Water Unavailability Methodology for the Delta Watershed

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1 Introduction

The Sacramento-San Joaquin Delta (Delta) watershed is currently experiencing extremely dry conditions following dry conditions in 2020. Currently, the 2021 and 2020 period is projected to be one of the driest two-year periods on record for runoff. These low runoff conditions have resulted in very low inflows to reservoirs and associated limited storage supplies for various purposes this summer and into the fall. To help address these conditions, the State Water Resources Control Board (State Water Board or Board) developed a methodology to assess water unavailability in the Delta watershed. This report describes that methodology identifying when available data indicates that natural and abandoned water supplies are unavailable for diversion by water right holders and claimants in the Delta watershed under their priority of right (Delta Water Unavailability Methodology or Water Unavailability Methodology for short).

Based on the output of a prior version of the Water Unavailability Methodology, on June 15, 2021, the State Water Board issued notices to all post-1914 appropriative water right holders in the Delta watershed indicating that water supplies are not available for their use based on the best available information (notices of water unavailability). Based on the current version of the Water Unavailability Methodology, additional notices were issued to more senior water right claimants on July 23, 2021.[1] In addition, on July 23, 2021, the State Water Board released draft emergency curtailment regulations for the Delta watershed. If adopted, the regulations would authorize curtailments based upon the Water Unavailability Methodology or other comparable tools, including any appropriate updates to the methodology that may be made in the future through the Board's processes. Additional information related to Delta curtailment regulations can be found on the Board's Delta drought webpage.

The Delta watershed includes supplies from both the Sacramento and San Joaquin river systems. As shown in Figure 1 below, these river systems, including their tributaries, drain water from about 40 percent of California's land area, supporting a variety of beneficial uses of water. The San Francisco Bay-Delta (Bay-Delta) is one of the most important ecosystems in California, as well as the hub of California's water supply system. As the largest tidal estuary on the western coast of the Americas, it provides essential habitat to a vast array of aquatic, terrestrial, and avian wildlife in the Delta,

[1] On July 23, 2021, notices were issued to all post-1883 appropriative water right claimants within the Sacramento River watershed and all pre-1914 appropriative water right claimants within the San Joaquin River watershed. In addition, notices were issued to pre-1883 appropriative water right claimants in specific Sacramento River tributary subwatersheds due to limited local supplies. Riparian claimants in the San Joaquin River watershed and the Bear River, Upper American River, and Putah Creek subwatersheds within the Sacramento River watershed were notified that water supplies were insufficient to meet the demands of all riparian claimants.

Figure 1. Delta Watershed Location

San Francisco Bay, and near-shore ocean, as well as a diverse assemblage of species upstream of the Delta. Water from the Delta provides a portion of the supplies to more than two-thirds of Californians, supports industry, and is used to irrigate millions of acres of farmland.

Given the importance of the water supplies in the Delta watershed for multiple purposes and the extreme limitations in water supplies this year, action is needed to determine when water supplies are not available under water right holders' or claimants' priorities of right. The Department of Water Resources' (DWR) State Water Project (SWP) and the U.S. Bureau of Reclamation's (Reclamation) Central Valley Project (CVP) (collectively Projects) are responsible for providing salinity control and meeting environmental flows in the Delta, as well as specific requirements for flows and temperature management on Project tributaries. Currently, many Project reservoir storage levels are at or near historical lows, creating significant concerns for salinity control, municipal water supplies (particularly from Folsom Reservoir), and temperature management and other environmental needs this year and going into next year. As a result of these concerns, the Projects have submitted, and were granted subject to terms and conditions, a temporary urgency change petition to reduce their obligations to release water from storage to meet flow and water quality requirements in the Delta.[2]

Concerns for reservoir storage levels are compounded when diversions occur by users when supplies do not exist at their priority of right, resulting in the need for additional releases of stored water from Project reservoirs in order to repel salinity intrusion from the ocean and meet other minimal needs.

Determining when water supplies are unavailable to users will be important to ensure that supplies are available to meet current water quality and flow requirements and the demands of senior water right holders. However, it may be unclear to water users when supplies are unavailable for their use because supplies are needed by downstream senior water right holders or because streamflows are comprised of releases of previously stored water that is released to serve contractors or to meet water quality or flow requirements.

The State Water Board has developed the Water Unavailability Methodology for identifying when available data indicates that natural and abandoned water supplies are unavailable for direct diversion or diversion to storage for consumptive use by water right holders and claimants in the Delta watershed under their priorities of right. The methodology is not intended to address other supplies of water like rediversion of previously stored water for use by Project contractors. The methodology also does not address water unavailability for non-consumptive uses of water like direct diversion for hydropower production when these supplies are returned back to the source stream.

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[2] The Board order conditionally approving the petition is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/2021/20210601_swb_tuco.pdf

However, since wet season diversions to storage for later production of hydropower may change the timing of flows and affect the availability of water for other users, the methodology will consider water unavailability for such diversions if applied during the wet season.

The methodology evaluates water supplies and demands on a monthly scale at the subwatershed and watershed scale for both the Sacramento River and San Joaquin River watersheds with currently available data, reporting, and tools. Results from the methodology are available through September 2021. The methodology is also planned to be used beyond September 2021, utilizing updated data on supplies and demands, including additional demand data that may be required by possible emergency regulations. The Water Unavailability Methodology improves upon methods used for determining water unavailability in prior droughts, most recently in 2014 and 2015. Major improvements are described below and are focused on ensuring that demands are not overinflated in ways that would overestimate water unavailability, causing more water users to receive notices of water unavailability or resulting in those notices applying for a longer time period. Other improvements include better supply estimates. With more time, better data, and improved tools, additional improvements will be possible.

This report and associated technical appendices describe the current approach and major assumptions for the Water Unavailability Methodology. Technical Appendix A describes the Water Unavailability Methodology spreadsheet, including the input data sources, computational steps, and outputs used to develop the water unavailability visualizations. Technical Appendix B describes the process used to collect and quality control the demand datasets. Appendix C summarizes the substantive technical, factual, or legal comments that have been received to date on the Water Unavailability Methodology, as well as any relevant sections of the report where those comments have been addressed. The technical appendices and spreadsheet are available on the State Water Board's Delta Water Unavailability Methodology webpage.

This report will continue to be updated, as appropriate, as the methodology is updated. All revisions will be made available on the Board's Delta Water Unavailability Methodology webpage.

The draft Water Unavailability Methodology was released for public comment on May 12, 2021. The Water Unavailability Methodology was updated based on comments received, and further review and an update of the methodology was released on June 15, 2021, along with notice of water unavailability to all post-1914 water right holders in the Delta watershed. At that time, the State Water Board indicated that additional modifications were planned to address water unavailability for more senior water right claimants, including pre-1914 appropriative and riparian claimants. This version of the methodology includes those updates, as well as additional updates to address comments received on the methodology and other updates based on further review.

Those changes include the following:

- Inclusion of methods to evaluate water unavailability for pre-1914 and riparian claimants, including disaggregation of these demands by water right priority. In this disaggregation, riparian rights are generally assumed to be senior to pre-1914 appropriative rights. While this may not be the case in every instance, on the scale of these analyses, exceptions are not generally expected to have a meaningful effect. To the extent that a pre-1914 appropriative claimant believes they have a senior right to riparian water rights, the Board will consider that information and make appropriate adjustments to any curtailment orders issued pursuant to the proposed emergency regulation.

- Changes to assumptions regarding available supplies for riparian diversions in the Legal Delta to exclude water from outside of the watershed where the diversion occurs. Specifically, riparian water right claimants in the Sacramento River portion of the Delta are only assumed to have supplies available from the Sacramento River and likewise riparian water right claimants located in the San Joaquin River portion of the Legal Delta are only assumed to have supplies available from the San Joaquin River. The proration methodology described in the June 15, 2021 version of the methodology continues to be used for any appropriative demands in the Legal Delta since those rights do not include the same source limitations and may draw water from an adjacent watershed.

- Changes to reflect that headwater subwatersheds are only "disconnected" from the larger Delta watershed if all post-1914 appropriative and all pre-1914 appropriative demands cannot be met. The June 15 version of the methodology only evaluated water unavailability for post-1914 water rights and, therefore, assumed disconnection when all post-1914 appropriative demands could not be met because the methodology was not evaluating relative water unavailability for more senior claims. In order to evaluate water unavailability for more senior claims, the relative priority of pre-1914 appropriators must be considered at the subwatershed as well as the watershed-wide scales. Because riparian water right holders are generally senior in priority to pre-1914 appropriators, those demands are assumed to be met prior to any pre-1914 appropriative demands. Where there are shortages in supplies for riparian claimants, shortages would be shared correlatively amongst them. Such shortages cannot currently be fully reflected in the methodology given the complexity of reflecting correlative shortages.

- The addition of an online visualization comparing monthly supply forecasts to daily cumulative supplies. This tool will be used to help ensure that curtailment decisions are tracking the correct hydrologic exceedance level. To address short term precipitation events, additional information regarding actual and forecasted precipitation and runoff will be considered to ensure that curtailments are

suspended in a timely manner when additional supplies become available, particularly for the purposes of refilling depleted reservoirs.

- Refinements to Bear River supply estimates to better reflect actual supplies in this sub-watershed.
- Other minor refinements.

The State Water Board has received and reviewed numerous public comments on the methodology, including comments received during a May 21, 2021 staff-led workshop and in writing by the May 25, 2021 comment deadline. Many commenters supported the methodology and acknowledged the substantial improvements compared to that used during the prior drought. Other commenters requested use of data and tools that do not currently exist and will not be possible to use for many years at the earliest. Given the dire water supply concerns that exist this year, assumptions were made using the best available data as discussed further in the report.

With over 17,000 water rights or claims on record in the watershed with even more points of diversion, numerous real-time and dynamic supply and demand issues that are not all well understood, and numerous other complexities, reasonable simplifying assumptions are necessary based on current best available information. These assumptions, as well as the implementation of the methodology itself, are intended to be conservative for the purpose of avoiding unwarranted curtailments.

Some commenters suggested the methodology should use real-time, verified, demand and return flow data. Currently demand data is self-reported annually by diverters on a monthly timestep, only received in arears, and not subject to systematic verification upon receipt. In addition, compliance with Senate Bill 88, which would improve reporting accuracy and frequency, is low, even among large diverters. The Board has made efforts to improve the demand data currently available for use in the methodology via a quality control process, described in sections 2.2.2 and 2.2.3. This quality-controlled dataset represents the most accurate demand dataset for the watershed available to the Board at this time. The proposed emergency regulation seeks to further improve the demand dataset by requesting monthly projected water demand from the watershed's largest users. Developing processes and tools that can accommodate daily or sub-daily demand data would take significant additional time and significant improvements in data and tools, which would not be available in time to respond to the present emergency. Reported diversion and use information for 2020 was not initially used for the methodology because it had not been received or quality controlled in time; however, it may be incorporated in the future. Further, there is currently no wide-scale system in place for measuring return flows or system losses from seepage, riparian vegetation, evaporation, and other sources, but reasonable assumptions are made in the methodology to account for these factors.

Similar to the comments received suggesting the use of more real-time demand data, some commenters suggested use of daily or sub daily, real-time, verified supply and

abandoned flow data. As with demand, developing real-time verified supply data is not possible in time to address this emergency, but will be explored further in the future.

Commenters also suggested that increased spatial resolution and dynamic supply/demand analyses are needed to reflect the specific issues of water availability at each point of diversion. This level of complexity would require significant, sustained, and widespread improvements in real-time measurement, reporting, quality control, and tools to develop. Improvement to the spatial and temporal resolution of water unavailability analyses will be further investigated in the future. For the current methodology, where sub-monthly time steps for consideration of precipitation and runoff are warranted, that information will also be considered in curtailment and water unavailability determinations to ensure that curtailments are suspended when supplies become available.

Some commenters suggested that adjudicative-like proceedings are needed prior to addressing issues of water unavailability. Given the number of right holders and the complexity of the related issues, such a process would likely take decades and require significant resources and would not permit the Board to adequately address the water supply shortages that exist this year. In the Stanislaus River, an adjudication was completed and a decree issued in 1929. One commenter suggested that, as a result, water from this subwatershed should not be included as available downstream supply. The Stanislaus River adjudication only determined the validity and parameters of appropriative rights within the Stanislaus River. The adjudication did not determine riparian rights or rights in the larger Sacramento or San Joaquin River watersheds. The commenter has not cited any legal authority for the proposition that the Stanislaus River adjudication had preclusive effect on water right holders outside the Stanislaus River watershed who may be entitled to natural flows originating in the Stanislaus River watershed. (See Wat. Code, §§ 2500, 2774 [preclusive effect of statutory stream adjudication only extends to rights acquired upon “the stream system embraced in the proceedings”].)

A commenter suggested that the methodology should consider prescriptive rights. The State Water Board does not have adequate information regarding the nature and validity of any prescriptive rights to factor those into the analysis. In addition, in the context of the drought emergency, the State Water Board does not have the time or resources to investigate and determine whether any of the thousands of water rights in the Delta watershed have been invalidated or rendered subordinate to junior water rights through prescription. (See *City of Pasadena v. City of Alhambra* (1949) 33 Cal.2d 908, 926-927 [setting forth common law elements of prescription].) To the extent that prescriptive rights may exist and are not accounted for, the emergency regulations would allow for that information to be considered, as well as other claims that changes to water right information should be made in the methodology.

Commenters asserted that stored water released from New Melones Reservoir should be treated as abandoned flow below Vernalis on the San Joaquin River. The

methodology does not treat stored water releases from New Melones as abandoned because the releases are being made to meet Delta outflow and other water quality requirements below Vernalis this year.

A number of commenters raised topics regarding issues in the Legal Delta. Commenters suggested that return flows from Legal Delta diversions should not be made available to diverters upstream. The methodology only makes return flows available within four downstream subwatersheds. As discussed above, data and tools for more granular analyses are not currently available at this time. Commenters suggested that provisions for in-Delta storage or fresh water supplies should be made. However, no specific sources for assumptions that should be made during the current hydrologic conditions were provided. As described further in section 2.3.3, given the extreme dry conditions that exist and have existed for a prolonged period, there is no basis to assume that any remaining storage of fresh water flows would exist in the Delta longer than the methodology's one-month time step.

To the extent that users can develop voluntary solutions, those voluntary solutions may address some of the long-standing legal and technical issues, at least in the short term for purposes of addressing current water unavailability. The Board intends to update the methodology as needed in order to administer the water rights priority system using the best available information. Due to the uncertainties that exist in determining water unavailability in the Delta watershed, conservative assumptions were used within the methodology itself and will also be used in the methodology's implementation.

1.1 Background

The mission of the State Water Board is: "To preserve, enhance, and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use, for the benefit of present and future generations." The Board's critical goals of providing safe drinking water to all Californians and maintaining the quality of our waterways, in keeping with both state and federal requirements, rely on the Board's successful administration of the water rights system. California's water rights system is one of the most complex in the nation, incorporating both riparian[3] and appropriative

[3] Generally, 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 are unquantified, allowing the diverter to take water from the natural flow of the water course for any immediate reasonable and beneficial use on the subject land. In times of shortage, all riparian rights share the shortage on a correlative basis; that is, each riparian is required to reduce its use proportionally so that the reduced supply is divided among all riparian rights.

water rights, including appropriative rights issued under the Board's authority and those in existence prior to the inception of its predecessor-in-interest.[4]

The water right priority system, based on the "priority date" of each water right, forms the basis for determining which users may divert, and how much, when there is insufficient water in the stream for all users. Older, more senior appropriative water rights have priority over more junior appropriative water rights. Senior water right holders are more likely to receive water at times of shortage than more junior water right holders. However, once water is stored or imported, the entity that stored or imported the water has the only right to it, though others may acquire contingent junior rights to any return flows.

When the amount of water available in a surface water source is not sufficient to support the needs of existing water right holders and in-stream uses, junior appropriators must cease diversion 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.

1.2 Current Conditions

After two years of low precipitation, the U.S. Drought Monitor now reports that the entirety of California is experiencing moderate to exceptional drought, of which 86 percent is experiencing extreme to exceptional drought (USDM 2021). The U.S. Seasonal Drought Outlook, released by the Climate Prediction Center on July 15, 2021 and valid through October 31, 2021, shows drought persisting throughout California (NOAA 2021). Within the Delta watershed, conditions have been extraordinarily dry, with Water Year (WY) 2020 ranking as the ninth driest on record and WY 2021 ranking as the fourth driest on record (DWR & Reclamation 2021). These dry conditions have resulted in reservoir storage levels that are significantly below average (DWR 2021a; DWR 2021c). As of July 21, 2021, storage volumes in major reservoirs, including Lake Shasta, Lake Oroville, and Folsom Lake are lower than 35 percent of capacity and below 50 percent of average storage conditions (*Ibid*).

As a result of the current dry conditions, on May 10, 2021, Governor Newson issued a drought emergency proclamation covering 41 of California's 58 counties. On July 8, 2021, the Governor expanded the emergency declaration to 9 additional counties and called on Californians to reduce their water use by 15 percent. The May 10

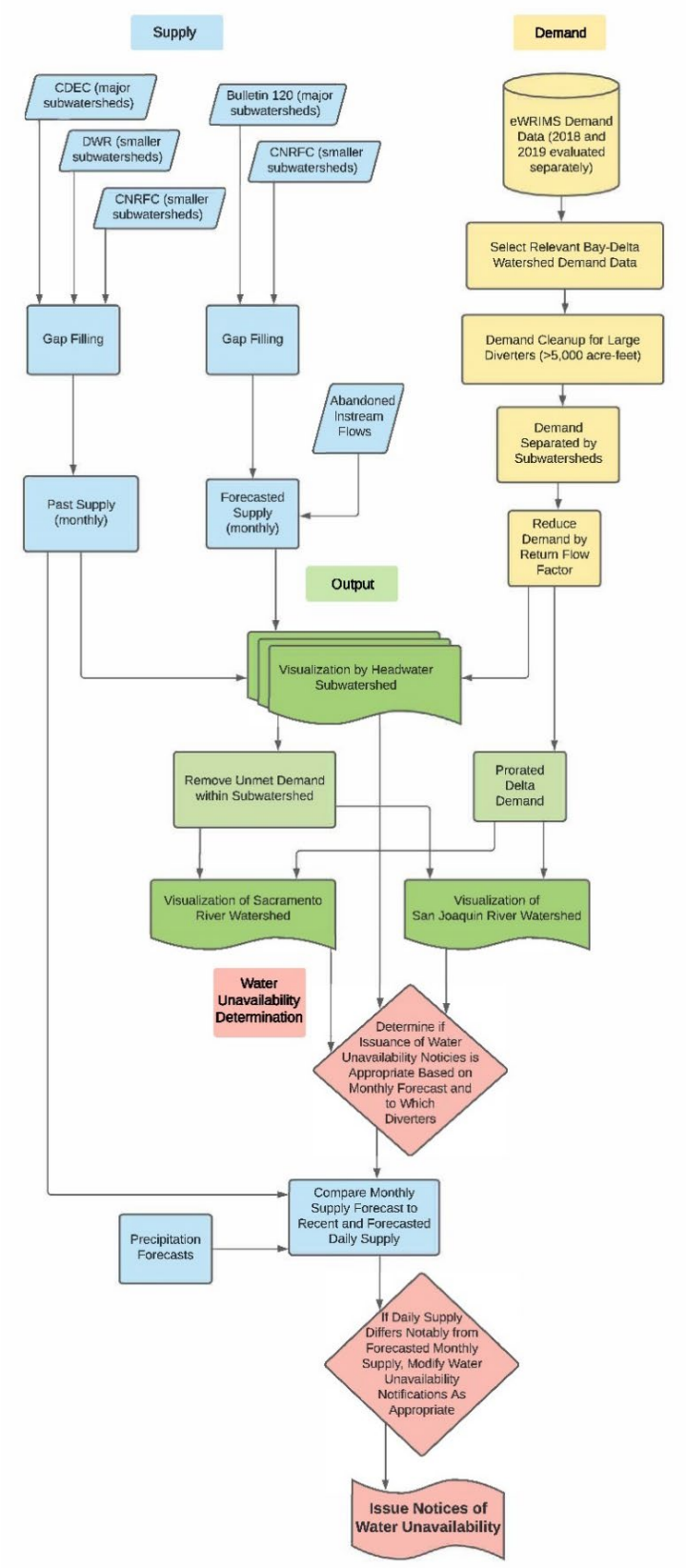
[4] Use of water on non-riparian land or seasonal storage of water for later beneficial use requires an appropriative water right. An appropriative water right that was initiated before the Water Commission Act went into effect on December 19, 1914, and subsequently perfected is called a pre-1914 appropriative water right. Appropriative rights initiated and acquired after this date are called post-1914 appropriative water rights, and they are administered and regulated by the State Water Board.

proclamation orders the State Water Board and other agencies to consider a number of actions to protect water needed for health, safety, and the environment in the Delta watershed. The proclamation specifically indicates that the State Water Board shall consider emergency regulations to curtail water diversions when water is not available at water right holders' priority of right or to protect previously stored releases of water (Exec 2021). Upon finalization, this methodology may serve as the technical basis for future emergency curtailment regulations pursuant to the directives in the emergency drought proclamation.

2 Water Unavailability Methodology

The Water Unavailability Methodology incorporates the best available supply data for the Delta watershed with the best available estimates of demand for the same area. The methodology compares this data for multiple areas within the Delta watershed: the Sacramento River watershed, San Joaquin River watershed, and headwater subwatersheds (see definition in section 2.3.1 below), to determine if supply may be insufficient to meet certain priorities of right. These comparisons are presented visually using interactive graphs and in spreadsheet format. The following sections describe the sources of the supply and demand data, adjustments made to the data as needed, and the resultant outputs of the comparisons. Figure 2 below shows an overview of the Water Unavailability Methodology that is covered in greater detail in the following sections.

Figure 2. Water Unavailability Methodology Flowchart



2.1 Supply

The purpose of this analysis is to account for the availability of natural and abandoned flows within the Delta watershed for diversion by water right holders under their priority of right. This analysis is not intended to account for the availability of imported supplies from other watersheds that do not contribute to available supplies for general use in the Delta watershed. Specifically, imported supplies from the Trinity River system are imported for use by Reclamation and their contractors and are not available to other users under their own water rights. The analysis is also not intended to account for releases of previously stored water for downstream delivery, use, or rediversion since those supplies are also not available to other users under their own water rights. In the case where previously stored water is released to meet instream flow requirements that apply in an upstream subwatershed, but not downstream watersheds, and the water is not released for delivery to a downstream user, these flows are considered to be abandoned and part of available supplies.

The methodology incorporates the use of past and projected future full natural flow (FNF) (or unimpaired flow) estimates (see section 2.1.4 below). FNF represents the natural water production of a river basin unaltered by upstream water diversion, storage, or import from or export to other watersheds (DWR 2015). FNF is a theoretical water supply estimate rather than a reconstruction of pre-development streamflows (DWR 2016). Though FNF values are not directly measured, the locations where they are estimated are referred to herein as “gages.”

Past FNF estimates are calculated from measured streamflows, adjusted for upstream operations by subtracting imported water and adding upstream diversions, changes in storage, and evaporative losses. The past FNF values serve two purposes in the methodology: (1) to provide historical context to current water supply conditions and (2) to show water supply conditions for the current year, from January 2021 to the present. Water years in the Sacramento and San Joaquin River watersheds are categorized as Wet, Above Normal, Below Normal, Dry, and Critically Dry based on equations defined in State Water Board Decision 1641 that account for the unimpaired runoff of each water year and its preceding water year (DWR 2021b). For both the Sacramento and San Joaquin River watersheds, 2021 is considered Critically Dry (see next section).

Forecasted FNF values are calculated from snowpack measurements, estimates of water content, expected weather, rates of evaporation, ground absorption, and other factors. Because future water supply cannot be predicted with absolute certainty, a forecast provides a range of expected water supply volumes. These potential volumes are assigned probabilities that they will occur based on current conditions. Probabilities are expressed in exceedances, or the percent chance that the future FNF will exceed a given amount. For example, the 10 percent exceedance indicates wetter than average conditions where there is a 10 percent chance that the FNF volume will exceed the forecast value, and a 90 percent chance that the FNF volume will be less than this forecast value. Similarly, a 90 percent exceedance indicates drier conditions where

there is a 90 percent chance that the FNF volume will exceed the forecast value and a 10 percent chance that the FNF volume will be less than this forecast value. A 50 percent exceedance indicates a 50 percent chance that the FNF volume will exceed the forecast value and a 50 percent chance that the FNF volume will be less than this forecast value. Generally, this forecast is the middle of the range of possible FNF volumes that can be produced given current conditions (50 percent exceedance is equivalent to the median). As the dry season approaches, forecasts become progressively more precise as actual events replace the variable range of potential conditions. Currently, conditions in the Delta watershed are extremely dry, tracking drier than the 99 percent exceedance.

2.1.1 **Supply Analysis**

The range of data available within the supply dataset described below allows for the comparison of historical FNF to current year estimates and forecasts. As described above, the current hydrology is tracking drier than the 99 percent exceedance forecast. For reference, both the 90 percent and 99 percent exceedances, provided in the official supply forecasts released in June 2021, are shown in Figure 3 and Figure 4 below. As indicated below, the current year supply within the Delta watershed is drier than the median critically dry year over the period of 1922 through 2019.

Figure 3. 2021 Supply Conditions Within the Sacramento River Watershed

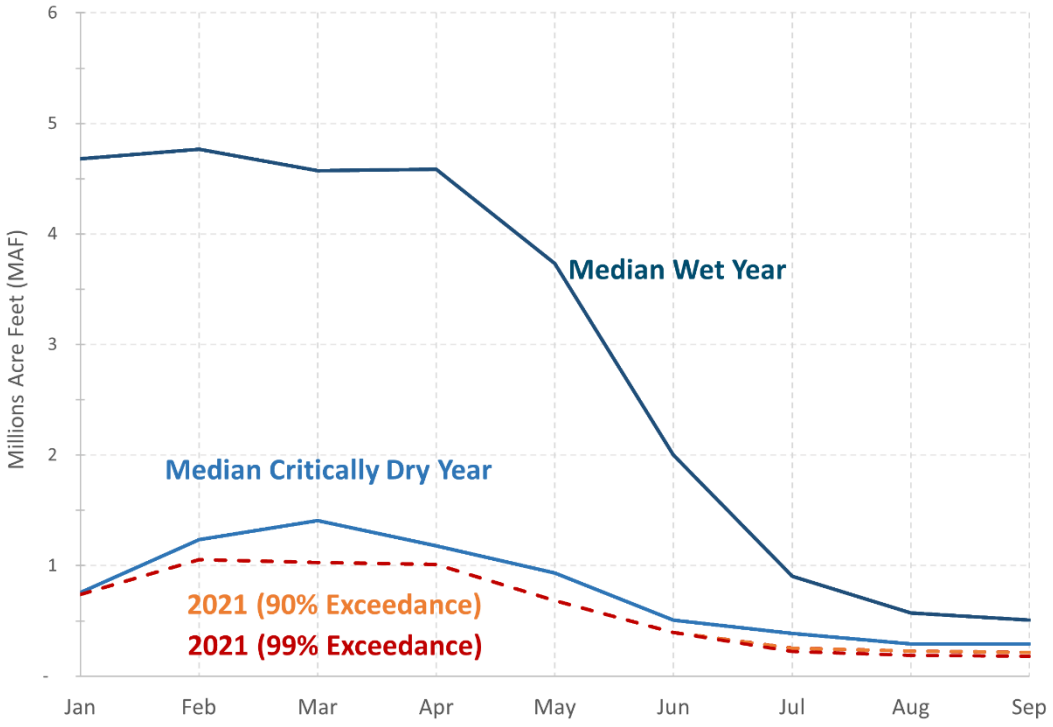
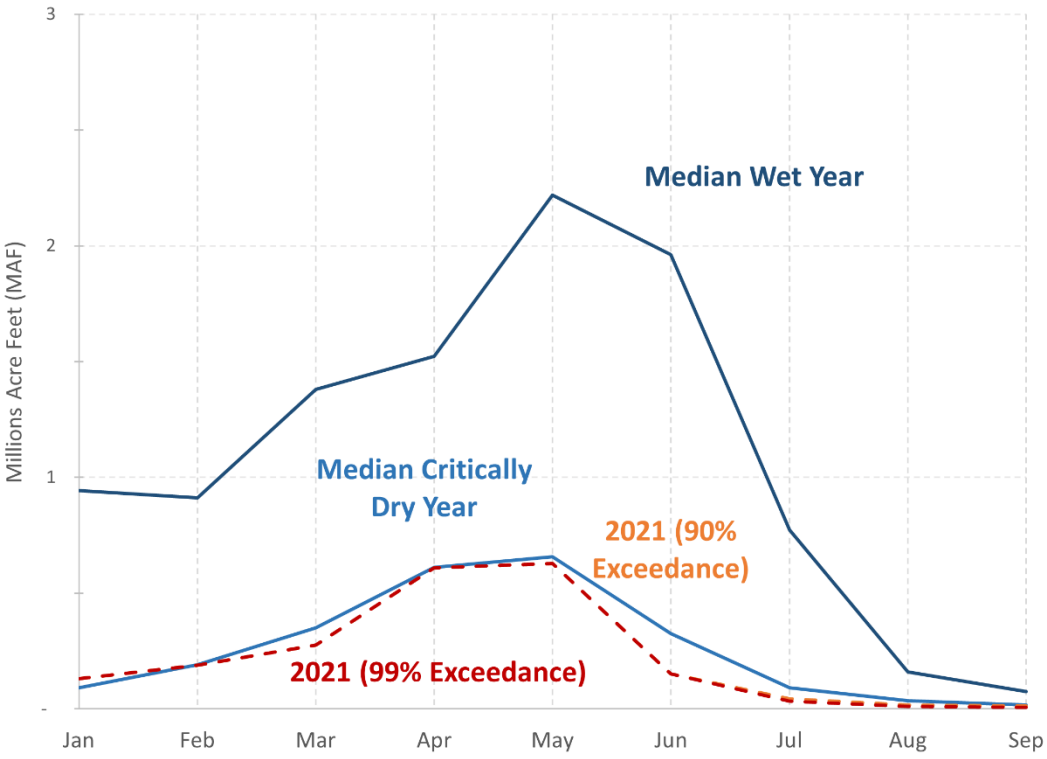


Figure 4. 2021 Supply Conditions Within the San Joaquin River Watershed



2.1.2 **Types of Water**

The water rights system is complex. In many cases during droughts, the observable water in a stream may not be available for diversion because the water: is needed to meet senior downstream demand; has been transferred for use or rediversion downstream; or is previously stored water that has been released to meet downstream demands, water quality and flow requirements, and contractual demands. This section discusses the additional complexities in determining whether water is available for diversion.

Water in a stream system may consist of a combination of "natural flows," imported supplies, storage releases, abandoned flows, and return flows:

1. **Natural flow** – Natural flows are the natural runoff of a river basin unaltered by upstream water diversion, storage, or import from or export to other watersheds. Natural flows, quantified as FNF, are the basis of this methodology.

2. **Imported Supplies** – Imported supplies include supplies that are brought from one water supply source to another for consumptive uses or non-consumptive uses. In the Delta watershed, imported supplies are brought in from outside of the watershed from the Trinity River. Other projects may import water to one subwatershed from another, entirely within the Delta watershed (e.g., the Yuba-

Bear and Drum-Spaulding projects, see section 2.2.7 below). These additional water supplies are not accounted for in this analysis because these supplies do not constitute natural or abandoned flows.

3. **Previously Stored Water** – Seasonally stored water, including releases of previously stored water for downstream use, is not available for diversion or use by diverters other than the entity that stored the water, their contractors, or recipients of a transfer. Accordingly, the methodology does not account for these storage supplies.

4. **Abandoned water** – Abandoned water is water that has been used or dedicated for a specific purpose for which it is no longer needed. If it was previously diverted, the diverter lays no further claim to the water, such as is commonly the case with return flow from agricultural uses. If the water was dedicated for instream use, it becomes abandoned once it flows out of the reach for which it was dedicated. Abandoned flows are available for downstream diversion.

    a. **Abandoned instream flows** – Water for instream use may be comprised of previously stored water releases that are foreign in time or imported from another watershed or bypassed natural flow that is provided for the purposes of preserving or enhancing wetlands, protecting fish and wildlife, and/or recreation. Some instream flows that only apply to a certain reach of a stream can be considered abandoned past that reach. Instream flows that are required to meet Delta instream flow, outflows, and salinity requirements are not considered abandoned. Section 2.1.6 below describes adjustments to the supply analysis to account for certain abandoned instream flows.

    b. **Abandoned return flows** – Return flows from other uses such as irrigated agriculture or municipal water treatment plants may be discharged back to the stream system with no residual claim of control, dominion, or right of further use. In such a case, this water would be available to appropriative diverters and may be available to riparian diverters if not foreign in time or source. Section 2.2.8 below describes adjustments made to the demand dataset to account for return flows from use within the Delta watershed.

The Water Unavailability Methodology assumes all FNF is available for diversion. The methodology also includes assumptions for return flows and abandoned instream flows that are available for diversion. Incorporation of return flows reduces demand calculated purely on reported diversions because a component of that diversion is introduced back into the system. As a simplifying assumption, the methodology does not distinguish between the types of water available within a stream system. Additional analysis will be needed to distinguish supplies that are foreign in time or watershed and not available to riparian diverters.

2.1.3 **Subwatershed Delineation**

The supply-demand analysis begins at a “subwatershed” level. Subwatershed boundaries were defined using the U.S. Geological Survey (USGS) Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD), which delineate land areas draining to streams. Subwatersheds in the Delta watershed were established based on Hydrologic Unit Code level 8 watersheds (HUC8s), which represent areas of sufficient size to capture as much of the available flow as possible within the watershed given the existing network of FNF gages.

Some subwatershed boundaries were defined as a combination of multiple HUC8s due to the presence of multiple HUC8s upstream of a single FNF gage location. These subwatersheds include the Sacramento River above Bend, the Upper American River, and the Upper Feather River. Some HUC8s containing small tributaries on the valley floor were also combined into a single subwatershed due to the locations of supply estimates produced by DWR,[5] including the Upper Sacramento River Valley, Sacramento River Valley Floor, and San Joaquin Valley Floor subwatersheds. A total of 20 Delta subwatersheds were used in the Water Unavailability Methodology: 10 each in the Sacramento and San Joaquin River watersheds (see Figure 5).

An inventory of available FNF gages from multiple sources (see section 2.1.4 below) was compared to the subwatershed boundaries, NHD stream maps, and water right points of diversion (PODs) to identify target FNF gages that are representative of water supplies and demands met by them within each subwatershed. These target FNF gages were considered during the prioritization of available supply data sources discussed in more detail in section 2.1.4 below.

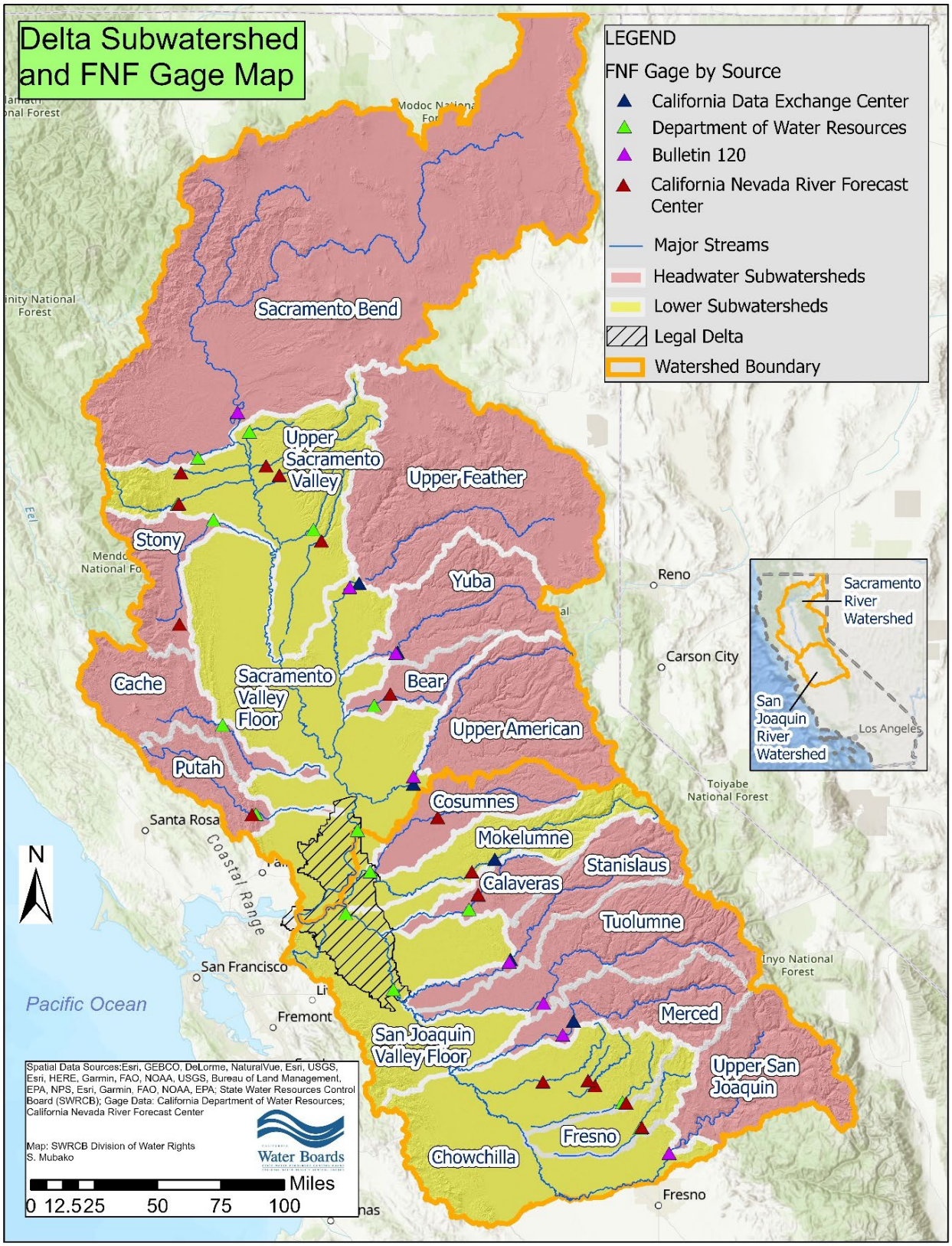
The Water Unavailability Methodology assumes that water supply data at each FNF gage shown in Figure 5 below is representative of the total FNF for the subwatershed as a whole, not only the portion of the subwatershed upstream of the location. This assumption may result in minimal underestimation of supply within certain upstream subwatersheds and minimal overestimation of supply in corresponding downstream subwatersheds. Given the broad spatial coverage of the methodology and the use of generally conservative estimates regarding supply, this assumption is not anticipated to significantly impact watershed-wide determinations of water unavailability.

Supplies and demands from the Tulare Lake watershed (including the Kings, Kern, Kaweah, and Tule Rivers) and the Panoche Creek subwatershed are not included in the Water Unavailability Methodology. Natural flows from the Tulare Lake watershed, despite not being a part of the Delta watershed, at times enter the watershed, largely from the Kings River via Fresno Slough. However, surface water contributions of the Tulare Lake region have historically been minimal and may have been significant only in wet years (DWR 2016). Natural flow would not reach the Delta watershed from the

[5] See DWR’s March 2016 Report on Unimpaired Flows in the Bay-Delta Watershed, described in section 2.1.4 below.

Tulare Lake watershed during the dry season of a critically dry year. Similarly, during the upcoming wet season, it is unlikely that natural flow from the Tulare Lake watershed would reach the Delta watershed as long as shortage conditions persist in the Delta watershed. Therefore, supplies and demands from the Tulare Lake watershed have been excluded from the methodology. In addition, the methodology excludes supply and demand from the Panoche Creek subwatershed, a relatively small tributary in the southwest corner of the San Joaquin River watershed. There is no available FNF supply data for Panoche Creek, and aerial photographs indicate that it terminates in agricultural fields west of Mendota. Therefore, it is assumed not to significantly contribute to available water supplies within the Delta watershed.

Figure 5. Delta Subwatershed and FNF Gage Map



2.1.4 **Supply Data Sources**

Because there is no single data source that provides both past and forecasted FNF estimates for the entire Delta watershed, supply data is derived from multiple sources which vary by location, timescale (i.e., historical data, including prior months of the current water year, and future forecasted data), and temporal resolution (i.e., daily or monthly). These data sources were considered hierarchically; that is, if data for a particular subwatershed was not available from the preferred data source, the next source was checked. If the data was available there, that data was incorporated into the dataset, and so on down the list.

The sources of past supply data, in order of priority of use, are:

1. The California Data Exchange Center (CDEC), which contains published FNF estimates made by water system operators within each watershed. These are primarily available for larger rivers and contain monthly data as far back as WY 1901 in some subwatersheds.
2. DWR's March 2016 Report on Unimpaired Flows in the Bay-Delta Watershed, which contains monthly FNF estimates for water years 1922 through 2014.
3. The National Oceanic and Atmospheric Administration (NOAA) National Weather Service California Nevada River Forecast Center (CNRFC) estimates of daily FNF.[6] These estimates are available for many streams beginning with WY 2013. This source was used only for streams where no other data was available.

The sources of forecasted supply data, in order of priority of use, are:

1. DWR's California Cooperative Snow Surveys Bulletin 120 Water Supply Forecast (B-120),[7] which contains monthly FNF forecasts for the current water year for only larger rivers. B-120 Water Supply Index (WSI) products include forecasts with 10, 25, 50, 75, 90, and 99 percent exceedance probabilities.
2. CNRFC daily FNF forecasts[8] were used only for minor tributaries. Exceedance probabilities were calculated from the available forecast data to match the B-120

[6] CNRFC data is published on a daily scale, which is summed to generate monthly values for the purpose of this analysis. Any negative daily FNF values were replaced with zero values.
[7] Bulletin 120 (B-120) provides FNF forecasts for the state's major watersheds. It is updated monthly, around the fifth business day of each month, from February to May of each year. The FNF calculation is made using DWR's own database of diversions upstream of unimpaired flow stations. The methodology relies upon DWR's unimpaired flow calculations and did not cross-check DWR's diversion database against the Board's records of reported diversions.
[8] CNRFC forecasts are presented in the form of 39 different daily FNF "traces." These daily values were summed, and exceedances were calculated from the resulting monthly forecasts.

format. During the October through January time period when B-120 forecasts are not available, CNRFC daily FNF forecasts will be used for locations that have relied upon B-120 forecasts to date.

If data was available from multiple sources for the same subwatershed (e.g., past data from both CDEC and DWR or forecasted data from both B-120 and CNRFC), both datasets were compared for an overlapping time period to validate that there we no substantial inconsistencies between them. These comparisons did not result in any changes to the assumed hierarchy of data sources described above.

The final water supply dataset used in the Water Unavailability Methodology's supply-demand comparison consists of monthly FNF data. The use of monthly supply forecasts and demand estimates (see section 2.2 below) is assumed to negate the need to consider the water's transit time within the Delta watershed (i.e., it takes less than a month for water to flow from its headwaters to a downstream diverter). Monthly data is also used because there is insufficient real-time data available to evaluate supplies for all streams in the Delta watershed on a daily timestep. Furthermore, daily supply data from sources such as CDEC are less accurate than published monthly values. However, for the purposes of sub-monthly short-term considerations of curtailment suspensions due to precipitation and runoff events, sub-monthly data will be considered to ensure that curtailments are suspended on a time step commensurate with available supplies.

CDEC provides both monthly and daily FNF estimates for many rivers in California. Daily FNF estimates are less accurate than monthly estimates because they are based on less data than is available at the completion of each month (DWR 2015). Therefore, daily CDEC FNF values are not used in the water unavailability graphs described in section 2.4 below. However, daily FNF estimates may be used to determine the most appropriate supply forecast (e.g., 10, 50, 90, or 99 percent exceedance probability) to use when issuing notices of water unavailability, as described in section 3.1.1 below.

Table 1 and Table 2 below summarize the sources of both past and forecasted supply data for each subwatershed included in the supply dataset for the Sacramento River watershed and the San Joaquin River watershed, respectively. The source information includes the agency from which the data was obtained and the unique identifier for each FNF gage site. Past source data is broken down into the sources of monthly and daily estimates; daily sources with date ranges in Table 1 and Table 2 were summed to generate monthly past data, while those shown without date ranges were used only for periodic forecast monitoring (see section 3.1.1). The monthly past source data also includes the years for which data is available, such as WY 1906 to present. For forecasted supply data, information is provided on the resolution, frequency, and format of forecast updates. Subwatersheds where gap-filling procedures were applied (see section 2.1.5 below) are denoted with asterisks, and all gap-filled values are specifically identified as such in the supply dataset.

Table 1. Sacramento River Watershed Supply Data Sources

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage, Date Range if applicable)*	
Sacramento River at Bend	CDEC SBB: Sacramento River above Bend Bridge, sensor 65 (WY 1906-Present)	CDEC BND: Sacramento River at Bend Bridge, sensor 8	DWR B-120 SRWSI: Sacramento River above Bend Bridge (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC BDBC1: Sacramento River-Bend Bridge (daily TCFS for next year in 39 traces)
Stony Creek	DWR UF4: Stony Creek at Black Butte (WY 1922-2014)	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (WY 2015-Present)*	CNRFC EPRC1: Little Stony Creek-East Park Reservoir (daily TCFS for next year in 39 traces)*
Cache Creek	DWR UF3: Cache Creek above Rumsey (WY 1922-2014)	*	*
Upper Feather River	CDEC FTO: Feather River at Oroville, sensor 65 (WY 1906-Present)	CDEC ORO: Oroville Dam, sensor 8	DWR B-120 SRWSI: Feather River at Oroville (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC ORDC1: Feather River- Lake Oroville (daily TCFS for next year in 39 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage, Date Range if applicable)*	
Yuba River	CDEC YRS: Yuba River near Smartville, sensor 65 (WY 1901-Present)	CDEC YRS: Yuba River near Smartville, sensor 8	DWR B-120 SRSWI: Yuba River near Smartville plus Deer Creek (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC HLEC1: Yuba River-Englebright Reservoir (daily TCFS for next year in 39 traces)
Bear River	DWR UF10: Bear River near Wheatland (WY 1922-2014)	*	*
Upper American River	CDEC AMF: American River at Folsom, sensor 65 (WY 1901-Present)	CDEC NAT: Lake Natoma (Nimbus Dam), sensor 8	DWR B-120 SRWSI: American River below Folsom Lake (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC FOLC1: American River-Folsom Lake (daily TCFS for next year in 39 traces)
Putah Creek	DWR UF2: Putah Creek near Winters (WY 1922-2014)	*	*

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage, Date Range if applicable)*	
Upper Sacramento River Valley	DWR UF5: Sacramento Valley West Side Minor Streams (WY 1922-2014)	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (WY 2015-Present)*	CNRFC EDCC1: Elder Creek-Paskenta + TCRC1: Thomes Creek-Paskenta (daily TCFS for next year in 39 traces)*
	DWR UF7: Sacramento Valley East Side Minor Streams (WY 1922-2014)	CNRFC MLMC1: Mill Creek-Los Molinos + DCVC1: Deer Creek-Vina + BKCC1: Butte Creek-Chico (WY 2015-Present)*	CNRFC MLMC1: Mill Creek-Los Molinos + DCVC1: Deer Creek-Vina + BKCC1: Butte Creek-Chico (daily TCFS for next year in 39 traces)*
Sacramento River Valley Floor	DWR UF1: Sacramento Valley Floor (WY 1922-2014)	*	*

*Gap filling procedure used to adjust existing data or fill-in missing data (see section 2.1.5).

Table 2. San Joaquin River Watershed Supply Data Sources

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Chowchilla River	DWR UF20: Chowchilla River at Buchanan Reservoir (WY 1922-2014)	CNRFC BHNC1: Chowchilla River-Buchanan Reservoir (WY 2015-Present)	CNRFC BHNC1: Chowchilla River-Buchanan Reservoir (daily TCFS for next year in 39 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Upper San Joaquin River	CDEC SJF: San Joaquin River below Friant, sensor 65 (WY 1901-Present)	CDEC SJF: San Joaquin River below Friant, sensor 8	B-120 SJWSI: San Joaquin River inflow to Millerton Lake (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC FRAC1: San Joaquin River-Millerton Reservoir (daily TCFS for next year in 39 traces)
Fresno River	DWR UF21: Fresno River near Daulton (WY 1922-2014)	CNRFC HIDC1: Fresno River-Hensley Lake (WY 2015-Present)	CNRFC HIDC1: Fresno River-Hensley Lake (daily TCFS for next year in 39 traces)
Merced River	CDEC MRC: Merced River near Merced Falls, sensor 65 (WY 1901-Present)	CDEC EXC: New Exchequer-Lake McClure, sensor 8	B-120 SJWSI: Merced River below Merced Falls (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC EXQC1: Merced River-Exchequer Reservoir (daily TCFS for next year in 39 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Tuolumne River	CDEC TLG: Tuolumne River-La Grange Dam, sensor 65 (WY 1901-Present)	CDEC TLG: Tuolumne River-La Grange Dam, sensor 8	B-120 SJWSI: Tuolumne River below La Grange Reservoir (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC NDPC1: Tuolumne River-New Don Pedro Reservoir (daily TCFS for next year in 39 traces)
Stanislaus River	CDEC SNS: Stanislaus River-Goodwin, sensor 65 (WY 1901-Present)	CDEC GDW: Goodwin Dam, sensor 8	B-120 SJWSI: Stanislaus River below Goodwin Reservoir (monthly TAF for current WY in 6 exceedances); when DWR B-120 unavailable, CNRFC NMSC1: Stanislaus River-New Melones Reservoir (daily TCFS for next year in 39 traces)
Calaveras River	DWR UF15: Calaveras River at Jenny Lind (WY 1922-2014)	CNRFC NHGC1: Calaveras River-New Hogan Reservoir (WY 2015-Present) CDEC NHG: New Hogan Lake, sensor 8 (WY 2015-Present)	CNRFC NHGC1 (daily TCFS for next year in 39 traces)

Subwatershed	Past Supply Data Sources		Forecasted Monthly Supply Data Sources *(Agency, Gage, Forecast Resolution)*
	Monthly *(Agency, Gage, Date Range)*	**Daily** *(Agency, Gage)*	
Mokelumne River	CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 65 (WY 1901-Present)	CDEC MKM: Mokelumne River-Mokelumne Hill, sensor 8	CNRFC CMPC1: Mokelumne River-Mokelumne Hill (daily TCFS for next year in 39 traces)
Cosumnes River	CDEC CSN: Cosumnes River at Michigan Bar, sensor 65 (WY 1908-Present)	CDEC MHB: Cosumnes River at Michigan Bar, sensor 8	CNRFC MHBC1: Cosumnes River-Michigan Bar (daily TCFS for next year in 39 traces)
San Joaquin River Valley Floor	DWR UF12: San Joaquin Valley East Side Minor Streams + UF17: San Joaquin Valley Floor + UF24: San Joaquin Valley West Side Minor Streams (WY 1922-2014)	CNRFC MPAC1: Mariposa Creek-Mariposa Reservoir + OWCC1: Owens Creek-Owens Reservoir + MEEC1: Bear Creek-McKee Road*	CNRFC MPAC1: Mariposa Creek-Mariposa Reservoir + OWCC1: Owens Creek-Owens Reservoir + MEEC1: Bear Creek-McKee Road (daily TCFS for next year in 39 traces)*

*Gap filling procedure used to adjust existing data or fill-in missing data (see section 2.1.5).

2.1.5 **Filling Supply Data Gaps**

After the compilation of supply data from the sources listed in section 2.1.4 above, data "gaps" remain for some subwatersheds in the Delta watershed. These gaps include periods of missing past or forecasted data and past or forecasted data that cover only a portion of a subwatershed, as defined for this analysis (see section 2.1.3 above). These gaps were filled using extrapolation and augmentation processes, respectively, to create a complete supply dataset for use in the Water Unavailability Methodology. Technical Appendix A contains descriptions of specific gap-filling processes for each subwatershed where they were applied.

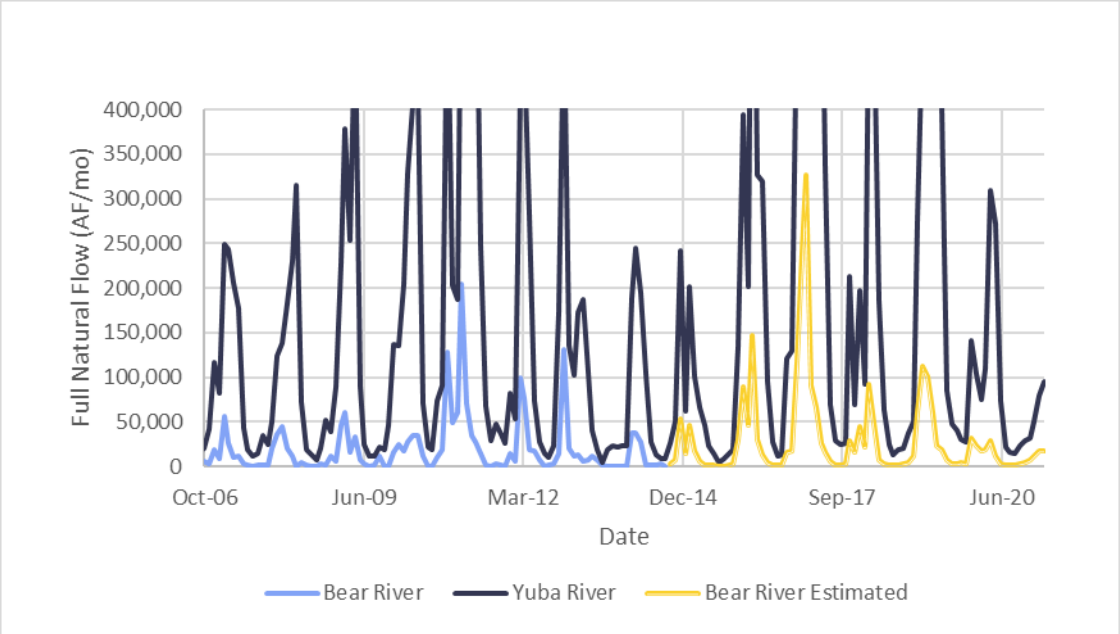
2.1.5.1 ***Extrapolation***

To fill missing past or forecasted supply data gaps, overlapping historical data between the subwatershed with missing data ("Stream") and a nearby watershed with similar

hydrology but more robust data ("River") were analyzed. The Stream:River ratio was calculated[9] for each month over this period, and outliers were removed. Then, the River FNF estimates were multiplied by the average monthly Stream:River ratio to extrapolate reasonable FNF estimates to fill the gaps in the subwatershed's dataset.

For example, February 2021 supply data for the Bear River subwatershed was not available from any of the sources listed in section 2.1.4 above. Therefore, prior February FNF estimates for the Bear River subwatershed were compared to the neighboring Yuba River and a ratio of 1:5 was calculated (Bear:Yuba). Missing February data for the Bear River subwatershed was estimated by multiplying the Yuba River subwatershed's February 2021 FNF estimate by this ratio. Figure 6 below illustrates the Bear:Yuba extrapolation for the period of WY 2014 to present.

Figure 6. Extrapolation Example: Estimation of Bear River FNF (WY 2014–present) Based on Yuba River FNF



2.1.5.2 *Augmentation*

In other areas, past or forecasted data may exist but not represent the entire FNF supply of a watershed that would be expected to be available for diversion. This was the case for watersheds consisting of multiple small tributary streams, in which only some streams have available supply forecasts through CNRFC. DWR's 2016 Bay-Delta Unimpaired Flow Report includes past FNF estimates that cover all tributaries in these subwatersheds. To increase the "CNRFC" forecasts to approximate a forecast for the entire subwatershed (as the past supply estimates from "DWR" do), overlapping historical data between the two sources were analyzed. The ratio DWR:CNRFC was

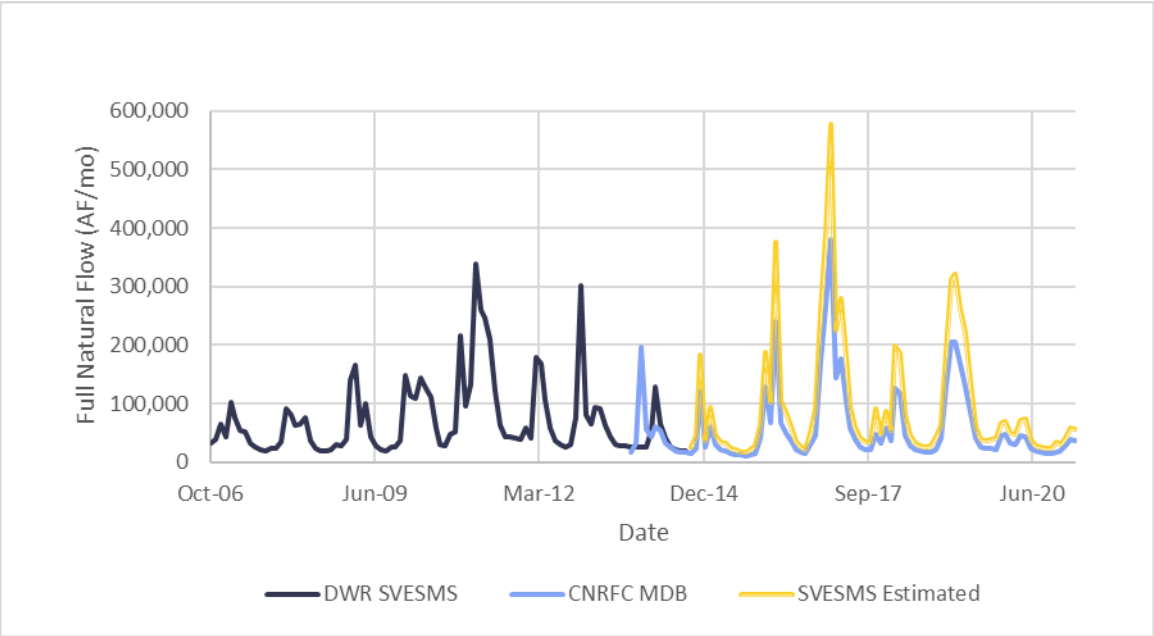
[9] The Stream:River ratio calculation is analogous to a linear interpolation each month, with the y-intercept always set to zero.

calculated on a monthly basis over this period, and outliers were removed.[10] Then, the past and forecasted CNRFC values were augmented by multiplying them by the monthly average DWR:CNRFC ratio to produce a reasonable FNF forecast estimate for the subwatershed.

For example, DWR's past (WY 1922–2014) unimpaired flow estimates for the Sacramento Valley East Side Minor Streams (UF7 in DWR's Report), part of the Upper Sacramento Valley subwatershed, include Antelope Creek, Mill Creek, Deer Creek, Big Chico Creek, Butte Creek, and other minor tributaries from Big Chico Creek to the Feather River (DWR 2016). CNRFC only has past (WYs 2013–present) and forecasted FNF data available for Mill, Deer, and Butte Creeks (MDB, in total). By comparing historical FNF values for a period with overlapping data (WYs 2013 and 2014), a monthly relationship ratio can be calculated. In this example, for February, the total Sacramento Valley East Side Minor Streams unimpaired flow was about 1.5 times the MDB supply. Therefore, missing February data in the Upper Sacramento Valley subwatershed would be estimated by multiplying the MDB supply by 1.5. The Upper Sacramento Valley subwatershed also includes supplies from West Side Minor Streams, which were estimated using a similar method with different DWR and CNRFC gages. Figure 7 below illustrates the DWR:CNRFC augmentation to estimate FNF for the Sacramento Valley East Side Minor Streams.

[10] Because the DWR FNF values include data for all of the CNRFC streams and additional tributaries, the value of the DWR:CNRFC ratio is always greater than one. This ratio calculation is analogous to a linear interpolation each month, with the y-intercept always set to zero.

Figure 7. Augmentation Example: Adjusting CNRFC Data for Mill, Deer, and Butte Creeks (MDB) to Estimate FNF Within Sacramento Valley East Side Minor Streams (SVESMS), a Portion of the Upper Sacramento Valley Subwatershed, Based on DWR's FNF Estimate for SVESMS



2.1.6 **Abandoned Instream Flows**

Specific reaches of streams within the Delta watershed may be subject to minimum instream flow requirements due to water right permit/license conditions, Board orders/decisions/regulations, Federal Energy Regulatory Commission (FERC) hydropower license conditions, biological opinion requirements, or private agreements. If these instream flow requirements are met by diverters bypassing flow, these flows are already included in FNF values. If these instream flow requirements are met via releases of stored water, these flows are not captured by FNF calculations. Beyond the reach for which they are intended for instream use, these storage releases are available for diversion, and, therefore, may theoretically be considered alongside FNF values to more accurately represent the amount of water available for downstream diversion unless there are provisions making these flows unavailable for use.

Current data limitations prevent a precise accounting of when instream flow requirements that will be abandoned have been met by stored water. Therefore, to incorporate abandoned instream flows into the supply dataset without artificially inflating estimates of available supply by assuming all abandoned instream flows have been met by releases of stored water, the methodology uses the greater of the FNF value and the abandoned instream flow value to represent the amount of supply contribution of the subwatershed to the respective watershed-wide supply. In other words, it was assumed that if the FNF is greater than the instream flow then instream flow requirement is being met by FNF; conversely, if the instream flow is greater than the FNF then it was

assumed that the instream flow is met at least in part by storage releases which can be considered abandoned below their intended reach.

For the purpose of this analysis, all abandoned instream flows whose intended reach ends near the bottom of a subwatershed were considered. If two instream flow requirements exist in series in a watershed, it is possible that the same water could be used to meet both requirements. To avoid double counting of additional supplies, the methodology does not include instream flows that end higher up in the subwatershed. Using data from the State Water Board's Sacramento Valley Water Allocation Model (SacWAM)[11] and Water Supply Effects (WSE) model,[12] a total of seven instream flow requirements that would produce abandoned flows were identified. These flow requirements, locations, and amounts are summarized in Table 3 and Table 4 below for the Sacramento and San Joaquin River watersheds, respectively. Water released by the Projects to meet water quality and flow requirements included in State Water Board Decision 1641 is not considered abandoned because those flows are intended to remain instream through the Delta and as outflow from the Delta.

[11] SacWAM is a hydrologic and system operations model developed by the Stockholm Environment Institute (SEI) and State Water Board using the Water Evaluation and Planning (WEAP) platform to represent the Sacramento River watershed, Delta, and eastside tributaries to the Delta (the Calaveras, Cosumnes, and Mokelumne Rivers). Information on SacWAM is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sacwam/

[12] WSE is a hydrologic and system operations model developed by the State Water Board to represent the lower San Joaquin River and its lower tributaries (the Merced, Tuolumne, and Stanislaus Rivers). Information on WSE is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/2018_sed/

Table 3. Sacramento River Watershed Flows Considered to Contribute Abandoned Supplies[13]

Sub-watershed	Abandoned Instream Flow (cfs)					Notes
	May	June	July	Aug.	Sept.	
Upper North Fork Feather River	300	300	300	300	250	FERC P-2107 license (below Poe Dam)
Yuba River	500	500	250	250	250	Board Decision 1644 (at Marysville, assumes Extreme Critical year, does not include flows transferred to DWR)
Bear River	25	25	10	10	10	FERC P-2997 license (below Camp Far West Diversion Dam, does not include flows transferred to DWR)
Upper American River	425	475	425	425	350	FERC 20140820 license (South Fork below Chili Bar, assumes Dry year, includes Conditions 1 and 3) and P-2079 license (North Fork below American River Pump Station)
Putah Creek	5	5	5	5	5	2000 Putah Creek Accord (outflow to Toe Drain)
Total	**1,255**	**1,305**	**990**	**990**	**865**	

[13] Abandoned flows from Stony Creek were included in the May 12, 2021 version of the methodology but have been excluded from this updated version because, given current hydrology, any abandoned instream flow from Stony Creek is expected to seep into the underlying groundwater basin prior to reaching the Sacramento River and contributing to available downstream supplies.

Table 4. San Joaquin River Watershed Flows Considered to Contribute Abandoned Supplies

Sub-watershed	Abandoned Instream Flows (cfs)					Notes
	May	June	July	Aug.	Sept.	
Merced River	60	15	15	15	15	FERC P-2179 license (below Crocker Huffman Diversion Dam, assumes Dry year)
Tuolumne River	311	50	50	50	50	FERC P-2299 license (below La Grange Diversion Dam, assumes SJR 60-20-20 index is between 1.5 and 2.0 MAF)
Total	**371**	**65**	**65**	**65**	**65**	

For simplicity of analysis, the Water Unavailability Methodology does not currently account for whether the abandoned flows included in the supply dataset are foreign in either time or source and not available for use by riparian diverters. On a watershed-wide scale, these additional flows are not significant and would not significantly affect the analysis.

2.2 Demand

The Water Unavailability Methodology evaluates demands for natural and abandoned flows by basis of water right. It is not intended to account for demands for previously stored water, imported supplies, and contractual demands. The analysis to date has relied on reported demand data from the State Water Board's Electronic Water Rights Information Management System (eWRIMS) computer database.[14] The State Water Board may also rely upon updated reporting of projected demands for larger users that is provided pursuant to emergency regulations. Projections of demands during the wet season are expected to be more accurate than historical diversion data for purposes of estimating demands, particularly for storage which historically occurred when flows were present, which does not necessarily reflect demands that would exist this year The eWRIMS data system contains information regarding water rights, including but not limited to:

- Water right ownership information
- Water right type (e.g., "Appropriative" or "Statement of Diversion and Use")

[14] A public version of the eWRIMS database is available at: https://ciwqs.waterboards.ca.gov/ciwqs/ewrims/EWPublicTerms.jsp

- Water right claim type for Statements of Diversion and Use (e.g., "Riparian," "Pre-1914," etc.) as reported in the diverter's Initial Statement of Water Diversion and Use or annual Supplemental Statements of Diversion and Use.
- Water right status (e.g., active, inactive, revoked, etc.)
- Authorized diversion seasons and volumes
- Authorized beneficial uses, including both consumptive (e.g., irrigation) and non-consumptive (e.g., hydropower generation) beneficial uses
- Spatial location of PODs,[15] including HUC8 watershed(s)
- Electronically reported water diversion and use information, available on a monthly basis

The eWRIMS database system contains information for various water right types, including both riparian and appropriative water rights. Within the eWRIMS database system, post-1914 appropriative water rights are categorized as "Appropriative," and other claims of right, which mainly consist of pre-1914 appropriative and riparian claims, are categorized as "Statements of Diversion and Use." The eWRIMS database system also includes information for other minor water right types, such as water right registrations.

Currently, all diverters are required to submit annual reports of water diversion and use (annual reports) to the State Water Board electronically through the eWRIMS Report Management System (RMS). The annual reports are mandatory filings that document water diversions and uses made during each month of the previous calendar year, including monthly direct diversion volumes, monthly diversion to storage volumes, and monthly water use volumes. A separate annual report of water diversion and use is required for each water right each year; therefore, a diverter may be required to submit more than one annual report if they hold or claim more than one right. Reports for the prior calendar year are due by April 1 for appropriative water rights, stockpond certificates,[16] and registrations[17] and by July 1 for groundwater recordations and statements of water diversion and use. Diversion data contained within the annual reports forms the basis for estimates of water demand used in the Water Unavailability Methodology. Water right holders and claimants that divert water under Statements of Diversion and Use also provide information about the water right claim type (e.g., riparian, pre-1914 appropriative, etc.) in annual reports.

[15] The eWRIMS database contains a mapping application to view the spatial location of PODs.
[16] Stockpond certificates are appropriative water rights issued by the State Water Board through 1997 and are limited to diversion of 10 acre-feet (AF) or less per year.
[17] Water right registrations are appropriative water rights issued by the State Water Board through an expedited acquisition process for certain small projects first available in 1989. Water right registrations are available for small domestic use, livestock stockpond use, small irrigation use, and cannabis small irrigation use.

For this analysis, water demand is based on the total monthly diversion amount reported for each water right record, including monthly direct diversions and monthly diversions to storage. The demand dataset used in the Water Unavailability Methodology is specifically derived from the reported annual diversion data for calendar years 2018 and 2019, the most current years available. 2020 diversion data has not yet been used for this analysis because the full dataset is not yet available, though 2020 data may be used in the future.[18] Demand data were not analyzed on a daily scale because annual reports contain only monthly reported diversion data. The transformation of monthly data to a finer timescale (e.g., daily) would not meaningfully impact the analysis because, without more detailed knowledge of operations by individual water users, monthly demand values would be divided equally between all days of each month. Furthermore, as described below, current compliance with new diversion measurement and reporting regulations have not made substantial daily and/or real-time diversion information available for even the largest water users in the Delta watershed.

The methodology primarily relies on 2018 demand data, with additional data from 2019 also available for comparison purposes. 2018 was a below normal water year in both the Sacramento and San Joaquin River watersheds and is assumed to more closely resemble demands during a critically dry year than 2019, which was a wet water year in both watersheds. The reliance on 2018 demand data may underestimate actual demand since demands are likely to be greater during a critically dry year due to drier soil conditions. There are also likely higher losses to evaporation and seepage in a critically dry year. Conservation activities that may be pursued this year may offset higher critical year demands to some degree, but it is assumed that using below normal year demand estimates in a critically dry year is a conservative assumption for the purposes of avoiding issuance of notices of water unavailability when they may not be warranted.

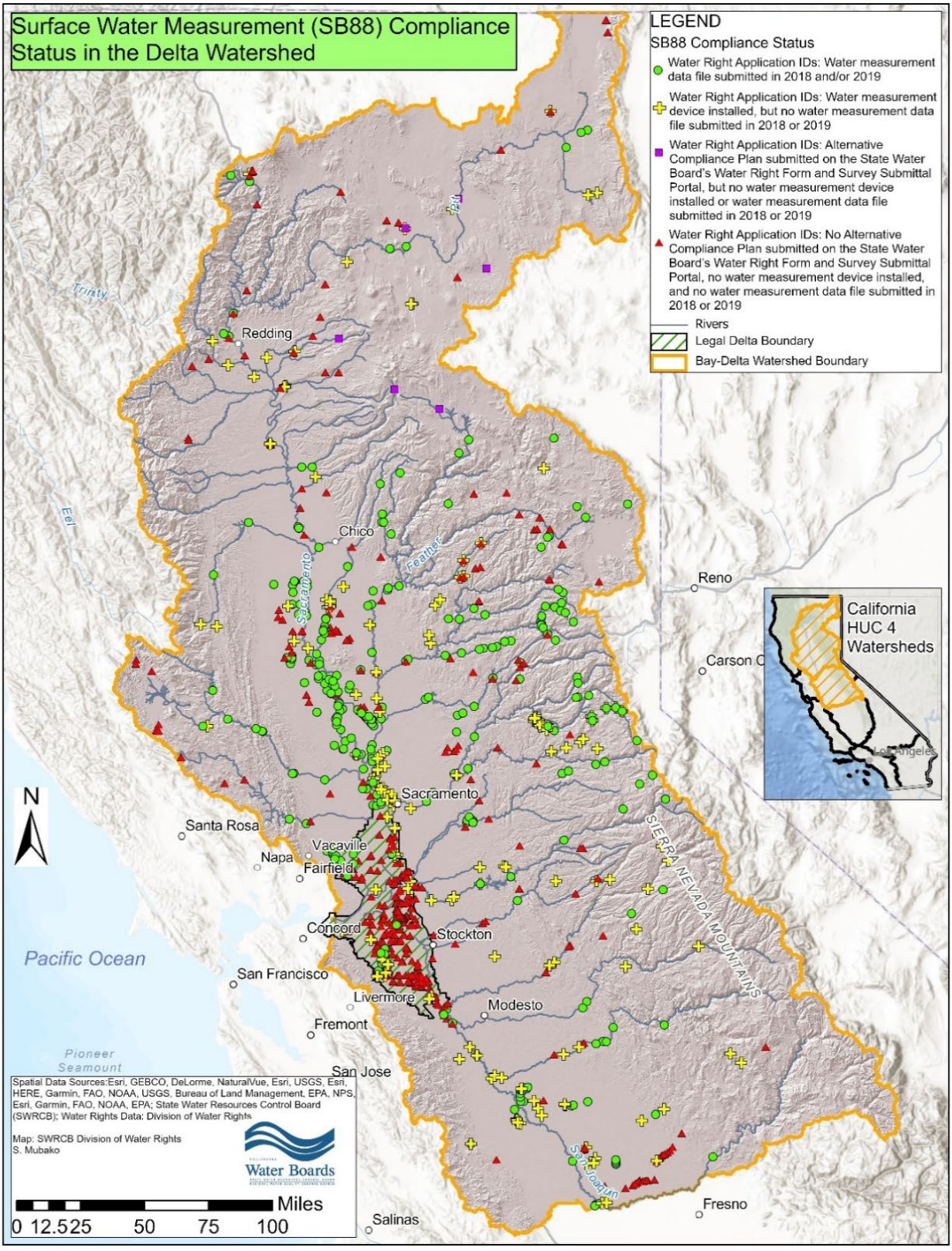
In addition, 2018 diversion data was used because it is the only drier year for which diversion data is available since updated water right measurement and reporting requirements went into effect with Senate Bill 88 (SB88). Pursuant to regulations implementing SB88, all water right diverters authorized to divert more than 10 AF annually from rivers, creeks, springs, or subterranean streams must comply with measurement requirements. There are three ways to achieve measurement compliance: (1) install, use, and maintain a device capable of measuring the rate of direct diversion; (2) propose an alternative compliance plan; or (3) utilize a measurement method for multiple diverters. SB88 set expectations for both the accuracy of measurement devices as well as the monitoring frequency of the device and included measurement device installation deadlines of January 1, 2018 or earlier.

[18] Because reporting of 2020 diversion and use information was not due for Statements of Diversion and Use until July 1, 2021, sufficient data were not available in time to complete this analysis but may be used in the future.

Although the implementation of SB88 has increased the frequency of required reporting for many diverters and may help to improve the quality of reported diversion and use data submitted to the State Water Board, many diverters have not yet achieved full compliance with the water right measurement requirements even though the measuring device installation deadlines have now passed. For example, among the 244 largest consumptive water right records in the Delta watershed located outside of the Legal Delta, diverters installed a measuring device and submitted a measurement data file for 2018 or 2019 in accordance with SB88 for only 57 percent (140) of the records. Diverters submitted proposed Alternative Compliance Plans pursuant to SB88 for an additional 2 percent (4) of the records. Diverters installed a measuring device but failed to submit a measurement data file for 2018 or 2019 for 27 percent (65) of the records, and did not install a measuring device, submit a measurement data file for 2018 or 2019, or submit a proposed Alternative Compliance Plan for 14 percent (35) of the records. Compliance with the measurement requirements may be even lower for smaller diverters.

Figure 8 below shows the locations of the PODs associated with the largest (those with a 5,000 AF or larger face value or 5,000 AF or larger of reported diversions) consumptive water right records in the Delta watershed and displays their SB88 compliance status.

Figure 8. Delta Watershed: Surface Water Measurement (SB88) Compliance Status



As discussed in more detail below, diversion data contained within annual reports is self-reported and is not systematically verified for accuracy upon submittal. As a result, an internal review and quality control effort was conducted.

2.2.1 **Initial Selection of Water Right Records**

A subset of the water right records in the eWRIMS database for the Delta watershed were selected for use in the Water Unavailability Methodology based on several criteria:

- Spatial Location: POD(s) located within the Delta watershed[19]
- Water Right Status: Active status types only, thereby excluding inactive-type statuses (e.g., inactive, revoked, cancelled, etc.)
- Water Right Type: “Appropriative” (i.e., post-1914 appropriative, excluding registrations and stockpond certificates) and “Statement of Diversion and Use” (i.e., pre-1914 appropriative and riparian), thereby excluding minor water right types
- Beneficial Uses: All beneficial uses except exclusively non-consumptive beneficial uses

Water right records with active-type statuses were selected to best approximate current year water demand since it is unlikely that inactive-type statuses (e.g., inactive, revoked, cancelled, etc.) would be reactivated during the current year. Only water right records with “Appropriative” and “Statement of Diversion and Use” water right types were included because minor water right types, such as registrations and stockponds, were assumed to constitute a negligible amount of the water diversion and use within the Delta watershed.

Water right records identified as non-consumptive based on their beneficial use type (e.g., hydropower generation, fish and wildlife preservation and enhancement, etc.) were also excluded. Non-consumptive uses, such as for hydropower generation, may change the timing of flows but do not reduce the amount of supply available unless they result in an interbasin diversion (see section 2.2.7 below). Given the temporal resolution of the supply and demand dataset (i.e., monthly) and the lesser amount of hydropower-related storage occurring during the dry season than the wet season, the potential impact of these non-consumptive diversions on the timing of flows is not assumed to be significant during the dry season. During the wet season, adjustments will be made to account for diversions to storage under hydropower rights to accurately reflect where these diversions make water unavailable for a period of time.

[19] All PODs within the Delta watershed were selected except for those within the Panoche Creek subwatershed. As described in section 2.1.3 above, supply data is not available for this subwatershed; therefore, neither supply nor demand for this area were included in this analysis.

This initial selection of water right records resulted in a demand dataset consisting of approximately 12,000 total records. Of these, approximately 5,000 were post-1914 appropriative water rights and 7,000 were statements of diversion and use.

2.2.2 **Initial Quality Control**

Water diversion data contained within the eWRIMS database originates from annual reports of water diversion and use electronically submitted by diverters. This self-reported data is not systematically verified for accuracy upon receipt and contains inaccuracies, inconsistencies, and other errors. Staff conducted a quality control effort following the initial selection of water right records for the demand dataset.

The approximately 12,000 total records existing within the demand dataset after initial selection were too numerous to feasibly review in their entirety at this time. Therefore, the scope of the review was narrowed to appropriative water rights with a face value (maximum diversion amount) of 5,000 AF or greater and statements of diversion and use with reported diversions of 5,000 AF or greater in either calendar year 2018 or 2019. This produced a manageable subset of water right records to review within a limited timeframe of approximately 580 records, including approximately 360 post-1914 appropriative rights and approximately 220 Statements of Diversion and Use. These records account for approximately 90 percent of the water diverted in the Delta watershed in 2018 and 2019 but less than 10 percent of the users.

For this narrower set of records, the 2018 and 2019 annual reports of water diversion and use associated with each record were reviewed to identify potential inaccuracies in the diversion data. During the review process, several types of data errors were identified and corrected, if the appropriate correction was discernable.[20] These corrections included:

- Correction of diversion data entry and reporting issues, such as incorrect units of measurement and decimal placement errors
- Removal of duplicate diversion values, such as the same diversions reported under multiple water right records
- Removal of non-consumptive diversions improperly appearing as consumptive
- Correction of diversion values as necessary where reported diversion exceeds the water right's face value

During the quality control process, if the appropriate correction was unclear, the affected records were flagged for potential further investigation beyond the information readily available in eWRIMS.

[20] Comments provided within the annual reports of water diversion and use often contained critical information to inform these corrections. For example, some diverters stated that their purpose of use is entirely non-consumptive. Others indicated that a particular diversion was fully reported under two or more separate rights (i.e., duplicated).

In addition to the records review described above, approximately 100 post-1914 appropriative rights were identified that reported diversions less than 5,000 AF but in excess of the face value of the water right. Most of these diversions are very small. Due to time constraints, these records were not investigated individually. Instead, for these rights, the reported diversion amounts within the demand dataset were updated to equal the face value of the right.

Except for the correction to reported diversions in excess of the face value of post-1914 rights, all water right records with a face value or reported use under 5,000 AF were included in the demand analysis without a quality control review. As mentioned above, these records constitute only about 10 percent of the total demand within the Delta watershed.

2.2.3 **Additional Quality Control**

After conducting the initial quality control review of 2018 and 2019 annual reports for the largest diversions as discussed above, and after applying corrections to rectify errors, some diversion values remained flagged as potentially including incorrect demand information with outstanding issues that could not be resolved without further information. Examples of these issues include:

- Possible duplicate reporting of diversion volumes under multiple water right records where it was not possible to quantify the duplicate reporting amount.
- Possible overreporting of diversion volumes that could not be corrected to reflect a best estimate of the actual diversion volume based on the available information. For example, some annual reports contained information that appeared to indicate that the diversion volume was not measured and, as a result, the maximum diversion amount authorized under the permit or license had been reported.
- Apparent inclusion of both consumptive and non-consumptive uses in the reported diversion amount where it was not possible to quantify the volume of water diverted only for consumptive uses.
- Other potential data reporting issues where an error was detected, but the appropriate correction was unclear.

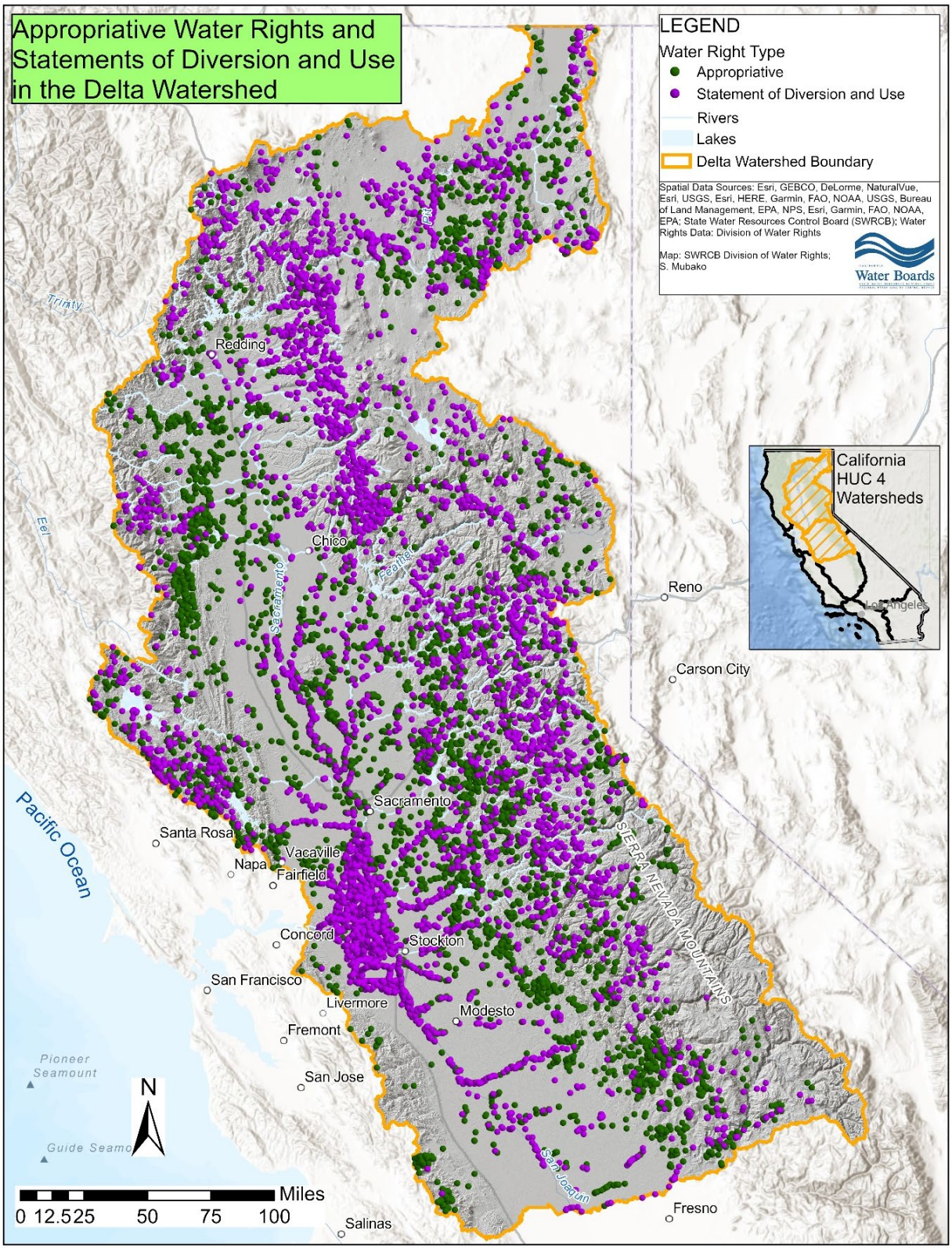
In these cases, additional information may be needed to determine the appropriate correction or resolve other reporting-related issues. State Water Board staff has contacted numerous water right holders, claimants, or their agents to gather this information. Diversion volumes within the demand dataset were updated according to the responses provided. However, it was not feasible to contact all water right holders, claimants, or agents in all cases where a potential reporting related error was identified or a correction applied to a diversion value. Efforts were prioritized to contact water right holders or agents based on several factors, including reported diversion size and relative level of uncertainty regarding potential reporting-related inaccuracies. In addition, some water right holders, claimants, and agents did not provide responses to

inquiries regarding potential reporting related errors. In the absence of additional information provided by the water right holder, claimant, or agent, best estimates of the actual diversion values were used based on information contained within the annual report of water diversion and use and supplemental information available within the eWRIMS database.

Further refinements to the demand dataset used in the Water Unavailability Methodology may occur. Diverters who are aware of reporting issues, including, but not limited to, the items discussed above, should contact the State Water Board at Bay-Delta@waterboards.ca.gov.In addition, the quality-controlled 2018 and 2019 demand datasets were compared to FNF for each of these years, respectively, at the subwatershed scale (see section 2.1.3 above), and at the Sacramento and San Joaquin River watershed scales to assess the reasonableness of the demand datasets. The demand datasets used in the Water Unavailability Methodology represent the State Water Board's current best estimate of demand for these years based on the available information.

Water right records included in the demand dataset at this time are shown in Figure 9 below.

Figure 9. Active Consumptive Appropriative Water Rights and Statements of Diversion and Use in the Delta Watershed



2.2.4 **Disaggregation of Statements of Diversion and Use**

The May 12, 2021 draft and June 15, 2021 version of the methodology were developed to identify when available data indicates that natural and abandoned water supplies are unavailable for post-1914 appropriative water users in the Delta watershed. These prior versions were not intended to identify when water supplies are unavailable for pre-1914 appropriative and riparian claims, and prior versions of the demand dataset did not separate Statements of Diversion and Use into categories. Instead, these earlier versions grouped water demand for all Statements of Diversion and Use under a single demand category with the same assumed senior priority rank.

The Statements of Diversion and Use have now been disaggregated into several assigned categories and have been assigned priority dates. This refinement provides for the forecasting of water unavailability for pre-1914 appropriative and riparian claims. Statements of Diversion and Use were assigned a category based on the water right claim types reported by diverters in Initial Statements of Water Diversion and Use and in 2018 and 2019 annual reports. This user-submitted information was not reviewed for accuracy as part of this analysis but represents the best information currently available. This information may be updated based on additional information, including information submitted by water right claimants through the emergency regulation process.

The following Statement of Diversion and Use categories are currently included in the demand dataset: Riparian, Pre-1914, Riparian/Pre-1914, Reserved, Other, and Unclassified. The vast majority (over 95 percent) of the Statements of Diversion and Use included in the demand dataset were categorized as Riparian, Pre-1914, or Riparian/Pre-1914. Water right records assigned to the Riparian, Pre-1914, and Riparian/Pre-1914 categories also constitute the vast majority (over 95 percent) of the Statement of Diversion and Use demand.

Technical Appendix B further describes the process used to categorize and assign priority dates to Statements of Diversion and Use.

2.2.5 **Demand Aggregation by Subwatershed**

The Water Unavailability Methodology requires that both the supply and demand data be aggregated to a common spatial resolution for comparison purposes. The supply data is generally only available at the HUC8 watershed scale or larger, while the demand data includes both the HUC8 watershed and the precise spatial location (latitude and longitude) of each POD. For the purpose of this analysis, demand values within the demand dataset were aggregated at the same subwatershed scale as supply values within the supply dataset (see section 2.1.3 above). The subwatershed assignments of specific PODs, such as those located near Folsom, Oroville, and Friant Dams, were reassigned on a case-by-case basis within the demand dataset to better fit the demand to the subwatershed from which it draws supply.

All of the PODs of most water right records are geographically located within a single subwatershed. In these instances, all of the demand associated with these rights is attributed to that subwatershed. Sixty-five water right records in the Delta watershed have PODs that span multiple subwatersheds. Of these, 11 are Project water rights, which frequently have PODs upstream at the major storage reservoirs, downstream on major tributaries, and within the Legal Delta. As described in section 2.2.6 below, the Water Unavailability Methodology treats these demands differently because of the unique circumstances of the Projects' diversions. For the 54 remaining non-Project rights that have PODs within multiple subwatersheds, the total reported diversion for each water right record was split among the applicable subwatersheds based on the proportion of the total active direct diversion PODs located within each subwatershed. For example, if a water right record had 3 associated PODs, one of which was located within the Sacramento Bend subwatershed and 2 within the Upper Sacramento Valley subwatershed, one-third of the total demand for the water right would be attributed to the Sacramento Bend subwatershed and two-thirds to the Upper Sacramento Valley subwatershed. An apportionment of demand based on the amount diverted at each POD is not possible at this time because water diversion and use information is typically reported by water right and not for individual PODs.

2.2.6 **Project Demands**

The Projects divert and store water for use by contractors both within and outside of the Delta watershed. These contractors include contractors that do not have their own basis of right and contractors that have their own bases of water right that may also receive supplemental contract supplies (referred to as settlement contractors). Settlement contractors entered into contracts with the Projects to resolve water right disputes related to construction of the Projects. These contracts are not synonymous with the underlying rights but are instead negotiated agreements. Project contractors that do not have their own water rights include CVP service contractors and SWP Table A contractors. CVP service contracts and SWP Table A contracts include contracts for use within the Delta watershed and use outside of the Delta watershed. Diversions by the Projects for uses outside of the Delta watershed are subject to area of origin protection pursuant to the Water Code.[21] This protection prohibits the Projects from diverting for purposes of exporting natural and abandoned flows needed for uses within the Delta watershed.

In recognition of area of origin protection, Project demands were assumed to have the lowest priority date among Delta watershed rights. While some of the Projects' diversions serve inbasin purposes that are not subject to area of origin protection, this summer all of these uses are expected to be met with previously stored water due to the lack of significant inflow and other Project obligations. Adjustments will be considered for the wet season to account for the priority of inbasin uses. However, any changes to the priority dates are not expected to have a significant effect on the analysis given the

[21] Wat. Code, §§ 11128, 11460.

Projects' relatively junior water right priority and the likelihood that curtailment will not be in place when Project direct diversions are occurring for inbasin uses. In addition to recognizing area of origin protection, identifying Project demands as junior to all others ensures that any duplicate reporting between the Projects and their various settlement contractors that have their own underlying water rights or claims of right does not inflate demands in a manner that materially affects the analysis. The exception to this approach is for New Melones Project water rights (A014858A and A014858B). Since New Melones water is not authorized for export out of the Delta watershed, these demands are assumed to be met in accordance with the original priority date of the rights.

Generally, the Projects will not be diverting natural and abandoned flow and will be releasing previously stored water under conditions when notices of water unavailability would be issued. The responsibility to meet water quality and flow requirements effectively results in curtailment of Project water rights without any further action. Accordingly, while notices of water unavailability may still be issued to the Projects, such notices are unlikely to have a material effect. .

2.2.6.1 *Trinity River Imports*

Several consumptive water rights associated with the CVP Trinity River Division (A005628, A015374, A015375, A016767, and A017374) have PODs within the Delta watershed, but the water they divert originates from the Trinity River watershed. These water rights and correlating diversion data were removed from the Delta watershed demand dataset for analysis because the water associated with these diversions is imported to the Delta watershed and does not impact supply forecasting for the watershed.

2.2.6.2 *Settlement Contractor Demands*

As discussed above, there are various water users in the Delta watershed that have settlement contracts with DWR and Reclamation that provide a contractual entitlement of a certain supply to these users. These contracts are intended to satisfy these users' underlying rights and to provide supplemental supplies. Because these users have both their own water rights or claims of right for which they likely report use and contractual supplies for which DWR and Reclamation report use, there may be overlapping reporting of demands.

For the purpose of this analysis, it is assumed that most settlement contractors, with the exception of the Exchange Contractors on the San Joaquin River (see below discussion), have demands for natural and abandoned flows in accordance with their water use reports and that these users will take water pursuant to their senior water rights first if it is available. The fact that the supply may not be available at the senior priority of right or claim of right is not assumed to diminish the demand. Accordingly, settlement contractors may receive notices of water unavailability under their own water

rights and would then need to rely upon contractual supplies to the extent those supplies are available.

Sacramento River and Feather River Settlement Contractor Demands

As a result of the very dry hydrologic conditions this year, allocations to Sacramento River and Feather River settlement contractors under their contracts during the contract period have been reduced to approximately 75 and 50 percent, respectively . However, these reductions are not assumed under this analysis because the contracts are not synonymous with the underlying right or claim. For example, Sacramento River settlement contract amounts total 2.1 million acre-feet (MAF) but reported use under these contractors' underlying water right claims is closer to 1.4 to 1.6 MAF (which is close to 75 percent of the contract amount). Also, these groups of users have different priorities of rights and include a combination of pre-1914 and post-1914 rights (e.g., over 600 thousand acre-feet of Sacramento River settlement contractors' reported use in 2018 occurred under post-1914 claims of right). Accordingly, it is not clear which rights demands should be reduced.

Exchange Contractors

The Exchange Contractors receive replacement supplies exported from the Delta in exchange for use of water from the San Joaquin River under the Exchange Contractors' underlying rights as part of settlement contracts related to the development of the Friant Project by Reclamation. Accordingly, all Exchange Contractor demands are assumed to be met with previously stored CVP supplies since the Exchange Contractors do not use water from the San Joaquin River under their underlying water right claims unless they are shorted supplies under their Exchange Contracts. If shortages occur the assumptions in the methodology will be adjusted to account for those shortages and the resulting demand for San Joaquin River water under the Exchange Contractors' claimed water rights.

2.2.7 **Interbasin Diversions (Yuba-Bear and Drum-Spaulding)**

Non-consumptive uses are generally not included in demand estimates under the methodology at this time. However, the May 12, 2021 draft methodology identified that adjustments were planned to be made to account for the interbasin diversions that occur from the Yuba River watershed to the Bear and American Rivers as part of highly complex hydroelectric project operations under Pacific Gas and Electric Company's (PG&E) Upper Drum-Spaulding Hydroelectric Project and Lower Drum Hydroelectric Project and Nevada Irrigation District's (NID) Yuba-Bear Hydroelectric Project. Under Upper Drum-Spaulding and Yuba-Bear hydroelectric project operations, water is exported from the Yuba River watershed to the Bear River via the South Yuba Canal and the Drum Canal.

Since May 12, 2021, adjustments to the demand dataset to account for interbasin diversions between the Yuba River watershed and Bear River watershed were considered. However, a review of information contained within the applicable PG&E

and NID water right records indicated that diversions through the South Yuba Canal and Drum Canal are already reported under water right records located in the Yuba River subwatershed. In addition, it appears that previously stored water accounts for a large portion of the water transferred from the Yuba River to the Bear River during the summer months. Therefore, adjustments were not applied to account for the interbasin diversions at this time. Adjustments will be considered for the wet season and based on updated demand data that may be submitted pursuant to an emergency regulation.

2.2.8 **Accretions and Return Flow Estimates**

Accretions in the valley floor during the dry season are primarily due to return flows. In recognition that only a portion of diversions are actually consumptively used due to return flows from irrigation and, to a lesser extent, municipal uses, a return flow factor was applied to diversion values within the Delta watershed demand dataset. Return flows are water that is diverted and returned to the river as part of agricultural and urban uses. Agricultural return flows include operational spills from canals, flow through and draining of rice paddies, and drainage from other agricultural fields. The volume of return flows from agriculture varies based on type of use, crop type, location, soils, and season. Urban return flows are primarily comprised of treated effluent from wastewater treatment plants. Natural depletions due to stream-groundwater interaction and demand by riparian vegetation are difficult to estimate and not accounted for in the methodology, which represents a conservative assumption that may overestimate water availability and reduce curtailments.

Out of the hundreds of return flow sources in the Delta watershed, the rates and volumes of most are unknown and only a handful have measurement gages. Rates of return flow can be estimated using models developed to simulate surface and groundwater hydrology. Models that have been developed for the Delta watershed include SacWAM, CalSim, C2VSIM, and regional water budgets developed by DWR. Of these models, CalSim 3 is the most complete hydrologic simulation model of the Sacramento and San Joaquin River watersheds. SacWAM provides detailed representations of the hydrologic processes including return flows in the Sacramento River watershed but does not include a representation of the San Joaquin River watershed. CalSim 3 return flow rates show similar trends to SacWAM results for the Sacramento River watershed. DWR's surface-groundwater model, C2VSIM fine grid, may provide useful information on return flows with future calibration efforts, but at this time the surface hydrology does not correspond well with observed data during dry periods. DWR's regional water budgets may also provide useful estimates of return flows in the future, but at this time they are not available.

CalSim 3 includes simulations for the 1922–2015 period. For the purpose of estimating return flows for the methodology, results for water year 2014 were analyzed because it is a recent year out of the period of simulation that has hydrology that most closely matches current and forecasted conditions for 2021. The CalSim 3 results, summarized in Table 5 and Table 6 below, show an increasing return flow as a percent of diversion

after May continuing throughout the remainder of the irrigation season in the Sacramento River watershed and generally lower and more constant return flows in the San Joaquin River watershed. The increasing proportion of return flow in the Sacramento River watershed is primarily due to decreased diversions in August and September and draining of rice fields in September. Given the extreme dry conditions this year and changes in rice acreage this year, return flow assumptions in the September and to some extent August may be high representing a conservative assumptive that would reduce curtailments. Urban return flows remain relatively constant throughout the irrigation season. In the San Joaquin River watershed, agricultural and urban return flows remain relatively constant throughout the summer.

Table 5. CalSim 3 Results of Monthly Diversions and Return Flows for Sacramento River Watershed, May–September 2014

Month	Diversions (TAF)	Return (TAF)	Percent Return
May	829	320	39%
June	845	161	19%
July	875	184	21%
August	660	187	28%
September	339	324	96%
Annual Average	**4,990**	**2,093**	**42%**

Table 6. CalSim 3 Results of Monthly Diversions and Return Flows for San Joaquin River Watershed, May–September 2014

Month	Diversions (TAF)	Return (TAF)	Percent Return
May	313	75	24%
June	362	76	21%
July	403	85	21%
August	331	68	21%
September	216	54	25%
Annual Average	**2,566**	**605**	**24%**

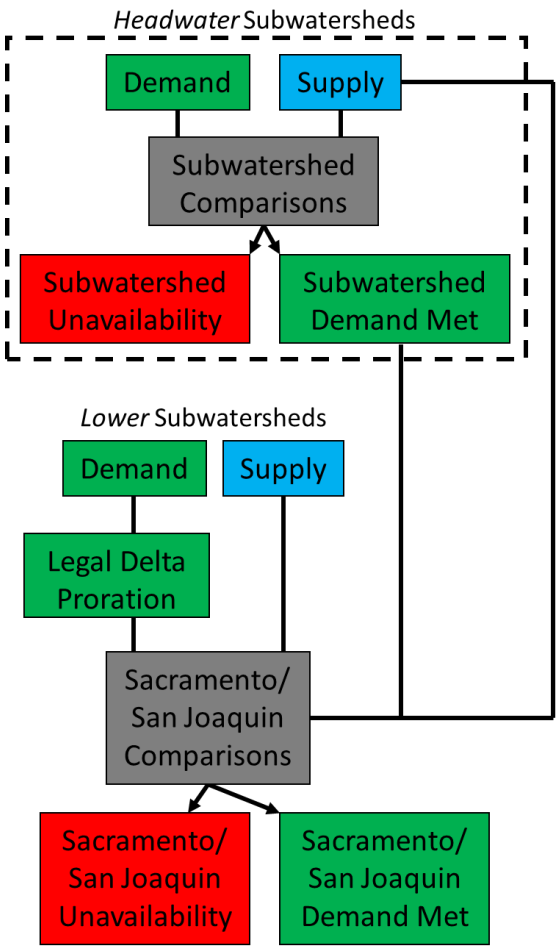
Spatially, most diversions and return flows occur in the Sacramento and San Joaquin Valley regions. Accordingly, return flow factors were only applied to demands in the Sacramento Bend, Upper Sacramento Valley, Sacramento River Valley Floor, and San Joaquin River Valley Floor subwatersheds.

2.3 Adjustments to the Supply and Demand Datasets

2.3.1 Elimination of Unmet Demand

A significant improvement over the water unavailability methodology used in the previous drought is the implementation of a more granular analysis, evaluating supply and demand on both a subwatershed level (e.g., a single tributary like the Feather River) and watershed-wide level (the Sacramento and San Joaquin River watersheds). The watershed-wide analysis also includes water rights that divert from within the Legal Delta (see section 2.3.3 below). This allows for water unavailability to be determined based on physical supplies within a headwater stream and for the accounting of senior demands that may have priority to divert that supply further downstream. Supply and demand are compared at a subwatershed level for those subwatersheds that are not downstream of any other subwatershed. Demands within these “headwater” subwatersheds can only be met by supply originating within the subwatershed itself. Figure 10 below is a schematic showing how this analysis was performed using the supply and demand data previously described.

Figure 10. Schematic of Supply and Demand Analysis at the Subwatershed and Watershed Levels



As shown in Figure 10, supply and demand are first compared within headwater subwatersheds. While supplies from headwater subwatersheds are considered available to meet downstream demands in the larger Sacramento or San Joaquin River watershed analyses, only headwater subwatershed demand that is able to be met by available supply in the headwater subwatershed is considered in the watershed analysis.

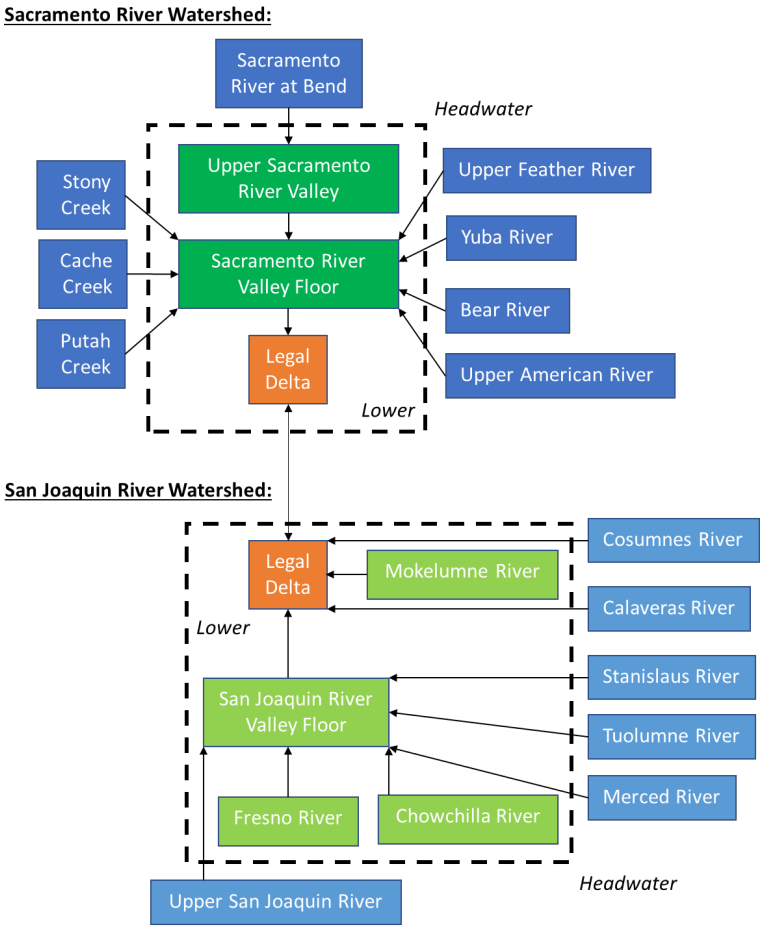
The headwater subwatersheds in the Sacramento River watershed include the Sacramento River and tributaries above Bend, Stony Creek, Cache Creek, Putah Creek, the Upper Feather River above Oroville Dam, Yuba River, Bear River, and the Upper American River above Folsom Dam (see Figure 5). The headwater subwatersheds in the San Joaquin River watershed are the Upper San Joaquin River above Friant Dam, Merced River, Tuolumne River, Stanislaus River, Calaveras River, and the Cosumnes River. Figure 11 below shows a schematic of the subwatersheds previously mapped in Figure 5. A small number of rights in the headwater Putah Creek, Stanislaus River, Calaveras River, and Cosumnes River subwatersheds which lie within

the Legal Delta were excluded from the headwater subwatershed analysis and included only in the Sacramento and San Joaquin watershed-wide analyses, as they have access to water from both the Sacramento and San Joaquin Rivers (see section 2.3.3 below).

Lower subwatersheds are defined as such because they contain demands that can be met by supplies from outside tributaries (the headwater subwatersheds). The Upper Sacramento River Valley and Sacramento River Valley floor subwatersheds are considered lower watersheds because demands within them may be met from the mainstem of the Sacramento River flowing in from the Sacramento River at Bend. Similarly, the San Joaquin River Valley Floor includes demands on the mainstem of the San Joaquin River that can be met by inflow from the Stanislaus, Tuolumne, Merced, and Upper San Joaquin River subwatersheds.

Additional subwatersheds in the San Joaquin River watershed were classified as lower subwatersheds because their boundaries, based on HUC8 watersheds mapped in the USGS NHD (see section 2.1.3 above), contain demands that are not met from supplies within the subwatershed. These consist of the Chowchilla River (which includes minor east side tributaries and the mainstem of the San Joaquin River from Friant Dam to the confluence with the Merced River), Fresno River (which includes diversion points on the Eastside Bypass that are supplied by San Joaquin River flood flows), and the Mokelumne River (which includes demands on the mainstem of the San Joaquin River within the Legal Delta) subwatersheds. The Legal Delta is not a distinct subwatershed; it is a category of rights within several subwatersheds which have access to water from both the Sacramento and San Joaquin Rivers (see section 2.3.3 below).

Figure 11. Subwatersheds Schematic



Diverters within headwater subwatersheds whose demand cannot be physically met by the supply available within those subwatersheds may receive notices of water unavailability based on the headwater subwatershed-level analysis. In addition, if demand in a headwater subwatershed exceeds the available supply, the excess demand is eliminated from the larger watershed-wide analysis. As a result, demand that cannot be met by physically available supplies is not "charged against" supplies from elsewhere in the Delta watershed.

The evaluation of water availability at the headwater subwatershed scale is only part of the evaluation of water availability. Though water may be physically available within a headwater subwatershed, it may be needed to meet the demand of senior users downstream that may have the right to some of the water originating in the headwater subwatershed. This broader availability is shown in the watershed-wide analysis for the Sacramento and San Joaquin River watersheds.

2.3.2 **Treatment of Riparian Demands and Elimination of Supply and Demand in Disconnected Headwater Subwatersheds**

The Water Unavailability Methodology does not currently specifically evaluate water unavailability for individual riparian claimants unless there is no flow available.[22] In times of shortage, riparian rights provide for sharing of those shortages. Given the scale and complexity of the Delta watershed, the methodology does not yet fully evaluate how that sharing should occur. However, the methodology can be used to evaluate general quantities of water that may be unavailable for riparian claimants and when riparian claimants should implement measures to address those shortages. In the future, refinements to the methodology may be made to further address water unavailability for riparian claimants.

If the headwater subwatershed analysis indicates that the total demands of riparian claimants exceed the available supply in a particular headwater subwatershed, the headwater subwatershed's supplies and demands are removed from the watershed-wide analysis for that month. In other words, the methodology assumes that the given stream would not have continuity with the larger Delta watershed and would be considered "disconnected" due to fulfillment of the local senior water right demands.

The Water Unavailability Methodology Spreadsheet, available on the State Water Board's Delta Water Unavailability Methodology webpage, contains a table in the 'Analysis Headwaters' tab which summarizes which headwater subwatersheds were assumed to be disconnected from the Delta watershed in specific months as a result of this analysis.

2.3.3 **Proration of Legal Delta Demands**

Diverters with appropriative water rights with points of diversion within the Legal Delta (as defined in Water Code section 12220) may have access to water supplies entering the Delta from both the Sacramento and San Joaquin River watersheds. To account for this, appropriative demands within the Legal Delta were prorated between the two watersheds based on the monthly proportion of connected supply available (see section 2.3.2 above) from each watershed. For example, if the Sacramento River watershed contributes 80 percent of the water supply reaching the Legal Delta in a given month, 80 percent of Legal Delta appropriative demand is allocated against Sacramento River watershed supply for that month and 20 percent is charged against San Joaquin River watershed supply. The proration of Legal Delta appropriative demands is only applicable to the assessment of water unavailability at a watershed-wide scale and does not impact the assessment of water unavailability at the headwater subwatershed scale.

[22] These demands are assumed to be senior in priority to all other demands for the purposes of the methodology. As discussed above, there may be instances where a pre-1914 appropriative right is senior to a riparian. In those cases, adjustments can be made.

Consistent with the analysis contained in State Water Board Order WR 89-8, the methodology assumes that riparian claims do not have access to supply outside the watershed where they are located (i.e., a riparian claim along the San Joaquin River in the Legal Delta does not have a right to divert natural or abandoned flow of water originating from the Sacramento River). Therefore, Statements of Diversion and Use with points of diversion within the Legal Delta that claim only riparian rights (see section 2.2.4 above) are excluded from the Legal Delta proration process described in the previous paragraph and are only charged against supply in the watershed where they are located. Statements of Diversion and Use with points of diversion in the Legal Delta claiming both riparian rights and pre-1914 or other non-riparian categories of right were assumed for the purposes of the methodology to be riparian claims and were therefore accorded senior priority over all appropriative water rights.[23] Statements of Diversion and Use with points of diversion in the Legal Delta that claim only pre-1914 or other non-riparian categories of right are prorated as described in the previous paragraph.

Monthly supply ratios for the Sacramento and San Joaquin River watersheds were calculated based on data for 2021; for past months of 2021, these months' FNF values were used. For current or future months, the exceedance forecast selected for use in determining water unavailability for each watershed (see section 3.1.1 below) was used for the proration. These supplies include abandoned instream flows in excess of FNF (see section 2.1.6 above) and do not include flows from headwater subwatersheds assumed to be disconnected from the Delta watershed (see section 2.3.2 above).

Water rights and claims with points of diversion within the Legal Delta that claim only non-riparian rights will only receive notices of water unavailability if both the Sacramento River watershed analysis and the San Joaquin River watershed analysis show that water will be unavailable at their priority of right. The hydrology of the Legal Delta is complex, and this proration method offers a simplified and generous assessment of water availability to appropriators in the Legal Delta during this critically dry period.

The methodology does not assume there is storage (residence time) longer than a month in the Legal Delta that would affect water availability given the extremely dry conditions that have persisted for an extended period and the supplementation of flows in the Delta with previously stored water for many months. The methodology also only accounts for freshwater natural flows from the Sacramento and San Joaquin Rivers as part of the available supplies and does not include any water supplies from tidal inflows to the Legal Delta. Saline water entering the Legal Delta from the San Francisco Bay

[23] This categorization of colorable riparian claims within the Legal Delta is consistent with the legal principles described in a memorandum dated December 15, 2017, regarding Issues Related to Overlap between Pre-1914 and Riparian Water Right Claims in the Delta and available on the website of the Office of the Delta Watermaster (Overlap Memo).

via tidal action is assumed to be of insufficient quality to be usable for agricultural or municipal purposes.

2.4 Water Unavailability Visualizations

The Water Unavailability Methodology includes two major types of water unavailability visualizations: the headwater subwatershed visualizations (14 in total) and the watershed-wide visualizations,[24] consisting of one for the Sacramento River watershed and one for the San Joaquin River watershed. Samples of these graphs are provided below in Figures 12, 13, and 14. Each graph can display demand data from either the 2018 or 2019 demand datasets. The demands are sorted by water right priority, with riparian demand at the bottom of the graphs, followed by pre-1914 appropriative demand and post-1914 appropriative demand, which are grouped by priority decade. Project demands are stacked at the top (see section 2.2.6 above).

The subwatershed visualization displays four water supply scenarios: the 10 percent, 50 percent, 90 percent, and 99 percent FNF exceedance forecasts, representing optimistic, neutral, pessimistic, and extremely pessimistic forecasts, respectively. Because conditions in the Delta watershed are currently extremely dry, the adjustments to the supply and demand datasets described in section 2.3 above were done using the 90 percent FNF exceedance forecast.[25] As a result, the watershed-wide visualizations display a single supply scenario, the adjusted 90 percent exceedance forecast.

[24] Supply and demand within the watershed-wide analyses is adjusted as described in section 2.3 above.

[25] Section 3.1.1 below describes how daily FNF may be used to determine which monthly FNF exceedance forecast most closely represents actual conditions.

Figure 12. Sample Headwater Subwatershed Water Unavailability Visualization (Yuba River)

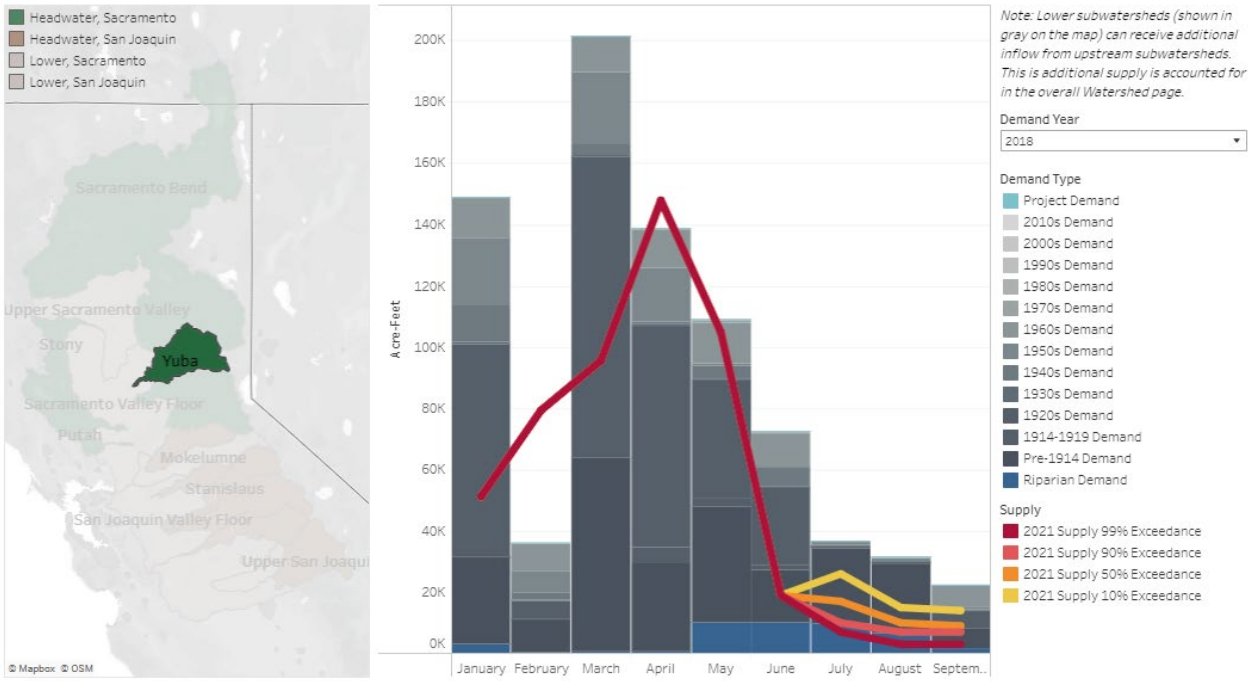


Figure 13. Sample Sacramento River Watershed Water Unavailability Visualization

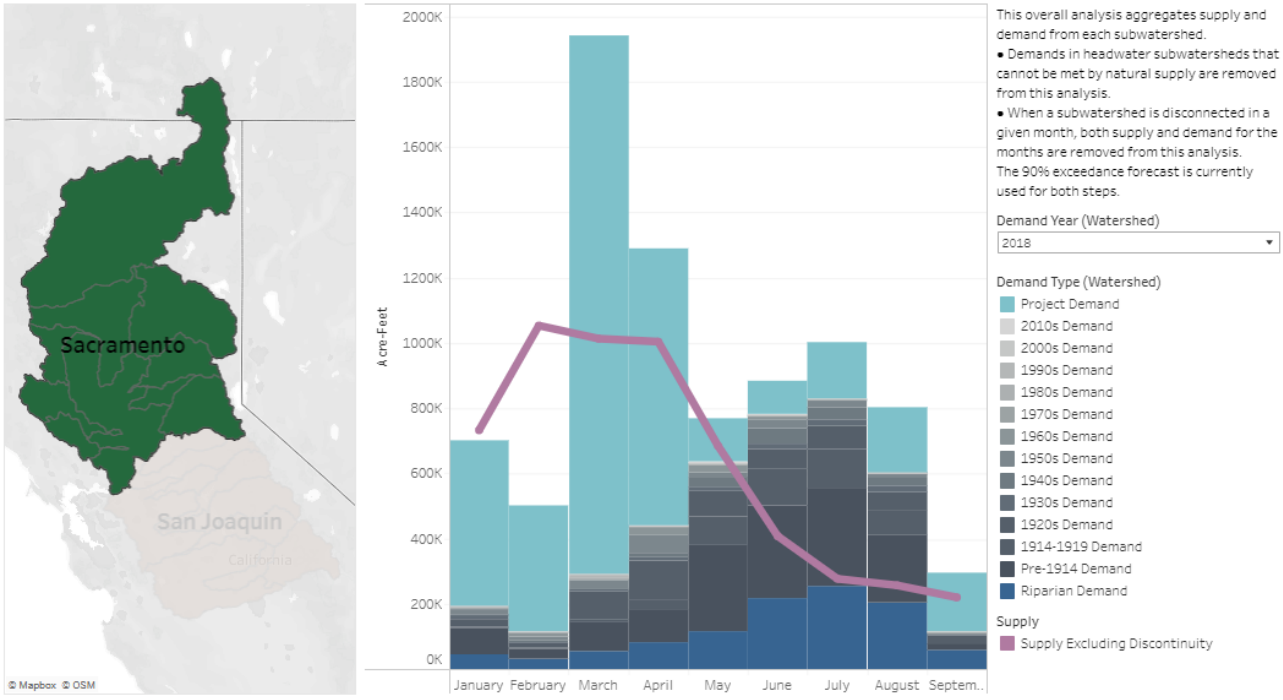
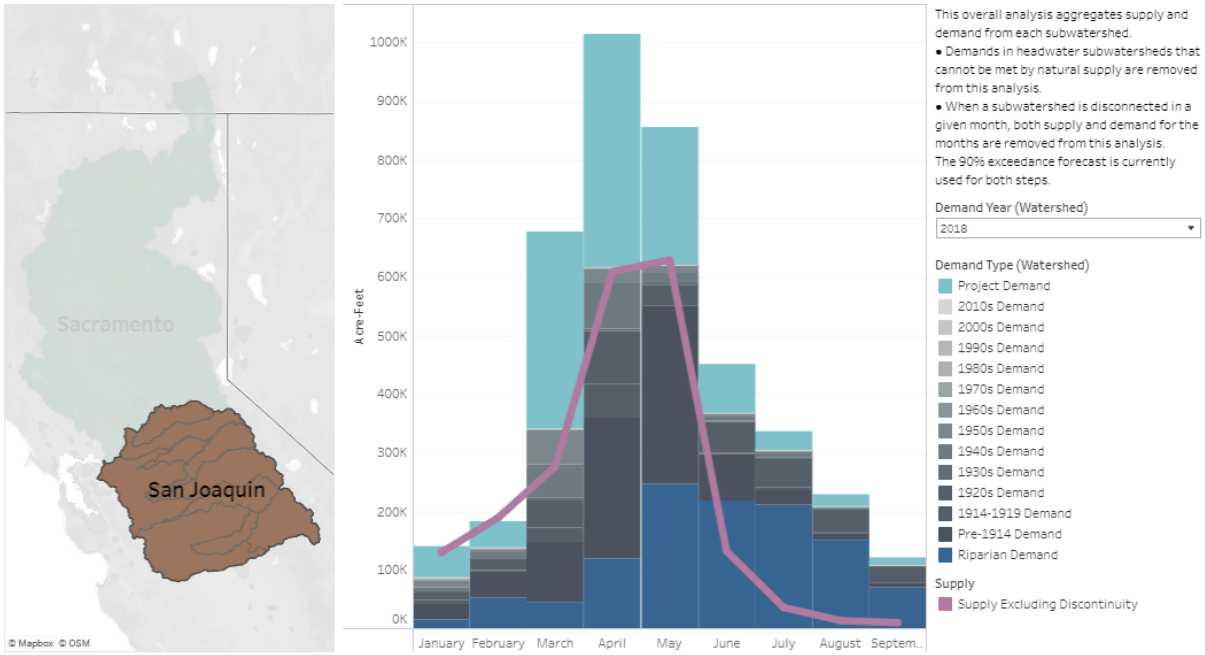


Figure 14. Sample San Joaquin River Watershed Water Unavailability Visualization



The visualizations have been made available on the Board's Delta Water Unavailability Methodology webpage using the Tableau interactive platform and will be updated monthly to reflect current supply conditions and forecasts. As discussed above, the 2018 demand dataset is planned to be used to assess if insufficient supply is available to meet demands (i.e., the demands positioned above the applicable supply line(s) in the visualizations). In cases where riparian demand exceeds supply (i.e., in disconnected headwater subwatersheds or for riparian demands above the applicable supply line(s) in the visualization) there may be water unavailable to meet all riparian demands. Section 3.1 below describes the proposed process for issuing notices of water unavailability to diverters.

3 Implementation

3.1 Issuance of Notices of Water Unavailability

The Water Unavailability Methodology is being used to determine when there is insufficient supply to meet diverters' priorities of right within the Delta watershed based on the best available information, either at the scale of a headwater subwatershed or the wider Sacramento or San Joaquin River watersheds. Based on the prior output of the methodology, on June 15, 2021, the State Water Board issued notices of water unavailability (also referred to simply as "notices") to all post-1914 appropriative water right holders in the Delta watershed indicating that water supplies are not available for

their use. On July 23, 2021, the State Water Board issued further notices of water unavailability to certain pre-1914 users, including all pre-1914 claimants in the San Joaquin River watershed and pre-1914 appropriative claimants in the Sacramento River watershed down to an 1883 priority date. The July 23 notices also notified riparian claimants in the San Joaquin River watershed of correlative supply deficits through September 2021.

Notices are not directives to stop diverting and are different from curtailment orders. Rather, they inform affected diverters that water is expected to be unavailable for their diversion in a future time frame. These notices also play an important policy and public relations role by offering the opportunity for voluntary compliance prior to formal enforcement action by the Board. Diverting unavailable water can result in penalties for injuring more senior water right holders and public trust resources. As discussed above, this methodology may serve as the technical basis for future emergency regulations and associated curtailment orders.

As discussed above, appropriative diverters in the Legal Delta will only receive notices of water unavailability if supply is unavailable to them from both the Sacramento and the San Joaquin Rivers, the issuance of which will be coordinated with the Office of the Delta Watermaster. In addition, implementation of this methodology will operate separately from issuance of curtailment notices pursuant to standard water right Term 91, which has been in effect since April 29, 2021, and is likely to be in effect until significant precipitation occurs.

3.1.1 **Exceedance Forecast Selection**

The methodology requires the selection of an appropriate future supply forecast (e.g., 10 percent, 50 percent, 90 percent, or 99 percent exceedance forecasts) for use in determining which diverters should receive notices of water unavailability or curtailments. To account for the potential variability of daily water supply and the degree of uncertainty inherent in monthly forecasts, cumulative daily FNF estimates[26] for the current month, sourced from CDEC and CNRFC[27] (see Table 1 and Table 2 above) will be compared to the most recent monthly supply forecasts. Interactive visualizations of these comparisons for total supplies in the Sacramento and San Joaquin River watersheds have been made available on the Board's Delta Water Unavailability Methodology webpage using the Tableau interactive platform. These plots will be updated periodically throughout each month to reflect current supply conditions.

[26] As described in section 2.1.4 above, daily FNF data are valuable for the purpose of this check but are not suitable to replace past or forecasted monthly FNF values because they are based on fewer data points than are available at the end of each month and due to the lag time between upstream operations and their effect on downstream flow measurements.

[27] Occasionally, CDEC or CNRFC may report negative daily FNFs. These values are replaced with zero values before any further calculations are performed.

The comparison of monthly forecasts to cumulative daily supplies over the month will provide an indication of which forecast is likely to be the most accurate predictor of actual conditions. These evaluations are planned to error in favor of reducing curtailments. For example, if the cumulative daily FNF tracks close to the 90 percent monthly supply forecast, the 90 percent supply forecast would be used to determine the priority at which notices should be issued. If the daily cumulative FNF exceeds the 90 percent supply forecast only part way through the month, the 50 percent supply forecast may be used. In addition, the State Water Board will continually evaluate the need to discontinue notices of water unavailability based on forecasted or actual precipitation and runoff that does, or is expected to, result in a measurable increase to available supplies. Additional available datasets that may be used to monitor and forecast precipitation and runoff include Quantitative Precipitation Forecasts (QPF) from CNRFC, Atmospheric River (AR) Activity sub-seasonal outlooks from the Center for Western Weather and Water Extremes, use of the USGS Basin Characterization Model, and other tools.

Different exceedance forecasts may be used between the Sacramento River watershed and the San Joaquin River watershed, if appropriate. The exceedance forecast selected for the watershed-wide analyses will also be used for that watershed's headwater subwatershed analyses. For example, if the 90 percent exceedance forecast is determined to be the most likely to accurately predict conditions in the Sacramento River watershed, it will be used for the Sacramento River watershed-wide analysis as well as each of the headwater subwatershed analyses for that watershed.

3.2 Water Quality and Public Trust Resources

The Water Unavailability Methodology does not account for any of the following: (a) water needs for public trust resources; (b) natural instream losses and evaporation; or (c) non-agricultural consumptive uses in the Delta (e.g., open water evaporation, riparian vegetation, etc.).[28] Currently, notices of water unavailability are not proposed to be issued to make water available for the environment, only to make water available for senior water right holders and claimants and to prevent the unlawful diversion of storage releases which are intended to meet water quality and flow requirements or contract demands. The methodology does not affect other obligations that water users may have for meeting flow and other requirements.

3.3 Communication and Public Engagement Strategy

State Water Board staff has engaged with a number of water users on issues related to the development of the Water Unavailability Methodology. In addition, a public workshop regarding the May 12, 2021 draft version of the methodology was held on

[28] For context, the State Water Board's 1977 Drought Report Appendix, Table 14 estimated that non-agricultural consumptive water use in the Delta was as high as 74,560 AF in June 1977.

May 21, 2021, during which numerous parties provided oral comment. Numerous written comments on the draft methodology were also timely received by the May 25, 2021 deadline. Since that time, modifications have been made to the methodology to support the determination of water unavailability for water right holders and claimants in the Delta watershed. These changes are described throughout this document, as well as its technical appendices.

The State Water Board will continue to regularly update the information used to determine water unavailability in the methodology as new data becomes available and as needed to address wet season information needs as described above. Regular updates regarding issues related to water unavailability will be provided to the public during Board meetings. At least monthly updates will also be provided on the Board's Delta Water Unavailability Methodology webpage, including updated water availability visualizations. If daily cumulative FNF significantly exceeds the forecasted monthly supply used in the methodology, the webpage will be updated more frequently to communicate any changed conditions to diverters.

This methodology does not represent a static assessment of how the State Water Board will determine water unavailability within the Delta watershed. The methodology may change as the season progresses and based on new information and refined analyses, as appropriate. This methodology is a first step toward refining the Board's process for issuing notices of water unavailability, which includes refinements upon the 2014 and 2015 methodology that were feasible given existing time and data constraints. Additional refinements to the methodology beyond those discussed above may be needed if the methodology is applied during the upcoming wet season.

4 Areas of Potential Refinement

4.1 Near-Term Opportunities

4.1.1 **Supply**

California water supply data is generated by agencies other than the State Water Board and is, therefore, subject to the data quality assurance programs and improvements of those agencies. In the near-term, the State Water Board will continue to focus refinement efforts on improvements to the preparation of supply data for use in water unavailability analyses. These improvements relate to analysis repeatability, automation of the data preparation process, and data documentation. Within the next few years, the Board may further improve the preparation of supply data via the implementation of additional data validation methods, refinement of the process to identify and fill data gaps, and incorporation of new supply data as it becomes available. The Board may also alter the assumptions of the analysis to reflect increased understanding of groundwater interactions, riparian evapotranspiration, and evaporative losses.

4.1.2 **Demand**

The State Water Board will continue to refine the demand dataset used in the Water Unavailability Methodology as appropriate by streamlining existing processes and improving demand estimates and accounting. This includes the identification of additional data entry errors, estimation of demand values where necessary and feasible, and additional data quality control methods. In addition, as discussed above, emergency regulations may be adopted that require the submittal of demand projections that can be used in the methodology as appropriate. Refinement of the representation of non-consumptive uses will also be evaluated. The Board will also continue ongoing work with diverters to improve water accounting by minimizing instances of duplicate reporting, identifying incorrectly reported re-diversions, refining estimates of return flows from larger scale diverters such as those diverting more than 100,000 AF per year, and increasing compliance with the regulations that resulted from SB88. The Board may also consider specific demand issues within the Legal Delta for lands below sea level as described in the proposed emergency regulations.

Over the next few years, the State Water Board plans to develop cross-validation methods using other datasets such as aerial imagery, OpenET, and land use datasets to assess the validity of reported demand values. The Board may also refine the subwatershed demand aggregation method (see section 2.2.5 above) by developing more accurate estimates of proportional demand for water rights that have PODs located in more than one subwatershed. In addition, the Board may use the historical demand record to develop statistical and predictive approaches to identify outliers in the demand dataset and, in conjunction with outside datasets, develop higher temporal resolution for demand estimates.

4.2 Longer-Term Opportunities

In the next several years as part of larger efforts, the State Water Board will work toward developing a data management plan for the demand dataset. The plan's primary functions will be to formalize quality assurance measures, improve data intake processes, and publish the dataset in accordance with Assembly Bill 1755 and the State Water Board's Open Data Resolution to the extent feasible. During the plan development, the Board will expand upon existing data validation efforts using land use-based demand estimates and collaborate with other agencies or organizations to identify where the installation of telemetered diversion gages is needed to enable the validation of demand data to an acceptable level of accuracy. The Board may also look to refine internal and external accounting methods for contracted water, water transfers, and other issues.

Ultimately, the demand data is most limited by the number of required or available telemetered diversion measurement gages and the relatively infrequent manual reporting requirements. These spatial and temporal limitations prevent the State Water Board from conducting a finer scale analysis and responding in real time to limited water

availability. New requirements for reporting diversions and transitioning to land use-based demand estimates could improve the spatial and temporal coverage of water demand data in California and improve the Board's ability to effectively monitor and manage water supplies.

In the long-term, the Board is also planning to evaluate the use of more sophisticated dynamic evaluation tools capable of addressing the complexities of water unavailability issues in the Delta watershed and other areas of the state with greater spatial and temporal resolution. To be effective, however, these tools are dependent on data of adequate quality.

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Technical Appendix A

Technical Appendix A: Methodology Spreadsheet Description is available on the Delta Water Unavailability Methodology webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html

Technical Appendix B

Technical Appendix B: Demand Dataset Description and Preparation is available on the Delta Water Unavailability Methodology webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html

Appendix C

Appendix C: Summary of Public Comments is available on the Delta Water Unavailability Methodology webpage at https://www.waterboards.ca.gov/drought/drought_tools_methods/delta_method.html

Technical Appendix A: Methodology Spreadsheet Description

This appendix outlines the process used to assess water supply and demand in the Sacramento-San Joaquin Delta (Delta) watershed and describes each input used for the analysis and output produced by the analysis. Each section of this document describes a separate tab in the Delta Water Unavailability Methodology Excel workbook ("spreadsheet"), the significance of each column, and data sources.

Subwatersheds

This tab shows how Hydrologic Unit Code Level 8 (HUC8) watersheds from the U.S. Geological Survey (USGS) Watershed Boundary Database (WBD) are categorized into "subwatersheds" for the purpose of this analysis. It also indicates the primary watershed that each subwatershed is tributary to, as well as the subwatershed "type" (headwater or lower) assigned to each. These relationships underpin much of the analysis. A map of Delta subwatersheds can be found in Figure 5 of the main report.

Field Name(s)	Definition & Methodology	Data Source(s)
Watershed	The two primary river systems in the Delta watershed: Sacramento and San Joaquin.	USGS WBD
Subwatershed	An area encompassing one or more HUC8 watersheds, determined based on geospatial mapping of stream and diversion locations and the availability of full natural flow (FNF) supply locations ("gages"). Subwatershed is the smallest area over which water availability is determined.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Subwatershed Type	Subwatersheds are categorized as either 'headwater' or 'lower' for the purpose of this analysis: - A headwater subwatershed contains water demands which can only be met by water supplies within the subwatershed (i.e., there are no tributaries flowing into the subwatershed). - A lower subwatershed can receive water supplies from outside its boundaries (i.e., it is located downstream of the headwaters).	Staff-determined
HUC8	The boundaries of watersheds which contain land that all drains to the outlet, as delineated and classified by the USGS. This delineation provides a consistent boundary for classifying water supplies and demands for the analysis.	USGS WBD

To the right of the data table is a key for the various colors used for each tab of the spreadsheet. **Green tabs** contain data fields that can be updated or revised to change the analysis; cells with modifiable data are **highlighted green** throughout the spreadsheet. **Orange tabs** contain only a limited number of data fields that accept updates. **Red tabs** contain only data outputs and should not be modified.

Supply Past Monthly

This tab contains historical monthly supply data for each of the 20 subwatersheds in the analysis, dating back as far as water year (WY) 1901 for some subwatersheds (NOTE: a water year runs from October of the previous year through September; e.g., WY 2021 is October 2020 through September 2021). Supply data consists of full natural flow (FNF, also known as "unimpaired flow") data compiled from the California Data Exchange Center (CDEC), a March 2016 report from the Department of Water Resources (DWR) on unimpaired flows in the Central Valley from WY 1922-2014, and the California Nevada River Forecast Center (CNRFC). Direct links to individual gage datasets are provided in the spreadsheet. Supply volumes are provided in units of acre-feet (AF), converted from thousand acre-feet (TAF) for some data sources. Certain fields are estimated or adjusted using gap-filling (GF) procedures, which are explained in the next section.

Field Name(s)	Definition & Methodology	Data Source(s)
Year, WY, Month	The calendar year, water year, and calendar year month of the respective water supply volume. The dataset begins with water year 1901 (starting in October 1900) and continues through the end of water year 2021 (September 2021); data fields for current and future months are blank.	--
Sacramento Bend	Monthly FNF data for the Sacramento River at Bend subwatershed (including the Sacramento, McCloud, and Pit Rivers above Shasta Reservoir and Cow, Cottonwood, Battle, Clear, and Paynes Creeks): - CDEC station SBB, sensor 65 for WY 1906-Present.	CDEC
Stony	Monthly FNF data for the Stony Creek subwatershed (at Black Butte Reservoir): - DWR subbasin UF4 for WY 1922-2014. - CNRFC station EPRC1 (daily TAF summed to monthly AF) with GF augmentation for WY 2015-Present.	DWR, CNRFC w/ staff adjustments
Cache	Monthly FNF data for the Cache Creek subwatershed (above Rumsey): - DWR subbasin UF3 for WY 1922-2014. - GF extrapolation based on Stony Creek for WY 2015-Present.	DWR, staff estimates
Upper Feather	Monthly FNF data for the Upper Feather River subwatershed (at Oroville Dam): - CDEC station FTO, sensor 65 for WY 1906-Present.	CDEC
Yuba	Monthly FNF data for the Yuba River subwatershed (near Smartville): - CDEC station YRS, sensor 65 for WY 1901-Present.	CDEC
Bear	Monthly FNF data for the Bear River subwatershed (near Wheatland): - DWR subbasin UF10 for WY 1922-2014. - GF extrapolation based on Yuba River for WY 2015-Present.	DWR, staff estimates

Field Name(s)	Definition & Methodology	Data Source(s)
Upper American	Monthly FNF data for the Upper American River subwatershed (at Folsom Dam): - CDEC station AMF, sensor 65 for WY 1901-Present.	CDEC
Putah	Monthly FNF data for the Putah Creek subwatershed (near Winters): - DWR subbasin UF2 for WY 1922-2014. - GF extrapolation based on Stony Creek for WY 2015-Present.	DWR, staff estimates
Upper Sacramento Valley	Monthly FNF data for the Upper Sacramento River Valley subwatershed (tributaries between Bend and Butte Slough, including Redbank, Elder, Thomes, Antelope, Mill, Deer, Big Chico, and Butte Creeks): - DWR subbasins UF5+UF7 for WY 1922-2014. - CNRFC stations EDCC1+TCRC1+MLMC1+DCVC1+BKCC1 (daily TAF summed to monthly AF) with GF augmentation for WY 2015-Present.	DWR, CNRFC w/ staff adjustments
Sacramento Valley Floor	Monthly FNF data for the Sacramento Valley Floor subwatershed (minor east and west side tributaries between Stony Creek and the Delta, including tributaries to the Lower Feather and American Rivers): - DWR subbasin UF1 for WY 1922-2014. - GF extrapolation based on Sacramento, Feather, and American Rivers for WY 2015-Present.	DWR, staff estimates
Sac Total	The sum of all subwatershed supplies in the Sacramento River watershed for the given month.	Calculated
Sac Complete Dataset?	Indicates if supply data values are present for all 10 subwatersheds in the Sacramento River watershed for the given month (TRUE/FALSE).	Calculated
Sac Water Year Type	Reconstructed water year hydrologic classification index for the Sacramento Valley, as published by DWR.	DWR

Field Name(s)	Definition & Methodology	Data Source(s)
Chowchilla	Monthly FNF data for the Chowchilla River subwatershed (at Buchanan Reservoir): - DWR subbasin UF20 for WY 1922-2014. - CNRFC station BHNC1 (daily TAF summed to monthly AF) for WY 2015-Present.	DWR, CNRFC
Upper San Joaquin	Monthly FNF data for the Upper San Joaquin River subwatershed (at Friant Dam): - CDEC station SJF, sensor 65 for WY 1901-Present.	CDEC
Fresno	Monthly FNF data for the Fresno River subwatershed (near Daulton or at Hidden Dam): - DWR subbasin UF21 for WY 1922-2014. - CNRFC station HIDC1 (daily TAF summed to monthly AF) for WY 2015-Present.	DWR, CNRFC
Merced	Monthly FNF data for the Merced River subwatershed (near Merced Falls): - CDEC station MRC, sensor 65 for WY 1901-Present.	CDEC
Tuolumne	Monthly FNF data for the Tuolumne River subwatershed (at La Grange Dam): - CDEC station TLG, sensor 65 for WY 1901-Present.	CDEC
Stanislaus	Monthly FNF data for the Stanislaus River subwatershed (below Goodwin Reservoir): - CDEC station SNS, sensor 65 for WY 1901-Present.	CDEC
Calaveras	Monthly FNF data for the Calaveras River subwatershed (at Jenny Lind or New Hogan Reservoir): - DWR subbasin UF15 for WY 1922-2014. - CNRFC station NHGC1 (daily TAF summed to monthly AF) for WY 2015-Present.	DWR, CNRFC

Field Name(s)	Definition & Methodology	Data Source(s)
Mokelumne	Monthly FNF data for the Mokelumne River subwatershed (near Mokelumne Hill): - CDEC station MKM, sensor 65 for WY 1901-Present.	CDEC
Cosumnes	Monthly FNF data for the Cosumnes River subwatershed (at Michigan Bar): - CDEC station CSN, sensor 65 for WY 1908-Present.	CDEC
San Joaquin Valley Floor	Monthly FNF data for the San Joaquin River Valley Floor subwatershed (including minor east and west side tributaries between the Chowchilla and American Rivers): - DWR subbasins UF12+UF17+UF24 for WY 1922-2014. - CNRFC stations MPAC1+OWCC1+MEEC1 (daily TAF summed to monthly AF) + GF extrapolation based on Mokelumne, Cosumnes, San Joaquin, Merced, Tuolumne, and Stanislaus Rivers for WY 2015-Present.	DWR, CNRFC, staff estimates
SJ Total	The sum of all subwatershed supplies in the San Joaquin River watershed for the given month.	Calculated
SJ Complete Dataset?	Indicates if supply data values are present for all 10 subwatersheds in the San Joaquin River watershed for the given month (TRUE/FALSE).	Calculated
SJ Water Year Type	Reconstructed water year hydrologic classification index for the San Joaquin Valley, as published by DWR.	DWR
Total Supply	The sum of all water supplies in the Delta (Sacramento and San Joaquin River watersheds) for the given month.	Calculated
% Sacramento	The percent of the given month's total Delta watershed supply which came from the Sacramento River watershed.	Calculated
% San Joaquin	The percent of the given month's total Delta watershed supply which came from the San Joaquin River watershed.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Delta Complete Dataset?	Indicates if supply data values are present for all 20 subwatersheds in the Delta watershed for the given month (TRUE/FALSE).	Calculated

Supply Gap Filling (GF)

This tab contains monthly factors which are used to fill gaps in supply data for select subwatersheds, either to estimate missing past/forecasted data (extrapolation) or to adjust existing supply data (augmentation). These monthly average factors are computed based on supply data described in the previous section, and detailed methods for each subwatershed are described in the table below.

Field Name(s)	Definition & Methodology	Data Source(s)
Month	Month of the calendar year for which the gap-filling factor applies.	--
Cache-Stony Ratio (CSR)	Monthly factor used to extrapolate the FNF supply for the Cache Creek subwatershed based on data for the Stony Creek subwatershed: - CSR = DWR subbasin UF3 / DWR subbasin UF4 for WY -1922-2014, removed outlying values >20 and averaged by month. - GF Cache = CSR*(EPRC1*SIF) for WY 2015-Present and Forecasts.	Calculated
Stony Increase Factor (SIF)	Monthly factor used to augment recent FNF supply values for the Stony Creek subwatershed to approximate the entire subwatershed's supply based on past DWR data (CNRFC station EPRC1 is located upstream of several tributaries): - SIF = DWR subbasin UF4 / CNRFC station EPRC1 for WYs 2013-2014, removed outlying values >6 and averaged by month. - GF Stony = SIF*EPRC1 for WY 2015-Present and Forecasts.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Bear-Yuba Ratio (BYR)	Monthly factor used to extrapolate the FNF supply for the Bear River subwatershed based on data for the Yuba River subwatershed: - BYR = DWR subbasin UF10 / CDEC station YRS for WY -1922-2014, removed outlying value >1 and averaged by month. - GF Bear = BYR*YRS for WY 2015-Present and Forecasts.	Calculated
Elder-Thomes Increase Factor (ETIF)	Monthly factor used to augment recent FNF supply values for west side tributaries in the Upper Sacramento River Valley subwatershed to approximate the supply of all west side tributaries based on past DWR data (CNRFC stations EDCC1 and TCRC1 do not include all west side tributaries): - ETIF = DWR subbasin UF5 / (CNRFC stations EDCC1+TCRC1) for WYs 2013-2014, removed outlying values >8 and averaged by month. - GF Upper Sacramento Valley West = ETIF*(EDCC1+TCRC1) for WY 2015-Present and Forecasts.	Calculated
Mill-Deer-Butte Increase Factor (MDBIF)	Monthly factor used to augment recent FNF supply values for east side tributaries in the Upper Sacramento River Valley subwatershed to approximate the supply of all east side tributaries based on past DWR data (CNRFC stations MLMC1, DCVC1, and BKCC1 do not include all east side tributaries): - MDBIF = DWR subbasin UF7 / (CNRFC stations MLMC1+DCVC1+BKCC1) for WYs 2013-2014, averaged by month. - GF Upper Sacramento Valley East = MDBIF*(MLMC1+DCVC1+BKCC1) for WY 2015-Present and Forecasts.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Putah-Stony Ratio (PSR)	Monthly factor used to extrapolate the FNF supply for the Putah Creek subwatershed based on data for the Stony Creek subwatershed: - PSR = DWR subbasin UF2 / DWR subbasin UF4 for WY 1922-2014, removed outlying values of zero and averaged by month. - GF Putah = PSR*(EPRC1*SIF) for WY 2015-Present and Forecasts.	Calculated
Sacramento Valley Ratio (SRVR)	Monthly factor used to extrapolate the FNF supply for the Sacramento River Valley Floor subwatershed based on data for the Sacramento, Feather, and American Rivers (no recent or projected supply data exists for the Valley Floor): - SRVR = DWR subbasin UF1 / CDEC stations SBB+FTO+AMF for WY 1922-2014, removed outlying values >0.3 and averaged by month. - GF Sacramento Valley Floor = SRVR*(SBB+FTO+AMF) for WY 2015-Present and Forecasted.	Calculated
San Joaquin-Mokelumne-Cosumnes Ratio (SJMCR)	Monthly factor used to extrapolate the FNF supply for east side tributaries in the San Joaquin River Valley Floor subwatershed based on data for the Mokelumne and Cosumnes Rivers (no recent or projected supply data exists for the Valley Floor): - SJMCR = DWR subbasin UF12 / CDEC stations MKM+CSN for WY -1922-2014, removed outlying values >5 and averaged by month. - GF San Joaquin Valley Floor East = SJMCR*(MKM+CSN) for WY 2015-Present and Forecasted.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
San Joaquin-Merced-Tuolumne-Stanislaus Ratio (SJMTSR)	Monthly factor used to estimate the FNF supply for west side tributaries in the San Joaquin River Valley Floor subwatershed based on data for the San Joaquin, Merced, Tuolumne, and Stanislaus Rivers (no recent or projected supply data exists for the Valley Floor): - SJMTSR = DWR subbasin UF24 / CDEC stations SJF+MRC+TLG+SNS for WY - 1922-2014, removed outlying values >0.06 and averaged by month. - GF San Joaquin Valley Floor West = SJMTSR*(SJF+MRC+TLG+SNS) for WY 2015-Present and Forecasted.	Calculated

Supply Adjust (SA)

This tab contains monthly instream flow requirements for each subwatershed, which are used to increase available supplies to account for the abandonment of these dedicated flows below their intended reach. Flow requirements are sourced from the Division's Sacramento Valley Water Allocation Model (SacWAM) and Water Supply Effects (WSE) model. Only requirements which crossed subwatershed boundaries or ended near the bottom of a subwatershed (less than 30 river miles from its mouth) are included. If the instream flow reach ends higher up in the subwatershed, such that it may meet demand within that subwatershed itself, the abandoned instream flow is not considered in the analysis. The origin of each instream flow requirement is detailed in the Note column.

All flow values in the Supply Adjust (SA) table are given in average cubic feet per second (CFS) by month, which are converted to acre-feet (AF) per month later in the analysis (see Headwater Reductions and Analysis Watersheds sections below). The supply contribution of each subwatershed to the watershed-wide analysis is represented by the greater of either the past or forecasted full natural flow (FNF, see next section) or the abandoned instream flow in this table for the respective subwatershed and month. In other words, during very dry conditions instream flows were assumed to consist of supplemental reservoir releases which would replace available natural flows when abandoned below their intended reach. During wet conditions instream flows were assumed to consist of bypassed natural flows, which would not contribute abandoned water in excess of FNF below their intended reach.

Supply Forecast

This tab contains forecasted monthly supply data for each of the 20 subwatersheds in the analysis. Like past supply data, forecasted values consist of full natural flow (FNF, also known as "unimpaired flow") estimates published by other agencies. Sources include DWR's Bulletin 120 Water Supply Forecast (B-120) Sacramento Water Supply Index (SRWSI) and San Joaquin Water Supply Index (SJWSI), the California Nevada River Forecast Center (CNRFC), and gap-filled (GF) data for certain watersheds without published forecasts. Direct links to individual forecast datasets are provided in the spreadsheet. Supplies volumes are provided in units of thousand acre-feet (TAF) and converted in the spreadsheet to acre-feet (AF).

This tab is grouped vertically into six tables, separated by black rows. Each table contains forecasted FNF values with a given exceedance probability: 10%, 25%, 50%, 75%, 90%, and 99%. Data fields for past months of the year reference the Past Supply Monthly tab, while forecast values for future months are updated at the beginning of each month. CNRFC forecasts are downloaded on the first of each month, while new B-120 SRWSI/SJWSI forecasts are published on the fifth business day of each month from December-May. CNRFC forecasts require additional intermediate data processing to convert from their default format of 39 daily forecast traces in thousands of cubic feet per second (TCFS) to monthly exceedance probabilities in TAF, which is done outside of the spreadsheet.

Field Name(s)	Definition & Methodology	Data Source(s)
Year, Month, Date	The calendar year, calendar year month, and date of the respective water supply forecast.	--
Sacramento Bend	Monthly FNF forecasts for the Sacramento River at Bend subwatershed: - B-120 SRWSI. - When B-120 unavailable, CNRFC station BDBC1 (daily TCFS converted to monthly TAF).	B-120
Stony	Monthly FNF forecasts for the Stony Creek subwatershed (at Black Butte Reservoir): - CNRFC station EPRC1 (daily TCFS converted to monthly TAF) with GF augmentation.	CNRFC w/ staff adjustments
Cache	Monthly FNF forecasts for the Cache Creek subwatershed (above Rumsey): - GF extrapolation based on Stony Creek.	Staff estimates

Field Name(s)	Definition & Methodology	Data Source(s)
Upper Feather	Monthly FNF forecasts for the Upper Feather River subwatershed (at Oroville): - B-120 SRWSI. - When B-120 unavailable, CNRFC station ORDC1 (daily TCFS converted to monthly TAF).	B-120
Yuba	Monthly FNF forecasts for the Yuba River subwatershed (near Smartville plus Deer Creek or Englebright Reservoir): - B-120 SRWSI. - When B-120 unavailable, CNRFC station HLEC1 (daily TCFS converted to monthly TAF).	B-120
Bear	Monthly FNF forecasts for the Bear River subwatershed (near Wheatland): - GF extrapolation based on Yuba River.	Staff estimates
Upper American	Monthly FNF forecasts for the Upper American River subwatershed (below Folsom Lake): - B-120 SRWSI. - When B-120 unavailable, CNRFC station FOLC1 (daily TCFS converted to monthly TAF).	B-120
Putah	Monthly FNF forecast for the Putah Creek subwatershed (near Winters): - GF extrapolation based on Stony Creek.	Staff estimates
Upper Sacramento Valley	Monthly FNF forecasts for the Upper Sacramento River Valley subwatershed (tributaries between Bend and Butte Slough, including Redbank, Elder, Thomes, Antelope, Mill, Deer, Big Chico, and Butte Creeks): - CNRFC stations EDCC1+TCRC1+MLMC1+DCVC1+BKCC1 (daily TCFS converted to monthly TAF) with GF augmentation.	CNRFC w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Sacramento Valley Floor	Monthly FNF forecasts for the Sacramento Valley Floor subwatershed (minor east and west side tributaries between Stony Creek and the Delta, including tributaries to the Lower Feather and American Rivers): - GF extrapolation based on Sacramento, Feather, and American Rivers.	Staff estimates
Sac Total	The sum of all subwatershed supplies in the Sacramento River watershed for the given month and forecast exceedance.	Calculated
Supply forecasts for all Sacramento subwatersheds are converted to AF.		
Chowchilla	Monthly FNF forecasts for the Chowchilla River subwatershed (at Buchanan Reservoir): - CNRFC station BHNC1 (daily TCFS converted to monthly TAF).	CNRFC
Upper San Joaquin	Monthly FNF forecasts for the Upper San Joaquin River subwatershed (inflow to Millerton Lake): - B-120 SJWSI. - When B-120 unavailable, CNRFC station FRAC1 (daily TCFS converted to monthly TAF).	B-120
Fresno	Monthly FNF forecasts for the Fresno River subwatershed (at Hidden Dam): - CNRFC station HIDC1 (daily TCFS converted to monthly TAF).	CNRFC
Merced	Monthly FNF forecasts for the Merced River subwatershed (below Merced Falls or Exchequer Reservoir): - B-120 SJWSI. - When B-120 unavailable, CNRFC station EXQC1 (daily TCFS converted to monthly TAF).	B-120

Field Name(s)	Definition & Methodology	Data Source(s)
Tuolumne	Monthly FNF forecasts for the Tuolumne River subwatershed (below La Grange Reservoir or New Don Pedro Reservoir): - B-120 SJWSI. - When B-120 unavailable, CNRFC station NDPC1 (daily TCFS converted to monthly TAF).	B-120
Stanislaus	Monthly FNF forecasts for the Stanislaus River subwatershed (below Goodwin Reservoir or New Melones Reservoir): - B-120 SJWSI. - When B-120 unavailable, CNRFC station NMSC1 (daily TCFS converted to monthly TAF).	B-120
Calaveras	Monthly FNF forecasts for the Calaveras River subwatershed (New Hogan Reservoir): - CNRFC station NHGC1 (daily TCFS converted to monthly TAF).	CNRFC
Mokelumne	Monthly FNF forecasts for the Mokelumne River subwatershed (near Mokelumne Hill): - CNRFC station MHBC1 (daily TCFS converted to monthly TAF).	CNRFC
Cosumnes	Monthly FNF forecasts for the Cosumnes River subwatershed (at Michigan Bar): - CNRFC station MHBC1 (daily TCFS converted to monthly TAF).	CNRFC
San Joaquin Valley Floor	Monthly FNF forecasts for the San Joaquin River Valley Floor subwatershed (including minor east and west side tributaries between the Chowchilla and American Rivers): - CNRFC stations MPAC1+OWCC1+MEEC1 (daily TCFS converted to monthly TAF) + GF extrapolation based on Mokelumne, Cosumnes, San Joaquin, Merced, Tuolumne, and Stanislaus Rivers.	CNRFC, staff estimates
SJ Total	The sum of all subwatershed supplies in the San Joaquin River watershed for the given month and forecast exceedance.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Supply forecasts for all San Joaquin subwatersheds are converted to AF.		
% Sacramento	The percent of total Delta watershed supply for the given month and forecast exceedance which came from the Sacramento River watershed.	Calculated
% San Joaquin	The percent of total Delta watershed supply for the given month and forecast exceedance which came from the San Joaquin River watershed.	Calculated
Stony	Original monthly FNF forecasts (pre-GF augmentation) for the Stony Creek subwatershed (at Black Butte Reservoir): - CNRFC station EPRC1 (daily TCFS converted to monthly TAF).	CNRFC
Sacramento Minor Streams West	Original monthly FNF forecasts (pre- GF augmentation) for two west side streams in the Upper Sacramento River Valley subwatershed (Elder and Thomes Creeks at Paskenta): - CNRFC stations EDCC1+TCRC1 (daily TCFS converted to monthly TAF).	CNRFC
Sacramento Minor Streams East	Original monthly FNF forecasts (pre- GF augmentation) for three east side streams in the Upper Sacramento River Valley subwatershed (Mill Creek at Los Molinos, Deer Creek at Vina, and Butte Creek at Chico): - CNRFC stations MLMC1+DCVC1+BKCC1 (daily TCFS converted to monthly TAF).	CNRFC
San Joaquin Valley Floor	Original daily FNF data (before being added to other GF extrapolated datasets) for three east side streams in the San Joaquin River Valley Floor subwatershed (Mariposa Creek at Mariposa Reservoir, Owens Creek at Owens Reservoir, and Bear Creek at McKee Road): - CNRFC stations MPAC1+OWCC1+MEEC1 (daily TCFS converted to monthly TAF).	CNRFC

Supply Daily Monitoring

This tab contains daily cumulative supply data (full natural flow, FNF) for a single month, which are compared to the monthly water supply forecasts described in the previous section for the purpose of selecting the most appropriate supply forecast to use when issuing notices of water unavailability. Additional methods to assess water availability based on precipitation events or other forecasts may be used during the wet season.

There are inherent uncertainties in the forecasting of water supply, and daily water supplies may vary depending on changing conditions (e.g., precipitation, temperatures, or snowpack). Since supply forecasts are only updated at the beginning of each month, this daily cumulative data monitoring helps provide an indication of which forecast is likely to be the most accurate predictor of actual conditions as the month continues. If the daily cumulative FNF exceeds a given forecast only partway through the month, the next highest forecast may be used to adjust the timing or scope of notices of water unavailability.

This tab is grouped vertically into three tables, separated by black rows:

1. The top table shows monthly forecasted FNF values for each subwatershed by exceedance, all in acre-feet (referencing the Supply Forecast tab). The cells in this table have conditional formatting to **highlight red** if the cumulative daily supply for that subwatershed (middle table) has exceeded the given monthly forecast.
2. The middle table shows the calculated total cumulative daily FNF for each subwatershed, all converted to acre-feet (AF).
3. The bottom table contains the daily FNF supply values, which are updated from the data sources linked in the middle table (NOTE: any negative reported values are changed to zero). These values are in the default units of each source: AF, thousand acre-feet (TAF), or cubic feet per second (CFS).

Unless otherwise noted, the below table defines fields from the bottom table in the spreadsheet. Values in the top table reference the previous Supply Forecast tab, while values in the middle table are computed from data in the bottom table.

Field Name(s)	Definition & Methodology	Data Source(s)
Forecast	The exceedance probability of the given forecasted supply value (top table only).	--
Date	Days of the (calendar year) month over which water supply is being tracked. This tab can only track one month's supply at a time.	--

Field Name(s)	Definition & Methodology	Data Source(s)
Sacramento Bend	Daily FNF data for the Sacramento River at Bend subwatershed: - CDEC station BND, sensor 8	CDEC
Stony	Daily FNF data for the Stony Creek subwatershed (at Black Butte Reservoir): - CNRFC station EPRC1 with GF augmentation (original data to right of the main table).	CNRFC w/ staff adjustments
Cache	Daily FNF data for the Cache Creek subwatershed (above Rumsey): - GF extrapolation based on Stony Creek (with GF augmentation).	Staff estimates
Upper Feather	Daily FNF data for the Upper Feather River subwatershed (at Oroville Dam): - CDEC station ORO, sensor 8.	CDEC
Yuba	Daily FNF data for the Yuba River subwatershed (near Smartville): - CDEC station YRS, sensor 8.	CDEC
Bear	Daily FNF data for the Bear River subwatershed (near Wheatland): - GF extrapolation based on Yuba River.	Staff estimates
Upper American	Daily FNF data for the Upper American River subwatershed (at Lake Natoma): - CDEC station NAT, sensor 8.	CDEC
Putah	Daily FNF data for the Putah Creek subwatershed (near Winters): - GF extrapolation based on Stony Creek.	Staff estimates
Upper Sacramento Valley	Daily FNF data for the Upper Sacramento River Valley subwatershed (tributaries between Bend and Butte Slough, including Redbank, Elder, Thomes, Antelope, Mill, Deer, Big Chico, and Butte Creeks): - CNRFC stations EDCC1+TCRC1+MLMC1+DCVC1+BKCC1 with GF augmentation (original data to right of main table).	CNRFC w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Sacramento Valley Floor	Daily FNF for the Sacramento Valley Floor subwatershed (minor east and west side tributaries between Stony Creek and the Delta, including tributaries to the Lower Feather and American Rivers): - GF extrapolation based on Sacramento, Feather, and American Rivers.	Staff estimates
Sac Total	The sum of all subwatershed supplies in the Sacramento River watershed for the given day (all converted to AF).	Calculated
Chowchilla	Daily FNF data for the Chowchilla River subwatershed (at Buchanan Reservoir): - CNRFC station BHNC1.	CNRFC
Upper San Joaquin	Daily FNF data for the Upper San Joaquin River subwatershed (at Friant Dam): - CDEC station SJF, sensor 8.	CDEC
Fresno	Daily FNF for the Fresno River subwatershed (at Hidden Dam): - CNRFC station HIDC1.	CNRFC
Merced	Daily FNF for the Merced River subwatershed (at New Exchequer Dam/Lake McClure): - CDEC station EXC, sensor 8.	CDEC
Tuolumne	Daily FNF data for the Tuolumne River subwatershed (at La Grange Dam): - CDEC station TLG, sensor 8.	CDEC
Stanislaus	Daily FNF data for the Stanislaus River subwatershed (at Goodwin Dam): - CDEC station GDW, sensor 8.	CDEC
Calaveras	Daily FNF data for the Calaveras River subwatershed (at New Hogan Reservoir): - CNRFC station NHGC1.	CDEC
Mokelumne	Daily FNF data for the Mokelumne River subwatershed (near Mokelumne Hill): - CDEC station MKM, sensor 8.	CDEC
Cosumnes	Daily FNF data for the Cosumnes River subwatershed (at Michigan Bar): - CDEC station MHB, sensor 8.	CDEC

Field Name(s)	Definition & Methodology	Data Source(s)
San Joaquin Valley Floor	Daily FNF data for the San Joaquin River Valley Floor subwatershed (including minor east and west side tributaries between the Chowchilla and American Rivers): - CNRFC stations MPAC1+OWCC1+MEEC1 (original data to right of main table) + GF extrapolation based on Mokelumne, Cosumnes, San Joaquin, Merced, Tuolumne, and Stanislaus Rivers.	CNRFC, staff estimates
SJ Total	The sum of all subwatershed supplies in the Sacramento River watershed for the given day (all converted to AF).	Calculated
Total Supply	The sum of all water supplies in the Delta (Sacramento and San Joaquin River watersheds) for the given day (all converted to AF).	Calculated
% Sacramento	The percent of the given month's total Delta supply which came from the Sacramento River watershed.	Calculated
% San Joaquin	The percent of the given month's total Delta supply which came from the San Joaquin River watershed.	Calculated
Stony	Original daily FNF data (pre-GF augmentation) for the Stony Creek subwatershed (at Black Butte Reservoir): - CNRFC station EPRC1.	CNRFC
Sacramento Minor Streams West	Original daily FNF data (pre-GF augmentation) for two west side streams in the Upper Sacramento River Valley subwatershed (Elder and Thomes Creeks at Paskenta): - CNRFC stations EDCC1 and TCRC1.	CNRFC
Sacramento Minor Streams East	Original daily FNF data (pre-GF augmentation) for three east side streams in the Upper Sacramento River Valley subwatershed (Mill Creek at Los Molinos, Deer Creek at Vina, and Butte Creek at Chico): - CNRFC stations MLMC1, DCVC1, and BKCC1.	CNRFC

Field Name(s)	Definition & Methodology	Data Source(s)
San Joaquin Valley Floor	Original daily FNF data (before being added to other GF extrapolated datasets) for three east side streams in the San Joaquin River Valley Floor subwatershed (Mariposa Creek at Mariposa Reservoir, Owens Creek at Owens Reservoir, and Bear Creek at McKee Road): - CNRFC stations MPAC1, OWCC1, and MEEC1.	CNRFC

Demand

This tab contains monthly water diversion (demand) data for active, consumptive water right records in the Delta watershed. This data originated from the State Water Board's Electronic Water Rights Information Management System (eWRIMS) database. Technical Appendix B describes the process used to select these water right records and quality-control reported data to produce this dataset. In this tab each row quantifies water diversions (demand) for a single water right or claim in each month of the 2018 and 2019 calendar years, which are used as proxies for 2021 water demand in this analysis. Demand data are further adjusted in the Demand Separated tab (see next section) to account for water rights with diversion points in multiple subwatersheds and return flows.

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Water Right Application ID Number; each water right record on file with the State Water Board is assigned a unique Application ID Number.	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
Water Right Type	Water right type (see Appendix B for additional information on the different Statement assigned categories): - Appropriative: A post-1914 appropriative water right pursuant to a permit or license from the Board. - Statement of Div[ersion] and Use (Riparian): A riparian water right claim. - Statement of Div[ersion] and Use (Riparian/Pre-1914): A riparian and pre-1914 appropriative water right claim. - Statement of Div[ersion] and Use (Pre-1914): A pre-1914 appropriative water right claim. - Statement of Div[ersion] and Use (Reserved): A federal reserved water right claim. - Statement of Div[ersion] and Use (Other): Any other category of water right claim (e.g. court decreed/adjudicated or contract/agreement). - Statement of Div[ersion] and Use (Unclassified): A water right claim with an unspecified category.	eWRIMS database w/ staff adjustments
Water Right Status	Status of the water right or claim, according to the Board's records: - Licensed: A post-1914 appropriative water right for which the Board has issued a license. - Permitted: A post-1914 appropriative water right for which the Board has issued a permit. - Claimed: A water right claimed by the owner (i.e., Statements of Diversion and Use) which the Board has not verified.	eWRIMS database
Primary Owner	Name of the primary owner of the water right record.	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
Beneficial Use(s)	Concatenated list of the beneficial use(s) of water associated with the water right record, as defined by Water Code §§ 660-669.	eWRIMS database
Priority Date	The priority date of the water right records (YYYY/MM/DD): - Appropriative: Assumed to be the earlier of the Application Acceptance Date and Application Received Date attributes. - Statement of Div[ersion] and Use (Riparian): 'Riparian' and assumed to be senior to all non-Riparian demands. - Statement of Div[ersion] and Use (Riparian/Pre-1914, Pre-1914, Reserved, or Other): Assumed to be January 1st of the earliest claimed Year Diversion Commenced attribute, which is present in the Initial Statement of Diversion and Use and annual Supplemental Statements of Diversion and Use. Further adjusted in the Demand Separated tab for Riparian/Pre-1914 and Other Statements and Appropriative Project rights.	eWRIMS database
Face Value (AFA)	The maximum annual amount of water authorized for diversion under an appropriative water right. Statements, including Riparian and Pre-1914 Appropriative claims, do not have an assigned face value; for the purposes of this analysis, their face value is assumed to be zero.	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
2018/2019 Annual Diversion	The total reported diversion of the water right record in calendar year 2018 or 2019. These values include user-reported direct diversions and diversions to storage from annual reports. Values for select water right records were manually reviewed by staff and corrected as necessary.	eWRIMS database w/ staff adjustments
2018/2019 Review	Indicates whether and how the 2018 or 2019 reported diversion was reviewed or corrected by staff: - Estimated Downward: Staff reviewed and corrected the user-reported diversion value to be higher than reported. - Estimated Upward: Staff reviewed and corrected the user-reported diversion value to be lower than reported. - Reviewed Not Changed: Staff reviewed the reported diversion value but did not apply a correction. - Not Reviewed: Staff did not manually review this annual report.	Staff-determined
Jan-Dec 2018/2019 Diversion	The total reported diversion of the water right record in each month of calendar year 2018 or 2019. These values include user-reported direct diversions and diversions to storage from annual reports. Values for select water right records were manually reviewed by staff and corrected as necessary.	eWRIMS database w/ staff adjustments

Demand Factors

This tab contains monthly factors which are used to adjust demand data to account for return flows within each subwatershed on a monthly basis. Demand factors are calculated for each month in the Sacramento and San Joaquin River watersheds as the percent of diversion which returned as flow within the same month (Factor = Total Diversions / Total Return Flows) from May through September. Data used to determine

the factors, which include return flows from both agricultural and municipal water uses, were sourced from CalSim 3 results published by DWR. Results from WY 2014 are used, as its hydrology most closely matches forecasts for the remainder of WY 2021.

All values in the Demand Factor table are given as multipliers (i.e., a demand factor of 0.6 means that the analysis will reduce demands within the given subwatershed in the given month by 40%). Demand values in the analysis are adjusted by multiplying monthly demand for a given water right by the monthly factor for the appropriate subwatershed where it diverts. The 2021 Methodology currently only applies demand factors to reduce demands within lower valley portions of the Delta watershed (the Sacramento Bend, Upper Sacramento Valley, Sacramento Valley Floor, and San Joaquin Valley Floor subwatersheds) because return flows from diversions within headwater subwatersheds are not expected to be available within the same subwatershed (i.e., they return further downstream on the valley floor). Demand adjustments are done in the Demand Separated tab of the spreadsheet (see next section).

Demand Separated

This tab contains monthly demand data for water rights in the Delta watershed, which are modified from the Demand tab (see previous section) to account for return flows and water rights with points of diversion (PODs) in multiple subwatersheds. This demand separation is necessary because annual water right reports, and thus the data in the Demand tab of the spreadsheet, are provided for each water right rather than each POD. While the data necessary to separate demands originated from the Division's eWRIMS database, staff judgement is required to develop the Demand Weights listed in this tab based on the nature of PODs associated with each right. Demand adjustments to account for return flows are sourced from the Demand Factors tab of the spreadsheet. Each row quantifies monthly demands from a single water right's POD(s) within a single HUC8.

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Application ID of the water right, sourced from the Demand tab. Water rights with PODs in multiple HUC8s are split into multiple rows, one for each HUC8.	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
Water Right Type	Water right type, sourced from the Demand tab: - Appropriative: A post-1914 appropriative water right pursuant to a permit or license from the Board. - Statement of Div[ersion] and Use (Riparian): A riparian water right claim. - Statement of Div[ersion] and Use (Riparian/Pre-1914): A riparian and pre-1914 appropriative water right claim. - Statement of Div[ersion] and Use (Pre-1914): A pre-1914 appropriative water right claim. - Statement of Div[ersion] and Use (Reserved): A federal reserved water right claim. - Statement of Div[ersion] and Use (Other): Any other category of water right claim (e.g. court decreed/adjudicated or contract/agreement). - Statement of Div[ersion] and Use (Unclassified): A water right claim with an unspecified category.	eWRIMS database w/ staff adjustments
HUC8	The name of the Hydrologic Unit Code Level 8 where demand in the row is located. Water right PODs are automatically assigned a HUC8 value in eWRIMS based on their location. This tab contains additional detail not found in the Demand tab, splitting rights that have PODs in multiple HUC8s into multiple rows (one for each HUC8).	eWRIMS database, USGS WBD
Subwatershed	Subwatershed where demand in the row is located. Sourced from the Subwatersheds tab based on the HUC8 value.	Staff-determined
Watershed	The watershed in which the demand occurs: the Sacramento River watershed or the San Joaquin River watershed. Sourced from the Subwatersheds tab based on the HUC8 value.	eWRIMS database, USGS WBD

Field Name(s)	Definition & Methodology	Data Source(s)
Legal Delta?	Indicates if demand for that row occurs within the Legal Delta (TRUE/FALSE). Assigned in the eWRIMS database based on the location of water right POD(s) and validated to ensure only rows which account for Legal Delta demands are flagged as TRUE. Statements claiming only Riparian rights which are located in the Legal Delta are marked as FALSE (with a note in the Demand Comment column) because these demands are not prorated between watersheds per Board Order WR 89-8 (see Watershed Viz and Watershed Analysis sections).	eWRIMS database w/ staff adjustments
Priority Date	The priority date of a water right or claim, sourced from the Demand tab (YYYY/MM/DD), with some exceptions: - The priorities of Statements categorized as “Riparian”, “Riparian/Pre-1914” or “Other” are marked as ‘Riparian’ because the water right record does not contain sufficient information to further disaggregate their demands. They are conservatively assumed to have a more senior priority date than all appropriative water rights. [1] - Project rights listed in Board Decision 1641 (excepting 2 New Melones Project rights, per Board Decision 1422) are marked as ‘Project’ and assumed to be junior to all other water rights.	eWRIMS database w/ staff adjustments
Priority Year	The year of the priority date, sourced from the previous column. Riparian or Project priorities are shown as blank.	eWRIMS database w/ staff adjustments

[1] For claims within the Legal Delta, this categorization of colorable riparian claims is consistent with recent judicial decisions (see e.g., *Modesto Irrigation District v. Heather Robinson Tanaka*, 48 Cal.App.5th 898 (2020)) and with the legal principles described in a memorandum dated December 15, 2017 regarding Issues Related to Overlap between Pre-1914 and Riparian Water Right Claims in the Delta and available on the website of the Office of the Delta Watermaster (Overlap Memo).

Field Name(s)	Definition & Methodology	Data Source(s)
Demand Weight	The percent of the specified water right's demand which occurs within the specified HUC8: - Demand Weight = (number of PODs within the respective HUC8) / (total number of PODs). Only active PODs that are not Points of Rediversion or Points of Offstream Storage are considered in this calculation. - The sum of Demand Weights for most water rights is equal to one (see exception in next column).	Staff-determined
Demand Comment	Additional detail about the Demand Weight or other aspects of the demand: - Has POD(s) outside Delta watershed: The water right has one or more associated PODs which divert from streams outside the Delta watershed (sum of Demands Weights is less than one). - In Legal Delta but not prorated between watersheds: The POD in the specified HUC8 is located within the Legal Delta but is associated with a Statement claiming only riparian rights. Per Board Order WR 89-8, the riparian demand is not prorated between watersheds. - Inactive: The POD in the specified HUC8 is not actively used (Demand Weight is zero). - Point of Rediversion/Offstream Storage: The POD does not divert natural flow (Demand Weight is zero). - Project: The water right is listed in Board Decision 1641, so its Priority Date is set to 'Project.' Also indicates actual water right Priority Date, sourced from Demand tab.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
January-December 2018/2019	Monthly demands of the specified water right within the specified HUC8, calculated as follows: (Application ID Demand for month of 2018 or 2019, sourced from Demand tab) * (Demand Factor for subwatershed and month, sourced from Supply Adjust tab) * (Demand Weight)	Calculated

Headwater Reductions

This tab compiles supply and demand data from each subwatershed in the Delta watershed and: 1) reduces any demands that cannot be met in headwater subwatersheds so that they are not reflected in the watershed-wide analysis, and 2) removes both supply and demand for any headwater subwatersheds considered to be disconnected from the Delta watershed because local supplies are insufficient to meet all riparian demands. Supply data is sourced from the Supply Forecast tab of the spreadsheet, while demand data is sourced from the Demand Separated tab of the spreadsheet.

Field Name(s)	Definition & Methodology	Data Source(s)
Subwatershed	Smallest area over which water availability is determined, based on one or more HUC8s. Sourced from the Demand Separated tab.	Staff-determined
Subwatershed Type	Subwatersheds are categorized as either - 'headwater' or 'lower' for the purpose of this analysis: - A headwater subwatershed contains water demands which can only be met by water supplies within the subwatershed (i.e., there are no tributaries flowing into the subwatershed). - A lower subwatershed can receive water supplies from outside its boundaries (i.e., it is located downstream of the headwaters).	Staff-determined
Watershed	The two primary river systems in the Delta: Sacramento and San Joaquin.	USGS WBD

Field Name(s)	Definition & Methodology	Data Source(s)
MonthNum and Month	The calendar year month (either number or three-letter abbreviation) of the respective water supply and demand.	--
Riparian Demand 2018	The sum of calendar year 2018 demand for all Riparian water right claims (Water Right Type = Riparian, Riparian/Pre-1914, or Other Statements) for the respective subwatershed and month, excluding demands in the Legal Delta. Sourced from the Demand Separated tab.	eWRIMS database w/ staff adjustments
Pre-1914 Demand 2018	The sum of calendar year 2018 demand for all pre-1914 appropriative water right claims (Water Right Type = Pre-1914 or Unclassified Statements) for the respective subwatershed, month, and demand year, excluding demands in the Legal Delta. Sourced from the Demand Separated tab.	eWRIMS database w/ staff adjustments
1914-1919, 1920s, 1930s, 1940s, 1950s, 1960s, 1970s, 1980s, 1990s, 2000s, and 2010s Demand 2018	The sum of calendar year 2018 demand for all Post-1914 Appropriative rights (Water Right Type = Reserved Statement or Appropriative) with a priority date within the specified decade for the respective subwatershed and month, excluding demands in the Legal Delta. Sourced from the Demand Separated tab.	eWRIMS database w/ staff adjustments
Project Demand 2018	The sum of calendar year 2018 demand for all Project water rights which export water outside the Delta watershed for the respective subwatershed and month, excluding demands in the Legal Delta. Sourced from the Demand Separated tab.	eWRIMS database w/ staff adjustments
2019 demand data is disaggregated in the same manner as 2018 demand data.		
Supply Forecast 10%, 50%, 90% or 99% Exceedance	Supply for the respective subwatershed and month. For past months, the actual value from the Supply Past Monthly tab is shown. For future months, the forecasted supply with the respective exceedance probability from the Supply Forecast tab is shown.	CDEC, B-120, CNRFC, staff estimates

Field Name(s)	Definition & Methodology	Data Source(s)
Discontinuity? (2018 Demand, 90% Exceedance Supply)	Whether a given headwater subwatershed is considered disconnected from the Delta watershed in a given month (Yes/No). A headwater subwatershed is considered disconnected when the supply (using the 90% exceedance forecast for future months) is insufficient to meet the 2018 demands of all riparian claims of right in the subwatershed.	Staff-determined
2018 Total Demand	The sum of 2018 all demand values for the respective subwatershed and month.	Calculated
2018 Reduced Demand for Discontinuity & Unmet Demand (90% Exceedance Supply)	2018 demands for the respective subwatershed and month, eliminating any demand which cannot physically be met by available supply: - In headwater subwatersheds, the lesser of 2018 Total Demand or 90% Supply Forecast 90% Exceedance. - In disconnected headwater subwatersheds, equal to zero. - In lower subwatersheds, the 2018 Total Demand (no reduction due to supply).	Calculated
2019 demand data is summed and analyzed for discontinuity in the same manner as 2018 demand data.		
Supply Forecast 90% Exceedance with Headwater Abandoned Flow Replacement	Supply for the respective subwatershed and month which contributes to the Delta watershed. The greater of either the Supply Forecast 90% Exceedance value or the abandoned flow for the respective subwatershed and month (sourced from the Supply Adjust tab, converted to acre-feet per month).	B-120, CNRFC, staff estimates

Field Name(s)	Definition & Methodology	Data Source(s)
2018/2019 Reduced Supply for Discontinuity (90% Exceedance with Abandoned Flow Replacement)	When discontinuity is found for the respective subwatershed and month based on demand data from the respective year (i.e., Discontinuity? = Yes), both supply and demand are removed from the watershed-wide analysis. This column sets supplies for disconnected headwater subwatersheds to zero.	Calculated

Subwatershed Viz

This tab compiles supply and demand data from each subwatershed in the Delta watershed to generate the interactive Headwater Subwatershed Analysis visualization at:

https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/drought_tools_methods/delta_method.html

Field Name(s)	Definition & Methodology	Data Source(s)
Subwatershed	Smallest area over which water availability is determined, based on one or more HUC8s. Sourced from the Demand Separated tab.	Staff-determined
Subwatershed Type	Subwatersheds are categorized as either 'headwater' or 'lower' for the purpose of this analysis: - A headwater subwatershed contains water demands which can only be met by water supplies within the subwatershed (i.e., there are no tributaries flowing into the subwatershed). - A lower subwatershed can receive water supplies from outside its boundaries (i.e., it is located downstream of the headwaters).	Staff-determined
Watershed	The two primary river systems in the Delta: Sacramento and San Joaquin.	USGS WBD

Field Name(s)	Definition & Methodology	Data Source(s)
MonthNum and Month	The calendar year month (either number or three-letter abbreviation) of the respective water supply and demand.	--
Discontinuity?	Whether a given headwater subwatershed is considered disconnected from the Delta watershed in a given month based on a given year of demand data (Yes/No). Sourced from the Discontinuity? column in the Headwater Reductions tab.	Staff-determined
Demand Type	Demand category, based on water right priority. Post-1914 appropriative demands are largely separated by priority decade, except for demand by the Central Valley Project and the State Water Project (Project Demand).	eWRIMS w/ staff adjustments
Demand Year	Calendar year of demand data (2018 or 2019).	eWRIMS database
Demand	Monthly total demand for the respective subwatershed, month, demand year, and demand type, prior to the elimination of unmet headwater demand and demand in disconnected subwatersheds. Sourced from the Demand columns in the Headwater Reductions tab.	eWRIMS database w/ staff adjustments
Demand After Reduction (90% Exceedance Supply)	Monthly demand for the respective subwatershed, month, and demand year, after unmet headwater demand and demand in disconnected subwatersheds are removed. If Cumulative Demand exceeds the available supply, the remaining supply is credited towards the last added (senior) demand type and later (junior) demands are zero.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
2021 Supply 10%, 50% 90%, and 99% Exceedance	Supply for the respective subwatershed and month. For past months, the actual value from the Supply Past Monthly tab is shown. For future months, the forecasted supply with the respective exceedance probability from the Supply Forecast tab is shown (NOTE: supply is available to all demand types by priority; values are shown only in the Riparian Demand rows due to Tableau plotting limitations).	CDEC, B-120, CNRFC, staff estimates
Supply After Reduction (90% Exceedance Supply)	Monthly supply for the respective subwatershed and month (past months from the Supply Past Monthly tab, future months from the Supply Forecast tab). Set to zero if Discontinuity? = Yes.	Calculated
Cumulative Demand for Subwatershed & Month	Total cumulative demand for the respective subwatershed, month, and demand year (used as an intermediate calculation to inform the Demand After Reduction value). Added from most senior to most junior rights.	Calculated
Watershed Supply Summary Table (Watershed, MonthNum, Month, Supply Type, Supply)	Monthly supply statistics for the Sacramento River and San Joaquin River watersheds. Sourced from the Supply Past Monthly and Supply Forecast tabs to compare median hydrologic conditions of past wet years and critically dry years to 90% exceedance forecasts for 2021.	CDEC, B-120, CNRFC, staff estimates

Watershed Viz

This tab compiles supply and demand data used to assess water unavailability at the watershed level. Formulas in this tab: 1) remove any demands that cannot be met in headwater subwatersheds, 2) remove both supply and demand for any disconnected headwater subwatersheds, and 3) distribute demand within the Legal Delta between the Sacramento River and the San Joaquin River watersheds before producing final supply and demand values that populate the interactive Watershed Analysis visualization at:

https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/drought_tools_methods/delta_method.html

Field Name(s)	Definition & Methodology	Data Source(s)
Watershed	The two primary river systems in the Delta: Sacramento and San Joaquin.	USGS WBD
MonthNum and Month	The calendar year month of the respective water supply and demand.	--
Delta Watershed Supply Ratio	The percent of supply that the respective watershed (Sacramento River or San Joaquin River) contributes to the Delta watershed in the respective month. Based on 90% exceedance supply forecasts, including the greater of FNF or subwatershed abandoned flow, and calculated after supplies from disconnected subwatersheds are removed based on demands for the respective year. Sourced from the 2018 and 2019 Reduced Supply for Discontinuity columns in the Headwater Reduction tab.	Calculated
Demand Type	Demand category, based on water right priority. Post-1914 appropriative demands are largely separated by priority decade, except for demand by the Central Valley Project and the State Water Project (Project Demand).	eWRIMS w/ staff adjustments
Demand Year	Calendar year of demand data (2018 or 2019).	eWRIMS database
Headwater Demand Reduction	The amount of demand removed from the watershed-wide analysis due to reduction of demands that cannot be met by supplies in headwater subwatersheds. Sourced from the Subwatershed Viz tab: Headwater Demand Reduction = Demand column – Demand after Reduction	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Demand w/o Legal Delta (Headwater Reduced)	Total demand for the respective watershed, month, and demand year, excluding demand in the Legal Delta. Sourced from the Demand Separated tab: Demand w/o Legal Delta (Headwater Reduced) = total watershed demand – demand from PODs in the Legal Delta (Legal Delta? = TRUE) – Headwater Demand Reduction	Calculated
Legal Delta Demand	Demand for PODs within the Legal Delta (Legal Delta? = TRUE) for the respective month and demand type. Sourced from the Demand Separated tab.	eWRIMS w/ staff adjustments
Legal Delta Demand Prorated by Watershed	Demand for PODs within the Legal Delta (Legal Delta? = TRUE) for the respective watershed, month, and demand type. Legal Delta demands are prorated between the Sacramento River and San Joaquin River watersheds based on the percent of supply that each contributes in a given month (based on the 90% exceedance supply forecast, accounting for supply reductions due to disconnection and the replacement of abandoned instream flows in excess of subwatershed FNF): Prorated Legal Delta Demand by Watershed = Delta Watershed Supply Ratio * Legal Delta Demand In other words, if the Sacramento River watershed constitutes 80% of Delta watershed supply in a given month, then 80% of Legal Delta demand is charged against the Sacramento River watershed supply for that month and 20% is charged against the San Joaquin River watershed.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Total Watershed Demand	Total demand for the respective watershed, month, and demand year after Legal Delta demand has been prorated between the two watersheds: Total Watershed Demand = Demand w/o Legal Delta (Headwater Reduced) + Legal Delta Demand Prorated by Watershed	Calculated
Total Watershed Supply	Total supply for the respective watershed and month after excluding supply from disconnected subwatersheds. Sourced from the 2018 and 2019 Reduced Supply for Discontinuity columns in the Headwater Reduction tab (NOTE: supply is available to all demand types by priority; values are shown only in the Riparian Demand rows due to Tableau plotting limitations).	Calculated

Daily Supply Viz

This tab compiles monthly supply data from the Supply Forecast tab and daily supply data from the Supply Daily Monitoring tab to produce a comparison between monthly forecasts and cumulative daily supply, which may be used to adjust the timing or scope of notices of water unavailability. This data populates the interactive Watershed Analysis Weekly Supply Updates visualization at:

https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/drought_tools_methods/delta_method.html

Field Name(s)	Definition & Methodology	Data Source(s)
Date	Individual days of the current month.	--
Watershed	The two primary river systems in the Delta: Sacramento and San Joaquin.	USGS WBD

Field Name(s)	Definition & Methodology	Data Source(s)
Daily Cumulative	The cumulative total supply (sum of respective date and all previous days of the month) for the respective watershed, in acre-feet. Equal to '#N/A' if supply data are not available for all subwatersheds in the respective watershed (i.e., dates in the future). Sourced from the Supply Daily Monitoring tab.	CDEC, CNRFC, staff estimates
Fcast 99%, 90%, 75%, 50%, 25%, and 10% exc	Monthly forecasted supply for the respective watershed and exceedance probability, in acre-feet, Equal to the same value for all days of the month in order to plot as a horizontal line. Sourced from the Supply Forecast tab.	B-120, CNRFC, staff estimates

Analysis Headwaters

This tab contains a tabular version of the water supply and demand visualizations for 14 headwater subwatersheds in the Delta watershed. In each, past and forecasted supplies are used to determine water availability for each water right in order of priority date. Rights which are not expected to have water available to meet their demands due to limited local supplies are flagged for the receipt of a notice of water unavailability, and these unmet demands are excluded from the Watershed Analysis (see next section). If the Headwaters Analysis indicates that any Riparian claims of right (senior demands) would face water unavailability, all supplies and demands from that subwatershed are excluded from its respective Watershed Analysis. In other words, these streams are assumed to not have connectivity to the Delta watershed due to senior demands exceeding all available water supplies.

This analysis is set-up for each headwater subwatershed as follows:

1. The water rights listed in the Demand Separated tab of the spreadsheet are grouped by subwatershed.
2. Any rights located in the Legal Delta (Legal Delta? = TRUE) are excluded; this only occurs in the furthest downstream reaches of the Putah Creek, Stanislaus River, Calaveras River, and Cosumnes River headwater subwatersheds. Water availability for these rights is only analyzed in the Watershed Analysis, as they are assumed to have access to water from both the Sacramento and San Joaquin Rivers and not be limited by local supplies.
3. Any duplicate rights within each subwatershed are merged; this only occurs in the Sacramento River above Bend and Upper American River headwater

subwatersheds, where there are rights that divert from multiple HUC8s within the same subwatershed.

4. Rights within each subwatershed are sorted by priority date, with the most senior rights first: Riparian, Pre-1914 Appropriative, Appropriative, Project (see the explanations of Statement assigned categories and priority assumptions in the Demand and Demand Separated sections). All Riparian claims of right are assumed to have senior priority over all pre-1914 appropriative claims, which are in turn assumed to have priority over all post-1914 appropriative rights.
5. On a monthly basis for each right within a subwatershed, each of the following parameters is calculated or determined: demand, cumulative supply available, water availability (i.e., will this right receive a notice of water unavailability?), demand met, and demand unmet.

This tab is grouped into sixteen tables. The fourteen tables on the left, separated by black rows, contain the analysis for each headwater subwatershed: Sacramento River above Bend, Stony Creek, Cache Creek, Upper Feather River, Yuba River, Bear River, Upper American River, Putah Creek, Upper San Joaquin River, Merced River, Tuolumne River, Stanislaus River, Calaveras River, and Cosumnes River.

The upper table on the right side of this tab indicates the supply forecast exceedance and monthly supply volumes used for each individual subwatershed, sourced from the Supply Forecast tab. The lower table on the right side of this tab indicates if any Riparian claims within each subwatershed faced water unavailability in each month (i.e., if the subwatershed's supplies and demands should be excluded from the Watershed Analysis due to lack of connectivity with the Delta watershed). These cells have conditional formatting to **highlight red** if the subwatershed lacks connectivity.

NOTE: To save computation time, this tab contains largely static values. The first row of the top table (or the first two rows of the 2021 Supply Cumulative column), **highlighted in blue**, contain sample formulas described in detail in the table below.

Field Name(s)	Definition & Methodology	Data Source(s)
Subwatershed	Smallest area over which water availability is determined, based on one or more HUC8s. This tab contains data for only headwater subwatersheds (see Subwatersheds section), sourced from the Demand Separated tab.	Staff-determined
Application ID	Application ID of each water right, sourced from the Demand Separated tab. Any duplicate Application IDs within a single subwatershed are merged.	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
Primary Owner	Name of the primary owner of the water right or water right claim, sourced from the Demand tab.	eWRIMS database
Water Right Type	Water right type, sourced from the Demand tab: Appropriative or Statement of Div[ersion] and Use (Riparian, Riparian/Pre-1914, Pre-1914, Reserved, Other, or Unclassified).	eWRIMS database w/ staff adjustments
Priority Date	The priority date of a water right or claim, sourced from the Demand tab (YYYY/MM/DD). Riparian, Riparian/Pre-1914, and Other Statements are denoted as 'Riparian' priority and are assumed to be senior to all other demands, while Project rights listed in Board Decision 1641 are denoted as 'Project' priority and are assumed to be junior to all other demands.	eWRIMS database w/ staff adjustments
2018 Demand, Jan-Sep	Monthly demands by each water right in the respective subwatershed, summed from the Demand Separated tab. Excludes any demands in the Legal Delta.	eWRIMS database w/ staff adjustments
2021 Supply Cumulative, Jan-Sep	Available water supply to meet each water right's Demand, calculated as follows: - For the first water right in each subwatershed, equal to the subwatershed's monthly supply from the upper-right table in the spreadsheet. - For the next water right, the Supply Cumulative available to the previous right minus the previous rights' Demand Potentially Met in Subwatershed (see below). - Continued for each next junior water right, until all Demands are accounted for or there is no remaining water supply available.	CDEC, B-120, CNRFC, staff estimates, staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Water Unavailable? Jan-Sep	If water is anticipated to be unavailable to the respective water right in the respective month. Determined if Demand exceeds Supply Cumulative (TRUE/FALSE). These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Demand Potentially Met in Subwatershed, Jan-Sep	Amount of each right's Demand which can be met by available supply within a given month, calculated as follows: - If Supply Cumulative > Demand, equal to Demand. - If 0 < Supply Cumulative < Demand, equal to Supply Cumulative (i.e., Water Unavailable, but a portion of Demand can be met). - If Supply Cumulative = 0, equal to zero (i.e., Water Unavailable).	Calculated
Demand Unmet in Subwatershed, Jan-Sep	Amount of each right's Demand which cannot be met by available water supply within a given month, calculated as follows: - If Demand Potentially Met = Demand, equal to zero. - If Demand Potentially Met < Demand, equal to Demand – Demand Potentially Met. - If Demand Potentially Met = 0, equal to Demand.	Calculated

Analysis Watersheds

This tab contains a tabular version of the Sacramento and San Joaquin Watershed-wide water supply and demand visualizations. In each watershed, total forecasted supplies are used to determine water availability for each right in order of priority date. Demands compared in this analysis include those in headwater subwatersheds which may be met by local supplies (see previous section), as well as all demands located in lower subwatersheds and within the Legal Delta. Rights which are not expected to have water available to meet their demands are flagged for the receipt of a notice of water unavailability. This is in addition to notices identified in the Headwater Subwatershed Analysis; while there may be enough water present locally to meet a given demand,

those supplies may not actually be available if they are needed to supply more senior rights further downstream in the watershed. Headwater subwatersheds where senior demands (Priority Date = Riparian) may receive notices have their supplies and demands removed from the Watershed Analysis.

This analysis is set-up for each watershed as follows:

1. The water rights listed in the Demand Separated tab of the spreadsheet are grouped by watershed. Rights within the Legal Delta (Legal Delta? = TRUE) are present in both watersheds so that they can be prorated to each based on available supplies.
2. Any duplicate rights within each subwatershed are merged; this occurs only in the Sacramento River above Bend, Upper American River, Upper Sacramento Valley, Sacramento Valley Floor, and San Joaquin Valley Floor subwatersheds, where some rights divert from multiple HUC8s within the same subwatershed.
3. Rights within each subwatershed are sorted by priority date, with the most senior rights first: Riparian, Pre-1914 Appropriative, Appropriative, Project (see the explanations of Statement assigned categories and priority assumptions in the Demand and Demand Separated sections). All Riparian claims of right are assumed to have senior priority over all pre-1914 appropriative claims, which are in turn assumed to have priority over all post-1914 appropriative rights.
4. On a monthly basis for each right within a watershed, each of the following parameters is calculated or determined: demand (both total and headwater subwatershed demand which can potentially be met by local supplies), cumulative supply available, water availability (i.e., will this right receive a notice of water unavailability?), demand met, and demand unmet.

This tab is grouped into four tables. The two tables on the left, separated by black rows, contain the analysis for the Sacramento and San Joaquin River watersheds. The upper table on the right side of this tab indicates the supply forecast exceedance and monthly supply volumes used for each individual subwatershed, which are summed to a total for each watershed. Monthly supply ratios for the Delta watershed are calculated for each watershed for the purpose of Legal Delta demand proration. The lower table on the right side of this tab indicates any headwater subwatersheds whose supplies and demands were excluded if any Riparian claims were flagged for receipt of a notice of water unavailability (sourced from the Analysis Headwaters tab). These cells have conditional formatting to **highlight red** if the subwatershed was excluded.

NOTE: To save computation time, this tab contains largely static values. The first row of the top table (or the first two rows of the 2021 Supply Cumulative column), **highlighted in blue**, contain sample formulas described in detail in the table below.

Field Name(s)	Definition & Methodology	Data Source(s)
Watershed	The watershed in which the demand occurs, Sacramento River or San Joaquin River. Sourced from the Demand Separated tab. Legal Delta demands (Legal Delta? = TRUE) are present in both watersheds, with their demands prorated between them.	USGS WBD
Subwatershed	Smallest area over which water availability is determined, based on one or more HUC8s. Sourced from the Demand Separated tab.	Staff-determined
Application ID	Application ID of each water right, sourced from the Demand Separated tab. Any duplicate Application IDs within a single subwatershed are merged.	eWRIMS database
Water Right Type	Water right type, sourced from the Demand tab: Appropriative or Statement of Div[ersion] and Use (Riparian, Riparian/Pre-1914, Pre-1914, Reserved, Other, or Unclassified).	eWRIMS database w/ staff adjustments
Primary Owner	Name of the primary owner of the water right or water right claim, sourced from the Demand tab.	eWRIMS database
Priority Date	The priority date of a water right or claim, sourced from the Demand tab (YYYY/MM/DD). Riparian, Riparian/Pre-1914, and Other Statements are denoted as 'Riparian' priority and assumed to be senior to all other demands, while Project rights listed in Board Decision 1641 are denoted as 'Project' priority and are assumed to be junior to all other demands.	eWRIMS database w/ staff adjustments
Legal Delta?	If demand for that row occurs within the Legal Delta (TRUE/FALSE), sourced from the Demand Separated tab. Each water right located in the Legal Delta is present in both the Sacramento and San Joaquin Watershed Analyses.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Headwater Subwatershed?	If demand for that row occurs within a headwater subwatershed (TRUE/FALSE), sourced from the Subwatersheds tab.	Staff-determined
2018 Demand, Jan-Sep	Monthly demands by each water right in the respective subwatershed, summed from the Demand Separated tab. If the right is located in the Legal Delta (Legal Delta? = TRUE), the demand is multiplied by the respective watershed's supply ratio for the respective month (from the upper-right table in the spreadsheet) in order to prorate these demands between both watersheds.	eWRIMS database w/ staff adjustments
Water Unavailable in Subwatershed? Jan-Sep	If water is anticipated to be unavailable in a headwater subwatershed (TRUE/FALSE): - If located in a headwater subwatershed, equal to the Water Unavailable? value in the Analysis Headwaters tab for the respective right and month. - FALSE if located in a lower subwatershed. These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Demand Potentially Met in Subwatershed, Jan-Sep	Monthly demands by each water right which can physically be met within the respective subwatershed: - If any Riparian Statements received notices in the given headwater subwatershed and month, equal to zero (see lower table to right in spreadsheet). - If located in a headwater subwatershed and nonzero, equal to the Demand Potentially Met in Subwatershed value in the Analysis Headwaters tab for the respective right and month. - If located in a lower subwatershed, equal to 2018 Demand.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
2021 Supply Cumulative, Jan-Sep	Available water supply to meet each water right's Demand Potentially Met, calculated as follows: - For the first water right in each watershed, equal to the total watershed monthly supply from the upper-right table in the spreadsheet. - For the next water right, the Supply Cumulative available to the previous right minus the previous right's Demand Met in Watershed (see below). - Continued for each next junior water right, until all Demands are accounted for or there is no remaining water supply available.	CDEC, B-120, CNRFC, staff estimates
Water Unavailable in Watershed? Jan-Sep	If water is anticipated to be unavailable to the respective water right in the respective month. Determined if Demand Potentially Met exceeds Supply Cumulative (TRUE/FALSE). These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Demand Met in Watershed, Jan-Sep	Amount of each right's Demand Potentially Met which can be met by available supply within a given month, calculated as follows: - If Supply Cumulative > Demand Potentially Met, equal to Demand Potentially Met. - If 0 < Supply Cumulative < Demand Potentially Met, equal to Supply Cumulative (i.e., Water Unavailable, but a portion of Demand can be met). - If Supply Cumulative = 0, equal to zero (i.e., Water Unavailable).	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Demand Unmet in Watershed, Jan-Sep	Amount of each right's Demand which can be physically met in the watershed that will be unmet by available water supply within a given month, calculated as follows: - If Demand Met = Demand Potentially Met, equal to zero. - If Demand Met < Demand Potentially Met, equal to Demand Potentially Met – Demand Met. - If Demand Met = 0, equal to Demand Potentially Met.	Calculated
Water Unavailable? Jan-Sep	If the water right is anticipated to receive a notice of water unavailability in the given month, either from the Headwaters Analysis (Water Unavailable in Subwatershed?) or Watershed Analysis (Water Unavailable in Watershed?). These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Demand Deficit, Jan-Sep	Amount of each right's total Demand which will be unmet, either by unavailable headwater subwatershed supply or by overall watershed supply, within a given month. Calculated as follows: - If Subwatershed is disconnected, equal to Demand Unmet in Subwatershed from the Headwater Analysis tab. - If Subwatershed is not disconnected, equal to Demand Unmet in Watershed.	Calculated

Analysis Legal Delta

This tab contains information on water rights located in the Legal Delta. Because these rights are assumed to have access to supplies from both the Sacramento and San Joaquin Rivers to meet their demands (see 2018 Demand column in Analysis Watersheds tab), this tab quantifies total demands and demands met from each watershed to identify which rights may receive notices of water unavailability. Per State Water Board Order WR 89-8, this analysis assumes that demands by Statements of Diversion and Use claiming only Riparian water rights can only be met by supply from

the watershed in which they are located; therefore, they are excluded from all demand proration between watersheds and are not listed in this tab.

Water rights in the Legal Delta will only receive a notice if water is anticipated to be unavailable from both watersheds. This tab does not contain any new analysis, it only compiles values from the Analysis Watersheds tab for rights located in the Legal Delta (Legal Delta? = TRUE in the Demand Separated tab). Duplicate rights were merged in this tab, so each row represents a single water right's total demand.

NOTE: To save computation time, this tab contains largely static values. The first row of the table, **highlighted in blue**, contain sample formulas described in detail in the table below.

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Application ID of each water right, sourced from the Demand Separated tab.	eWRIMS database
Primary Owner	Name of the primary owner of the water right or water right claim, sourced from the Demand tab.	eWRIMS database
Priority Date	The priority date of a water right or claim, sourced from the Demand tab (YYYY/MM/DD). Riparian/Pre-1914 and Other Statements are denoted as 'Riparian' priority and assumed to be senior to all other demands, while Project rights listed in Board Decision 1641 are denoted as 'Project' priority and are assumed to be junior to all other demands.	eWRIMS database w/ staff adjustments
2018 Sacramento Demand, Jan-Sep	Monthly demands by each water right from the Sacramento River watershed, sourced from the 2018 Demand column of the Analysis Watersheds tab.	eWRIMS database w/ staff adjustments
2018 San Joaquin Demand, Jan-Sep	Monthly demands by each water right from the San Joaquin River watershed, sourced from the 2018 Demand column of the Analysis Watersheds tab.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Water Unavailable from Sacramento? Jan-Sep	If the water right is anticipated to face water unavailability from the Sacramento River watershed in a given month, sourced from the Water Unavailable? column of the Analysis Watersheds tab. These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Water Unavailable from San Joaquin? Jan-Sep	If the water right is anticipated to face water unavailability from the San Joaquin River watershed in a given month, sourced from the Water Unavailable? column of the Analysis Watersheds tab. These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined
Sacramento Demand Met, Jan-Sep	Amount of each right's Demand in the Sacramento River watershed which can be met by available supplies, sourced from the Analysis Watersheds tab.	Staff-determined
San Joaquin Demand Met, Jan-Sep	Amount of each right's Demand in the San Joaquin River watershed which can be met by available supplies, sourced from the Analysis Watersheds tab.	Staff-determined
Water Unavailable? Jan-Sep	If the water right is anticipated to face water unavailability from both the Sacramento and San Joaquin River watersheds in a given month, meaning it would receive a notice of water unavailability. These cells have conditional formatting to **highlight red** if water is unavailable for a given right and month.	Staff-determined

Technical Appendix B: Delta Watershed Demand Dataset

This appendix documents the process used to prepare the Sacramento-San Joaquin Delta (Delta) watershed demand dataset for the Water Unavailability Methodology for the Delta Watershed (methodology). Specifically, this appendix summarizes: (1) the process used to select water right records in the Delta watershed, (2) the quality control process used to review diversion data submitted by water right holders and claimants and address diversion data reporting inaccuracies, and (3) demand dataset updates and formatting. In the future, the State Water Board may also rely upon updated reporting of projected demands for larger users that is provided pursuant to emergency regulations.

Initial Selection of Water Right Records in the Delta Watershed

This section describes the process and computer code logic used to select water right records in the Delta watershed for inclusion in the demand dataset. These water right records were selected from the full list of all of California's water right records using information contained within the State Water Resources Control Board's (State Water Board) Electronic Water Rights Information Management System (eWRIMS) database. The eWRIMS database contains information on water right permits and licenses issued by the State Water Board and other claimed water rights, including reported diversion and use data submitted by water right holders and claimants through the Report Management System (RMS). The eWRIMS database system can be accessed at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/

Selection of All Water Right Records in California

Using information from the eWRIMS database, a dataset of all water right records in California was created. The dataset of all water right records included other associated information, such as the water right type, status, and reported diversions for calendar years 2018 and 2019.

To compile this dataset, the full record of California's water rights and claims and annually reported water diversion information was obtained from the eWRIMS database. The eWRIMS database is continuously updated by modifications to water right records, such as the addition of new water right records or changes in water right

status. Water diversion and use information contained within the eWRIMS database is also updated when annual reports of water diversion and use (annual reports) are submitted or modified by diverters. The initial selection of water right records in the Delta watershed and quality control review described below required a static copy of the eWRIMS datasets, which were downloaded on January 15, 2021.

Several plain text comma-separated values (.csv) files, known as eWRIMS flat files, contain the data fields used to create the dataset. Data was compiled from the eWRIMS flat files by the water right Application ID Number. The eWRIMS flat files that contain the data fields used to create the dataset are titled:

- **Water Rights Master Flat File**: This file contains general information associated with each water right record on file with the State Water Board. Several fields within this flat file were selected, such as: primary owner name, water source name, water right face value, water right status (e.g., active, etc.), and water right type (e.g., Appropriative, Statement of Diversion and Use, etc.).
- **Water Rights Annual Water Use Report**: This file contains the monthly water diversion and use data submitted by water right holders and claimants in annual reports. Reported total diversions, which included the amounts directly diverted and the amounts diverted or collected to storage, were selected for each month during calendar years 2018 and 2019. For Statements of Diversion and Use, this file contains information about the water right type (e.g., pre-1914, riparian, etc.) submitted by water right claimants as well as information about the year diversion first commenced, as discussed under *Disaggregation of Statements of Diversion and Use.*
- **Water Rights Uses and Seasons**: This file contains additional information regarding authorized diversion and storage seasons and beneficial uses[1] for each water right record. Beneficial use information was selected and compiled for each water right record. Some water right records have multiple beneficial uses, and each of the beneficial uses for each of the water right records was aggregated by Application ID Number.
- **Water Rights Point of Diversion Flat File**: This file contains general information associated with each water right record on file with the State Water Board, including several fields that are also available in the Water Rights Master Flat File. This file contains additional fields that were incorporated into the demand dataset, including: point of diversion location (latitude/longitude), application received date, and application acceptance date. The application acceptance date and application

[1] The beneficial uses of water pertaining to water rights are defined in the California Code of Regulations (CCR) §§ 659-672 to include: domestic, irrigation, power, municipal, mining, industrial, fish and wildlife preservation and enhancement, aquaculture, recreational, stockwatering, water quality, frost protection, and heat control.

received date fields were used to identify a water right priority date for the post-1914 appropriative water right records, as discussed under *Update and Format Demand Dataset*.

Information from the eWRIMS flat files was used to create one dataset of water rights and claims for all of California on record with the State Water Board.

Selection of Active Water Right Records in California

The dataset of all water right records was limited to those with an active-type water right status, which includes the following water right statuses:

- Claimed
- Licensed
- Permitted
- Registered
- Certified

By only including active-type statuses, water rights with inactive-type statuses, such as inactive, rejected, and cancelled, were excluded from the demand dataset.

Selection of Active Water Right Records in the Delta Watershed

The dataset of active water right records in California was then limited to diversions located in the Delta watershed. Using geographic information system (GIS) software, water right records located in the Delta watershed were selected based on the spatial location of each water right Point of Diversion (POD).

The Division of Water Rights has created an eWRIMS Web Mapping Application that provides the spatial location of all of the water right PODs in California. A public version of the eWRIMS GIS System is available at: https://waterrightsmaps.waterboards.ca.gov/viewer/index.html?viewer=eWRIMS.eWRIMS_gvh#

The Delta watershed boundaries used for the spatial selection include the following Hydrologic Unit Code level 4 (HUC4) watersheds, as defined by the U.S. Geological Survey (USGS) Watershed Boundary Dataset (WBD):

HUC4 Subregion Number	HUC4 Subregion Name
1802	Sacramento
1804	San Joaquin

The GIS attributes of water right PODs within the Delta watershed were then exported as a plain text .csv file.

Selection of Consumptive Water Right Records in the Delta Watershed

The Delta watershed demand dataset was then further subdivided to include only water right records with consumptive beneficial uses. Water right records that contain only non-consumptive beneficial uses were excluded from the Delta watershed demand dataset. These beneficial use types and combinations include:

- Power
- Power and Recreational
- Power and Industrial
- Power and Domestic
- Power and Fish and Wildlife Preservation and Enhancement
- Fish and Wildlife Preservation and Enhancement

The above beneficial use types and combinations were assumed to be associated primarily with non-consumptive uses of water, including hydropower generation and instream flows. Water right records with the Power and Industrial and Power and Domestic beneficial use combinations were assumed to be primarily associated with hydropower generation, with a negligible amount of incidental industrial or domestic uses of water as a conservative assumption for purposes of avoiding overestimation of demands. Accounting for instream flows is described in the main report.

A small number of water right records did not contain beneficial use information in the eWRIMS flat files. These water right records were initially included in the demand dataset. However, many of these were eventually found to be non-consumptive during the review process described below.

Selection of Appropriative Water Rights and Statements of Diversion and Use in the Delta Watershed

The Delta watershed demand dataset was again subdivided to include only the following water right types:

- Appropriative
- Statement of Diversion and Use

Appropriative water rights include post-1914 appropriative water rights (e.g., water right permits and licenses). Statements of Diversion and Use include pre-1914 appropriative and riparian claims.

By limiting the demand dataset to Appropriative water rights and Statements of Diversion and Use, minor water right types such as Stockponds and Registrations were excluded from the dataset. Similarly, other types of water right records such as Temporary Permits were also excluded. These other water right types were assumed to constitute a negligible amount of the water diversion and use within the Delta watershed. Excluding these uses represents a conservative assumption for the purposes of avoiding overestimation of demands.

Quality Control Review

Diversion data contained within annual reports is self-reported and is not systematically verified for accuracy upon submittal to the State Water Board. As a result, an internal review and quality control effort was conducted. The quality control review process was focused on the review of the total diversion amounts for 2018 and 2019 reported by water right holders or their agents in annual reports. The total diversion amount includes the amount directly diverted and the amount diverted or collected to storage.

The water right records in the Delta watershed demand dataset after initial selection were too numerous to feasibly review in their entirety at this time. Therefore, the scope of the review was narrowed to a subset of water right records, with a focus on the largest diversions in the Delta watershed.

Selection of Largest Diversions in Delta Watershed for Quality Control Review

The approximately 12,000 total water right records in the demand dataset after initial selection were subdivided to approximately 580 water right records that include the largest diversions in the Delta watershed. Criteria used to identify this selection of water right records includes:

- Statements of Diversion and Use with total reported diversion of 5,000 acre-feet (AF) or greater for either 2018 or 2019
- Appropriative water rights with a face value of 5,000 AF or greater, or a total reported diversion of 5,000 AF or greater for either 2018 or 2019

These water right records were the focus of the quality control review process described below, and together represent over 90% of demands in the Delta watershed.

Quality Control Review

The quality control process focused on review of diversion data obtained from annual reports submitted by water right holders and their agents for calendar years 2018 and 2019. For each of the approximately 580 water right records included in the quality control review, the 2018 and 2019 annual reports were accessed through the eWRIMS

database system. The contents of the annual reports were reviewed, including but not limited to the following information:

- Purpose of Use
- Amount of Water Diverted and Used, including monthly amounts directly diverted, monthly amounts diverted or collected to storage, and monthly amounts used
- Maximum Rate of Diversion, including maximum monthly diversion rates
- Comments and Additional Remarks

The specific issues that were investigated during the quality control review, and corrected when possible, included:

- Non-consumptive diversions improperly appearing as consumptive
- Duplicate diversion values, such as the same diversions reported under multiple water right records
- Diversion data entry and reporting errors, such as incorrect units of measurement and decimal placement errors
- Reported diversions in excess of the water right's face value (applies to post-1914 appropriative water rights only)

In general, the issues that were investigated relate to the correction of over-reporting of diversion amounts. An overview of the commonly identified issues and corrections that were applied to the demand dataset is provided below.

In some cases, it was not possible to resolve outstanding issues without further information. State Water Board staff has contacted numerous water right holders or their agents to gather this information. However, it was not feasible to contact all water right holders or agents in all cases where a potential reporting related error was identified or a correction applied to a diversion value. Efforts were prioritized to contact water right holders or agents based on several factors, including reported diversion size and relative level of uncertainty regarding potential reporting-related inaccuracies. Some water right holders and agents did not provide timely responses to inquiries regarding potential reporting related errors. In the absence of additional information provided by the water right holder or agent, estimates of the actual diversion amounts were used based on information contained within the annual report and supplemental information available within the eWRIMS database.

Non-Consumptive Diversions and Uses

Annual reports reviewed for some water right records appeared to indicate that water was diverted only for non-consumptive use. Water right records were generally identified as non-consumptive based on the reported purposes of use contained within the 2018 and 2019 annual reports. Some non-consumptive purposes of use identified during the quality control review include instream flow uses (e.g., "maintain a live

stream"), power generation, or non-consumptive aquaculture uses. These records were removed from the demand dataset.

In some cases, annual reports included both consumptive and non-consumptive purposes of use, such as both power generation and irrigation. It was generally assumed that all water diverted under these records was used consumptively. However, for some water right records, comments or additional remarks included in the annual report appeared to indicate that only a portion of the water diverted was used consumptively, but information was not provided within the annual report to quantify the volume of water diverted for consumptive uses. If it was not possible to quantify the volume of water diverted for consumptive uses, the water right record was identified for outreach to the water right holder to resolve the issue.

Duplication of Reported Diversion Amounts

Some 2018 and 2019 annual reports contain comments, additional remarks, or other information that clearly indicated that a particular diversion was fully reported under two or more separate rights (i.e., duplicated). In these cases, reported diversions were retained for only one record and were changed to zero for the other record(s) in the demand dataset.

Some water right holders have multiple water rights or claims. In some cases, identical monthly diversion amounts were reported under multiple records associated with a particular water right holder, but the annual reports did not clearly indicate if the same diversion volumes were reported under multiple water right records. If it was not possible to determine if the water right holder had reported duplicative diversion volumes under multiple records, the water right records were identified for outreach to the water right holder to resolve the issue.

Some 2018 and 2019 annual reports contain information that appeared to identify some duplicate reporting of the same diversion volumes under multiple water right records, including water right records held by different water right holders. If it was not possible to quantify the volume of water reported under multiple water right records, the water right records were identified for outreach to the water right holders to resolve the issue.

Diversion Data Entry and Reporting Issues

Numerous diversion data entry and reporting issues were identified during the quality control review, including data entry, unit reporting, and other related issues. Commonly encountered diversion data entry and reporting issues are summarized below.

Diversion data entry issues encountered during the quality control review include misplaced decimal points, apparent reporting of monthly diversion volumes in the wrong data field within the annual report, and other similar issues. When the data entry issue was identifiable, the diversion data was corrected accordingly.

Unit reporting issues encountered during the quality control review include apparent reporting of monthly diversion amounts using incorrect units of measurement, such as reporting of diversion volumes in units of acre-feet instead of gallons. These unit reporting errors generally resulted in unreasonably large diversion amounts, particularly when compared with the reported purpose of use. Other information contained within the annual report, such as the reported purpose of use, crop acreage, maximum rate of diversion, amount beneficially used, and comments and additional remarks, was generally used to identify and correct the reported diversion amounts. In some cases, a comparison of 2018 and 2019 reported diversions with reported diversions in prior annual reports provided information that informed a correction to the diversion amount.

In some cases, a diversion data entry or unit reporting error was detected, but it was unclear how the reported diversion amounts should be corrected. If it was not possible to correct the diversion amount without supplemental information provided by the water right holder, the water right record was identified for outreach to the water right holder to resolve the issue.

Some additional data reporting errors were also identified during the quality control review, such as annual reports that contain reported monthly diversion volumes in excess of the reported maximum monthly rate of diversion. In some cases, it was determined that the water right holder or their agent likely reported the maximum monthly rate of diversion using incorrect units, such as gallons per day (GPD) instead of gallons per minute (GPM). In many cases, this specific issue did not require a correction to the reported monthly diversion amounts. However, some other miscellaneous reporting-related issues were identified during the quality control review that required additional information to resolve. These water right records were generally identified and prioritized for outreach to the water right holder.

Reported Diversions in Excess of Water Right Face Value

Annual reports submitted for some post-1914 appropriative water rights included reported diversions in excess of the water right face value. In most instances, the reported diversion amount was changed to the face value amount or other updated value based on information contained within the annual report or supplemental information available in other documentation accessed through the eWRIMS database, such as the water right permit or license.

In addition to the records review described above, approximately 100 post-1914 appropriative rights were identified that reported diversions less than 5,000 AF but in excess of the face value of the water right. Most of these diversions are very small. Due to time constraints, no investigation of the approximately 100 post-1914 appropriative water right records with 2018 or 2019 reported diversions in excess of the water right face value was conducted. In these cases, the reported diversion amounts within the demand dataset were updated to equal the face value of the water right.

Update and Format Demand Dataset

Following completion of the quality control review process described above, several additional steps were completed to update, format, and export the demand dataset for use in the Water Unavailability Methodology Excel workbook (spreadsheet). The contents of the spreadsheet are described in Appendix A.

Select water right records (Application ID Numbers) were removed from the initial demand dataset as a result of the quality control review discussed above, including water right records that appeared to divert water only for non-consumptive use. As discussed in the main report, several consumptive water right records were also removed from the dataset, including consumptive water rights associated with the Central Valley Project (CVP) Trinity River Division (A005628, A015374, A015375, A016767, and A017374). A small number (less than 10) of additional water right records were determined to be located outside of the Delta watershed based on their Hydrologic Unit Code level 8 (HUC8) watershed and were also removed from the demand dataset. These records all contain PODs located near the boundary of the Delta watershed that were improperly included in the spatial selection of water right records in the Delta watershed.

The quality control process described above focused on the review of the annual total diversion amounts for calendar years 2018 and 2019. If an annual diversion amount was adjusted as a result of a correction applied during the quality control process, the monthly diversion values were adjusted in a proportional manner.

Some water right holders did not submit annual reports in 2018 or 2019. When an annual report is not submitted, there is no diversion data value recorded in the eWRIMS flat files. In instances where a water right holder did not submit an annual report, the diversion amount was recorded as zero in the demand dataset. This provides a conservative assumption for the purposes of avoiding the overestimation of demands.

Upon completion of the quality control review process, diversion values were merged with a March 16, 2021 copy of the eWRIMS datasets to produce a demand dataset that reflects updates to eWRIMS database information that occurred between January 15 and March 16, 2021. For example, a small number of diverters submitted new or revised 2018 or 2019 annual reports between January 15 and March 16, 2021. These new or revised diversion values were incorporated into the demand dataset. In addition, seven water right records were removed from the demand dataset due to changes in water right status from an active-type status to an inactive-type status between January 15 and March 16, 2021.

Appendix A contains more information about the field names and content included in the demand dataset used in the spreadsheet. Many of the demand dataset fields were obtained directly from the eWRIMS flat files. Several other fields, including the Watershed and Legal Delta (True/False) fields, were determined based on a GIS

analysis. One field, Priority Date, was determined for post-1914 appropriative rights and select Statements of Diversion and Use using multiple data fields contained within the eWRIMS flat files. The Priority Date for post-1914 appropriative water right types was based on the 'Application Acceptance Date' and 'Application Received Date' fields in the eWRIMS database and was determined to be the earlier date among the two fields. The Priority Date for Statements of Diversion and Use was based on the year diversion first commenced or was assigned a Priority date of "Riparian," depending on the Statement of Diversion and Use assigned category. These Statement of Diversion and Use assigned categories and priority dates are described in greater detail in the next section.

The demand data diversion values are structured in a wide format, such that each water right record (Application ID Number) exists on a single row with total annual and monthly diversion amounts for both 2018 and 2019. Some water right records divert from multiple subwatersheds or divert within the Legal Delta, with access to water from both the Sacramento and the San Joaquin River watersheds. The demands of these water right records are modified and expanded upon in the Demand Separated tab of the methodology spreadsheet. Appendix A provides additional details on these modifications.

Disaggregation of Statements of Diversion and Use

Water right holders and claimants that divert water under Statements of Diversion and Use provide information about the water right claim type to the State Water Board in Initial Statements of Water Diversion and Use and in annual reports (Supplement Statements of Diversion and Use). This user-submitted information was obtained from the Initial Statements of Diversion and Use and the 2018 and 2019 annual reports, and was used to disaggregate Statements of Diversion and Use into several categories.

Statement of Diversion and Use water right claim type information provided in the Initial Statement of Diversion and Use is stored in the 'Sub-Type' field in the Water Rights Point of Diversion Flat File. Statement of Diversion and Use water right claim type information provided in the 2018 and 2019 annual reports is stored in the 'Diverted and Used Under' field in the Water Rights Annual Water Use Report Flat File. Water right claim type information were concatenated, capitalized for uniformity, and reduced to a minimum set of unique and ordered values for each Statement of Diversion and Use.

The Statement of Diversion and Use water right claim type information was then searched for keywords and a category (Riparian, Riparian/Pre-1914, Pre-1914, Reserved, Other, or Unclassified) was assigned based on matches as summarized below. The search was conducted in sequence and stopped when the first match was found, following the sequence below with the assigned category in bold:

1. **Riparian/Pre-1914** – Keywords: RIPARIAN, or RIPERIAN and PRE-1914, PRE-14, PRE1914, or PRE14
2. **Riparian** – Keywords: RIPARIAN, or RIPERIAN
3. **Pre-1914** – Keywords: PRE-1914, PRE-14, PRE1914, or PRE14
4. **Reserved** – Keywords: RESERVE, or RESERVATION
5. **Other** – Keywords: COURTADJ, COURTDECREE, COURT DECREE, HOLDING CONTRACT, COWELL AGREEMENT, or CONTRACT WITH YOLO COUNTY
6. Removal from demand dataset – Keywords: STOCKPOND, STOCK POND, PENDING, or PENDINGAPPROPRIATE
7. **Unclassified** – did not contain any of the above keywords.

Statements of Diversion and Use assigned to the Riparian category contain the keyword RIPARIAN or RIPERIAN, but do not contain the keywords PRE-1914, PRE-14, PRE1914, or PRE14. Statements of Diversion and Use assigned to the Pre-1914 category contain the keyword PRE-1914, PRE-14, PRE1914, or PRE14, but do not contain the keywords RIPARIAN or RIPERIAN. Statements of Diversion and Use assigned to the Riparian/Pre-1914 category contain keywords for both the Riparian and Pre-1914 categories.

Priority dates were assigned to each record in the Riparian/Pre-1914, Pre-1914, Reserved, and Unclassified categories based upon the earliest 'Year Diversion Commenced' value reported in the Initial Statements of Diversion and Use, the 2018 annual report, or the 2019 annual report. These values can be found in the 'Year Diversion Commenced' column of both the Water Rights Point of Diversion Flat File and the Water Rights Annual Water Use Report Flat File. Though priority dates were assigned to Statements of Diversion and Use in the Riparian/Pre-1914 category, for the purposes of evaluating water unavailability these claims are assigned a non-priority date value of "Riparian" and are assumed to have senior priority over all appropriative water rights.[2] Statements in the Riparian and Other categories are similarly assigned a "Riparian" priority and assumed to all have equal senior priority.

[2] For claims within the Legal Delta, this categorization of colorable riparian claims is consistent with recent judicial decisions (see e.g., *Modesto Irrigation District v. Heather Robinson Tanaka*, 48 Cal.App.5th 898 (2020)) and with the legal principles described in a memorandum dated December 15, 2017 regarding Issues Related to Overlap between Pre-1914 and Riparian Water Right Claims in the Delta and available on the website of the Office of the Delta Watermaster (Overlap Memo).

Appendix C: Summary of Public Comments

The table below summarizes the substantive technical, factual, or legal comments that have been received to date regarding the Water Unavailability Methodology as well as the section of the Water Unavailability Methodology summary report that is responsive to each comment.

Commenter	Summary of Comments	Response Section
Written Comments		
Valley Aglands, Inc.	Notices of Water Unavailability (Notices) should be issued earlier to manage post-1914 priorities of right. If conditions are very dry, Notices should be issued to partially curtail all riparians as well.	1
Association of California Water Agencies	Notices should be very clear that they are not curtailment orders.	See June 15, 2021 Notices
Byron-Bethany Irrigation District	Methodology cannot support any curtailments. Some of the flaws from Order WR 2016-0015 still exist. Distinguish supply gages in Figure 5. Add Hydrologic Unit Code level 8 watersheds map. Do not make Delta return flows available to rights upstream. Treat Delta as its own supply and demand area with water always present. Legal Delta's return flows stay available locally. Add municipal return flows as additional supply. Do not omit mainstem reservoir releases in excess of full natural flow (FNF). Acknowledge residence time of water in the Delta (about 3 months). Use hydrodynamic models for Delta water availability instead of upstream FNF. Consider Delta water quality. Include return flows from rediversion of stored Project water. Attached 2016 Expert Report of Susan Paulsen.	1, 2.1.3, 2.2.8, 2.3.3

Commenter	Summary of Comments	Response Section
California Farm Bureau Federation	Better describe actual curtailment process. How will the recent Temporary Urgency Change Petition from the Department of Water Resources' (DWR) State Water Project (SWP) and the U.S. Bureau of Reclamation's (Reclamation) Central Valley Project (CVP) (collectively Projects) affect this effort? Focus on improved functional data instead of poor reporting/measurement. Encourage voluntary agreements instead of curtailments.	3
Central Delta Water Agency	Tidal flow should be available natural flow supply (about 330,000 cubic feet per second or about 19.6 million acre-feet per month). Identify any rights within tidal influence zone. Natural tidal flows are of sufficient quality for beneficial use; the Projects are required to ensure this. Historically the Delta was less salty but development (deepening ship channels) have made it saltier. Acknowledge that Delta lowland diversions help the Projects by improving Delta water quality. Curtailing Delta lowland rights would not save any water due to weed growth and shallow groundwater. Account for water transfers (e.g., groundwater substitution or land fallowing) and channel accretions/depletions. Do not curtail any water users in the Delta. Attached 1993 Delta Atlas Tidal Flows figure, 2014 testimony of Christopher Neudeck, 2014 South Delta sounding elevations map, 2010 Contra Costa Water District memo on historical Western Delta salinity, 1956 DWR Report on Delta Lowland water quality, 1993 Delta Atlas elevation map, 2014 GEI memo on Delta Wetlands curtailment, and 1993 Delta Atlas Legal Delta map.	1, 2.1.2, 2.2.8, 2.3.3
Cold Springs Water Company	Inadequate justification for curtailing any water rights in San Joaquin Watershed. Support users with no alternative water sources.	See June 15, 2021 Notices

Commenter	Summary of Comments	Response Section
California Water Research	Consider diversions by Sacramento River Settlement Contractors under Reclamation's CVP permits (Reclamation's reports are unclear on relationship). Cross-check diversions greater than face value. Document assumptions on Settlement Contractor demand met by stored water versus natural flow. Ensure Reclamation is complying with reporting requirements for CVP. Attached data table estimating diversions by contractors with post-14 rights.	2.2.2, 2.2.6
East Bay Municipal Utility District	Methodology not real-time or appropriate for individual curtailments (i.e., demands based on 2018 which may not represent current conditions). More technical documentation of process needed. Better describe actual curtailment process. Why is the Mokelumne River subwatershed considered a lower subwatershed? Were adjustments made to include the entire watershed in FNF gages? Better explain treatment of riparian and pre-1914 users. Better explain calculations of pasted values.	2.1.3, 2.2, 2.2.4, 2.3.1, Technical Appendix A
Jennifer Spaletta (Delta and tributary water users)	Acknowledge that Delta channels below sea level always have water; the issue is quality not quantity. Use 2020 Demand data for permits and licenses and real-time data for largest diverters with telemetry (e.g., Projects). Support voluntary agreements (e.g., fallowing/forbearance). Attached 2016 Expert Report of Susan Paulsen.	1, 2.2, 2.3.3
Merced Irrigation District	Disagrees with treatment of Projects as most junior. Methodology too generous to SB88 violators. Make sure that abandoned flows are actually abandoned and not being delivered downstream. Do not enact emergency regulations and risk litigation. More information coming on proposed San Joaquin voluntary agreement.	2.2.6, 2.2.8

Commenter	Summary of Comments	Response Section
Northern California Water Association	Curtailments based on waste and unreasonable use are not effective. Better align water availability with actual and projected water supplies (see MBK comments at workshop). Real-time system like Term 91 works well. Sacramento water rights should not be curtailed for users south of North Delta Water Agency, reconsider Legal Delta proration (see Order WR 89-8). The State Water Resources Control Board's (State Water Board or Board) January 1978 Report has good recommendations. Fully utilize complaint process. Use online alert system to lift curtailments. Support voluntary agreements (flow agreements exist on nearly all Sacramento tributaries).	2.1, 2.3.3
Tim O'Laughlin	Do not include Stanislaus River water as available downstream (adjudicated). Include New Melones releases as abandoned downstream of Vernalis. Reclamation's planned New Melones releases for Delta outflow are illegal. Most of Reclamation's Project diversions are San Joaquin River water. Decide if the Delta is a "pool" or not. Curtailing diversions in the Delta does not save water. Are flows to meet X-2 protected? Is tidal flow available for appropriation? Do Central and South Delta have a right to stored water? See comment letter for additional questions.	1, 2.2.6, 2.3.3
Santa Clara Valley Water District	Consider impacts on transfers and exchanges. Enforce SB88 requirements. Balance human water needs with environment.	2.1.2

Commenter	Summary of Comments	Response Section
San Joaquin Tributaries Authority	Supply forecasts of FNF are insufficient to support curtailments, and DWR's Bulletin 120 (B-120) has been inaccurate in 2021. Evaluate supply on a daily basis. Better explain how past data is used in forecasts. Disclose all CalSim 3 results and better validate San Joaquin River return flows. Abandoned flows in headwater subwatersheds not included. Demand estimates based on past data are inaccurate. Disaggregate statement demand into riparian and pre-1914 demands. Account for reductions in demand due to drought. Better explain headwater subwatershed disconnection. Contractor demands double-counted. Do not include rediversions of rim dam releases. Regulations and curtailments of riparian and pre-1914 users are outside the Board's jurisdiction without adjudication. Assuming flow connectivity may be incorrect. Only enforce priority system through complaints.	1, 2.1.4, 2.1.6, 2.2, 2.2.4, 2.2.6, 2.2.8, 2.3.2, 4.1.2
State Water Contractors	Use smaller timestep than monthly. Validate demand data using land use information. Rely on real-time water use data. Supports voluntary agreements. Critiques arguments of Delta water users.	2.1.4, 2.2, 4.1.2
Jeanne Zolezzi (Banta-Carbona Irrigation District, Patterson Irrigation District, West Stanislaus Irrigation District)	Methodology has not improved since 2015 and is insufficient to curtail individual users. Use updated (lower) demand data for this year. Remove riparian demands if no natural flow available. Use finer time scale than monthly. California Data Exchange Center station data inaccurate. Summer San Joaquin Project demand is too high. Include San Joaquin River accretions. New Melones releases are abandoned after Vernalis. Curtailments not necessary on San Joaquin River. The State Water Board has no duty to protect the Projects.	1, 2.2, 2.2.6, 2.2.8, 2.3.2

Commenter	Summary of Comments	Response Section
Verbal Comment		
Mark Van Camp (MBK Engineers)	Appreciates the inclusion of abandoned water at a subwatershed scale. Appreciates the approach of erring on the side of conservative demand estimates and liberal supply estimates so curtailments are not premature. Compare B-120 and California Nevada River Forecast Center forecasts for Sacramento River watershed locations. Reconsider the apportionment of Delta demands between watersheds.	2.1.4, 2.3.3
Late Comment		
Environmental Law Foundation	Consider public trust needs before making allocation decisions. Revise demand estimates to include demands for instream flow. Create a separate public trust process to ensure that there are sufficient flows for fish survival during the drought. Apply methodology to all users including pre-1914 users.	2.2.4, 3.2