DRAFT

DATA AND METHODS USED TO DETERMINE WATER AVAILABILITY IN THE LOWER RUSSIAN RIVER WATERSHED

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The Drought Water Rights Allocation Tool (DWRAT) described in section 877.2 of the Regulation for the Curtailment of Diversions to Protect Water Supplies and Threatened and Endangered Fish in the Russian River Watershed (California Code of Regulations, title 23, sections 877 through 879.2) (Regulation) was applied to allocate available supply based on the water right priority of each demand within the Lower Russian River (LRR). DWRAT works by solving equations that maximize the allocation of water to diverters based upon their demand and priority of right, subject to streamflow mass balance equations and certain legal constraints applicable to each water right. The stream network is mathematically represented by a series of sub-basins and a connectivity matrix that characterizes the connection between each sub-basin, and the tool routes water through this network. Allocations are made at the sub-basin level, ensuring that they are made where flow is physically available. In the first module of DWRAT, allocations are made for riparian demands in the sub-basin demands, based upon the principle of equal seniority, and sharing of any shortfall. If all riparian demand is satisfied, any remaining basin flow is then allocated to appropriative users according to their demand and priority of right, via a second independent module. Water users may receive curtailments based on unavailability of flow, or due to a more senior downstream right.

Available water supplies in the Lower Russian River (LRR) were compared to the water rights demand to determine whether there is adequate supply to meet all demand. In the LRR, available supply is based on the quantity of water derived from precipitation falling within the LRR watershed that remains instream after losses, such as evapotranspiration from natural vegetation and percolation to groundwater. All water rights with points of diversion within the boundary of the LRR rely on this supply and reduce the amount of water that would otherwise drain from the outlet of the LRR watershed. Once water demand exceeds available supply, there is insufficient water to satisfy all water rights and shortages will occur. When there is insufficient water to supply all riparian right holders, they must share the shortage. Appropriative water rights are curtailed completely in reverse order of priority (i.e., junior appropriators curtailed first).

DWRAT was applied by dividing the LRR into 14 sub-basins and calculating the water supply available for diversion in each of those sub-basins. Sub-basin delineations were based on a combination of existing hydrologic model basin delineations and the Hydrologic Unit Code 12 Digit (HUC 12) Watershed Boundary Dataset from the United

States Geological Survey (USGS). Each sub-basin drains to another sub-basin until ultimately draining to the Pacific Ocean. The locations of sub-basins are shown in Figure 1. This connectivity of sub-basins results in a network of demand from water rights and supply flows across the entire LRR, which allows a finer spatial resolution of assessing the quantity of water supply that might be available for diversion in any given sub-basin relative to both other water right priorities in the sub-basin or downstream sub-basins. The resolution of assessing available supply against demand was further refined by classifying water rights within each sub-basin as either mainstem or tributary. This results in only water rights on the mainstem of each sub-basin being allocated flows entering from an upstream sub-basin, which ensures DWRAT is allocating available supply to only diversions along the flow path of that supply.

Two separate existing hydrologic models, the Russian River Precipitation Runoff Modeling System (PRMS) and the Santa Rosa Plain Hydrologic Model (SRPHM), were used to forecast unimpaired surface water runoff at sub-basin outlets, which is used to estimate local sub-basin supply contributions to the flow network. The existing modeled outputs from the Russian River PRMS model were used to inform the delineation of nine of the sub-basins located within the area covered by the PRMS model. For the remaining five sub-basins covered by the SRPHM, sub-basin boundaries were delineated to match the drainage outlets of the HUC 12 watershed boundaries.

Watershed hydrologic modeling accounts for hydrologic process such as solar radiation, evapotranspiration, soil infiltration, runoff, groundwater, and streamflow to produce a timeseries of surface water flows. The Precipitation Runoff Modeling System (PRMS) identified above is a spatially distributed physical-based model developed by USGS that simulates a watershed's hydrological processes, including surface and groundwater flow, evapotranspiration, soil moisture dynamics, and streamflow. Sub-basins within PRMS are developed with defined outlet points, which provides for analysis of water availability at various locations of interest.

USGS developed a specific application of the PRMS model for the Russian River, referred to as the Russian River PRMS model. State Water Board staff updated the model calibration to better simulate the spring recession and summer streamflow timing and rate. State Water Board staff calibrated parameters that impact hydraulic conductivity as well as groundwater and subsurface flow to better simulate natural runoff and streamflow for the months of April to October, while still holding the calibration quality for the other months. The calibrated parameters include 'ssr2gw_rate,' 'ssr2gw_exp,' 'gwflow_coef,' 'slowcoef_lin,' and 'slowcoef_sq.'

The Russian River PRMS model simulated conditions from 1/1/1990 to 12/31/2015. To extend the model to 2021, staff extended the climate observation data for the Russian River PRMS model from 1/1/2016 to 06/30/2021 using updated records from the same observation stations originally used in the model. Any data gaps in the observed stations were filled using Oregon State University's Parameter-elevation Regressions on Independent Slopes (PRISM) datasets at the respective climate station locations. Finally, the model was run from 1/1/1990 to 6/30/2021. This method will be used to continue incorporating updated climate observation data through 2021.

USGS, in cooperation with Sonoma County Water Agency (SCWA) and others, developed a hydrologic model known as the Santa Rosa Plain Hydrologic Model (SRPHM).[1] The SRPHM simulates the interaction of the groundwater system and the surface system when estimating available surface flows. The surface water component of SRPHM is modeled using PRMS while the groundwater component is modeled by the USGS Modular Groundwater Flow Model (MODFLOW_NWT). The SRPHM has been completed and the final report is available at the following location: https://pubs.usgs.gov/sir/2014/5052/pdf/sir2014-5052.pdf.

State Water Board staff extended the climate inputs of the SRPHM to 6/30/2021 by updating the model meteorological precipitation and temperature stations using spatial interpolation with Oregon State University's PRISM 4k daily climate values. The existing Santa Rosa Plain Hydrologic model has agricultural pumping demand available from October 1, 1974 to December 31, 2018. While extending the SRPHM climate inputs and resulting simulation of hydrology is feasible, updating simulated agricultural pumping to present day is a time-intensive process that is not feasible to complete this summer. The model's simulation of the effects of groundwater pumping demand on streamflow was extended from 2018 to 2021 by calculating the modeled percent reduction in streamflow at the HUC 12 sub-basin scale with simulated agricultural pumping demand on versus off. Since 2020 and 2021 were drought years, the dry years of 2001, 2008, 2009, 2014 and 2015 were used to determine the average percent reduction in streamflow due to agricultural pumping demand in 2020 and 2021. The SRPHM was then executed with agricultural pumping off from 2019 to 2021 and the percent reductions in streamflow were applied to the stream flows calculated at each sub-basin outlet point for each month of 2020 and 2021. 2019 was not a dry year, so the average of the last 10 years was used to determine monthly percent reductions in streamflow due to agricultural groundwater pumping demand for each month of 2019.

The precipitation input used to forecast flows for both the Russian River PRMS model and the SRPHM will be set to zero inches/mm from mid-May to September 2021, given the lack of appreciable precipitation since May and that precipitation is unlikely to occur in August or September based on historical observed precipitation. The year 2014 shows similar temperature variability to 2021 from January to April, so the 2014 temperature minimum and maximum daily values were used from mid-May to September 2021. Outputs from the SRPHM and the Russian River PRMS model were tabulated as acre-feet per month of surface water available for diversion in each of the 14 sub-basins in the Lower Russian River.

Water right demand estimates are based on information from annual reports of water diversion and use (annual water reports) submitted to the State Water Board for the years of 2017 through 2019. Staff applied the Standardized Demand QA/QC Methodology (QA/QC Methodology), as noticed and discussed at an April 16, 2021

[1] The Santa Rosa Plain is a subarea of the LRR, located on the southeast side of the Russian River watershed.

Board workshop. Staff identified the water rights to include in the analysis using the "watershed" field in the eWRIMS database. The dataset was further refined by geospatially identifying each point of diversion (POD) associated with a water right to ensure it was within one of the HUC 12 watershed boundaries of the Russian River Watershed. The priority date for each water right was manually reviewed and assigned based on Division of Water Rights hard copy file for each water right and information available in the eWRIMS database. The monthly reported direct diversion and diversion to storage values were averaged over the 2017, 2018, and 2019 calendar years to estimate monthly demands in acre-feet per month.

A subset of data flags from the QA/QC Methodology representing the most important sources of error were selected for the Russian River watershed dataset to expedite the data review process. These related to excessive reported diversions, duplicate reporting, unit conversion errors, missing water use reports, confirming priority dates, and identifying primary beneficial use. Staff manually reviewed the flagged records and associated water rights records to identify probable data errors and apply corrections. The most common correction made was to annual water reports that reported the same amount of direct diversions and diversions to storage, including for water rights that do not have a storage component. This error had the effect of doubling monthly demands; the correction removed the diversion to storage value in most cases. The next most common correction was in converting overreported usage due to incorrect units of measurement, where the annual water reports listed diversion amounts meant to be in gallons per month that were inadvertently recorded as acre-feet per month, greatly inflating monthly demand. Often the two corrections above were applied in conjunction. The quality control for these corrections was applied by reviewing the corrected and uncorrected data against other annual water reports for the affected water right and against the affected water rights' permit, license, or initial reported use.

In summary, DWRAT was used to allocate available supply amongst water right holders based on their respective water right priority and water demands. Available supply was estimated using a combination of two hydrologic models, the Russian River PRMS model that covered the majority of the LRR, and the SRPHM for a portion of the LRR where the Russian River PRMS model had not been developed. Demand was based on annual water reports submitted by water right holders for the years of 2017, 2018, 2019; average demands were calculated for each month. Water right priority was based on the Board's hard copy water right files and the eWRIMS database. DWRAT allocated available supply to water rights demands across 14 sub-basins across the LRR and provided a result that identifies which priority of water right can be satisfied within each sub-basin.