is expected to stay static through at approximately 15,023 acre-feet.

Table 6-1. Deer Creek System Projected Demands.

Year	Irrigation Season Demand (Acre-Feet)	Irrigation Season Average Flow (cfs)	Winter Season Demand (Acre-Feet)	Total System Demand (Acre-Feet)
2020	37,245	103	15,023	52,268
2030	43,034	119	15,023	58,057
2040	48,252	133	15,023	63,275
2050	53,822	148	15,023	68,845
2060	60,134	166	15,023	75,157

6.2 Bear River System

Table 6-2 shows the estimated irrigation season demand for the Bear Creek system from 2020 through 2060 as well as the average irrigation system flow rate and total system demand. Summer irrigation season represents the majority of NID's water demand, and demand during the winter is relatively constant. Consistent with the 2011 RWMP, the winter demand is expected to stay static through the timeline of this plan at approximately 25,355 acre-feet.

Table 6-2. Bear River System Projected Demands.

Year	Irrigation Season Demand (Acre-Feet)	Irrigation Season Average Flow (cfs)	Winter Season Demand (Acre-Feet)	Total System Demand (Acre-Feet)
2020	72,839	201	25,355	98,194
2030	83,244	229	25,355	108,599
2040	93,455	257	25,355	118,810
2050	100,910	278	25,355	126,265
2060	108,424	299	25,355	133,779

6.3 Total System Demands

Table 6-3 shows the estimated annual demand for the entire system (including irrigation and winter flows) from 2020 through 2060 as well as the total demand including environmental flows. Dry year environmental flows, per FERC requirements, are 27,900 acre-feet. Wet year environmental flows are 59,800 acre-feet.

Table 6-3. Total System Projected Demands.

Year	Annual System Demand (Acre-Feet)	Total System Demand Dry Year (Acre-Feet)	Total System Demand Wet Year (Acre-Feet)
2020	150,462	178,362	210,262
2030	166,657	194,557	226,457
2040	182,085	209,985	241,885
2050	195,110	223,010	254,910
2060	208,936	236,836	268,736

7 References

Kleinschmidt, West Yost & Associates, and Robertson-Bryan, Inc. (NID). 2005. Nevada Irrigation District Raw Water Master Plan Update, Phase 1. September 2005.

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Water Supply Analysis TM – Final Report

Nevada Irrigation District (NID)

November 12, 2020

Date:____11/12/2020___________________________

Sergio Jimenez, P.E.
HDR Engineering, Inc.
Civil Engineer, C55698
Expiration Date: December 31, 2020

Megan Lionberger

Date:_11/12/2020________________________________

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Expiration Date: December 31, 2020

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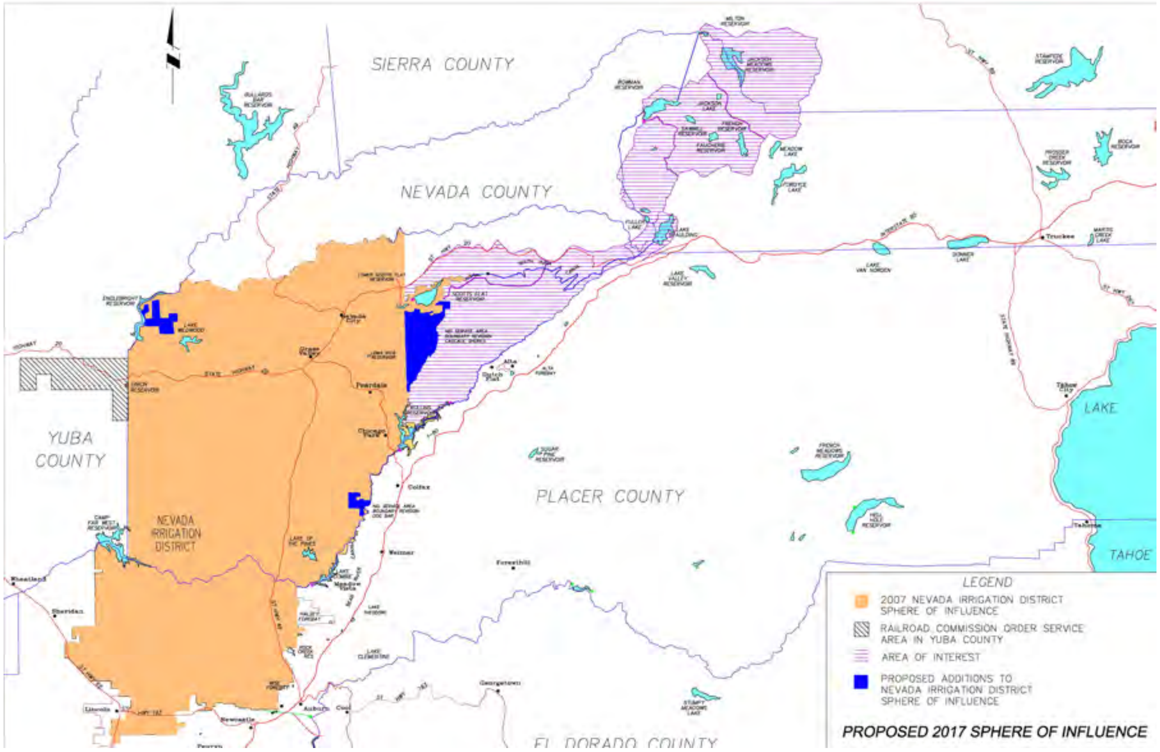
1 Introduction

Nevada Irrigation District (NID) is an independent public agency that is governed by a five-member elected Board of Directors and employs approximately 200 full- and part-time employees. The District supplies water to nearly 25,000 homes, farms, and businesses in portions of Nevada, Placer and Yuba counties in the foothills of Northern California's Sierra Nevada. (Figure 1-1) Water is collected from mountain watersheds and stored in a system of reservoirs. As water flows to its customers in the foothills, it is used to generate clean, hydroelectric energy in excess of 354 gigawatt hours per year, to maintain environmental flows, and to provide public recreation opportunities. NID supplies both treated drinking water and raw water for irrigation. Approximately 90 percent of NID's annual demand is made up of raw water/agricultural demand during the irrigation season, April 15 – October 15 annually.

NID's water supply system is primarily a "store and release" system, in that reservoirs store snow melt and seasonal rains for release during the typically dry irrigation seasons. NID also has direct diversion water rights for the irrigation season in a number of tributaries. Based on the timing of seasonal precipitation events, NID's water supply management is dependent on a combination of springtime snowmelt and winter period rains to fill its storage reservoirs. While there is some natural runoff during the summer months, much of this water is required to meet necessary environmental flows in the rivers; therefore, the irrigation season demand is met primarily with withdrawals from storage reservoirs. Careful management and operation of storage reservoirs is essential to capture the maximum amount of runoff, minimize spillage from reservoirs, and ensure there is sufficient volume available in reservoirs to accommodate runoff during the spring snow melt and storm events.

Figure 1-1. Nevada Irrigation District Location Map



1.1 Water Supply Projection Update

NID regularly evaluates and updates its water supply availability projections. In the past, this was completed through the Raw Water Master Plan (RWMP), originally developed in 1985. The primary purpose of the RWMP was to assess the adequacy of the existing water storage and conveyance system to accommodate current and future water demand. Since 1985, the RWMP has been updated in two phases. The phase I update was completed in 2005 (Kleinschmidt et al. 2005), and the phase II update was completed in 2011 (Kleinschmidt Associates 2011).

NID's water supply comes from four main sources: natural runoff (including snowmelt) from the contributing watershed areas, reservoir carryover storage, contract water purchases, and recycled water. Events such as drought and climate change create imminent challenges for NID in maintaining a sustainable water supply system. According to NID's RWMP (Kleinschmidt Associates 2011), the margin between average watershed runoff volume and NID customer demand is diminishing. Increased future demands within NID's service area and increased environmental flows will result in increased demand on water storage and greater drawdown of NID's reservoirs, especially during summer months when there is little natural runoff.

The 2011 RWMP was based on projected 2032 water management practices. The following supply projection updates are needed to reflect current regulatory standards, climate change analyses, and anticipated operations:

- Expand the planning horizon to 50 years, to be consistent with other regional planning studies (Sustainable Groundwater Management Act and the 2018 California Water Plan Update)[1].
- Update customer demand projections to reflect the new planning horizon based on the updated demand model described in the Raw Water Demand Model Update TM.
- Utilize hydrologic impacts from climate change, which is expected to change the volume and timing of watershed runoff relative to existing conditions.
- Include new Federal Energy Regulatory Commission (FERC) license conditions, which will generally increase flow in rivers downstream of NID reservoirs for environmental benefit, resulting in less available water to meet NID customer demand.
- Include new long-term water purchase agreement with Pacific Gas and Electric (PG&E).
- Expand the extreme drought water supply analysis from 3 years to 5 years, per Executive Order SB-37-16(8).

1.2 Goals and Objectives

The goal of this study is to update and present the water supply projections. This study will present projections for future water supply under critical drought scenarios within the service areas for NID. In February 2018, HDR prepared a memorandum (Appendix A) summarizing updated assumptions for water supply projections. The work in this technical memorandum builds upon that analysis, with the work completed in the Hydrologic Analysis TM (HDR, 2020a) and Raw Water Demand Model Update TM (HDR, 2020b).

2 Projected Water Supply

The State of California is developing new guidelines to define a 5-year drought in their 2020 update to the Urban Water Management Plan (UWMP) guidebook. At the time this TM is being written, these guidelines are not yet available to the public. In anticipation of this new requirement, water supply for a 5-year drought has been developed, based on the best available information to NID, which includes climate change projections, This section summarizes the process used to develop the projected 5-year drought water supply for NID in 2070 utilizing the following methodology and assumptions.

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[1] There is not a strict rule on planning horizons, although Integrated Regional Water Management Plans and Urban Water Management need “at least” 20 years. The Sustainable Groundwater Management Act (SGMA) stipulates that the planning and implementation horizon is a **50-year time period** over which (groundwater sustainability) plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield. Other related plans have followed suit, such as the 2018 California Water Plan Update. The new 2020 guidelines for UWMPs are expected to be released in the summer of 2020.

2.1 Watershed Runoff

Unimpaired flow is defined as the hydrologic response of watershed basins with no influence (i.e., regulation) of stream flow by man-made structures such as dams or diversions. Quantification of unimpaired flow is important because it is used to estimate watershed runoff. Watershed runoff is the largest contributor to NID's water supply (Kleinschmidt Associates 2011).

HDR prepared historical unimpaired hydrology data and modeling tools developed for the joint FERC relicensing of NID's Yuba-Bear Hydroelectric Project (FERC Project Number 2266) and PG&E's Drum-Spaulding Hydroelectric Project (FERC Project Number 2310). These data and tools were accepted by FERC, other state and federal agencies, and non-governmental organizations to adequately represent historical conditions within the two hydroelectric project areas and were used to evaluate impacts to water resources as a result of potential operations and facilities modifications during the relicensing process.

Following completion of the historical unimpaired hydrology data set developed during the 2008 FERC relicensing, as part of the current supply projection update study, HDR updated these data to transform the historical unimpaired hydrology data set to represent projected conditions in 50 years (2070) as a result of three climate change scenarios. The three climate change scenarios are:

- Median climate change conditions, based on 20 global climate models (GCMs) and representative concentration pathway (RCP) combinations;
- Drier/extreme-warming (DEW) conditions, representing a pessimistic trajectory of greenhouse gas emissions throughout this century; and
- Wetter/moderate-warming (WMW) conditions, representing an optimistic trajectory of greenhouse gas emissions throughout this century.

Hydrologic projections for future conditions representative of year 2070 were developed using simulated historical and projected runoff from the Variable Infiltration Capacity (VIC) model (Liang et al., 1994) to translate historical unimpaired hydrology, developed during the 2008 FERC relicensing, into projected unimpaired hydrology. VIC model runoff predictions for water years 1976 through 2011 were provided by the California Water Commission (CWC, 2016). A full description of the hydrologic data and methods used to develop the 2070 projection of unimpaired hydrology are presented in the Hydrologic Analysis TM (HDR, 2020a).

Current DWR guidelines require urban water suppliers to submit a multiple-dry year drought assessment of three or more years (DWR 2016). Under Executive Order SB-37-16, urban water suppliers will now be required to submit a five-year drought risk assessment[2]. The study region has not experienced a continuous five-year drought during the available 1976 through 2011 period of record; however, there are a number of dry years that can be juxtaposed to simulate a hypothetical five-year drought.

Annual runoff of the projected 2070 unimpaired hydrology was quantified as the watershed runoff in watersheds where NID has water rights (Middle Yuba River, South

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[2] Guidelines are not yet available from the State of California to define the annual assessment methodology for a five-year drought.

Yuba River, Bear River, Deer Creek, Wolf Creek, Coon Creek, and Auburn Ravine). Watersheds were generally grouped into two categories:

- Watersheds with storage reservoirs that can capture runoff year-round.
- Watersheds without storage reservoirs that divert runoff during the irrigation season (April 16-October 15).

It was assumed that year-round runoff was able to be stored in watersheds with storage reservoirs within NID's water rights[3] and was quantified in the annual runoff volume as runoff over the entire year. In watersheds without storage reservoirs, only runoff occurring during the irrigation season was quantified in the annual runoff volume calculation. Not all runoff is available for use by NID. Some runoff is used to meet environmental flow requirements below NID facilities, or is lost to spill when NID reservoirs are full. Annual runoff was not adjusted to account for either.

To simulate watershed runoff conditions for a five-year drought the five driest water years were placed back to back and ordered from wettest to driest, based on their annual runoff volume: 1994, 1987, 1988, 1976 and 1977.

2.2 Carryover Storage

Carryover storage is stored water in NID reservoirs held in reserve for droughts or for emergency supply to avoid water shortages, and to meet environmental flow requirements. Reservoir carryover storage is the second largest source of water supply available to NID to meet customer demand (Kleinschmidt Associates 2011). Carryover storage is the water remaining in reservoir storage at the end of the irrigation season, around October 15.

Carryover storage is likely to change relative to historical conditions because of increased environmental flow requirements (Table 2-1) and changes in the timing and magnitude of reservoir inflows resulting from climate change (Dettinger et al., 2018). The HEC-ResSim reservoir operations model, described in the Hydrologic Analysis Technical Memorandum (HDR 2020a), was run to simulate reservoir conditions with 2070 median climate change hydrology (HDR 2020a), anticipated FERC license conditions (minimum flow requirements), and 2060 projections of customer demand (HDR, 2020b). Based on model output, the average annual carryover storage for Water Years 1976 through 2011 was 87,520[4] acre-feet (ac-ft), 30,073 ac-ft less than the historical baseline model scenario.

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[3] PG&E has water rights to the first 350 cfs of natural Bear River inflow to Rollins Reservoir.

[4] Carryover does not include 9,218 ac-ft of unusable storage (HDR, 2020a). Unusable storage is the volume within a reservoir that cannot be drained by gravity through a dam's outlet works or a regulatory minimum-pool requirement.

Table 2-1. Non-recoverable environmental flow requirements below NID facilities (FERC, 2014).

Environmental Flow Requirement	Water Year Type	Non-Recoverable Environmental Flow Volume (ac-ft)
Existing	All Years	7,600
Projected	Wet	59,800
	Above Normal	51,800
	Below Normal	42,000
	Dry	27,900
	Critically Dry	22,700
	Extremely Critically Dry	16,400

Assuming an average annual carryover storage (87,520 ac-ft) beginning in year 1, carryover storage can be calculated for sub-sequent years of the theoretical 5-year drought using mass balance as the previous year's available carryover storage[5] plus the previous year's inflows (watershed runoff, PG&E contract purchases, and recycled water) minus outflows (water supplied to customers, and non-recoverable environmental flows). Based on the 2015 NID drought management plan (Appendix B), the drought action stage was determined for each year of the 5-year drought based on the projected supply. Demand reduction targets provided by the drought contingency plan were applied to projected 2060 demands to determine the annual demand after reduction. Environmental flow requirements are firm demands that cannot be reduced. Carryover storage was calculated as the difference between the annual supply, and annual demand with reduction. Results are presented below in Section 3.

2.3 Contract Purchases

Contract purchases between NID and PG&E are dictated by long-term consolidated contracts. For this analysis, contract purchase assumptions are based on the Coordinated Operations Agreement between PG&E and NID (NID 2018). In an average year, contract purchases are projected to be 7,500 ac-ft per year. For the 5-year drought scenario in this analysis, contract purchases were estimated based on Appendix B of the Coordinated Operations Agreement.

2.4 Recycled Water

The most up to date projection of municipal recycled water is available from the 2015 Urban Water Management Plan (UWMP) (NID 2016). Table 5-4 of the UWMP provides projections of recycled water every 5 years from 2015 to 2040. A value of 5,275 ac-ft for 2070 was obtained by extending the UWMP values to 2070.

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[5] Carryover does not include 9,218 ac-ft of unusable storage. Unusable storage is the volume within a reservoir that cannot be drained by gravity through a dam's outlet works or a regulatory minimum-pool requirement.

3 Conclusion

The Projected 2070 total water supply during a 5-year drought is shown in Table 3-1. All components of NID's total water supply drop throughout the 5-year drought except the recycled water estimate, which is a small contribution to the total water supply. Carryover storage drops to essentially zero after the first two years, contributing to a greater than 85% overall reduction of supply at the end of the 5-year hypothetical drought. Two other alternative 5-year drought scenarios are presented in Appendix C and Appendix D.

Table 3-1. Summary of 2070 5-Year Drought Water Supply.

Analysis Variable	Avg. Year	Hypothetical 5-Year Drought				
		1994	1987	1988	1976	1977
Watershed Runoff (ac-ft)[1]	383,500	101,350	97,200	95,250	85,500	38,300
Available Carryover Storage (ac-ft)[2,3]	87,500	87,500	25,126	1,289	0	0
Contract Purchases from PG&E (ac-ft)[4]	7,500	37,300	31,800	30,300	27,500	26,200
Recycled Water (ac-ft)[5]	5,300	5,300	5,300	5,300	5,300	5,300
Total Supply (ac-ft) [6]	***483,800***	***231,450***	***159,426***	***132,139***	***118,300***	***69,800***
Environmental Flow Requirement (ac-ft)	46,200	31,100	24,700	24,000	23,200	16,400
Total Demand Before Reduction (ac-ft)	255,136	240,036	233,636	232,936	232,136	225,336
Drought Action Stage	-	I	IV	IV	IV	IV
Drought Demand Reduction	0%	20%	40%	50%	50%	50%
Total Demand with Reduction (ac-ft)	255,136	206,324	158,137	132,506	127,668	120,868
Shortage With Reductions & Contract Purchases (ac-ft)	0	0	0	-367	-9,368	-51,068

1 Average and drought year watershed run-off based on results of the Hydrologic Analysis TM under median climate change conditions, per NID water rights.
2 Average year available carryover storage is the 1976-2011average modeled usable storage on October 15 (carry over storage minus 9,218 ac-ft dead storage). Model scenario is based on FERC FEIS minimum flows, 2060 projected demands from the Raw Water Demand Model Update, and 2070 median climate change hydrology developed in the Hydrologic Analysis TM.
3 Drought year available carryover storage represents conditions at beginning water year and is calculated as the previous year's carryover storage plus the previous year's total supply minus the previous year's total demand with reduction.
4 Estimates based on Appendix B of the Coordinated Operations Agreement. Availability is subject to hydrologic conditions.
5 Projected municipal recycled water supply from 2015 UWMP.
6 Total supply is equal to watershed runoff + available carryover storage + contract purchases from PG&E + recycled water.

4 References

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Appendix A. Updated 2032 Projected Water Supply Deficits Under Extreme Hypothetical Drought

Memo

Date:	Monday, February 05, 2018
To:	NID - Doug Roderick
From:	HDR - Megan Lionberger and Linda Fisher
Subject:	**Updated 2032 Projected Water Supply Deficits Under Extreme Hypothetical Drought**

1.0 Introduction

A key planning document in NID's future water supply outlook is the Raw Water Master Plan (RWMP), originally developed in 1985. The RWMP has been updated in two phases. Phase I update completed in 2005 (NID 2005), documented:

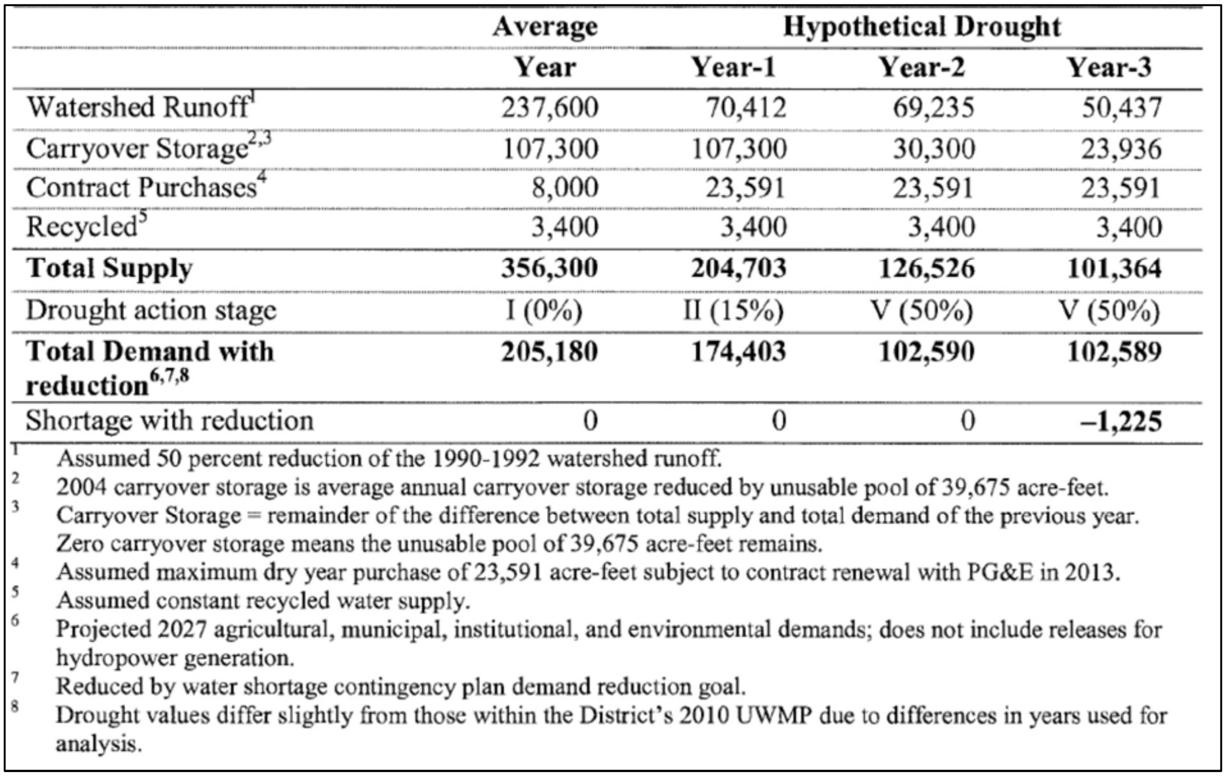
- NID's conveyance system and water supply and delivery including water sources and storage; NID's water rights; and NID's water deliveries;
- Estimated consumptive water demand for 2002 through 2027 by season (irrigation season and winter season);
- A comparison of water supply to estimated demand;
- An examination of existing system capacity to determine whether the system is of adequate size and condition to accommodate projected demand;
- A review of NID's policies and regulations for consistency with California's 1994 Water Plan Update;
- General recommendations for capital improvements to support NID's ability to meet estimated demand and continue servicing its customers into the future;
- A discussion of environmental issues that may affect operations of future capital projects; and,
- A review of NID's operations to enhance cost-effective and reliable delivery of water.

The Phase II update of the RWMP was completed in 2011 (NID 2011) to meet the following goals:

- Quantify long-term water demands and available long-term water supplies, including drought year provisions;
- Recommend improvements for expansion, maintenance, and operation of raw water infrastructure, through the development of a Capital Improvement Plan, which provides a list of necessary improvements to meet projected system demands;
- Provide guidelines for future raw water system policies, operations and improvements;
- Meet NID's long-term water service obligations, pursuant to State Water Code Division 11;
- Maximize use of available water; and,
- Minimize significant effects to environmental and cultural resources.

In the 2011 update of the 1985 *Raw Water Master Plan* (RWMP), Nevada Irrigation District (NID) determined that within the RWMP planning horizon (2032), NID's water rights and typical water supply would be adequate to meet NID's projected demands during normal and single-dry year drought conditions. However, the 2011 RWMP update report showed that NID would not be able to consistently meet projected demands during extreme multi-year drought conditions (NID 2011, p. 5-26). Table 1 below is a reproduction from the 2011 RWMP.

Table 1. Raw Water Master Plan Extreme Hypothetical Drought with 2032 Demands (reproduced)



	Average	Hypothetical Drought		
	Year	Year-1	Year-2	Year-3
Watershed Runoff[1]	237,600	70,412	69,235	50,437
Carryover Storage[2,3]	107,300	107,300	30,300	23,936
Contract Purchases[4]	8,000	23,591	23,591	23,591
Recycled[5]	3,400	3,400	3,400	3,400
Total Supply	**356,300**	**204,703**	**126,526**	**101,364**
Drought action stage	I (0%)	II (15%)	V (50%)	V (50%)
Total Demand with reduction[6,7,8]	**205,180**	**174,403**	**102,590**	**102,589**
Shortage with reduction	0	0	0	**–1,225**

[1] Assumed 50 percent reduction of the 1990-1992 watershed runoff.

[2] 2004 carryover storage is average annual carryover storage reduced by unusable pool of 39,675 acre-feet.

[3] Carryover Storage = remainder of the difference between total supply and total demand of the previous year. Zero carryover storage means the unusable pool of 39,675 acre-feet remains.

[4] Assumed maximum dry year purchase of 23,591 acre-feet subject to contract renewal with PG&E in 2013.

[5] Assumed constant recycled water supply.

[6] Projected 2027 agricultural, municipal, institutional, and environmental demands; does not include releases for hydropower generation.

[7] Reduced by water shortage contingency plan demand reduction goal.

[8] Drought values differ slightly from those within the District's 2010 UWMP due to differences in years used for analysis.

The extreme hypothetical drought in Table 1 compares supply with demand on an annual basis to estimate the demand shortage. The table shows that in an average year, and in Years 1 and 2, there is adequate supply to meet demand. Only Year-3 results in shortage. In this analysis, carryover storage is used to offset demand that was not met from the other supply sources: watershed runoff, contract purchases and recycled water. For example, in Year-1 77,000 ac-ft of carryover storage (107,300 ac-ft minus 30,300 ac-ft) was utilized to meet demand and avoid shortage. In all three years, carryover storage was utilized to meet customer demand until there was insufficient carryover storage remaining to fill the void, as occurred in Year-3.

The 2011 RWMP analysis shown in Table 1 was based on projected 2032 water management practices at the time, which did not include future, projected Federal Energy Regulatory Commission (FERC) license conditions or climate change. The purpose of this memo is to present updates to the projected water supply deficit for a multi-year drought under 2032 conditions with the most up to date information available regarding future FERC license conditions, projected hydrologic conditions under climate change, and projected water management practices. This will be done in two steps. The first step is to update values in Table 1 with up to date projections while preserving theoretical watershed runoff representing a 50 percent reduction of the 1990-1992 historical watershed runoff. The second step incorporates revised drought hydrology representative of 2032 climate change conditions.

2.0 Step 1 – Update of Projected Extreme Hypothetical Drought with Current Projections of Future Water Management Practices

Many of the assumptions used to estimate variables included in Table 1 are now out of date, either because new information is available or regulatory conditions are projected to change. To update the extreme hypothetical drought scenario with current projections of 2032 conditions, the following variables were revised:

- Watershed Runoff
- Environmental flow requirements
- Carryover storage
- Updated contract purchases from PG&E
- Recycled water
- Drought Contingency Plan

The following sections document assumptions used to update the extreme hypothetical drought analysis.

2.1 Watershed Runoff

Previous estimates of watershed runoff (Table 1) did not include estimates of runoff from the Bear River (NID 2011). Both NID and Pacific, Gas and Electric (PG&E) have water rights to local runoff in the Bear River. PG&E has senior water rights over NID such that in dry water years[1], NID receives little to no water from Bear River runoff. An analysis was performed using daily unimpaired hydrology for water years 1976 through 2008 developed during FERC relicensing of the Yuba-Bear Hydroelectric Project (NID 2012) for the Bear River upstream of Combie Reservoir to estimate the average annual runoff available to NID from the Bear River based on water rights. The analysis resulted in an average annual runoff of 90,300 ac-ft available to NID. For this analysis, 90,300 ac-ft was added to the average annual watershed runoff reported in Table 1 for a total of 327,900 ac-ft. Watershed runoff for Years 1, 2 and 3 were not adjusted to include Bear River runoff because they are dry years and PG&E's senior water rights would result in very little water available to NID.

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[1] A water year begins October 1 and ends on September 30.

The Extreme Hypothetical Drought scenario presented in the RWMP (Table 1) assumes a 50% reduction in runoff during the historic worst three-year drought on record (as of 2011). This assumption comes from a requirement from the California Water Code Section 10632, which requires Urban Water Master Plans to assess a 50 percent reduction in supply and to estimate the minimum water supply using the driest three years on record. The RWMP utilized the same criteria for consistency.

2.2 Environmental Flow Requirements

NID's previous FERC operating license for the Yuba-Bear Project Hydroelectric Project expired in April 2013. The Yuba-Bear Hydroelectric Project is currently operating on annual licenses until FERC issues a new license. Existing environmental flows, which include current FERC license requirements, totals 7,700 ac-ft per year. Under the new license, environmental flow requirements are expected to increase (FERC 2014). Table 2 summarizes projected 2032 environmental flow requirements, for the Yuba River, Wilson Creek, Canyon Creek, Texas Creek, Clear Creek, Fall Creek, Trap Creek, Rucker Creek, Bear River and Deer Creek. For this analysis, the water year type is assumed to be Above Normal in the year preceding the drought, followed by Extremely Critical in Years 1, 2 and 3. For this analysis, water year types were updated in April[2].

Table 2. Projected 2032 environmental flow requirements.

Water Year Type[1]	Environmental Flow requirements[2] (ac-ft)
Wet	59,800
Above Normal	51,800
Below Normal	42,000
Dry	27,900
Critically Dry	22,700
Extremely Critical	16,400

[1] Water Year types are based NID's Yuba-Bear and PG&E's Drum-Spaulding hydroelectric projects proposed water year types, as accepted by FERC in the Final Environmental Impact State for Hydropower License (FERC/EIS-F-0244, December 2014).

[2] Environmental flow requirements on the Middle Yuba River below Milton Diversion Dam, Wilson Creek below Wilson Creek Diversion Dam, Canyon Creek below Bowman-Spaulding Diversion Dam, Texas Creek below Texas Creek Diversion Dam, Clear Creek below Clear Creek Diversion Dam, Fall Creek below Fall Creek Diversion Dam, Trap Creek below Trap Creek Diversion Dam, Rucker Creek below Rucker Creek Diversion Dam, Bear River below Lake Combie, and Deer Creek below Scotts Flat Reservoir.

2.3 Carryover Storage Requirements

Current carryover storage management practices have not changed from 2011 to 2017. It is anticipated that carryover storage requirements will be increased under the new FERC license to accommodate increased environmental flow requirements. For this analysis, average

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[2] Proposed Water Year types are based on the DWR forecast of total unimpaired Runoff in the Yuba River at Smartsville or the DWR Full Natural Flow (FNF) near Smartsville and are updated in the months of February, March, April, May and October. A reasonable forecast of watershed runoff for the remainder of the water year is typically available in April.

carryover storage was increased by 5,900 ac-ft from 107,300 ac-ft (Table 1) to 113,200 ac-ft, which is the difference in environmental flow requirements between existing conditions (7,700 ac-ft) and an extremely critical water year (13,600 ac-ft). At the onset of Year-1, carryover storage is assumed to be at average.

2.4 Contract Purchases

Contract purchases between NID and PG&E are dictated by long-term consolidated contracts. The previous consolidated contract between NID and PG&E expired in 2013. NID and PG&E are in the process of approving a new consolidated contract, pending finalization of the Deer Creek Coordinated Operations Agreement. For this analysis, contract purchase assumptions are based on a pending Coordinated Operations Agreement between PG&E and NID. In an average year, contract purchases are projected to decrease slightly from 8,000 ac-ft per year to 7,500 ac-ft per year. In dry years, contract purchases are expected to increase (see Table 3).

2.5 Recycled Water

The most up to date projection of municipal recycled water is available from the 2015 Urban Water Management Plan (UWMP) (NID 2016). Table 5-4 of the UWMP provides projections of recycled water every 5 years from 2015 to 2040. A value of 3,000 ac-ft for 2032 was obtained by linearly interpolating between values for 2030 (2,852 ac-ft) and 2035 (3,157 ac-ft).

2.6 Drought Contingency Plan

An update to NID's Drought Contingency Plan was accepted by the NID Board on November 18, 2015 (NID 2016, Appendix J). The plan identifies drought action levels, water demand reduction goals, and provides recommended demand management measures. The updated Drought Contingency Plan specifies that reductions to deliveries begin on April 1st, when a reasonable forecast of watershed runoff for the remainder of the water year is available. Based on NID's historical water usage, 17% of annual deliveries are made from October through March. Therefore, drought contingency actions can only reduce the remaining 83% of water year deliveries. For this analysis it is assumed that a drought action stage is initiated on April 1 and continues into the following year until drought conditions are reassessed on April 1.

2.7 Updated Extreme Hypothetical Drought Analysis

An update to the extreme hypothetical drought presented in the RWMP (NID 2011), and reproduced in Table 1, with updated assumptions is shown in Table 3. Additional detail was added to Table 3, as compared to Table 1, but only for clarity; they represent the same analysis. Carryover storage values represent conditions at the beginning of the water year (October 1) and are calculated using mass balance as the previous year's available carryover storage[3] plus

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[3] Carryover storage values presented in Tables 1 and 3 do not include 39,675 ac-ft of dead storage. Dead storage, or inactive storage, is the volume within a reservoir that cannot be drained by gravity through a dam's outlet works.

the previous year’s inflows (watershed runoff, contract purchases, and recycled water) minus outflows (demands, environmental flows).

In each year of the analysis, the supply shortage was calculated based on the difference between the total supply and the total demand before reduction. The drought action stage was determined based on the supply storage. Demand reduction targets provided by the drought contingency plan were applied to projected 2032 demands to determine the total demand with reduction. Environmental flow requirements are firm demands that cannot be reduced. Annual shortages were calculated as the difference between the total demand with reduction and the total supply.

The analysis presented in Table 3 below, shows that carryover storage is reduced to approximately 33,000 ac-ft after Year-1, and is eliminated after Year-2, resulting in a second year deficit of approximately 6,500 ac-ft and a third year deficit of approximately 38,000 ac-ft. Year-3 deficit is equivalent to 33% of the projected demand with reductions.

Based on tree ring reconstruction of historical watershed runoff for the Sacramento River watershed (Meko et. al. 2001), the recurrence of a 3-year drought of this severity is greater than 1 in 1,000 years (a probability of less than 0.001).

Table 3. Summary of extreme hypothetical drought with 2032 demands and revised water management practices analysis.

Analysis Variable	Avg. Year	Hypothetical Drought		
		Year-1	Year-2	Year-3
Watershed Runoff (ac-ft) [1]	327,900	70,400	69,250	50,450
Available Carryover Storage (ac-ft) [2,3]	113,200	113,200	32,900	0
Contract Purchases from PG&E (ac-ft) [4]	7,500	34,600	27,200	24,450
Recycled Water (ac-ft) [5]	3,000	3,000	3,000	3,000
Total Supply (ac-ft) [6]	*451,600*	*221,200*	*132,350*	*77,900*
Projected 2032 demands (ac-ft) [7]	197,500	197,500	197,500	197,500
Environmental flow requirements (ac-ft) [8]	46,200	23,600	13,600	13,600
Total Demand before Reduction (ac-ft) [8]	*243,700*	*221,100*	*211,100*	*211,100*
Supply Shortage [10]	0%	0%	37%	63%
Drought Action Stage [11]	-	I	IV	IV
Drought Demand Reduction [12]	0%	20%	40%	50%
Oct-Mar 2032 Projected Demand with Previous Year Reduction (ac-ft) [13]	33,650	33,650	26,950	20,200
Apr-Sep 2032 Projected Demand with Reduction (ac-ft) [14]	163,800	131,050	98,300	81,900
Total Demand with Reduction (ac-ft) [15]	*243,650*	*183,400*	*138,850*	*115,700*
Shortage after Reduction (ac-ft) [16]	**0**	**0**	**-6,500**	**-37,800**

[1] Average historical watershed run-off includes Middle Yuba River above Milton Diversion, Canyon Creek above Bowman Dam, Texas, Clear, Fall, Trap, Rucker creeks above the Bowman-Spaulding Canal, Bear River subject to PG&E's senior water rights, and Deer Creek above Scotts Flat Reservoir. The analysis does not include the South Yuba River due to hydrologic and water right considerations. Assumed 50 percent reduction of the observed 1990 to 1992 watershed runoff.

[2] 113,200 is the average historical annual net carryover storage (not including dead storage) (Table 1), plus 5,900 ac-ft for additional environmental flows.

[3] Carryover storage represents conditions at beginning water year and is calculated as the previous year's carryover storage plus the previous year's total supply minus the previous year's total demand with reduction.

[4] Assumes pending coordinated operations agreement between PG&E and NID is in effect. Availability is subject to hydrologic conditions.

[5] Projected municipal recycled water supply from 2015 UWMP.

[6] Total supply is equal to watershed runoff + available carryover storage + contract purchases from PG&E + recycled water.

[7] Projected agricultural, municipal, and institutional demands from 2015 RWMP, Table 4-6.

[8] Environmental flow requirements are based on Above Normal water year type requirements in the average year, Critically Dry water year type requirements in Years 1, and Extremely Critically Dry water year type requirements in Years 2 and 3. Water year types are updated monthly from February to May, and again in October. Prior to February, the previous water year type from the October update is in effect. See Table 2.

[9] Total demand before reduction is equal to 2032 projected demand without reduction (197,479 ac-ft (NID, 2011)) + environmental flow requirements.

[10] Supply Shortage is the total supply divided by the total demand before reduction

[11] Drought Action Stage, as defined by the Drought Contingency Plan adopted by the NID Board of Directors on November 18, 2015.

[12] Demand reduction, as required by the 2015 Drought Contingency Plan (NID, 2016, Appendix J).

[13] The Drought Contingency Plan actions apply based on forecasted water supply on April 1st each year. This volume represents the already-delivered portion of the 2032 projected demand reduced by the previous year's drought actions. On average 17% of the projected demand occurs from October through March.

[14] The Drought Contingency Plan actions apply based on forecasted water supply on April 1st each year. This volume represents the portion of the 2032 projected demand reduced by the current year's drought actions, using perfect foresight of carryover storage and Supply Shortage. On average 83% of the projected demand occurs from April through September.

[15] 2032 projected demand reduced by the drought demand reduction.

[16] Shortage is equal to the total supply minus total demand with reduction.

3.0 Step 2 - Projected Extreme Hypothetical Drought with Climate Change

The first step described in the previous section updated the extreme hypothetical drought scenario, first presented in the RWMP and shown in Table 1, assuming a 50% reduction in runoff during the historic worst three-year drought on record (as of 2011). The second step described below, incorporates revised drought hydrology representative of 2032 climate change conditions. To modify this analysis for climate change, watershed runoff and environmental flow requirements were revised.

3.1 Watershed Runoff

Current climate change science indicates that the frequency and severity of droughts in California will likely increase (Griffin and Anchukaitis 2014; Cook, Ault, and Smerdon 2015; Pagan et al. 2015). The effects of climate change on historical hydrology were recently quantified by the California Water Commission (CWC) for the Water Storage Investment Program (WSIP) using the Variable Infiltration Capacity (VIC) model for 1995, 2030 and 2070 (CWC 2016). NID previously developed historical unimpaired hydrology data during FERC relicensing of NID's Yuba-Bear Hydroelectric Project for the period of water years 1976 to 2008 (NID 2012). To characterize climate changed watershed runoff under 2032 conditions, historical unimpaired hydrology were modified using VIC model results. Monthly ratios were produced for each unimpaired hydrology sub-basin relating 2030 VIC output to 1995 VIC output. Ratios were applied as multipliers to the daily unimpaired hydrology on a monthly basis. Watershed runoff was quantified using these data for each water year in the 33-year period of record. These results were used to characterize climate change hydrology in 2032, assuming little to no difference between 2030 and 2032 conditions. Average annual watershed runoff representative of 2032 conditions for water years 1976 through 2008 is 395,500 ac-ft per year, ranging from a minimum of 33,300 in water year 1977 to 918,900 in water year 1983. Quantification of watershed runoff includes the Middle Yuba River above Milton Diversion, Canyon Creek above Bowman Dam, Texas, Clear, Fall, Trap, Rucker creeks above the Bowman-Spaulding Canal, the Bear River subject to PG&E's senior water rights, and Deer Creek above Scotts Flat Reservoir.

Instead of using the previous methodology from the RWMP of reducing watershed runoff for the three driest consecutive years by half, the climate change analysis utilizes watershed runoff for the driest three years available in the 1976 through 2008 period of record based on VIC modified watershed runoff, representative of 2032 conditions: water years 1976 (88,300 ac-ft), 1977 (33,300 ac-ft) and 1994 (114,650 ac-ft). These three years were arranged from dry to driest, and represent a 3-year drought with approximately a 1 in 400 year recurrence (a probability of 0.0025) based on historical tree ring reconstructed hydrology for the Sacramento River (Meko, 2001). Even though this drought is less severe statistically than the 3-year drought presented in Table 3 and in the RWMP, Year 3 (1977) is more extreme in this scenario. Water year 1977 has a single drought year recurrence of approximately 1 in 130 years (a probability of 0.008), based on tree ring reconstructed hydrology. For NID's current and future planning purposes, a multi-year drought with a recurrence of 1 in 400 years provides a more plausible scenario than a drought scenario with a recurrence of greater than 1 in 1,000 year. This drought also utilizes the CWC's statewide accepted and adopted WSIP VIC model, which provides relevant and applicable climate change methodology. Therefore, this updated drought scenario provides a more conservative and refined basis for NID's future water supply planning and management.

3.2 Environmental Flow Requirements

Water year types were determined based on climate changed watershed runoff for 1994, 1976 and 1977. For this analysis, Water year types were updated in the month of April. Under this scenario the year prior to 1994 is classified as Above Normal, 1994 is classified as Critically Dry, and both 1976 and 1977 are classified as Extremely Critical (see Table 2).

3.3 Extreme Hypothetical Drought Analysis with Climate Change

An updated extreme hypothetical drought scenario with projected 2032 climate change hydrology is shown in Table 4. Even though this drought scenario is less severe statistically than the 3-year drought presented in Table 3 and in the RWMP, Year 3 (1977) is more extreme in this scenario, resulting in similar third year deficits.

Shortages in this updated scenario were avoided in 1994 and 1976 following demand reduction guidelines mandated in the Drought Contingency Plan. In the third year, 1977, shortages were unavoidable. The table shows that there wasn't enough carryover storage remaining to meet demands, even with demand reductions of 25 percent in the second year and 50 percent in the third year. A demand reduction of 77% in the third year or an increase in carryover storage greater than 50,000 ac-ft at the onset of the drought would have been necessary to fully eliminate the remaining deficit. Under each of these alternative scenarios, there would not have been any usable carryover storage remaining in the event of additional drought years beyond year 3.

Table 4. Summary of climate change hydrology based extreme hypothetical drought with 2032 demands analysis.

Analysis Variable	Avg. Year	Hypothetical Drought		
		1994	1976	1977
Watershed Runoff (ac-ft) [1]	395,500	114,650	88,300	33,300
Available Carryover Storage (ac-ft) [2,3]	113,200	113,200	58,750	13,550
Contract Purchases from PG&E (ac-ft) [4]	7,500	37,300	31,750	26,850
Recycled Water (ac-ft) [5]	3,000	3,000	3,000	3,000
Total Supply (ac-ft) [6]	*519,200*	*268,150*	*181,800*	*76,700*
Projected 2032 demands (ac-ft) [7]	*197,500*	*197,500*	*197,500*	*197,500*
Environmental flow requirements (ac-ft) [8]	46,200	28,300	15,100	13,600
Total Demand before Reduction (ac-ft) [9]	*243,700*	*225,800*	*212,600*	*211,100*
Supply Shortage [10]	0%	0%	14%	64%
Drought Action Stage [11]	-	I	II	IV
Drought Demand Reduction [12]	0%	10%	25%	50%
Oct-Mar 2032 Projected Demand with Previous Year Reduction (ac-ft) [13]	33,650	33,650	30,300	25,250
Apr-Sep 2032 Projected Demand with Reduction (ac-ft) [14]	163,800	147,450	122,850	81,900
Total Demand with Reduction (ac-ft) [15]	*243,650*	*209,400*	*168,250*	*120,750*
Shortage With Reductions and Contract Purchases (ac-ft) [16]	**0**	**0**	**0**	**-44,050**

[1] Average climate changed watershed run-off representative of 2032 conditions for 1976 – 2008 includes Middle Yuba River above Milton Diversion, Canyon Creek above Bowman Dam, Texas, Clear, Fall, Trap, Rucker creeks above the Bowman-Spaulding Canal, Bear River subject to PG&E's senior water rights, and Deer Creek above Scotts Flat Reservoir. The analysis does not include the South Yuba River due to hydrologic and water rights consideration. 1994, 1976, and 1977 historical runoff adjusted for climate change using VIC multipliers.

[2] 113,200 is the average annual net (not including dead storage) carryover storage, plus 5,900 ac-ft for additional environmental flows.

[3] Carryover storage represents conditions at beginning water year and is calculated as the previous year's carryover storage plus the previous year's total supply minus the previous year's total demand with reduction.

[4] Assumes pending coordinated operations agreement between PG&E and NID is in effect. Availability is subject to hydrologic conditions.

[5] Projected municipal recycled water supply from 2015 UWMP.

[6] Total supply is equal to watershed runoff + available carryover storage + contract purchases from PG&E + recycled water.

[7] Projected agricultural, municipal, and institutional demands from 2015 RWMP, Table 4-6.

[8] Water Year types are based NID's Yuba-Bear and PG&E's Drum-Spaulding hydroelectric projects proposed water year types, as accepted by FERC in the Final Environmental Impact State for Hydropower License (FERC/EIS-F-0244, December 2014). Environmental flow requirements are based on Above Normal water year type requirements in the average year, Critically Dry water year type requirements in Years 1, and Extremely Critically Dry water year type requirements in Years 2 and 3. Water year types are updated beginning in February. Prior to February, the previous water year is in effect.

[9] Total demand before reduction is equal to 2032 projected demand without reduction (197,479 ac-ft (NID, 2011)) + environmental flow requirements.

[10] Supply Shortage is the total supply divided by the total demand before reduction

[11] Drought Action Stage, as defined by the Drought Contingency Plan adopted by the NID Board of Directors on November 18, 2015.

[12] Demand reduction, as required by the 2015 Drought Contingency Plan

[13] The Drought Contingency Plan actions apply based on forecasted water supply on April 1st each year. This volume represents the already-delivered portion of the 2032 projected demand reduced by the previous year's drought actions. On average 17% of the projected demand occurs from October through March.

[14] The Drought Contingency Plan actions apply based on forecasted water supply on April 1st each year. This volume represents the portion of the 2032 projected demand reduced by the current year's drought actions, using perfect foresight of carryover storage and Supply Shortage. On average 82% of the projected demand occurs from April through September.

[15] 2032 projected demand reduced by the drought demand reduction.

[16] Shortage is equal to the total supply minus total demand with reduction.

4.0 Sources of Uncertainty

Climate change hydrology used to develop the updated extreme hypothetical drought presented in Table 4 is based on an average of twenty climate change scenarios developed from ten different global circulation models, all of which predict different levels of climate change impact, ranging from drier with extreme warming to wetter with moderate warming (California Water Commission 2016). By averaging different model results, a reasonable value can be reached, but it is one that lacks the extremes found in individual model results. Climate projections from individual climate change models may predict more extreme droughts than what was used in this analysis.

This analysis assumes current (2017) projections of water management practices, including carryover storage requirements and drought contingency planning. A reduction of snowpack in average years is predicted due to climate change along with a shift in runoff timing to early winter months resulting in additional stress on reservoir storage (DWR 2015). More conservative water management practices may be needed in the future to mitigate the impacts of runoff timing and magnitude due to climate change.

Uncertainty of other assumptions in the analysis has the potential to increase projected deficits. PG&E contract purchases are subject to water availability. In the third year of a consecutive 3-year drought, the amount of water available from PG&E cannot be accurately predicted. To be conservative, it was assumed that the full contract amount would be available. Another assumption in this analysis is that the drought actions will be implemented exactly as requested by NID customers. In reality, it is not certain that the requested reductions in demand would be met.

Another source of uncertainty is projected customer demand. Customer demand is forecast in NID's RWMP (NID 2011) through 2032. Demand estimates are based on assumptions of population growth rates, land use, and conservation within NID's service area. Projected demands include a customer conservation rate of 20% by 2020, as mandated by the 20x2020 Water Conservation Act (SBx7 7). Customer demand uncertainty can come from many sources, including:

- Population growth rate
- Land use changes
- State or Federally imposed conservation targets
- Expansion of marijuana cultivation resulting from passage of California Proposition 64

It is NID's goal to continue to provide a dependable, quality water supply to its customers into the future acknowledging that there is uncertainty in both supply and demand.

5.0 Conclusions

The updated extreme hypothetical drought with climate change presented in this document (Table 4) is an update to the analysis first presented in Phase II of the RWMP (NID 2011). It includes projected increases to environmental flow requirements, an updated Drought Contingency Plan, and revised hydrology representative of 2032 climate conditions using the best available climate science. This document can and should be used as a reference for NID’s future water supply planning documents and projects. The results of this updated analysis clearly demonstrate the need for additional, reliable water supply within NID’s system, given the anticipation of more frequent and severe multi-year droughts projected under climate change (Griffin and Anchukaitis 2014; Cook, Ault, and Smerdon 2015; Pagan et al. 2015). .

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Appendix B. NID Drought Management Plan

NEVADA IRRIGATION DISTRICT
Drought Contingency Plan

(Adopted by the Board of Directors, November 18, 2015)

The purpose of the Nevada Irrigation District's Drought Contingency (Plan) is to provide guidance to staff and customers to help minimize drought or water supply shortage impacts. The plan identifies drought action levels, appropriate agency responses, water demand reduction goals, and provides recommended demand management measures to assist customers in water conservation.

The District currently supplies about 150,000 acre feet (AF) of water for all classes of customers, and has non-recoverable in stream flow requirements of 7,700 AF. Historically, 7,500 AF of water is purchased from PG&E annually and is required to provide reliable flows in the system and meet District operational needs. The District has determined 78,000 AF of carry over storage to be the minimum amount of water that the District will endeavor to hold over from water season to water season for the health and safety of the District domestic and agricultural water users. The minimum carryover amount will be evaluated every five years and will be updated as deemed necessary by the District.

Prior to the beginning of the irrigation season, but no later than the first board meeting in April, the District will evaluate its forecasted water supply to determine what water supply stage will apply during the year. In order to effect the most current information the March snow survey results, current reservoir levels, forecasted runoff, and availability of PG&E contract water (Contract) will be analyzed to make a preliminary determination of the District's water supplies

The mandatory reduction measures implemented through this plan are designed to preserve minimal supplies for public health and safety. Mandatory reduction stages will trigger the formation of the Drought Hardship Committee whose purpose is to review hardship applications and determine whether additional water can be provided to the applicants with an economic hardship and/ or those utilizing best management practices.

In the event the State Water Resources Control Board imposes regulations that differ from the regulations in this plan, the District may impose additional mandated restrictions through the resolution process to comply.

Water Availability Guidance

	Forecasted Available Supply April 1st	Demand Reduction Targets	Operational Changes	Rate Changes
Normal Operations	> 235,700	Encourage Conservation	Normal Operation	Standard Rates
Stage 1	235,700 to 205,700	10 – 20% Voluntary Usage Reduction	• Leak repair receives higher priority • Increase public outreach and drought awareness • Target 75% of end of month October storage for carryover.	Standard Rates
Stage 2	205,700 to 198,200	10 – 25% Mandatory Usage Reduction	• Communicate mandatory reduction targets to retail customers • Purchase of available Contract water to achieve a target carryover of 90,000 acre feet • Distribution system flushing only for public health & safety • Organize Drought Hardship Committee	• Implement Contract water purchase rates to reimburse the District for the costs associated with purchase of water above the 7,500 acre feet for normal operational needs. Charges to be reimbursed through the appropriate funding mechanisms. Water purchased will be utilized to meet carryover target.
Stage 3	198,200 to 175,700	25 - 40% Mandatory Usage Reduction	• Purchase of available Contract water to achieve a target carryover of 80,000 acre feet	• Implement Contract water purchase rates • Implement Conservation Rates as established in the Districts Rate Schedule
Stage 4	<175,700	> 40% Mandatory - Reductions based on available allotment and target carryover.	• Purchase full allotment of Contract water to achieve target carryover of 78,000 acre feet	• Implement Contract water purchase rates • Implement Conservation Rates as established in the Districts Rate Schedule

Stage 1

(Voluntary 10 to 20%)

Treated Water and Municipal Water Customer Reduction Actions

- Customers shall comply with the Conservation Regulations as spelled out in section 3.05 of the Districts Rules and Regulations
- Request restaurant owners to only serve water upon request
- Limit fire department practice drills and flow testing of hydrants

Ag Water Reduction Actions

- Allow Ag customers to voluntarily reduce purchase allotment for the year while reserving their right to return to their previous purchase allotment in the following year if water supply is available
- Declare no new or increased Surplus water availability
- Limit new raw water sales and increases to 1 miners inch

District Actions

- Increase public outreach to inform customers of reduction targets
- Target 75% of historical end of month October storage for carryover.
- Limit District flushing program to areas required by regulation or as needed for public health and safety
- District leak repair receives higher priority
- Inform Municipal customers of the reduction targets

Stage 2

(Mandatory 10 – 25%)

All of Stage 1 recommendation shall remain in place, except where they are replaced by more restrictive actions in this stage

Treated Water and Municipal Water Customer Reduction Actions

- Customers shall limit outdoor water use to every other day
- Customers shall adjust outdoor water timers to reduce each watering zone by the target reduction percentage (10 - 25%)
- Large landscapes with treated water accounts shall reduce their usage by the target reduction percentage (10 - 25%)
- Corresponding with the fall daylight savings time change, customers shall limit outdoor watering to 1 day a week.
    - Saturdays for even addresses and Sundays for odd addresses.

Ag Water Reduction Actions

- Declare no Surplus water availability to outside District customers
- Limit new raw water sales and increases to ½ miners inch
- Impose Irrigation season delivery alternatives with a target reduction of 10 - 25%
- Declare no new or increase fall or winter water sales

District Actions

- Inform Municipal customers of the reduction targets of 10 - 25%
- Purchase available Contract water to achieve a minimum target carryover storage of 90,000 acre feet for the end of October
- Implement Contract water purchase rates through the appropriate funding mechanism to cover procurement costs
- Organize Drought Hardship Committee

Stage 3

(Mandatory 25 – 40%)

All of Stage 2 restrictions shall remain in place, except where they are replaced by more restrictive actions in this stage

Treated Water and Municipal Water Customer Reduction Actions

- Outdoor watering shall be limited to three days a week
    - Customers with an even - numbered street address shall limit watering to Tuesday, Thursday, and Saturday.
    - Customers with an odd - numbered street address shall limit outdoor watering to Wednesday, Friday, and Sunday
- Customers shall adjust outdoor water timers to reduce each watering zone by the target reduction percentage (25 - 40%)
- Large landscapes with treated water accounts shall reduce their usage by the target reduction percentage (25 - 40%)
- Irrigation of ornamental turf on public street medians with potable water shall be prohibited

Ag Water Reduction Actions

- Declare no Surplus water availability
- Declare no new or increased Ag water sales
- Impose Irrigation season delivery alternatives with a target reduction of 25 - 40%
- Declare no fall water availability

District Actions

- Purchase available Contract water to achieve a minimum target carryover storage of 80,000 acre feet for the end of October
- Dedicate additional staff hours for water waste notification and patrolling
- Implement conservation rates as established in the Districts rates schedule

Stage 4

(Mandatory > 40%)

All of Stage 3 restrictions shall remain in place, except where they are replaced by more restrictive actions in this stage

Treated Water and Municipal Water Customer Reduction Actions

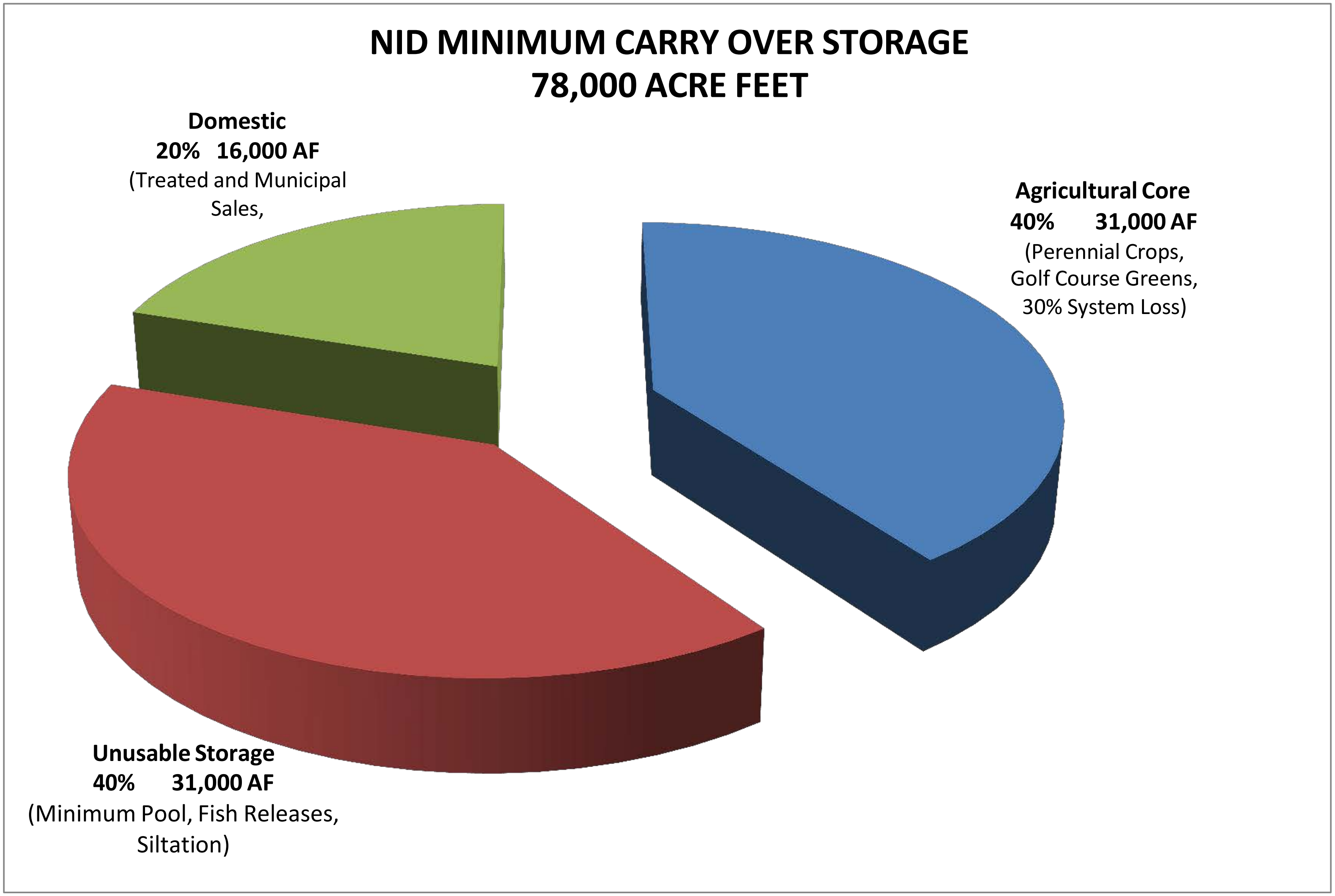
- Outdoor watering shall be limited to two days a week
    - Customers with an even – numbered street address shall limit outdoor watering to Wednesday and Saturday.
    - Customers with an odd - numbered street address shall limit outdoor watering to Thursday and Sunday
- Customers shall adjust outdoor water timers to reduce each watering zone by the target reduction percentage (40%)
- Large landscapes with treated water accounts shall reduce their usage by the target reduction percentage (>40%)

Ag Water Reduction Actions

- Impose Irrigation season delivery alternatives with a target reduction of >40%

District Actions

- Purchase available Contract water to achieve a minimum target a carryover storage of 78,000 acre feet for the end of October


NID MINIMUM CARRY OVER STORAGE
78,000 ACRE FEET
Domestic
20% 16,000 AF
(Treated and Municipal
Sales,
Agricultural Core
40% 31,000 AF
(Perennial Crops,
Golf Course Greens,
30% System Loss)
Unusable Storage
40% 31,000 AF
(Minimum Pool, Fish Releases,
Siltation)

DROUGHT HARDSHIP COMMITTEE AND VARIANCES

During implementation of a mandatory reduction stage of the Drought Contingency Plan, the Board of Directors of the Nevada Irrigation District may appoint a Drought Hardship Committee. The Drought Hardship Committee is an advisory body and shall consist of one appointee from each director's division and the Water and Hydroelectric Operations (WHO) Board Committee. District Operation's staff will work closely with the committee.

The Drought Hardship Committee's purpose is to review the applications and determine whether additional water can be provided to the applicant. Before any appeal for a variance can be heard by the Drought Hardship Committee, the customer must submit a Drought Hardship Application and provide proof the water is being used for commercial agricultural purposes.

For the purposes of this Plan, the definition of commercial agriculture is an agricultural producer engaged in a for profit operation with a minimum gross annual sales of $3,000 and a minimum capital investment of $15,000. Commercial agricultural producers file a Schedule F with the Internal Revenue Service for their farming or ranching operation.

Preference will be given to applicants with an economic hardship and/ or those utilizing best management practices and with efficient irrigation practices in place. Variances may be approved for increases in water deliveries, seasonal variances or other protocols as determined by the Drought Hardship Committee. No such variance or appeal, however, shall be granted if the Board of Directors finds that the variance or appeal will adversely affect the public health or safety of others and is not in the public's best interest.

Under the California Water Code, in critical water supply situations, there is a priority that shall be allocated as follows:

1. Human Consumption
2. Livestock and Animals
3. Perennial Crops
4. Annual Crops

Upon granting a Drought Hardship Variance or appeal, the Board may impose any other conditions it deems to be just and proper.

APPLICATION FOR DROUGHT HARDSHIP

Name:		**Canal:**	
Address			
Parcel No.:		Phone No.:	
Land Utilization:	Map Attached	Yes	No
Livestock (number of)		Stock water needs:	Yes or No
Cattle	Horses		
Sheep	Other		
Hogs			

Crop	**Acres Planted**	**Amount Water Applied**	**Period of critical water need**	**Method of Irrigation**
Pasture				
Orchard				
Rice				
Other				
Total acres of land irrigated at location:				

	Year	**Miners Inches**
Water Purchase		
Allocated		
Is property within Nevada Irrigation District boundaries?	Yes	No
Do you have proof the water is being used for commercial agricultural purposes	Yes	No
Statement by landowner of hardship		
Intended use of additional water by landowner		
Describe efficient irrigation practices in use		
Do you file a Schedule F with the Internal Revenue Service? Yes or No		

Please attach separate sheet for any additional information. Fraudulent statements will result in loss of water purchase.
I certify the above statements to be true and factual to the best of my knowledge.

Signed____Date_______________

Appendix C. Alternative 5-Year Drought Based on the Five-Consecutive Driest Years in the 1976-2011 Period of Record

Memo

Date: Tuesday, October 06, 2020

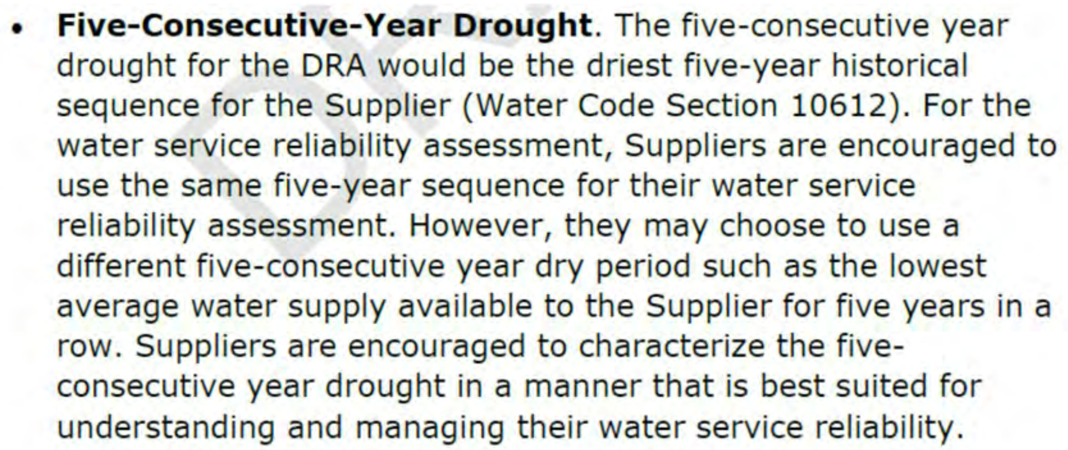
Project: Water Supply Analysis TM

To: Doug Rodderick, NID

From: Megan Lionberger, P.E. and Sergio Jimenez, P.E.

Subject: Alternative 5-year drought based on the five-consecutive driest years in the 1976-2011 period of record

DWR recently released its Urban Water Management Plan draft guidebook for public review. The guidebook directs urban water suppliers to include a water service reliability assessment for a normal year, a single dry year and a five-consecutive-year drought. The following screenshot from the guidebook describes the definition of a five-year drought. While it directs the water supplier to use the driest five-year sequence within the historical period of record, DWR will allow suppliers to characterize the five-year drought differently.



- **Five-Consecutive-Year Drought**. The five-consecutive year drought for the DRA would be the driest five-year historical sequence for the Supplier (Water Code Section 10612). For the water service reliability assessment, Suppliers are encouraged to use the same five-year sequence for their water service reliability assessment. However, they may choose to use a different five-consecutive year dry period such as the lowest average water supply available to the Supplier for five years in a row. Suppliers are encouraged to characterize the five-consecutive year drought in a manner that is best suited for understanding and managing their water service reliability.

From Section 7.7.7.1, https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans/Draft-2020-UWMP-Guidebook.pdf?la=en&hash=266FE747760481ACF779F0F2AAEE615314693456

NID asked HDR to modify the 5-year drought recently developed for the Water Supply Analysis Technical Memorandum (TM), presented as Table 3-1, to use the 5-consecutive driest years in the 1976-2011 2070 Median climate change hydrologic period of record. Figure 1 shows the 5-year running average watershed runoff. The five driest consecutive years are 1987 through 1991. Year types for these 5 years based on the Smartsville Index are 1987 - critically dry, 1988 - dry, 1989 - above normal, 1990 - dry, and 1991 – dry.

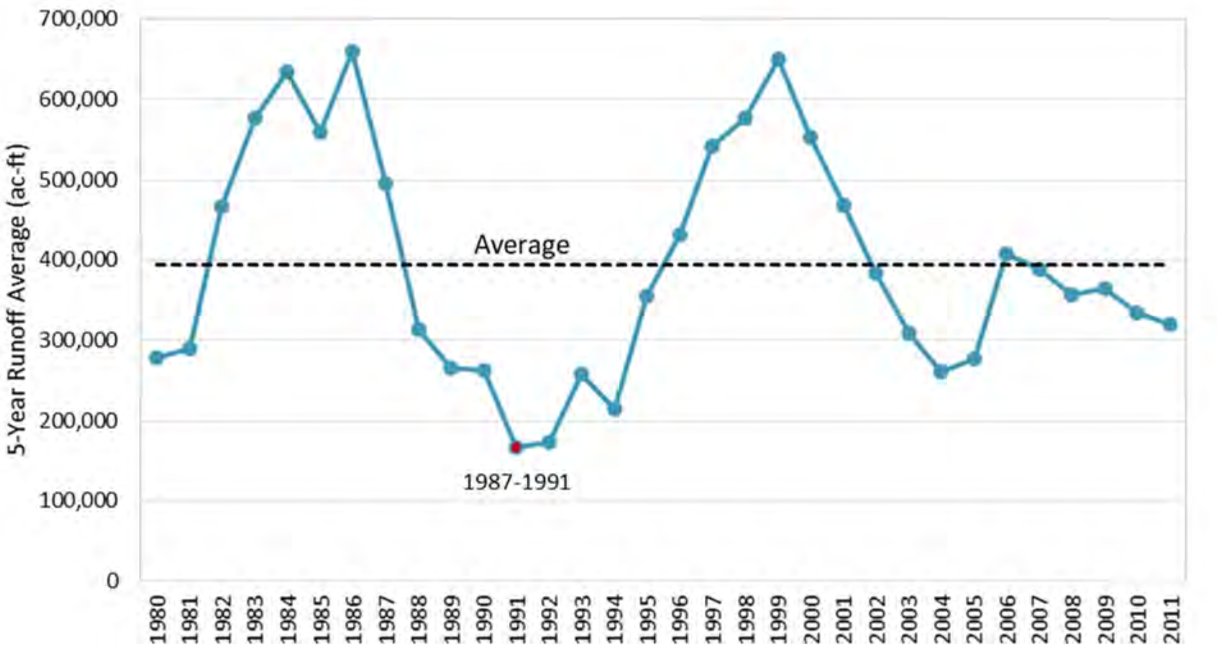


Figure 1. Running five-year average water runoff, showing the 1987-1991 five-year minimum.

The analysis presented in Table 3-1 of the Supply TM was updated using consecutive Water Years 1987 through 1991, shown in Table 1, below. In addition to watershed runoff, environmental flow requirements and PG&E contract purchase values were also updated. An assessment of the total annual supply indicated that the first year, 1987, was in drought stage I of the NID drought management plan, with a voluntary usage reduction of 10-20%. Assuming a 10% reduction in usage in year 1, year 2, 1988, was a drought stage 4, requiring a 40% usage reduction. Year 2 was the only year in analysis resulting in a water supply shortage. Year 3, an above normal Water Year essentially resets the system resulting in a higher than average carryover storage going into year 4, assuming no runoff is lost to spill. 1990 and 1991 are both moderately dry years, relative to the first two year in the drought analysis. Runoff in these years, in combination with the higher than average initial carryover storage results in adequate supply to meet full deliveries in the last two years of the 5-year drought.

Table 2. Summary of 2070 5-Year Drought Water Supply, assuming conditions in consecutive Water Years 1987 through 1991.

Analysis Variable	Avg. Year	Hypothetical 5-Year Drought				
		1987	1988	1989	1990	1991
Watershed Runoff (ac-ft) [1]	383,500	97,200	95,200	315,900	158,200	166,700
Available Carryover Storage (ac-ft) [2,3]	87,500	87,500	8,120	0	118,215	72,279
Contract Purchases from PG&E (ac-ft) [4]	7,500	38,100	32,200	34,900	30,500	30,900
Recycled Water (ac-ft) [5]	5,300	5,300	5,300	5,300	5,300	5,300
Total Supply (ac-ft) [6]	***483,800***	***228,100***	***140,820***	***356,100***	***312,215***	***275,179***
Environmental Flow Requirement (ac-ft) [7]	46,200	27,900	24,000	45,100	31,000	27,000
Total Demand Before Reduction (ac-ft) [8]	255,136	236,836	232,936	254,036	239,936	235,936
Drought Action Stage [9]	-	I	IV	-	-	-
Drought Demand Reduction [9]	0%	10%	40%	0%	0%	0%
Total Demand with Reduction (ac-ft) [8]	255,136	219,980	161,475	237,885	239,936	235,936
Water Supply Shortage (ac-ft) [10]	0	0	-20,655	0	0	0

1 Period of Record average and Water Years 1987-1991 watershed run-off are based on results of the Hydrologic Analysis TM under median climate change conditions, per NID water rights (see Section 2.1 of the Water Supply TM).
2 Average available carryover storage is usable storage simulated by the HEC-ResSim model (average October 15 carryover storage minus 9,218 ac-ft dead storage) based on FERC FEIS minimum flows, 2060 projected demands from the Raw Water Demand Model Update, and 2070 median climate change hydrology developed in the Hydrologic Analysis TM.
3 Carryover storage represents conditions at beginning water year and is calculated as the previous year's carryover storage plus the previous year's total supply minus the previous year's total demand with reduction.
4 Estimates are based on Appendix B of the Coordinated Operations Agreement. Availability is subject to hydrologic conditions.
5 Projected municipal recycled water supply from 2015 UWMP.
6 Total supply is equal to watershed runoff + available carryover storage + contract purchases from PG&E + recycled water.
7 Environmental flow requirements are based the Smartsville Index and historical DWR Bulletin 120 data.
8 Total demand is equal to customer demand + environmental flow requirement.
9 Based on NID's 2015 Drought Management Plan.
10 Total Supply minus the total demand with reduction, if less than 0.

Appendix D. Alternative 5-Year Drought Based on the Repeated Average of the Five-Consecutive Driest Years in the 1976-2011 Period of Record

Memo

Date: Tuesday, October 06, 2020

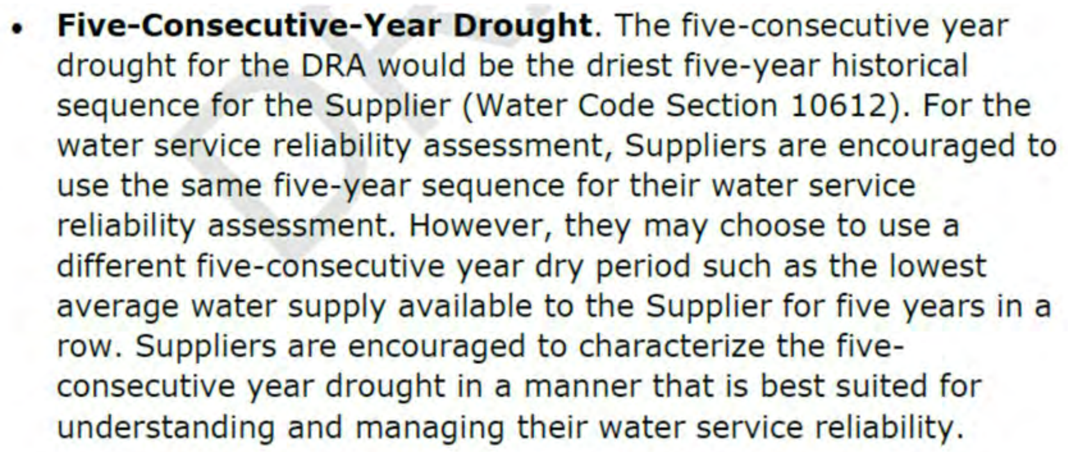
Project: Water Supply Analysis TM

To: Doug Rodderick, NID

From: Megan Lionberger, P.E. and Sergio Jimenez, P.E.

Subject: Alternative 5-year drought based on the repeated average of the five-consecutive driest years in the 1976-2011 period of record

DWR recently released its Urban Water Management Plan draft guidebook for public review. The guidebook directs urban water suppliers to include a water service reliability assessment for a normal year, a single dry year and a five-consecutive-year drought. The following screenshot from the guidebook describes the definition of a five-year drought. While it directs the water supplier to use the driest five-year sequence within the historical period of record, DWR will allow suppliers to characterize the five-year drought differently.



- **Five-Consecutive-Year Drought**. The five-consecutive year drought for the DRA would be the driest five-year historical sequence for the Supplier (Water Code Section 10612). For the water service reliability assessment, Suppliers are encouraged to use the same five-year sequence for their water service reliability assessment. However, they may choose to use a different five-consecutive year dry period such as the lowest average water supply available to the Supplier for five years in a row. Suppliers are encouraged to characterize the five-consecutive year drought in a manner that is best suited for understanding and managing their water service reliability.

From Section 7.7.7.1, https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans/Draft-2020-UWMP-Guidebook.pdf?la=en&hash=266FE747760481ACF779F0F2AAEE615314693456

NID asked HDR to modify the 5-year drought recently developed for the Water Supply Analysis Technical Memorandum (TM), presented as Table 3-1, to use the repeated average of the 5-consecutive driest years in the 1976-2011 2070 Median climate change hydrologic period of record. Figure 1 shows the 5-year running average watershed runoff. The five driest consecutive years are 1987 through 1991. Year types for these 5 years based on the Smartsville Index are 1987 - critically dry, 1988 - dry, 1989 - above normal, 1990 - dry, and 1991 – dry.

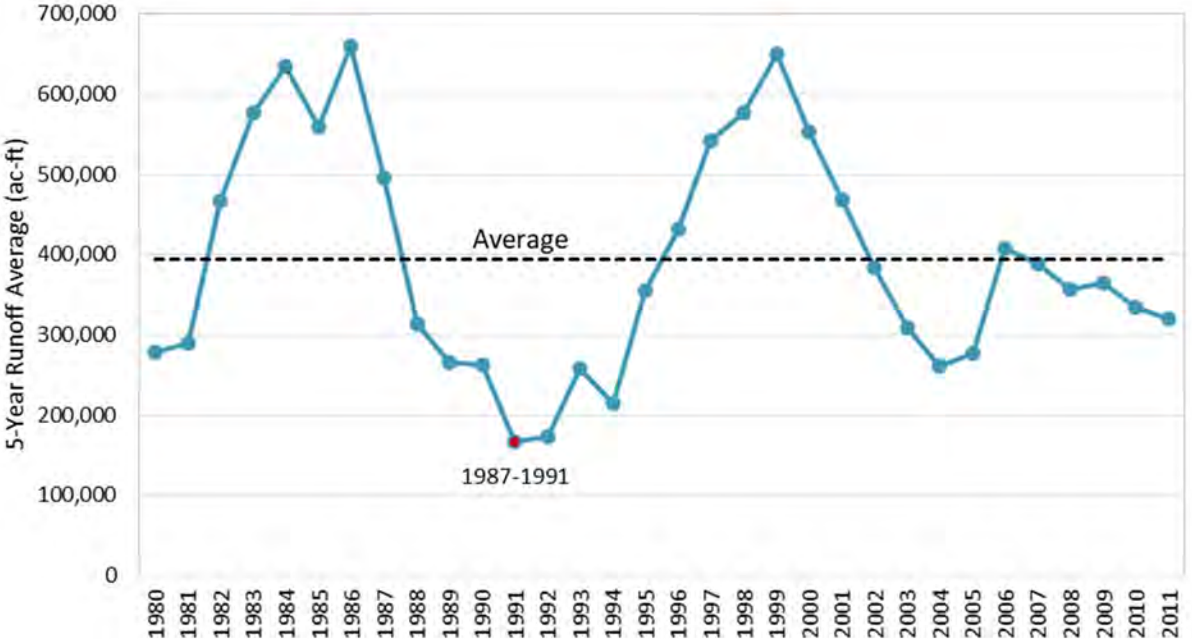


Figure 1. Running five-year average water runoff, showing the 1987-1991 five-year minimum.

The analysis presented in Table 3-1 of the Supply TM was updated using the average watershed runoff for 1987 through 1991 for each year of the drought, shown in Table 1, below. In addition to watershed runoff, environmental flow requirements and PG&E contract purchase values were also updated. The average environmental flow requirement and PG&E contract purchase for Water Years 1987-1991 were assumed for each year of the analysis. An assessment of the total annual supply indicated that the first two years of the drought had sufficient supply for normal operations with no demand reduction requirements. Year 3 available supply results in drought stage I of the NID drought management plan, with a voluntary usage reduction of 10-20%. Assuming a 10% reduction in usage in Year 3, Year 4 available supply results in a drought stage 2, requiring a 10-25% usage reduction. A 15% reduction in usage was assumed. Carryover storage was completely exhausted by the end of Year 4 resulting in a water supply shortage of approximately 5,000 ac-ft. The available supply in Year 5 results in a second year of drought stage 2, and a 15% reduction in usage was similarly applied resulting in a water supply shortage of approximately 3,000 ac-ft.

Table 2. Summary of 2070 5-Year Drought Water Supply, assuming average 1987 through 1991 conditions.

Analysis Variable	Avg. Year	Hypothetical 5-Year Drought				
		Year 1	Year 2	Year 3	Year 4	Year 5
Watershed Runoff (ac-ft) [1]	383,500	166,640	166,640	166,640	166,640	166,640
Available Carryover Storage (ac-ft) [2,3]	87,500	87,500	52,824	18,148	328	0
Contract Purchases from PG&E (ac-ft) [4]	7,500	33,320	33,320	33,320	33,320	33,320
Recycled Water (ac-ft) [5]	5,300	5,300	5,300	5,300	5,300	5,300
Total Supply (ac-ft) [6]	***483,800***	***292,760***	***258,084***	***223,408***	***205,588***	***205,260***
Environmental Flow Requirement (ac-ft) [7]	46,200	31,000	31,000	31,000	31,000	31,000
Total Demand Before Reduction (ac-ft) [8]	255,136	239,936	239,936	239,936	239,936	239,936
Drought Action Stage [9]	-	-	-	I	II	II
Drought Demand Reduction [9]	0%	0%	0%	10%	15%	15%
Total Demand with Reduction (ac-ft) [8]	255,136	239,936	239,936	223,080	210,615	208,596
Water Supply Shortage (ac-ft) [10]	0	0	0	0	-5,027	-3,336

[1] Period of record average, and Water Years 1987-1991 average watershed run-off are based on results of the Hydrologic Analysis TM under median climate change conditions, per NID water rights (see Section 2.1 of the Water Supply TM).

[2] Average available carryover storage is usable storage simulated by the HEC-ResSim model (average October 15 carryover storage minus 9,218 ac-ft dead storage) based on FERC FEIS minimum flows, 2060 projected demands from the Raw Water Demand Model Update, and 2070 median climate change hydrology developed in the Hydrologic Analysis TM.

[3] Carryover storage represents conditions at beginning water year and is calculated as the previous year's carryover storage plus the previous year's total supply minus the previous year's total demand with reduction.

[4] Estimated 1987-1991 average contract purchases from PG&E. Estimates based on Appendix B of the Coordinated Operations Agreement. Availability is subject to hydrologic conditions.

[5] Projected municipal recycled water supply from 2015 UWMP.

[6] Total supply is equal to watershed runoff + available carryover storage + contract purchases from PG&E + recycled water.

[7] Estimated 1987-1991 average environmental flow requirement, based the Smartsville Index and historical DWR Bulletin 120 data.

[8] Total demand is equal to customer demand + environmental flow requirement.

[9] Based on NID's 2015 Drought Management Plan.

[10] Total Supply minus the total demand with reduction, if less than 0.

Water Planning Projections (FATR #1041)

Public Questions & Answers

NID

Water for Life

Water Planning Projections

All Questions Submitted by Public with Answers

Q1. Why is it that none of the upper division dams, conveyances and reservoirs are mentioned in the Water Demand Model? What about environmental demand in the upper division?

A1. The upper division facilities are supply facilities and don't have customers that consume water. As a result, these facilities are not included in the Demand TM. You will find them in the Supply TM. The environmental demand is included in the Demand TM and is summarized in that document on page 25.

Q2. According to the Dept. of Finance Regional Census Data, (cited in the report), Nevada County had a loss of 650 people during the last decade. Since 80% of the District is within Nevada County, (4 of the 5 Divisions), that had a net loss of population over the last decade, **why does the model project raw water demand increases of 44% over 40 years for the Deer Creek System and 36% increase for the Bear River System?** The factors leading to these outcomes and the weight given to each factor need to be specifically listed and clearly explained.

A2. Population projections are just one of the components of the demand factor. NID agrees that general population projections for the Nevada County portion of the District are relatively flat. However, NID's demand factors also look at new hook ups from existing parcels, which are growing, for example between 2000-2020 NID has added 3,329 new connections. Capital improvements on "moratorium" canals also add additional capacity and customer use. In addition, the model takes into account the potential for feasible future service areas (soft service areas).

Q3. How do you justify the validity of using soft service areas, canal capacity, parcel data, and arable land base to determine future need when we live in such unpredictable times with pandemic caused economic recession, catastrophic wildfires, rolling blackouts, and public safety power shut offs? We cannot count on business as usual for total "potential demand" **How does NID account for these significant and unpredictable future events? What weight do you give this complicated and increasingly baseless estimate?**

A3. The Nevada Irrigation District views the Water Planning Projections as a long term planning tool built to look at long term trends. It is not intended to address short term impacts such as those mentioned above.

It is important to note however, the model is a living document and is adjustable. If NID finds a new trend that becomes important for long term planning, the model can be adjusted to consider new assumptions.

Q4. The minimum environmental flows below Rollins Dam are captured by Combie Reservoir. **Why are these flows considered lost to the system?**

A4. The flows below Rollins are captured by Combie and reused by NID so they are not considered lost to system. The flows below Combie are lost to District and included in the environmental flow calculation.

Q5. Where is the data demonstrating how much, where, and why the environmental flows are lost to the system?

A5. NID tabulates the amount of the environmental flow requirement that is unrecoverable. Locations include Middle Yuba below Milton diversion, Wilson Creek below Wilson Creek diversion, Canyon Creek below the Bowman Spaulding diversion, Texas Creek below the diversion, Clear Creek below the diversion, Fall Creek below diversion, Trap Creek below diversion, Rucker Creek below diversion, Bear River below Lake Combie, and Deer Creek below Scotts Flat.

Q6. When talking about the agreed upon environmental flows, it says "These minimum flows are not recovered and, therefore, factored into demand **estimations."** The Water Supply Memo Table 3-1 notes the environmental flow requirement again. **Is this subtracted again to determine the shortage?**

A6. Yes, it is. In the table you reference, the environmental flows have been backed out of the demand, so there is no double counting

Q7. Looking at P7 – 3rd paragraph under Section 4.2 **Why didn't we compare the last 10 years of actual data to the projected to confirm if the trend supports the correlation of these two single data points from 13 and 18 years ago?**

A7. Looking at the Demand TM section 4.2 – this section summarizes the model used in 2011 update. The current update also includes the last ten years with the several dry years that occurred. NID also looks at growth projections and the land use trends and how they affect the overall trends. Because NID works with assumptions in the model, the number would not necessarily correlate. This is why a high and low bracket is developed, so we can capture those scenarios.

Q8. Looking at Demand TM, Page 11 – 1st paragraph, how much water is associated with the PG&E and CDFW contracts?

A8. The PGE contract is a supply contract and the amount of water available in the agreement is variable, and based on current year hydrology. The maximum amount of water available from PG&E is 54,000 acre-feet however, a full allotment of water is rarely available. The California Department of Fish & Wildlife (CDFW) agreement stems from the acquisition of water rights for the development of the 1963 Hydroelectric Division, and include instream flow requirements. The environmental flows lost to the District include a minimum of 7,700 acre feet.

Q9. Demand TM, page 25 (4th paragraph) –Clarify if average flow or peak flow values are included in the Total Demand value.

A9. Both are calculated. Peak flows are used in future planning for infrastructure, such as conveyance systems, to size for future demand. The average flow is used to derive the total system demand and evaluate the adequacy of our existing supply. Average is used in the total demand value.

Q10. In the water demand projection model figure 3-3 shows dramatic population increases for Placer County. **Did this analysis separate out the NID District boundaries from the County?**

A10. The data was not broken out that way, rather we looked at zoning within the District by parcel not at county population growth in the Placer portion of NID.

Q11. What is the population growth in the NID portion of the County?

A11. The data was not broken out that way, rather we looked at zoning within the District by parcel not at county population growth in the Placer portion of NID.

Q12. What is the raw water projected demand in the NID portion of Placer County?

A12. The data was not broken out that way, rather we looked at zoning within the District by parcel not at county population growth in the Placer portion of NID.

Q13. Does the TM assume any expansion of NID service area in Placer County between2020-2060?

A13. It does assume some growth in the “soft service areas,” parcels within the District that may request water service from NID in the future, but it does not consider any changes to NID’s District boundary.

Q14. In the water demand projection model update table 6-3 shows a 10% increase in annual demand for every decade. According to NID records the actual demand from 2008 to 2017 decreased by 15%. **Why and how do you arrive at a 10% per decade increase over the next 40 years?**

A14. Looking at the Demand TM, Table 6-3 does show a ten percent increase. There is not a historical decrease in total demand. There is a decrease in potable water demand which is small component of the overall demand. Historically, there has been an overall increase in total demand driven by existing residents adding connections and greater use of raw water for irrigation purposes. Nearly 85% of NID’s deliveries are raw water, for irrigation use, so the demand numbers are not driven simply by population changes.

Q15. Why are there inconsistencies regarding the number of years projected in the various tables? Many projections are to the year 2060 and others are to the year 2070. There should be consistency.

A15. The NID numbers are consistent with census figures and the Dept. of Finance projections which go out to 2060. The NID Board has asked to see projections out 50 years, to 2070.

Q16. Referring to the "objective" stated in the Demand TM, at the top of page 8, "consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts," **please describe whether this means that the present TM uses the same assumptions regarding the rate of demand increase that NID's consultants used in previous demand analyses in 2005 and 2011,** except for new regulations and climate change impacts. **If there are other differences in the methodology of the 2020 demand projections and those in the previous analyses, please describe them.**

A16. There was no change to the methodology. The model has merely been updated with ten years of actual usage, the new Dept. of Finance growth projections, and the County land-use projections. NID has also incorporated the new environmental flow requirements from the FERC permitting process. These inputs will change the trends but not methodology.

Q17. In the Water Supply TM, Please describe which of the figures in Table 3-1 are modeled and which of them are calculated; if calculated, please describe the data sources and process of developing the calculations.

A17. In table 3-1 is the summary of 2070 five year drought water supply. It begins by summing up incremental supply sources. Then it sums up demand (the environmental flow and customer demand). Based on mass balance, it calculates both the updated carry over storage and shortages that result from the difference between supply and demand.

The only modeled number is the available carryover storage in the averaged year which is the starting condition in year one. Based on the reservoir operations model with the 2070 median hydrology, the updated 2060 demands, and the projected FERC environmental flows, we ran that for years 2006-2011. The carryover storage is what remained on 10 /15 for each year of model, the values were averaged together getting to the 7,500 number, the initial starting carryover storage for analysis.

Essentially in each year, the total supply is calculated and then based on the drought management plan, the demand is reduced according to the Drought Management Plan, action stages. The demand is reduced (except the environmental flows because they are fixed). Mass balance is then calculated in each year and updates the resulting carrying over storage based on previous years' supply and demand.

Q18. Please explain the **meaning of the phrase "per NID water rights"** in footnote 1 to Table 3-1. Does this mean that the table shows only the Watershed Runoff minus the amount to which PG&E has water rights or first call? Does it assume that PG&E water rights for power generation have priority over NID rights for water supply? If other, please explain.

A18. It is referencing that most of NID's water rights have a time period when NID can divert or store water. The average historical run off calculation took those collection periods into account to ensure NID is not taking water that was not collectable per our water rights. This watershed information is described in the Water Supply TM, 2.1

Q19. Please explain the rule curves used in the modeling that govern carryover storage for each of the NID storage reservoirs.

A19. For the reservoir operations model in Res-sim, conservation curves were used in each of the reservoirs developed for FERC relicensing, and those have not changed. For Table 3-1, the conservation curves don't apply to the analysis. It was strictly a mass balance analysis to determine the difference between supply and demand to update the carryover storage from year one to year two and so on….

Q20. On page 11, the required flows are listed as 27,900 and 58,800 cfs. **I think they should be 27,900 and 58,800 acre-feet per year.**

A20. Yes, it should be acre-feet per year. This has been corrected in the document.

Q21. Demand TM, on page 22, the text mentions six NID treatment plants, and Figure 5-9 shows 7 NID treatment plants. **How many water treatment plants are there?**

A21. During the time period of data referenced in the TM's, NID had 7 water treatment plants. In 2016, NID consolidated Cascade Shores into the Elizabeth George water treatment plant. We now have six water treatment plants. When eight treatment plants are mentioned in the document, it is referencing the Grass Valley and Nevada City treatment plants which are supplied raw water by the District.

Q22. What was NIDs rationale for planning for drought by picking the five worst years on record, and putting them in sequence for calculating water supply projections? In other words, **why did NID pick this methodology**?

A22. This work began shortly after the drought (2018) and, at the time, then Governor Brown signed an executive order requiring water suppliers to perform an analysis using five driest water years on record for the projections. The State is in the process of changing the Urban Water Management Plan and recently issued draft guidelines to require the five driest consecutive years. This is a living document and we can adjust to the new requirement.

NID has run, as requested, 2 additional Five Year Drought Alternative Analysis

Q23. In the Water Supply Memo Table 3-1, **are the drought years values presented here based on using the operations modeling and with historic time series for initial conditions, or an average carryover storage going into the drought years?**

A23. The only modeled value in the table is the initial condition of carryover storage based on model run of 2070, with projected demands including the new FERC requirements.

Q24. How old are the inputs? Are they still relevant to use? Figures 5-4, 5-5, 5-7, 5-8, and 5-9 in the Water Demand Technical Memorandum (Demand TM) imply that data collection and use ended in 2017.

A24. Actual use data goes through 2018 and, yes, they are current and relevant. The land-use growth is from the most recent census and Dept. of Finance projections with any recent general plan data. This is the most recent data available. The documents were developed beginning in 2018 so that is why the data stops at 2018.

Q25. Are Mutual Water Company customers and NID urban water customers being held to the same standard of conservation and drought response?

A25. Yes, NID follows the Drought Contingency Plan during times of drought and mandatory conservation. Mutual Water Companies are held to the same standard as all other raw water users. However, an exception might be if the State issues mandatory conservation measures that differ from our drought contingency plan, then the District abides by the State requirements.

Q26. How are you defining/using the term “environmental flows?”

A26. Environmental flows are regulatory required in-stream flows that can’t be recovered by the District and minimum dead pool requirements for the District reservoirs. Information is in the Demand TM, page 25.

Q27. Why is there no mention of the higher probability and frequency of flooding in the Hydrology TM, and how could this important issue be addressed in these TMs?

A27. The District is not a flood agency. We operate our reservoirs for water supply not flood control. The TM’s are focused on demand and supply and not focused on flooding conditions. However, by modeling the carryover storage with the Res-sim model, we somewhat capture the change of reservoirs conditions as a result of climate change. It shows run-off with more spikes and those spikes occurring earlier in the year. That does have an impact in carryover storage.

Q28. H**ow do the various consumption factors interact: Is it applied water based on crop type and irrigated acreage v. canal flow data v. consumption values obtained from customer billings**.

A28. Yes, NID looks at all of these demand factors and breaks them into raw water demand based on evaluation on canal gages, crop survey report, losses, total acreage, current land uses, and future demand. The other big category is treated water. This is pulled from actual customer billing plus Mutual Water Companies, treatment plants, loses, and per customer demand. In the model each is kept separate so high and low scenarios can be observed. NID can see how sensitive the changes are. Changes may interact on timing so we pull out winter usage from summer usage.

Q29. How do you validate the model projecting out to 2060 based on 2018 baseline? You should go back to 2007 data and apply your model, see how looks.

A29. The model does not begin with a baseline of 2018. It looks at all of the data from the last two updates and added 2007-2018. When all the data is incorporated there is a trend line. Long term projections are more likely to be a straight line vs. peaks and valleys. The model contemplates highs and lows to get a range in order to project the future conditions.

The model is a long-term trend projection tool and is not meant to predict discrete outcomes under multi-variable temporal inputs. It is similar to climate change modeling that is used to project long-term trends, but not used do predict tomorrow's weather. Peaks and valleys are visible over short periods of time but hard to predict into the future. Over the long term, peaks and valleys flatten and one would expect to see a straight line.

Q30. Unsatisfied with demand of 1% per year. How did you get to 1% when Nevada County population is flat?

A30. The overall demand shows an increasing trend. Customer growth is not directly proportional to population growth. NID annual customer account growth has increased an average of 0.2% (raw water customers) and 0.8% (treated water customers) over the last 20 years. Customer growth can occur when existing homes/residents connect to the system for a variety of reasons. Unit water demands are applied to each customer connection to calculate projected demands. Reduction in unit water demands can be the result of conservation programs the District may select as part of a suite of alternatives identified in the Plan for Water process.

Q31. How are you using General Plan data on Deer Creek watershed? Are Deer Creek flows below Scotts Flat lost?

A31. The model incorporated projected land-use data and overlaid GIS data base for demand types within that area. Flows in Deer Creek below Scotts Flat are imported by the District for re-diversion to the Newtown, Tunnel, and Keystone Canals. Flows beyond Lake Wildwood reservoir are lost to the District.

Q32. Demand question number 10 re: growth. Census, Dept. of Finance, General plan data, and last urban water management plan. When you used 2015 UWMP assumptions, how were they used?

A32. The original individual growth parameters from the 2011 Raw Water Master Plan were used as a starting point for each of the service areas within the NID system. The County General Plans were reviewed to determine if it was appropriate to adjust based on land use, and various sources of population and growth projections were reviewed to determine if the growth projections should be adjusted. The review of censes, Dept. of Finance, General Plan, and UWMP data was subjective.

Q33. NID ran scenarios that did not consider conservation alternatives that could be done in Ag sector, some that have been showed in other districts and countries that could realize significant savings.

A33. Conservation, demand management, and other demand reducing policies are a water resources planning alternative strategy to be evaluated and compared to other alternatives in the future Plan for Water process. The supply projection did take into account reductions of 40 to 50% during drought and is a form of conservation.

Q34. Why are the PGE storage lakes a loss to the District?

A34. Bowman/Spaulding canal is an NID conveyance so minimum flows are NID's responsibility.

Q35. Where do I find minimum inflow streams?

A35. Some of NID's instream flows are part of the 1963 Hydro-electric water rights and are attached to those filings. Future instream flows are a result of FERC relicensing negotiations, and can be found in those documents. Deer Creek instream flows are part of an ongoing water rights process and have not been finalized, however preliminary targets have been included in the model.

Q36. Will NID utilize the Water Budget model put out by State DWR?

A36. District will adhere to the Water Budget as it is required for the UWMP. During the UWMP update, NID and consultants will be incorporating data from the model to complete the update.

NID's existing planning processes, and specifically the hydrology, supply, and demand analysis already include many of the approaches and methodologies listed in the Draft DWR Handbook for Water Budget Development. As identified in the Handbook, the extent of the analysis is a local decision based on the district's needs, capacity, and available resources.

Q37. On page 19, figures 5-6, and 5-7, raw water sales are only shown for 5 years and increased 2.5% while demand per customer decreased 40%. What is the long term conservation target for raw water use?

A37. This is a policy related question and should be addressed as a Board-directed target through the Plan for Water and associated policies. As mentioned before, the model is intended for dynamic use and expected to be updated annually as conditions, policy, and technology changes.

Conservation, demand management, and other demand reducing policies are a water resources planning alternative strategy to be evaluated and compared to other alternatives in the future Plan for Water process.

Q38. According to figure 5-7, page 21, potable water use dropped by 26% even though the number of customers increased by 7%. What is the long term conservation target for treated water?

A38. This is a policy related question and should be addressed as a Board-directed target through the Plan for Water and associated policies. As mentioned before, the model is intended for dynamic use and expected to be updated annually as conditions, policy, and technology changes.

Conservation, demand management, and other demand reducing policies are a water resources planning alternative strategy to be evaluated and compared to other alternatives in the future Plan for Water process. Additionally, the District will incorporate future conservation mandates developed by the state and incorporate them into the model.

Q39. Why is there only 5 years of raw water data shown while there is 10 years of potable water data shown? How then can these be compared?

A39. Canal/gage data entry is a time consuming and costly exercise (thousands of data points). After it was decided that the 2011 model would be used, the direction was to focus on the 2012 to 2018 raw water data since that captured recent dry years. The dry year comparison (2012 to 2018) is still valid.

I don't know, but it would be helpful to show 20-30 years of #customers and AFY demand for raw, treated, and wholesale/mutual customers.

Q40. Where is an environmental water management plan and why has the environmental demand been limited to 2 paragraphs in this update when environmental water demand is the majority of the natural flow?

A40. The District does not have an "environmental water management plan". Environmental Flows are established by regulation are their own "management plan". They include the volume of water based upon the water year type, and the timing of flows. The District is required to follow this plan.

Q41. Why doesn't NID use the Handbook for Water Budget Development format for the Raw Water Master Plan when both the upcoming Ag Water Management Plan and Urban Water Management Plans will require this format?

A41. The District is currently in the process of updating the UWMP and the AWMP and will follow the state's guidelines and format as appropriate. When the District begins engaging in updating the Plan for Water, it will assess the appropriate format to use. Recall, the RWMP is a District-developed plan, and not required by state guidelines or format however it may decide to utilize the states Handbook for Water Budget Development format if it is appropriate.

NID's existing planning processes, and specifically the hydrology, supply, and demand analysis already include many of the approaches and methodologies listed in the Draft

DWR Handbook for Water Budget Development. As identified in the Handbook, the extent of the analysis is a local decision based on the district's needs, capacity, and available resources.

Q42. Where is the groundwater demand addressed given the majority of residents in the District depend on wells and groundwater?

A42. NID's water rights and the entire NID system is based on surface water, not groundwater. Determining the adequacy and sustainability of private groundwater wells on properties within District boundaries is not part of this analysis.

Q43. Given that water is a finite resource, how does NID plan to curb demand?

A43. This is a policy related question and should be addressed as a Board-directed target. As mentioned before, the model is intended for dynamic use and expected to be updated annually as conditions, policy, and technology changes. However the model does contemplate the District drought management plan in the analysis.

Conservation, demand management, and other demand reducing policies are a water resources planning alternative strategy to be evaluated and compared to other alternatives in the future Plan for Water process.

Q44.In the water supply analysis TM: Table 3-1 shows a total demand of 255,136 acre feet for an average year in 2070. The highest demand in table 6-3 of the "Demand" document is 208,936 AF for 2060. What is the relationship between these 2 documents? Why is there a 22% increase in demand in the "Supply" document? The demand estimates in the "Demand" document include environmental flows. The "Supply" document adds these flows again. Is there double counting of environmental flows?

A44. There is no double counting of the environmental flows. The supply analysis TM table 3-1 shows an average year total demand of 255,136, which is the sum of the annual system demand of 208,936 ac-ft (as identified in the demand TM table 6-3) and average year environmental flow demand of 46,200 ac-ft.

Q45. Please describe why NID did not elect to re-evaluate the rate of demand increase, other than for new regulations and climate change, with an updated methodology.

A45. The rate of demand increase was re-evaluated between the 2011 study and the 2020 study. The basic methodology remained the same, but new data was evaluated and the rate of demand increase changed between the 2011 and 2020 studies.

Conservation, demand management, and other demand reducing policies are a water resources planning alternative strategy to be evaluated and compared to other alternatives in the future Plan for Water process.

The demand projections are considered a baseline value, using historical customer data. In addition to alternative strategies to reduce unit water demands, it is possible future regulations will also mandate maximum allowable usage, and NID will incorporate any future restrictions as it updates its projections over time.

Q46. Please describe how the TM considers cost of water in water supply demand projections.

A46. Cost of water is not considered in the projections.

Q47. Please discuss how the 5-year drought values was developed and used in the water demand projections. The water supply memo says that: *To simulate watershed runoff conditions for a five-year drought the five driest water years were placed back to back and ordered from wettest to driest, based on their annual runoff volume: 1994, 1987, 1988, 1976 and 1977.* Can you talk about how and if this back-to-back modeling was included in the operations modeling?

A47. DWR recently released its Urban Water Management Plan draft guidebook for public review. The guidebook recommends urban water suppliers to include a water service reliability assessment for a normal year, a single dry year and a five-consecutive-year drought. While it directs the water supplier to use the driest five-year sequence within the historical period of record, DWR will allow suppliers to characterize the five-year drought differently. NID asked HDR to modify the 5-year drought recently developed for the Water Supply Analysis Technical Memorandum (TM), presented as Table 3-1, to use the 5-consecutive driest years in the 1976-2011 2070 Median climate change hydrologic period of record. HDR subsequently created two alternative analysis, one using the 5-year running average watershed runoff and one using the 5-year actual watershed runoff.

The back-to-back five year drought was not simulated in the operations model. The calculations in Table 3-1 were developed in a spreadsheet. The one value in Table 3-1 that is model derived is the average annual carryover storage, which was used as the initial carryover storage value going into year 1 of the five year drought. This value is based on modeled long-term average carryover storage for water years 1976 through 2011 under projected 2070 conditions.

Q48. During relicensing. NID and PG&E provided copies to the relicensing participants of a post-processing water delivery assessment tool called the "red blue model" (YB and DS Water Allocation Module.xlsx) which used operations model data output to help summarize water deliveries to each of NID and PCWA's demand locations. Is this updated tool available for this current set of scenarios?

A48. The red blue model was not used for any of the analyses included in the TMs, therefore, it is not available for the current set of scenarios.

Q49. The Hydrologic Analysis Technical Memorandum (Hydrology TM) Summary states,"[t]he optimistic WMW scenario indicates up to 148 percent of historical

runoff volume in lower watersheds and the pessimistic DEW scenario reduces runoff volumes to approximately 90 percent of historical and indicates the potential for drier dry years. The median scenario indicates a slight increase over historical runoff volumes, with wetter wet years." After taking into account all of the contributors to annual water supplies minus the average demand amounts from the Hydrology and Water Supply Analysis Technical Memorandum (Supply TM) reports, plus the Total System Demand in the Demand TM projected to 2060, the reports' data show significant surpluses in both projected Wet and Dry years. Is that a correct interpretation, why or why not?

A49. Watershed runoff in high elevation watershed under current conditions is predominantly snowmelt driven. In the future under climate change, watershed runoff will be more precipitation driven, resulting in flashier runoff events resulting in more spill from reservoirs. In addition, late spring water deliveries from high elevation reservoirs under climate change will be drawn from reservoir storage rather than snowmelt runoff. Both of these factors contribute to reductions in reservoir carryover storage. Projected carryover storage is expected to decrease by approximately 20,000 ac-ft, relative to historical average annual carryover storage (Table 5-16, 2012 Raw Water Master Plan). Carryover storage is the second largest source of NID water supply (2012 Raw Water Master Plan).

One other notable difference between the Supply TM and the 2012 Raw Water Master Plan in the quantification watershed runoff. Watershed runoff in the Supply TM includes runoff in the Bear River, and other small tributaries where NID has direct diversion rights during the irrigation season. Previously, runoff from these watersheds were not included resulting in an underestimate of watershed runoff. As a result, the two values of watershed runoff are not comparable.

Q50. What are the specific, numerical or other assumptions that you are putting into the models used for the Water Demand TM?

A50. Assumptions in the water demand TM including the following; future land use (general plans), future saturation of service areas (currently cannot exceed 80% for most service areas), population growth by sub-area (department of finance, 2015 RWMP), and canal losses (~15%). These assumptions can be adjusted in the model tool.

Q51. The water demand projection as shown in the Water Supply TM Table 6-3 shows a 10% increase in annual demand for every decade. According to NID records, the actual demand from 2008 to 2017 decreased by 15 percent. Why and how do you arrive at a 10 percent per decade increase over the next 40 years?

A51. From 2020 to 2030, the demand growth rate (without environmental flows) shown is 1.1% per year, 2030 to 2040 is 0.9% per year, 2040 to 2050 is 0.7% per year, and 2050 to 2060 is 0.7% per year as shown in Table 6-3 – less than is indicated in the question.

It is unclear which data the question is pointing to for a 15% decrease between 2008 and 2017. Potable demand has decreased under a similar time frame by about 2.3% per year as shown in Table 5-4. However, total raw water demand between 2012 and 2017 has increased about 0.8% per year (see Figure 5-4). Raw water makes up about 80% of the entire NID system. It should also be noted that there were economic factors as well as drought that impacted water demands during the 2008 to 2017 time period.

Q52. How do you justify projecting an increase in water demand from agricultural production in this region given the projected impacts from climate change? *See* Informational Presentation to Nevada County Planning Commission by University of California Cooperative Farm Advisors Cindy Fake and Dan Macon regarding the state of agriculture in the County, December 2019.

A52. Projections are based on existing General Plan land uses and historic water usage. Future scenarios could increase or decrease the unit water demands of a respective land use. Planning assumptions will be updated once changes and/or legal actions have been made to change land use, restrict water use, or further define allowable uses.

Q53. Why is there no mention of wildfire or forest management in the Hydrology TM? Shouldn't reduced evapotranspiration from wildfire and forest management be incorporated into future run-off and supply estimates?

A53. While studies have shown reduced evapotranspiration after biomass removal and fuels reduction following wildfire or forest management, these events and/or management practices are discrete events that are not included in the modeling due to the uncertainty of actual location and impacts. These types of events are potential water management strategies that could be investigated in the Plan for Water process. Hydrologic projections for 2070 unimpaired flows were derived using simulated historical and projected 2070 surface runoff and base flow from the Variable Infiltration Capacity (VIC) model (Liang et al. 1994). The VIC model is a gridded hydrologic model that simulates land-surface-atmosphere exchanges of moisture and energy at each model grid cell. Projected changes in evapotranspiration resulting from climate change are included.

Q54. Water Supply TM, Table 3-1, looking at environmental flow in acre feet source 1984 -1988. Don't line up with 2-1 in same TM? Where do numbers 31,000 in environmental flows in 1991?

A54. Environmental flow requirements in Table 3-1 are based on historical Smartsville index based water year types. Water year types were updated in February, March, April, May and June, corresponding to monthly DWR Bulletin 120 forecasts of watershed runoff. As the water year type is updated from month to month, environmental flow requirements are adjusted accordingly. Table 2.1 values are for a single water year type. Table 3-1 is representative of what the environmental flow requirements would have been if the five years occurred back to back. The table does not capture releases above environmental flows (i.e. spills).

Q55. Table 3-1 season of diversion but talks about PGE rights to first 350??? cfs into Rollins. Does projection back out water for PGE?

A55. Yes, it does for each of the water years.

Q56. Acre feet projection, NID demand up to 2060 is a 43% increase in acre feet? Were those numbers used here?

A56. During FERC process, the projected demand scenario was to 2062. At the time, NID RWMP was projected to 2032. So we took the 2032 data and extrapolated out to 2062.

Q57. How will the new look at groundwater change your methodology? Water lost to the system is not really lost.

A57. District is a surface water only agency. Our water rights allow for the capture and diversion of surface water only. NID water that percolates into the ground water table is no longer accessible by NID. Additionally, a majority of the Districts boundary does not fall within a recognized ground water basin. When we say lost to the system, it means the District's supply system can't collect and deliver that water to its customers or its other obligations.

Q58: Although three different water scenarios based upon climate change are modeled in the Hydrologic Analysis and used in the Water Supply Analysis TM, no alternative demand scenarios are modeled in the Demand Analysis. Question: Can HDR explain why there are no alternative demand scenarios in the Demand Analysis.

A58. Two demand scenarios were provided based on a range of environmental flow requirements. Growth, loss, and saturation. Values can be adjusted to develop additional demand scenarios.

Water Planning Projections (FATR #1041)

Public Input Received

NID

Water for Life

Dianna Suarez
[redacted]

Oct. 10, 2020

Comment on the Water Supply Analysis Technical Memorandum , table 3.1

According to: Executive Order B-13-16,
Making Water Conservation a California Way of Life,

"State Agencies shall update temporary emergency water restrictions and transition to permanent, long term improvements in water use by taking the following actions: The Department shall strengthen requirements for **urban water** shortage contingency plans, which urban water agencies are required to maintain. These updated requirements shall include adequate actions to respond to droughts lasting at least five years, as well as more frequent and severe periods of drought. While remaining customized according to local conditions, the updated requirements shall also create common statewide standards so that these plans can be quickly utilized during this and any future drought."

Further information:

During the September 24 webinar, there was discussion of the need for Table 3-1 to fulfill the requirements of the current draft *Guidebook for 2020 Urban Water Management Plans* and be based on the driest five consecutive years.[1] In addition, neither Executive Order B-37-16 (8) referenced in the *Water Supply Analysis TM*, nor the draft *2020 Agricultural Water Management Plan Guidebook*, nor the California Water Code § 10826.2, et sec. require a 5-year drought risk analysis for agricultural water uses such as that depicted in Table 3-1.[2]

Given these directives, the actions and assumptions of the Nevada Irrigation District (NID) (District) have appeared biased and prejudicial. In fact:

1. The District took a state requirement for an **urban water** shortage contingency plan and expanded it to include the raw water demands, which comprise 90% of the total water volume sold annually. ***Please re-do this 5 year drought analysis using only the Urban (Treated) Water demand.*** The purpose of the Urban Water drought analysis is to support the right to **drinking water**. Since raw water is not potable, it is not subject to the same scrutiny.

2. NID did not look for consecutive years of drought but selected the 5 single worst drought years in the last 4 decades and lined them up consecutively. This action alone compromises the validity of the outcome. The probability of this scenario within the next 60 years is zero. Starting a study with data

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[1] California Water Code § 10612 requires that a drought plan that is based on the "driest five-year historic sequence for the agency's water supply."

[2] California Water Code § 10826.2, et sec.

that provide zero probability, is a guarantee of failure, and a complete waste of the money spent on the analysis. This flawed alternative must be totally removed from Water Supply Analysis, Technical Memorandum , table 3.1.

From: Otis Wollan
To: NID Info
Subject: comment submittal
Date: Wednesday, September 23, 2020 9:01:36 AM

CAUTION: This email originated from outside your organization. Exercise caution when opening attachments or on clicking links from unknown senders.

To: Nevada Irrigation District
From: Otis Wollan, [redacted] [redacted], Colfax, CA
RE: Comments on HDR hydrology, and NID model(s)
Date: Wednesday, September 23, 2020

I submitted questions previously when HDR first presented the hydrology. The primary points were that the demand projections for 2010-2020 in the model were based on previous planning projections, not actuals. The projected steeply increasing demand during that period were starkly at odds with the actuals for that period that had been presented by NID staff in May of 2018. Actuals from 2019 are available, as are very close projections for 2020. Those actuals show flat demand. The fact that the model is so terribly wrong for this past decade is not encouraging. Further, I questioned the basis for the 1% growth per year assumption. I will here expand on questioning those assumptions.

The modeling assumptions used by NID are reactive, not proactive. The hydrology is calibrated with the past, and is used to predict the future. If the assumptions are wrong, the model is useless. We have all learned that tragically in the past six months with the pandemic, and the models projecting the various assumptions. These ranged from 15 cases going to zero to 2 million deaths within a year--- it was just the assumptions that were different.

With modeling water, this is an era of climate change, and the paradigms are shifting faster than we can keep up. I will point out several paradigm shifts that are fundamental assumptions for any water modeling for the future. The conservative model used by NID does not accommodate these paradigm shifts. And, one of the principles of paradigm shifts is that we humans often don’t perceive them until the shift actually occurs. Our perception of reality unfolds as we predict until it doesn’t, and the old set of rules don’t work. Only then do we re-evaluate. The cost of not anticipating these major shifts is that the system doesn’t work in the new paradigm.

An example. NID has chosen to use the State’s provided parameters for climate change modeling---- the 90% to 148% assumption. I would suggest modeling “hot drought”, which has been studied by Roger Bales at UC Merced. “Hot drought” has been studied extensively in the Colorado Basin, where the basin experienced drought conditions with regard to system water storage, but the precipitation levels were near normal. Several ecosystem factors acted to override the precipitation factors to create near disastrous

drought conditions: increased transpiration used for plant cooling in hotter conditions, extended growing season leading to increased transpiration, ecosystem disruption and plant migration leading to increase in plant volume hence increased transpiration, increase in snow sublimation, and more. The simple result was that watershed yield was reduced so significantly that basic reservoir storage arrived at historic lows--- even though precipitation was near normal.
Roger Bales has documented this phenomenon of “hot drought” for the Sierra Nevada. I’ll bet that if hot drought were modeled for NID, your outcomes would be totally different. Currently, some within NID are using this HDR hydrology report to justify increasing storage, specifically calling for Centennial Dam. I would wager that most predictions from the “hot drought” modeling would show that no matter how much storage was increased, it would not fill--- just like what occurred in the Colorado Basin. The prediction would be so dire that the old paradigm of “build more storage and the water will come” would be thrown out the window. The new paradigm would be how radically efficient can water be utilized to accommodate what will likely be a future far more stark than the HDR model shows using the State’s conservative parameters. So this is an example of paradigm shift on the precipitation prediction side.

Another example of paradigm shift on the precipitation prediction side is very understandable and obvious. Almost all climate change scenarios indicate an increase in the number and severity of atmospheric rivers. NID’s current modeling of this near certainty in the future is simply included in the wet year runoff modeling. The model that NID needs in response to this phenomenon is an operations vulnerability model. With almost 500 miles of canal and flume and syphon systems, NID’s infrastructure will be subject to storm damage at unprecedented levels. The pictures of the flume failure on the South Canal dramatically depict what will be the new normal as rains pummel, and rain-on-snow trashes NID’s completely exposed system. The response to this new paradigm will be, for example, tunneling the ten to twenty miles of flume and canal running from Bear Valley toward Scotts Flat. It will not be a situation of addressing the current condition of deferred maintenance of the canal/flume hanging on the edge of the Bear River canyon. It will be getting the water supply underground to protect it from the hostile elements of climate change. So the new paradigm for NID will be: save your pennies now, because you will need every cent you have to just provide reliability for the water supply you currently have.

Further paradigm shifts will include the new world of vulnerability to fire. This is pretty easy to understand this year. For example, that same wooden flume coming out of Bear Valley is now and in the future will be increasingly vulnerable to destruction by wildfire. Again, the internal paradigm will shift to save your pennies now, you’ll need every cent in the future. Spending your future revenues on debt financing of infrastructure that you think you need to respond to future precipitation changes and snow pack storage is madness. Here I’m referring to debt financing the billion dollar Centennial Reservoir, thus eliminating any debt capacity for emergency response for the next fifty years. That’s just not smart.

The most immediate paradigm shift, however, is in the demand projection. The HDR model is basically “what we have done in the past, we will do in the future, adjusted for a steady incremental increase of folks moving into the neighborhood.” Here, NID is simply projecting increases to “agricultural water demand”.

One simple paradigm shift could change this dramatically, and perhaps already has. I personally have two houses, and cannot get fire insurance for one, and for the other, got cancelled and can only get fire insurance from the State program, at triple the cost. That State program will likely not endure, as urban folks will lose interest in insuring rural residents who live in fire hazard areas. It is entirely possible that we are already on the front end of declining rural populations. The examples of Paradise and Talent suggest that rural small town living may not grow either. What would the model show if customer base is decreasing, not increasing? The increasing costs of maintaining the system with the decreasing revenue of a shrinking customer base will be sobering.

Perhaps most importantly as an example of paradigm shift in demand is this. While raw water demand was agricultural in 1921, now at NID’s Centennial anniversary, agricultural water use is probably less than ⅓ or less of the raw water consumption, with ⅔ or more going to urban raw water uses like landscaping, hobby farming, horses, aesthetics like water features including ponds, and the like----none of which qualify as “agriculture”. And studies are showing the agricultural outlook is not prosperous; real ag water demand will decline in the future. So NID is already in denial of the paradigm shift that has already happened.

The problem is that NID has no idea what the actual use of the water that is sold as “ag water”. You don’t know really how much water is delivered to each customer; you only know the contract amount. And that you can oversell the aggregate volume because customers don’t use all that they contract for. But you have no idea which customers are using how much, or how well they are using it, or what efficiencies might be gained by which conservation measure, or even how much the customers are simply wasting. You don’t know the environmental benefit of the waste, or, more likely, you don’t know how much of the waste simply contributes to environmentally degraded ecosystems like blackberry invasions. NID will never understand how to manage the raw water system efficiently until you understand who is using how much for what. NID is basically in the dark. There are a plethora of efficiencies available. But NID will never know what is possible, from efficient irrigation methods to xeriscaping to simply collaborative agreements during drought. Who could save how much how fast and when?

The only way to understand demand is to do a thorough study of the system. That would be an audit of every single user, and an inventory of the potential savings. That will give you a basis for cost/benefit studies. The policy of encountering the future when you literally know nothing of the present is bankrupt. The volatility of the future dictates that you need to know as much as you can about the present, and the capacity for change to adapt to an uncertain future.

Even the present policies of DWR is calling for this paradigm shift in management. DWR is requiring agricultural water deliveries to be measured at the gate, and is requiring that the utility understand how efficiently the water is being used by the customer. NID has to change its paradigm to meet the requirements of the law. NID gets to choose. Do you want to embrace your future with intelligence, with information, with data, with customer collaboration? Or do you want to be dragged into the future kicking and screaming about “draconian requirements” or “creeping socialism” and the like.

In this world of paradigm shift, here is another example. Many within NID fear that Southern California interests who want NID’s surplus water will muscle into the region, build a dam if we don’t build it first, and “steal our water”. In the new paradigm, why would they bother. Those same interests at some point in time will simply point out how ignorant and wasteful our water use is, and demand that these foothill water agencies delivering canal water that is a legacy of the mining just comply with modern efficiency standards. They will force efficient use and compliance with the law (which we will pay for) and thus make the water available for downstream uses. They won’t have to steal it at their expense; they will receive it free at our expense by just forcing us to live within the law.

The new paradigm is not hard to envision. It’s about smart water use and investment in the customer, watershed yield and management, distributed power and water management, fire ecosystem adaptation, community health, ecosystem health, regional and state collaboration.

It’s simply time for NID (and all other foothill raw water canal delivering water agencies) to wake up and get smart, get efficient, get proactive and befriend your customers, and get with the new paradigm. This current NID/HDR hydrologic modeling exercise is reactive to the old paradigm, and is so narrow in scope that it does not begin to model our truly uncertain future. It is possible to envision the new paradigm and model it. Garbage in, garbage out. Refined intelligence in, refined intelligence out. It’s time to make a choice.

From: rebecca wu
To: NID Info
Subject: Comment
Date: Monday, October 19, 2020 5:00:31 PM

I do not agree with the bear river dam

Sent from Yahoo Mail for iPhone

California Sportfishing Protection Alliance
"An Advocate for Fisheries, Habitat and Water Quality"
Chris Shutes, FERC Projects Director
1608 Francisco St., Berkeley, CA 94703
Tel: (510) 421-2405 E-mail: blancapaloma@msn.com
Web: www.calsport.org

California Sportfishing Protection Alliance (CSPA) information requests regarding technical memos on water supply and water demand produced as part of NID's "Water Planning Projections 2020" (https://nidwater.com/2020/08/water-planning-projections/)

September 22, 2020

NID Technical Team
info@nidwater.com

Dear NID Technical Team:

The California Sportfishing Protection Alliance (CSPA) thanks you for the opportunity to request clarification regarding the technical memos referenced above. Our questions and other requests for information are stated below, organized by technical memo.

Water Demand Technical Memo 082520

1. Referring to the "objective" stated at the top of page 8, "consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts," please describe whether this means that the present TM uses the same assumptions regarding the rate of demand increase that NID's consultants used in previous demand analyses in 2005 and 2011, except for new regulations and climate change impacts. If there are other differences in the methodology of the 2020 demand projections and those in the previous analyses, please describe them.

2. Please describe why NID did not elect to re-evaluate the rate of demand increase, other than for new regulations and climate change, with an updated methodology.

3. Please describe how the TM considers cost of water in water supply demand projections.

4. Referring to Figure 3-3 (Population Projections), please explain how much of the current population and expected population increase in Placer County is within NID's service area, and whether the TM assumes any expansion of NID's service area between 2020 and 2060.

Water Supply Technical Memo 082520

5. Please describe which of the figures in Table 3-1 are modeled and which of them are calculated; if calculated, please describe the data sources and process of developing the calculations.

6. Please explain the meaning of the phrase "per NID water rights" in footnote 1 to Table 3-1. Does this mean that the table shows only the Watershed Runoff minus the amount to which PG&E has water rights or first call? Does it assume that PG&E water rights for power generation have priority over NID rights for water supply? If other, please explain.

7. Did NID perform disaggregated and partially aggregated model runs (base case, base case with climate change only, base case with water demand change only, base case with new FERC flow requirements only, base case with new FERC requirements and climate change but no change in demand, base case with new FERC requirements and change in demand with no climate change), with output for each of the elements covered in Table 3-1? If not, please run these scenarios and make the output available. Please provide a table that describes the assumptions of each of the model runs and a table or summary that provides a legend or key for the DSS output.

8. Please develop a series of tables for each water year of the period of record in chronological sequence that shows each of the output elements of Table 3-1, under both the scenario assumed in Table 3-1 and for scenarios with each of the elements disaggregated as suggested in Request #7 above.

9. Please explain the rule curves used in the modeling that govern carryover storage for each of the NID storage reservoirs.

10. Please provide CDFW with the updated ResSim model that includes the current additions that HDR made to the model used in relicensing, and the model runs that HDR developed to inform these TM's.

Thank you for considering our requests.

Respectfully submitted,

Chris Shutes
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10-18-2020

Comment on NID Hydrology Report TM

Development of a Hydrogeologic Conceptual Model

The current NID hydrology report is based on linear concepts and modeling of 2 dimensional relationships. The next evolution of planning with water budgets will involve 3 dimensional models and planning. It is important for NID to start the transition to this next generation, 3 dimensional Hydrogeologic Concept using the Water Budget format for the Plan for Water. It is inadequate to proceed with the same frame of reference and linear thinking that produced the grossly misleading 5 consecutive year drought contingency plan from the Water Supply Analysis, Technical Memorandum , table 3.1.

This same limited grasp of our relationship with water was exposed when NID answered the question about future drought, catastrophic wildfire, power shutoffs, soaring home insurance prices, economic recession, and pandemics with, “Oh, those are only short term events”. Nothing could be further from the truth. We are now in active climate change. The management at NID has not yet realized this “new normal” and continues to proceed with linear models and linear growth projections. When the past estimates of water sales are compared to what actually happened, the estimates were off by up to 40%. Most people would find this to be an unacceptable margin of error.

One answer to this large discrepancy is, “Well, they had an anomaly, the drought”. This “anomaly” is far more certain than the linear progressions that have proven so inaccurate within NID’s planning documents. NID management seems to think that they can continue with the simplistic linear models and just fill in the blanks when a comprehensive water budget is required by state agencies. A paradigm shift is needed to move ahead and understand the complex and multifaceted water cycles that extend well beyond the boundaries of the Nevada Irrigation District.

Three dimensional planning offers a third plane to describe and account for unexpected and unforeseen future events that have major impacts on water supply, demand, and NID’s ability to transport and supply water. As we continue with the effects associated with a pandemic, wildfire, power shutoffs, soaring home insurance prices, and economic recession, understanding water cycles, and modeling the hydrogeologic structure of our watersheds will provide answers to water supply strategies to insure future resilience and ecological health. Please start creating hydrogeological models for Bear River and Yuba River watersheds as explained in the Handbook for Water Budget Development.

FOOTHILLS WATER NETWORK

September 23, 2020

Greg Jones, Interim General Manager
Ricki Heck, Division I, President, Board of Directors
Chris Bierwagen, Division II, Board Member
Dr. Scott Miller, MD, Division III, Board Member
Laura L. Peters, Division IV, Board Member
Nick Wilcox, Division V, Board Member
Nevada Irrigation District
1036 West Main Street
Grass Valley, CA 95945

Re: Water Planning Projections Technical Clarification Questions

Dear Mr. Jones, President Heck, and Board Members,

The Foothills Water Network (the Network) is a coalition of non-governmental organizations[1] concerned with watershed management issues in the American, Bear, and Yuba River watersheds. The Network anticipated the release of the updated Nevada Irrigation District (NID) Hydrology and Hydraulics modeling or Water Planning Projections for many years and appreciates NID's making them publicly available for review. These are important components for accurately updating NID's Agricultural Water Management Plan (AWMP) and Urban Water Management Plan (UWMP), both due in 2021[2] and an important new requirement, a water budget. The Raw Water Master Plan (RWMP), also known as the Plan for Water, will ultimately need to reconcile the various plan perspectives and conclusions.

FWN thanks the NID Board for scheduling an additional opportunity to review and analyze this data with HDR consultants. After an initial review of the Water Planning Projections Technical Memoranda and Appendices, the Network has a few questions we hope HDR will be able to answer.

Overarching Questions

1. How old are the inputs? Are they still relevant to use? Figures 5-4, 5-5, 5-7, 5-8, and 5-9 in the Water Demand Technical Memorandum (Demand TM) imply that data collection and use ended in 2017.
2. The Hydrologic Analysis Technical Memorandum (Hydrology TM) Summary states, "[t]he optimistic WMW scenario indicates up to 148 percent of historical runoff volume

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[1] Foothills Water Network, American Rivers, American Whitewater, California Outdoors, California Sportfishing Protection Alliance, Friends of the River, Gold Country Fly Fishers, Northern California Council of Fly Fishers International (formerly Northern California Council Federation of Fly Fishers), Sierra Club, South Yuba River Citizens League, and Trout Unlimited.

[2] *See* California Water Code, §§10610-10656, §10608 and new AWMP content requirements of AB 1668 (Friedman, Statute of 2018).

in lower watersheds and the pessimistic DEW scenario reduces runoff volumes to approximately 90 percent of historical and indicates the potential for drier dry years. The median scenario indicates a slight increase over historical runoff volumes, with wetter wet years." After taking into account all of the contributors to annual water supplies minus the average demand amounts from the Hydrology and Water Supply Analysis Technical Memorandum (Supply TM) reports, plus the Total System Demand in the Demand TM projected to 2060, the reports' data show significant surpluses in both projected Wet and Dry years. Is that a correct interpretation, why or why not?

3. Are Mutual Water Company customers and NID urban water customers being held to the same standard of conservation and drought response?
4. How are you defining/using the term "environmental flows"?

Water Supply Questions

5. What was your rationale for planning for drought by picking the five worst years on record, and putting them in sequence for calculating water supply projections? In other words, why did you pick this methodology?

Water Demand Questions

6. What are the specific, numerical or other assumptions that you are putting into the models used for the Water Demand TM?
7. The water demand projection as shown in the Water Supply TM Table 6-3 shows a 10% increase in annual demand for every decade. According to NID records, the actual demand from 2008 to 2017 decreased by 15 percent. Why and how do you arrive at a 10 percent per decade increase over the next 40 years?
8. How do you justify projecting an increase in water demand from agricultural production in this region given the projected impacts from climate change? *See* Informational Presentation to Nevada County Planning Commission by University of California Cooperative Farm Advisors Cindy Fake and Dan Macon regarding the state of agriculture in the County, December 2019.

Hydrology Questions

9. Why is there no mention of the higher probability and frequency of flooding in the Hydrology TM, and how could this important issue be addressed in these TMs?
10. Why is there no mention of wildfire or forest management in the Hydrology TM? Shouldn't reduced evapotranspiration from wildfire and forest management be incorporated into future run-off and supply estimates?

The Network appreciates your time and consideration of this request, and looks forward to hearing from you this Thursday.

Respectfully submitted,

Traci Sheehan Van Thull
Foothills Water Network

FOOTHILLS WATER NETWORK

October 19, 2020

Greg Jones, Interim General Manager
Ricki Heck, Division I, President, Board of Directors
Chris Bierwagen, Division II, Board Member
Dr. Scott Miller, MD, Division III, Board Member
Laura L. Peters, Division IV, Board Member
Nick Wilcox, Division V, Board Member

Nevada Irrigation District
1036 West Main Street
Grass Valley, CA 95945

Submitted via e-mail: info@nidwater.com

Re: Water Planning Projection Documents

Dear Mr. Jones, President Heck, and Board Members,

The Foothills Water Network (the Network) is a coalition of non-governmental organizations[1] concerned with watershed management issues in the American, Bear, and Yuba River watersheds. The Network has been anticipating the release of the updated Nevada Irrigation District (NID) Hydrology and Hydraulics modeling or Water Planning Projections documents for many years and appreciates that NID has made them publicly available for review. These are important components for accurately updating NID's Agricultural Water Management Plan (AWMP) and Urban Water Management Plan (UWMP), both due in 2021[2] and for developing an important new requirement, a water budget. The Raw Water Master Plan (RWMP), also known as the Plan for Water, will ultimately need to reconcile the various plan perspectives and conclusions.

The Network thanks the NID Board for convening a webinar on September 24, 2020, which afforded an opportunity for HDR consultants to better explain the models and assumptions used to Network members and other stakeholders ("September 24 webinar"). After further

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[1] Foothills Water Network, American Rivers, American Whitewater, California Outdoors, California Sportfishing Protection Alliance, Friends of the River, Gold Country Fly Fishers, Northern California Council of Fly Fishers International (formerly Northern California Council Federation of Fly Fishers), Sierra Club, South Yuba River Citizens League, and Trout Unlimited.

[2] *See* California Water Code, §§10610-10656, §10608 and new AWMP content requirements of AB 1668 (Friedman, Statute of 2018).

review of the Water Planning Projections documents and Appendices, and in consideration of the technical clarifications provided by HDR staff during the webinar, the Network presents the following comments and recommendations.

I. Overarching Comments

In April 2018, NID hit the pause button on efforts to develop its proposed Centennial Dam project and undertook an update of its Raw Water Master Plan (RWMP).[3] As the Network understood it, the underlying rationale for this was to evaluate the District's long-term water supply and needs before potentially embarking on an expensive and controversial new reservoir.

The Water Planning Projections documents and underlying technical work make some important strides in the evaluation of the District's long-term water supply and needs.

The update in the *Hydrologic Analysis Technical Memorandum (TM)* and supporting documents, whose purpose is to re-evaluate future hydrology in light of various climate change scenarios, generally makes sense and seems well supported. The decision to evaluate several scenarios makes sense, as does the decision to use the runoff projections from the median climate change scenario for most of the analysis.[4] The Network appreciates the even-handedness of using the median climate change scenario when performing analysis in other documents.

HDR's update to the ResSim operations model that NID and Pacific Gas & Electric Company (PG&E) developed in the Federal Energy Regulatory Commission (FERC) relicensing for NID's Yuba-Bear Hydroelectric Project[5] also makes sense. The update adds the Deer Creek system of NID's operation and the lower section of NID's Bear River system to complete the model of NID's water supply operations. These added portions of the model were not included in detail in relicensing. The new ResSim model will be a tool that adds technical precision and competence to multiple future evaluations by NID and stakeholders.

On the downside, NID reports the output from the new ResSim model only in the extremes: a very high-level summary in the *Water Supply Analysis Technical Memorandum (TM)* and extensive DSS-Vue files for actual model run output. More analytical tables, similar in scale to Appendix C for the *Hydrologic Analysis TM*, would be appropriate. The Network discusses this in greater detail below.

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[3] The Foothills Water Network (FWN) is a broad coalition of more than a dozen local, state and national conservation groups that has challenged the proposed Centennial Dam since 2014. FWN is leading the formal regulatory process, commenting on what NID should study in its environmental review. FWN also filed a protest of the water rights application as did more than a dozen other organizations including the California Department of Fish and Wildlife (CDFW), U.S. Bureau of Reclamation, and South Sutter Water District.

[4] *Hydrologic Analysis Technical Memorandum (TM)*, p. 14. While the overall *TM* is generally supported, the Network would appreciate additional clarification as to why HDR only used the Cisco Grove gage at 5,000 ft elevation rather than incorporating readings from other gages at higher elevations, such as Jackson Meadows.

[5] The Federal Energy Regulatory Commission (FERC) hydroelectric relicensing process for NID's Yuba-Bear Hydroelectric Project No. 2266 ("relicensing") with all related federal, state and nongovernmental organizations is still ongoing as of October 19, 2020.

The new demand projections that NID has developed, as described in the *Water Demand Projection Model Update*, are less satisfactory. The Network considers this the heart of the planning exercise. Unfortunately, the "objective" stated at the top of page 8, "consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts," does not appear to reflect a major change in the methodology of how the demand projection model translates land use projections into demand projections. In other words, the results in the *Water Demand Projection Model Update* do not actually produce an "update" for planning purposes. For example, if NID assumes a one percent per year increase in demand over the next fifty years, then NID is likely to need more water. This is a predictable outcome of the "previous water planning assumptions" that did not require a new water planning effort to determine. Alas, this is not an accurate assumption that can be utilized for planning purposes.

The *Water Supply Analysis TM* relies heavily on two tables: Table 2-1 and Table 3-1.

Water Supply Analysis TM Table 2-1 is confusing because it is presented in the context of carryover storage. This overlooks the fact that some of the instream flow requirements, particularly in December-June of wetter water years, will be met by water that is, or will be, runoff in rivers and streams. This is generally spill that could not be captured by NID anyway. The parties in relicensing, including NID,[6] that designed the new flow requirements accounted for this spill water, recognizing that higher flow requirements during periods of high runoff change the *timing* of spill but not the overall *quantity* of spill. In sum, Table 2-1 suggests that the amounts of water listed all come out of NID's storage and are reflected as decreases in carryover storage on a one-to-one basis. This is not true.

This misconception is one that has arisen several times over the past year. For example, during Agenda Item 9 of the NID Board Meeting on January 22, 2020, NID staff made a presentation to the Board that suggested that the flow requirements of the new FERC license would cause NID's end-of-year storage in wet years to be much less than storage in drier years. Staff made the mistake of simply subtracting the number of acre-feet of required flow (the same amounts shown in *Water Supply Analysis TM* Table 2-1) from end-of-year-storage.[7] However, again, the water needed to meet the instream flow requirements, particularly in Wet years, does not come exclusively from storage. Instream flows come in substantial part from spill or from water that NID chooses to release from storage for power generation knowing that it will fill its reservoirs later in the year. For further discussion and clarification, please see the comments of the California Department of Fish and Wildlife (CDFW) to NID's Water Planning Projections.

Water Supply Analysis TM Table 3-1 does not make best use of the tools that NID and HDR have developed. As clarified in the September 24 webinar, the data presented in Table 3-1 is not output from the ResSim model. Rather, the ResSim model was used only to calculate the starting carryover storage value for the year previous to the first year of the "projected 5-year

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[6] NID negotiated in good faith for more than 10 years with State and Federal agencies, PG&E, neighboring water agencies, and the Network within the relicensing process for the Yuba-Bear Project to establish essential flows for all stakeholders, including NID customers and the environment. NID proposed the new flows in their Final License Application to FERC. Flows were negotiated and agreed to based on existing infrastructure.

[7] *See* https://nidwater.com/wp-content/uploads/2020/01/01222020_BOD_Item_9.pdf, slides 15 and 17.

drought water supply" that NID selected for analysis. As discussed during the webinar and below, the projected 5-year drought is problematic because it strings together the five worst water years in the period of record to analyze. But of perhaps even greater concern is that this does not allow use of the ResSim model. One of the consequences is that the calculated outcome appears to assume that all water for minimum instream flows comes out of storage.

Below, the Network discusses in greater detail our concerns with the *Water Demand Projection Model Update* and the *Water Supply Analysis TM* in particular. We also make recommendations to improve the analysis and its presentation in these documents and associated appendices.

II. Comments on the ResSim Model Runs Performed for the 2020 Water Planning Projections

In order to evaluate different elements of current and future water demand and supply, NID commissioned HDR to model several different scenarios with the revised ResSim operations model.

These simulations include:

1. Existing hydrology, existing flow requirements, existing NID demand.
2. Existing hydrology, Final Environmental Impact Statement (FEIS) projected future FERC flow requirements, existing NID demand.
3. Existing hydrology, FEIS projected future FERC flow requirements, projected 2060 NID demand.
4. Median climate change hydrology, FEIS projected future FERC flow requirements, projected 2060 NID demand.

Notably absent from these simulations is the following scenario:

5. Median climate change hydrology, FEIS projected future FERC flow requirements, *existing* NID demand.

This absent scenario is important because it would allow comparison of the relative impact on NID water supply operations of the new FERC flow requirements and projected demand increases under climate change hydrology. In an Opinion Editorial piece published September 13, 2020, NID Director Wilcox stated: "The largest single impact on carryover storage is, in fact, environmental flows and not increased consumption."[8] Existing modeling shows that this is clearly not the case under historical hydrology, and on its face we believe it is incorrect under climate change hydrology. However, without a model run that allows direct comparison of different demand requirements and the new FERC requirements under climate change hydrology, **there is no way to support this contention under future hydrology.**

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[8] Nick Wilcox, *Our Community's Water Future*, Yubanet September 13, 2020. Available at: https://yubanet.com/regional/op-ed-nick-wilcox-our-communitys-water-future/.

The Network also notes that the California Department of Fish and Wildlife (CDFW) and South Yuba River Citizens League (SYRCL) Watershed Science staff reached different values for average carryover storage under each of the modeled scenarios than did HDR.[9] HDR and NID should endeavor to reconcile these discrepancies.

Requests and Recommendations:

1. The Network requests that NID commission HDR to run an additional model scenario (median climate change hydrology, FEIS projected future FERC flow requirements, *existing* NID demand) and provide the output in DSS-Vue format to allow direct comparison with the other scenarios.
2. The Network recommends presentation of additional tables and figures in an appendix to the *Water Supply Analysis TM* showing model inputs and output, in order to increase transparency and reduce the need to rely on a few aggregated summary numbers. The Network would be pleased to discuss specific data that would be particularly useful to include. In addition, the Network includes specific recommendations below regarding the presentation of additional data.
3. The Network recommends that HDR create a subset of data output for all modeled runs in DSS-Vue format and make these data available to stakeholders. The Network recommends discussions with CDFW and Network representatives to focus on the most useful output. Something on the order of 100 lines of output per run should help make the output more accessible to knowledgeable users.
4. The Network requests that NID schedule a webinar or phone call(s) with CDFW and the Network to talk through discrepancies in existing data output.

III. Comments on the *Water Demand Projection Model Update* and Recommendations

As discussed above, the *Water Demand Projection Model Update* does not take a fresh look at the calculation of increases in water supply for various projected changes in land use. The *Water Demand Projection Model Update* continues to extrapolate demand from "future, gross land area receiving water."[10]

It is unclear why NID assumes that there will be increases in gross land area receiving water. The *Water Demand Projection Model Update* describes projected changes in population in Placer and Nevada counties, but does not connect these changes with prospective increases in acreage receiving water. Indeed, the projection for Nevada County is for a decrease in population (Figure 3-3). For Placer County, Figure 3-3 shows an overall projected increase in population, but does not differentiate how much of this projected increase will occur in NID's service area. There is little persuasive evidence that these changes will contribute to an increase in NID's raw water demand. As pointed out during the September 24 webinar, the model predicts a 44% raw water demand increase in the Deer Creek System (Nevada County) by 2060

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[9] *See* comments of CDFW.
[10] *Water Demand Projection Model Update*, p. 7.

and a 36% raw water increase in the Bear River System (largely in Placer County).[11] In aggregate, these projections are excessively high and not justified.

Projecting future raw water demand by examining incremental changes in land use has an inherent propensity for error because small degrees of overestimation compounded over forty years creates an overall large error. A reasonable way to ground-truth such seemingly inflated, acre-by-acre calculations is to review actual historical demand performance over extended periods of time. Several participants in the September 24 webinar raised this issue. HDR staff were reluctant to include recent demand trends in their analysis, however, observing that there had been both very wet years and drought years in the recent past. However, this may, in fact, be NID's 'new normal'.

The Network recommends NID include a longer dataset for its raw water demand in a revised memorandum, at least as long as the 2006-2017 time period that the *Water Demand Projection Model Update* provides for urban use.

Another way to produce more accurate water demand projections is to look at similar counties to observe their patterns of growth over the past two decades. El Dorado County, for example, passed an update to its General Plan in the early 2000's that anticipated substantial growth in both urban and raw water demand.[12] However, the recession of 2008 left El Dorado Irrigation District (EID) significantly overextended in its infrastructure construction program and associated financing, forcing large cutbacks in EID staff.[13] EID has subsequently restored equilibrium and revised its projected demand figures. In 2001, EID secured water rights permit 21112 to serve anticipated growth in El Dorado County. However, EID has not used almost any of the water available under this permit, and earlier in 2020 issued a Notice of Preparation for a petition to the State Water Resources Control Board to extend the time to put this permitted water to use.[14] NID can take a valuable lesson from the experience of El Dorado County and EID, which is similar in many ways to Nevada County.

During the September 24 webinar, HDR staff suggested unpredictable events are generally short-term. While this may have largely been true in the past, the era of climate change appears to be making it less true.[15] Large floods from atmospheric rivers (AR) and fires, for example, may affect the durability or productivity of acreage under cultivation for years after

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[11] *Id.*, Tables 6-1 and 6-2.

[12] County of El Dorado Adopted General Plan. 2004. Available at: https://www.edcgov.us/Government/planning/generalplan/Documents/2004%20General%20Plan%20Adopted%207-19-04%20(original).pdf.

[13] Lamb, Celia. "Irrigation District Lays off 31 people." Sacramento Business Journal. December 9, 2008. Available at: https://www.bizjournals.com/sacramento/stories/2008/12/08/daily33.html.

[14] EID, Notice of Preparation of an Environmental Impact Report and Notice of Scoping Meeting for the Permit 21112 Project. Available at: https://www.eid.org/home/showdocument?id=13432. *See esp.* p. 7: "The District has been mindful of its ratepayers by making efficient use of its existing supplies to meet current demands. This responsible use of existing supplies has allowed EID to avoid premature investments in costly infrastructure that are not yet needed to meet current demands."

[15] Dhakal, N., S. Jain, A. Gray, M. Dandy, and E. Stancioff (2015), Nonstationarity in seasonality of extreme precipitation: A nonparametric circular statistical approach and its application, Water Resour. Res., 51, doi:10.1002/2014WR016399.

the actual event. Increases in ambient temperature may change the viability of various crops, including wine grapes. All of these factors are likely to change levels of risk for both urban and agricultural development in the NID service area. Among many other factors, increases in insurance premiums of all types will accompany increased risk, and insurance for some property may become unavailable. Whether those levels of risk will lead to decisions to reduce development is not known. However, it does call into question the apparent assumption that, since the last drought is behind us, the patterns of growth predicted in 2005 and 2011 remain reasonable predictions for the future.[16] The Network recommends that NID include in a revised memorandum discussion and evaluation of such potential landscape-level changes.

Additionally, the *Water Demand Projection Model Update* does not factor cost into predictions of future demand increases at all. It is extremely unlikely that NID will be able to continue to deliver raw water at the same relatively low cost as it has in the past. It is the Network's understanding that NID's financial reserves are low. Hydropower revenues are down.[17] Issuance of a new FERC license will increase NID's expenses substantially. HDR's predicted total cost for the license over fifty years is $212 million, with a single year cost of $22 million in the third year after license issuance.[18]

Nonetheless, the *Water Demand Projection Model Update* makes no evaluation of how changing costs for raw or treated water will influence future demand. The Network urges NID to revise the memorandum to evaluate and discuss this factor. It is reasonable to assume that an increase in cost could result in less demand.

The *Water Demand Projection Model Update* states that, as part of its development, HDR and NID recalculated actual usage of water in NID's system and trued-up current estimates for the number of acre-feet various local crops use per acre. There is value in improving accuracy on these calculations. Unfortunately, this misses the overarching issue of continuing to apply the assumption from 2005 and 2011 that there will be perpetually increasing raw water demand based on some kind of projected, but unsubstantiated, expansion of population, or increased agriculture or landscaping, or both.

The *Water Demand Projection Model Update* treats "Environmental Water" as a demand similar to raw and treated water deliveries and lumps them together under the category "total system demands."[19] This shorthand is confusing, for reasons stated above and below in the context of supply. The confusion is reproduced in the document *How NID Uses Water Planning Projections*: "Up to nearly 60,000 acre-feet per year *of NID's water supply* must be dedicated to flow requirements to enhance riparian and aquatic habitat for fish and other species and cannot

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[16] *Water Demand Projection Model Update,* Figure 5-1, p. 9. This Figure supports the Network's comments that the demand increases are based on the old methodology founded on land use and cropping patterns. It additionally raises the question of how NID selected among the baseline, low and high projections for scenario planning.

[17] *See* e.g, Kathan, Jesse. "Decline in hydropower hampered by drought will impact utility costs." Mercury News. August 9, 2020. Available at: https://www.mercurynews.com/2020/08/09/decline-in-hydropower-hampered-by-drought-will-impact-utility-costs/.

[18] NID Board of Directors meeting July 8, 2020, Agenda Item 4 "Update on New FERC license." Available at: https://nidwater.com/wp-content/uploads/2020/07/07082020_BOD_Item_4.pdf.

[19] *Water Demand Projection Model Update,* pp. 27-28.

be used by NID to meet customer demand (up from 5,000 acre-feet per year from the previous license)."[20]

Requests and Recommendations:

1. The Network strongly recommends removing the "Environmental Flows" section, including Table 5-6, from the *Water Demand Projection Model Update*. Minimum instream flows, unlike consumptive demand, are met, in part, by uncaptured water. Conflating minimum instream flows with consumptive demand is inherently confusing and misleading.
2. Similarly, the Network recommends removal of minimum instream flows from Table 6-3 ("Total System Projected Demands"), limiting the table to Annual Consumptive Demands (currently labeled "Annual System Demand").
3. Throughout the water planning effort, the Network recommends replacing the term "environmental flows" with the more neutral term "unrecoverable minimum instream flows."
4. In order to accurately account for the water supply effects of new minimum instream flows, the Network recommends the following approach: for each of the four existing model runs and the fifth model run recommended above, include a table in an appendix that shows the year-by-year quantity of water in acre-feet that minimum instream flow requirements are actually delivered from storage. This table can also be used to complete the replacement for Table 3-1 in the *Water Supply Analysis TM*, as described below.
5. The Network requests that the *Water Demand Projection Model Update* add analysis of the effects of raw water pricing on raw water demand. If available, NID could start such analysis with the demand response to the largest recent raw water price increase within the District. Additional analysis could come from case studies, preferably from foothill counties in California.
6. The Network recommends addition of an appendix to the *Water Demand Projection Model Update* that analyzes projected and actual water demand in El Dorado County, as discussed above.
7. The Network recommends NID add a section or an appendix to the *Water Demand Projection Model Update* that analyzes the potential impacts of landscape-level changes that have a reasonable likelihood of affecting future water demand within the District. Broadly, these potential changes are likely to be related to climate change. They include, but are not limited to, floods, wildfire, and changes in crop suitability. The Network further recommends that this analysis include potential policy decisions that NID should consider in responding to the effects of such changes.
8. The Network recommends adding to the *Water Demand Projection Model Update* an analysis that accounts for the uncertainty of water demand increases within the District's service area in the next 40 years. This analysis should focus on comparison of two model runs, identified above as Run 4 (median climate change hydrology, FEIS projected future FERC flow requirements, projected 2060 NID demand) and

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[20] *How NID Uses Water Planning Projections*, August 26, 2020. Available at: https://nidwater.com/2020/08/how-nid-uses-water-planning-projections/(emphasis added).

requested Run 5 (climate change hydrology, FEIS projected future FERC flow requirements, existing NID demand). This will bracket likely ranges of demand. It will also present the NID Board with the consequences of potential policy choices that encourage or discourage demand increases.

IV. Comments on the *Water Supply Analysis Technical Memorandum* and Recommendations

The *Water Supply Analysis TM* is built almost entirely around Table 3-1, titled "*Summary of 2070 5-Year Drought Water Supply*." This table is problematic in and of itself. It takes one hypothetical extreme drought as the only focus of analysis. As described above, it presents data that is calculated, not modeled.[21] It also does not provide a view of the overall effect over an extended period of the various elements it analyzes.

NID references the general guidance in California Executive Order B-37-16 (8) to justify the 5-Year Drought Planning analysis. To fulfill this requirement, NID evaluated the five driest years in the period of record and sequenced them in Table 3-1.[22] Neither the draft *Guidebook for 2020 Urban Water Management Plans*[23] nor the draft *2020 Agricultural Water Management Plan Guidebook*[24] require the methodology NID employed. On the contrary, California Water Code § 10612 requires that a drought plan be based on the "driest *five-year historic sequence* for the agency's water supply."[25] NID selected the individual five driest years (almost one from every decade) and calculated supply as if they were in sequence, rather than using a more realistic historic drought scenario for estimation.

The Network appreciates the recently published HDR memos showing alternative 5-year drought scenarios. However, the Network recommends that NID commission HDR to complete the model run described above (Median climate change hydrology, FEIS flow requirements, *existing* NID demand) and, together with the 4 runs HDR has already performed, present a series of tables built around the year-by-year output for the period of record. The tables should include the categories (outputs) shown in the existing Table 3-1. They should add a line that shows on an annual basis how much of the modeled required minimum instream flow comes from storage and how much comes from spill or discretionary power releases.

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[21] NID used mass-balance calculations rather than a model such as Hec-ResSim. CDFW recommends NID use the Hec-ResSim model because "1) the tool has been vetted by many stakeholders, 2) the tool better accounts for natural system variability when assessing for drought impacts to water delivery potential, and 3) the tool allows for comparative analysis of relative impacts to reservoir carryover storage." *See* CDFW Comments.

[22] California Water Code § 10826.2, et sec.

[23] California Department of Water Resources. Urban Water Management Plan Guidebook 2020. Available at: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-WaterManagement-Plans.

[24] California Department of Water Resources. Agricultural Water Management Plan Guidebook 2020 (draft). Available at: https://water.ca.gov/News/Events/2020/Sept-20/Draft-2020-Agricultural-Water-Management-Plan-Guidebook-Virtual-Public-Meeting.

[25] California Water Code § 10612 (emphasis added).

The Network believes that modeled, rather than calculated, scenarios will provide a much more accurate view of the effects of each of the scenarios on NID's water supply operations. From each modeled scenario, the reader will be able to pick out the five-year sequence with the greatest shortages. Some technical discussion will be needed to decide how to incorporate NID's Drought Contingency Plan and any other water shortage policies into the ResSim model.[26]

Footnote 1 of Table 3-1 in the *Water Supply Analysis TM* refers to watershed runoff "per NID water rights." On clarification provided during the September 24 webinar, HDR staff explained that this meant that water available to PG&E was backed out of the calculation. This means that based on the calculations in the *Water Supply Analysis TM*, PG&E water for power generation would, in some cases, have priority over NID water supply. This particular prioritization does not make sense when considering regional water supply vulnerabilities to climate change.

A revised *Water Supply Analysis TM* should include analysis of the opportunity for NID to acquire the Lower Drum Hydroelectric Project and partially re-operate it to prioritize water supply over power generation. In addition, an update of the "red-blue" tool developed in relicensing that determines water available to PG&E (red) and to NID (blue) would enable a more granular analysis of how much water NID would have available for water supply in a modeled period of record. This would improve the transparency and accuracy of the calculated "watershed runoff" available to NID.

The Network thanks NID for attempting to diversify potential drought scenarios by releasing two additional technical memoranda from HDR on October 8, 2020. On brief review, the calculations in these memoranda seem to indicate that NID will generally have adequate water supply to meet water demands, even in a consecutive five-year drought. However, the new drought scenarios remain based on calculated outcomes, not the output of model runs. The Network's recommendations above regarding use of modeled data in preference to calculated data remain the same.

The Network recommends that NID develop additional analysis regarding climate change, wildfire and forest management. This would most likely fit best as an appendix to the *Hydrologic Analysis TM* and/or the *Water Supply Analysis TM.* Drought contingency is not the only new risk facing watersheds in the Sierra Nevada. NID's current collective water planning documents do not address uncertainties related to the potential damage to or failure of dams and conveyance infrastructure, the higher probability of atmospheric rivers (AR) and flooding, or the impacts of forest fires and forest management on watershed yield.

NID should consider the influence that reduced evapotranspiration from wildfire and forest management will have on runoff. Wildfire decreases tree density and evapotranspiration, while increasing soil moisture and runoff.[27] A study from the University of California Merced

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[26] The two alternative drought scenario memorandums released by HDR during this comment period do not provide this technical discussion.

[27] Boisrame´, G., Thompson, S., Collins, B., & Stephens, S. (2017) Managed wildfire effects on forest resilience and water in the Sierra Nevada. *Ecosystems* (2017) 20: 717–732. DOI: 10.1007/s10021-016-0048-1.

(UC Merced) found that post-fire evapotranspiration decreased significantly for 5-20 years following wildfire in densely forested areas of the Yuba River and American River watersheds.[28] Forest management, already practiced to some degree by NID, decreases evapotranspiration in similar ways. UC Merced researchers estimate that improved forest management in large areas in the Yuba River and Bear River watersheds could increase runoff by 4 percent to 10 percent, depending on the extent and types of practices used. [29] The upper Yuba watershed has substantial storage of subsurface water that allows trees to tap into deep water during warm, dry periods in the summer[30] and facilitates recovery after wildfire. Continued forest management will reduce evapotranspiration and increase runoff.

NID should also consider the likelihood that mega-floods (like that of 1862) will become more frequent due to more atmospheric rivers (AR).[31] Runoff from these storm events could double, on average, in the latter half of this century.[32] Researchers from University of California Los Angeles (UCLA) warn: "…[H]ydroclimatic extremes may rise more rapidly than the gradual projected shift in regional mean precipitation."[33] And the "…increase in runoff during the most extreme AR events could present major flood control challenges for the region."[34] Analyzing and planning for these impacts is particularly important for NID's raw water customers and the agricultural sector in the Yuba and Bear River watersheds.

Requests and Recommendations

1. The Network recommends replacing the 5-year drought scenario that the *Water Supply Analysis TM* analyzes in Table 3-1 with the "five-consecutive driest years scenario" (Alternative 1) that NID developed in response to the September 24 webinar.[35] This will allow NID to use data derived from output from the HEC ResSim model, rather than calculated data, greatly increasing the accuracy, transparency, and utility of the memorandum.
2. The Network recommends that NID commission HDR to develop the data needed to re-create a table similar to Table 3-1 using data output from the model runs recommended above: Run 4 (median climate change hydrology, FEIS projected future FERC flow requirements, projected 2060 NID demand) and requested Run 5

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[28] Roche, J.W., Ma, Q., Rungee, J., & Bales, R.C. (2020). Evapotranspiration mapping for forest management in California's Sierra Nevada. *Frontiers in Forests and Global Change*. Vol. 3. Available at: https://www.frontiersin.org/article/10.3389/ffgc.2020.00069, DOI=10.3389/ffgc.2020.00069

[29] *Id.*

[30] *Id.*

[31] Swain, D.L., Langenbrunner, B., Neelin, J.D., & Hall, A. D. (2018). Increasing precipitation volatility in twenty-first century California. *Nature Climate Change* VOL 8 | MAY 2018 | 427–433, https://doi.org/10.1038/s41558-018-0140-y

[32] Huang, X., Stevenson, S., & Hall, A. D. (2020). Future warming and intensification of precipitation extremes: A "double whammy" leading to increasing flood risk in California. *Geophysical Research Letters*, 47, e2020GL088679. https://doi.org/ 10.1029/2020GL088679.

[33] Swain et al., *op. cit.*

[34] Huang et al., *op. cit.*

[35] HDR, "Alternative 5-year drought based on the five-consecutive driest years in the 1976-2011 period of record," October 6, 2020 ("five-consecutive driest years scenario"). Available at: https://nidwater.com/wp-content/uploads/2020/10/Consecutive-5-year-drought-Memo_Alt1.pdf

(climate change hydrology, FEIS projected future FERC flow requirements, existing NID demand).

3. The Network further recommends that HDR create 2 tables or sets of tables to replace Table 3-1 of the *Water Supply Analysis TM*. HDR should base one table or set of tables on Run 4 and another on Run 5. Rather than limiting the tables to the 5-year drought sequence alone, the Network recommends showing the output for each year in the period of record, with the data for 5-year drought sequence highlighted.
4. The Network recommends that new tables replace the line for "environmental flow requirement" with data that shows the actual amount of water required from storage in each year to meet unrecoverable minimum instream flows. (*See* parallel recommendation #4 for the *Water Demand Projection Model Update*, above).
5. The Network recommends that, in addition, HDR include in a revised *Water Supply Analysis TM* total system storage for October 15 of each year in the period of record under Run 4 and Run 5. The Network further recommends that HDR use this data to form the basis for a revised Section 2.2 (Carryover Storage) in the *Water Supply Analysis TM.* The revised Section 2.2 should present October 15 total system storage in both table format and as screenshots of DSS-Vue output. (*See* example in CDFW comments, Appendix 1, Figure 3, p. 5).
6. The Network strongly recommends deleting the existing Table 2-1 from the *Water Supply Analysis TM*. As described above, minimum instream flows, unlike consumptive demand, are met in part by uncaptured water. Conflating minimum instream flows with consumptive demand is inherently confusing.
7. Similarly, the Network recommends removal of minimum instream flows from Table 6-3 ("Total System Projected Demands") in the *Water Supply Analysis TM*, and should instead limit the table to Annual Consumptive Demands (currently labeled "Annual System Demand").
8. As stated above, the Network recommends replacing the term "environmental flows" in the *Water Supply Analysis TM* with the more neutral term "minimum instream flows."
9. The Network recommends that NID commission HDR to update the "red-blue" calculator developed during relicensing that quantifies water that belongs to PG&E and NID respectively in ResSim model runs.
10. Finally, the Network recommends the revised *Water Supply Analysis TM* include analysis of the opportunity for NID to acquire the Lower Drum Hydroelectric Project and partially re-operate it to prioritize water supply over power generation.

V. Comments on the Use and Policy Implications of the *Water Projections Memoranda*

Fundamental to the Network's concerns and recommendations is the overall purpose of the Water Planning Projection documents.[36] The Water Planning Projection documents utilize sophisticated models to analyze a particular set or range of inputs and assumptions. The models themselves are tools that allow a variety of inputs and assumptions to be evaluated and reported

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[36] *See* Nevada Irrigation District's 2020 Water Projection documents generally, *Hydrologic Analysis TM, Water Supply Analysis TM,* and *Water Demand Projection Model Update.*

as needed.[37] The documents as presented are based on a particular set of inputs to the models at a point in time. As NID pointed out in its web document, *How NID Uses Water Planning Projections*, "[t]here is a wide range of assumptions that can be made for any particular data point, all of which may be equally valid." [38]

NID should continue to make use of the tools it has developed to engage the public in considering different assumptions and evaluating different outcomes. For instance, different approaches to a 5-year drought, as discussed above and already begun by NID, is only one of many potential assumptions that should be tested. NID can draw many different subjective conclusions from these documents because they turn on District policy decisions. It will be helpful for NID Board and staff, and for the general public, for the water planning documents to begin to describe the interaction between policy decisions and water supply and demand assumptions and outcomes.

Requests and Recommendations:

1. NID will need to consider costs and risks on a variety of issues and levels, and will need to weigh various tradeoffs of costs and risk. The Network recommends that NID develop a policy outline document that describes some of the major policy decisions NID must make in considering future water planning.
2. The Network recommends that one policy area in a policy outline document focus on NID's need to address and prioritize the degree to which NID devotes resources to maintaining and upgrading existing infrastructure, including the watershed itself.
3. The Network recommends that a second policy area that NID focus on is the degree of preference that NID will give to existing customers and uses of water as opposed to new customers and uses.

VI. Conclusion

The Network requests that NID adopt and implement the requests and recommendations enumerated above.

The Network once again thanks NID for releasing these important documents to the public and soliciting comments before incorporating them into the updates of the AWMP and UWMP in 2021. These tools are key for developing District policy priorities that will in turn assist our region to achieve a sustainable water future. The Network recognizes the value of an ongoing dialogue regarding the details of assumptions, model inputs, and model functions to achieve a mutual understanding for water planning purposes.

Thank you for consideration of the Network's comments on NID's Water Planning Projection documents. Please contact Traci Van Thull, Coordinator, Foothills Water Network, if you have any questions.

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[37] For example, *Water Demand Projection Model Update*, p. 6 states, "The demand model described in Section 5 includes the ability to adjust the growth rate to evaluate the impacts of growth on water demand."

[38] *How NID Uses Water Planning Projections, op. cit.*

Respectfully submitted,

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Water Planning Analysis Technical Memos
Water Demand Projection Model Update
Submitted by Laura L. Peters
September 21, 2020

Please post the following updated appendices:

2011 Appendix A: Service Area Soft Boundary Changes (as discussed on page 18)

2011 Appendix C: Demand Analysis Results (as discussed on page 25)

P7 - 3rd paragraph under Section 4.2

Why didn't we compare the last 10 years of actual data to the projected to confirm if the trend supports the correlation of these two single data points from 13 and 18 years ago?

P11 – 1st paragraph.

1) How much water is associated with the PG&E and CDFW contracts?
2) When talking about the agreed upon environmental flows, it says "*These minimum flows are not recovered and, therefore, factored into demand estimations.*" The Water Supply Memo Table 3-1 notes the environmental flow requirement again. Is this subtracted again to determine the shortage?

P12 – 3rd bullet. Provide a summary of the updated parameters based on recent historical growth patterns.

P25

1) Table 5-6 – Provide an additional column showing the assumed Watershed Runoff associated with each of the Water Year Types.
2) (4th paragraph) – Clarify if average flow or peak flow values are included in the Total Demand value.

From: Mikos Fabersunne
To: NID Info
Subject: NID – Attention Water Planning Projections
Date: Tuesday, September 22, 2020 10:18:34 PM
Attachments: Water Demand TM_comments mf.pdf
NID_2016 Aggregated Farm Gate Reporting Form.pdf

Dear NID,

Enclosed please find my comments and questions in the document titled, “Water Demand TM_comments mf.pdf” and an attachment, "NID_2016 Aggregated Farm Gate . . ..pdf” for delivery to HDR in advance of the Technical Clarification Public Meeting on September 24, 2020. I plan on attending the Public Meeting.

Thank you for your consideration of my comments.

Mikos Fabersunne, P.E.
[redacted]
[redacted] [redacted]x
Nevada City, CA 95959-2156
[redacted] mobile & text
VOIP

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Water Demand Projection Model Update—Questions and Requests
Submitted by Mikos Fabersunne
September 22, 2020

To: Nevada Irrigation District
From: Mikos Fabersunne, P.E.
Subject: Questions and Requests regarding the Water Demand Projection Model Update

I am submitting the following questions and associated requests for additional information regarding the Water Demand Projection Model Update (Demand Analysis) in response to NID's requests for questions on the Technical Memoranda prepared by HDR as part of the forthcoming 2020 Raw Water Master Plan update:

1. Section 5: Demand Analysis, HDR Model Objectives: p.8, bullet 1 states, "[The objective is] Consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts."

   The stated objective implies that the water planning assumptions in the previous Raw Water Master Plan (RWMP) documents (which were not explicitly stated) are appropriate for projecting water demand out 40 years to the year 2060. However, the changes to the model are described only in general terms and not in sufficient detail to enable my full comprehension. It is unclear how the various consumption factors interact: applied water based on crop type and irrigated acreage v. canal flow data v. consumption values obtained from customer billings.

   Apparently the new 2018 consumption (demand) basis was generated using an updated model from the Phase 2 RWMP, which itself was an update of the Phase 1 RWMP model, and which included adjustments to the NID service boundaries, expansion of the irrigated crop areas to reflect the gross areas that could be used for irrigation versus the (net) areas that were reported in use by the customer, and use of the data from two gaging stations to distribute actual consumption over the parcels of lands under irrigation by the agricultural customers. Crop water consumption data, traditionally provided to NID by the customers and used in the prior RWMP reports, were <u>not</u> used because they were believed to be unreliable. Other factors, including climate change, crop rotation, land use changes, and canal deterioration were used to make further adjustments the model. The results of running the model with these adjustments established the new (2018) baseline consumption parameters. HDR claims that the resulting model was verified by comparison with the gaged 2007 canal flow data as well as with the 2002 data. HDR's conclusion was, ". . . the resulting model would be a good predictor of future demand." (sec 4.2, p.7).

   Request: Please have HDR review my summary above and indicate whether it is accurate, or if not, correct any errors/misunderstandings.

2. Lacking in the Demand Analysis are the values of consumption parameters used to establish the 2018 baseline. Given the confidence expressed by HDR in the model's capability of accurately predicting demand, presumably the model produced

estimates of demand that not only matched the actual demand values for 2018, but also those for the preceding years (2007-2018).

Request: Please direct HDR to provide the modeling results for the predicted water demand over the period of 2007-2018. If such results are not available, or if they are available but deviate significantly from the actual demand values, have HDR explain why the public and NID should accept their word that the model will be a good predictor of future water demand/consumption.

3. Plots of the projected consumption values in the Demand Analysis, Tables 6.1 and 6.2, yield curves with nearly constant positive slopes over the period from 2020 to 2060. Because HDR states in its Supply Analysis TM that the model utilizes periods of drought throughout the 40-year term, a reader would expect the estimated demand to vary in accordance with those fluctuations as well: less water consumption/more water conservation in dry years; more consumption in wet years, as is reflected in Figures 5.4 and 5.5. However, this effect does not appear to be present in the results of the Demand analysis.

   Although this phenomenon could be explained by elasticity in the supply side (due to reservoir storage), realistic scenarios during drought conditions suggest that curtailment by regulatory entities of water deliveries for less essential or lower priority uses, coupled with voluntary reductions in consumption by water customers, will have a significant impact in reducing demand. In the drought between 2013 and 2017, according to Demand Analysis Figure 5-5, the total demand for raw water per customer dropped from a peak in 2013 to a minimum in 2017—a reduction of 50%.

   Request: Please direct HDR to explain why there are no observed fluctuations in the demand projections that parallel such expected variations in the climate.

4. Although three different water scenarios based upon climate change are modeled in the Hydrologic Analysis and used in the Water Supply Analysis TM, no alternative demand scenarios are modeled in the Demand Analysis.

   Request: Please direct HDR to explain why there are no alternative demand scenarios in the Demand Analysis.

5. The State Water Resources Control Board (SWB) requires that irrigation districts present strategies in their planning documents for “Efficient Water Management Practices” to reduce water consumption.

   Item 1 in Table 7-1 of the 2015 Agricultural Water Management Plan (AWMP), under Critical Efficient Management Practices, mandates that NID measure the volume of water delivered to customers “with sufficient accuracy” to comply with the requirement that it submit an annual report to the SWB summarizing the aggregated farm-gate delivery data, on a monthly or bimonthly basis, "using best professional practices."

However, to my knowledge, NID has yet to fully comply with this mandate. Unlike other nearby irrigation districts that measure the amount of water actually delivered to its agricultural customers, NID apparently submits at most two values per year, each representing the aggregated sum of the deliveries to the over 5000 farm gates in its district—one for the sum of the deliveries during the irrigation season and the other for the sum of deliveries in the off-season. This becomes obvious when one examines the 2016 farm-gate report submitted to the SWB (copy attached). If actual measurements were taken on a monthly (or bimonthly) basis, the entries in the boxes on the form would vary from month to month.

NID's standard practice, according to the description in the 2012 AWMP, Section 2.6, p. 2-18 and Figures 2.9.1-2.9.6, is "to check the customer's [Standard Water Box] at the beginning of irrigation season and periodically throughout the season for accuracy." The water box utilizes a board with an orifice plate that can be placed to meter the flow in accordance with the height of the water level above the orifice—the greater the height of the water surface, the more flow through the orifice.

Clearly, such a <u>manual</u> system of setting/checking the position of the orifice plate in the water box offers little or no opportunity to change the flow to the customer in response to varying weather conditions, crop requirements, or to a change in any other important variable.

NID could replace the largest farm-gates (those controlling larger flows, up to 40 miners-inches) as well as large diversion structures (flows above 40 miners-inches) with automated dispatchable diversion equipment capable of controlling flow via reception of a radio signal transmitted from a convenient location. When such automated control systems have been deployed elsewhere, savings in agricultural water consumption have been 15% or more (savings in water consumption in open canal irrigations systems reported from the *Northern Victoria Irrigation Renewal Project* by the state of Victoria, Australia after deployment of water flow control automation).

Request:

a) Please direct HDR to perform additional simulations of their demand model with inputs showing decreased consumption due to the deployment of water conserving measures such as automated dispatchable water diversion/control equipment. I suggest spanning across a range of seasonal water consumption reductions: 5, 15, and 20%, for example.

b) Please have HDR consider other technical, administrative, or educational measures to reduce or encourage the reduction of water consumption by agricultural users and where possible apply them as additional conservation alternatives in an amended Demand Analysis.

6. From the Demand Analysis, “NID operates an extensive network of flow gages on their canal system”, stating that the District has 198 flow gauges, 170 of which are listed in Table 5-3. In past AWMPs, there have been statements that the accuracy of the data collected by the gages is within +/- 5-10% (2012 AWMP, section 2.2.2., p. 5-11).

   Request: To understand the technology used to collect the flow/stage data and to assess the veracity of NID/HDR’s claim regarding the accuracy of the gages, please direct HDR or NID staff to provide the following:

   a) representative photos of the various types of flow measurement devices in use
   b) the precision and accuracy of measurement for each type of device
   c) the count of the number of each type of gage that are in place

7. The list of flow gages in Table 5-3 of the Demand Analysis does not match those illustrated on the map of Fig 2.6, p. 2-11 of the 2012 AWMP.

   Request: Please direct HDR to explain the reason or the discrepancies between the map and the list in the respective documents.

Thank you for the opportunity to present my questions and requests to NID and its consultant HDR. I look forward to participating in the forthcoming Technical Clarification Public Meeting on September 24, 2020.

Sincerely,

Mikos Fabersunne

Agricultural Aggregated Farm-Gate[1] Delivery Reporting Form for Article 2

Title 23, Division 2, Chapter 5.1, Article 2 of the CCR requires water supplier subject to the regulation to report to DWR the previous calendar year's aggregated farm gate delivery by July 31 of the subsequent year

1. Water Supplier Information

Name: Nevada Irrigation District

Address: 1306 West Main Street Grass Valley, CA 95945

Phone Number: (530) 273-6185

Fax: (530) 274-3605

Total Number of Farm-Gates: 5593

Number of Measured Farm-Gates: 5593

Irrigated Acreage for Reporting Period: 29,300 Irrigated Acreage

Total Service Area Acreage: 287,000 Acre Boundaries

2. Contact information

Name: Nathan Wasley

Title: Water Superintendent

Address: 1036 West Main Street Grass Valley, CA 95945

Phone Number: (530) 273-6185 ext 291

Fax: (530) 274-3605

E-mail: wasley@nidwater.com

Submittal date: 5/10/17

Reporting year: 2016

3. Aggregated Farm-Gate Delivery Data[2]: (*provide monthly or bimonthly data, acre-feet*)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Monthly Deliveries	1331	1331	1331	16378	16378	16378	16378	16378	16378	16378	1331	1331	121302

	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	**Total**
Bimonthly Deliveries							

4. Explanations, Comments and Best Professional Practices[3]:

NID's winter sales consumption starts in November and ends in March. NID's summer sales consumption starts in April and ends in October. We send out payment to everyone in

Note: An agricultural water supplier's total water use may be different from Aggregated Farm-Gate deliveries because measurement at these points may not account for other practices (such as groundwater recharge/conjunctive use, water transfers, wheeling to other agencies, urban use, etc).

[1] "Farm-gate" means the point at which water is delivered from the agricultural water supplier's distribution system to each of its individual customers as specified in the Agricultural Water Measurement Regulation (Title 23, Division 2, Chapter 5.1, Article 2 of the CCR).

[2] "Aggregated farm-gate delivery data" means information reflecting the total volume of water an agricultural water supplier provides to its customers and is calculated by totaling its deliveries to customers.

[3] "Best Professional Practices" is defined in Title 23, Division 2, Chapter 5.1, Article 2 of the CCR, Section 597.2.

Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
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916-358-2900
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

October 9, 2020

Greg Jones
Interim General Manager
Attention: Water Planning Projections
Nevada Irrigation District
1036 West Main Street
Grass Valley, CA 95945
jonesg@nidwater.com
info@nidwater.com

Dear Mr. Jones:

Subject: 2020 Water Planning Projections prepared by Nevada Irrigation District

This correspondence is in response to the 2020 Water Planning Projections prepared by Nevada Irrigation District (NID) and shared on August 26, 2020. The 2020 Water Planning Projections include a Hydrologic Analysis Technical Memorandum[1], Water Supply Analysis Technical Memorandum[2], and Water Demand Projection Model Update[3]. Public comments were requested by October 12, 2020.

AUTHORITY

The fish and wildlife resources of the State of California are held in trust for the people of the State by and through the California Department of Fish and Wildlife (CDFW) (Fish & G. Code § 711.7). CDFW has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of those species (Fish & G. Code § 1802). The mission of CDFW is to manage California's diverse fish, wildlife, and plant resources, and the habitats on which they depend, for their ecological values and for their use and enjoyment by the public. Accordingly, CDFW is providing comments on NID's 2020 Water Planning Projections and associated technical memoranda.

COMMENTS

CDFW recommends the following updates be made to the technical memoranda to better inform NID's water projections and operations planning:

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[1] Nevada Irrigation District. Hydrologic Analysis Technical Memorandum, prepared by HDR Engineering, Inc. 2020. https://nidwater.com/wp-content/uploads/2020/08/Hydrologic_-Analysis_-TM_20200825_signed.pdf

[2] Nevada Irrigation District. Water Supply Analysis Technical Memorandum, prepared by HDR Engineering, Inc. 2020. https://nidwater.com/wp-content/uploads/2020/08/Water-Supply-TM-082520-Signed.pdf

[3] Nevada Irrigation District. Water Demand Projection Model Update, prepared by HDR Engineering, Inc. 2020. https://nidwater.com/wp-content/uploads/2020/08/Water-Demand-Model-TM-82520-Signed.pdf

1. Instead of mass-balance calculations, use the vetted HEC-ResSim operations model to analyze annual supply, projected carryover storage, available water for demand, and potential water supply shortages. Consistent with the August 2020 Urban Water Management Plan (UWMP) Guidebook[4], use the results of the Five-Year Drought Scenario comprising the driest consecutive five-year period on record to estimate drought impacts on water availability.

2. Present water projections under a range of projected demand scenarios and put in context NID's water supply sensitivity to each of FERC agreed-upon minimum instream flows, projected water demand, and climate projections in order to better understand potential water supply vulnerabilities and associated management solutions.

1. HEC-ResSim Drought Scenario Modeling

CDFW recommends NID use an existing, vetted operations model (Hec-ResSim) for water planning projections, including drought scenario modeling[5], rather than relying on mass-balance calculations. The HEC-ResSim tool capitalizes on 39-years of historic hydrology to explore various water planning scenarios. CDFW recommends use of this tool for water operations modeling, water projections and planning, and for communicating with stakeholders the implications of future water use and availability scenario, because: 1) the tool has been vetted by many stakeholders, 2) the tool better accounts for natural system variability when assessing for drought impacts to water delivery potential, and 3) the tool allows for comparative analysis of relative impacts to reservoir carryover storage.

HEC-ResSim Tool Development

During NID's Federal Energy Regulatory Commission (FERC)-relicensing process, CDFW staff participated in a technical group to provide feedback on the development of the unimpaired hydrology and HEC-ResSim operations model. CDFW and other FERC relicensing stakeholders agreed to use the results of the operations modeling to compare operational scenarios for FERC-license instream flow releases, including minimum instream flows[6]. The tool and various modeled outputs were used to develop a flow proposal that was agreed-upon and submitted by NID to FERC in their Amended Final License Application and later adopted in FERC's Final Environmental Impact Statement.

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[4] Department of Water Resources. Urban Water Management Plan Guidebook 2020. https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans

[5] NID developed projected water supply and demand in compliance with Executive Order SB-37-16(8) and in anticipation of the release of the 2020 update to the UWMP Guidebook. Specifically, NID developed the required five-year drought scenario using five of the driest years on record, and subsequently amended projections based on the updated guidelines dated August 2020 using the driest *consecutive* five-year period on record. NID modeled these drought scenarios using mass-balance calculations.

[6] NID technical memoranda frequently refer to FERC agreed-upon minimum instream flows as 'environmental flows.'

Water Deliveries

Use of the Hec-ResSim tool allows for more accurate consideration of natural system variability when compared to the mass-balance approach used for current water projections. Reservoirs in this system fill and spill in winter and spring of wet years, which effects water balance calculations which are reflected in the modeling. Reservoir spill effectively resets the mass balance equations to full reservoir storage. Though FERC agreed-upon minimum instream flows are higher during wet years, the minimum flows are often met by naturally spilled water rather than water released from reservoir storage (Appendix A, Comments on Water Supply Technical Memorandum).

CDFW staff summarized NID water deliveries during the 39-year period of operations modeling for four scenarios (Appendix A, Table 1):

- Base case (existing conditions)
- FERC minimum instream flows
- FERC flows + 2060 projected water demands
- FERC flows + 2060 projected water demands + 2070 climate change scenarios

Hec-ResSim results show that NID's ability to meet existing water deliveries under present-day climatic conditions is impacted by FERC minimum instream flows in only two years (Appendix A, Table 1). Though deliveries are further impacted when considering projected demand and climate scenarios, substantial water deliveries are still possible even during dry year sequences. CDFW recommends updating Table 3-1 in the Water Supply Technical Memorandum with values from a modeled consecutive five-year drought scenario to more accurately characterize how future conditions will impact water supply.

Reservoir Carryover Storage

Using the operations modeling and the driest sequential five-year period on record, 1987-1991, CDFW similarly summarized reservoir carryover storage for the four scenarios presented above. When compared to the base case scenario, reservoir storage is impacted to a small degree by FERC minimum instream flows (7%) and to a larger extent in the scenarios that include projected water demands and climate change scenarios (Appendix A, Table 2), suggesting demand projections and climate change each have a proportionally greater impact on water storage than FERC minimum instream flows.

2. Characterization of Water Projections

CDFW recommends that NID update the technical memoranda to present modeled scenarios that reflect a range of water demand projections. CDFW requests a clarification on the assumptions used to generate water demand projections and recommends using the previous 10 years of water use data to calibrate demand projections based on both population growth and historic water use trends. CDFW also recommends incorporating water demand projections by sector to better account for anticipated land use changes.

Updating the technical memoranda with well-justified demand scenarios will better reflect the proportional impacts that climate change, water demand projections, and FERC minimum instream flows each have on NID’s water system, rather than considering them only in the aggregate. CDFW recommends also developing a water projection scenario that only considers FERC minimum instream flows and climate change, thereby isolating demand impact to water vulnerability in the planning period. We recommend this scenario because NID has the ability to manage demand, but not climate or FERC-mandated flows.

CONCLUSION

CDFW recommends updating the 2020 Water Planning Projections technical memoranda through use of NID’s operations model, HEC ResSim. This method will better incorporate natural system variability and will allow for a more detailed analysis of projected water supplies in NID’s service area. Additional information that summarizes the individual impacts of the FERC minimum instream flows, water demand projections, and climate change scenarios on NID’s water operations is necessary context for accurately interpreting the technical memoranda. The FERC minimum instream flows represent a small impact on NID’s water supply, deliveries, and carryover storage. By presenting additional ranges of projected water demand and analyzing sensitivity in supply projections, the vulnerabilities in the system and their drivers can be more clearly identified.

CDFW appreciates the opportunity to comment on the 2020 Water Planning Projections. Questions regarding this letter or further coordination should be directed to Bridget Gibbons, Environmental Scientist at (916) 767-3993 or bridget.gibbons@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Kevin Thomas
A2A0A9C574C3445...

Kevin Thomas
Regional Manager

Attachments
Appendix A: Comments on Technical Memoranda

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California Department of Fish and Wildlife

Appendix A: Comments on Technical Memoranda

Comments on Hydrologic Analysis Technical Memorandum:

CDFW staff participated in a technical group to provide feedback during the development of the unimpaired hydrology and dependent HEC-ResSim operation model development during the FERC-relicensing process. CDFW and other stakeholders agreed to use the results of the operations modeling at that time to compare different operational scenarios of proposals for the FERC-license instream flow releases. Ultimately use of this tool, and various outputs from this modeling, were extensively used to develop a proposal that was agreed-upon and submitted by NID to FERC in their Amended Final License Application and later adopted in FERC's Final Environmental Impact Statement. For the purpose of this Appendix, CDFW will refer to the agreed-upon FERC flows as "FERC minimum instream flows." CDFW supports use of this HEC-ResSim tool for water operations modeling, water planning, and for communicating with various stakeholders the implications of future use scenarios.

Comments on Water Supply Technical Memorandum:

Water Deliveries

CDFW staff understand that NID has developed the projected water supply demands for this memorandum in compliance with Executive Order SB-37-16(8) and in anticipation of the release of The State of California guidelines in their 2020 update to the Urban Water Management Plan (UWMP) guidebook. We understand that NID developed projections for this memo using five of the driest years on record, and subsequently, updated drought water supply projections using the five driest *sequential* years on record per the UWMP guidebook. CDFW supports UWMP updated methodology for determination of drought water supply based on the five driest consecutive water years on record.

The use of the five sequential years of modeling (called "drought sequence" modeling in this appendix) will allow NID to use their already-developed, vetted, operations modeling that capitalizes on 39 years of historic hydrology to look at various water planning scenarios. NID's previous reliance on five non-sequential years to create a hypothetical drought (called "hypothetical drought years" in this appendix) forced use of mass-balance calculations for water supply and reliability considerations of annual supply, projected carryover storage, available water for demand, and potential shortages to customers. These mass-balance calculations do not reflect natural year-to-year variability and can overestimate impacts these supply considerations.

When natural variability is considered, the reservoirs on this project fill and spill in winter and spring in wet years. Reservoir spill has two effects on water balance calculations and modeling. First, it resets the mass balance calculations, essentially starting over with full reservoir storage. Second, although the instream flows may be higher in the wetter years, most of the time those flows are eclipsed by spill from the project reservoirs, and therefore prescribed minimum instream flows are therefore inconsequential in determining how much water will need to be released by NID from storage to provide required minimum instream flows to the rivers. Therefore, wet year minimum instream flows, although they look larger on paper, do not affect water supply.

To illustrate this difference between spill and minimum instream flows, several points downstream of reservoirs were considered. In the figures below, we selected output from the operations modeling from 1976-1984 so that the driest year/s on record (drought of 1976-1977) could be considered as well as two wet years (1982 and 1983) and two additional dry years (1981 and 1985).

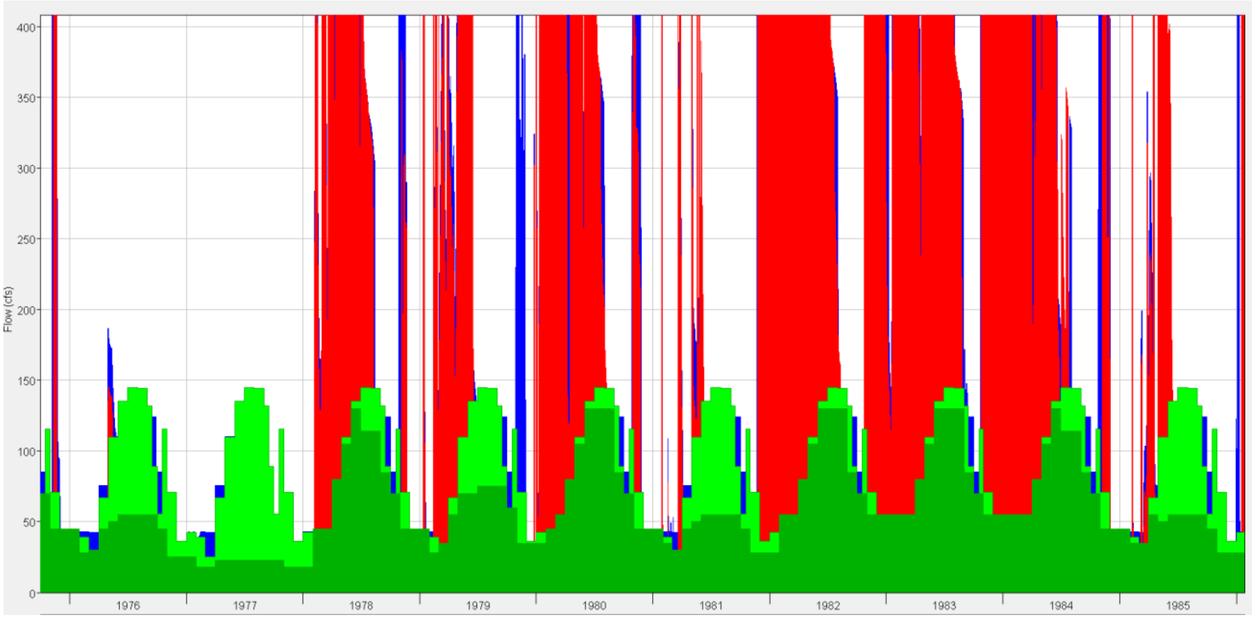


Figure 1. Instream flow downstream of Rollins Reservoir, dark green shaded area = minimum instream flows, light green shaded area = minimum instream flows plus required reservoir releases for deliveries to node NID-3, blue shaded area = base case (existing conditions), red shaded area = existing conditions with FERC minimum instream flows.

In Figure 1, note that although minimum instream flows vary during each water year type, the (light green) demand pattern does not change because instream flows are not “lost to the system” and are able to be picked up and used for delivery out of Combie. In 1976 and 1977 the only flows released to the river are represented by the stepped pattern of minimum instream flow releases plus water delivery releases to node NID-3. Those are years where the reservoir does not spill. In all other years, including parts of dry years 1981 and 1985 at Rollins, the reservoirs spills (shown below where red and blue shading are greater than the green minimum instream flows) and during this time, minimum instream flow releases do not govern reservoir operational releases.

Appendix A
Page 3

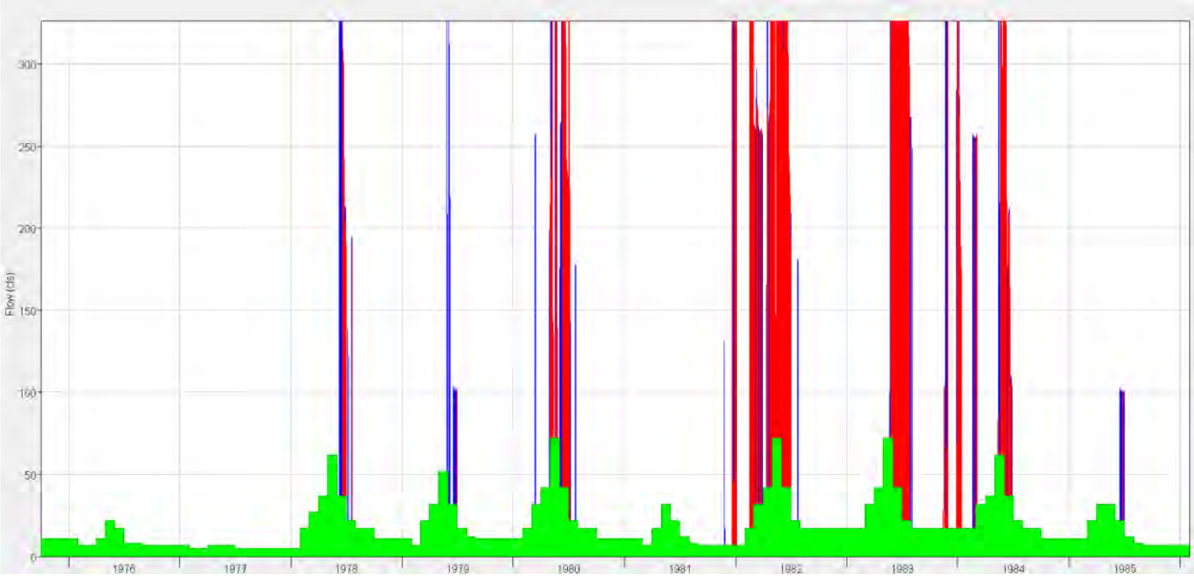


Figure 2. Instream flow downstream of Milton Diversion Dam, green shaded area = minimum instream flows plus required reservoir releases for deliveries to node NID-3, blue shaded area = base case (existing conditions), red shaded area = existing conditions with FERC minimum instream flows.

In Figure 2 spill patterns are not as large, because Jackson Meadows reservoir spills less than Rollins, and the Milton-Bowman canal is capable of capturing up to 425 cubic feet per second. However, it is worth noting that spill in 1978, 1979, and 1980 is after the period of high minimum instream flow releases. Minimum instream flows are characterized in the Water Supply Memorandum as "Non-Recoverable Environmental Water," however it is worth noting here that as illustrated above, these environmental flows do not impact water supply, because had the water been saved in storage at Jackson Meadows, it would have spilled in spring regardless. Spill patterns were a major consideration in development of these instream flows during relicensing; spill flow hydrology governs the ability to reliably deliver higher minimum instream flows without significant impact to water supply or hydropower production.

NID's demand nodes were summarized in Table 4-1 of the Hydrologic Analysis Technical Memorandum as:

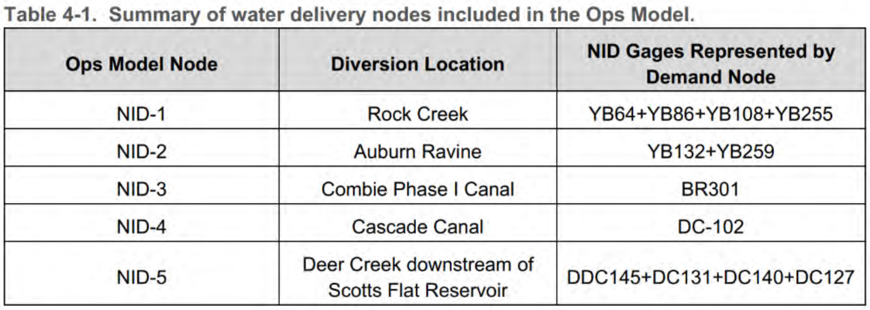
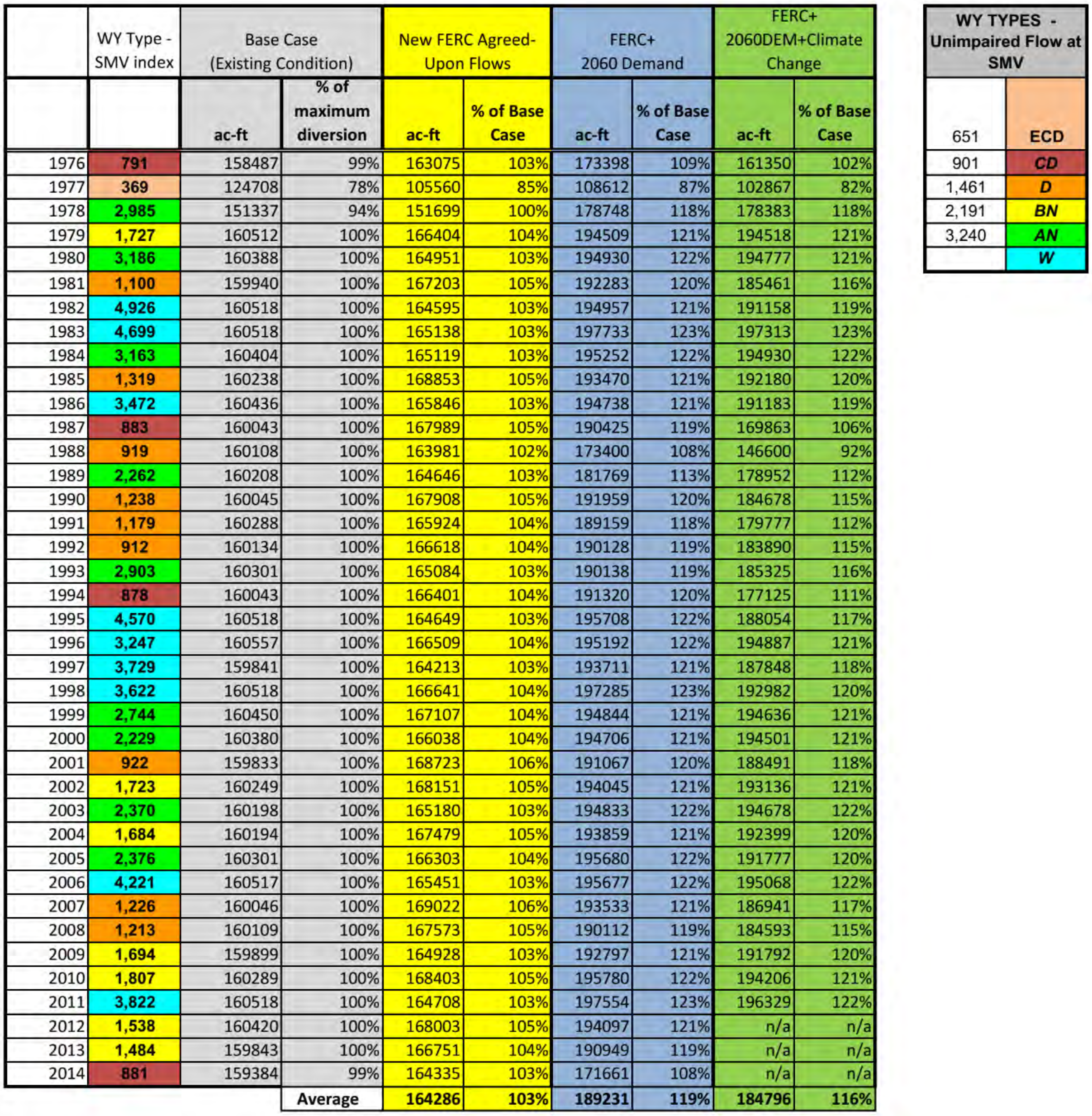


Table 4-1. Summary of water delivery nodes included in the Ops Model.

Ops Model Node	Diversion Location	NID Gages Represented by Demand Node
NID-1	Rock Creek	YB64+YB86+YB108+YB255
NID-2	Auburn Ravine	YB132+YB259
NID-3	Combie Phase I Canal	BR301
NID-4	Cascade Canal	DC-102
NID-5	Deer Creek downstream of Scotts Flat Reservoir	DDC145+DC131+DC140+DC127

Using these nodes, we summarized below the NID deliveries during the 39-year period of operation modeling for the FERC increased minimum instream flows, FERC flows plus 2060 projected demands, and FERC flows plus 2060 demand plus 2070 climate change scenarios in Table 1 below.[1] Water year types using the “Smartsville Index” are also included; thresholds for determination of water year types are included on the right and indicate DWR’s calculated unimpaired natural inflow in thousands of acre-feet.

Table 1. Total Annual (by Water Year) Diversions from NID Delievery Nodes 1-5, From HEC-ResSim Operations Modeling Results



	WY Type - SMV index	Base Case (Existing Condition)		New FERC Agreed-Upon Flows		FERC+ 2060 Demand		FERC+ 2060DEM+Climate Change	
		ac-ft	% of maximum diversion	ac-ft	% of Base Case	ac-ft	% of Base Case	ac-ft	% of Base Case
1976	791	158487	99%	163075	103%	173398	109%	161350	102%
1977	369	124708	78%	105560	85%	108612	87%	102867	82%
1978	2,985	151337	94%	151699	100%	178748	118%	178383	118%
1979	1,727	160512	100%	166404	104%	194509	121%	194518	121%
1980	3,186	160388	100%	164951	103%	194930	122%	194777	121%
1981	1,100	159940	100%	167203	105%	192283	120%	185461	116%
1982	4,926	160518	100%	164595	103%	194957	121%	191158	119%
1983	4,699	160518	100%	165138	103%	197733	123%	197313	123%
1984	3,163	160404	100%	165119	103%	195252	122%	194930	122%
1985	1,319	160238	100%	168853	105%	193470	121%	192180	120%
1986	3,472	160436	100%	165846	103%	194738	121%	191183	119%
1987	883	160043	100%	167989	105%	190425	119%	169863	106%
1988	919	160108	100%	163981	102%	173400	108%	146600	92%
1989	2,262	160208	100%	164646	103%	181769	113%	178952	112%
1990	1,238	160045	100%	167908	105%	191959	120%	184678	115%
1991	1,179	160288	100%	165924	104%	189159	118%	179777	112%
1992	912	160134	100%	166618	104%	190128	119%	183890	115%
1993	2,903	160301	100%	165084	103%	190138	119%	185325	116%
1994	878	160043	100%	166401	104%	191320	120%	177125	111%
1995	4,570	160518	100%	164649	103%	195708	122%	188054	117%
1996	3,247	160557	100%	166509	104%	195192	122%	194887	121%
1997	3,729	159841	100%	164213	103%	193711	121%	187848	118%
1998	3,622	160518	100%	166641	104%	197285	123%	192982	120%
1999	2,744	160450	100%	167107	104%	194844	121%	194636	121%
2000	2,229	160380	100%	166038	104%	194706	121%	194501	121%
2001	922	159833	100%	168723	106%	191067	120%	188491	118%
2002	1,723	160249	100%	168151	105%	194045	121%	193136	121%
2003	2,370	160198	100%	165180	103%	194833	122%	194678	122%
2004	1,684	160194	100%	167479	105%	193859	121%	192399	120%
2005	2,376	160301	100%	166303	104%	195680	122%	191777	120%
2006	4,221	160517	100%	165451	103%	195677	122%	195068	122%
2007	1,226	160046	100%	169022	106%	193533	121%	186941	117%
2008	1,213	160109	100%	167573	105%	190112	119%	184593	115%
2009	1,694	159899	100%	164928	103%	192797	121%	191792	120%
2010	1,807	160289	100%	168403	105%	195780	122%	194206	121%
2011	3,822	160518	100%	164708	103%	197554	123%	196329	122%
2012	1,538	160420	100%	168003	105%	194097	121%	n/a	n/a
2013	1,484	159843	100%	166751	104%	190949	119%	n/a	n/a
2014	881	159384	99%	164335	103%	171661	108%	n/a	n/a
			Average	**164286**	**103%**	**189231**	**119%**	**184796**	**116%**

WY TYPES - Unimpaired Flow at SMV	
651	**ECD**
901	***CD***
1,461	***D***
2,191	***BN***
3,240	***AN***
	W

Deliveries, as compared to those available in the base case (existing condition) are impacted by agreed-upon FERC minimum instream flows (see yellow columns) in only two

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[1] To be additionally conservative when considering drought impacts, NID could expand the operations modeling further to include the 2012-2016 drought sequence, which contains a different pattern of back-to-back drought years than 1987-1992 in that there was four below normal to dry years in a row. Having two different drought sequences in the full period of record would allow NID additional surety in their drought planning.

years: 1977 (about 18% decrease in delivery potential) and 1978 (about 3% decrease in delivery potential), assuming an adjusted delivery base of 103% to account for modeling differences in the diversion time series. In the expanded 2060 water demand scenarios and climate change scenarios, there are some impacts to NID's ability to make full expanded deliveries in all water years. However, even during the driest year sequence (1987-1992), substantial water deliveries are still possible.

Because the reservoirs do fill and spill, a mass balance calculation starting from a hypothetical drought scenario cannot represent true reservoir conditions, because once a reservoir spills, the mass balance is reset with a full reservoir. Using the output from the operations modeling thus allows the users to more accurately look at how future conditions will impact NID's ability to deliver water.

Reservoir Carryover Storage Reliability

Table 4-1 in the Water Supply Technical Memorandum indicates that in back-to-back stacked drought years, there is essentially no carryover storage in the system by the third year of the drought. Using the reservoir operations modeling, and choosing the driest five *consecutive* years on the record, 1987-1991, we can examine in more detail the impact to reservoir storage of the FERC increased minimum instream flows, FERC flows plus 2060 projected demands, and FERC flows plus 2060 demand plus 2070 climate change scenarios.

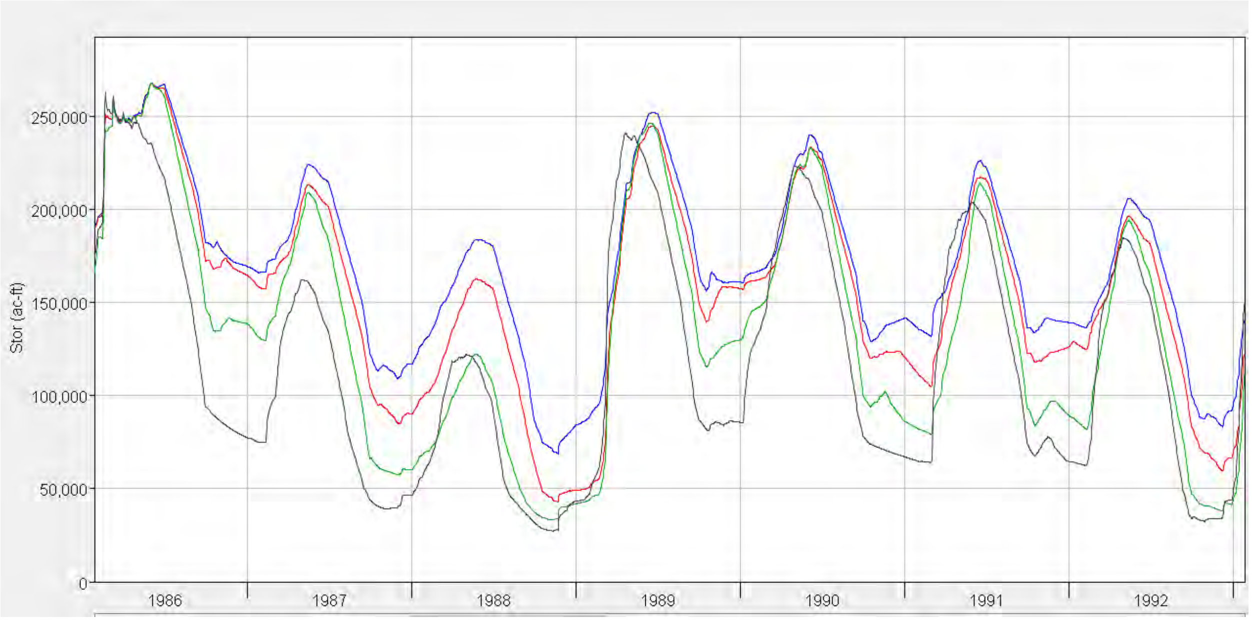
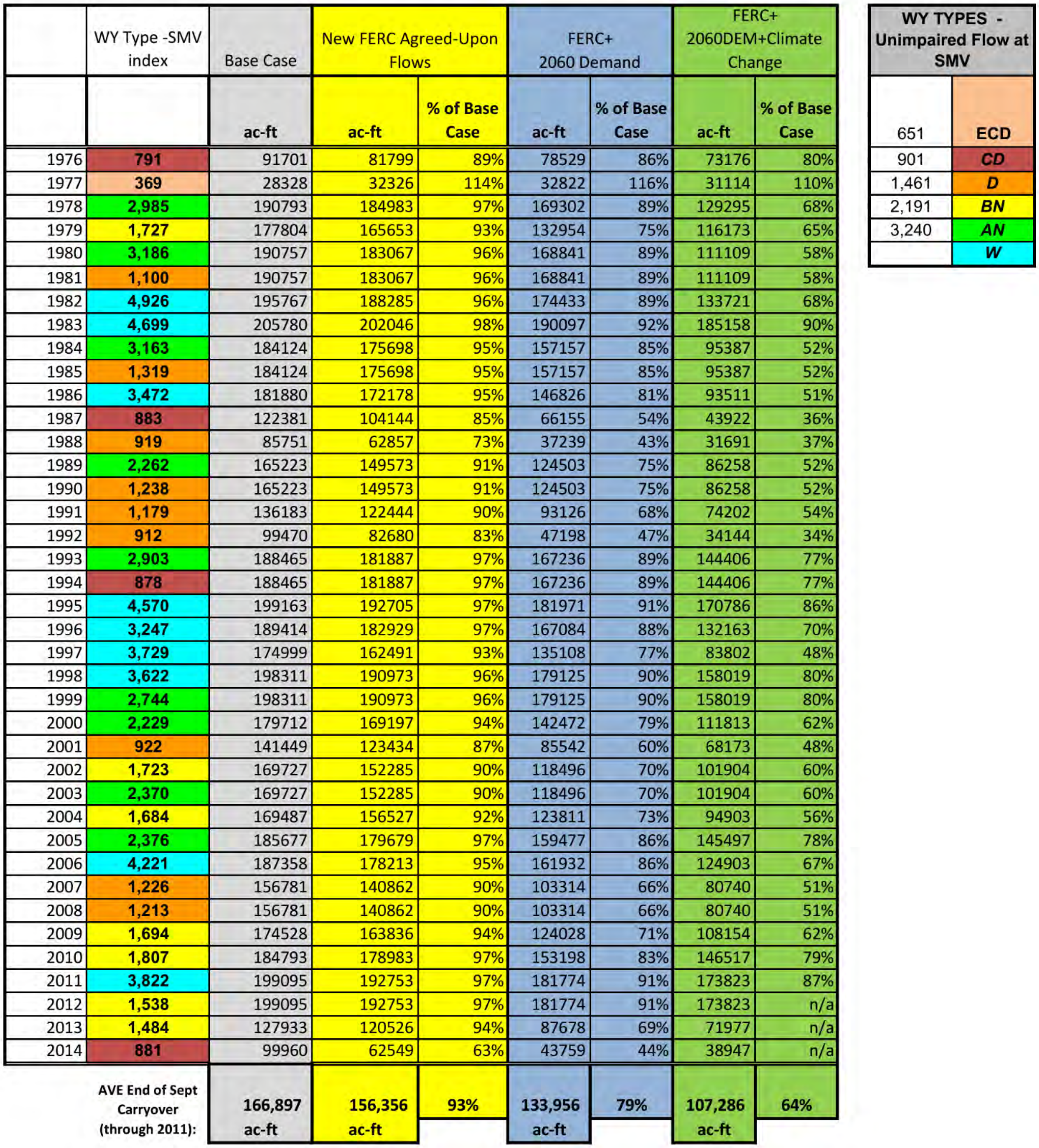


Figure 3. Total system storage during the driest drought year sequence on (modeling) record including Bowman, Faucherie, French, Jackson Meadows, Lake Combie, Rollins, Sawmill, and Scotts Flat Reservoirs: blue Line = base case (existing conditions), red line = existing conditions with FERC minimum instream flows, green Line = FERC flows plus future NID water demand, black line = FERC flows plus future water demand plus climate change.

The carryover storage component is usually summarized by considering the end-of-September (EOS) reservoir storage values. Using this EOS value for each year for the eight reservoirs with total storage over 3,000 ac-ft, we summarized below the NID carryover storage potential during the 39-year period of operation modeling for the FERC increased minimum instream flows, FERC flows plus 2060 projected demands, and FERC flows plus 2060 demand plus 2070 climate change scenarios in Table 2 below:

Table 2. Total Average (by Water Year) End of September Carryover Storage, From HEC-ResSim Operations Modeling Results, Using NID Reservoirs with Over 3000 ac-ft of Storage (Bowman, Faucherie, French, Jackson Meadows, Combie, Rollins, Sawmill, Scott's Flat)



	WY Type -SMV index	Base Case	New FERC Agreed-Upon Flows		FERC+ 2060 Demand		FERC+ 2060DEM+Climate Change	
		ac-ft	ac-ft	% of Base Case	ac-ft	% of Base Case	ac-ft	% of Base Case
1976	791	91701	81799	89%	78529	86%	73176	80%
1977	369	28328	32326	114%	32822	116%	31114	110%
1978	2,985	190793	184983	97%	169302	89%	129295	68%
1979	1,727	177804	165653	93%	132954	75%	116173	65%
1980	3,186	190757	183067	96%	168841	89%	111109	58%
1981	1,100	190757	183067	96%	168841	89%	111109	58%
1982	4,926	195767	188285	96%	174433	89%	133721	68%
1983	4,699	205780	202046	98%	190097	92%	185158	90%
1984	3,163	184124	175698	95%	157157	85%	95387	52%
1985	1,319	184124	175698	95%	157157	85%	95387	52%
1986	3,472	181880	172178	95%	146826	81%	93511	51%
1987	883	122381	104144	85%	66155	54%	43922	36%
1988	919	85751	62857	73%	37239	43%	31691	37%
1989	2,262	165223	149573	91%	124503	75%	86258	52%
1990	1,238	165223	149573	91%	124503	75%	86258	52%
1991	1,179	136183	122444	90%	93126	68%	74202	54%
1992	912	99470	82680	83%	47198	47%	34144	34%
1993	2,903	188465	181887	97%	167236	89%	144406	77%
1994	878	188465	181887	97%	167236	89%	144406	77%
1995	4,570	199163	192705	97%	181971	91%	170786	86%
1996	3,247	189414	182929	97%	167084	88%	132163	70%
1997	3,729	174999	162491	93%	135108	77%	83802	48%
1998	3,622	198311	190973	96%	179125	90%	158019	80%
1999	2,744	198311	190973	96%	179125	90%	158019	80%
2000	2,229	179712	169197	94%	142472	79%	111813	62%
2001	922	141449	123434	87%	85542	60%	68173	48%
2002	1,723	169727	152285	90%	118496	70%	101904	60%
2003	2,370	169727	152285	90%	118496	70%	101904	60%
2004	1,684	169487	156527	92%	123811	73%	94903	56%
2005	2,376	185677	179679	97%	159477	86%	145497	78%
2006	4,221	187358	178213	95%	161932	86%	124903	67%
2007	1,226	156781	140862	90%	103314	66%	80740	51%
2008	1,213	156781	140862	90%	103314	66%	80740	51%
2009	1,694	174528	163836	94%	124028	71%	108154	62%
2010	1,807	184793	178983	97%	153198	83%	146517	79%
2011	3,822	199095	192753	97%	181774	91%	173823	87%
2012	1,538	199095	192753	97%	181774	91%	173823	n/a
2013	1,484	127933	120526	94%	87678	69%	71977	n/a
2014	881	99960	62549	63%	43759	44%	38947	n/a
	AVE End of Sept Carryover (through 2011):	166,897 ac-ft	156,356 ac-ft	93%	133,956 ac-ft	79%	107,286 ac-ft	64%

WY TYPES - Unimpaired Flow at SMV	
651	ECD
901	CD
1,461	D
2,191	BN
3,240	AN
	W

Similar to the water delivery discussion above, reservoir storage is impacted a small amount by increased FERC minimum instream flows, and to a larger extent by increases to 2060 projected water demands and climate change scenarios.

From: Lawson, Beth@Wildlife
To: NID Info
Cc: Gibbons, Bridget@Wildlife; Seapy, Briana@Wildlife
Subject: Questions for 9/24 technical meeting
Date: Wednesday, September 23, 2020 9:24:10 AM

Thank you for providing an opportunity to provide questions in advance of the 9/24 technical meeting. CDFW submits the following questions for our discussion tomorrow:

1. Model data was provided by NID. Please point us to the time series in the DSS timeseries that have the modeled output of simulated stream flow and reservoir conditions with:
    a. Baseline conditions (existing hydrology, existing streamflow requirements)
    b. 2070 median climate change hydrology,
    c. Anticipated FERC license conditions (minimum flow requirements), and
    d. 2060 projections of customer demand.

2. Please discuss how the 5-year drought values was developed and used in the water demand projections. The water supply memo says that: *To simulate watershed runoff conditions for a five-year drought the five driest water years were placed back to back and ordered from wettest to driest, based on their annual runoff volume: 1994, 1987, 1988, 1976 and 1977.* Can you talk about how and if this back-to-back modeling was included in the operations modeling?

3. We would like to walk through the numbers in the Water Supply Memo Table 3-1 and talk through each of the lines to understand whether each of the values presented here are calculated from modeling data or summation values from other analyses. Are the drought years values presented here based on using the operations modeling and with historic time series for initial conditions, or an average carryover storage going into the drought years?

Thank you for consideration of these questions. We look forward to a productive conversation tomorrow.

Elizabeth Lawson, P.E.
Senior Hydraulic Engineer

California Department of Fish and Wildlife
North Central Region - Water Program
1701 Nimbus Road, Suite A
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Phone: (916) 358-2875

From: Lawson, Beth@Wildlife
To: NID Info
Cc: Gibbons, Bridget@Wildlife; Seapy, Briana@Wildlife
Subject: RE: Questions for 9/24 technical meeting
Date: Wednesday, September 23, 2020 10:39:10 AM

Oops - one more question for the 9/24 meeting:

During relicensing. NID and PG&E provided copies to the relicensing participants of a post-processing water delivery assessment tool called the “red blue model” (YB and DS Water Allocation Module.xlsx) which used operations model data output to help summarize water deliveries to each of NID and PCWA’s demand locations. Is this updated tool available for this current set of scenarios?

From: Lawson, Beth@Wildlife
Sent: Wednesday, September 23, 2020 9:23 AM
To: 'info@nidwater.com' <info@nidwater.com>
Cc: Gibbons, Bridget@Wildlife <Bridget.Gibbons@Wildlife.ca.gov>; Seapy, Briana@Wildlife <Briana.Seapy@Wildlife.ca.gov>
Subject: Questions for 9/24 technical meeting

Thank you for providing an opportunity to provide questions in advance of the 9/24 technical meeting. CDFW submits the following questions for our discussion tomorrow:

1. Model data was provided by NID. Please point us to the time series in the DSS timeseries that have the modeled output of simulated stream flow and reservoir conditions with:
    a. Baseline conditions (existing hydrology, existing streamflow requirements)
    b. 2070 median climate change hydrology,
    c. Anticipated FERC license conditions (minimum flow requirements), and
    d. 2060 projections of customer demand.

2. Please discuss how the 5-year drought values was developed and used in the water demand projections. The water supply memo says that: *To simulate watershed runoff conditions for a five-year drought the five driest water years were placed back to back and ordered from wettest to driest, based on their annual runoff volume: 1994, 1987, 1988, 1976 and 1977.* Can you talk about how and if this back-to-back modeling was included in the operations modeling?

3. We would like to walk through the numbers in the Water Supply Memo Table 3-1 and talk through each of the lines to understand whether each of the values presented here are calculated from modeling data or summation values from other analyses. Are the drought years values presented here based on using the operations modeling and with historic time series for initial conditions, or an average carryover storage going into the drought years?

Thank you for consideration of these questions. We look forward to a productive conversation tomorrow.

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From: John Norton
To: NID Info
Subject: September 24, 2020 – Water Planning Projections Technical Clarifications Meeting
Date: Tuesday, September 22, 2020 3:55:58 PM

Here are my Questions for the September 24th, Technical Clarification Meeting.

In the water demand projection model figure 3-3 shows dramatic population increases for Placer County. Did this analysis separate out the NID District boundaries from the County? What is the population growth in the NID portion of the County? What is the raw water projected demand in the NID portion of Placer County?

In the water demand projection model update table 6-3 shows a 10% increase in annual demand for every decade. According to NID records the actual demand from 2008 to 2017 decreased by 15%. Why and how do you arrive at a 10% per decade increase over the next 40 years?

There are inconsistencies regarding the number of years projected in the various tables. Many projections are to the year 2060 and others are to the year 2070. There should be consistency.

In the water supply analysis TM: Table 3-1 shows a total demand of 255,136 acre feet for an average year in 2070. The highest demand in table 6-3 of the “Demand” document is 208,936 AF for 2060. What is the relationship between these 2 documents? Why is there a 22% increase in demand in the “Supply” document? The demand estimates in the “Demand” document include environmental flows. The “Supply” document adds these flows again. Is there double counting of environmental flows?

Thank You

John Norton
[redacted]

Dianna Suarez Sept. 18, 2020

Water Demand Projection
Model Update
Nevada Irrigation District (NID)
August 26, 2020

Questions:

1. Why is it that none of the upper division dams, conveyances and reservoirs are mentioned in the Water Demand Model Projections Update? What about Environmental demand in the upper division?

2. How do you justify the validity of using soft service areas, canal capacity, parcel data, and arable land base to determine future need when we live in such unpredictable times with pandemic caused economic recession, catastrophic wildfires, rolling blackouts, and public safety power shut offs? We cannot count on business as usual for total "potential demand". How do you account for these significant and unpredictable future events? What weight do you give this complicated and increasingly baseless estimate?

3. According to the Dept. of Finance Regional Census Data, (cited in the report), Nevada County had a loss of 650 people during the last decade. Since 80% of the District is within Nevada County, (4 of the 5 Divisions), that had a net loss of population over the last decade, why does the model project raw water demand increases of 44% over 40 years for the Deer Creek System and 36% increase for the Bear River System? The factors leading to these outcomes and the weight given to each factor need to be specifically listed and clearly explained.

4. On page 19, figures 5-6, and 5-7, raw water sales are only shown for 5 years and increased 2.5% while demand per customer decreased 40%. What is the long term conservation target for raw water use?

5. According to figure 5-7, page 21, Potable Water use dropped by 26% even though the number of customers increased by 7%. What is the long term conservation target for treated water?

6. Why is there only 5 years of raw water data shown while there is 10 years of potable water data shown? How then can these be compared?

7. The minimum environmental flows below Rollins Dam are captured by Combie Reservoir. Why are these flows considered lost to the system?

8. Where is the data demonstrating how much, where, and why the environmental flows are lost to the system? Where is an environmental water management plan and why has the environmental demand been limited to 2 paragraphs in this update when environmental water demand is the majority of the natural flow?

9. Why doesn't NID use the Handbook for Water Budget Development format for the Raw Water Master Plan when both the upcoming Ag Water and Treated Water Management Plans will require this format?

10. Where is the groundwater demand addressed when the majority of residents in the District depend on wells and groundwater?

11. Given that water is a finite resource, how does NID plan to curb demand?

Dianna Suarez, [redacted]

From: Walter Roche
To: NID Info
Subject: Water Demand Update
Date: Wednesday, September 23, 2020 8:55:34 AM

Thank you for the opportunity to comment on the Water Demand Update Report. My comments are as follows:

1. On page 11, the required flows are listed as 27,900 and 58,800 cfs. I think they should be 27,900 and 58,800 acre-feet per year.
2. On page 22, I recommend mentioning that some of the water for the Nevada City Treatment Plant comes from a diversion on Little Deer Creek.
3. Also on page 22, the text mentions 6 NID treatment plants, and Figure 5-9 shows 7 NID treatment plants.

I look forward to participating in the Zoom meeting on September 24.

W. Martin Roche, Consulting Engineer