STAFF REPORT

Water Availability Analysis Methodology for Pending Applications on The Mainstem Russian River in Mendocino and Sonoma Counties and Dry Creek Downstream of Lake Sonoma in Sonoma County

March 2025

Division of Water Rights
Permitting Section
State Water Resources Control Board
California Environmental Protection Agency

1 Executive Summary

The State Water Resources Control Board (State Water Board or Board), Division of Water Rights (Division) has developed the Russian River Water Availability Analysis Tool (Tool). The purpose of this tool is to analyze water availability for pending and prospective water right applications requesting diversion from the mainstem Russian River and Dry Creek downstream of Lake Sonoma.

2 Introduction

Analysis of water availability provides critical information to prospective applicants and in support of the permitting process. Prior to filing and investing in an application, prospective applicants typically scope potential projects with consideration of whether or how much and when water may be available. While developing an application package, applicants must provide, “sufficient information to demonstrate a reasonable likelihood that unappropriated water is available for the proposed appropriation” (Wat. Code, § 1260, subd. (k).). This demonstration requires analysis of supply and demand of water that accounts for diversions, senior in priority, both upstream and downstream as well as instream needs.

During the permitting process, assessments must be generated to inform required findings pursuant to Water Code section 1375(d) and 1243 that “unappropriated water is available to supply the applicant.” (Wat. Code, § 1375, subd. (d).). “In determining the amount of water available for appropriation for other beneficial uses, the [State Water Board] shall take into account, whenever it is in the public interest, the amounts of water required for recreation and the preservation and enhancement of fish and wildlife resources.” (Id., § 1243.). In the North Coast geographic area (including the Russian River watershed shown in Figure 1), these assessments of water availability must comport with requirements contained in the Policy for Maintaining Instream Flows in Northern California Coastal Streams (Policy). Tool results are intended to inform and support the above considerations and requirements.

This memorandum is organized by topic area as follows:

- Water Availability Analysis Methodology: the methodology section explains how the Tool calculates supply and demand. In brief, the Tool estimates water that may be available to supply a new appropriation by balancing average patterns of demand against modeled unimpaired runoff. The Tool considers long-term variability of flow conditions (including under climate change[1]) and applies a demand pattern of senior diverters fully using their rights. The structure of the Russian River Water Availability Analysis Tool (Tool) is based on the State Water Board’s Division of Water Rights Allocation Tool

[1] In February 2021, State Water Board staff developed a report detailing data needs and recommendations for incorporating climate change analysis into water rights permitting procedures. One of the major findings of this report was that existing climate change data should be leveraged in water availability analysis for water rights permitting as projects will be diverting future flows. This effort helps to implement this recommendation by incorporating climate change analysis functionality into the Tool, as described in later sections within this report.

(DWRAT) which was developed for curtailment analyses in the Russian River watershed.

- Results: the results section discusses the output of the Tool and how those results will be presented on a project specific basis.

- Discussion: the discussion section (1) details how the methodology relates to the Policy Principles, (2) elaborates on the assumptions and limitations made in developing the methodology, and (3) establishes how the methodology will be updated and versioned.

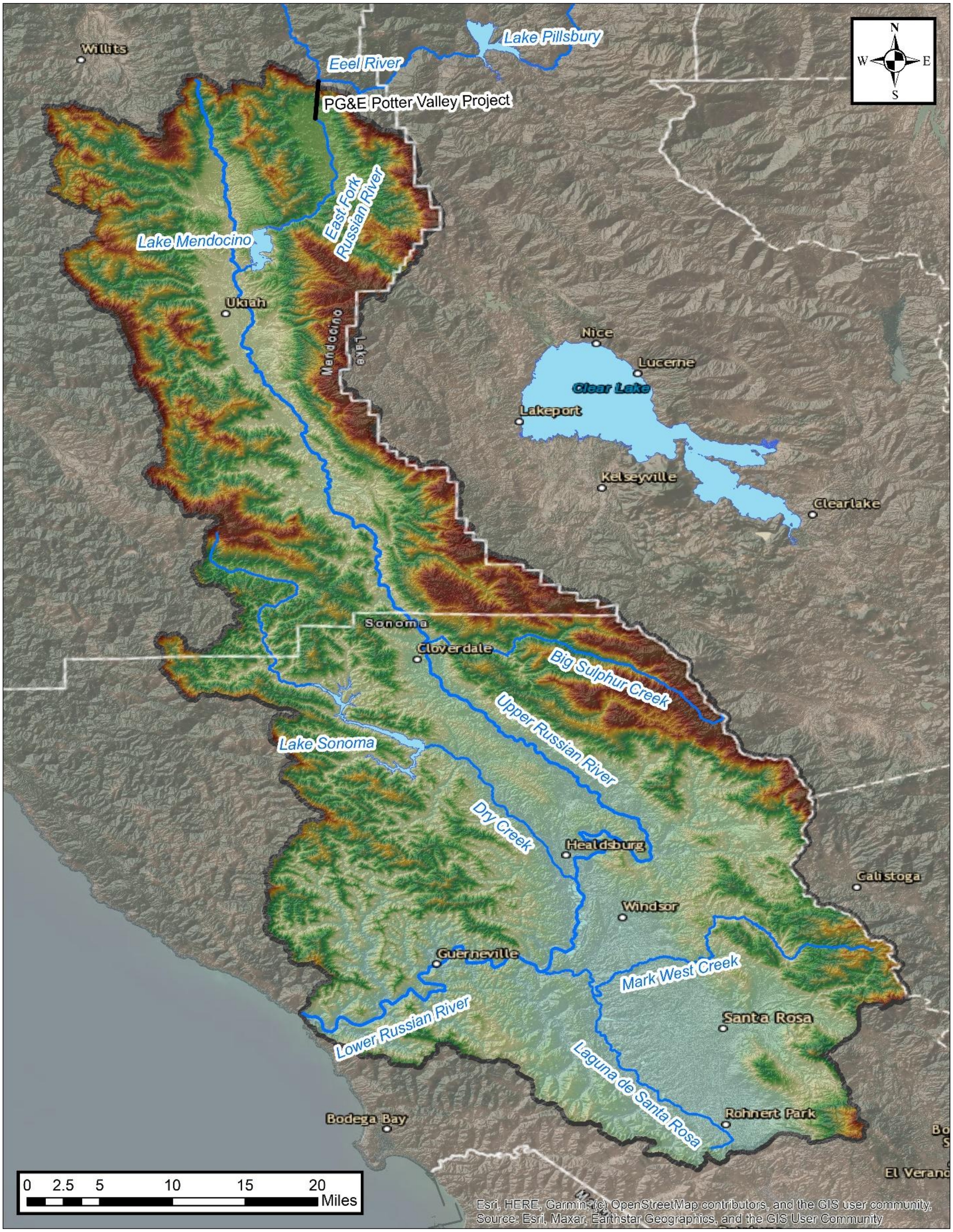

Figure 1 - Russian River Watershed

3 Water Availability Analysis Methodology

The Tool is designed to account for the availability of natural flows within the Russian River watershed to evaluate if there is water available for appropriation by applicants for water right permits and generate conditions for consideration towards how an application comports to the Instream Flow Policy requirements. This section provides detail on the Tool's methods for calculating supply and demand in subsections below.

The structure of the Tool is based on the State Water Board's Division of Water Rights Allocation Tool (DWRAT) which was developed for curtailment analyses in the Russian River watershed, as described in Appendix A. DWRAT and the Tool derive supply data (i.e. streamflow) at the subbasin scale from two existing Russian River watershed models, the Russian River Precipitation Runoff Modeling System (PRMS) Model and the Santa Rosa Plain Hydrologic Model (SRPHM). Demand data for the Tool is sourced from the State Water Board's Electronic Water Rights Information Management System (eWRIMS) and the various public datasets available in the California OpenData portal. The basic relationship between the various components of the Tool is depicted in Figure 2. Further detail on the formulation of DWRAT can be found in Lord et al., 2018.[2]

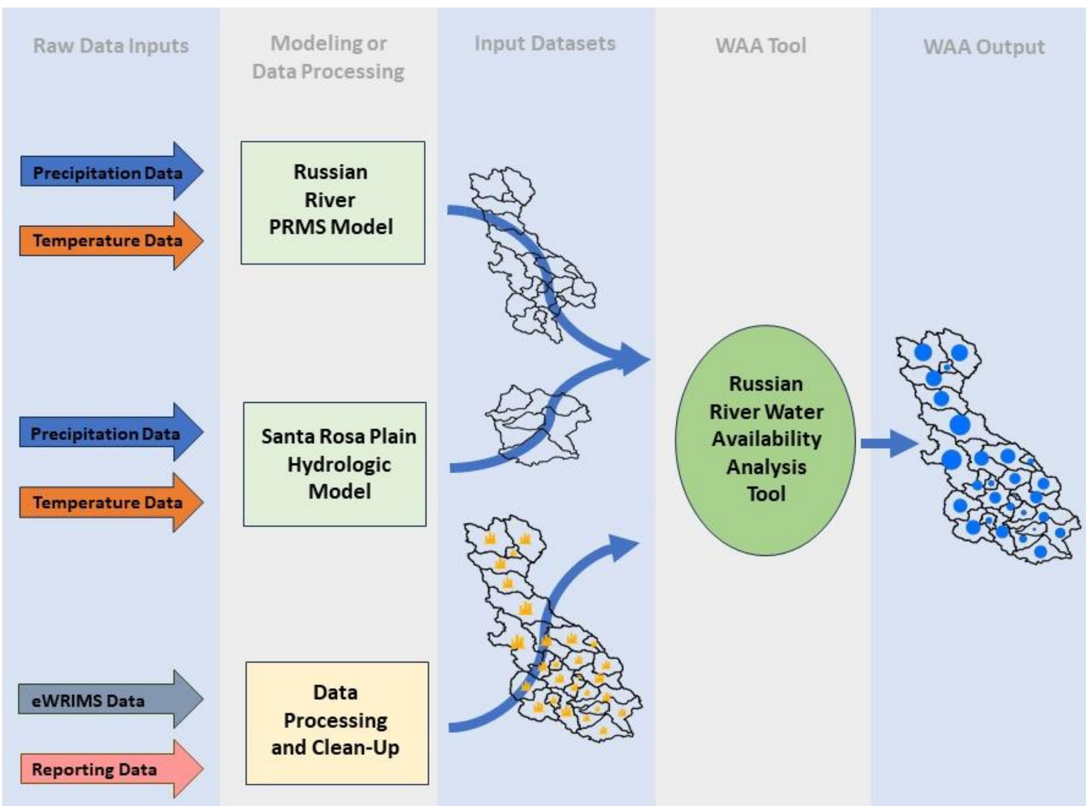

Figure 2 - Russian River WAA Tool Model Framework

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[2] Lord, Benjamin & Magnuson-Skeels, Bonnie & Tweet, Andrew & Whittington, Chad & Adams, Lauren & Thayer, Reed & Lund, Jay. 2018. *Drought Water Right Curtailment Analysis for California's Eel River.* Journal of Water Resources Planning and Management. 144. 10.1061/(ASCE)WR.1943-5452.0000820. https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29WR.1943-5452.0000820

3.1 Supply Analysis

The Tool uses modeled unimpaired streamflow data to represent available supply. As such, the supply data represents only natural flows, negating the need for differentiation between types of flow that are only available to certain subsets of senior diverters. This analysis does not account for return flows, releases of previously stored water, and imported water supplies. While any of these types of flow that have been abandoned may be considered unappropriated supply under Water Code section 1202(d), they are not included in the Tool as they could not be accurately modeled.

3.1.1 Subwatershed Delineation

The Tool divides the Russian River Watershed into 28 geospatially distinct subbasins, as shown in Figure 3, below. Subwatershed delineation was based largely on the locations of USGS streamflow gage locations to allow for calibration of the Tool. 17 of these subbasins (basins 2-6, 9-10, 12-19, 21, and 24) are further subdivided to distinguish between the headwaters and mainstem Russian River. Differentiation between the mainstem and headwaters within subbasins allows for supply and demand to be further geographically constrained. Water rights identified as being within the “headwaters” of a subbasin will not have access to inflows from upstream subbasins. Input flow data for the Tool was generated using the Russian River PRMS model for subbasins 1-22 and the SRPHM for subbasins 23-28, as shown in Figure 3.

Figure 3 - Russian River WAA Tool subbasins

3.1.2 Hydrologic Model Development

Both the Russian River PRMS Model and SRPHM were originally developed for other purposes before being modified and adapted for use with the Tool. This section provides a brief overview of each model, including the development process.

3.1.2.1 Russian River PRMS Model

The Precipitation Runoff Modeling System (PRMS) is an open-source, publicly available surface water model developed by the USGS. PRMS is a spatially distributed physical-based model that simulates hydrological watershed processes including runoff, groundwater flow, evapotranspiration, soil moisture dynamics, and streamflow. PRMS allows for dividing a watershed area into subbasins with defined outlet points, allowing for the separation of drainage areas for analysis of water availability at various points of interest.

A PRMS model of the Russian River watershed was developed by the USGS.[3] This model was calibrated to predict flows from November through April and was then shared with State Water Board staff for use in performing water right curtailment analysis. State Water Board Division of Water Rights staff performed additional calibration of the model to better represent spring and summer streamflows. The calibration effort was documented in detail in the State Water Board Finding of Emergency and Informative Digest for the Russian River Watershed document.[4]

The original Russian River PRMS model (as designed by USGS) produced a time-series of unimpaired flow estimates for 1/1/1990 through 12/31/2015 at a daily timestep for subbasins 1-22 within the Russian River Watershed, as shown in Figure 3. The model was modified by State Water Board staff for use with DWRAT, extending the model timeframe to 9/30/2022. The model was further modified for use with the Tool by extending the modeled period back to 10/1/1961 in order to produce unimpaired flow estimates for 10/1/1961 through 9/30/2022.

3.1.2.2 Santa Rosa Plain Hydrologic Model

The Santa Rosa Plain is an area located in the southeast portion of the Russian River watershed. In order to simulate the hydrology of the Santa Rosa Plain watershed, the USGS in cooperation with Sonoma Water, the cities of Cotati, Rohnert Park, Santa Rosa, Sebastopol, the town of Windsor, California American Water Company, and the County of Sonoma developed a fully coupled surface and groundwater hydrologic model, known as the Santa Rosa Plain Hydrologic Model (SRPHM).

The SRPHM was developed using the USGS groundwater and surface water flow model, GSFLOW. GSFLOW integrates PRMS (used for surface flows) with MODFLOW-NWT, a groundwater model. A detailed description of the SRPHM including model setup and calibration is available in Woolfenden et al., 2014.[5] USGS staff are preparing to release an updated version of the SRPHM. Following release of the updated model, the Russian River WAA Tool will be modified to accommodate the revised flow estimates for the Santa Rosa Plain.

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[3] This model is still in development and the final model along with documentation is expected to be released in 2024.

[4] State Water Resources Control Board. April 29, 2022, Revised May 11, 2022. *Finding of Emergency and Informative Digest for the Russian River Watershed.* https://www.waterboards.ca.gov/drought/russian_river/docs/2022/revised-russian-river-reg-digest.pdf

[5] Woolfenden, L.R., and Nishikawa, Tracy, eds. 2014. *Simulation of groundwater and surface water resources of the Santa Rosa Plain watershed, Sonoma County, California: U.S. Geological Survey Scientific Investigations Report* 2014–5052, 258 p., http://dx.doi.org/10.3133/sir20145052

The original SRPHM was developed to simulate years 1990-2018. Division of Water Rights staff extended the climate inputs of the SRPHM through Water Year 2022 for use with DWRAT. The SRPHM was further modified for use with the Tool by extending the modeled period back to 10/1/1961 in order to produce flow estimates for 10/1/1961 through 9/30/2022.

The SRPHM generates flow outputs for six locations at a daily timestep. These locations, denoted as Gage 1, Gage 2, Gage 3, Gage 4, Gage 5, and Gage 6 and shown in Figure 4, relate to outlet points for HUC12 watersheds and are used to derive flows for subbasins 23-28 in the Tool, as shown in Table 1. Unlike the Russian River PRMS model, the SRPHM does not produce unimpaired flow estimates because it accounts for groundwater-surface water interactions related to agricultural groundwater pumping as well as reclaimed water inputs at numerous locations within the basin.[6] These aspects of the SRPHM also had to be updated to adapt the SRPHM for use with the Tool and are further described below.

Table 1 - Flow calculations for Russian River WAA Tool based on SRPHM Model Outputs

Subbasin	HUC12	SRPHM Outlet ID	Subbasin Flow Calculation
Subbasin 23	180101100705 Windsor Creek	Gage 1	Gage 1
Subbasin 24	180101100706 Porter Creek-Mark West Creek	Gage 6	Gage 6 – (Gage 1 + Gage 5)
Subbasin 25	180101100704 Lower Laguna De Santa Rosa	Gage 5	Gage 5 – (Gage 3 + Gage 4)
Subbasin 26	180101100703 Lower Santa Rosa Creek	Gage 4	Gage 4 – Gage 2
Subbasin 27	180101100702 Upper Santa Rosa Creek	Gage 2	Gage 2
Subbasin 28	180101100701 Upper Laguna De Santa Rosa	Gage 3	Gage 3

Reclaimed Water Inputs

The original SRPHM incorporates volumetric reclaimed wastewater inputs which are added to daily precipitation inputs for several of the model subwatershed areas (see Woolfenden et al., 2014[7]). Reclaimed wastewater data were provided by the towns of Windsor and Santa Rosa for 1990-2018. In order to extend the model period to encompass 10/1/1961 through 9/30/2022 for use with the Tool, monthly averages by subwatershed area for the most recent 15 years of available reclaimed water data (2004-2018) were generated and applied uniformly throughout the entire modeled time period. The 2004 through 2018 period was selected due to an apparent decline in reclaimed water inputs beginning in 2004 as compared with 1990 through 2003. This decline may be a result of increased use of recycled water in the City of Santa Rosa.

[6] In the context of this effort, SRPHM results are considered "unimpaired" because they do not account for surface water diversions and will be referred to as "unimpaired" for the remainder of this report.
[7] Woolfenden, L.R., and Nishikawa, Tracy, eds. 2014. *Simulation of groundwater and surface water resources of the Santa Rosa Plain watershed, Sonoma County, California: U.S. Geological Survey Scientific Investigations Report* 2014–5052, 258 p., http://dx.doi.org/10.3133/sir20145052

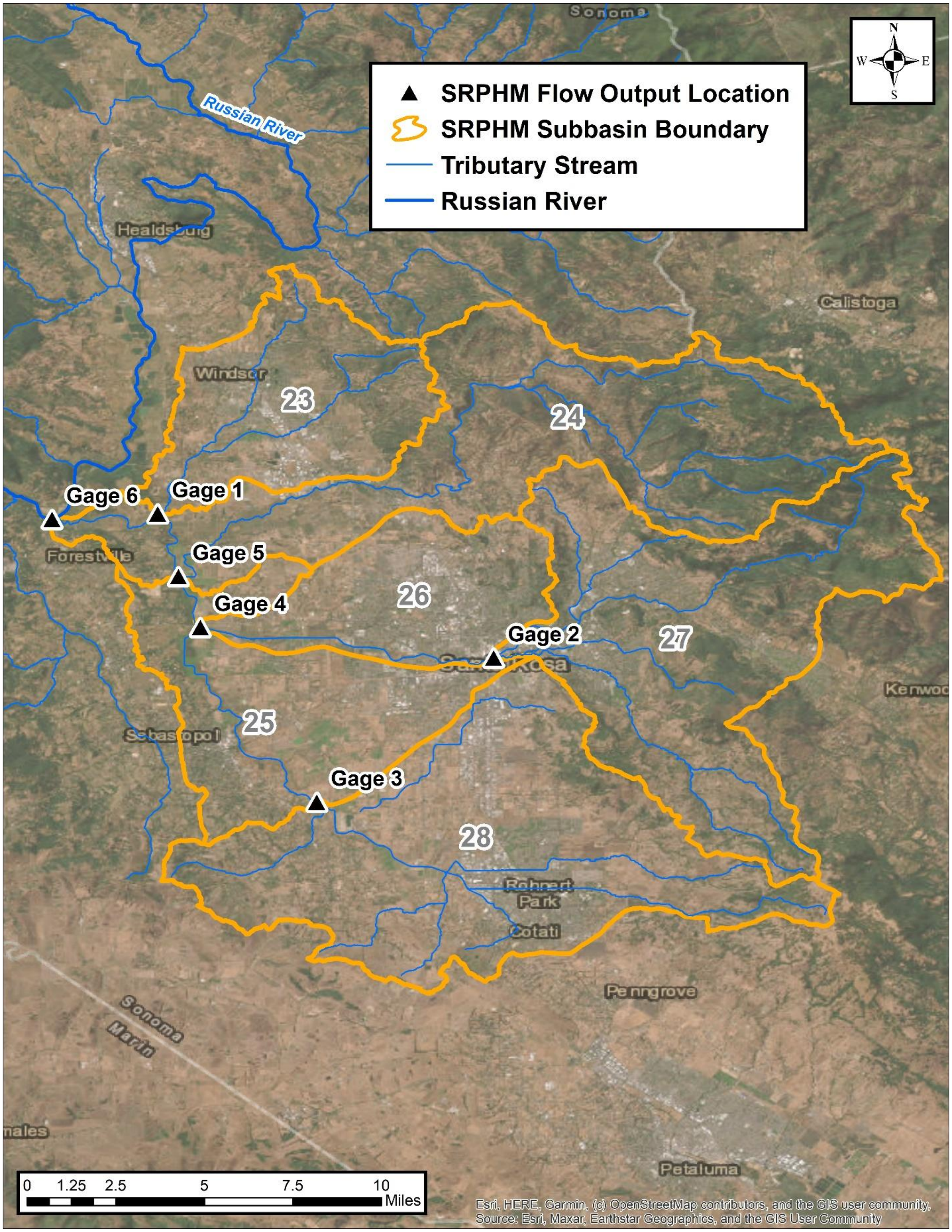

Figure 4 - SRPHM subbasin boundaries and flow output locations

Agricultural Groundwater Pumping

The original SRPHM included groundwater pumping demand through December 31, 2018. Updating groundwater pumping in the entire watershed model was not feasible for this effort, so an alternative approach was developed to extend the model period with the impact of groundwater pumping demand taken into consideration. The original SRPHM was run for years 1990-2018 with groundwater pumping demand on and off, and the resulting percent reduction in streamflow was calculated. The monthly percent reductions in streamflow were then applied uniformly to modeled flows as a post-processing step. Because these percent reductions are long-term averages, they will tend to overrepresent the impacts of agricultural groundwater pumping on streamflow in wet years and underrepresent the impacts in dry years. The monthly percent reductions used in the model are shown in Table 2.

Table 2 - SRPHM agricultural groundwater pumping streamflow reduction factors

Month	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6
January	3.4%	2.8%	5.0%	4.0%	5.3%	4.7%
February	2.2%	1.9%	4.6%	2.8%	4.3%	3.5%
March	5.0%	4.1%	8.3%	5.8%	7.9%	6.5%
April	8.0%	6.4%	12.0%	9.7%	12.3%	11.3%
May	12.0%	8.9%	14.8%	14.0%	16.2%	16.4%
June	36.6%	17.0%	41.1%	32.5%	40.3%	42.1%
July	54.7%	20.2%	53.7%	40.4%	50.3%	56.0%
August	64.2%	21.8%	62.9%	46.1%	55.7%	63.5%
September	50.1%	21.7%	47.9%	44.5%	53.6%	60.7%
October	7.1%	10.8%	11.1%	17.3%	18.2%	19.3%
November	2.1%	5.1%	5.9%	7.0%	7.8%	7.2%
December	2.0%	2.2%	3.6%	2.9%	3.8%	3.2%

3.1.2.3 Climate Data Inputs

As described above, both the Russian River PRMS Model and SRPHM were modified for use with the Tool by extending the modeled time frame. This required extending the climate data inputs for each model, as described in this section.

Russian River PRMS Model Climate Data

The Russian River PRMS model requires precipitation inputs (daily precipitation totals) at 15 locations and temperature inputs (daily maximum and daily minimum) at 8 locations (see Figure 5). Many of the climate data sources used in the original model did not have periods of record extending back to 1961. In order to extend the PRMS model functionality back to 10/1/1961 for use with the Tool, precipitation and temperature data from the nearest station with data for the full period of record was used, as shown in Table 3.

SRPHM Climate Data

The SRPHM requires precipitation, daily maximum temperature, and daily minimum temperature inputs at two locations. The climate data sources used in the original model did not extend back to 1961. In order to extend the SRPHM functionality back to 10/1/1961 for use with the Tool, the original input climate data sets were supplemented with precipitation and temperature data from nearby climate stations as shown in Table 4.

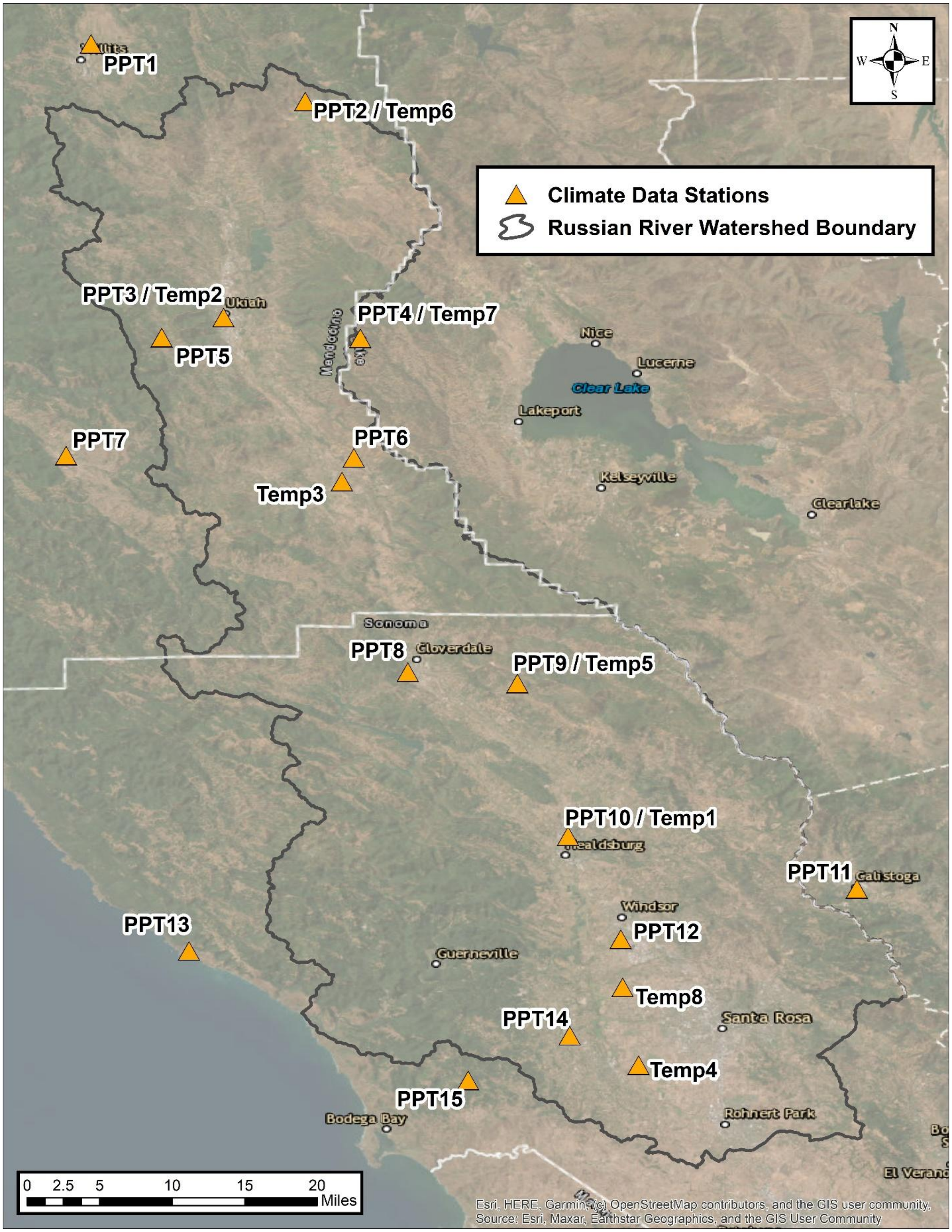

Figure 5 – Climate data stations used for Russian River PRMS and SRPHM Models

Table 3 – Russian River PRMS Model Climate Data Sources

Station ID	Variable	Data Start Date	Data End Date	Location	Data Source
PPT1	Precipitation	10/1/1961	9/30/2022	Willits, CA	NOAA[1]
PPT2 / Temp6	Precipitation / Temperature	10/1/1961	9/30/2022	Potter Valley Powerhouse, CA	NOAA[2]
PPT3 / Temp2	Precipitation / Temperature	10/1/1961	9/30/2022	Ukiah, CA	NOAA[3]
PPT4 / Temp7	Precipitation / Temperature	10/1/1961	3/15/1988	Taken from PPT3 and Temp2	NOAA[3]
		3/16/1988	9/30/2022	Lyons Valley, CA	NOAA[4]
PPT5	Precipitation	10/1/1961	7/9/1962	Taken from PPT3	NOAA[3]
		7/10/1962	9/30/2022	Ukiah, CA	NOAA[5]
PPT6	Precipitation	10/1/1961	9/22/1989	Taken from PPT3	NOAA[3]
		9/23/1989	9/30/2022	Hopland, CA	CIMIS[6]
PPT7	Precipitation	10/1/1961	12/30/1987	Taken from PPT5	NOAA[5]
		12/31/1987	9/30/2022	Boonville, CA	CDEC[7]
PPT8	Precipitation	10/1/1961	9/30/2022	Cloverdale, CA	NOAA[8]
PPT9 / Temp5	Precipitation / Temperature	10/1/1961	9/15/1993	Taken from PPT8 (including temp.)	NOAA[8]
		9/16/1983	9/30/2022	Hawkeye, CA	NOAA[9]
PPT10 / Temp1	Precipitation / Temperature	10/1/1961	9/30/2022	Healdsburg, CA	NOAA[10]
PPT11	Precipitation	10/1/1961	9/30/2022	Calistoga, CA	NOAA[11]
PPT12	Precipitation	10/1/1961	12/13/1990	Taken from PPT14	NOAA[13]
		12/14/1990	9/30/2022	Windsor, CA	CIMIS[6]
PPT13	Precipitation	10/1/1961	9/30/2023	Fort Ross, CA	NOAA[12]
PPT14	Precipitation	10/1/1961	9/30/2023	Graton, CA	NOAA[13]
PPT15	Precipitation	1/1/1961	9/30/2023	Occidental, CA	NOAA[14]
Temp3	Temperature	10/1/1961	1/31/1991	Taken from Temp2	NOAA[3]
		2/1/1991	9/30/2023	Sanel Valley, CA	CIMIS[6]
Temp4	Temperature	10/1/1961	12/31/1989	Taken from Temp1	NOAA[10]
		1/1/1990	9/30/2023	Santa Rosa, CA	CIMIS[6]
Temp8	Temperature	10/1/1961	9/30/2023	Taken from Temp1	NOAA[10]

[1]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00049684/detail
[2]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00047109/detail
[3]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00049122/detail
[4]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USR0000CLYO/detail
[5]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00049124/detail
[6]https://cimis.water.ca.gov/Stations.aspx
[7]http://cdec.water.ca.gov/dynamicapp/staMeta?station_id=BNV
[8]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00041838/detail
[9]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USR0000CHAW/detail
[10]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00043875/detail
[11]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00041312/detail
[12]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00043191/detail
[13]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00043578/detail
[14]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00046370/detail

Table 4 – SRPHM Climate Data Sources

Station ID	Variable	Data Start Date	Data End Date	Location	Data Source
PPT10 / Temp4	Precipitation / Temperature	10/1/1961	12/31/1989	Healdsburg, CA	NOAA[1]
		1/1/1990	9/30/2022	Santa Rosa, CA	CIMIS[2]
PPT14 / PPT12	Precipitation / Temperature	10/1/1961	12/13/1990	Graton, CA	NOAA[3]
		12/14/1990	9/30/2022	Windsor, CA	CIMIS[2]

[1]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00043875/detail
[2]https://cimis.water.ca.gov/Stations.aspx
[3]https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00043578/detail

3.1.2.4 Modeled Streamflows

The updated Russian River PRMS and SRPHM models were used to simulate unimpaired streamflow at the subbasin scale for the entire Russian River watershed under baseline and climate change conditions, as described in this section.

Baseline

The updated Russian River PRMS and SRPHM models were used to simulate a baseline flow scenario for the Russian River watershed based on observed climate data from October 1, 1961, through September 30, 2022. As described above, unimpaired flow outputs from the Russian River PRMS model (daily average flow rate in cfs) served as supply inputs to the Tool for subbasins 1-22, and the unimpaired flow outputs from the SRPHM (daily average flow rate in cfs) served as supply inputs for subbasins 23-28. The results are shown in Figure 6.

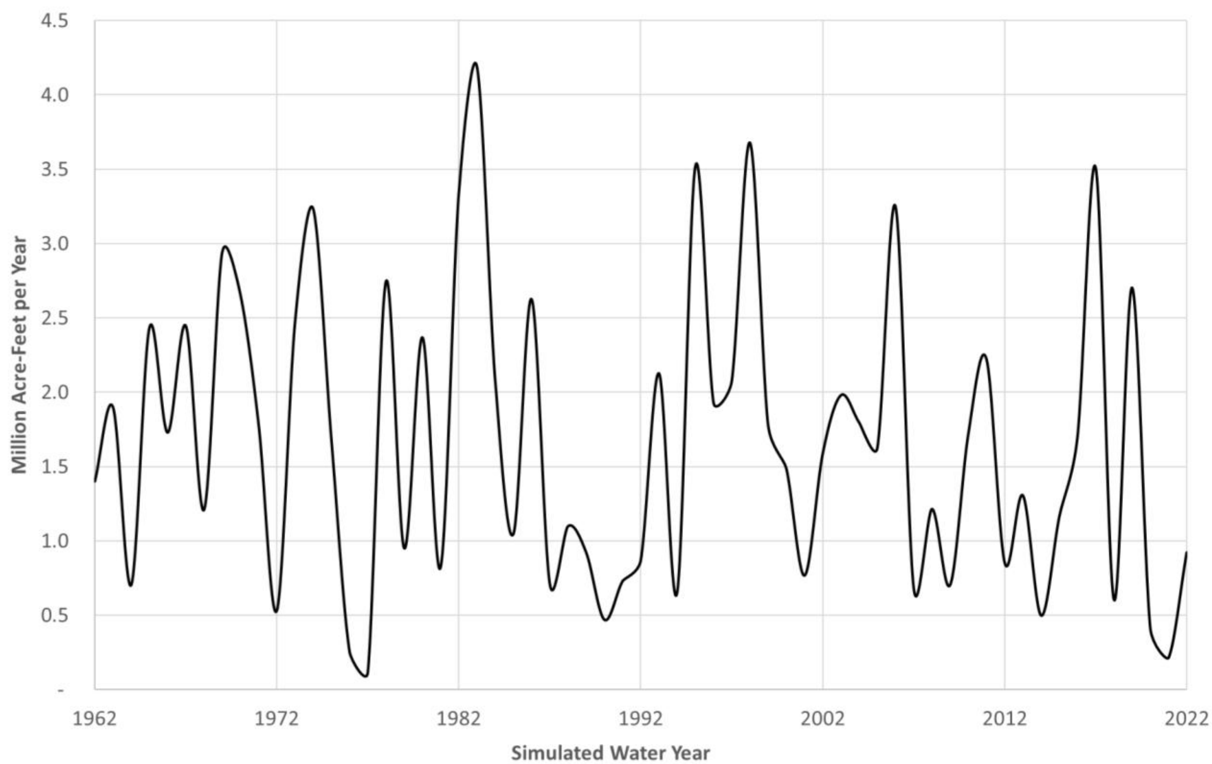

Figure 6 - Annual modeled total flow for the Russian River watershed under the baseline scenario for water years 1962-2022

Climate Change Conditions

Water availability in the Russian River watershed will be impacted by climate change as increasing temperatures increase evapotranspiration and shifting precipitation patterns alter the historic hydrology of the basin. Cal-Adapt[8] provides climate data for California based on work done as part of California's Fourth Climate Change Assessment[9]. Table 5 provides a snapshot of modeled temperature and precipitation impacts for two locations within the Russian River watershed: Santa Rosa, California in the southern portion of the watershed and Ukiah, California in the northern portion of the watershed. For both Santa Rosa and Ukiah, annual average maximum temperature and precipitation are expected to increase over the next century.

Table 5 - 30-year annual average maximum temperature and precipitation for Santa Rosa, California and Ukiah, California based on data from Cal-Adapt

<table>
<tr><th colspan="2">30-Year Annual Averages</th><th colspan="2">Santa Rosa, CA</th><th colspan="2">Ukiah, CA</th></tr>
<tr><th colspan="2">Scenario</th><th>Maximum Temperature (°F)</th><th>Precipitation (inches)</th><th>Maximum Temperature (°F)</th><th>Precipitation (inches)</th></tr>
<tr><td>Observed (1961-1990)+</td><td>Historical</td><td>71.5</td><td>29.8</td><td>72.6</td><td>39.2</td></tr>
<tr><td rowspan="2">Modeled Mid-Century (2035-2064)++</td><td>Medium Emissions (RCP 4.5)</td><td>74.6</td><td>31.6</td><td>75.6</td><td>41.0</td></tr>
<tr><td>High Emissions (RCP 8.5)</td><td>75.4</td><td>32.2</td><td>76.4</td><td>41.7</td></tr>
<tr><td rowspan="2">Modeled End-Century (2070-2099)++</td><td>Medium Emissions (RCP 4.5)</td><td>75.7</td><td>32.4</td><td>76.7</td><td>41.9</td></tr>
<tr><td>High Emissions (RCP 8.5)</td><td>78.6</td><td>33.3</td><td>79.5</td><td>43.1</td></tr>
</table>

+Observed historical data derived from Gridded Observed Meteorological Data. Details in Livneh et al., 2015.[10]

++Data derived from 32 LOCA downscaled climate projections. Details in Pierce et al., 2018.[11]

The Russian River watershed is one of the areas of California expected to experience the greatest increase in precipitation over the next century due to climate change, with model results showing as much as a twelve percent increase in Santa Rosa and as much as a ten percent increase in Ukiah by 2099.[12] Data available through Cal-Adapt also points to significant increases in the maximum 1-day precipitation and maximum length of dry spell in both Santa Rosa and Ukiah. This indicates that future winters will likely have more intense storms and that summers will likely be longer and drier. All these factors have the potential to significantly alter

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8 https://cal-adapt.org/
9 https://climateassessment.ca.gov/
10 Livneh, B., Bohn, T., Pierce, D. et al. 2015. *A spatially comprehensive, hydrometeorological data set for Mexico, the U.S., and Southern Canada 1950–2013*. Sci Data 2, 150042. https://doi.org/10.1038/sdata.2015.42
11 Pierce, D. W., J. F. Kalansky, and D. R. Cayan, (Scripps Institution of Oceanography). 2018. *Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment. California's Fourth Climate Change Assessment, California Energy Commission*. Publication Number: CNRA-CEC-2018-006.
12 https://cal-adapt.org/tools/maps-of-projected-change/#lat=38.4362&lng=-122.7022&boundary=place&climvar=Precipitation

the historical hydrologic regime in the Russian River watershed, ultimately impacting water availability.

In order to simulate the impacts of climate change on flows in the Russian River watershed, four sets of streamflow change factors, developed by the California Department of Water Resources (DWR), were applied to the baseline flow data generated by the Russian River PRMS and SRPHM models for water years 1962-2011. When used to perturb historical hydrologic data, these streamflow change factors generate hydrographs that represent potential future streamflow based on climate model predictions. The four scenarios represented by these streamflow change factors are based on the results from ten downscaled general circulation models (GCMs)[13].Of the four available climate change scenarios, the ‘2070 Central Tendency’ scenario was chosen for this use case as it represents an average of the predictions for 2070 from the set of ten downscaled GCMs.

This scenario is meant to be representative of potential hydrologic conditions that water managers in the Russian River watershed should consider when planning long-term water supply projects. Of note, this climate change scenario does not account for population or land use change resulting from climate change impacts. The streamflow change factors are described in more detail in Appendix B.

Figure 7 shows the annual average total modeled streamflows for the Russian River watershed under the baseline and 2070 Central Tendency climate change scenario. Under 2070 Central Tendency climate change conditions flows are expected to increase. Figure 8 shows the monthly average modeled streamflows for the Russian River watershed under baseline and climate change scenarios; streamflow impacts under climate change conditions are most pronounced between November and February.

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[13] Derived as part of California’s Fourth Climate Change Assessment and described in:
Thomas, N., Mukhtyar, S., Galey, B., Kelly, M. (University of California Berkeley). 2018. *Cal Adapt: Linking Climate Science with Energy Sector Resilience and Practitioner Need. California’s Fourth Climate Change Assessment, California Energy Commission*. Publication Number: CCCA4-CEC-2018-015

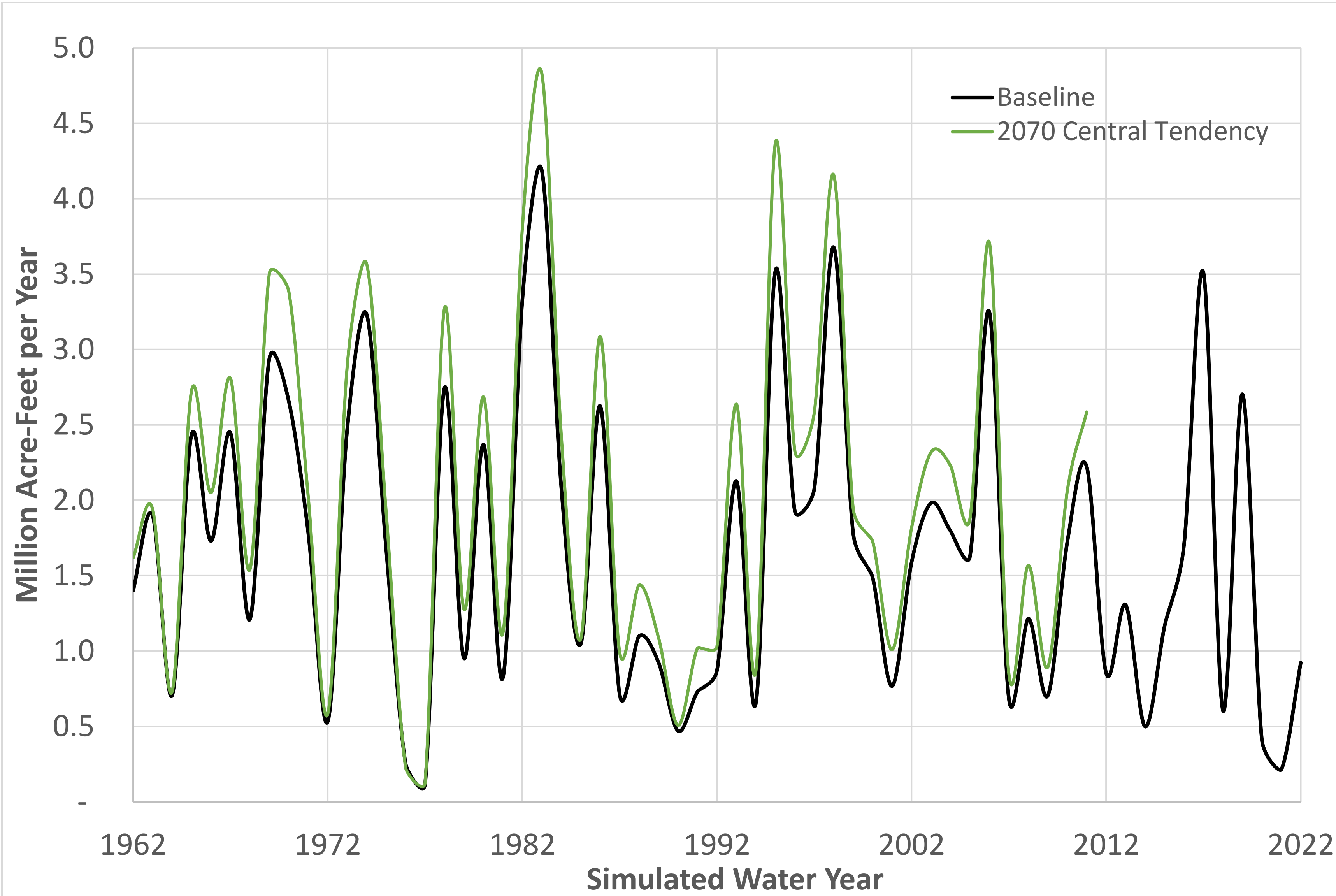

Figure 7 - Annual modeled total flow for the Russian River watershed under baseline and climate change scenarios for water years 1962-2011

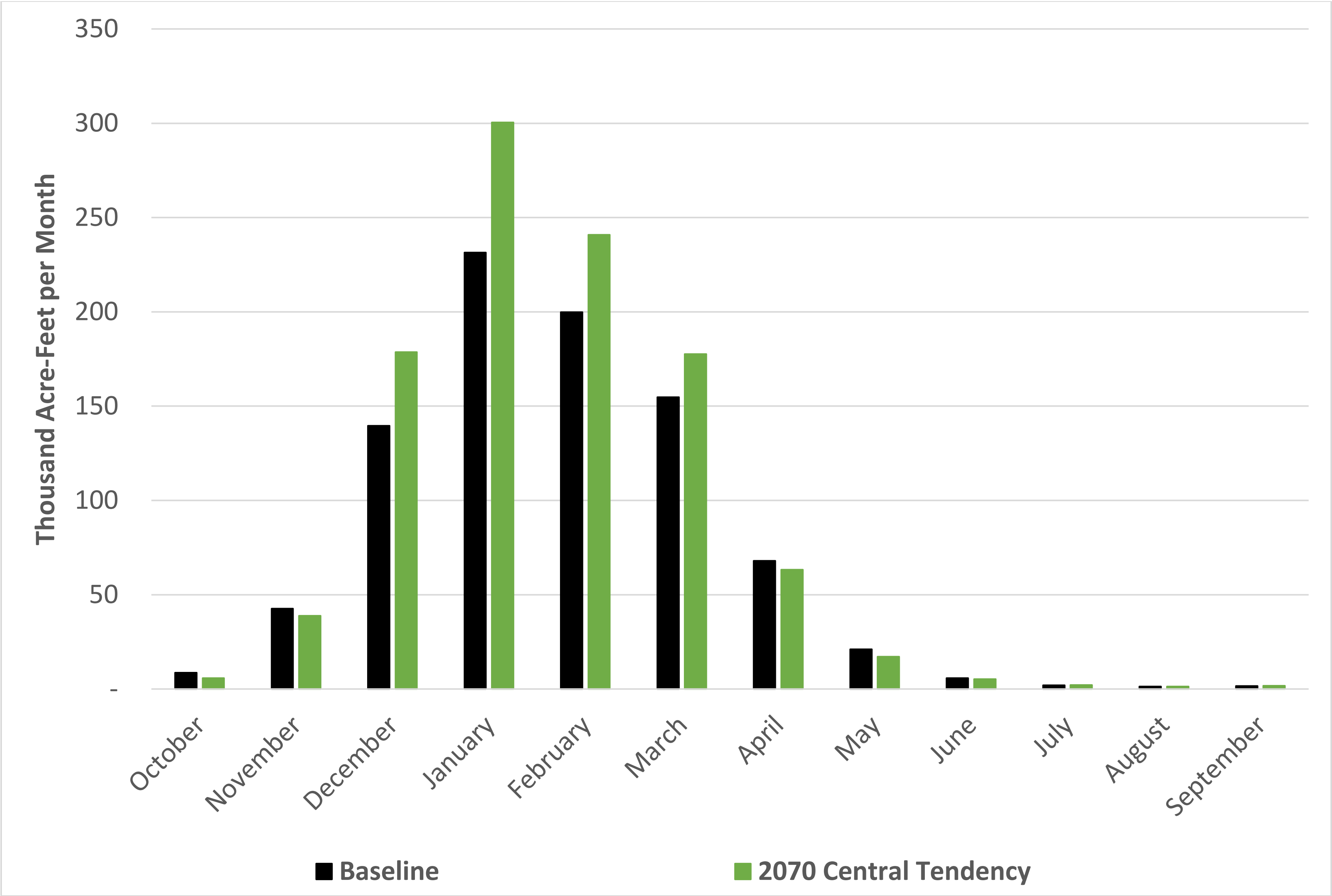

Figure 8 – Monthly average modeled total flow for the Russian River watershed under baseline and climate change scenarios for water years 1962-2011

3.2 Demand Analysis

Obtaining an accurate estimate of demand for each diverter in the watershed is a critical component of generating accurate results. This section discusses the approach used to select senior diverters and estimate their demand, including instream needs. This section also examines special cases for senior demand estimations, including estimates of diversion demand at Lake Mendocino and Lake Sonoma, for state-filed applications, for diverters that directly divert for frost protection, and for diverters operating with combined right caps. The WAA tool represents demand using a daily time series for each diverter and is derived from a combination of data points including face values, max diversion rates, and seasons of diversion.

3.2.1 Selection of Water Right Records

All active water right records within the Russian River Watershed are included in the Tool. The list of records included was originally developed by Division staff for the purposes of curtailment. Permitting staff updated the list to include records received after the original list development, include all pending applications, incorporate any updates to records since the original list development and remove diverters that are inactive, revoked, or canceled. When the tool is used to evaluate water availability for a specific water right application, all pending applicants that are junior to the subject application are manually removed.

3.2.2 Senior Demand Estimation

3.2.2.1 Pre-1914 Appropriative and Riparian Claims

The demand for pre-1914 appropriative water right claims[14] and riparian water right claims[15] at each daily timestep is calculated using season of diversion and an estimated rate of diversion. The rates and seasons of diversion were estimated using maximum historic reporting data of quantity and rate from the California Open Data Portal "California Water Rights Water Use Reported" dataset.[16] The dataset was filtered to include electronically available annual reports for water diversions for riparian and pre-1914 appropriative claims within the Russian River Watershed from 1914 through 2020, generally consisting of reports filed on or after 2009; this time period was selected so as to ensure a sufficiently representative sample size that was reflective of current operational trends for claimants.

An R script was used iterate through each claim to determine: (1) the total volume diverted across all reports through 2020 in acre-feet (V_{Total}) (2) the total volume diverted in each month across all reports through 2020 in acre-feet ($V_{Month,Total}$) and (3) the maximum volume diverted in any one year through 2020, or in the initial report submitted in acre-feet ($V_{Max\ Annual}$).

For each claim, the total volume diverted in each month across all years was divided by the total volume diverted across all years, yielding an average percentage of reported diversions that

[14] An appropriative water right that was initiated before the Water Commission Act went into effect on December 19, 1914, is called a pre-1914 appropriative water right. These rights can only be corroborated by a court decree, and do not require a permit. Diverters who believe they have a valid pre-1914 appropriative water right may file a claim and annual reports for the amounts diverted.

[15] A riparian water right is a right to use the natural flow of water on land contiguous to a natural water course; riparian water rights do not include a right to divert water that is foreign in time or source. As with pre-1914 appropriative water rights, riparian rights can only be corroborated by a court decree. In the absence of a court decree, diverters who believe they have a valid riparian right may file a claim and annual reports for the amounts diverted.

[16] Division of Water Rights. 2021. https://data.ca.gov/dataset/california-water-rights-water-use-reported

occur during that given month (f_{Month}). For example, the average percentage of annual diversions that occurred in February was calculated as follows:

$$f_{Feb} = V_{Feb,Total} / V_{Total}$$

The percentages for each month were then multiplied by the maximum volume of water diverted in any year to determine a reasonable upper bound on the volume of water diverted per month by that senior diverter in acre-feet (V_{Month}). Following the above example for February, this value is calculated as follows:

$$V_{Feb} = f_{Feb} \times V_{Max\ Annual}$$

These values are intended to be representative of actual operational trends while still ensuring that sufficient water is allocated to them by scaling based on the highest diversion year. The monthly diversion volumes were divided by the number of days in the month to determine an average rate of diversion in acre-feet per day (afd), then converted to cubic feet per second ($Q_{Month,Daily}$). This value was cross-checked with the reported maximum rate of diversion (Q_{Max}) to ensure the calculated value is reasonable and does not reflect any unit errors contained in the reports; the greater of the two data fields containing information on maximum rate of diversion—"MAX_RATE_OF_DIVERSION" and "MAX_DD_APPL"—was used in this check. Continuing the example for February, the values were calculated as follows:

$$Q_{Feb,Daily} = V_{Feb} / 28\ days \times 1\ cfs / 1.983\ afd$$

$$\text{If } Q_{Feb,Daily} < Q_{Max},\ \text{use } Q_{Feb,Daily}$$
$$\text{If } Q_{Feb,Daily} > Q_{Max},\ \text{use } Q_{Max}$$

The value above was used to represent demand for that given diverter for each day in February across each year the model was run. This process would then be repeated for each month for each diverter, yielding a complete demand dataset. Due to the prevalence of unit errors in the available reporting data, all claims with daily demand estimated at greater than 10 cfs were verified by Division staff. Either the capacity of the diversion works or the maximum recent annual volume reckoned as a daily rate, as reported in the initial statement, was taken as the demand for any month with a greater value. Failing this, the maximum amount reported across all their annual reports, absent any clear unit errors, replaced any month with a greater value. Of the 30 claims evaluated in this manner, 20 were modified. A list of these rights can be found in Appendix C. Additionally, there are a further 110 diverters who have no reported diversions in the "California Water Rights Water Use Reported" public dataset, but do have an initial reported diversion amount listed. Because there was no information available in the dataset regarding seasonality of diversions under these claims, this initial reported diversion amount was distributed evenly across the calendar year.

There are 64 riparian and pre-1914 diverters that are represented by zero demand in the Tool. These claims either have no available reports during the evaluation period, do not report any diversions, or otherwise did not have available information in the dataset. Division staff completed a spot check of these claims, and for all claims evaluated, the claimant has either never reported any diversions after their initial claim, or is filing annual statements to maintain their claim despite only using non-jurisdictional sources of water (e.g., contracted water sources or groundwater pumping). Based on the median annual demand of the other riparian and pre-1914 appropriative diverters, Division staff estimate that the annual demand of these 64 zero-demand diverters is approximately 0.66% of the total riparian and pre-1914 appropriative demand. While additional data are available from both pre-2009 reports and initial statements that are not currently accounted for, the new data would need to be processed, formatted, and assimilated into the dataset on a per-project basis. Because manually incorporating the new data would be prohibitively time consuming, and because the demand of these diverters is proportionally small, the decision was made to continue representing them with zero demand. For more information about this assumption, and potential future updates to the demand dataset, see sections 5.2.2 and 5.4 respectively.

Approximately 37 pre-1914 claims report diversion to onstream storage and direct diversion under the same statement. These claims are represented by the same approach as outlined above, in spite of the potential for instantaneous diversion rates to be higher as the onstream reservoirs are filling. The Division of Water Rights statement reporting form allows parties to claim diversion under multiple categories including, but not limited to, riparian, pre-1914, and disclosure of existing unauthorized diversions that the entity is attempting to obtain permit or registration to cover. Statement reports that include both (1) a riparian or pre-1914 appropriative claim and (2) existing diversions under a pending application were treated as described in this section. This may result in demand overestimation as the diversions under the pending application do not need to be considered unless senior to the pending application being evaluated. If the pending application reporting diversions is in fact senior to the pending application being evaluated, then its demand will already be represented as described in section 3.2.2.2 below. This assumption may lead to the potential double counting of some of the demand, but is a necessity given the lack of clarity of readily available existing data obtained from “California Water Rights Water Use Reported” dataset to separate total reported diversion between claims and water perused under a pending application.

Future iterations of the Tool could improve by refining the evaluation of statements to better reflect actual diversion practices and operations. Broad assumptions were made to apply a uniform approach to all diverters; more detailed input data could potentially be generated given sufficient staff time to evaluate senior diverters on an individual basis rather than collectively. This is discussed further in section 5.2.

3.2.2.2 Post-1914 Appropriative Rights

The demand for post-1914 appropriative water right filings at each daily timestep is calculated using the face value, maximum diversion rate, and season of diversion. This information was pulled from the California Open Data Portal “California Water Rights Uses and Seasons” dataset.[17] For filings with separate seasons for direct diversion and diversion to storage, the season of diversion was reckoned as the combination of the two seasons. Maximum diversion rate is the maximum rate at which an applicant requests or right holder is allowed to divert water—generally, diversions at onstream dams do not have a maximum diversion rate as the reservoir will be filled at the rate the stream flows, then spill over once full. Below is a summary of the maximum diversion rate used for different cases; more than one special case may apply.

- For onstream reservoirs or filings with no maximum diversion rate, a value of 99,999 cfs was used.
- For filings containing both direct diversion and diversion to onstream storage, the maximum diversion rate is represented with a value of 99,999 cfs.

[17] Division of Water Rights. 2023. https://data.ca.gov/dataset/california-water-rights-uses-and-seasons

- For filings involving both direct diversion and diversion to offstream storage the maximum rate was represented by the greater of either the diversion rate to offstream storage or the direct diversion rate.
- Approximately 600 post-1914 appropriative filings did not have a maximum diversion rate listed in either eWRIMS or the OpenData dataset. In these cases, the value was determined by staff review of the application, permit, or license.

The Water Availability Analysis tool iteratively calculates the demand at each timestep to ensure the face value of each senior demand is not surpassed. The total amount diverted since the beginning of the diversion season is tracked. For each timestep, the demand is the minimum of either the maximum diversion rate or the remaining water required to reach face value. The amount diverted is added to the running total to be referenced in the next timestep. The total amount diverted in a given season is reset when the diversion season starts again the next year.

As an illustrative example, take a hypothetical diverter that has a maximum diversion rate of 2 cfs, a face value of 10 acre-feet, and a season of December 15 through March 31 of the following year. If the diverter has diverted a cumulative 9 acre-feet as of March 1, on March 2 the Tool will first determine whether the maximum diversion rate (2 cfs) or the remainder of their face value (1 acre-foot, or approximately 0.5 cfs) is smaller. Since the remaining face value is smaller, this will become the demand for that timestep. The tool will then determine whether there is sufficient supply at that timestep to meet this demand. If there is enough to supply the full 0.5 cfs, then the face value will be updated to reflect the full 10 acre-feet and no water will be diverted for the rest of the diversion season. When the Tool reaches December 15 again, the face value will be reset to zero.

3.2.2.3 State-Filed Applications

All senior pending applications are considered part of senior diverter demand. State-filed applications are standard appropriative water right applications filed by a state agency as part of a general or coordinated plan for the development of water resources within the state. Parties can petition to be assigned a portion of the state filing if their project comports with project described in the state-filed application, and is not in conflict with the general or coordinated plan discussed in the underlying state-filed application or with water quality objectives established pursuant to law.[18]

The Russian River Watershed has four state-filed applications. Due to their magnitude and priority date, they exert significant influence on the amount of unappropriated water available to junior diverters and applicants. As such, it is critical to capture the availability of water for applicants both with and without consideration of the state-filed applications; this can be done by simply removing the appropriate row for the relevant state-filing from the input demand dataset. In cases where the tool indicate there is only sufficient water to supply the proposed project when the demand from one or more state filing is excluded from the demand dataset, the applicant may consult with staff for options to proceed with processing of the application. .

Below is a discussion of how each of the four state-filed applications in the watershed are modeled:

[18] https://waterboards.ca.gov/waterrights/water_issues/programs/applications/state_filed_applications/

Lake Mendocino (A012919SF and A012920SF)

There are two state-filed applications that cover Lake Mendocino, A012919SF and A012920SF, which were originally filed by the Department of Finance in 1949. A012919SF was partially assigned to Sonoma Water (Application ID A012919A, Permit ID 12947A) and Mendocino County Russian River Flood Control and Water Conservation Improvement District (District) (Application ID A012919B, License ID 13898). These two partial assignments are currently appropriated and are not subject to releases from priority; as such, they are always included as demands associated with Permit 12947A and License 13898 in the WAA tool. For both the unassigned and assigned portions of the state-filed applications, the demand has been broken out into storage and direct diversion. The storage component is assumed to have a slightly higher priority than the direct diversion in order for the tool to be able to run properly. The demand is broken out in Table 6. Lake Mendocino is treated as a spillover reservoir with no maximum rate of diversion to storage. Water is allocated to Lake Mendocino until it reaches capacity, or the maximum amount allowed per the rule curve for Lake Mendocino.[19] Table 6 below only indicates allocations under each state-filing or the purposes of inclusion in the Tool--these allocations and are not reflective of actual assignments from the state-filings.

Table 6 - Allocation of demand across state-filed applications A012919 and A012920.

Water Right ID	Source	Diversion Type	Rate (cfs)	Face Value (af)	Season
Permit 12947A (A012919A)	East Fork Russian River (R_03_M)	Onstream Storage	n/a	122,500	Year round
Permit 12947A (A012919A)	East Fork Russian River (R_03_M)	Direct Diversion	92	n/a	Year round
License 13898 (A012919B)	East Fork Russian River (R_03_M)	Direct Diversion	28	n/a	Year round
A012919SF	East Fork Russian River (R_03_M)	Onstream Storage	n/a	77,500	Year round
A012919SF	East Fork Russian River (R_03_M)	Direct Diversion	430	n/a	Year round
A012920SF	East Fork Russian River (R_03_M)	Onstream Storage	n/a	200,000	Year round
A012920SF	East Fork Russian River (R_03_M)	Direct Diversion	550	n/a	Year round

Division staff note that License 13898 also has a storage component of 82,600 af. However, this storage component is included in a shared cap of 122,500 af between License 13898 and Permit 12947A. To avoid double counting the associated demand, the storage component of License 13898 was omitted from the Tool.

[19] United States Army Corps of Engineers. 1986. *Water Control Manual for Coyote Valley Dam.*

The United States Army Corps of Engineers (USACE) defined a rule curve for Lake Mendocino in a Water Control Manual, drafted in 1986. This rule curve stipulates the maximum amount of water that can be stored in Lake Mendocino on any given day to ensure that there is sufficient room to capture water from a storm surge, preventing the downstream lands from flooding. In terms of analyzing water availability using the Tool, the rule curve is represented by dynamically changing the face value for the rights involving Lake Mendocino at each time step to reflect the current maximum storage quantity. The Tool has been adapted to determine the maximum for the given day, then modify the face values of A012919A and A012919B proportionally relative to their respective original face values. From November 1 to March 1, the sum of the face values for A012919A and A012919B is set to 68,400 af; from March 1 to May 10, the sum on each day is linearly distributed between 68,400 af and 111,000 af; from May 10 to October 1, the sum is set to 111,000 af; and from October 1 to November 1, the sum is linearly distributed between 111,000 af and 68,400 af. In the case where the state-filed applications A012919SF and A012920SF are included in the senior demand, no rule curve is used as there is no rule curve defined for the future reservoir that would be able to store entire the remaining (unallocated) face value of both state filings.

The Division is aware of an ongoing effort to manage releases from Lake Mendocino using a Forecast-Informed Reservoir Operations (FIRO) approach.[20] A major planned deviation from the Water Control Manual was drafted and approved for 2021 through 2026; however, as these modifications to the rule curve are not permanent in nature, the prior rule curve values established in the 1986 Water Control Manual will be used to inform operations of the Tool. The values used by the Tool can be modified to run using the FIRO rule curve should the results be desired, but using the original unmodified values from the Water Control Manual is considered the base scenario for conducting water availability analyses.

Knight's Valley Reservoir (A021181 and A021182)

State-filed applications A021181SF and A021182SF were both filed in 1963 by the Department of Water Resources for the potential future creation of Knight's Valley Reservoir. Neither of these state-filed applications has been partially assigned yet. The reservoir would dam both Franz Creek and Maacama Creek to create a reservoir with the potential to see 1.1 million acre-feet of water diverted per year. A021181SF has a face value of 300,000 acre-feet of water to be diverted from Franz Creek and Maacama Creek. A021182SF has a face value of 800,000 acre-feet to be diverted from various locations along the mainstem Russian River, then stored in the reservoir on Franz and Maacama Creeks. Because of the large geographic differences in the locations of the PODs for A021182SF, its demand has been broken out into several separate segments; note that this was done to generate more accurate results for the Tool and is not representative of the actual application as filed. The diversion rate for each of these segments is inferred from the capacities of the diversion works in the application as filed; the face values were scaled from the total 800,000 acre-feet based on the relative diversion rates as well. Both state-filed applications have yet to be assigned out. Their demand as included in the WAA tool is presented below in Table 7.

[20] Sonoma Water. Accessed March 5, 2024. https://www.sonomawater.org/firo

Table 7 - Allocation of demand for state-filed applications A021181 and A021182.

Application ID	Source	Diversion Type	Rate (cfs)	Face Value (af)	Season
A021181SF	Franz and Maacama Creeks (R_12)	Onstream Storage	n/a	300,000	Year round
A021182SF-Cloverdale+ Geyserville	Mainstem RR (R_09_M)	Offstream Storage	4,000	771,084	Year round
A021182SF-Knights Valley	Mainstem RR (R_12_M)	Offstream Storage	150	28,916	Year round

3.2.2.4 Instream Needs and Fisheries Resources

Water Board Decision 1610 (D1610)[21] sets minimum instream flow requirements for the upper Russian River, lower Russian River, and Dry Creek. These requirements are designed, in part, to ensure the protection and preservation of fish and wildlife and recreational uses on the mainstem Russian River and Dry Creek. The instream flow requirements vary based on location, water year type (as determined by the October 1 storage level of Lake Pillsbury in the Eel River watershed), and the current date.

Analyses of water availability pursuant to both Water Code section 1260k, and Water Code sections 1375(d) and 1243 must consider instream needs—as such, it is critical that the Tool incorporate instream needs as well. Table 8 below depicts the representation D1610 in the Tool; both line items are represented as riparian claims with the highest levels of priority, effectively requiring the first amount of natural flow at each location to be allocated to instream needs. The requirements in Table 8 below are based on the normal flow condition requirements. Only the instream flow requirements for the upper Russian River and Dry Creek are included, as those are assumed to be sufficiently protective of instream needs in the lower Russian River (below the confluence with Dry Creek), because the sum of the upper Russian River and Dry Creek requirements are greater than the requirement for the lower Russian River.

Table 8 - Allocation of demand for instream needs pursuant to Decision 1610.

Demand	Source	Rate (cfs)	Face Value (af)	Season
D1610_RR	Russian River (R_04_M)	185 (Apr. to Aug.) 150 (Sept. to Mar.)	n/a	Year round
D1610_DC	Dry Creek (R_14_M)	75 (Jan. to Apr.) 80 (May to Oct.) 105 (Nov. to Dec.)	n/a	Year round

3.2.2.5 Senior Demand Estimation Special Cases

There are several unique cases that can apply to various subsets of senior diverters. The assumptions and approaches used for estimating demand for frost protection, combined face values, and combined maximum diversion rates, are discussed in detail below.

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[21] State Water Resources Control Board. April 17, 1986. *Decision 1610 – Russian River Project*. https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1600_d1649/wrd1610.pdf

Lake Sonoma

Lake Sonoma is a reservoir located on Dry Creek tributary to the mainstem Russian River. Lake Sonoma is authorized via Permit 16596 (A019351) of Sonoma Water. As with Lake Mendocino, USACE defined a rule curve for the reservoir in a Water Control Manual from 2003. This rule curve limits the amount of water that can be stored to ensure there is sufficient space to capture flood waters. For Lake Sonoma, the rule curve is static at a value of 381,000 acre-feet. As such, no dynamic component was added to the Tool to modify the face values based on the date. Given that the storage face value for Permit 16596 (A019351) is less than 381,000 acre-feet, no change was made to the input demand. The input demand for A019351 is depicted below:

Table 9 - Allocation of demand for water right A019351.

Water Right ID	Source	Diversion Type	Rate (cfs)	Face Value (af)	Season
Permit 16596 (A019351)	Dry Creek (R_14_M)	Direct Diversion	180	n/a	Year Round
Permit 16596 (A019351)	Dry Creek (R_14_M)	Storage	n/a	245,000	10/1 to 5/1

Frost Protection Demand Estimation

During localized frost events, many diverters may turn on pumps simultaneously for frost protection. The resulting instantaneous drawdown has the potential to strand fish resulting in mortalities.[22] To capture localized instantaneous effects and prevent excessive drawdown that can kill anadromous salmonids, it is critical to analyze frost protection by direct diversion.

Policy Appendix B.2.1.4 (3) outlines the approach for estimating senior demand for frost protection. The approach is to assume senior diverters that include frost protection as a purpose of use are diverting water at their maximum direct diversion rate for 10 hours a day for 8 days between March 15 and March 31. However, this approach is not ideal for the WAA Tool because the tool evaluates availability on the scale of the whole watershed; modeling frost diversions on the same 8 days across the entire watershed at once is too far removed from physical operations to be an accurate measure of demand for frost protection and basin-wide water availability. Because of this issue, the Tool uses a more localized and dynamic approach for modeling frost protection. For each application evaluated using the Tool, staff will review local temperature data from the nearest USGS gage for the HUC 12 of the pending application and the HUC 12 immediately downstream. When temperatures fall below freezing, 32 degrees Fahrenheit, diverters are assumed to be diverting for frost protection as is common agricultural practice.[23] Frost diversions are modeled to occur on any date that temperatures are below 32 degrees, not just during the dates of March 15 and March 31. This captures localized temperature conditions and avoids artificially increasing demand for frost protection in the larger region while still allowing for instantaneous effects to be evaluated in a way that is congruent with the goals of the approach outlined in the Policy. This approach is only applied to those diverting directly for frost protection; those diverting to storage for frost protection are assumed

[22] California Code of Regulations, Division 3, Title 23, Section 862.
[23] Cole, Brooke, Howerton, Heidi, Minton, Valerie, et al. *Vineyard Frost Protection Guide for Northern Coastal California*. https://sonomarcd.org/wp-content/uploads/2017/06/Vineyard-Frost-Protection.pdf

to be using water previously stored during frost events and are treated the same as non-frost diversions to storage.

To implement this approach for riparian and pre-1914 appropriative diverters, frost demand is represented by the highest rate calculated using the scaling approach described in Section 3.2.2.1. For any date the minimum temperature of the nearest gaging station is below freezing, their existing demand is overwritten by this maximum value during pre-processing. For appropriative diverters, demand is iteratively recalculated at each timestep based on a given diverter's total amount diverted season-to-date and their face value. For appropriative frost diverters, this approach is slightly modified; if the temperature is below freezing, the max rate of diversion is *not* recalculated, ensuring that frost diversion will still occur at the maximum possible rate regardless of whether the face value has already been met. This is necessary to ensure that frost diversions from appropriative diverters are still represented on these dates. However, a necessary drawback of this approach is that it will allow select appropriative frost diverters to divert more than their allowable face value. Because of the small number of diverters involved, it was determined that this demand overestimation was permissible. For more information about this assumption, see section 5.2.2.

Modifications for Combined Right Caps—Face Value and Diversion Rate
A combined right cap is a total limitation of either rate or quantity between more than one right. Combined right caps are noted as terms within permits or licenses. With respect to water availability, presence of a combined right cap reduces the amount of appropriated water and thus potentially leads to a greater showing of availability for a new water right application. In general, combined right caps have the most impact if they involve larger face values or maximum rates of diversion. Reviewing for combined right caps is labor intensive as this information needs to be generally checked using the water right document rather than extracted from the eWRIMS or OpenData datasets. For this reason, staff conducted a limited review of the rights in the Russian River for combined right caps.

Permitting staff reviewed approximately 700 post-1914 appropriative rights to determine if they were subject to a combined right cap, and 3.5% of those were found to have either a combined face value or combined diversion rate cap. The approximately 700 rights examined for caps accounted for around 98% of all demand by face value. Staff estimate around 60% of all post-1914 appropriative rights were evaluated. Because not all rights were checked for a combined right cap, there is small potential that senior demand may be overestimated, leading to an underestimate of water availability for a new application. A list of all rights identified as involving a combined cap during staff review can be found in Appendix D.

For projects with multiple different caps defined for different subsets of related water rights, the largest value was taken to represent the maximum rate or face value amount across all relevant water rights. It is possible that this assumption may either overestimate or underestimate senior demand if the largest combined rate cap is either more or less restrictive than the other caps defined for smaller subsets of related rights.

4 Results

Together, the supply and demand inputs discussed above in sections 3.1 and 3.2 are fed into the Tool. The Tool allocates supply to all diverters according to their demand in two stages. First, water is allocated to all riparian and pre-1914 appropriative diverters, then water is allocated to all post-1914 appropriative diverters. An initial amount of water is considered available at each timestep in each subbasin. Water is allocated to the rights in each subbasin based on their priority, bypassing water for senior diverters in downstream basins as necessary. All riparian and pre-1914 claims are assumed to have equal priority and post-1914 appropriative diverters are assigned a priority order based on their respective seniority. The output of the tool includes daily amounts of water allocated to all users. The daily amounts allocated to the applicant are aggregated on a monthly and yearly basis for the purposes of analyzing yield and helping support a showing of water availability. While an analysis of aggregated monthly and yearly results is the standard approach for each pending application, the applicant may request the daily results at their discretion. As discussed in section 5.1.1 (1) below, additional runs may be conducted with an arbitrarily high face value for the applicant (e.g. 999,999,999 af) for the purpose of evaluating the seasonality of unappropriated flow availability.

The Tool provides a means for Division staff to conduct water availability analyses for prospective or pending applications. The Tool is not a required method in the Water Code, California Code of Regulations, or the Policy for conducting water availability analyses. Results from the Tool will be presented on a case-by-case basis for each application. For each water availability analysis conducted, results from the Tool's analysis will be entered into the record. The owner of the pending application can then consider the results and decide if they concur with the analysis. Should they disagree, they may choose to conduct an independent analysis that still evaluates the relevant Policy principles and includes demand wholistically, including state-filed applications. If a separate analysis is completed, it will also be entered into the record.

Water availability findings for a given filing are based on all relevant information available. This generally includes a combination of sources, including information provided as part of the initial filing of the application, and additional analyses conducted typically during processing of the application. Depending on the project specifics, the Tool may need to be combined with additional analysis to sufficiently evaluate water available for a given project (especially for more complex projects).

It is critical to note that while the Tool may show potential availability during the season of diversion, this does not mean water will be physically available for diversion at all points during that diversion season. The tool assumes perfect information sharing between all diverters in the Watershed, allowing fractional amounts of water to be bypassed or diverted to ensure all the water in the system is allocated as efficiently as possible. This is not operationally feasible in a real-world environment; to avoid potential injury to fisheries resources and senior diverters, restrictions will be placed on when and how much a new Permittee may divert water. As such, the results of the Tool will be presented to the applicant in concert with a bypass term that will impose those restrictions. This bypass term is discussed further in Section 5.1.1.

5 Discussion

This section discusses how the Tool intersects with the Policy Regional Criteria, Policy Principles, and other Policy requirements; assumptions and limitations of the Tool; and planned updates to the Tool over time.

5.1 North Coast Instream Flow Policy Considerations

The North Coast Instream Flow Policy sets forth the requirements for Water Availability Analyses in the North Coast geographic area, including specific scoping for flow-regulated mainstem rivers. A flow-regulated mainstem river is defined as "a river or stream in which scheduled releases from storage are made to meet minimum instream flow requirements established by State Water Board Order or Decision." The Tool is intended to evaluate water availability on the mainstem Russian River and Dry Creek, both of which are flow-regulated mainstem rivers.[24] Policy section 3.2 states, "The regionally protective instream flow criteria for season of diversion, minimum bypass flow, maximum cumulative diversion, and the cumulative diversion analysis requirements do not apply to water diversions from flow-regulated mainstem rivers. However, diversions from these streams shall comply with the rest of this policy, including the policy principles." The Tool's intersection with the Policy principles and other Policy requirements is discussed below.

5.1.1 Policy Principles

Policy section 2.1 sets forth five principles that must be applied in the administration of water rights. While Policy section 3.2 states that projects on flow-regulated mainstems are not held to the Cumulative Diversion Analysis (CDA) requirements or regional criteria thresholds, they must still comply with the Policy principles. Each of those five principles is evaluated below in relation to the Tool.

1. *Water diversions shall be seasonally limited to periods in which instream flows are naturally high to prevent adverse effects to fish and fish habitat*.

   Being precipitation-based, the input supply for the Tool as generated by PRMS and SRPHM is representative of natural, unimpaired flows. This unimpaired flow estimate, paired with the Tool's daily timestep and the inclusion of minimum instream flows as an explicit demand in the system, allow Division staff to use the Tool's results to determine whether the requested season falls within a timeframe where flows are sufficiently naturally high to prevent adverse effects to fish and fish habitat.

   In practice, the season of diversion for applications on the mainstem Russian River and Dry Creek will be limited to the dates during which the results of the Tool show water yield for the applicant. For example, if the results show water available as early as November 13 in one year and as late as April 3 in a different year, their season will be, at the longest, November 13 through April 3 of the succeeding year. This approach will ensure that the mainstem is not over allocated, thereby protecting both instream needs and senior diverters. In cases where (1) the results do not already show water available at the beginning and end of the requested diversion season and (2) the entire face value of the application is received in any of the years evaluated, there may be additional water available at the end of the diversion season that isn't reflected in the results. In these scenarios, the Tool will be re-run with a face value of 999,999,999 acre-feet to determine which dates water is available for appropriation.

   Note that no additional water will be appropriated from the Russian River when and where it is designated as a fully appropriated stream unless the State Water Board

[24] The State Water Board established the current minimum instream flow requirements for the mainstem Russian River and Dry Creek with Decision 1610.

adopts an order revoking the fully appropriated streams status or revising any relevant condition specified in such a declaration.

2. *Water shall be diverted only when streamflows are higher than the minimum instream flows needed for fish spawning, rearing, and passage.*

   To ensure the water is only diverted when streamflows are higher than the minimum instream flows needed for fish spawning, rearing, and passage, any eventual permittee on the mainstem Russian River or Dry Creek is anticipated to be held to a bypass term restricting diversions. Specifically, diversions will be limited to times at which both the flow measured at the USGS gage directly upstream *and* directly downstream of the point(s) of diversion record flow rates higher than the sum of: (1) the senior demand downstream of the identified USGS gage; (2) the normal condition minimum flow requirement for the appropriate reach of either the mainstem Russian River or Dry Creek as established in Decision 1610, or any future modifications made to the minimum flow requirements as represented in Permits 12947A, 12949, 12950 and 16596; and (3) a variable buffer flow requirement intended to account for transit time of releases made from Lake Mendocino and Lake Sonoma pursuant to Decision 1610.[25] The bypass requirement at the time of permitting will be calculated and included in the term using the senior demand as discussed in section 3.2. These values are dynamic and may change over time; the numbers included in the term will only reflect the requirement at the time of permit issuance. A draft version of this permit term will be presented to the applicant with the results of the Tool.

3. *The maximum rate at which water is diverted in a watershed shall not adversely affect the natural flow variability needed for maintaining adequate channel structure and habitat for fish.*

   As discussed in Section 5.1 above, scheduled releases are made from Lake Mendocino and Lake Sonoma to meet minimum instream flow requirements set by Decision 1610. Similarly, Lake Mendocino and Lake Sonoma play a critical role in flood protection for the Russian River watershed by capturing high flows, as required by the United States Army Corps of Engineers.[26,27] Because of these flood control procedures, however, natural flow variability is altered.

   Nevertheless, for each project evaluated using the Tool, staff will complete an evaluation of impacts to flow variability using an approach similar to that outlined in Policy Appendix B.5.3.5. Staff will determine the percent reduction in existing impaired 1.5-year peak flows and 1.5-year peak flows impaired by the senior diverters and the project relative to the unimpaired condition (1) in the subbasin where the project POD(s) are located, (2) immediately downstream of the confluence of the mainstem Russian River and Dry Creek, if downstream of the project, and (3) immediately upstream of the Russian

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[25] This value is determined considering, in part, the project's location and season of diversion.
[26] United States Army Corps of Engineers. Accessed July 24, 2024. https://www.spn.usace.army.mil/Missions/Projects-and-Programs/Current-Projects/Coyote-Valley-Dam-Lake-Mendocino-CA-O-M-/
[27] United States Army Corps of Engineers. Accessed July 24, 2024. https://www.spn.usace.army.mil/Missions/Projects-and-Programs/Current-Projects/Dry-Creek-Lake-Sonoma-Warm-Springs-Dam/

River's confluence with the Pacific Ocean. The 1.5-year peak flows at each location for each impairment scenario will be estimated using the methodology described in Policy Appendix B.5.2.3 (A); the exceedance curve plots generated per Appendix B.5.2.3 (A) (5) will be included in each project memorandum discussing results of the Tool. Based on the 1.5-year peak flow estimates, Division staff will make a qualitative assessment of whether the project poses a potential risk to the flow variability necessary for channel maintenance and formation, notwithstanding the above discussion of the inherent contradiction of the mainstem Russian River and Dry Creek being flow regulated. If either (1) the project does not represent an increase in impairment from the existing impaired 1.5-year peak flow or (2) the project and senior diversions cause less than a 5% reduction in unimpaired 1.5-year peak flow, as described in Policy Appendix B.5.3.5 (3), Division staff will consider the project to have no potential for causing adverse effects on the natural flow variability needed for maintaining adequate channel structure and habitat for fish.

If the project results in a measurable increase in impairment, Division staff will qualitatively review the 1.5-year peak flow values in the context of the 2008 *Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance* (2008 Biological Opinion). The 2008 Biological Opinion examines how the operations of Coyote Valley Dam (Lake Mendocino) and Warm Springs Dam (Lake Sonoma) impact flow variability. Below are some relevant excerpts discussing the impacts of each dam on channel forming flows:

> ***Coyote Valley Dam (CVD)***
>
> "Channel forming flows, the dominant discharge known to mobilize the streambed, occur every one to two years (Kondolf and Williams 1999). In the Russian River near Ukiah the dominant discharge flow is estimated to be 4,200 cfs (Florsheim and Goodwin 1993). Further downstream at Hopland such flows are in the vicinity of 9,500 cfs (Corps and SCWA 2004)."
>
> "At Healdsburg, the effects of CVD winter flood flow regulation are negligible, with a flow for a 1.5 year event of about 25,000 cfs for the regulated and unregulated condition."
>
> "[USACE] attempts… to the extent possible manage releases to help limit flows on the Russian River at Guerneville to 35,000 cfs."
>
> ***Warm Springs Dam (WSD)***
>
> "The 1.5 year peak flow prior to dam construction was 11,000 cfs, and now is reduced to about 2,500 cfs in the post dam condition… Channel forming flows in Dry Creek are 7,000 cfs below Pena Creek and 5,000 cfs between Pena Creek and the WSD. These channel forming flows are achieved in Dry Creek about once every six years."

Qualitatively evaluating the impairment to 1.5-year peak flows in the context of the post-dam channel forming flow values in the 2008 Biological Opinion—or any more accurate estimates available at the time of analysis—will aid in making a determination in cases where there is a potential for the project to cause adverse impacts to flow variability.

4. *The cumulative effects of water diversions on instream flows needed for the protection of fish and their habitat shall be considered and minimized.*

   The flow requirements for Decision 1610 are incorporated into the tool alongside all senior demand in the watershed. Water is not allocated to the applicant until the demand from Decision 1610 is first met, then the demand from all senior diverters is met. The inclusion of the Decision 1610 requirements as the highest priority demand ensures that there is always sufficient flow available for fish spawning, rearing, and passage when assessing water availability; similarly, the requirement that water be allocated to all senior diverters before the applicant ensures that cumulative effects are evaluated as well. Furthermore, the potential for instantaneous drawdown from frost protection diverters in the localized region around the project is captured by the approach discussed in section 3.2.2.4. As such, the results of the Tool ensure that the cumulative effects of water diversions on instream flows needed for the protection of fish and their habitat are considered and minimized during the water availability process.

   To ensure cumulative effects are considered and minimized during actual operations, the bypass term discussed in item (2) above will be imposed on any eventual permittee on the mainstem Russian River or Dry Creek. The implementation of this bypass term will ensure that all flows needed to supply anadromous fish downstream *and* downstream senior demand are maintained, thereby minimizing cumulative effects of water diversions on instream flows needed for the protection of fish and their habitat.

5. *Construction or permitting of new onstream dams shall be restricted. When allowed, onstream dams shall be constructed and permitted in a manner that does not adversely affect fish and their habitat.*

   At the time the Tool development, there are no pending appropriative water right applications with point(s) of diversion on the mainstem Russian River or Dry Creek that involve an onstream dam. However, should a future party submit an application involving an onstream dam, they would be restricted by Policy section 2.4 as both the mainstem Russian River and Dry Creek are class 1 streams. If such an applicant elects to pursue a case-by-case exception, the Tool may be a valuable resource for assessing impacts to instream flows, as the Tool assumes that onstream dam projects operate in a manner that does not adversely affect fishery resources by requiring flows for instream needs and senior diverters be bypassed. Further analysis and discussion may be needed to ensure that there are no other adverse impacts from the onstream dam not captured by the Tool.

5.1.2 Policy Water Availability Requirements

Policy section 2.3 defines a Water Availability Analysis as consisting of two parts, a Water Supply Report (WSR) and a CDA. As noted above, Policy section 3.2 exempts projects on flow-regulated mainstems from the requirement for a CDA and the regional criteria thresholds.

As the Policy does not explicitly exempt applicants on flow-regulated mainstems from the requirement for a Water Supply Report, each of the individual requirements of a Water Supply Report listed in Policy Appendix A.1.2 is discussed below in relation to the Tool:

1. *A map showing the locations of the points of diversion (PODs) of senior diverters and water right claimants in the watershed. The map must conform to the map requirements contained in section A.1.3;*

   For projects on the mainstem Russian River and Dry Creek, a map developed pursuant to Policy Appendix A.1.3 would be required to display the entire watershed with nearly two thousand diverters. The data included in the map would include the same data as is presently available digitally via eWRIMS.

2. *A list of the senior diverters (unpermitted applications with a higher priority than the project being analyzed, claims of pre-1914 or riparian water rights, permits, licenses, certificates, or registrations), their seasons of diversion, and face values of their permits or licenses. To the extent information is available in the State Water Board's records, or other sources of information, the demand and season of diversion of riparian and pre-1914 appropriative water right holders and claimants shall also be included.*

   A list of senior diverters is inherently captured in the Tool input. As such, this requirement is met by the methodology outlined in Section 5.

3. *Unimpaired flows may be estimated either through an adjustment of streamflow records method or through the use of a precipitation-based streamflow model. If reference streamflow gages are used in the analysis, the water supply report shall include a description of the reasons why the selected streamflow gage is appropriate for use in the analysis.*

   Estimates of unimpaired streamflows are inherently captured in the Tool input via precipitation-based streamflow models (PRMS and SRPHM). As such, this requirement is met by the methodology outlined in Section 4.

4. *A tabulation of the estimated percentages of unappropriated water supply available at the POD for each senior priority water right on the water flow path after accounting for senior demands. This percentage may be obtained using estimates of the unimpaired flow volume of the stream at each senior POD and the seasonal demand volumes of the senior water right holders. For details on calculation methods, please see Appendix B sections B.2.0 through B.2.2… For guidance on estimating the demand volumes of the senior water right holders, please refer to section B.2.1.4. All results shall be presented in a table listing the calculated percentage for each identified senior POD.*

   PRMS and SRPHM are precipitation-based models that model unimpaired flow. The Tool then allocates that unimpaired flow to all diverters in the watershed according to their priority. As such, the results of the Tool inherently capture information on the availability of unimpaired flow at various locations along the flow path.

5. *A calculation of the ratio of the proposed project's demand to the remaining unappropriated water supply at each identified senior POD. This analysis is needed for the purposes of (1) identifying locations where the proposed project is likely to have minimal impacts to the rate of flow, and (2) to assist with selection of points of interest for the cumulative diversion analysis. The ratio shall be obtained by dividing the proposed*

project's water demand volume by the remaining unappropriated water supply at each senior POD. These values shall also be presented in a table.

Regarding the first point, as discussed in (4) above, unimpaired flow modeled by PRMS and SRPHM is allocated to diverters according to their priority; this inherently captures information on locations where the proposed project is likely to have minimal impacts on rate of flow. The second purpose listed is to aid in POI selection. POI selection is an important step before developing a CDA pursuant to the Policy. However, it does not serve a purpose for mainstem Russian River and Dry Creek projects, as they are exempt from the requirement for a CDA.

6. *A flow frequency analysis of the seasonal unimpaired flow volume. A set of flow frequency analyses shall be provided at the POD(s) of the proposed project, the senior POD at which the percentage calculated in step 3 is the lowest, and any other senior PODs at which the ratio is less than 50%, if any. The frequency of occurrence of the average seasonal unimpaired flow volumes for each year of record should be determined and plotted graphically.*

   Flow frequency analyses allow staff to develop a high-level understanding of the seasonality of unimpaired flow. As with items (4) and (5) above, the unimpaired flow as modeled by PRMS and SRPHM inherently captures information on seasonality. Additionally, the exceedance curves produced in evaluating impacts to flow variability as discussed under item (3) in Section 5.1.1 will capture valuable information on this seasonality; these graphs will be presented in each project-specific memorandum discussing Tool results.

Given the above discussion, Division staff feel that the results of Tool, in concert with a memorandum discussing those results, address the requirements of a Water Supply Report.

5.2 Assumptions and Limitations

The WAA tool, while robust, necessarily makes assumptions regarding input supply and demand data, expected operations, and projections of water availability. These assumptions, their implications, and limitations, are discussed below; they have been divided into three groupings — those related to supply, those related to demand, and other miscellaneous assumptions and limitations.

5.2.1 Assumptions and Limitations Relating to Supply Data

Potter Valley Project

Historically, water has been imported to the East Fork Russian River from the Eel River via Potter Valley to generate hydroelectric power. This hydroelectric facility, the Potter Valley Project, is owned by Pacific Gas and Electric Company (PG&E).

Inflows for the Potter Valley Project have promoted agricultural growth in the region since it was completed in 1922. The project has supplemented the storage of water in Lake Mendocino since it was constructed in 1959. However, inflows from the Potter Valley Project have historically decreased due to operational concerns with the hydroelectric facility. It is becoming increasingly likely that the Potter Valley Project will be decommissioned; on November 17, 2023, PG&E released an initial draft of their surrender application and decommissioning plan of the Potter Valley project, and a final draft of their surrender application and decommissioning plan is expected by January 29, 2025.[28]

As the goal of the Tool is to evaluate long term water availability for water rights that will exist in perpetuity, Potter Valley flows are not incorporated in the WAA tool. Effectively, this results in a decreased water supply relative to historic supply trends. This will result in less water showing as available than if the Potter Valley flows were included. The Division is aware of a developing plan, spearheaded by the Eel Russian Project Authority, to negotiate with PG&E during the decommissioning of the Potter Valley Project and potentially develop and operate a new diversion facility near the Cape Horn Dam.[29]

Precipitation-Based Modeling

Only natural flows are available in the Tool because (1) the input supply data is modeled from precipitation data rather than gage data, and (2) the Tool doesn't account for imported water via the Potter Valley Project, abandoned water (diverted water that is then released), or return flows (water that returns to the river after being put to use). Natural flows being the only supply available in the Tool negates the need for differentiating flows that are only available to appropriative diverters. However, it also means that abandoned flows and return flows, which are available for appropriation, are not incorporated either.

This set of assumptions will have an impact on the results as they differ from real-world operations. They have the potential to both overestimate and underestimate water availability findings, depending on which types of flow are typically physically available during that period of the year. For small wintertime diversions, the typical application in the Russian River watershed, there is typically high volumes of natural flow in addition to abandoned flows released from Lake Mendocino and Lake Sonoma for flood control. Which of these is dominant at any given timestep is likely to fluctuate, so there is no clear way to estimate how the results are impacted.

Climate Change

As discussed in section 2, the Russian River watershed is one of the areas of California that is expected to experience the greatest increase in precipitation due to climate change over the next century. The monthly streamflow change factors provided in Appendix B – Monthly Streamflow Change Factors for the Russian River Watershed, 1915-2011 are one approach for modeling the hydrologic impacts associated with expected precipitation changes. While these streamflow change factors represent the current "state of the science" for understanding the likely effects of climate change on streamflow (and therefore supply inputs to the Tool) in the Russian River watershed, it is likely that better data and tools will become available over time (e.g. as a result of California's Fifth Climate Change Assessment, currently underway).

5.2.2 Assumptions and Limitations Relating to Demand Data

Seasonal Distribution of Demand

Section 3.2.2 of this memorandum outlines the procedures used for determining daily demand for all senior diverters within the Russian River watershed. The assumptions therein have the potential to affect water availability findings in several different ways.

[28] Pacific Gas and Electric Company. 2023. *Potter Valley Hydroelectric Project (FERC Project No. 77) Initial Draft Surrender Application and Conceptual Decommissioning Plan*. https://www.pottervalleysurrenderproceeding.com/

[29] Eel Russian Project Authority. Accessed February 26, 2024. https://www.eelrussianauthority.org/

For riparian and pre-1914 appropriative diverters, scaled demand values based on historic trends from 1914 through 2020, generally consisting of reports filed on or after 2009, were used. Scaling yields a dataset that is representative of typical diversion trends, but relying on averages may result in the demand estimates being low in years where more water is available, or high in years where water is less available. As such, it is possible that demand could be both underestimated and overestimated in any given year. Additionally, assuming the same diversion rate for a given month is a necessary step due to the limitations in reporting data. However, this will necessarily flatten out peak demand days where there is high flow, potentially resulting in underestimated demand and overestimated water availability.

Post-1914 appropriative diverters are assumed to divert at their maximum allowable rate until they hit their face value. While this is an effective approach for ensuring each diverter is given their full, legally allocated demand, it is not necessarily representative of actual operations. For example, some diverters may know that they need more water in May for a specific crop, so they will intentionally wait to divert until it is most prudent based on their needs. The approach used in generating the demand dataset does not capture these small seasonal shifts. These shifts have the potential to make the results of the tool either an underestimate or an overestimate.

Frost Protection

Before 1979, frost protection was included under irrigation as a beneficial use. As a result, the tool might not represent such diverters as directly diverting for frost protection. This has the potential to underestimate direct diversion by frost protection and therefore underestimate any potential instantaneous drawdown effects caused by localized frost events, thereby overestimating water availability for projects within the frost season.

Additionally, the approach described in section 3.2.2.5 allows appropriative frost diverters to divert more than their face value. This results in a slight overestimation of demand, particularly demand during the peak frost diversion months of March and April. Because of the small number of diverters this applies to, however, it is anticipated that this assumption will only slightly underestimate water availability for the application being evaluated.

Pre-1949 Rights

Board Decision 1030 states, “The Board finds that the protection of water uses supplied from the Russian River which existed at the time Applications 12919 and 12920 were filed in 1949 is in the public interest, and that permits issued to the Sonoma and Mendocino Districts should be appropriately conditioned for that purpose. Although the assignment of the State applications did not specifically reserve water to the extent of the pre-1949 uses in the Russian River Valley, there is no question that both the Corps of Engineers and the State contemplated that only water surplus to these uses was to be appropriated by means of the Project for future requirements.” [30]

In short, appropriative water rights filed after 1949—the date that state-filed applications A012919 and A012920 were filed—that have been demonstrably applying water to beneficial use prior to 1949 may have claim to pre-1949 status. Effectively, pre-1949 status gives a release of priority from the partially assigned portions of the aforementioned state-filed

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[30] State Water Resources Control Board. Adopted August 17, 1961. *Decision 1030.* https://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1000_d1049/wrd1030.pdf

applications. Though we do know the geographic region pre-1949 rights are located (e.g. Russian River lands as defined in term 0000800 of Permit 12947A and term 0500999 of License 13898), there is currently no database of water rights that fall into this pre-1949 category. The absence of these rights may result in water being allocated differently by the Tool within the pool of senior water rights. It is not expected that this will have large implications for the outcome of the Tool for any pending applications it is applied to, as the pending applications will be junior to any potential pre-1949 claimants regardless of whether the claim is substantiated, though there may be cascading effects in the Tool output as a result of the shifting in priority of senior diverters.

Reservations
Sonoma Water's right to export water under application A012919A (Permit 12947A) is subject to depletion by diversion of up to 10,000 acre-feet of Russian River project water appropriated under other permits which may be issued for agricultural and domestic purposes with the Russian River valley in Sonoma County for uses commencing after 1949. Water rights issued pursuant to the 10,000-acre-foot reservation do not include terms and conditions restricting diversion to the reservation only; as such, these senior diverters can divert from the same pool of supply as modeled by the Tool. Accordingly, tool results may include demand from right holders that are diverting reservation water. Currently, there is not a clear method for identifying whether a right holder is diverting reservation water or natural flow. Prior to developing the Tool, Division staff gathered a list of potential 10,000-acre-foot reservation users. Curtailment staff separately gathered information on users during the 2021-2022 drought on which diverters claimed they were diverting under the reservation. However, neither of these efforts produced a conclusive list that could be used in running the Tool. The absence of the reservations could underestimate water availability for pending applications.

Implementation of Instream Flow Requirements
As discussed in section 3.2.2.4, demands corresponding to the upper mainstem Russian River and Dry Creek pursuant to D1610 requirements were implemented at two locations—directly below the confluence of the east and west forks of the Russian River, and directly below Lake Sonoma respectively. Division staff note that the location of both demands may allow for a scenario where, should the demand for the corresponding D1610 requirement not be met, contributory flows from tributaries downstream may allow junior diverters on the mainstem Russian River and Dry Creek to divert. Operationally, if the D1610 requirements are not met, Sonoma Water is required to release flows from Lake Mendocino and/or Lake Sonoma to meet those requirements pursuant to water right permits 16956, 12957A, 12949, and 12950. While these releases are not modeled directly by the Tool, the current implementation of D1610 requirements is assumed to be in concert with physical operations of the watershed. Accordingly, this assumption is not expected to have a significant impact on the results of the Tool in either direction.

Division staff also note that only the instream flow requirements for the upper Russian River and Dry Creek are included, as the sum of the upper Russian River and Dry Creek requirements are greater than the requirement for the lower Russian River. This may not be true in physical, real-world operations if evaporation and percolation reduce flows below those thresholds; this would result in a slightly higher showing of water availability for the applicant.

Changes to Instream Flow Requirements
Each year, Sonoma Water submits Temporary Urgency Change petitions to modify the D1610 instream flow requirements per the 2008 National Marine Fisheries Service Biological Opinion. The WAA tool currently models instream needs using the D1610 values as those are the standing legal requirement—as these values are typically higher than those authorized by the Temporary Urgency Change petitions, this could underestimate water availability.

Sonoma Water has also filed long-term change petitions to modify the D1610 instream flow requirements. Pursuant to the 2008 Biological Opinion. If approved, D1610 requirements would be modified as a result of these change petitions, the instream needs requirements as modeled by the Tool will be adjusted accordingly.

Priority Dates
A priority date was inferred for all rights and claims in the watershed. For the sake of simplicity, all riparian claims and pre-1914 appropriative claims are assumed to have the highest priority and are allocated water first by the Tool. Next, water is allocated to all post-1914 appropriative rights in order of seniority using the reported priority date in eWRIMS. If the priority date was not listed in eWRIMS, the filing date, then the acceptance date was used instead in that order. Because all the rights included in the Tool are senior to the pending application being evaluated regardless of how their priority is modeled, it is not expected that there will be any significant impact on results in either direction.

Combined Direct Diversion and Diversion to Onstream Storage
For senior diverters other than the state-filed applications and their partial assignments (Lake Mendocino and Knight's Valley Reservoir) that include both direct diversion and diversion to onstream storage, the input demand was represented by a single combined direct diversion and storage face value and a maximum diversion rate of 99,999 cfs. This 99,999 cfs diversion rate effectively models the water right as an onstream reservoir fills until full and spills over or bypasses the entirety of the streamflow for downstream senior diverters. This has the potential to overestimate demand by effectively inflating the size of the reservoir by including the direct diversion face value and by allowing the direct diversion component to be diverted at an artificially high rate. This artificially high rate of diversion could either overestimate demand on a given date, or result in a senior diverter reaching their face value earlier than they would have otherwise. For these reasons, this assumption could either result in slightly lower or slightly higher showings of water availability.

Pending Applications
As discussed in Section 3.2.2.1, some statements report diversions under both (1) a riparian or pre-1914 appropriative claim, and (2) a pending post-1914 appropriative water right application. In cases where the associated pending application is junior to the application being evaluated by the Tool, the demand for the senior pending application will be double counted. In cases where the pending application is senior to the application being evaluated, it will result in the demand for the junior pending application being counted when it otherwise would not be. This is necessary step due to data limitations; it is difficult to identify on a large scale which statements are reporting diversions under a pending right, and it is also difficult to determine which reported diversions within those statements fall under the riparian or pre-1914 claim versus the pending appropriative application. As such, this potential overestimation of demand is a necessary step; however, it will result in a slightly lower showing of water availability for the application being evaluated.

Zero-Demand Statements
As explained in Section 3.2.2.1, there are 64 riparian and pre-1914 appropriative diverters that are represented by zero demand in the Tool. These diverters, representing an estimated 0.66% of riparian and pre-1914 appropriative demand, do not have any reporting data available in the "California Water Rights Water Use Reported" public dataset. Based on spot checks completed by Division staff, these 64 diverters either have never reported any diversions after their initial claim or are filing annual statements to maintain their claim despite only using non-jurisdictional sources of water. The administrative record for some diverters contains additional reporting data, however, this data is not currently available in the dataset and would be prohibitively time consuming to process, format, and assimilate. As such, demand from these diverters is underrepresented in the Tool, resulting in a higher showing of water availability for the application being evaluated.

5.2.3 Other Miscellaneous Assumptions and Limitations

Model Timestep
The Tool currently operates on a daily timestep. While this is necessary due to computational limitations, this inherently flattens the effects of instantaneous demand and supply spikes by representing them as a single, smaller value averaged across 24 hours. In the case of supply, this would fail to capture small flood pulses that would make additional water available to diverters for short periods within a day. In the case of demand, this timestep limitation fails to capture instantaneous changes in demand, such as for localized frost events. It is expected that the timestep chosen could both underestimate and overestimate water availability.

Bypass Flow Requirements
Division staff estimate that there are upwards of 90 permits with bypass requirement terms both on the mainstem Russian River and on streams tributary to the mainstem Russian River. These values are not currently incorporated into the tool in any capacity. As such, there may be more unappropriated water reaching the mainstem than the tool currently projects, resulting in the Tool underestimating availability.

5.3 Data Availability

The accuracy of the WAA tool is limited by the accuracy of the data used to run it. While staff have made a concerted effort to catch and fix inconsistencies and errors in the reporting data and the data populated in eWRIMS, it is expected that revisions to the input data will be made as errors and inaccuracies are identified. Additional data will be used as it becomes available, where appropriate.

5.4 Planned Updates to Methodology and Tool

As mentioned above, it is expected that inaccuracies will be identified in the data and Tool itself over its lifespan. When such errors are identified, the data and Tool will be revised. As the Tool will be run on an individual basis for pending applications, any changes, deviations, or improvements will be documented in the project-specific results memorandum. Additionally, over time, more rights will be claimed, permitted, licensed, or applied for in the Russian River watershed, and more data will be added to or revised in the "California Water Rights Water Use Reported" dataset. A check for additional rights and/or new and revised data will be performed on a routine basis, such as before the Tool is applied to a pending water right application or on an annual basis.

Prior to developing the Tool, Division staff historically tracked a list of potential 10,000-acre-foot reservation users. Curtailment staff separately gathered information on users during the 2021-2022 drought on which diverters claimed they were diverting under the reservation. In future iterations of the tool, these two sources could be used to potentially incorporate the reservation into the Tool’s operations.

The Division is aware the USGS is developing an interactive groundwater and surface water precipitation-based model for the Russian River watershed. Pending the public release of the model and supporting documentation, additional revisions may be made to the Tool if appropriate. It is not clear at this time what the scope of these revisions would be, if any are made at all.

Lastly, the application of Streamflow Change Factors as discussed in Appendix B – Monthly Streamflow Change Factors for the Russian River Watershed, 1915-2011 represents a current approach for modeling climate change and water availability. As a more robust understanding of the impacts of climate change is developed, Division staff will re-evaluate and determine how the results of the Tool are impacted and modify the Tool if deemed appropriate.

5.5 Tool Versioning

As the Tool is updated the newest version will be marked by the date it was run in the format “YYYYMMDD”. The Change Log will document reasoning and changes made to the Tool. Version of the Tool used will be noted in each pending water right’s WAA memo to file and the Project Use Tracking Log. Addendums will be added to this document to summarize cumulations of changes as necessary.

Appendix A – Curtailment History and the Division of Water Rights Allocation Tool

When the amount of water available in a surface water source is not sufficient to support the needs of existing diverters and in-stream uses, junior appropriators must cut back or cease diversion entirely in favor of higher-priority rights. However, it is not always clear to a junior diverter whether there is sufficient natural flow in the system to support their diversion and senior water uses and instream needs downstream. As part of administrating water rights, the State Water Board may issue notices of curtailment to water rights holders based on California's water rights priority system. Such curtailments were issued in 2021 and 2022 in response to the persistent dry conditions and abnormally low precipitation of the Russian River watershed. Under the drought emergency regulation, the Division was able to more easily exercise its authority to curtail diverters when water was not available.[31]

In 2021 and 2022, drought curtailment decisions were made with the support of the Division of Water Rights Allocation Tool (DWRAT) (formerly the Drought Water Rights Allocation Tool). DWRAT incorporates geography, water supply, and the California water rights priority system into drought curtailment decisions.[32] The theoretical framework and the first iteration of for DWRAT was funded by the State Water Resources Control Board and developed by the University of California, Davis, Center for Watershed Sciences during the drought that began in 2014. DWRAT has since been iteratively improved and was implemented to issue curtailments during the drought beginning in 2021. In 2023, Division staff modified DWRAT to fit the permitting use case in what would become the Tool described in this memorandum.

[31] State Water Resources Control Board. April 29, 2022, Revised May 11, 2022. *Finding of Emergency and Informative Digest for the Russian River Watershed*. https://www.waterboards.ca.gov/drought/russian_river/docs/2022/revised-russian-river-reg-digest.pdf

[32] State Water Resources Control Board. February 2, 2023. *Drought Tools and Methods: Water Allocation Tool*. https://www.waterboards.ca.gov/drought/drought_tools_methods/

Appendix B – Monthly Streamflow Change Factors for the Russian River Watershed, 1915-2011

The California Department of Water Resources (DWR) has created resources related to climate change analysis to be used primarily to aid development of Groundwater Sustainability Plans (GSPs) by Groundwater Sustainability Agencies (GSAs) (https://data.cnra.ca.gov/dataset/sgma-climate-change-resources). These resources are based on the results of the California Water Commission's Water Storage Investment Program (WSIP) climate change analysis (https://data.cnra.ca.gov/dataset/climate-change-projections-wsip-2030-2070). The provided climate change data are intended to be used, among other things, for developing long-term water budgets, and are thus applicable to water availability analysis.

The available datasets were developed based on the WSIP analysis for projected climate conditions centered around 2030 and 2070. The climate projections include a 2030 central tendency, a 2070 central tendency, and 2070 extreme scenario that is drier with extreme warming, and a 2070 extreme scenario that is wetter with moderate warming. The climate scenario datasets preserve historical variability from January 1915 through December 2011 while increasing or decreasing the magnitude of events based on projected changes in precipitation and air temperature from downscaled general circulation models (GCMs). The underlying downscaled GCM datasets were derived as part of California's Fourth Climate Change Assessment and are described in Thomas et al., 2018.[33]

Available datasets include precipitation, reference evapotranspiration, hydrology data, and water operations data for the Central Valley. For Central Valley streams, streamflows have been simulated using the variable infiltration capacity (VIC) model for climate change scenarios. For areas outside of the Central Valley, including the Russian River watershed, unimpaired streamflow change factors have been developed for all HUC 8 watersheds in California. These streamflow change factors are calculated as a future scenario divided by the historical detrended scenario. The resulting ratios can be used to perturb historical data to represent projected future conditions. Table B-1 contains monthly streamflow change factors for the Russian River watershed for the 2030 central tendency, 2070 central tendency, 2070 drier with extreme warming, and 2070 wetter with moderate warming climate scenarios for years 1915-2011. For the purposes of the analysis presented in this report, only the 2070 central tendency streamflow change factors were used.

[33] Thomas, N., Mukhtyar, S., Galey, B., Kelly, M. (University of California Berkeley). 2018. *Cal Adapt: Linking Climate Science with Energy Sector Resilience and Practitioner Need. California's Fourth Climate Change Assessment, California Energy Commission*. Publication Number: CCCA4-CEC-2018-015

Table B 1 - Monthly streamflow change factors for the Russian River watershed for the 2030 central tendency, 2070 central tendency, 2070 drier with extreme warming, and 2070 wetter with moderate warming climate scenarios for years 1915-2011

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
1/1/1915	1.11	1.56	1.14	1.53
2/1/1915	1.05	1.22	1.47	1.70
3/1/1915	1.02	1.06	1.15	1.22
4/1/1915	1.01	0.97	0.87	1.06
5/1/1915	1.08	0.85	1.12	0.88
6/1/1915	0.99	0.83	0.79	0.83
7/1/1915	0.98	0.94	0.92	0.94
8/1/1915	1.00	0.99	0.99	0.99
9/1/1915	1.00	1.00	1.00	1.00
10/1/1915	0.96	0.95	0.89	0.96
11/1/1915	1.09	0.86	0.51	1.60
12/1/1915	1.23	1.40	1.17	3.09
1/1/1916	1.14	1.33	0.89	1.48
2/1/1916	1.03	1.11	1.16	1.82
3/1/1916	1.08	1.05	1.06	1.61
4/1/1916	1.06	0.94	0.82	1.06
5/1/1916	0.97	0.87	0.80	0.94
6/1/1916	0.93	0.87	0.85	0.96
7/1/1916	1.09	1.18	0.98	1.05
8/1/1916	0.99	0.99	0.99	1.09
9/1/1916	1.01	0.98	0.97	1.16
10/1/1916	0.92	0.89	0.78	0.92
11/1/1916	1.10	0.87	0.53	1.51
12/1/1916	1.18	1.31	0.99	2.57
1/1/1917	1.16	1.22	0.70	3.17
2/1/1917	1.08	1.33	1.64	2.35
3/1/1917	1.12	1.14	0.87	1.57
4/1/1917	0.96	0.85	0.70	0.80
5/1/1917	0.92	0.78	0.68	0.86
6/1/1917	0.97	0.93	0.88	0.96
7/1/1917	0.99	0.99	0.98	0.99
8/1/1917	1.00	1.00	1.00	1.00
9/1/1917	0.99	0.98	0.98	1.11
10/1/1917	1.00	1.00	1.00	1.00
11/1/1917	1.09	0.90	0.37	1.74
12/1/1917	1.37	1.53	0.87	2.53
1/1/1918	1.01	1.30	0.77	2.22

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1918	1.17	1.56	1.86	4.83
3/1/1918	1.12	1.33	1.05	2.06
4/1/1918	1.01	0.99	0.86	1.23
5/1/1918	0.97	0.91	0.88	1.05
6/1/1918	0.97	0.94	0.92	1.00
7/1/1918	1.00	0.99	0.99	1.00
8/1/1918	1.00	1.00	1.00	1.00
9/1/1918	1.15	1.67	0.75	3.65
10/1/1918	0.81	0.80	0.44	0.86
11/1/1918	1.07	0.90	0.35	1.60
12/1/1918	1.17	1.20	0.92	3.30
1/1/1919	1.17	1.48	0.83	2.30
2/1/1919	1.04	1.19	1.40	2.41
3/1/1919	1.02	1.07	1.08	1.24
4/1/1919	0.98	0.89	0.74	0.93
5/1/1919	0.95	0.83	0.76	0.92
6/1/1919	0.98	0.93	0.90	0.97
7/1/1919	0.99	0.99	0.98	0.99
8/1/1919	1.00	1.00	1.00	1.00
9/1/1919	1.08	1.10	0.93	1.92
10/1/1919	0.86	0.82	0.69	0.92
11/1/1919	1.04	0.90	0.67	1.47
12/1/1919	1.20	1.30	1.06	2.61
1/1/1920	1.10	1.21	0.78	2.77
2/1/1920	1.01	1.02	1.40	3.42
3/1/1920	1.07	1.13	0.88	2.91
4/1/1920	0.96	0.90	0.72	1.76
5/1/1920	0.98	0.94	0.70	1.50
6/1/1920	0.90	1.03	0.89	1.18
7/1/1920	1.00	1.01	0.98	1.02
8/1/1920	0.99	1.00	0.99	1.01
9/1/1920	0.99	0.98	0.95	1.21
10/1/1920	0.87	0.68	0.21	0.68
11/1/1920	1.01	1.00	1.15	1.19
12/1/1920	1.11	1.20	0.64	1.76
1/1/1921	1.02	1.28	0.95	1.33
2/1/1921	0.98	0.99	1.10	1.48
3/1/1921	1.05	0.98	0.99	1.34
4/1/1921	1.05	0.90	0.75	1.04
5/1/1921	0.98	0.80	0.75	0.88

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1921	0.98	0.92	0.90	0.96
7/1/1921	1.00	0.99	0.98	0.99
8/1/1921	1.00	1.00	1.00	1.00
9/1/1921	1.00	0.99	0.98	1.19
10/1/1921	0.81	0.76	0.49	0.79
11/1/1921	1.06	0.86	0.31	1.56
12/1/1921	1.19	1.31	0.99	2.41
1/1/1922	1.09	1.20	0.44	3.61
2/1/1922	1.13	1.40	1.41	3.37
3/1/1922	1.08	1.16	1.10	1.49
4/1/1922	1.04	0.97	0.78	1.03
5/1/1922	0.97	0.86	0.78	0.91
6/1/1922	0.97	0.92	0.89	0.92
7/1/1922	1.00	0.99	0.99	0.99
8/1/1922	1.00	1.00	1.00	1.00
9/1/1922	1.00	1.00	1.00	1.00
10/1/1922	0.88	0.67	0.25	0.62
11/1/1922	1.14	0.82	0.45	1.48
12/1/1922	1.24	1.32	0.85	2.71
1/1/1923	1.13	1.23	0.55	1.73
2/1/1923	1.04	1.07	0.91	1.67
3/1/1923	1.00	0.94	0.93	1.46
4/1/1923	0.95	0.82	0.74	0.75
5/1/1923	0.94	0.83	0.74	0.84
6/1/1923	0.92	0.84	0.87	0.91
7/1/1923	0.99	0.97	0.96	0.97
8/1/1923	0.99	1.00	1.00	0.99
9/1/1923	1.16	1.47	0.84	3.13
10/1/1923	0.81	0.78	0.52	1.00
11/1/1923	0.99	0.86	0.54	1.56
12/1/1923	1.26	1.27	0.75	3.61
1/1/1924	1.10	1.38	1.11	1.65
2/1/1924	1.05	1.24	2.14	3.84
3/1/1924	1.17	1.12	0.87	2.46
4/1/1924	1.09	0.96	0.80	1.43
5/1/1924	1.00	0.96	0.89	1.10
6/1/1924	1.01	1.01	0.98	1.04
7/1/1924	1.00	1.00	0.99	1.02
8/1/1924	1.00	1.00	1.00	1.00
9/1/1924	1.00	1.00	1.00	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1924	0.88	0.67	0.16	0.62
11/1/1924	1.04	0.80	0.37	1.32
12/1/1924	1.10	1.02	0.60	2.22
1/1/1925	1.03	0.96	0.37	1.96
2/1/1925	1.03	1.13	1.27	1.83
3/1/1925	1.04	1.03	1.15	1.30
4/1/1925	0.99	0.89	0.82	0.98
5/1/1925	1.06	0.86	1.63	0.90
6/1/1925	0.94	0.75	0.73	0.77
7/1/1925	0.99	0.96	0.94	0.94
8/1/1925	0.99	0.99	1.00	0.99
9/1/1925	1.06	1.11	0.92	1.93
10/1/1925	0.98	0.97	0.95	1.00
11/1/1925	1.12	0.89	0.37	1.77
12/1/1925	1.25	1.27	0.76	2.15
1/1/1926	1.11	1.52	1.05	1.34
2/1/1926	1.17	1.45	1.60	3.09
3/1/1926	1.08	1.16	1.08	1.96
4/1/1926	0.90	0.82	0.81	0.70
5/1/1926	0.94	0.84	0.78	0.85
6/1/1926	0.97	0.94	0.92	0.95
7/1/1926	0.99	0.99	0.99	0.98
8/1/1926	1.00	1.00	1.01	0.99
9/1/1926	1.00	1.00	1.00	1.00
10/1/1926	0.83	0.77	0.46	0.77
11/1/1926	1.04	1.03	0.73	1.48
12/1/1926	1.15	1.17	0.52	2.04
1/1/1927	1.09	1.33	0.78	1.49
2/1/1927	1.01	1.16	1.50	1.86
3/1/1927	1.04	1.02	0.94	1.15
4/1/1927	0.98	0.88	0.78	0.75
5/1/1927	0.94	0.85	0.79	0.89
6/1/1927	0.91	0.84	0.90	0.92
7/1/1927	0.99	0.99	0.98	0.98
8/1/1927	1.00	1.00	1.00	1.00
9/1/1927	1.00	1.00	1.00	1.00
10/1/1927	0.79	0.75	0.48	0.76
11/1/1927	1.14	0.85	0.55	1.45
12/1/1927	1.35	1.42	1.04	3.05
1/1/1928	1.25	1.18	0.52	3.33

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1928	1.08	1.14	0.91	2.13
3/1/1928	1.07	1.17	1.08	1.46
4/1/1928	0.99	0.95	0.86	1.03
5/1/1928	0.95	0.86	0.78	0.94
6/1/1928	0.97	0.94	0.91	0.97
7/1/1928	0.99	0.99	0.98	0.99
8/1/1928	1.00	1.00	1.00	1.00
9/1/1928	1.00	1.00	1.00	1.00
10/1/1928	0.88	0.84	0.73	0.89
11/1/1928	1.24	0.92	0.77	1.53
12/1/1928	1.18	1.22	1.01	2.28
1/1/1929	1.21	1.33	0.66	4.97
2/1/1929	1.15	1.21	1.24	3.41
3/1/1929	1.26	1.10	0.81	1.49
4/1/1929	1.05	0.86	0.66	0.94
5/1/1929	1.00	0.88	0.73	0.96
6/1/1929	0.92	1.11	0.73	0.77
7/1/1929	1.00	0.99	0.98	0.99
8/1/1929	1.00	1.00	0.99	1.00
9/1/1929	1.00	1.00	1.00	1.00
10/1/1929	0.99	0.98	0.98	0.99
11/1/1929	1.00	1.00	1.00	1.00
12/1/1929	1.18	1.58	1.27	2.47
1/1/1930	1.20	1.52	0.87	1.91
2/1/1930	1.07	1.29	1.69	2.24
3/1/1930	1.09	1.08	1.03	1.45
4/1/1930	0.98	0.86	0.90	0.99
5/1/1930	0.94	0.78	0.75	0.90
6/1/1930	0.98	0.93	0.90	0.97
7/1/1930	0.99	0.98	0.98	0.99
8/1/1930	1.00	1.00	1.00	1.00
9/1/1930	1.03	1.00	0.96	1.14
10/1/1930	0.92	0.90	0.77	0.94
11/1/1930	1.10	0.83	0.54	1.64
12/1/1930	1.26	1.29	0.89	2.53
1/1/1931	1.19	1.62	0.97	2.11
2/1/1931	1.22	1.58	1.03	8.07
3/1/1931	1.29	1.30	0.86	3.91
4/1/1931	1.24	1.23	0.69	2.13
5/1/1931	1.06	0.89	0.89	1.02

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1931	0.89	0.97	0.86	0.87
7/1/1931	1.01	1.00	0.98	1.01
8/1/1931	1.00	1.00	0.99	1.00
9/1/1931	1.00	1.00	1.00	1.00
10/1/1931	0.82	0.71	0.32	0.70
11/1/1931	1.07	0.81	0.27	1.49
12/1/1931	1.19	1.44	1.10	2.42
1/1/1932	1.10	1.23	0.38	2.27
2/1/1932	0.99	1.05	0.85	2.30
3/1/1932	1.09	1.01	0.80	1.55
4/1/1932	1.03	0.88	0.73	0.97
5/1/1932	1.09	0.82	0.64	0.77
6/1/1932	1.01	0.91	0.88	0.93
7/1/1932	1.00	0.98	0.97	0.98
8/1/1932	1.00	1.00	0.99	1.00
9/1/1932	1.00	1.00	1.00	1.00
10/1/1932	0.99	0.98	0.97	0.99
11/1/1932	1.12	0.84	0.36	1.77
12/1/1932	1.28	1.33	0.85	2.35
1/1/1933	1.19	1.58	0.84	2.22
2/1/1933	1.33	1.69	0.67	3.73
3/1/1933	1.08	1.19	0.78	1.55
4/1/1933	1.03	1.08	0.68	1.23
5/1/1933	1.19	0.86	0.83	0.87
6/1/1933	1.02	0.91	0.83	0.93
7/1/1933	1.00	0.97	0.96	0.97
8/1/1933	1.00	1.00	1.00	0.99
9/1/1933	0.99	0.99	1.00	1.02
10/1/1933	0.82	0.71	0.37	0.71
11/1/1933	0.97	0.95	0.92	0.95
12/1/1933	1.25	1.49	1.12	2.46
1/1/1934	1.26	1.69	0.58	3.83
2/1/1934	1.20	1.53	1.51	3.49
3/1/1934	1.17	1.29	1.27	2.18
4/1/1934	1.12	1.01	0.91	1.26
5/1/1934	1.04	0.82	0.78	0.88
6/1/1934	0.87	0.77	0.77	0.91
7/1/1934	1.00	0.98	0.97	0.99
8/1/1934	1.00	1.00	0.99	1.00
9/1/1934	0.99	0.99	1.00	1.02

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1934	0.85	0.69	0.28	0.68
11/1/1934	1.20	0.91	0.60	1.44
12/1/1934	1.20	1.15	0.80	3.25
1/1/1935	1.14	1.34	0.56	1.84
2/1/1935	1.02	1.08	1.08	2.59
3/1/1935	1.03	1.10	1.08	1.35
4/1/1935	0.95	0.88	0.80	0.89
5/1/1935	0.92	0.82	0.74	0.88
6/1/1935	0.97	0.94	0.91	0.96
7/1/1935	0.99	0.98	0.98	0.98
8/1/1935	1.00	1.00	1.01	0.99
9/1/1935	0.99	0.98	0.99	1.19
10/1/1935	0.82	0.77	0.45	0.79
11/1/1935	1.02	0.78	0.40	1.52
12/1/1935	1.22	1.28	0.87	2.29
1/1/1936	1.10	1.53	0.93	2.01
2/1/1936	1.02	1.21	1.59	2.22
3/1/1936	1.01	1.05	1.07	1.21
4/1/1936	1.09	0.89	0.77	0.87
5/1/1936	0.97	0.85	0.77	0.90
6/1/1936	0.84	0.97	0.64	0.71
7/1/1936	1.00	1.02	0.96	0.99
8/1/1936	1.00	1.00	0.99	0.99
9/1/1936	1.00	1.00	1.00	1.00
10/1/1936	0.97	0.95	0.91	0.96
11/1/1936	1.00	0.99	0.98	1.07
12/1/1936	1.23	1.30	0.98	3.54
1/1/1937	1.14	1.39	0.93	1.62
2/1/1937	1.11	1.41	1.65	2.79
3/1/1937	1.07	1.21	1.01	1.50
4/1/1937	1.00	0.96	0.78	1.00
5/1/1937	0.96	0.86	0.75	0.92
6/1/1937	0.89	1.05	0.76	0.84
7/1/1937	0.99	0.99	0.97	0.98
8/1/1937	1.00	1.00	1.00	1.00
9/1/1937	1.00	1.00	1.00	1.00
10/1/1937	0.84	0.75	0.39	0.74
11/1/1937	1.05	0.94	0.80	1.44
12/1/1937	1.13	1.19	0.93	2.30
1/1/1938	1.12	1.27	0.56	1.73

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1938	1.03	1.16	1.40	1.82
3/1/1938	1.02	1.14	1.05	1.19
4/1/1938	0.97	0.93	0.85	0.97
5/1/1938	0.94	0.84	0.72	0.93
6/1/1938	0.97	0.94	0.89	0.97
7/1/1938	0.99	0.98	0.98	0.99
8/1/1938	1.00	1.00	1.00	1.00
9/1/1938	1.00	0.97	0.97	1.27
10/1/1938	0.84	0.70	0.27	0.72
11/1/1938	1.09	0.81	0.33	1.45
12/1/1938	1.28	1.42	0.82	2.13
1/1/1939	1.07	1.21	0.85	1.93
2/1/1939	1.01	0.98	0.73	4.95
3/1/1939	1.18	1.04	0.64	2.05
4/1/1939	1.08	0.97	0.66	1.45
5/1/1939	1.07	0.86	0.89	0.93
6/1/1939	1.00	0.98	0.94	1.01
7/1/1939	1.00	0.99	0.98	1.00
8/1/1939	1.00	1.00	0.99	1.00
9/1/1939	0.99	0.99	1.00	1.01
10/1/1939	0.95	0.93	0.85	0.94
11/1/1939	0.98	0.93	0.70	1.23
12/1/1939	1.21	1.34	1.04	2.67
1/1/1940	1.06	1.59	1.05	2.11
2/1/1940	1.04	1.22	1.58	2.01
3/1/1940	1.03	1.08	1.13	1.09
4/1/1940	1.01	1.02	0.92	1.02
5/1/1940	1.01	0.80	0.79	0.82
6/1/1940	0.95	0.87	0.81	0.86
7/1/1940	0.99	0.97	0.97	0.97
8/1/1940	1.00	1.00	1.00	1.00
9/1/1940	1.04	1.01	0.99	1.24
10/1/1940	0.81	0.74	0.35	0.70
11/1/1940	1.05	0.80	0.26	1.44
12/1/1940	1.10	1.50	1.04	2.24
1/1/1941	1.01	1.28	0.89	1.36
2/1/1941	1.01	1.15	1.47	2.10
3/1/1941	1.04	1.14	1.20	1.25
4/1/1941	0.98	0.97	0.93	0.93
5/1/1941	1.07	0.84	0.64	0.76

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1941	0.93	0.85	0.73	0.85
7/1/1941	0.99	0.95	0.91	0.94
8/1/1941	1.00	1.00	0.99	0.99
9/1/1941	1.00	1.00	1.00	1.01
10/1/1941	0.79	0.75	0.45	0.75
11/1/1941	1.02	0.85	0.30	1.55
12/1/1941	1.21	1.52	0.85	2.57
1/1/1942	1.11	1.34	0.83	1.55
2/1/1942	1.05	1.21	1.38	1.57
3/1/1942	1.08	1.02	0.91	1.40
4/1/1942	0.94	0.86	0.77	0.88
5/1/1942	1.00	0.79	0.60	0.72
6/1/1942	1.04	0.81	0.69	0.78
7/1/1942	0.99	0.94	0.91	0.93
8/1/1942	1.00	0.99	0.99	0.99
9/1/1942	1.00	1.00	1.00	1.00
10/1/1942	0.87	0.84	0.68	0.85
11/1/1942	1.26	0.88	0.51	1.65
12/1/1942	1.22	1.35	1.09	2.80
1/1/1943	1.07	1.35	0.83	1.69
2/1/1943	1.02	1.09	0.83	2.13
3/1/1943	0.99	0.99	0.95	1.69
4/1/1943	0.96	0.85	0.74	1.00
5/1/1943	0.88	0.72	0.68	0.90
6/1/1943	0.88	0.79	0.79	0.90
7/1/1943	0.98	0.96	0.96	0.98
8/1/1943	1.00	0.99	0.99	1.00
9/1/1943	1.00	1.00	1.00	1.00
10/1/1943	0.83	0.79	0.53	0.77
11/1/1943	1.02	0.78	0.38	1.39
12/1/1943	1.18	1.19	0.74	2.38
1/1/1944	1.15	1.40	0.94	1.77
2/1/1944	1.32	1.70	1.46	4.34
3/1/1944	1.24	1.31	1.21	1.96
4/1/1944	0.97	0.89	0.83	1.02
5/1/1944	0.94	0.75	0.71	0.84
6/1/1944	0.89	0.81	0.75	0.84
7/1/1944	0.98	0.96	0.95	0.97
8/1/1944	1.00	0.99	0.99	0.99
9/1/1944	1.00	1.00	1.00	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1944	0.83	0.72	0.36	0.73
11/1/1944	1.10	0.91	0.33	1.51
12/1/1944	1.28	1.11	0.68	3.34
1/1/1945	1.28	1.03	0.28	3.06
2/1/1945	1.14	1.30	0.98	2.06
3/1/1945	1.05	1.10	0.69	1.27
4/1/1945	1.01	0.97	0.68	1.05
5/1/1945	1.04	0.82	0.79	0.88
6/1/1945	0.98	0.91	0.86	0.95
7/1/1945	1.00	0.98	0.98	0.99
8/1/1945	1.00	1.00	1.00	1.00
9/1/1945	1.00	1.00	1.00	1.00
10/1/1945	0.88	0.61	0.17	0.94
11/1/1945	1.18	0.94	0.37	1.65
12/1/1945	1.17	1.30	0.69	2.16
1/1/1946	1.03	1.07	0.65	1.18
2/1/1946	0.98	1.00	1.33	3.26
3/1/1946	1.04	0.98	1.15	2.49
4/1/1946	1.24	0.97	0.69	1.25
5/1/1946	1.00	0.90	0.81	1.00
6/1/1946	1.00	0.96	0.93	1.00
7/1/1946	1.02	1.03	0.99	1.01
8/1/1946	1.00	1.00	1.00	1.00
9/1/1946	1.00	1.00	1.00	1.01
10/1/1946	0.95	0.93	0.83	0.94
11/1/1946	1.24	0.90	0.59	1.57
12/1/1946	1.23	1.30	1.01	2.34
1/1/1947	1.02	1.27	0.80	2.75
2/1/1947	1.10	1.26	2.03	6.07
3/1/1947	1.15	1.27	0.80	2.50
4/1/1947	1.05	1.03	0.60	1.39
5/1/1947	0.98	0.93	0.77	1.02
6/1/1947	0.91	1.21	0.76	0.83
7/1/1947	0.99	1.02	0.96	0.98
8/1/1947	1.00	1.01	0.99	0.99
9/1/1947	1.00	1.01	0.99	1.00
10/1/1947	0.90	0.69	0.18	0.64
11/1/1947	0.96	0.77	0.32	1.20
12/1/1947	1.24	1.30	0.71	2.36
1/1/1948	1.01	1.11	0.81	1.72

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1948	0.91	0.88	1.01	5.58
3/1/1948	1.02	1.01	0.94	2.17
4/1/1948	0.87	0.85	0.52	1.13
5/1/1948	0.83	0.76	0.51	0.89
6/1/1948	0.89	0.77	0.68	0.80
7/1/1948	0.96	0.91	0.86	0.93
8/1/1948	0.99	0.98	0.98	0.99
9/1/1948	1.04	1.07	0.99	1.30
10/1/1948	0.85	0.81	0.66	0.87
11/1/1948	1.07	0.81	0.36	1.59
12/1/1948	1.15	1.19	0.86	2.59
1/1/1949	1.05	1.24	0.68	5.77
2/1/1949	1.15	1.34	1.10	6.15
3/1/1949	1.06	1.21	0.97	1.56
4/1/1949	1.00	1.01	0.80	1.12
5/1/1949	0.96	0.90	0.80	0.94
6/1/1949	0.98	0.96	0.93	0.98
7/1/1949	1.00	1.00	1.00	1.00
8/1/1949	0.99	1.00	1.01	1.00
9/1/1949	1.00	1.00	1.00	1.00
10/1/1949	0.99	0.99	0.98	0.99
11/1/1949	1.14	0.85	0.54	1.63
12/1/1949	1.21	1.22	0.80	2.53
1/1/1950	1.15	1.69	0.86	2.56
2/1/1950	1.16	1.43	1.24	2.17
3/1/1950	1.08	1.08	0.81	1.24
4/1/1950	1.01	0.87	0.70	0.96
5/1/1950	0.92	0.74	0.88	0.89
6/1/1950	0.96	0.90	0.91	0.91
7/1/1950	0.99	0.99	0.98	0.99
8/1/1950	1.00	1.00	1.00	1.00
9/1/1950	1.00	1.00	1.00	1.03
10/1/1950	0.89	0.65	0.17	0.62
11/1/1950	1.20	0.90	0.55	1.51
12/1/1950	1.15	1.10	0.55	1.97
1/1/1951	1.09	1.28	0.73	1.44
2/1/1951	1.04	1.14	1.30	2.00
3/1/1951	1.14	1.10	0.95	1.72
4/1/1951	1.01	0.90	0.87	1.06
5/1/1951	1.11	0.78	0.94	0.88

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1951	1.00	0.92	0.91	0.96
7/1/1951	1.00	0.98	0.98	0.98
8/1/1951	1.00	0.99	1.00	0.99
9/1/1951	1.00	1.00	1.00	1.00
10/1/1951	0.85	0.70	0.33	0.68
11/1/1951	1.17	0.92	0.32	1.55
12/1/1951	1.23	1.35	0.81	2.17
1/1/1952	1.06	1.26	0.78	1.35
2/1/1952	1.03	1.13	1.21	1.85
3/1/1952	1.03	1.06	0.98	1.33
4/1/1952	0.98	0.92	0.79	1.04
5/1/1952	0.93	0.80	0.77	0.89
6/1/1952	0.90	0.99	0.80	0.78
7/1/1952	0.99	0.98	0.97	0.98
8/1/1952	1.00	1.00	0.99	1.00
9/1/1952	1.00	1.00	1.00	1.00
10/1/1952	0.99	0.98	0.96	0.98
11/1/1952	1.13	0.90	0.46	1.53
12/1/1952	1.12	1.49	1.01	2.47
1/1/1953	1.05	1.30	0.98	1.38
2/1/1953	0.99	1.04	0.90	1.30
3/1/1953	1.04	1.02	0.91	1.24
4/1/1953	0.92	0.81	0.70	0.82
5/1/1953	0.89	0.70	0.54	0.64
6/1/1953	0.85	0.72	0.64	0.69
7/1/1953	0.97	0.93	0.90	0.92
8/1/1953	0.99	1.00	1.00	1.04
9/1/1953	1.00	1.00	0.99	1.00
10/1/1953	0.81	0.76	0.45	0.75
11/1/1953	1.17	0.82	0.34	1.56
12/1/1953	1.23	1.26	0.79	3.27
1/1/1954	1.08	1.44	0.86	1.80
2/1/1954	1.08	1.24	0.91	2.56
3/1/1954	1.04	1.12	0.81	1.33
4/1/1954	0.95	0.91	0.81	0.94
5/1/1954	0.89	0.80	0.73	0.88
6/1/1954	0.91	0.86	0.82	0.85
7/1/1954	0.99	0.98	0.97	0.98
8/1/1954	1.19	1.14	0.77	10.22
9/1/1954	1.00	1.00	1.00	1.32

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1954	0.83	0.80	0.54	0.94
11/1/1954	1.20	0.91	0.51	1.62
12/1/1954	1.26	1.23	0.86	3.52
1/1/1955	1.20	1.19	0.40	2.96
2/1/1955	1.10	1.05	0.57	2.77
3/1/1955	1.06	0.92	0.68	3.65
4/1/1955	0.97	0.81	0.72	0.77
5/1/1955	0.94	0.71	0.51	0.91
6/1/1955	0.97	0.92	0.87	0.98
7/1/1955	0.99	0.97	0.96	0.98
8/1/1955	1.00	1.00	0.99	1.00
9/1/1955	0.99	0.97	0.98	1.25
10/1/1955	0.92	0.90	0.80	0.92
11/1/1955	1.05	0.88	0.24	1.67
12/1/1955	1.00	1.24	1.07	2.35
1/1/1956	0.99	1.23	0.92	1.35
2/1/1956	1.04	1.22	1.44	1.65
3/1/1956	1.05	1.06	1.07	1.38
4/1/1956	0.97	0.86	0.85	0.95
5/1/1956	0.90	0.70	0.62	0.74
6/1/1956	0.96	0.90	0.88	0.92
7/1/1956	0.99	0.98	0.98	0.98
8/1/1956	1.00	0.99	0.99	0.99
9/1/1956	0.99	0.99	1.00	1.01
10/1/1956	0.84	0.60	0.21	0.71
11/1/1956	0.94	0.82	0.55	1.22
12/1/1956	1.23	1.10	0.70	2.74
1/1/1957	1.23	1.59	0.98	1.68
2/1/1957	1.18	1.53	1.94	3.05
3/1/1957	1.15	1.24	0.84	1.95
4/1/1957	0.97	0.84	0.75	0.98
5/1/1957	1.05	0.80	0.74	0.71
6/1/1957	0.99	0.82	0.73	0.77
7/1/1957	0.99	0.95	0.93	0.94
8/1/1957	1.00	0.99	0.99	0.99
9/1/1957	1.17	2.02	0.68	3.72
10/1/1957	0.85	0.67	0.17	0.81
11/1/1957	1.08	0.83	0.27	1.71
12/1/1957	1.23	1.16	0.61	3.12
1/1/1958	1.13	1.38	0.43	1.87

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1958	1.07	1.21	1.41	1.84
3/1/1958	1.04	1.07	0.98	1.06
4/1/1958	0.99	0.97	0.94	0.91
5/1/1958	0.94	0.86	0.80	0.91
6/1/1958	0.87	0.87	0.75	0.85
7/1/1958	1.01	1.03	0.96	0.99
8/1/1958	1.00	1.00	1.00	1.00
9/1/1958	1.00	1.00	1.00	1.00
10/1/1958	0.98	0.96	0.92	0.97
11/1/1958	1.02	0.90	0.67	1.49
12/1/1958	1.28	1.31	0.89	2.66
1/1/1959	1.07	1.66	1.14	1.79
2/1/1959	1.13	1.48	1.68	2.46
3/1/1959	1.10	1.22	1.09	1.64
4/1/1959	1.16	1.04	0.82	1.05
5/1/1959	1.01	0.93	0.84	0.99
6/1/1959	1.00	0.97	0.95	0.99
7/1/1959	1.00	1.00	1.00	1.00
8/1/1959	1.00	1.00	1.00	1.00
9/1/1959	1.09	1.61	0.66	3.21
10/1/1959	1.00	1.06	0.94	1.06
11/1/1959	1.01	1.03	0.96	1.09
12/1/1959	1.24	1.33	1.01	2.41
1/1/1960	1.12	1.45	0.86	1.60
2/1/1960	1.15	1.52	1.59	2.50
3/1/1960	1.06	1.18	1.05	1.28
4/1/1960	1.01	0.98	0.74	1.00
5/1/1960	0.97	0.76	0.77	0.85
6/1/1960	0.98	0.90	0.86	0.94
7/1/1960	0.99	0.98	0.98	0.98
8/1/1960	1.00	1.00	1.00	1.00
9/1/1960	1.00	1.00	1.00	1.00
10/1/1960	0.86	0.85	0.67	0.87
11/1/1960	1.16	0.91	0.35	1.66
12/1/1960	1.22	1.27	0.84	2.57
1/1/1961	1.18	1.32	0.90	2.32
2/1/1961	1.17	1.23	0.96	2.64
3/1/1961	1.05	1.13	0.85	1.25
4/1/1961	0.99	0.96	0.77	0.97
5/1/1961	0.92	0.74	0.63	0.80

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1961	0.96	0.90	0.85	0.92
7/1/1961	0.99	0.98	0.98	0.99
8/1/1961	1.00	1.00	1.01	1.00
9/1/1961	0.99	0.98	0.97	1.16
10/1/1961	0.89	0.86	0.72	0.88
11/1/1961	1.21	0.91	0.43	1.80
12/1/1961	1.34	1.42	0.92	2.50
1/1/1962	1.16	1.28	0.82	2.79
2/1/1962	1.07	1.22	1.48	2.52
3/1/1962	1.03	1.10	1.04	1.29
4/1/1962	0.98	0.95	0.81	1.01
5/1/1962	0.97	0.89	0.82	0.95
6/1/1962	0.98	0.95	0.92	0.98
7/1/1962	1.00	0.99	0.99	1.00
8/1/1962	0.99	1.00	1.00	1.01
9/1/1962	1.02	0.99	0.98	1.27
10/1/1962	0.85	0.65	0.08	1.23
11/1/1962	1.09	0.83	0.49	1.48
12/1/1962	1.24	1.26	0.98	2.44
1/1/1963	1.18	1.47	1.23	1.78
2/1/1963	1.16	1.19	0.98	2.51
3/1/1963	1.07	1.15	0.95	1.29
4/1/1963	0.94	0.97	0.86	0.92
5/1/1963	0.88	0.79	0.62	0.79
6/1/1963	0.95	0.90	0.85	0.92
7/1/1963	0.97	0.94	0.92	0.95
8/1/1963	1.00	0.99	0.99	0.99
9/1/1963	1.00	1.00	1.00	1.00
10/1/1963	0.87	0.70	0.28	0.68
11/1/1963	1.09	0.88	0.35	1.67
12/1/1963	1.37	0.98	0.41	4.14
1/1/1964	1.23	1.30	0.61	2.13
2/1/1964	1.12	0.98	0.12	1.96
3/1/1964	1.16	1.01	0.55	1.64
4/1/1964	1.12	0.94	0.39	1.18
5/1/1964	0.97	0.82	0.60	0.93
6/1/1964	0.93	0.86	0.79	0.87
7/1/1964	1.00	1.01	0.97	1.00
8/1/1964	1.00	1.00	0.99	1.00
9/1/1964	1.00	1.00	0.99	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1964	0.83	0.69	0.31	0.66
11/1/1964	1.17	0.90	0.50	1.51
12/1/1964	1.05	1.24	0.87	2.29
1/1/1965	1.04	1.22	0.84	1.29
2/1/1965	1.01	1.05	1.01	1.68
3/1/1965	1.08	0.99	0.99	2.03
4/1/1965	1.03	0.85	0.74	0.92
5/1/1965	0.97	0.81	0.70	0.89
6/1/1965	0.98	0.92	0.88	0.95
7/1/1965	0.99	0.97	0.96	0.98
8/1/1965	1.00	1.02	0.99	1.27
9/1/1965	1.00	1.00	1.00	1.00
10/1/1965	0.98	0.96	0.93	0.97
11/1/1965	1.10	0.93	0.90	1.40
12/1/1965	1.25	1.29	0.99	2.86
1/1/1966	1.13	1.35	0.73	1.65
2/1/1966	1.04	1.16	1.18	1.99
3/1/1966	1.11	1.10	1.00	1.64
4/1/1966	1.03	0.84	0.81	0.94
5/1/1966	0.98	0.88	0.84	0.95
6/1/1966	0.98	0.95	0.96	0.96
7/1/1966	1.00	0.99	0.99	1.00
8/1/1966	0.99	1.00	1.01	1.00
9/1/1966	0.99	0.99	1.00	1.03
10/1/1966	1.00	1.00	1.00	1.00
11/1/1966	1.06	0.93	0.69	1.51
12/1/1966	1.18	1.21	0.64	2.55
1/1/1967	1.01	1.35	0.86	1.42
2/1/1967	0.99	1.02	0.89	1.16
3/1/1967	1.07	1.14	0.91	1.33
4/1/1967	0.98	0.96	0.78	0.88
5/1/1967	0.92	0.82	0.64	0.77
6/1/1967	0.91	1.33	0.77	0.80
7/1/1967	0.97	1.00	0.91	0.93
8/1/1967	1.00	1.01	0.99	0.98
9/1/1967	1.00	1.01	1.00	1.00
10/1/1967	0.84	0.81	0.53	0.80
11/1/1967	1.09	0.84	0.38	1.57
12/1/1967	1.21	1.23	0.84	2.16
1/1/1968	1.20	1.73	0.99	2.26

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1968	1.13	1.31	1.20	2.37
3/1/1968	1.07	1.09	1.02	1.33
4/1/1968	1.00	0.88	0.80	0.94
5/1/1968	0.95	0.86	0.79	0.90
6/1/1968	0.98	0.95	0.93	0.97
7/1/1968	1.00	1.00	1.00	1.00
8/1/1968	1.07	1.10	0.91	2.13
9/1/1968	1.00	1.00	1.00	1.09
10/1/1968	0.83	0.72	0.35	0.74
11/1/1968	1.02	0.84	0.22	1.62
12/1/1968	1.23	1.50	0.84	2.74
1/1/1969	1.06	1.27	0.92	1.41
2/1/1969	1.03	1.15	1.35	1.89
3/1/1969	1.07	1.10	1.14	1.34
4/1/1969	0.99	0.85	0.71	0.86
5/1/1969	0.94	0.84	0.78	0.91
6/1/1969	0.97	0.92	0.91	0.95
7/1/1969	0.99	0.98	0.98	0.98
8/1/1969	1.00	1.00	1.00	1.00
9/1/1969	1.00	1.00	1.00	1.00
10/1/1969	0.82	0.71	0.36	0.75
11/1/1969	1.02	0.73	0.37	1.41
12/1/1969	1.16	1.50	0.99	2.37
1/1/1970	1.18	1.34	1.04	1.31
2/1/1970	1.00	1.02	1.24	1.58
3/1/1970	1.10	1.04	1.03	1.39
4/1/1970	1.01	0.94	0.86	1.05
5/1/1970	0.98	0.92	0.86	0.99
6/1/1970	0.96	0.92	0.87	0.89
7/1/1970	1.00	1.00	1.00	1.00
8/1/1970	1.00	1.00	1.00	1.00
9/1/1970	1.00	1.00	1.00	1.00
10/1/1970	0.83	0.69	0.32	0.67
11/1/1970	1.11	0.91	0.50	1.51
12/1/1970	1.14	1.24	0.68	2.11
1/1/1971	1.07	1.20	0.83	1.41
2/1/1971	0.99	1.01	0.80	1.29
3/1/1971	1.05	1.15	0.95	1.48
4/1/1971	0.99	0.93	0.71	1.09
5/1/1971	0.94	0.80	0.67	0.89

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1971	0.97	0.92	0.87	0.96
7/1/1971	0.99	0.98	0.97	0.99
8/1/1971	1.00	1.00	1.00	0.99
9/1/1971	1.00	0.98	0.99	1.14
10/1/1971	0.91	0.89	0.81	0.92
11/1/1971	1.06	0.86	0.32	1.60
12/1/1971	1.12	1.21	0.93	3.06
1/1/1972	1.13	1.23	0.60	4.70
2/1/1972	1.11	1.19	0.82	4.77
3/1/1972	1.15	1.14	0.78	2.99
4/1/1972	1.02	0.83	0.63	1.03
5/1/1972	0.97	0.86	0.71	0.99
6/1/1972	0.97	0.92	0.90	0.96
7/1/1972	1.00	0.99	0.98	1.00
8/1/1972	0.99	1.00	1.00	1.00
9/1/1972	1.10	1.12	0.92	2.14
10/1/1972	0.89	0.71	0.21	0.80
11/1/1972	1.20	0.94	0.31	1.56
12/1/1972	1.31	1.11	0.67	4.24
1/1/1973	1.05	1.24	0.75	1.43
2/1/1973	1.06	1.22	1.33	2.04
3/1/1973	1.08	1.13	1.14	1.40
4/1/1973	1.05	0.96	0.77	1.03
5/1/1973	0.98	0.93	0.86	0.99
6/1/1973	0.99	0.97	0.95	0.99
7/1/1973	1.00	1.00	1.00	1.00
8/1/1973	1.00	1.00	1.00	1.00
9/1/1973	1.07	1.10	0.92	2.08
10/1/1973	0.86	0.64	0.22	0.75
11/1/1973	0.99	0.95	0.53	1.60
12/1/1973	1.07	1.10	0.42	1.97
1/1/1974	1.06	1.26	0.91	1.34
2/1/1974	1.01	1.09	1.22	2.24
3/1/1974	1.02	1.16	1.19	1.34
4/1/1974	0.97	0.98	0.89	0.96
5/1/1974	0.92	0.85	0.73	0.90
6/1/1974	0.97	0.93	0.89	0.96
7/1/1974	1.46	1.72	0.90	1.11
8/1/1974	1.01	1.03	1.00	1.00
9/1/1974	1.01	1.02	1.00	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1974	0.80	0.76	0.53	0.79
11/1/1974	1.00	0.75	0.36	1.61
12/1/1974	1.23	1.27	0.82	2.48
1/1/1975	1.06	1.16	0.82	2.97
2/1/1975	1.04	1.23	1.59	2.63
3/1/1975	1.03	1.15	1.01	1.21
4/1/1975	0.98	0.96	0.82	0.98
5/1/1975	0.90	0.76	0.64	0.87
6/1/1975	0.97	0.94	0.92	0.96
7/1/1975	1.00	1.01	0.98	0.99
8/1/1975	0.99	1.00	1.00	0.99
9/1/1975	1.00	1.00	1.00	1.00
10/1/1975	0.91	0.68	0.21	0.65
11/1/1975	1.08	0.81	0.27	1.43
12/1/1975	1.22	1.24	0.73	2.58
1/1/1976	1.06	1.07	0.62	1.90
2/1/1976	1.01	1.07	1.52	4.24
3/1/1976	1.21	1.01	0.72	4.74
4/1/1976	0.96	0.77	0.65	1.45
5/1/1976	0.99	0.88	0.75	1.42
6/1/1976	0.99	0.95	0.93	1.08
7/1/1976	1.00	0.99	0.98	1.03
8/1/1976	1.09	1.10	0.97	1.73
9/1/1976	1.00	0.99	0.98	1.16
10/1/1976	0.96	0.94	0.87	0.99
11/1/1976	1.10	0.84	0.46	1.64
12/1/1976	1.34	1.21	0.80	1.78
1/1/1977	1.16	1.28	0.77	1.57
2/1/1977	0.94	0.96	1.58	3.08
3/1/1977	1.17	1.08	0.93	1.37
4/1/1977	1.07	0.97	0.88	1.96
5/1/1977	1.04	0.86	0.66	0.94
6/1/1977	1.01	0.99	0.99	1.12
7/1/1977	1.00	1.00	0.99	1.04
8/1/1977	1.00	1.00	0.99	1.01
9/1/1977	1.15	1.52	0.84	2.90
10/1/1977	0.81	0.80	0.48	0.93
11/1/1977	1.20	0.90	1.17	1.33
12/1/1977	1.21	1.39	1.03	3.00
1/1/1978	1.05	1.28	1.04	1.46

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1978	1.07	1.22	1.45	1.87
3/1/1978	1.03	1.10	1.02	1.25
4/1/1978	0.96	0.86	0.72	0.80
5/1/1978	0.93	0.79	0.63	0.80
6/1/1978	0.97	0.93	0.89	0.95
7/1/1978	0.99	0.97	0.96	0.98
8/1/1978	1.00	1.00	1.00	1.00
9/1/1978	1.04	1.20	0.87	2.31
10/1/1978	1.00	1.00	1.00	1.04
11/1/1978	1.05	0.84	0.46	1.73
12/1/1978	1.29	1.15	0.83	2.51
1/1/1979	1.10	1.50	1.02	1.47
2/1/1979	1.21	1.71	1.96	4.26
3/1/1979	1.15	1.32	1.30	1.89
4/1/1979	1.04	0.97	0.85	1.09
5/1/1979	0.92	0.66	0.61	0.78
6/1/1979	0.97	0.92	0.88	0.95
7/1/1979	0.99	0.98	0.98	0.98
8/1/1979	1.00	1.00	1.00	1.00
9/1/1979	0.99	0.99	1.00	1.02
10/1/1979	0.86	0.58	0.16	0.68
11/1/1979	1.17	0.92	0.34	1.58
12/1/1979	1.20	1.17	0.89	2.23
1/1/1980	1.10	1.23	0.61	1.41
2/1/1980	1.01	1.17	1.53	1.97
3/1/1980	1.06	1.07	1.09	1.27
4/1/1980	0.95	0.79	0.72	0.86
5/1/1980	0.94	0.82	0.75	0.88
6/1/1980	0.94	0.87	0.85	0.91
7/1/1980	0.99	0.98	0.97	0.98
8/1/1980	1.00	1.00	1.00	1.00
9/1/1980	1.00	1.00	1.00	1.00
10/1/1980	0.88	0.84	0.68	0.84
11/1/1980	0.97	0.88	0.64	1.42
12/1/1980	1.24	1.36	1.15	3.14
1/1/1981	1.12	1.73	1.15	1.81
2/1/1981	1.10	1.51	1.23	3.84
3/1/1981	1.07	1.13	1.00	1.90
4/1/1981	1.04	0.99	0.75	1.14
5/1/1981	0.96	0.86	0.79	0.94

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1981	0.98	0.96	0.93	0.99
7/1/1981	1.00	1.00	1.01	1.00
8/1/1981	1.00	1.00	1.00	1.00
9/1/1981	1.04	1.04	0.97	1.50
10/1/1981	0.87	0.62	0.20	0.81
11/1/1981	1.05	0.93	0.47	1.71
12/1/1981	1.13	1.22	0.77	2.20
1/1/1982	1.07	1.23	0.81	1.30
2/1/1982	1.11	1.29	1.42	1.72
3/1/1982	1.09	1.20	1.19	1.31
4/1/1982	0.96	0.97	0.90	0.87
5/1/1982	0.92	0.87	0.76	0.85
6/1/1982	0.96	0.93	0.92	0.93
7/1/1982	0.98	0.97	0.96	0.97
8/1/1982	1.00	1.00	1.00	1.00
9/1/1982	1.07	1.08	0.93	1.68
10/1/1982	0.90	0.67	0.20	0.68
11/1/1982	1.14	0.92	0.48	1.66
12/1/1982	1.14	1.07	0.57	2.14
1/1/1983	1.04	1.29	0.80	1.34
2/1/1983	1.01	1.15	1.54	2.07
3/1/1983	1.04	1.21	1.07	1.09
4/1/1983	1.00	1.01	0.86	0.95
5/1/1983	0.94	0.81	0.71	0.79
6/1/1983	0.96	0.91	0.88	0.92
7/1/1983	1.00	0.99	0.94	1.01
8/1/1983	0.99	1.03	0.99	1.13
9/1/1983	1.04	0.99	0.95	1.30
10/1/1983	0.82	0.78	0.52	0.82
11/1/1983	1.01	0.98	0.68	1.60
12/1/1983	1.09	1.29	0.76	1.93
1/1/1984	1.03	1.12	0.88	1.24
2/1/1984	0.97	1.06	1.49	3.15
3/1/1984	1.12	1.05	0.98	1.91
4/1/1984	1.02	0.84	0.71	1.04
5/1/1984	0.95	0.77	0.67	0.86
6/1/1984	0.93	0.86	0.83	0.89
7/1/1984	1.00	0.99	0.99	1.00
8/1/1984	1.00	1.00	1.01	0.99
9/1/1984	0.99	0.99	1.00	1.02

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1984	0.83	0.70	0.31	0.67
11/1/1984	1.02	0.97	0.33	1.79
12/1/1984	1.08	0.97	0.17	3.50
1/1/1985	1.07	1.19	0.16	2.60
2/1/1985	1.01	1.10	1.05	2.14
3/1/1985	1.01	1.06	0.47	1.20
4/1/1985	0.99	0.99	0.38	1.09
5/1/1985	0.97	0.93	0.70	0.99
6/1/1985	0.98	0.96	0.92	0.98
7/1/1985	1.00	1.01	1.00	1.00
8/1/1985	1.00	1.00	1.00	1.00
9/1/1985	1.06	1.20	0.86	3.14
10/1/1985	0.80	0.72	0.38	0.82
11/1/1985	1.06	0.87	0.30	1.57
12/1/1985	1.26	1.35	0.87	2.61
1/1/1986	1.19	1.52	0.73	2.54
2/1/1986	1.08	1.22	1.36	1.66
3/1/1986	1.04	1.09	1.00	1.13
4/1/1986	0.99	0.95	0.80	1.02
5/1/1986	0.94	0.79	0.71	0.83
6/1/1986	0.97	0.93	0.90	0.96
7/1/1986	0.99	0.99	0.98	0.99
8/1/1986	1.00	1.00	1.00	1.00
9/1/1986	1.13	1.43	0.89	2.59
10/1/1986	0.85	0.81	0.60	0.93
11/1/1986	0.99	0.95	0.81	1.41
12/1/1986	1.17	1.21	0.69	3.60
1/1/1987	1.13	1.35	0.84	1.93
2/1/1987	1.30	1.82	1.80	5.25
3/1/1987	1.17	1.38	0.91	1.68
4/1/1987	1.09	1.14	0.75	1.23
5/1/1987	0.98	0.93	0.86	0.98
6/1/1987	0.99	0.97	0.95	0.99
7/1/1987	1.00	1.00	1.00	1.00
8/1/1987	1.00	1.00	1.00	1.00
9/1/1987	1.00	1.00	1.00	1.00
10/1/1987	0.79	0.76	0.46	0.76
11/1/1987	1.02	0.83	0.21	1.59
12/1/1987	1.28	1.44	0.76	2.76
1/1/1988	1.14	1.38	0.72	1.62

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1988	1.04	1.16	0.69	1.37
3/1/1988	1.10	1.08	0.83	1.56
4/1/1988	1.01	0.87	0.80	1.05
5/1/1988	0.95	0.74	0.62	0.84
6/1/1988	0.94	0.88	0.82	0.85
7/1/1988	0.99	0.98	0.97	0.99
8/1/1988	1.00	1.00	0.99	1.00
9/1/1988	1.00	1.00	0.99	1.00
10/1/1988	0.91	0.88	0.76	0.90
11/1/1988	1.17	0.91	0.30	1.77
12/1/1988	1.25	1.28	0.88	2.89
1/1/1989	1.31	1.33	0.35	5.04
2/1/1989	1.22	1.14	0.57	8.08
3/1/1989	1.11	1.27	0.55	1.74
4/1/1989	1.04	1.07	0.50	1.14
5/1/1989	0.97	0.89	0.68	0.92
6/1/1989	0.96	0.91	0.87	0.90
7/1/1989	0.99	0.98	0.96	0.98
8/1/1989	1.00	1.00	1.00	1.00
9/1/1989	1.05	1.33	0.80	2.75
10/1/1989	0.87	0.67	0.18	0.81
11/1/1989	1.10	0.82	0.46	1.41
12/1/1989	0.99	0.90	0.70	1.22
1/1/1990	1.17	1.50	1.03	1.60
2/1/1990	1.04	1.04	1.08	4.78
3/1/1990	1.21	1.09	0.48	2.34
4/1/1990	1.08	0.99	0.67	1.24
5/1/1990	1.13	0.92	1.33	1.02
6/1/1990	1.01	0.83	0.81	0.85
7/1/1990	1.00	0.97	0.96	0.97
8/1/1990	1.00	0.99	0.99	0.99
9/1/1990	1.00	0.99	0.99	1.05
10/1/1990	0.88	0.84	0.67	0.86
11/1/1990	0.95	0.88	0.68	1.39
12/1/1990	1.30	1.31	0.78	3.17
1/1/1991	1.06	1.42	0.68	1.65
2/1/1991	1.01	1.08	1.65	2.92
3/1/1991	1.11	1.46	1.51	1.65
4/1/1991	1.08	1.30	0.88	1.61
5/1/1991	0.99	0.94	0.78	1.04

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/1991	0.93	0.87	0.79	0.91
7/1/1991	0.99	0.98	0.97	0.99
8/1/1991	1.00	1.00	1.01	0.99
9/1/1991	1.00	1.00	1.00	1.00
10/1/1991	0.80	0.73	0.43	0.74
11/1/1991	1.02	0.74	0.35	1.43
12/1/1991	1.23	1.30	0.82	2.16
1/1/1992	1.05	1.16	0.81	1.55
2/1/1992	1.13	1.43	1.74	3.88
3/1/1992	1.06	1.13	1.02	1.57
4/1/1992	0.97	0.84	0.80	1.00
5/1/1992	0.97	0.88	0.86	0.98
6/1/1992	0.88	0.89	0.83	0.81
7/1/1992	1.00	1.00	0.99	0.99
8/1/1992	1.00	1.00	1.00	1.00
9/1/1992	1.00	1.00	1.00	1.00
10/1/1992	0.85	0.68	0.26	0.64
11/1/1992	0.94	0.76	0.38	1.44
12/1/1992	1.25	1.49	1.02	2.46
1/1/1993	1.03	1.30	0.87	1.50
2/1/1993	1.07	1.24	1.47	2.04
3/1/1993	1.08	1.10	1.08	1.22
4/1/1993	1.03	0.89	0.69	0.90
5/1/1993	1.08	0.83	0.68	0.78
6/1/1993	0.93	0.76	0.54	0.62
7/1/1993	0.99	0.93	0.88	0.91
8/1/1993	1.00	0.99	0.98	0.98
9/1/1993	1.00	1.00	0.99	0.99
10/1/1993	0.86	0.82	0.63	0.85
11/1/1993	1.08	0.82	0.43	1.62
12/1/1993	1.22	1.25	0.91	2.36
1/1/1994	1.05	1.22	0.86	2.77
2/1/1994	1.31	1.57	1.46	4.00
3/1/1994	1.29	1.41	1.11	2.68
4/1/1994	1.04	0.90	0.85	1.02
5/1/1994	0.97	0.76	0.65	0.81
6/1/1994	0.98	0.93	0.92	0.96
7/1/1994	1.00	0.99	0.98	0.99
8/1/1994	1.00	1.00	1.00	1.00
9/1/1994	1.00	1.00	1.00	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/1994	0.86	0.83	0.70	0.86
11/1/1994	1.14	0.93	0.39	1.57
12/1/1994	1.27	1.26	0.83	4.87
1/1/1995	1.22	1.35	0.86	1.46
2/1/1995	1.07	1.08	0.94	1.37
3/1/1995	1.06	1.25	1.25	1.16
4/1/1995	0.96	0.94	0.79	0.92
5/1/1995	1.01	0.75	0.65	0.78
6/1/1995	0.91	0.81	0.74	0.86
7/1/1995	0.98	0.94	0.90	0.94
8/1/1995	1.00	0.99	0.99	0.99
9/1/1995	1.00	1.00	1.00	1.00
10/1/1995	0.99	0.98	0.97	0.99
11/1/1995	0.99	0.97	0.86	1.23
12/1/1995	1.24	1.49	1.29	2.94
1/1/1996	1.14	1.73	0.96	2.39
2/1/1996	1.05	1.27	1.46	2.05
3/1/1996	1.05	1.10	1.14	1.32
4/1/1996	0.92	0.79	0.74	0.87
5/1/1996	1.13	0.85	0.88	0.84
6/1/1996	1.04	0.86	0.86	0.87
7/1/1996	1.00	0.96	0.95	0.95
8/1/1996	1.00	1.00	1.00	0.99
9/1/1996	0.99	0.99	0.99	1.03
10/1/1996	0.82	0.79	0.53	0.79
11/1/1996	1.03	0.84	0.28	1.58
12/1/1996	1.08	1.46	0.97	2.50
1/1/1997	1.00	1.26	0.94	1.30
2/1/1997	1.00	1.02	0.97	1.50
3/1/1997	1.16	1.02	0.82	1.77
4/1/1997	1.04	0.90	0.81	1.05
5/1/1997	0.97	0.85	0.75	0.92
6/1/1997	0.91	0.85	0.81	0.97
7/1/1997	1.00	0.99	0.98	0.99
8/1/1997	1.03	1.05	0.86	3.77
9/1/1997	1.02	1.00	0.99	1.62
10/1/1997	0.80	0.73	0.43	0.87
11/1/1997	1.12	0.90	0.26	1.70
12/1/1997	1.37	1.18	0.60	5.02
1/1/1998	1.09	1.30	0.57	1.57

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/1998	1.06	1.19	1.46	1.74
3/1/1998	1.02	1.01	0.93	1.06
4/1/1998	0.97	0.90	0.66	0.83
5/1/1998	1.00	0.80	0.73	0.73
6/1/1998	0.93	0.62	0.50	0.52
7/1/1998	0.97	0.92	0.86	0.89
8/1/1998	0.99	0.98	0.98	0.98
9/1/1998	1.00	0.99	1.00	1.01
10/1/1998	0.83	0.80	0.62	0.82
11/1/1998	1.16	0.92	0.29	1.72
12/1/1998	1.31	1.20	0.78	4.83
1/1/1999	1.22	1.27	0.50	2.82
2/1/1999	1.06	1.18	1.20	2.35
3/1/1999	1.02	1.10	1.05	1.31
4/1/1999	0.97	0.91	0.80	0.91
5/1/1999	0.94	0.84	0.78	0.90
6/1/1999	0.96	0.92	0.90	0.94
7/1/1999	0.99	0.98	0.97	0.99
8/1/1999	1.00	1.00	0.99	1.00
9/1/1999	1.00	1.00	1.00	1.00
10/1/1999	0.80	0.77	0.55	0.81
11/1/1999	1.10	0.88	0.23	1.56
12/1/1999	1.32	1.33	0.71	3.02
1/1/2000	1.23	1.46	0.68	2.61
2/1/2000	1.10	1.30	1.26	2.90
3/1/2000	1.07	1.10	1.06	1.21
4/1/2000	0.94	0.82	0.82	0.90
5/1/2000	0.98	0.78	0.70	0.78
6/1/2000	0.94	0.86	0.81	0.86
7/1/2000	0.99	0.97	0.96	0.97
8/1/2000	1.00	0.99	0.99	1.00
9/1/2000	0.99	0.98	0.99	1.07
10/1/2000	0.86	0.68	0.26	0.61
11/1/2000	1.04	0.77	0.31	1.51
12/1/2000	1.31	1.36	0.57	3.02
1/1/2001	1.12	1.34	0.81	1.66
2/1/2001	1.25	1.64	1.54	4.55
3/1/2001	1.20	1.29	1.05	1.69
4/1/2001	1.03	0.94	0.79	1.07
5/1/2001	0.99	0.93	0.85	0.99

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/2001	0.92	0.87	0.84	0.90
7/1/2001	1.00	1.00	1.00	1.00
8/1/2001	1.00	1.00	1.00	1.00
9/1/2001	1.00	1.00	1.00	1.02
10/1/2001	0.80	0.76	0.48	0.79
11/1/2001	1.07	0.88	0.38	1.61
12/1/2001	1.20	1.30	0.59	2.54
1/1/2002	1.09	1.20	0.86	1.32
2/1/2002	0.96	1.00	1.12	2.68
3/1/2002	1.07	0.99	0.91	1.71
4/1/2002	1.08	0.94	0.75	1.16
5/1/2002	0.95	0.82	0.82	0.93
6/1/2002	0.99	0.95	0.92	0.99
7/1/2002	1.00	0.99	0.99	1.00
8/1/2002	1.00	1.00	1.00	1.00
9/1/2002	1.00	1.00	1.00	1.00
10/1/2002	1.00	1.00	1.00	1.00
11/1/2002	1.12	0.88	0.62	1.65
12/1/2002	1.02	1.36	1.07	2.36
1/1/2003	1.06	1.23	0.94	1.34
2/1/2003	0.98	1.04	1.23	2.06
3/1/2003	1.06	1.02	1.08	1.48
4/1/2003	0.90	0.89	0.75	0.84
5/1/2003	0.88	0.80	0.70	0.77
6/1/2003	0.96	0.91	0.88	0.93
7/1/2003	0.98	0.96	0.95	0.96
8/1/2003	0.99	1.00	1.00	0.99
9/1/2003	1.00	1.00	1.00	1.00
10/1/2003	1.00	1.00	1.00	1.00
11/1/2003	1.08	0.91	0.38	1.68
12/1/2003	1.22	1.59	0.94	3.06
1/1/2004	1.12	1.31	0.72	1.69
2/1/2004	1.02	1.19	1.51	2.00
3/1/2004	1.03	1.06	1.13	1.41
4/1/2004	1.06	0.93	0.83	1.01
5/1/2004	0.98	0.88	0.81	0.96
6/1/2004	0.99	0.96	0.96	0.98
7/1/2004	1.00	0.99	0.99	1.00
8/1/2004	1.00	1.00	1.00	1.00
9/1/2004	1.00	1.00	1.00	1.00

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
10/1/2004	0.87	0.67	0.24	0.62
11/1/2004	1.07	0.81	0.25	1.46
12/1/2004	1.28	1.49	1.03	2.40
1/1/2005	1.17	1.24	0.42	1.85
2/1/2005	1.05	1.13	1.01	2.54
3/1/2005	1.04	1.13	1.10	1.55
4/1/2005	0.99	0.95	0.83	1.01
5/1/2005	1.05	0.82	1.35	0.81
6/1/2005	0.88	0.85	0.68	0.75
7/1/2005	0.96	0.93	0.88	0.91
8/1/2005	0.99	0.99	0.98	0.98
9/1/2005	1.00	1.00	1.00	1.00
10/1/2005	0.83	0.80	0.56	0.82
11/1/2005	1.02	0.84	0.24	1.54
12/1/2005	1.04	1.40	1.03	2.38
1/1/2006	1.05	1.25	0.80	1.35
2/1/2006	1.04	1.22	1.35	1.92
3/1/2006	1.02	1.12	1.00	1.18
4/1/2006	0.94	0.98	0.89	0.91
5/1/2006	0.90	0.85	0.74	0.87
6/1/2006	0.97	0.94	0.90	0.95
7/1/2006	0.99	0.98	0.96	0.98
8/1/2006	1.00	1.00	1.00	1.00
9/1/2006	1.00	1.00	1.00	1.00
10/1/2006	0.96	0.94	0.88	0.95
11/1/2006	1.08	0.89	0.31	1.83
12/1/2006	1.16	1.26	0.98	2.75
1/1/2007	1.31	1.38	0.47	6.11
2/1/2007	1.11	1.38	1.66	3.29
3/1/2007	1.12	1.23	1.15	2.28
4/1/2007	1.04	0.89	0.86	1.06
5/1/2007	0.98	0.78	0.69	0.88
6/1/2007	0.99	0.95	0.93	0.99
7/1/2007	1.01	1.01	1.01	1.00
8/1/2007	1.00	1.00	1.00	1.00
9/1/2007	1.00	1.00	1.00	1.01
10/1/2007	0.84	0.68	0.27	0.64
11/1/2007	0.94	0.81	0.54	1.33
12/1/2007	1.15	1.20	0.93	2.24
1/1/2008	1.04	1.48	0.96	2.02

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
2/1/2008	1.05	1.25	1.18	1.91
3/1/2008	1.04	1.08	1.08	1.58
4/1/2008	1.03	0.96	0.87	1.02
5/1/2008	0.99	0.94	0.89	1.00
6/1/2008	0.99	0.98	0.97	1.00
7/1/2008	1.00	1.00	1.00	1.00
8/1/2008	1.00	1.00	1.00	1.00
9/1/2008	1.00	1.00	1.00	1.00
10/1/2008	0.84	0.80	0.52	0.80
11/1/2008	1.03	0.85	0.56	1.33
12/1/2008	1.19	1.26	0.89	2.36
1/1/2009	1.07	1.23	0.68	3.38
2/1/2009	1.14	1.49	1.99	5.54
3/1/2009	1.17	1.28	1.19	2.22
4/1/2009	1.06	0.97	0.81	1.23
5/1/2009	1.25	0.90	1.06	0.90
6/1/2009	1.02	0.93	0.93	0.95
7/1/2009	1.00	0.98	0.98	0.98
8/1/2009	1.00	1.00	1.00	0.99
9/1/2009	0.99	0.99	1.00	1.02
10/1/2009	0.87	0.68	0.23	1.11
11/1/2009	1.06	0.79	0.33	1.54
12/1/2009	1.19	1.25	0.72	2.61
1/1/2010	1.03	1.45	0.92	2.00
2/1/2010	1.06	1.22	1.09	2.34
3/1/2010	1.05	1.09	1.11	1.54
4/1/2010	0.95	0.92	0.82	0.88
5/1/2010	0.93	0.81	0.61	0.75
6/1/2010	0.98	0.75	0.65	0.68
7/1/2010	0.98	0.93	0.88	0.91
8/1/2010	1.00	0.99	0.98	0.98
9/1/2010	0.99	0.99	0.98	1.05
10/1/2010	0.85	0.60	0.16	0.81
11/1/2010	1.06	0.89	0.29	1.47
12/1/2010	1.24	1.23	0.61	2.86
1/1/2011	1.11	1.16	0.22	1.63
2/1/2011	1.08	1.30	1.26	2.44
3/1/2011	1.06	1.24	1.00	1.29
4/1/2011	1.01	1.01	0.88	1.01
5/1/2011	1.03	0.86	0.72	0.82

Month Start Date	2030 Central Tendency	2070 Central Tendency	2070 Drier, Extreme Warming	2070 Wetter, Moderate Warming
6/1/2011	0.92	1.16	0.54	0.65
7/1/2011	0.98	0.98	0.88	0.91
8/1/2011	1.00	1.01	0.97	0.98
9/1/2011	1.00	1.01	0.99	0.99
10/1/2011	0.81	0.68	0.29	0.67
11/1/2011	1.07	0.79	0.25	1.51
12/1/2011	1.11	1.02	0.75	2.89

Appendix C – Lists of Claims Reviewed for Data Accuracy

As discussed in Section 3.2.2.1, below is a list of all pre-1914 appropriative water right claims or riparian right claims evaluated for having an estimated diversion rate of greater than 10 cfs in any month. Where appropriate, either the capacity of the diversion works, the maximum recent annual volume reckoned as a daily rate, or the maximum amount reported across all annual reports (omitting any clear unit errors) was taken as the demand.

Table C 1– A list of all water right claims quality checked for data accuracy.

Statement ID	Demand Value(s) Overwritten (Y/N)
S019594	Y
S023462	Y
S024188	Y
S013187	Y
S015790	Y
S022490	Y
S014313	N
S008071	N
S021309	N
S018710	Y
S024509	Y
S014063	N
S014064	N
S014065	N
S014088	N
S015751	Y
S022889	N
S024728	Y
S025270	Y
S025792	Y
S008586	Y
S009324	Y
S014479	Y
S015981	Y
S015997	N
S025698	Y
S014084	N
S015462	N
S008380	Y

Statement ID	Demand Value(s) Overwritten (Y/N)
S009299	Y

Appendix D – List of Rights Reviewed for Combined Right Caps

As discussed in Section 3.2.2.2, below is a list of all appropriative water rights reviewed by Permitting staff for a combined right cap. While this list is not exhaustive, it represents approximately 98 percent of all post-1914 appropriative demand in the watershed by volume. Where appropriate, the oldest right was taken to have the full face value and the other related rights had their face values reduced to zero.

Table D 1 – A list of all water rights reviewed for combined right caps.

Application ID	Combined Right Cap (Y/N)
A024996	N
A025334	N
A025600	N
A025740	N
A025823A01	N
A025823A02	N
A025823A03	N
A026022A	Y
A026055A	N
A026079	N
A026143	N
A026201	N
A026250	Y
A028635	N
A028636	N
A028641	N
A028642	N
A028643	N
A028647	N
A028648	N
A028650	N
D031475	N
D031476	N
D031477	N
D031542	N
D031563	N
D031589	N
D031606	N
D032022	N
D032762	N

Application ID	Combined Right Cap (Y/N)
D032859	N
H032009	N
H032331	N
H508419	N
L031378	N
L031414	N
L031415A	N
L031420	N
L031528	N
L031573	N
L031605	N
L032279	N
A016086	N
A016381	N
A017871	N
A024173	N
A025019	N
A025070	N
A025201	Y
A026769	Y
A026938	N
A028116	Y
A028824	N
A029995	N
A031461	N
C005834	N
D031376	N
D031592	N
D033025	N
H510424	N
L031457	N
L031582	N
D033083	N
A017642	N
A024898	N
A025123	N
A026111	Y

Application ID	Combined Right Cap (Y/N)
A027075	N
A029338	Y
A031171	N
A031183	N
A030125	Y
A017091A	N
A017091B	N
A017091C	N
A018274A	N
A018274B	N
A018328	N
A018648	N
A019336	N
A020657	N
A020791	N
A020872	N
A021429A	Y
A021429B	N
A021429C	N
A021809	N
A021950	N
A021966	N
A023282	N
A023337	N
A023399	N
A023408	N
A023451	N
A023488	N
A023489	N
A023536	N
A023558	N
A023605	N
A023615	N
A023707	N
A023748	N
A023792	N
A023802	N

Application ID	Combined Right Cap (Y/N)
A023836	N
A023869	N
A023895	N
A024025	N
A024028	N
A024044	N
A024056	N
A024104	N
A024126	N
A024130	N
A024344	N
A024425	N
A024488	Y
A024502	N
A024725	N
A024805	N
A024959	N
A029616	N
A029682	N
A029755	N
A029912	N
C002935	N
C002936	N
C005521	N
C005522	N
C006052	N
D029650	N
D031630	N
D031660	N
D032249	N
H031997	N
H032924	N
A020582	N
A024909	N
A025694	N
A030364	N
D030286	N

Application ID	Combined Right Cap (Y/N)
A016961	N
A018835	N
A019427	N
A020100	N
A022079	N
A023539	N
A027557	N
A028176	N
A029122	N
A031836	Y
A032115	Y
D031627	N
L032146	N
L032148	N
A021466	N
A030282	N
D031143	N
A013695	N
A016077	N
A016467	N
A018138	N
A020901	N
A021666	N
A026402	N
A026412	N
A029267	N
A029467	N
A030745	N
D030731	N
D030759	N
D031410	N
D032143	N
L031422	N
L031423	N
L031424	N
L031607	N
L031908	N

Application ID	Combined Right Cap (Y/N)
A001983	N
A015678	N
A024645	N
A012232	N
A023326	N
A023794	N
A023839	N
A023840	N
A024053	N
A024139	N
A024807	N
A025052	N
A029479	N
A031383	N
A031447	N
C000222	N
C000223	N
D031098	N
D032041	N
D032187	N
H032345	N
H505809	N
L031669	N
A024741	N
A027992	N
A028886	N
A031255	N
A020846	N
A022615	N
A022652	Y
A023681	N
A024404	Y
A024593A	N
A024854	N
A025749A	N
A025887A	Y
A027892	N

Application ID	Combined Right Cap (Y/N)
A029632	Y
C005161	N
C005162	N
C005163	N
C005164	N
C005165	N
C005343	N
C005624	N
D030863	N
D031947	N
D032057	N
D032141	N
D032238	N
H032131	N
H501328	N
H501536	N
L031353	N
L031764	N
L031885	N
L032006	N
L032027	N
L032128	N
A016655	N
A031870	Y
A031877	N
C005166	N
D032313	N
D032314	N
A020720	N
A021710	N
A022623	N
A023678	N
A023679	N
A023682	N
A031095	N
D031603	N
D032262	N

Application ID	Combined Right Cap (Y/N)
D032346	N
L032147	N
A029086	Y
A029087	Y
A012951	N
A015854	N
A020436	N
A020813	N
A022070	N
A022188	N
A024205	N
A024378	N
A024790A	Y
A025405	N
A025762	N
A026224	N
A027541	N
A029327	N
A029372	N
A028651	N
A028653	N
A028676	N
A028787	N
A028925	N
A026927	N
A027036	Y
A027301	N
A027460	N
A027791	N
A028127	N
A028632	N
A028633	N
A028926	N
A028927	N
A029202	Y
A029401	Y
A029595	N

Application ID	Combined Right Cap (Y/N)
A030349	Y
A030363	N
A031060	Y
A031259	N
A031435	N
D029448	N
D029572	N
D030346	N
D030969	N
D031411	N
D031472	N
D030898	N
D031318	N
D031427	N
L031319	N
L031391	N
L031392	N
L031393	N
A013716	N
A013967	N
A014466	N
A014735	Y
A014749	N
A014841	N
A014842	N
A014872	N
A015314	N
A015521	N
A018948	N
A019921	N
A020333	N
A020870	N
A020907	N
A020953	N
A021187	N
A021235	N
A021419	N

Application ID	Combined Right Cap (Y/N)
A021506	N
A021925	N
A022145	N
A022432	N
A023086	N
A023290	N
A024017	N
A024391	N
A024604	N
A024682	N
A025282	N
A026600	N
A026672	N
A027440	N
A027943	N
A028790	N
A029108	N
A030132	N
A030815	N
A030931	N
A031050	Y
D030727	N
D030732	N
D030755	N
D030760	N
D030820	N
D030881	N
D030890	N
D030891	N
D030904	N
D031390	N
D031731	N
D032081	N
H033072	N
L032032	N
A023255	N
A023297	N

Application ID	Combined Right Cap (Y/N)
A024101	N
A027327	N
A028855	Y
A029547	N
D031801	N
D032013	N
D032206	N
A015779	N
A019649	N
A020129	N
A022496	N
A025964	N
A029628	N
A031363	N
L031802	N
A016218	N
A017689	N
A018235	N
A022090	N
A022141	N
A022237	N
A023173	N
A025998	N
A027953	Y
A029199	N
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D030095	N
D031681	N
D031803	N
A020573	N
A021886	N
A015624	N
A015947	N
A017098	N
A017237	N
A017263	N
A017479	N

Application ID	Combined Right Cap (Y/N)
A017833	N
A018127	N
A019089	N
A019241	N
A019720	N
A020015	N
A020114	N
A020493	N
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A020733	N
A020951	N
A021052	N
A021191	N
A021210	N
A022151	Y
A023094	N
A024223	Y
A024544	N
A024782	Y
A026440	Y
A026442	N
A026561	N
A027031	N
A027702	N
A028402	N
A029538	N
A029986	N
A030173	N
A030933	N
C003981	N
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D030758	N
D031267	N
D031569	N
L032735	N
A020583	N
A022273	N

Application ID	Combined Right Cap (Y/N)
A023540	N
A023766	N
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A015237	N
A020264	N
A020557	N
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A020788	N
A020979	N
A025367	N
A025623	N
A027757	Y
A029671	N
C003979	N
A022608	N
A025021	N
A025301	N
A025393B	Y
A025939	N
A027149	Y
A029397	N
A018522	N
A020798	N
A021658	N
A021919	N
A024761	N
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A025325	N
A029502	N
A029610	N
A030882	N
D031555	Y
D031651	N
D032275	N
D032464	N
D032713	N
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Application ID	Combined Right Cap (Y/N)
A021015	N
A028365	N
A016545	N
A020261	N
A020584	N
A015894	N
A018736	N
A019515	N
A020384	N
A021977	N
A024827	N
A025137	N
A025831	N
A026228	Y
A027081	N
A028828	Y
A032372	N
C000511	N
C000512	N
D030256	N
D030460	N
D032229	N
D032768	N
A017795	N
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A030797	N
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A031362	N
H032335	N
A013958	N
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A014364	N
A015194	N
A015515	N
A015603	N
A016106	N
A017477	N

Application ID	Combined Right Cap (Y/N)
A017999	N
A019444	N
A019557	N
A019798	N
A019891	N
A020071	N
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A020401	N
A020509	N
A020634	N
A021355	N
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A022498	N
A022745	N
A023998	N
A024569	N
A024706	N
A025065	N
A026503	N
A026993	N
A029070	N
A029277	N
A029772	N
A029848	N
A029849	N
A029850	N
C001216	N
D032138	N
D032850	N
A014870	N
A015720	N
A018192	N
A018849	N
A020435	N
A021081	N
A022342	N
A022919	N

Application ID	Combined Right Cap (Y/N)
A023915	N
A024301	N
A024644	N
A024783	N
A025773	N
A025869	N
A025940	N
A027046	N
A027158	N
A028386	N
A029044	N
A029858	N
A031501	N
A031719	N
D031602	N
D031671	N
D032149	N
D032166	N
D032188	N
A029802	N
D032062	N
A020147	N
A022583	N
A014966	N
A019806	N
A027022	N
A012100	N
A013221	N
A013975	N
A014092	N
A014767	N
A014797	N
A013539	N
A016190	N
A016478	N
A016527	N
A016904	N

Application ID	Combined Right Cap (Y/N)
A018277	N
A018958	N
A018963	N
A019422	N
A020127	N
A021817	N
A022431	N
A023027	N
A023058	N
A023144	N
A023328	N
A024004	N
A024247	N
A026740	N
A026975	Y
A027424	N
A028370	N
A029515	N
A030124	Y
A031620	N
A031737	N
C000028	N
L032966	N
A017919	Y
A019013	N
A019652	N
A024817	N
A027143	N
C001166	N
D031331	N
A019351	N
A025691	N
A026624	Y
A028668	N
A026470	Y
A027177	N
A024955	N

Application ID	Combined Right Cap (Y/N)
A028319	N
A028320	Y
A025394	Y
A024929	Y
A024270B	Y
A029419	N
A025596	N
A027941	N
A029789	N
A025888A	N
A029418	N
A026298B	N
A029901	N
A029437	N
A027479	Y
A025344	N
A025888B	N
A029203	N
A027584	Y
A028854	Y
A030036	N