NEVADA IRRIGATION DISTRICT

PLAN FOR WATER

APPENDIX C

Water Supply Analysis Technical Memorandum – Final Report
with
Appendices

Appendix A - Updated 2032 Projected Water Supply Deficits Under Extreme Hypothetical Drought
Appendix B - NID Drought Management Plan
Appendix C - Alternative 5-Year Drought Based on the Five-Consecutive Driest Years in the 1976-2011 Period of Record **(Appendix E to RFP)**
Appendix D - Alternative 5-Year Drought Based on the Repeated Average of the Five-ConsecutiveDriest Years in the 1976-2011 Period of Record **(Appendix F to RFP)**

Water Supply Analysis TM – Final Report

Nevada Irrigation District (NID)

November 12, 2020

NID

NEVADA IRRIGATION DISTRICT

Date: 11/12/2020

Sergio Jimenez, P.E.

HDR Engineering, Inc.

Civil Engineer, C55698

Expiration Date: December 31, 2020

Date: 11/12/2020

Megan Lionberger, P.E.

HDR Engineering, Inc.

Civil Engineer, C74543

Expiration Date: December 31, 2020

Contents

Figures

Tables

Appendices

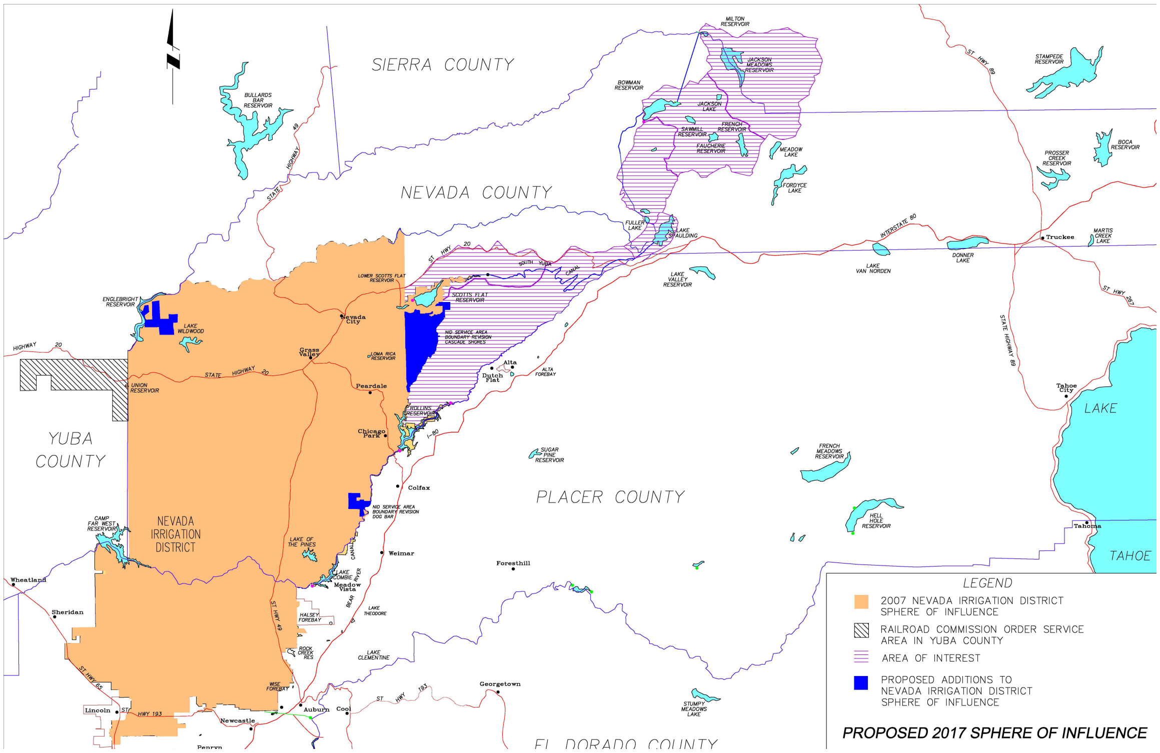
This page intentionally left blank.

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.

[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

---

[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.

[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.

[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

California Department of Water Resources (DWR), 2015 Urban Water Management Plans Guidebook for Urban Water Suppliers, Final, March 2016.

California Water Commission (CWC). 2016. Technical Reference, Water Storage Investment Program, November 2016.

Dettinger, Michael, Holly Alpert, John Battles, Jonathan Kusel, Hugh Safford, Dorian Fougeres, Clarke Knight, Lauren Miller, Sarah Sawyer. (United States Geological Survey). 2018. Sierra Nevada Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004.

Federal Energy Regulatory Commission (FERC). 2014. Final Environmental Impact Statement for Hydropower License. Upper Drum-Spaulding Hydroelectric Project, Project No. 2310-193 – California. Lower Drum Hydroelectric Project, Project No.14531-000 – California. Deer Creek Hydroelectric Project, Project No. 14530-000 – California. Yuba-Bear Hydroelectric Project, Project No. 2266-102 – California. FERC/EIS-F-0244. December 2014

HDR. 2020a. Hydrologic Analysis Technical Memorandum. March 2020.

HDR. 2020b. Raw Water Demand Model Update. March 2020.

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

Kleinschmidt Associates. 2011. Nevada Irrigation District Raw Water Master Plan Update, Phase 1. December 2011.

Liang, X., D. P. Lettenmaier, E. F. Wood, and S. J. Burges. 1994, A Simple Hydrologically Based Model of Land Surface Water and Energy Fluxes for General Circulation Models, Journal of Geophysical Research, 99, 14,415–14,428, doi:10.1029/94JD00483.

NID. 2016. Urban Water Management Plan. June 2016.

NID. 2018. Coordinated Operations Agreement Between Nevada Irrigation District and Pacific Gas and Electric Company. August 2018.

.

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.

[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

---

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

---

[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). .

6.0 References

California Water Commission. 2016. Water Storage Investment Program Technical Reference, November 2016, Appendix A.

California Department of Water Resources (DWR). 2015, California Climate Science and Data for Water Resources Management. June 2015

Cook, B. I., Ault, T. R., & Smerdon, J. E.. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Science Advances.

Federal Energy Regulatory Commission. 2014. Final Environmental Impact Statement for the Upper Drum-Spaulding Hydroelectric Project (P-2310-173), Lower Drum Hydroelectric Project (P-14531-000), Creek Hydroelectric Project (P-14530-000), and Yuba-Bear (P-2266-096) Hydroelectric Project, December 2014.

Griffin, D., Anchukaitis, K.J.. 2014. How unusual is the 2012–2014 California drought? Geophysical Research Letters, Volume 41, Issue 24.

Meko, D.M., M. D. Therrell, C. H. Baisan, and M. K. Hughes. 2001. Sacramento River Flow Reconstructed to A.D. 869 From Tree Rings, Journal of the American Water Resources Association, v.37, No.4, August 2001.

Nevada Irrigation District. 2016. Urban Water Management Plan (UWMP), June 2016.

Nevada Irrigation District. 2012. Application for new License Major Project – Existing Dam, Yuba-Bear Hydroelectric Project, FERC Project No. 2266-096.

Nevada Irrigation District. 2011. Raw Water Master Plan (RWMP) Update, Phase II.

Nevada Irrigation District. 2005. Raw Water Master Plan (RWMP) Update, Phase I.

Nevada Irrigation District. 1985. Raw Water Master Plan (RWMP).

Pagan BR, Pal JS, Gao C, Reichenberger J, Kendall DR, Ashfaq M, Rastogi D, Kao S-C, Naz B, Schubel J. 2015. Long Beach Climate Resiliency Study: Impacts on Water supply and Demand. Long Beach: Aquarium of the Pacific, Long Beach: 52p.

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

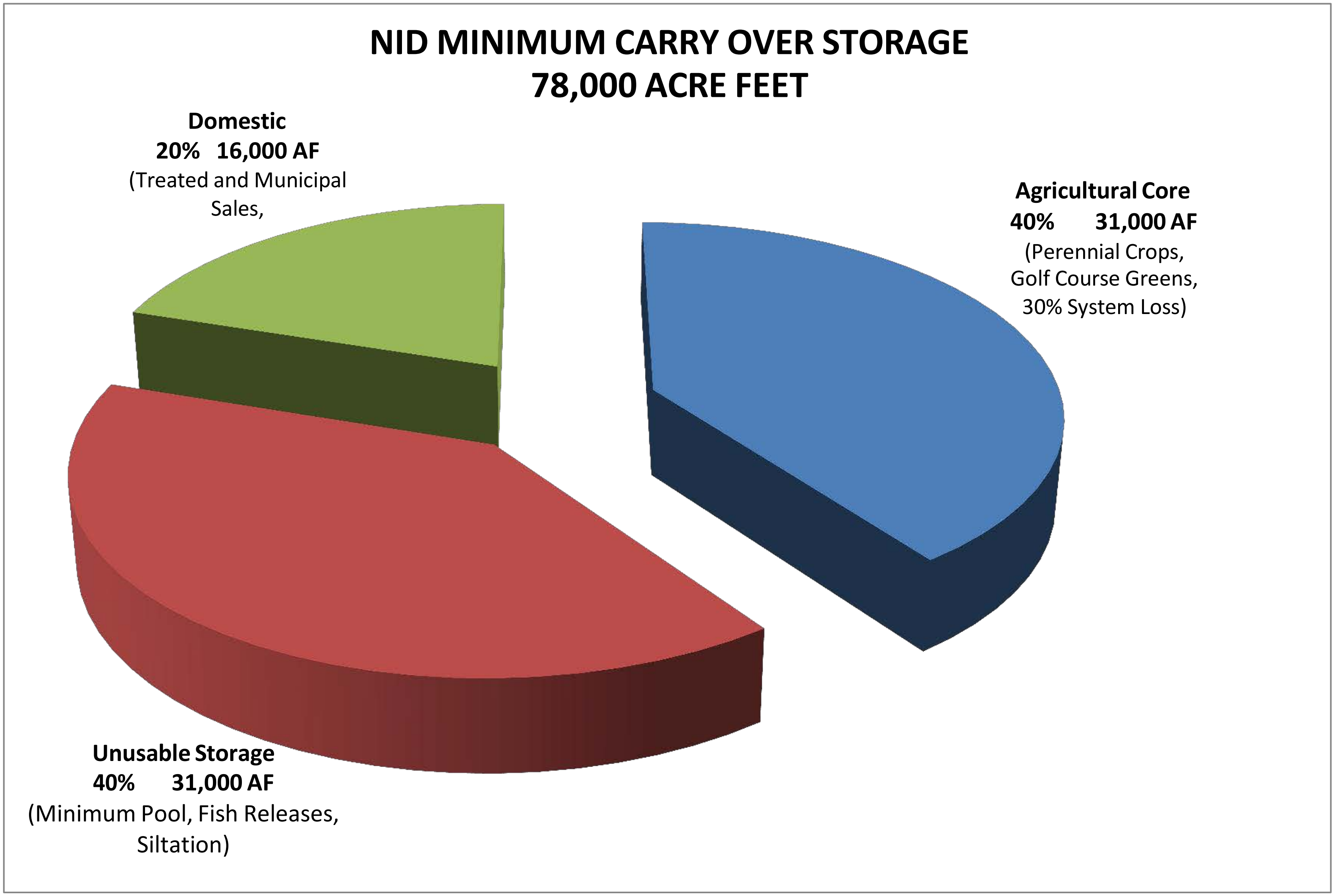
- Outdoor watering shall be limited to two days a week
    - Customers with an even – numbered street address shall limit outdoor watering to Wednesday and Saturday.
    - Customers with an odd - numbered street address shall limit outdoor watering to Thursday and Sunday
- Customers shall adjust outdoor 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.

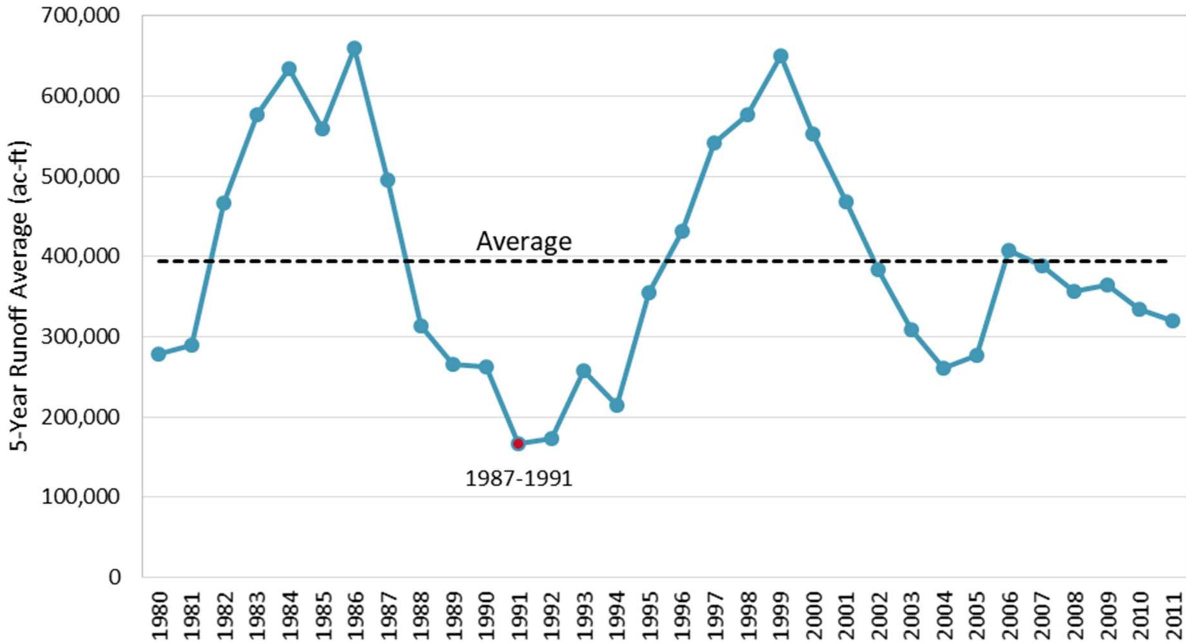


Figure 1. Running five-year average water runoff, showing the 1987-1991 five-year minimum.

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.

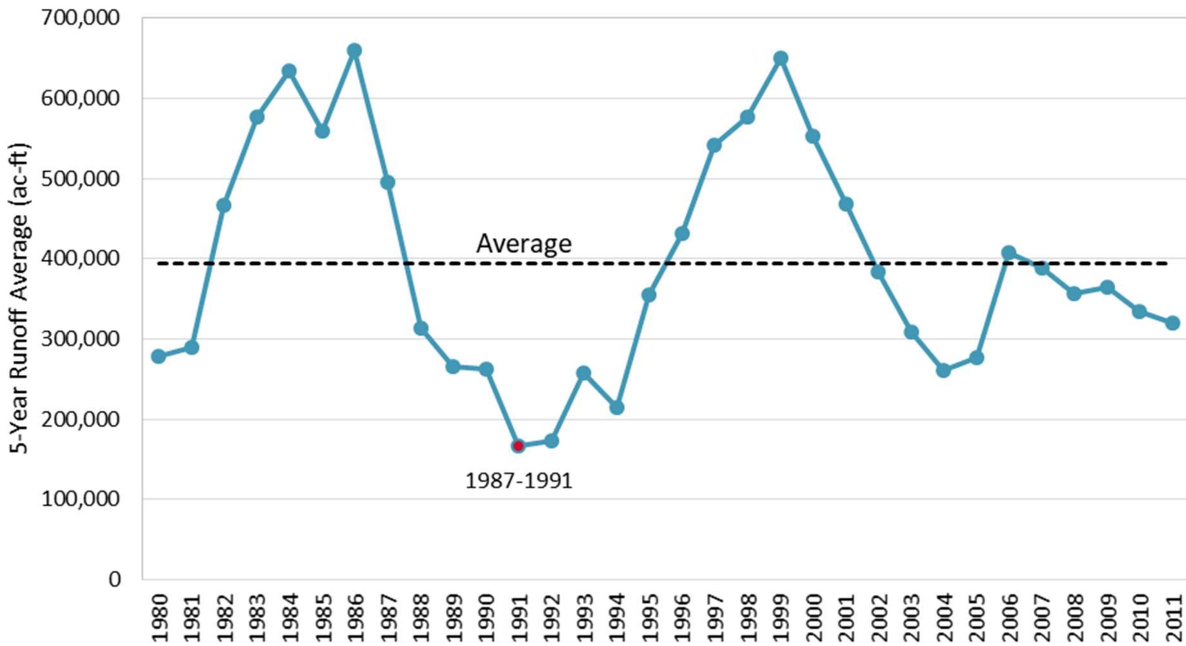


Figure 1. Running five-year average water runoff, showing the 1987-1991 five-year minimum.

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.