State of California
Office of Administrative Law

In re:
State Water Resources Control Board

Regulatory Action:

Title 23, California Code of Regulations

Adopt sections: 877.1, 878 , 879.1, 879.2
Amend sections: 876.1, 878.1, 878.2, 879, 879.3

NOTICE OF APPROVAL OF EMERGENCY REGULATORY ACTION

Government Code Sections 11346.1 and 11349.6

OAL Matter Number: 2022-0802-01

OAL Matter Type: Emergency Readopt (EE)

This action renews and amends emergency regulations to curtail water diversions in the Delta Watershed.

OAL approves this emergency regulatory action pursuant to sections 11346.1 and 11349.6 of the Government Code.

This emergency regulatory action is effective on 8/12/2022 and will expire on 8/14/2023. The Certificate of Compliance for this action is due no later than 8/11/2023.

Date: August 12, 2022

Anna Thomas
Attorney

For: Kenneth J. Pogue
Director

Original: Eileen Sobeck, Executive Director
Copy: Dana Heinrich

STATE OF CALIFORNIA--OFFICE OF ADMINISTRATIVE LAW

NOTICE PUBLICATION / REGULATIONS SUBMISSION

EMERGENCY

STD. 400 (REV. 10/2019)

For use by Secretary of State only

ENDORSED - FILED
in the office of the Secretary of State
of the State of California

AUG 12 2022

1:54 pm

OAL FILE NUMBERS	NOTICE FILE NUMBER	REGULATORY ACTION NUMBER	EMERGENCY NUMBER
	Z-	2022-0802-01EE	

For use by Office of Administrative Law (OAL) only

OFFICE OF ADMIN. LAW
2022 AUG 2 PM 1:36

NOTICE | REGULATIONS

AGENCY WITH RULEMAKING AUTHORITY
State Water Resources Control Board

AGENCY FILE NUMBER (If any)

A. PUBLICATION OF NOTICE (Complete for publication in Notice Register)

1. SUBJECT OF NOTICE	TITLE(S)	FIRST SECTION AFFECTED	2. REQUESTED PUBLICATION DATE

3. NOTICE TYPE	4. AGENCY CONTACT PERSON	TELEPHONE NUMBER	FAX NUMBER (Optional)
☐ Notice re Proposed Regulatory Action ☐ Other			

OAL USE ONLY	ACTION ON PROPOSED NOTICE	NOTICE REGISTER NUMBER	PUBLICATION DATE
	☐ Approved as Submitted ☐ Approved as Modified ☐ Disapproved/ Withdrawn		

B. SUBMISSION OF REGULATIONS (Complete when submitting regulations)

1a. SUBJECT OF REGULATION(S)
Emergency Reporting and Curtailment Regulation, Delta Watershed

1b. ALL PREVIOUS RELATED OAL REGULATORY ACTION NUMBER(S)
2021-0809-01E

2. SPECIFY CALIFORNIA CODE OF REGULATIONS TITLE(S) AND SECTION(S) **(Including title 26, if toxics related)**

SECTION(S) AFFECTED (List all section number(s) individually. Attach additional sheet if needed.)

ADOPT
877.1, 878, ~~878.1~~, 879.1, 879.2, ~~879.3~~ per agency request 8/12/22

AMEND
876.1, 878.2, 879, 878.1, 879.3

TITLE(S)
23

REPEAL

3. TYPE OF FILING

- ☐ Regular Rulemaking (Gov. Code §11346)
- ☐ Certificate of Compliance: The agency officer named below certifies that this agency complied with the provisions of Gov. Code §§11346.2-11347.3 either before the emergency regulation was adopted or within the time period required by statute.
- ☒ Emergency Readopt (Gov. Code, §11346.1(h))
- ☐ Changes Without Regulatory Effect (Cal. Code Regs., title 1, §100)
- ☐ Resubmittal of disapproved or withdrawn nonemergency filing (Gov. Code §§11349.3, 11349.4)
- ☐ File & Print
- ☐ Print Only
- ☐ Emergency (Gov. Code, §11346.1(b))
- ☐ Resubmittal of disapproved or withdrawn emergency filing (Gov. Code, §11346.1)
- ☒ Other (Specify) Wat. Code, § 1058.5.

4. ALL BEGINNING AND ENDING DATES OF AVAILABILITY OF MODIFIED REGULATIONS AND/OR MATERIAL ADDED TO THE RULEMAKING FILE (Cal. Code Regs. title 1, §44 and Gov. Code §11347.1)

5. EFFECTIVE DATE OF CHANGES (Gov. Code, §§ 11343.4, 11346.1(d); Cal. Code Regs., title 1, §100)

- ☐ Effective January 1, April 1, July 1, or October 1 (Gov. Code §11343.4(a))
- ☒ Effective on filing with Secretary of State
- ☐ §100 Changes Without Regulatory Effect
- ☐ Effective other (Specify)

6. CHECK IF THESE REGULATIONS REQUIRE NOTICE TO, OR REVIEW, CONSULTATION, APPROVAL OR CONCURRENCE BY, ANOTHER AGENCY OR ENTITY

- ☐ Department of Finance (Form STD. 399) (SAM §6660)
- ☐ Fair Political Practices Commission
- ☐ State Fire Marshal
- ☐ Other (Specify)

7. CONTACT PERSON	TELEPHONE NUMBER	FAX NUMBER (Optional)	E-MAIL ADDRESS (Optional)
Dana Heinrich	(916) 341-5188		dana.heinrich@waterboards.ca.

8. I certify that the attached copy of the regulation(s) is a true and correct copy of the regulation(s) identified on this form, that the information specified on this form is true and correct, and that I am the head of the agency taking this action, or a designee of the head of the agency, and am authorized to make this certification.

SIGNATURE OF AGENCY HEAD OR DESIGNEE
Eileen Sobeck, Executive Director Digitally signed by Eileen Sobeck, Executive Director Date: 2022.07.28 09:06:33 -07'00'

DATE
July 28, 2022

TYPED NAME AND TITLE OF SIGNATORY
Eileen Sobeck, Executive Director, State Water Resources Control Board

For use by Office of Administrative Law (OAL) only

ENDORSED APPROVED

AUG 12 2022

Office of Administrative Law

Emergency Curtailment Regulation to Protect Water Supplies in the Sacramento-San Joaquin Delta Watershed

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Readopt California Code of Regulations, Title 23, Division 3, Chapter 2, Article 24, Sections 877.1, 878, 878.1, 879.1, 879.2, and 879.3 and revise Sections 876.1, 878.2, and 879 to read:

Article 24 Curtailment of Diversions Due to Drought Emergency

876.1 Emergency Curtailments Due to Lack of Water Availability in the Sacramento-San Joaquin Delta Watershed

(a) This section applies to direct diversions and diversions to storage, of natural and abandoned flows, in the Delta Watershed as defined in section 877.1. This section also applies to the rediversion of water released from storage in the Delta Watershed, except to the extent authorized by a water right or contract.

(b) After the effective date of this regulation, when flows are determined to be insufficient to support all diversions, the Deputy Director as defined in section 877.1 may issue curtailment orders as defined in section 877.1 to water right holders and claimants in the Delta Watershed in order of water right priority, requiring the curtailment of water diversion under designated water rights and claims, except as provided in sections 878, 878.1, 878.2, and 879.1 subdivision (b). Before issuing curtailment orders to water right holders and claimants in the Legal Delta, the Deputy Director will consult with and obtain the concurrence of the Delta Watermaster.

(c) Initial orders requiring curtailment or reporting will be mailed to each water right holder, claimant, or the agent of record on file with the State Water Board, Division of Water Rights within the Delta Watershed. The initial orders will require reporting in accordance with section 879, subdivision (c)(1) and will either require curtailment or will instruct the water right holder, claimant, or agent of record regarding procedures for potential future curtailments. The water right holder, claimant, or agent of record is responsible for immediately providing notice of the orders to all diverters exercising the water right or claim covered by the orders. Communications regarding changes in water availability, including notification of when curtailments of water diversions are required and when curtailments are temporarily suspended or reimposed, will be provided by email to the State Water Board's Delta Drought email distribution list and by posting on the State Water Board's drought webpage. Notice provided by email and by posting on the State Water Board's drought webpage shall be sufficient for all purposes related to required curtailments and reporting pursuant to this section and section 879.

(d) In determining whether water is unavailable under a water right holder or claimant's priority of right and whether to order curtailment of water diversions under specific water rights, the Deputy Director will consider:

(1) Relevant available information regarding date of priority, including but not limited to claims of first use in statements of water diversion and use, judicial and State Water Board decisions and orders, and other information contained in the Division of Water Rights' files. Absent evidence to the contrary, riparian water rights are presumed senior to appropriative water rights for the purposes of curtailments pursuant to this section.

(2) Monthly water right demand projections based on reports of water use for permits and licenses, or statements of water diversion and use, from calendar years 2018, 2019, ~~or~~ 2020, or 2021, and water right demand projections based on annual watermaster reports.

(3) Monthly water right demand projections based on information submitted in response to an informational order issued under section 879, subdivision (c).

(4) Water supply projections based on the following sources of forecasted supply data:

(A) Monthly full natural flow forecasts contained in the Department of Water Resources' California Cooperative Snow Surveys Bulletin 120 Water Supply Forecast, where available;

(B) Daily full natural flow forecasts from the California Nevada River Forecast Center~~, where data is not available in the Bulletin 120 Water Supply Forecasts~~; and

(C) Other available and reliable data on projected or actual precipitation and runoff events that may inform water availability at a monthly or sub-monthly scale.

(5) Relevant available information regarding stream system disconnection where curtailing diversions would not make water available to serve senior downstream water rights or claims, including seasonal or temporary disconnections.

(6) The Deputy Director may also consider any other pertinent, reliable, and publicly available information when determining water right priorities, water availability, water supply projections, and demand projections.

(7) Evaluation of available water supplies against demands may be performed using the Water Unavailability Methodology for the Delta Watershed, or comparable tools. The Water Unavailability Methodology

for the Delta Watershed is described in the Water Unavailability Methodology for the Delta Watershed report dated June 27, 2022~~July 23, 2021~~, which is hereby incorporated by reference. Evaluation of available supplies against demands may be performed at the Hydrologic Unit Code level 4 Sacramento and Hydrologic Unit Code level 4 San Joaquin River watershed scale, or at the subwatershed scale. Subwatersheds within the Delta Watershed are defined in the Water Unavailability Methodology for the Delta Watershed report dated June 27,2022~~July 23, 2021~~, and were established based on Hydrologic Unit Code level 8 watersheds.

(8) Monthly demand projections for water rights or claims held by the Sacramento River Settlement Contractors (SRSC) or the Feather River Contractors (FRC) will not be reduced based on any reduction in contractual supplies to the SRSCs or the FRCs resulting from an operations plan for the Central Valley Project (CVP) or State Water Project (SWP) that is necessary to address dry hydrologic conditions and is designed to conserve water upstream later in the year in order to protect cold water pools for salmon and steelhead, improve water quality, protect carry over storage, or ensure minimum health and safety water supplies. It would be unreasonable for junior water right holders or claimants to divert any water projected to be unused under water rights or claims held by the SRSCs or FRCs under those circumstances because the water would not be available for diversion and use by junior water right holders or claimants but for the reduced contractual supplies, and the water would need to remain instream to conserve cold water pools, improve water quality, protect carry over storage, or ensure minimum health and safety water supplies in accordance with the operations plan.

(e) ~~Upon receipt of an initial order pursuant to this section, a~~ A water right holder or claimant may submit information to the Deputy Director to: support a proposed correction to the water right priority date of the right for which the order was issued; or propose that curtailment may not be appropriate for a particular diverter or in a specific stream system as demonstrated by verifiable circumstances, such as a system that has been adjudicated and is disconnected and curtailment would not make water available to serve senior downstream water rights or claims. ~~Any such proposals and all supporting information and analysis shall be submitted to the Deputy Director within 14 days of receipt of the initial order. Proposals, supporting information, and analyses submitted more than 14 days after receipt of an initial order may be considered to support corrections in advance of future curtailments.~~ The Deputy Director will review ~~timely-provided~~ proposals and supporting information and analyses as soon as practicable, make a determination regarding the proposal, and inform the affected water right holder or claimant of any appropriate update for purposes of water diversion curtailment orders. Before making any determinations within the Legal Delta, the Deputy Director will consult with the Delta Watermaster.

(f) Water right holders and claimants in the Delta Watershed must either subscribe to the Delta Drought email distribution list referenced in subdivision (c) or frequently check the State Water Board's drought webpage to receive updated information regarding water diversion curtailment and reporting orders and water unavailability.

(g) The Deputy Director will temporarily suspend curtailments for some diverters, in order of water right priority, when water availability increases or is projected to increase due to precipitation and runoff events or due to reductions in demand, and the Deputy Director determines that such increased water availability warrants a suspension. The Deputy Director will consider the best available information, such as water supply forecasts from the California Department of Water Resources and other similarly reliable sources, to determine the geographic scope and duration of suspension. By no later than October 1, 2021, and by no more than every 30 days thereafter, the Deputy Director will consider reliable and publicly available information that supports suspension, extension of suspension, or reimposition of curtailments of water diversions, and will publicly issue an update explaining any decisions resulting from the consideration of that information.

(h) All curtailment orders issued under this section shall be subject to reconsideration under article 2 (commencing with section 1122) of chapter 4 of part 1 of division 2 of the California Water Code.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 275, 1058.5, Water Code; *El Dorado Irrigation Dist. v. State Water Resources Control Board* (2006) 142 Cal.App.4th 937; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

877 [Reserved]

877.1 Definitions

(a) "Curtailment Order" refers to an order from the Deputy Director of the Division of Water Rights ordering a water right holder to reduce or cease diversions. A curtailment order may require the recipient to monitor and comply with a curtailment status list if curtailments are not required immediately upon issuance of the order.

(b) "Curtailment Status List" refers to a list published by the Deputy Director with the current status of curtailments noticed under a curtailment order.

(c) "Delta Watermaster" has the same meaning as in Water Code section 85230.

(d) "Delta Watershed" or "Sacramento-San Joaquin Delta Watershed" refers to the Hydrologic Unit Code level 4 Sacramento and the Hydrologic Unit Code level 4 San Joaquin subregions, as defined using the U.S. Geological Survey Hydrologic Units Dataset.

(e) "Deputy Director" refers to the Deputy Director of the Division of Water Rights, or duly authorized designee, at the State Water Resources Control Board.

(f) "Informational Order" refers to an order issued by the Deputy Director which orders reporting of water diversion and use information in the Delta Watershed to inform water unavailability determinations and to support the curtailment process described in section 876.1.

(g) "Legal Delta" has the same meaning as the Sacramento-San Joaquin Delta, as defined in Water Code section 12220.

(h) "Minimum human health and safety needs" refers to the amount of water necessary to prevent adverse impacts to human health and safety, for which there is no feasible alternate supply. "Minimum human health and safety needs" include:

(1) Domestic water uses including water for human consumption, cooking, or sanitation purposes. Further, domestic water uses include incidental uses necessary for household animals or domestic sustenance such as small vegetable gardens. As necessary to provide for domestic water use, water diverted for minimum human health and safety needs may include water hauling and bulk water deliveries, so long as the diverter maintains records of such deliveries and complies with the reporting requirements of section 879 of this article, and so long as such diversion and use is consistent with a valid water right.

(2) For Urban Water Suppliers, water uses consistent with demand reduction actions required by the strictest stage of that supplier's adopted Water Shortage Contingency Plan, which actions must achieve at least a 50% reduction in water use, as part of its Urban Water Management Plan, as described by Water Code Section 10632.

(3) Water supplies necessary for energy sources that are critical to basic grid reliability, as identified by the California Independent System Operator, California Public Utilities Commission, California Energy Commission, or a similar energy grid reliability authority.

(4) Water supplies necessary to prevent tree die-off that would contribute to fire risk to residences, and for maintenance of ponds or other water sources for fire fighting, in addition to water supplies identified by the California Department of Forestry and Fire Protection or another appropriate authority as regionally necessary for fire preparedness.

(5) Water supplies identified by the California Air Resources Board, a local air quality management district, or other appropriate public agency with air quality expertise, as necessary to address critical air quality impacts to protect public health.

(6) Water supplies necessary to address immediate public health or safety threats, as determined by a public agency with health or safety expertise.

(7) Other water uses necessary for human health and safety which a state, local, tribal or federal health, environmental, or safety agency has determined are critical to public health and safety or to the basic infrastructure of the state. Diverters wishing to continue diversions for these uses must identify the health and safety need, include approval or similar relevant documentation from the appropriate public agency, describe why the amount requested is critical for the need and cannot be met through alternate supplies, state how long the diversion is expected to continue, certify that the supply will be used only for the stated need, and describe steps taken and planned to obtain alternative supplies.

(i) "Russian River Watershed" refers to the area located in Mendocino and Sonoma Counties that drains towards the outlet of the Russian River at the Pacific Ocean.

(j) "State Water Board" refers to the State Water Resources Control Board.

(k) "Urban Water Supplier" has the same meaning as defined in Water Code section 10617.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art., X § 2; Sections 100, 100.5, 104, 105, 106.3, 275, 1058.5, Water Code; *Environmental Defense Fund v. East Bay Muni. Util. Dist.* (1980) 26 Cal.3d 183.

878 Non-Consumptive Uses

Non-consumptive uses under any valid basis of right may continue after issuance of a curtailment order without further approval from the Deputy Director, subject to the conditions set forth in this section. For the purposes of this section, a non-consumptive use is one for which direct diversion and use of water does not decrease downstream flows or the availability of water for downstream water users. Any diverter wishing to continue diversion under this section must submit to the Deputy Director a certification, under penalty of perjury, which describes the non-consumptive use of water and explains, with supporting evidence, how the diversion and use do not decrease downstream flows in the applicable watershed. The Deputy Director may request additional information and may invalidate any non-consumptive use certification if the information provided is insufficient to support eligibility or if more convincing evidence

contradicts the claims in the certification. If a certification submitted pursuant to this section is invalidated, the diversions are subject to any curtailment order issued for that basis of right.

This section applies to:

(a) Direct diversions solely for hydropower if discharges are returned to the source stream or its tributaries and water is not held in storage.

(b) Direct diversions dedicated to instream uses for the benefit of fish and wildlife pursuant to Water Code section 1707, including those that divert water to a different location for subsequent release, provided the location of release is hydraulically connected to the source stream.

(c) Direct diversions subject to curtailment orders issued under sections 877.2 and 877.3 where the Deputy Director, the California Department of Fish and Wildlife, and the Executive Officer of the North Coast Regional Board have approved a substitution of releases of either stored water or groundwater into the Russian River or a tributary thereof such that there is no net decrease in stream flow as a result of the diversion. The rate of releases made pursuant to this subdivision must be measured daily using a device or measurement method approved by the Deputy Director and provided to the Deputy Director on a monthly basis. Proposals involving the release of groundwater shall provide sufficient data and information to reasonably quantify any depletions of surface water caused by the groundwater pumping, the potential time lags of those depletions, and if additional groundwater releases beyond the diversion amounts are able to offset those depletions. The release of water does not have to be conducted by the owner of the water right proposed for the continued diversions, provided an agreement between the water right holder and the entity releasing the water is included in the proposal.

(d) Other direct diversions solely for non-consumptive uses if those diverters file with the Deputy Director a certification under penalty of perjury demonstrating that the diversion and use are non-consumptive and do not decrease downstream flows in the watershed or the availability of water for downstream water users.

(e) Direct diversions located within the Legal Delta used exclusively to irrigate lands entirely below sea level when comparison of diversion and drainage records provide substantial evidence that continued irrigation of those lands does not increase net channel depletions.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 187, 275, 348, Water Code

878.1 Minimum Human Health and Safety Needs

(a) Diversions described in this section under any valid basis of right may be authorized to continue notwithstanding curtailment of that right, subject to the conditions set forth in this section. A diversion that would otherwise be subject to curtailment may be authorized if:

(1) The diversion is necessary for minimum human health and safety needs; and therefore,

(2) The diversion is necessary to further the constitutional policy that the water resources of the state be put to beneficial use to the full extent they are capable, and that waste and unreasonable use be prevented, notwithstanding the effect of the diversions on more senior water rights or instream beneficial uses.

(b)

(1) Diversions for minimum human health and safety needs under any valid basis of right of not greater than 55 gallons per person per day may continue notwithstanding curtailment of that right without further approval from the Deputy Director, subject to the conditions set forth in this section. Any diverter wishing to continue diversion under this subdivision must submit to the Deputy Director certification, under penalty of perjury, of compliance with the requirements of subdivisions (b)(1)(A)-(E), below. The Deputy Director may request additional information or set additional requirements on continued diversion.

(A) Not more than 55 gallons per person per day will be diverted under all bases of right.

(B) The diversion is necessary to serve minimum human health and safety needs as defined in section 877.1, subdivision (h), after all other alternate sources of water have been used. To the extent other water sources are available, those sources will be used first and the total used will not exceed 55 gallons per person per day.

(C) The diverter and all end users of the diverted water have implemented all available conservation measures and are operating under the strictest existing conservation plan for that place of use, if such a plan exists for the area or service provider. If additional approvals are required before implementation of the conservation regime, the diverter must certify that all possible steps will be taken immediately to ensure prompt approval.

(D) If the diverter or anyone using water under the diverter's basis of right is an Urban Water Supplier, it has declared a water shortage emergency condition and either already has adopted

regulations and restrictions on the delivery of water or will adopt conservation and water delivery restrictions and regulations within a timeframe specified by the Deputy Director as a condition of certification.

(E) The diverter has either pursued steps to acquire other sources of water, but has not yet been completely successful, as described in an attached report, or the diverter will pursue the steps in an attached plan to identify and secure additional water.

(2) To the extent that a diversion for minimum human health and safety needs requires more than 55 gallons per person per day, or cannot be quantified on the basis of gallons per person per day, continued diversion of water notwithstanding curtailment of the applicable water right requires submission of a petition demonstrating compliance with the requirements of subdivisions (b)(1)(B)-(E) above and (b)(2)(A)-(F) below, and approval by the Deputy Director. The Deputy Director may condition approval of the petition on implementation of additional conservation measures and reporting requirements. Any petition to continue diversion to meet minimum human health and safety needs of more than 55 gallons per person per day must:

(A) Describe the specific circumstances that make the requested diversion amount necessary to meet minimum human health and safety needs.

(B) Estimate the amount of water needed.

(C) Certify that the supply will be used only for the stated need.

(D) Describe any other additional steps the diverter will take to reduce diversions and consumption.

(E) Provide the timeframe in which the diverter expects to reduce usage to no more than 55 gallons per person per day, or why minimum human health and safety needs will continue to require more water.

(F) As necessary, provide documentation that the use meets the definition of minimum human health and safety needs provided in section 877.1, subdivision (h). For water supplies necessary for fire prevention or firefighting purposes, substantiating documentation, such as guidance from the local fire department, local city or county ordinances, or equivalent local requirements, may be requested by the Deputy Director.

(c) For public water systems with 15 or greater connections and small water systems of 5 to 15 connections, gallons per person per day shall be

calculated on a monthly basis and the calculation methodology shall be consistent with the State Water Board's Percentage Residential Use and Residential Gallons Per Capita Daily Calculation (PRV and R-GPCD Calculation), dated September 22, 2020, which is hereby incorporated by reference.

(d) For water supplies necessary for electrical power generation critical to grid reliability, substantiating documentation, such as a letter of support from California Independent System Operator, California Public Utilities Commission, California Energy Commission, or a similar energy grid reliability authority, must be provided.

(e) To the extent necessary to resolve immediate public health or safety threats, a diversion subject to curtailment may continue while a petition under subdivision (b)(2) ~~or (d)~~ is being prepared and is pending. The Deputy Director may require additional information to support the initial petition, information on how long the diversion is expected to continue, and a description of other steps taken or planned to obtain alternative supplies.

(f) Notice of certifications, petitions, and decisions under this section and section 878 will be posted as soon as practicable on the State Water Board's drought webpage. The Deputy Director may issue a decision under this article prior to providing notice.

(g) Notwithstanding California Code of Regulations, Title 23, section 1064, a petition pursuant to Water Code section 1435 or 1725 solely for the provision of water for minimum human health and safety, as defined by section 877.1, subdivision (h), shall be accompanied by a filing fee of $250.

(h) Diversion and use within the Russian River Watershed or Delta Watershed, including Mill Creek and Deer Creek, that deprives water for minimum human health and safety needs in 2022, or which creates unacceptable risk of depriving water for minimum human health and safety needs in 2023, is an unreasonable use of water. The Deputy Director shall prevent such unreasonable use of water by implementing the curtailment methodology described in sections 877.2, 877.3, 877.4, and 877.5 for diversions in the Russian River Watershed, section 876.1 for diversions in the Delta Watershed, and section 876.5 for diversions in the Mill Creek and Deer Creek Watersheds.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 100.5, 104, 105, 106.3, 275, 1058.5, Water Code; *Environmental Defense Fund v. East Bay Muni. Util. Dist.* (1980) 26 Cal.3d 183; *Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463; *Stanford Vina Ranch Irrigation Co. v. State of California* (2020) 50 Cal.App.5th 976.

878.2 Alternative Water Sharing Agreements

Water users may propose alternatives to water diversion curtailment that achieve the intent~~purposes~~ of the curtailment process described under section 876.1 by submitting a proposal to the Deputy Director. Joint ~~P~~proposals must be explicitly agreed to by all participants and describe the setting, the parties, the actions, the provisions for monitoring, record keeping and reporting, and the purported benefits of the proposal in sufficient detail to demonstrate to the satisfaction of the Deputy Director that implementing the proposal will not injure non-party legal users of water or result in an unreasonable impact on fish and wildlife. In considering a proposal under this section, the Deputy Director may request additional information or consult with other entities that may have technical or legal information that should be considered in evaluating such proposals, including but not limited to the California Department of Water Resources (DWR) and United States Bureau of Reclamation (Reclamation). The Deputy Director will consult with the Delta Watermaster on any proposals among diverters within the Legal Delta. A proposal may be implemented pending review by the Deputy Director provided that potentially affected water right holders and claimants, including but not limited to DWR and Reclamation, concur with the proposal and no objections to the proposal are submitted to the Deputy Director. The Deputy Director may approve a proposal subject to conditions, including record keeping and reporting requirements, and provided that the Deputy Director finds implementing the proposal will not injure non-party legal users of water or result in an unreasonable impact on fish and wildlife. Diversions consistent with a proposal implemented or approved pursuant to this section are subject to this article, and violations of the terms of the proposal shall be subject to enforcement as a violation of this article or as an unauthorized diversion or use of water.

Notice of proposals and decisions under this section will be posted as soon as practicable on the State Water Board's Delta drought webpage. The Deputy Director may issue a decision under this section prior to providing such notice. Any interested person may file a comment or objection to the proposal or decision with the Deputy Director with simultaneous service to the parties who submitted the proposal. The Deputy Director will consider any comment or objection. The State Water Board may hold a hearing on any proposal to which parties have objected, after notice to all interested persons.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 100, 109, 275, 1011, 1011.5, 1051.5, Water Code; *City of Barstow v. Mojave Water Agency* (2000) 23 Cal.4th 1224.

879 Reporting

(a) All water users or water right holders whose continued diversion may be authorized under section 878.1 are required to submit, under penalty of perjury, information identified on a schedule established by the Deputy Director as a condition of certification or petition approval pursuant to section 878.1. The required information may include, but is not limited to, the following:

(1) The water right identification numbers under which diversions continue;

(2) The public water system identification number for any public water system served by the diversions.

(3) How the diverter complies with any conditions of continued diversion, including the conditions of certification under section 878.1, subdivision (b)(1);

(4) Any failures to comply with conditions, including the conditions of certification under section 878.1, subdivision (b)(1), and steps taken to prevent further violations;

(5) Conservation and efficiency efforts planned, in the process of implementation, and implemented, as well as any information on the effectiveness of implementation;

(6) Efforts to obtain alternate water sources;

(7) If the diversion is authorized under an approved petition filed pursuant to section 878.1, subdivision (b)(2), progress toward implementing the measures imposed as conditions of petition approval;

(8) If the diversion is authorized under section 878.1, subdivision (b)(2):

(A) The rate of diversion if it is still ongoing;

(B) Whether the water has been used for any other purpose; and

(C) The date diversion ceased, if applicable.

(9) The total water diversion for the reporting period and the total population served for minimum human health and safety needs. The total population must include actual or best available estimates of external populations not otherwise reported as being served by the water right holder, such as individuals receiving bulk or hauled water deliveries for indoor water use.

(10) Diversion amounts for each day in acre-feet per day, maximum diversion rate in cubic feet per second, and anticipated future daily diversion amounts and diversion rates.

(b) The Deputy Director, or delegee, may issue an order under this article requiring any person to provide additional information reasonably necessary to assess their compliance with this article. Any person receiving an order under this subdivision shall provide the requested information within the time

specified by the Deputy Director, but not less than ten (10) days after issuance.

(c) This subdivision applies to Delta Watershed curtailment orders and enhanced reporting to inform water unavailability determinations and the curtailment process described under section 876.1.

(1) All water right holders and claimants issued an initial order pursuant to section 876.1 are required, within the deadlines specified in the initial order but no sooner than seven calendar days following issuance of the order, to submit under penalty of perjury a certification that they have and will continue to take actions needed to comply with section 876.1, including the following actions:

(A) Regularly reviewing information posted on the State Water Board's drought webpage to determine when curtailments are required and when curtailments are suspended or reimposed, or subscribing to the State Water Board's Delta Drought email distribution list to receive updates directly; and

(B) Ceasing diversions of natural and abandoned flow when curtailments are ordered, except to the extent that continuing diversions are authorized in accordance with section 878, 878.1, 878.2, or 879.1 subdivision (b), and ceasing rediversions of water released from storage, except to the extent authorized by a water right or contract.

(2) In addition to the requirements identified under subdivision (c)(1), the Deputy Director may require water right holders and claimants who have been issued an initial order under section 876.1 and whose water right or claim has a total authorized face value or recent annual reported diversion amount of one thousand acre-feet or greater to report the following information by the date specified by the Deputy Director, but no earlier than seven days after receipt of the reporting order and as specified thereafter:

(A) Prior diversions, unless otherwise reported in annual reports of water diversion and use, including direct diversions and diversions to storage. Diversion volumes shall be provided in a daily, weekly, or monthly format, as identified in the order.

(B) Demand projections for subsequent months through October 1, 2023, including direct diversions and diversions to storage. Diversion volumes shall be provided in a daily, weekly, or monthly format, as identified in the order.

(C) Before issuing orders issued pursuant to subdivision (c)(2) to water right holders and claimants in the Legal Delta, the Deputy

Director will consult with and obtain the concurrence of the Delta Watermaster.

(3) In order to inform curtailment decisions, the Deputy Director, or the Delta Watermaster for rights in the Legal Delta, may issue informational orders under subdivision (c) of this section requiring a water right holder, diverter, or user to provide additional information related to a diversion or use of water in the Delta Watershed, including but not limited to: additional reporting of water diversions and use; the basis of right with supporting documents or other evidence; property patent date for the place of use; the date of initial appropriation; anticipated or actual water transfer amounts; or any other information relevant to forecasting demands and supplies and determining compliance with curtailment orders in the current drought year or in contingency planning for continuation of the current drought emergency. Informational orders may require reporting of diversions made in prior months and diversions anticipated during subsequent months on a recurring, monthly basis.

(4) Any water right holder or claimant receiving an order under subdivision (c) of this section shall provide the requested information within the deadlines specified therein, including any recurring deadlines associated with ongoing reporting requirements as applicable. The Deputy Director, or the Delta Watermaster for rights in the Legal Delta, may grant additional time for submission of information upon substantial compliance with the specified deadline and a showing of good cause. Information provided pursuant to subdivision (c) of this section shall be submitted in an online form maintained by the State Water Board and accessible through its website, or in an electronic format as specified by the Deputy Director or Delta Watermaster.

(5) Failure to provide the information required under subdivision (c) of this section within the deadlines specified in the order or any time extension granted by the Deputy Director, or the Delta Watermaster for rights in the Legal Delta, is a violation subject to civil liability of up to $500 per day for each day the violation continues pursuant to Water Code section 1846.

(6) In determining whether to impose reporting requirements under subdivision (c) of this section, the Deputy Director and Delta Watermaster will consider the need for the information for purposes of informing curtailment decisions and the burden of producing it, and will make reasonable efforts to avoid requiring duplicative reporting of information that is already in the State Water Board's possession.

(7) All orders issued under subdivisions (c)(2) and (c)(3) shall be subject to reconsideration under article 2 (commencing with section 1122) of chapter 4 of part 1 of division 2 of the California Water Code.

Authority: Sections 1058, 1058.5, Water Code

Reference: Sections 100, 187, 275, 348, 1051, 1058.5, 1841 Water Code.

879.1 Conditions of Permits, Licenses and Registrations

(a) Compliance with this article, including any conditions of certification or approval of a petition under this article, shall constitute a condition of all water right permits, licenses, certificates and registrations for diversions from any watershed identified in this article.

(b) Diversions may continue after the issuance of a curtailment order to the extent the maintenance of a mechanism allowing for the bypass of natural or abandoned flow is not conditioned in a water right permit, license, stockpond certificate, or registration not exceeding a total authorized face value of ten acre-feet per year.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 275, 1253, 1058.5, Water Code; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419.

879.2 Compliance and Enforcement

(a) A water user must comply with a curtailment order issued under this article, any updates to the curtailment status list, all conditions of certification or approval of a petition under this article, and all water right conditions under this article, notwithstanding receipt of more than one curtailment order. To the extent of any conflict between applicable requirements, the diverter must comply with the requirements that are the most stringent.

(b) When conducting an inspection to assess a diverter's compliance with this article, the State Water Board may obtain an inspection warrant pursuant to the procedures set forth in Title 13 (commencing with Section 1822.50) of Part 3 of the Code of Civil Procedure where access is not granted by the property owner.

(c) Failure to meet the requirements of this article or of any order issued thereunder constitutes a violation subject to civil liability pursuant to Water Code section 1846, and an infraction pursuant to Water Code section 1058.5, subdivision (d), each of which can carry a fine of up to five hundred dollars ($500) for each day in which the violation occurs.

(d) Nothing in this section shall be construed as limiting the enforceability of or penalties available under any other provision of law.

Authority: Sections 1058, 1058.5, Water Code

Reference: Cal. Const., Art. X, § 2; Sections 275, 1052, 1055, 1058.5, 1825, 1831, 1846, Water Code; Sections 1822.50 et al., California Code of Civil Procedure; *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419.

879.3 Redelegation of Authorities

Authorities delegated to the Deputy Director under this article may be redelegated.

Authority: Sections 1058, 1058.5, Water Code

Reference: Sections 7, 186, Water Code~~State Water Resources Control Board Resolution No. 2012-0029~~

Water Unavailability Methodology for the Delta Watershed

Prepared By:

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CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

June 2022

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1 Introduction

California and the Sacramento-San Joaquin Delta (Delta) watershed have experienced extremely dry conditions over the last three years. Statewide, water years 2020, 2021, and 2022 were the driest three-year period on record, resulting in very low runoff. These low runoff conditions resulted in very low inflows to reservoirs and associated limited storage supplies for various purposes. Currently, reservoir storage levels in the Delta watershed are significantly below average for most reservoirs and are expected to continue to decline. 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).

This report has been updated regularly since the initial draft was released for public review on May 12, 2021. The July 23, 2021 version of this report was incorporated by reference into the emergency regulations that became effective August 19, 2021 (see section 1.3 below). Since the emergency regulations became effective, four revised versions of the report have been released. Most of the revisions to the report did not reflect changes to the methodology that was described in the July 23, 2021 report, but some relatively minor refinements to the methodology have been made. These minor refinements include:

- Exclusion of the Goose Lake subwatershed due to disconnection from the lower watersheds such that curtailing diversions would not make water available to serve senior downstream water rights or claims.
- Adjustment of subwatershed boundary delineation for certain subwatersheds previously representing headwater and valley floor portions of the larger watershed.
- Allocation of abandoned instream flows to non-riparian water right holders and claimants only.
- Application of return flow factors to direct diversion demand only.
- Use of appropriate timesteps in between monthly and weekly to determine curtailments in response to precipitation and runoff events.
- Curtailment of non-riparian rights only when no water is available at the diverter's priority of right.

- Exclusion from curtailment of rights and claims in a headwater subwatershed based on the watershed-wide unavailability analysis if that subwatershed is assumed to be disconnected from the Delta watershed (i.e., local riparian demands exceed supply). Abandoned instream flows from the subwatershed may still contribute to watershed-wide supply if they are not diverted by local demands.

- Explanation that return flow factors may be applied to both valley floor regions and headwater subwatersheds.

The spatial refinements of the methodology served to improve the accuracy of the methodology in certain portions of the watershed, while the temporal refinement has enabled the temporary suspension of curtailments for a greater number of diverters during sub-monthly precipitation and runoff events.

Updates to the report introduced in this June version are summarized in section 1.6 below. Previous updates to this report are summarized within the introductory sections of those versions of the report, which are available on the Delta Drought webpage.

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[1] and appropriative water rights, including appropriative rights issued under the Board's authority and those in existence prior to the inception of its predecessor-in-interest.[2]

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[1] Generally, a riparian water right is a right to use the natural flow of water on land contiguous to a natural water course and does not include a right to divert water that is foreign in time or source. 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.

[2] Use of water on non-riparian land or seasonal storage of water for later beneficial use requires an appropriative water right. Appropriative water right holders can divert available supplies that are foreign in time or source. An appropriative water right that was initiated before the Water Commission Act went into effect on December 19, 1914, is called a pre-1914 appropriative water right, even if subsequently perfected. Appropriative rights initiated and acquired after this date are called post-1914

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 three years of low precipitation, the U.S. Drought Monitor reports that nearly the entirety of California is experiencing moderate to extreme drought, of which 97 percent is experiencing severe to extreme drought (USDM 2022). The U.S. Seasonal Drought Outlook, released by the Climate Prediction Center on May 31, 2022 and valid through August 31, 2022, shows drought is likely to persist at least until fall throughout California (NOAA 2022). Within the Delta watershed, conditions have been extraordinarily dry, with Water Years (WY) 2020, 2021, and 2022 ranking as the driest three-year period on record based on precipitation (DWR 2022a; DWR 2022b; DWR 2022c; DWR 2022d). These dry conditions have resulted in reservoir storage levels in the Delta watershed that are significantly below average (DWR 2022e). As of June 14, 2022, storage volumes in major reservoirs, including Lake Shasta and Lake Oroville are lower than 55 percent of capacity and below 70 percent of average storage conditions; recent precipitation has improved conditions in some reservoirs, such as Folsom Lake, which currently holds 88 percent of capacity and 111 percent of its historical average (DWR 2022f).

1.3 Emergency Proclamation and Regulations

As a result of the dry conditions last spring, on May 10, 2021, Governor Newsom issued a drought emergency proclamation covering 41 of California's 58 counties (Exec 2021a). On July 8, 2021, the Governor expanded the emergency declaration to 9 additional counties (Exec 2021b) and called on Californians to reduce their water use by 15 percent compared to 2020 levels (Exec 2021c). On October 19, 2021, the Governor

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appropriative water rights, and they are administered and regulated by the State Water Board.

further expanded the emergency declaration to cover the entire state and urged Californians to increase their water conservation efforts as urban water conservation to date had fallen significantly short of the 15 percent goal (Exec 2021d).

The May 10 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 (Exec 2021a). 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 (*Ibid*). On August 3, 2021, the Board adopted emergency regulations that authorize the use of this methodology as the technical basis for curtailment orders issued pursuant to the directives in the emergency drought proclamation. On August 19, 2021, the Office of Administrative Law approved the regulations, which became effective upon filing with the Secretary of State on the same day.

On January 4, 2022, the State Water Board also adopted an emergency regulation to supplement voluntary water conservation. The regulation went into effect on January 18, 2022 and is effective for up to one year unless readopted. An executive order issued March 28, 2022, further directed the State Water Board to consider adopting emergency regulations in support of urban water conservation that would require urban water suppliers to implement certain water shortage response actions. Following this, the State Water Board adopted a second emergency water conservation regulation on May 24, 2022. The regulation went into effect on June 10, 2022 and is effective for up to one year unless readopted (Exec 2022).

The State Water Board is planning to consider readoption of the Enhanced Water Use Reporting and Curtailment of Diversions due to Lack of Water Availability in the Sacramento – San Joaquin Delta Watershed emergency regulation, with revisions, in July of 2022. This version of the methodology is planned to support the current and potential readopted regulation going forward unless an updated version of the methodology is released.

1.4 Purpose of the Water Unavailability Methodology

The San Francisco Bay-Delta (Bay-Delta) watershed includes supplies from both the Sacramento and San Joaquin river systems and their tributaries. As shown in Figure 1 below, water from about 40 percent of California's land area drains to the Bay-Delta, supporting a variety of beneficial uses of water. The 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, San Francisco Bay, and near-shore ocean, as well as a diverse assemblage of species upstream of the Legal Delta. Water from the Delta watershed 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 on 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 Project or 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 well below average, creating significant concerns for salinity control, municipal water supplies, and temperature management and other environmental needs this year and next year if dry conditions continue. As a result of these concerns, the Projects submitted a request for, and were granted subject to terms and conditions, a temporary urgency change petition (TUCP) in water year 2021[3] and 2022[4] for April through June to reduce their obligations to release water from storage to meet flow and water quality requirements in the Delta. In water year 2021, over 2 million acre-feet of Supplemental Project Water was released from Project reservoirs to maintain water quality and meet outflow requirements in the Delta (SWRCB 2021). 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 to repel salinity intrusion from the ocean and meet other minimal needs.

Determining when water supplies are unavailable to users is 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 users when water is unavailable for their use because supplies are needed by downstream senior water right holders or because streamflows are comprised of previously stored water that has been released to serve contractors or to meet water quality or flow requirements.

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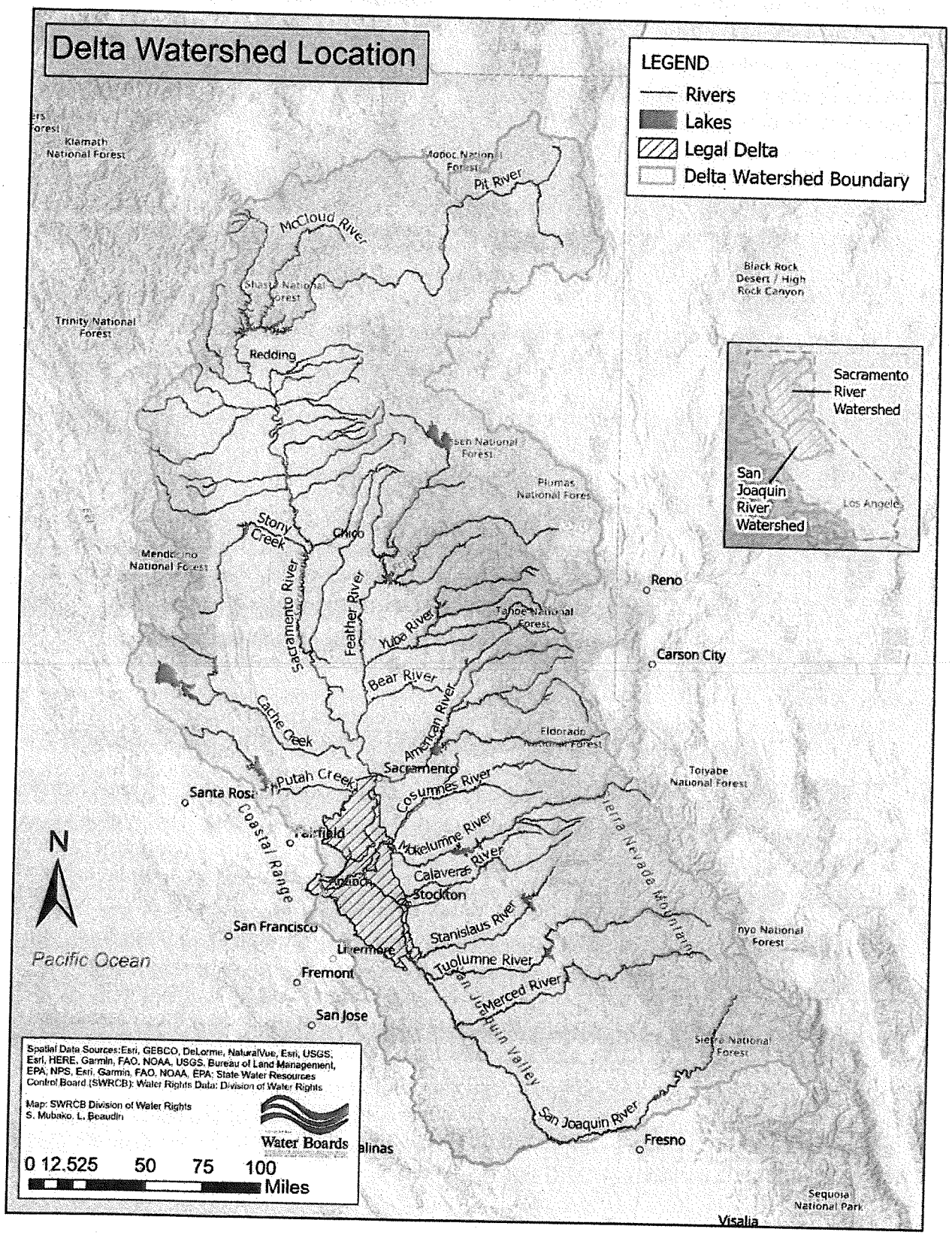
[3] The Board order conditionally approving the 2021 petition is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/docs/2021/20210601_swb_tuco.pdf.

[4] The Board order conditionally approving the 2022 petition is available at: https://www.waterboards.ca.gov/drought/tucp/docs/2022/20220404_tuco_swrcb.pdf

Figure 1. Delta Watershed Location



The State Water Board has developed the Water Unavailability Methodology to identify 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, such as rediversion of previously stored water for use by Project contractors. The methodology also does not address water unavailability for non-consumptive uses of water, such as direct diversion for hydropower production when these supplies are returned back to the source stream. 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 does consider these demands when determining water unavailability during the wet season.

The methodology evaluates water supplies and demands at the subwatershed and watershed scale for both the Sacramento River and San Joaquin River watersheds with currently available data, reporting, and tools. The methodology utilizes the best currently available data on supplies and demands, which may include use of past and projected demand data submitted in response to the August 20, 2021 curtailment and reporting orders and future orders. The Water Unavailability Methodology improves upon methods used for determining water unavailability in prior droughts, most recently in 2014 and 2015. Major improvements 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 curtailment orders or resulting in those notices or orders 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 regarding the Water Unavailability Methodology that were received prior to the release of the July 23, 2021 version of the report that was incorporated by reference into the emergency regulation, as well as any relevant sections of the report where those comments have been addressed. Technical Appendix D was included to respond to comments received regarding the hydrologic complexities of the Legal Delta and to provide additional explanation regarding the assumptions used in the methodology with regard to freshwater supplies in the Legal Delta and the exclusion of tidal inflows as a source of supply. As described further below, Technical Appendix D has been updated in this version of the report. The technical appendices and spreadsheet are available on the State Water Board's Delta Water Unavailability Methodology webpage.

The Board intends to update the methodology as needed 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. 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.

1.5 Curtailment Orders

Pursuant to the emergency regulation and based on the output of the methodology, on August 20, 2021, the Board issued curtailment and reporting orders to water right holders and claimants throughout the Delta watershed. In addition to imposing curtailments, the initial orders imposed reporting requirements on all water right holders and claimants in the Delta watershed and directed diverters to subscribe to the Board's Delta Drought email distribution list or visit the Delta Drought webpage to view the Delta Watershed Curtailment Status List (Curtailment Status List) for updates regarding these and future curtailment orders. On at least a weekly basis since August 20, 2021, updates to the curtailment status of all water right holders and claimants within the Delta watershed have been made available on the Delta Drought webpage and sent to the Board's Delta Drought email subscription list. Current curtailment statuses within the watershed will continue to be updated on a weekly basis, and more frequently if warranted due to precipitation and runoff forecasts. Additional information related to the Delta curtailment regulation and curtailment and reporting orders can be found on the Board's Delta Drought webpage.

1.6 Current Updates to the Water Unavailability Methodology Report

This June 2022 update to the report considers information and input provided during the May 12, 2022 staff workshop and corresponding written comment period ending May 19, 2022, regarding recent and proposed updates to the methodology. In particular, this report update describes:

- Initiation of further quality control review of the 2018 demand dataset to include all water rights and claims that have a face value or recent annual reported diversion volume of 1,000 AF or greater and refinements to enhanced reporting requirements to further refine the demand dataset and reduce the reporting burden for larger diverters (see sections 2.2.3 and 2.2.4).
- Adjustment of the demand dataset to reflect known changes to demands this year associated with extreme dry conditions, including Project export demand reductions associated with an April 4, 2022 Order Approving Temporary Urgency Changes to Water Right License and Permit Terms (see section 2.2.9), reduced allocations to Sacramento River Settlement Contractors and Feather River

Contractors (see section 2.2.9.2), and increases in demands for San Joaquin River water by San Joaquin River Exchange Contractors due to reduced deliveries from the Legal Delta to those users (see section 2.2.9.2).

- Additional description regarding how CalSim 3, used to estimate returns flows, incorporates return flow of stored water deliveries and produces return flows that may be applied in headwater subwatersheds in addition to the valley floor (see section 2.2.11).
- Clarification that no rights or claims in a headwater subwatershed will be curtailed based on the watershed-wide unavailability analysis if the subwatershed is assumed to be disconnected from the Delta watershed (i.e., local riparian demands exceed supply). However, abandoned instream flows may contribute to watershed-wide supply if they are not assumed to have been diverted locally by riparian claimants (see section 2.3.2).
- No Project rights in the Sacramento River Watershed or the Legal Delta will be curtailed based on watershed-wide unavailability when water is found to be unavailable to some, but not all, of these Project rights. This adjustment recognizes the Projects' Coordinated Operations Agreement, which has the practical effect of a voluntary water sharing agreement among Project water rights for the purpose of watershed-wide unavailability analyses (see section 3.1).
- Additional description regarding the selection of the most appropriate exceedance forecast for the analysis (see section 3.1.1).

The State Water Board received additional comments during the May workshop and comment period that do not warrant a change to the methodology at this time. The major comments will be addressed orally when the Board considers revision and readoption of the Delta watershed emergency regulation.

This update to the methodology report is accompanied by updates to Technical Appendix D, which includes updates to reflect current year conditions that were not available in the April 19, 2022 version of the methodology report. Interested parties may provide comments on updates to Appendix D by the comment period identified in the draft emergency regulation notice.

The focus of this report is factual and technical, not legal. Legal arguments made in the petitions for reconsideration are addressed as appropriate in the order responding to petitions for reconsideration of the curtailment and reporting orders, State Water Board Order WR 2022-0147-EXEC, rather than this report.

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.

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 water year. 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 (D1641) that account for the unimpaired runoff of each water year and its preceding water year (DWR 2021a). For both the Sacramento and San Joaquin River

watersheds, 2021 was considered Critically Dry, and as of the April 1 forecast, 2022 is projected to be Critically Dry, as well (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 conditions become less variable.

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. Conditions for water year 2022 to date, as well as recent 10, 50, and 90 percent exceedance forecasts (dated June 24, 2022 from the California Nevada River Forecast Center), are shown in Figure 2 and Figure 3 below. As indicated below, water year 2022 supply conditions began near median conditions (based on 1922-2021) for a wet year but have dropped to near-median conditions for critically dry years since February 2022. Conditions are expected to remain near-critical through summer 2022 regardless of forecast exceedance.

Figure 2. Water Year 2022 Supply Conditions in the Sacramento River Watershed

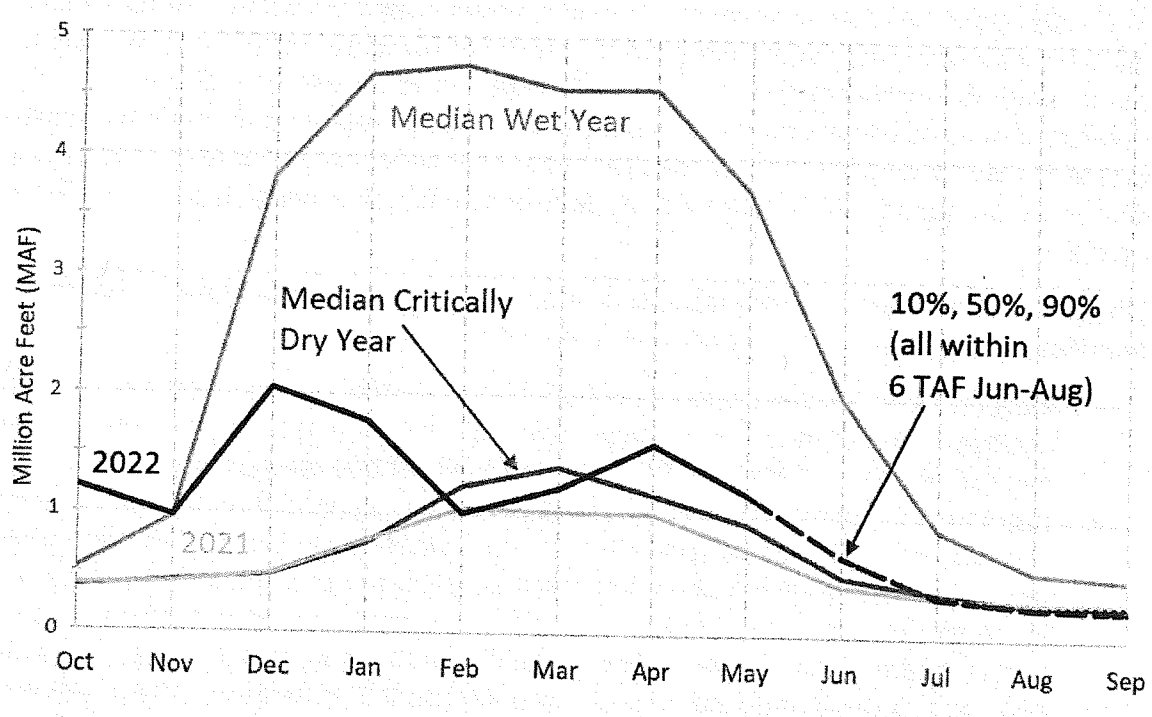
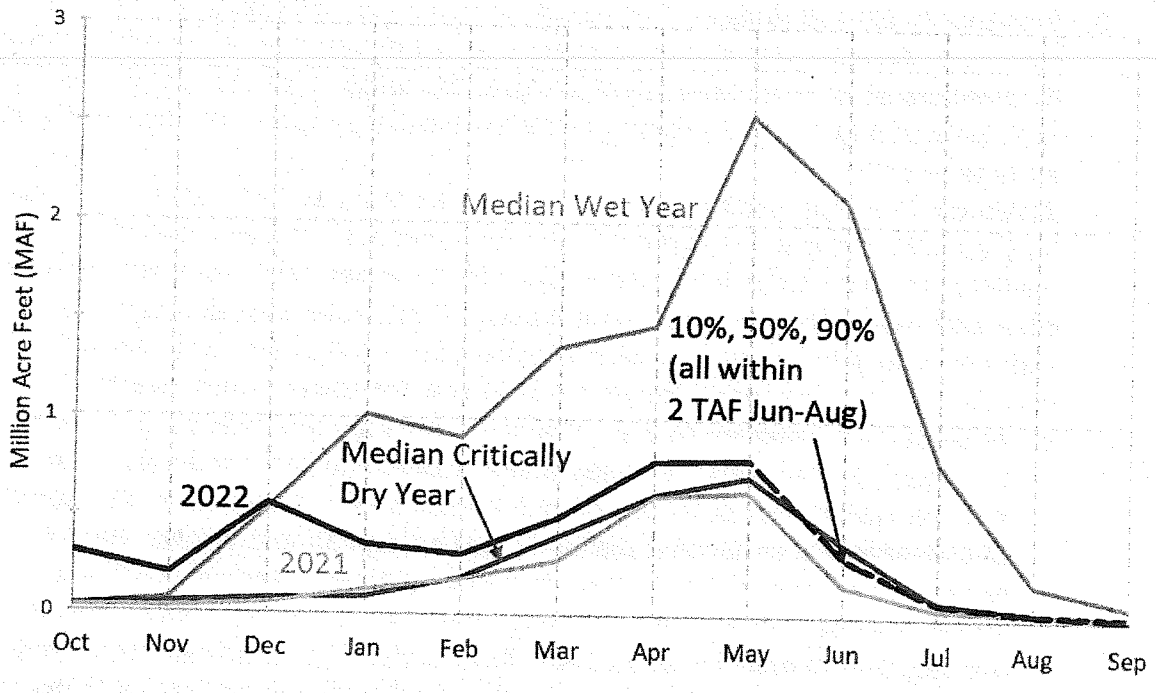


Figure 3. Water Year 2022 Supply Conditions in the San Joaquin River Watershed



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, or contractual demands. This section discusses the additional complexities in determining whether water is unavailable 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 2.2.10 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, 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 2.2.11 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. Return flows are incorporated by reducing demands for direct diversion 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 except with regard to abandoned instream flows, as described in section 2.1.6 below. Additional analysis would be needed to distinguish supplies originating from abandoned returned flows that are foreign in time or watershed and are therefore 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 primarily delineated 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. Due to the presence of some demands not met by local supplies within their HUC8 boundaries, the Mokelumne, Chowchilla, Fresno, and Calaveras River subwatersheds were instead delineated as a combination of smaller Hydrologic Unit Code level 10 (HUC10) watersheds and stream buffers (see section 2.3.1). A total of 20 subwatersheds were used in the Water Unavailability Methodology: 10 each in the Sacramento and San Joaquin River watersheds (see Figure 4). Consistent with the USGS WBD, the

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

methodology assumes that the Cosumnes, Mokelumne, and Calaveras Rivers are part of the San Joaquin River watershed.

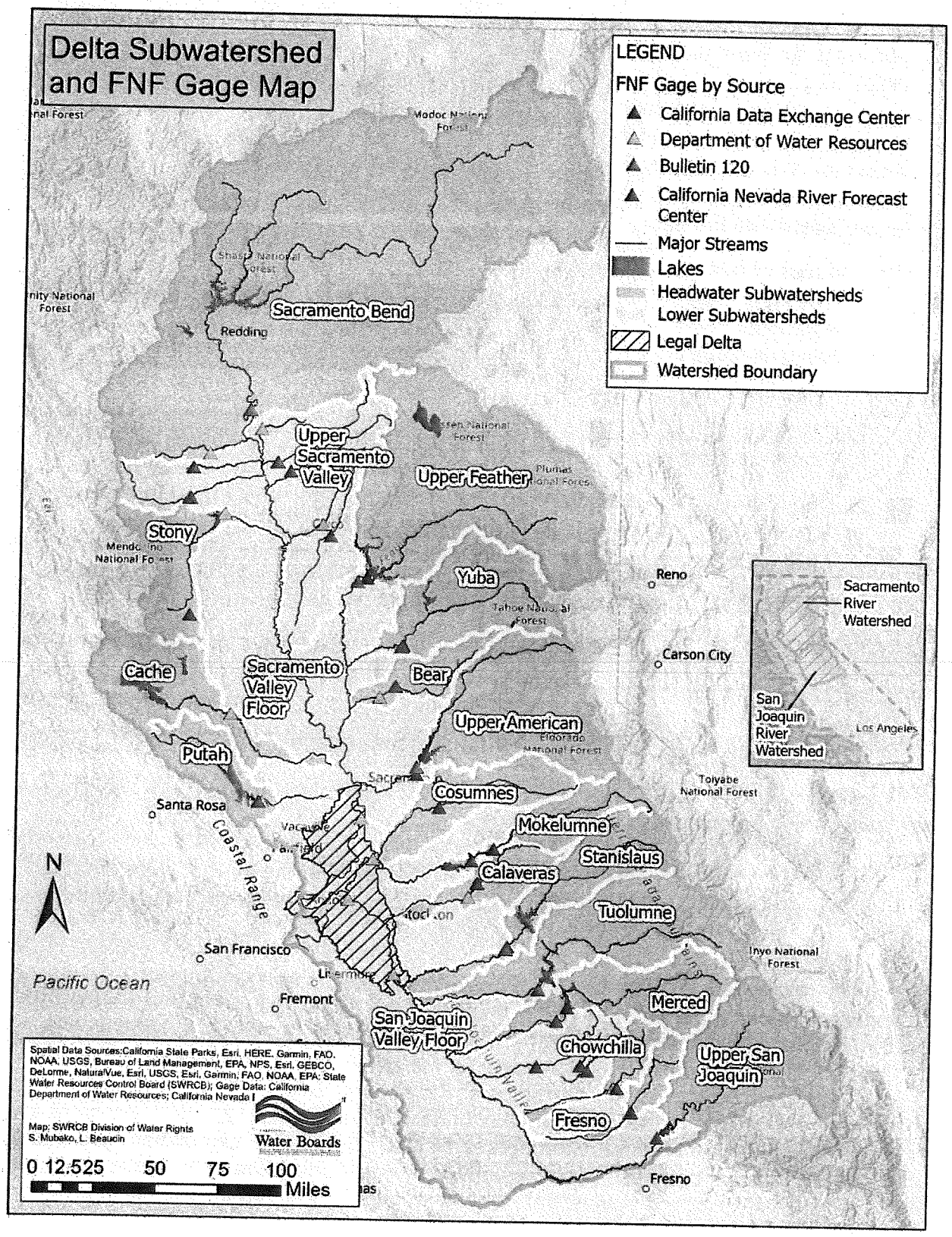
An inventory of available FNF gages from multiple sources (see section 2.1.4 below) was compared to the subwatershed boundaries, NHD stream maps, and water right points of diversion (PODs) to identify target FNF gages that are representative of water supplies and demands met by them within each subwatershed. 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 4 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 Goose Lake subwatershed, the Panoche Creek subwatershed, and Tulare Lake watershed (including the Kings, Kern, Kaweah, and Tule Rivers) are not included in the Water Unavailability Methodology. Goose Lake, located on the border of California and Oregon, is expected to only overflow into the North Fork of the Pit River during very wet conditions. Therefore, the methodology excludes supply and demand that occurs within the boundaries of the Goose Lake HUC8. The methodology also excludes supply and demand within the Panoche Creek HUC8, 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 imagery indicates that it terminates in agricultural fields west of Mendota, so it is assumed not to significantly contribute to available water supplies within the Delta watershed.

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 Tulare Lake watershed during the dry season of a critically dry year. Similarly, during the 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.

Figure 4. 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). For past supply data, the 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.

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 were no substantial inconsistencies between them. These comparisons did not result in any changes to any assumed hierarchy of data sources described above.

The sources of forecasted supply data 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

[6] CNRFC data is published on a daily scale, which is summed to generate values over longer periods for the purpose of this analysis. Any negative daily FNF values were included as-is in the sums.

[7] B-120 provides monthly FNF forecasts for the state's major watersheds, which are prorated to convert to shorter timesteps as necessary. B-120 WSI products are updated monthly from December to May of each year, while B-120 DIST forecasts are updated weekly from February through early June. B-120 FNF calculations are made using DWR's own database of diversions upstream of unimpaired flow stations, which were not cross-checked against the Board's records of reported diversions.

with 10, 25, 50, 75, 90, and 99 percent exceedance probabilities, while the B-120 Distribution (DIST) product includes only 50 percent exceedance forecasts.

2. CNRFC ensemble forecasts, [8] which contain daily FNF forecasts for the next 365 days, are available for both major and minor tributaries. Exceedance probabilities were calculated from the available forecast data.

Initially, the methodology used the B-120 forecast for streams where that data is available. However, given that CNRFC forecasts may better reflect expected hydrologic conditions over the short-term (7 to 14 days), CNRFC data has been relied on more recently.

The use of primarily monthly (shorter time steps have been used for curtailment suspensions) supply forecasts and demand estimates (see section 2.2 below) for curtailments 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). For the purposes of short-term considerations of curtailment suspensions due to precipitation and runoff events, sub-monthly (e.g., weekly) data are be considered to ensure that curtailments are suspended on a timestep commensurate with available supplies. Water unavailability analyses for the purpose of issuing curtailments in the Legal Delta are not performed on a timestep any shorter than 30 days (i.e., monthly).

CDEC provides both monthly and daily FNF estimates for many rivers in California. These 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 water unavailability analyses.

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 (e.g., 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.

[8] CNRFC forecasts are presented in the form of 41 different daily FNF "traces." These daily values are summed over longer timesteps and exceedances are calculated from the resulting forecasts.

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 and DIST: Sacramento River above Bend Bridge (monthly TAF for current WY in 6 exceedances); CNRFC BDBC1: Sacramento River-Bend Bridge (daily TCFS for next year in 41 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 41 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 and DIST: Feather River at Oroville (monthly TAF for current WY in 6 exceedances); CNRFC ORDC1: Feather River- Lake Oroville (daily TCFS for next year in 41 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 and DIST: Yuba River near Smartville plus Deer Creek (monthly TAF for current WY in 6 exceedances); CNRFC HLEC1: Yuba River-Englebright Reservoir (daily TCFS for next year in 41 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 and DIST: American River below Folsom Lake (monthly TAF for current WY in 6 exceedances); CNRFC FOLC1: American River-Folsom Lake (daily TCFS for next year in 41 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 41 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 41 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 41 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 and DIST: San Joaquin River inflow to Millerton Lake (monthly TAF for current WY in 6 exceedances); CNRFC FRAC1: San Joaquin River-Millerton Reservoir (daily TCFS for next year in 41 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 41 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 and DIST: Merced River below Merced Falls (monthly TAF for current WY in 6 exceedances); CNRFC EXQC1: Merced River-Exchequer Reservoir (daily TCFS for next year in 41 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 and DIST: Tuolumne River below La Grange Reservoir (monthly TAF for current WY in 6 exceedances); CNRFC NDPC1: Tuolumne River-New Don Pedro Reservoir (daily TCFS for next year in 41 traces)
Stanislaus River	CDEC SNS: Stanislaus River-Goodwin, sensor 65 (WY 1901-Present)	CDEC GDW: Goodwin Dam, sensor 8	B-120 SJWSI and DIST: Stanislaus River below Goodwin Reservoir (monthly TAF for current WY in 6 exceedances); CNRFC NMSC1: Stanislaus River-New Melones Reservoir (daily TCFS for next year in 41 traces)
Calaveras River	DWR UF15: Calaveras River at Jenny Lind (WY 1922-2014)	CDEC NHG: New Hogan Lake, sensor 8 (WY 2015-Present)	CNRFC NHGC1: Calaveras River-New Hogan Reservoir (daily TCFS for next year in 41 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	B-120 DIST: Mokelumne River below Pardee Reservoir (monthly TAF for current WY for 50% exceedance); CNRFC CMPC1: Mokelumne River-Mokelumne Hill (daily TCFS for next year in 41 traces)
Cosumnes River	CDEC CSN: Cosumnes River at Michigan Bar, sensor 65 (WY 1908-Present)	CDEC MHB: Cosumnes River at Michigan Bar, sensor 8	B-120 DIST: Cosumnes River at Michigan Bar (monthly TAF for current WY for 50% exceedance); CNRFC MHBC1: Cosumnes River-Michigan Bar (daily TCFS for next year in 41 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 41 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.

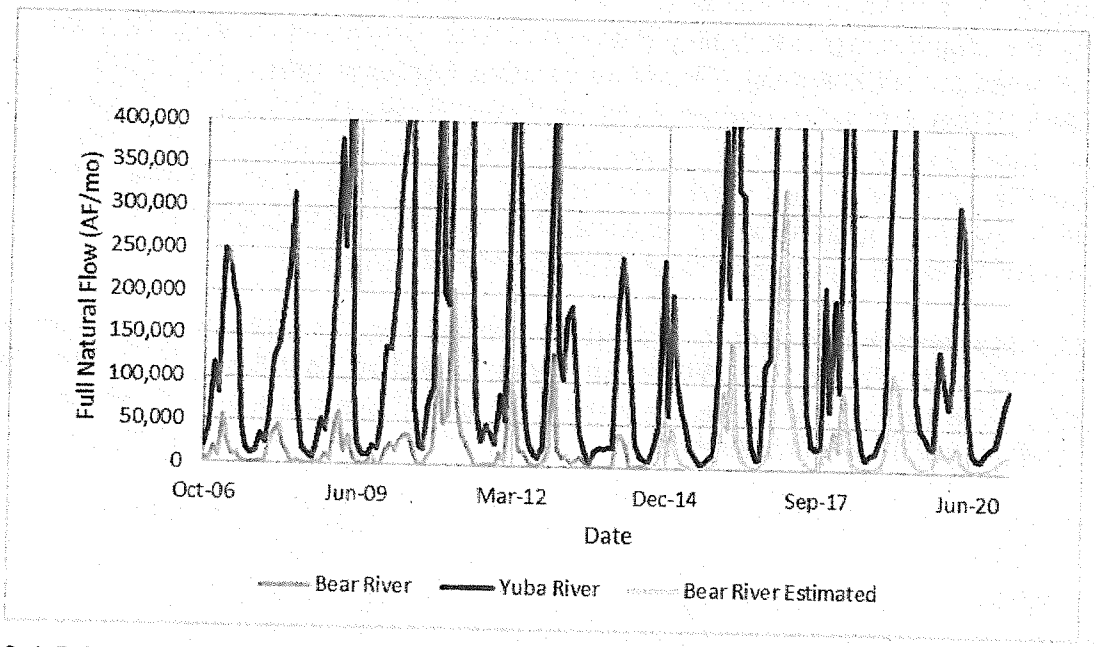
2.1.5.1 *Extrapolation*

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 outside three standard deviations from the overall mean 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 5 below illustrates the Bear:Yuba extrapolation for the period of WY 2014 to present.

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

Figure 5. Extrapolation Example: Estimation of Bear River FNF (WY 2014–present) Based on Yuba River FNF



2.1.5.2 *Augmentation*

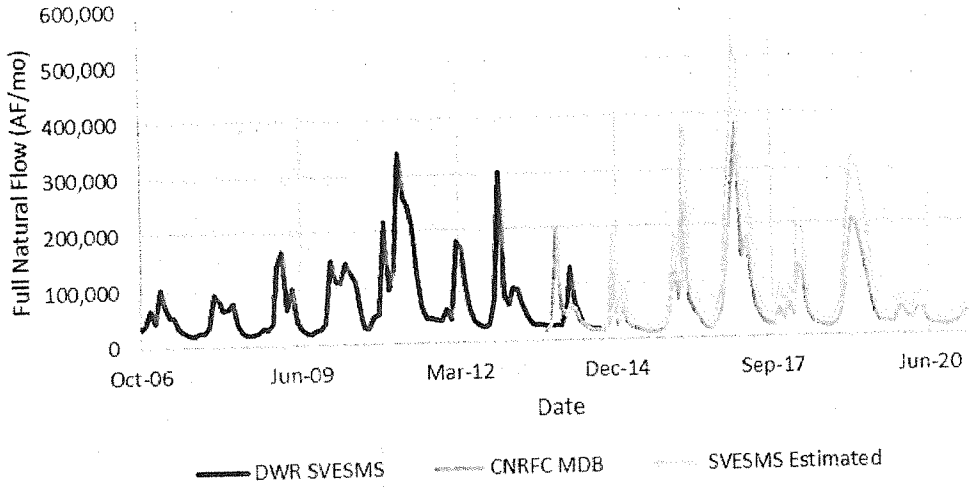
In other areas, past or forecasted data may exist but not represent the entire FNF supply of a watershed that would be expected to be available for diversion. This was the case for watersheds consisting of multiple small tributary streams in which only some streams have available supply forecasts through 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 calculated on a monthly basis over this period, and outliers outside three standard deviations from the overall mean 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 (SVESMS, known as 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–

[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.

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 6 below illustrates the SVESMS:MDB augmentation to estimate FNF for the Sacramento Valley East Side Minor Streams.

Figure 6. 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 natural 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 requirement then the instream flow requirement is being met by FNF; conversely, if the instream flow requirement is greater than the FNF then it was assumed that the instream flow requirement 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 to meet water quality and flow requirements included in State Water Board D1641 is not considered abandoned because those flows are intended to remain instream, including releases from Shasta, Folsom, and Oroville Reservoirs to meet D1641 requirements; releases from New Melones Reservoir to meet San Joaquin River flow requirements at Vernalis that are intended to contribute to Delta outflows and New Melones releases that are intended to contribute to meeting salinity requirements on the San Joaquin

[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, Legal Delta, and eastside tributaries to the Legal 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/

River and in the Legal Delta; and releases from Camanche Reservoir on the Mokelumne River pursuant to D1641 that are intended to contribute to Delta outflows.

Instream flow requirements are often based on a given water year type and are therefore subject to change. Generally, the requirements listed in Table 3 and Table 4 assume dry or critical conditions, resulting in the lowest possible flow requirements. Different flow requirements may be used in the methodology if appropriate due to varying hydrologic conditions during the applicable time period.

Table 3. Sacramento River Watershed Flows Considered to Contribute Abandoned Supplies13

Subwatershed		Upper Feather River[a]	Yuba River[b]	Bear River[c]	Upper American River[d]	Putah Creek[e]	*Total*
Abandoned Instream Flow (cfs)	**Jan.**	180	400	10	246	5	*841*
	Feb.	225	400	10	246	5	*886*
	Mar.	300	400	10	246	5	*961*
	Apr.	300	433	25	287	5	*1050*
	May	300	500	25	350	5	*1,180*
	Jun.	300	500	25	425	5	*1,255*
	Jul.	300	250	10	425	5	*990*
	Aug.	300	250	10	420	5	*985*
	Sep.	250	250	10	325	5	*840*
	Oct.	180	400	10	251	5	*846*
	Nov.	180	400	10	246	5	*841*
	Dec.	180	400	10	246	12	*848*

[a] Upper Feather River flow requirements are based on FERC project P-2107 license conditions for Upper North Fork Feather River flows below Poe Dam.
[b] Yuba River flow requirements are based on State Water Board Decision 1644 requirements at Marysville (assuming an Extreme Critical water year and not including flows transferred to DWR).
[c] Bear River flow requirements are based on FERC P-2997 license conditions for flow below Camp Far West Diversion Dam (not including flows transferred to DWR).
[d] Upper American River flow requirements are based on FERC P-2155 license conditions for South Fork American River flows below Chili Bar (assuming a Dry year and including Conditions 1 and 3) and P-2079 requirements for flows on the North Fork American River below the American River Pump Station.

[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.

[e] Putah Creek flow requirements are based on the 2000 Putah Creek Accord's requirements for outflow to the Toe Drain.

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

Subwatershed		Merced River[a]	Tuolumne River[b]	*Total*
Abandoned Instream Flow (cfs)	Jan.	60	150	*210*
	Feb.	60	150	*210*
	Mar.	60	150	*210*
	Apr.	60	245	*305*
	May	60	311	*371*
	Jun.	15	50	*65*
	Jul.	15	50	*65*
	Aug.	15	50	*65*
	Sep.	15	50	*65*
	Oct.	38	125	*163*
	Nov.	75	150	*225*
	Dec.	75	150	*225*

[a] Merced River flow requirements are based on FERC project P-2179 license conditions for flows below Crocker Huffman Diversion Dam (assuming a Dry year).
[b] Tuolumne River flows are based on FERC P-2299 license requirements for flow below La Grange Diversion Dam (assuming the San Joaquin River 60-20-20 index is between 1.5 and 2.0 million acre-feet (MAF) from May–September or less than 1.5 MAF October–April).

To account for the limitation on riparian rights to the diversion of only natural flow and not flow that is foreign in either time or source, the Water Unavailability Methodology allocates any portion of the incorporated instream flow requirements in excess of the FNF to only non-riparian diverters.

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 the emergency regulation. Projections of demands during the wet season may be more accurate than historical diversion data for purposes of

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

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")
- 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 watersheds
- 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 whose diversion and use is not reported by a watermaster[16] are required to submit annual reports of water diversion and use (annual reports) to the

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[15] The eWRIMS database contains a mapping application to view the spatial location of PODs.

[16] Watermasters are empowered to ensure water is allocated according to established water rights as determined by court adjudications or agreements (DWR 2021b). Some watermasters report the diversion and use of water within their areas of oversight to the Board via other means than the eWRIMS Report Management System. This data is not currently incorporated into the eWRIMS database except to the extent that individual diverters may have also mistakenly reported their diversions to the Board via the eWRIMS Report Management System. As a result, diversions in watermaster service areas are generally not included in the methodology's demand dataset and did not

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 2021 diversion information were due by April 1 for appropriative water rights, stockpond certificates,[17] and registrations[18] and by July 1 for statements of water diversion and use. Future annual reporting periods and deadlines will change pursuant to Senate Bill 155, signed into law on September 23, 2021.[19] Diversion data contained within annual reports form 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.

For this analysis, water demand is primarily based on the total monthly diversion amount reported for each water right record, including monthly direct diversions and monthly diversions to storage based on reported annual diversion data. Data from calendar year 2018, the most recent drier year (below normal) for which quality-controlled demand data is available, is used, except in cases where reliable updated information is available. Adjustments to this dataset are made as appropriate based on

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receive the August 20, 2021 curtailment and reporting orders or prior notices of water unavailability. Initial investigations suggest that a total of ten such watermaster service areas covering at least 16 different adjudications are located in the Delta watershed and overseen by DWR and Modoc County. From the standpoint of diverters included in the methodology, the omission of watermaster service areas results in an underestimation of watershed demands that may result in less curtailments. In the future, data from watermaster reports may be incorporated into the demand dataset and water rights within these watermaster service areas may be issued curtailment orders.

[17] 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.

[18] Water right registrations are appropriative water rights issued by the State Water Board through an expedited acquisition process for certain small projects, which first became available in 1989. Water right registrations are available for small domestic use, livestock stockpond use, small irrigation use, and cannabis small irrigation use.

[19] Senate Bill 155 changes the reporting period for all water rights and claims from the calendar year to the water year (October 1 through September 30) and consolidates the reporting deadlines into a single date for all water rights and claims. To transition to this new system, water diversion and use reporting for January 1 through September 30, 2021, will be due for all diverters on April 1, 2022. Thereafter, diversion and use reporting for each water year will be due on February 1 of the subsequent year (e.g., water diversion and use reporting for October 1, 2021, through September 30, 2022, will be due by February 1, 2023).

updated reliable demand projections, including data submitted as part of the enhanced reporting requirements under the emergency regulation and other reliable sources. Staff are planning updates to the enhanced reporting processes that would allow water right holders and claimants whose rights or claims have a face value or reported diversions in 2018 or 2019 of over 1,000 AF per year to identify if updates should be made to the demand assumptions used in the Methodology. This change is expected to reduce the burden of completing the enhanced demand reporting and increase compliance such that the data is usable in the Methodology.

In addition to historical use and enhanced reporting data, other reliable sources have been and will continue to be relied upon as appropriate. As the result of historic dry conditions, extremely low storage conditions in Shasta Reservoir, and the need to maintain water in storage for temperature control and minimal protection of endangered species and critical water supplies this year and going into next year, Reclamation has implemented extraordinary water supply reductions in contractual supplies for the Sacramento River Settlement Contractors (SRSC). DWR has also implemented substantial reductions in contractual supplies for Feather River Contractors (FRC) in recognition of the extremely dry conditions. Reclamation and DWR may also implement similar measures next year if drought conditions persist. These reductions in contractual supplies affect diversions under the contractors' underlying water rights as well as supplemental stored water supplies provided to these contractors under Reclamation's and DWR's water rights. Although natural and abandoned flows may be adequate to satisfy the contractors' underlying water rights early in the irrigation season, natural and abandoned flows will decrease as the season progresses, and the contractors must schedule their diversions based on the amount of supplemental stored water that will be available during the entire irrigation season in consideration of the need to maintain storage for critical purposes this year and next. Based on conditions this summer, demand data was adjusted to account for these reductions in diversions.

The draft emergency regulation includes proposed provisions that would allow for demands by these users not to be reduced on the basis that the reductions in diversions under the contractors' underlying rights are intended to preserve limited reservoir storage in upstream reservoirs to satisfy the contractors' reduced allocations, and meet water quality and other critical needs as part of an operations plan for the Projects, and are not intended to make water available to more junior water right holders. Given these circumstances and the need to maintain storage for critical purposes, it would be unreasonable for reduced diversions by SRSC and FRC to make water available to more junior water right holders and claimants. Any water unused by the SRSC and the FRC due to a reduction in their contractual supplies is needed to remain instream to allow Reclamation and DWR to conserve limited cold water pools, improve water quality, protect carry over storage, or ensure minimum health and safety water supplies in accordance with their operations plan. The emergency regulation includes provisions to prevent junior water right holders and claimants from diverting water that would be available under the SRSC and FRC underlying water rights, but is not being diverted in

order to preserve reservoir storage for critical purposes in accordance with an operations plan developed to meet specified objectives. If the proposed emergency regulation provisions are approved, these demands would not be reduced following approval of the emergency regulation.

In some cases, demand data are prorated from monthly values to shorter timesteps (assuming uniform average daily demand throughout each month) in order to better reflect the effects of precipitation and runoff events that occur on a shorter time scale in order to inform decisions to temporarily suspend curtailments. Appendix A contains additional information about how water demands for various periods are estimated using monthly data.

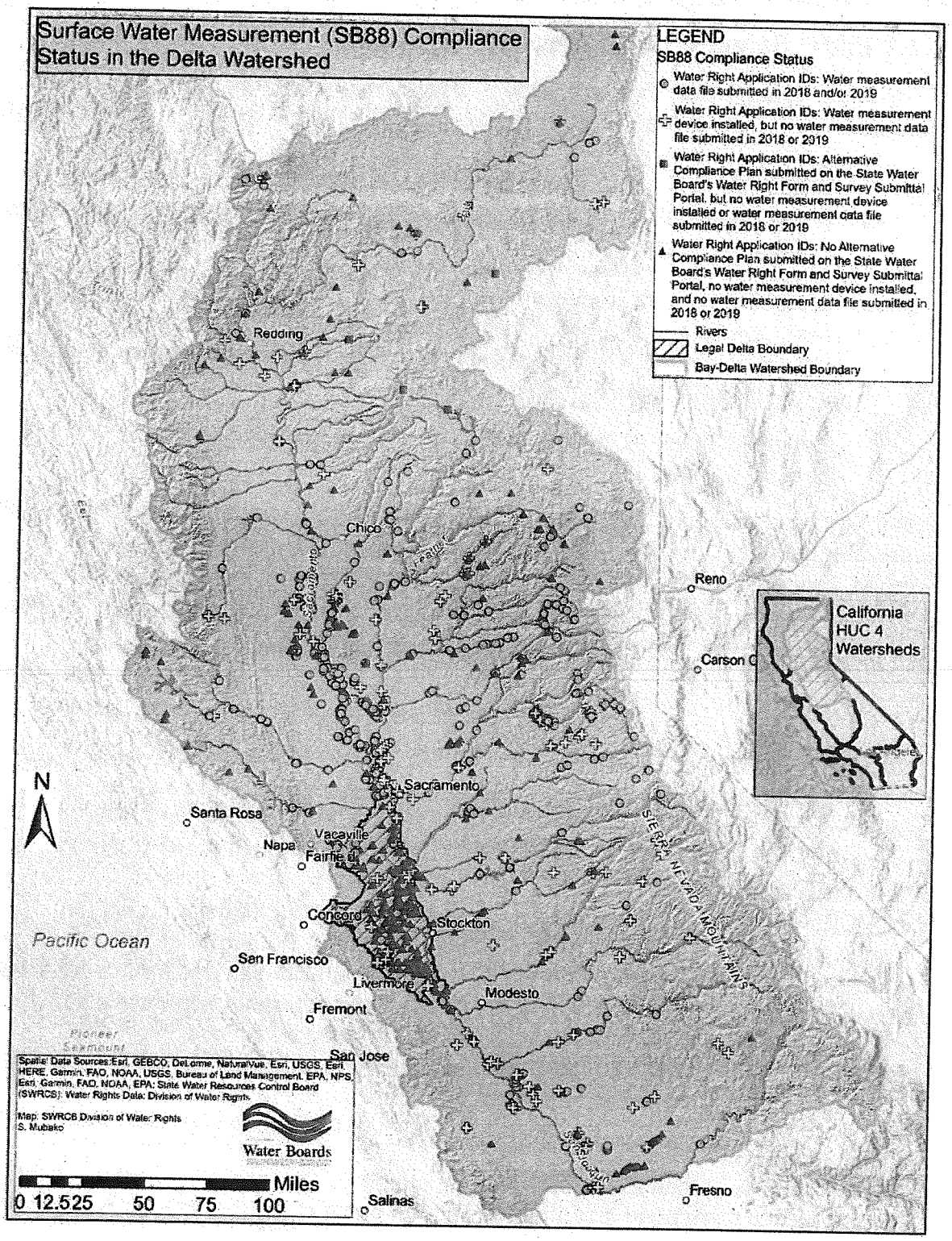
Diversion data from 2018 is primarily used because it is the first drier year for which quality-controlled diversion data is available since updated water right measurement and reporting requirements went into effect with Senate Bill 88 (SB88). This is a reasonable source of demand data. As discussed above, as appropriate other sources of demand data may also be used. 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.

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 7 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 as of March 2, 2021.

Figure 7. Surface Water Measurement (SB88) Compliance Status of Large Rights and Claims in the Delta Watershed[20]



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[21]
- 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 demands for minor water right types[22]
- Beneficial Uses: All beneficial uses except exclusively non-consumptive beneficial uses[23]

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 the demands for water right records with "Appropriative" and "Statement of Diversion and Use" water right types were included because minor water right types, such as

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[20] Figure 7 currently shows a watershed boundary that includes Goose Lake. The Goose Lake subwatershed will be removed from a future iteration of this report to accurately reflect its exclusion from the Delta watershed for the purposes of this analysis due to disconnection.

[21] 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. PODs within the Goose Lake subwatershed were also excluded due to its assumed disconnection with the Delta watershed.

[22] Minor right types, such as stockponds and water right registrations, are included in the current version of the demand dataset but are assumed to constitute a negligible demand. Accordingly, all demand values for these records have been set to zero in the demand dataset.

[23] As discussed in section 2.2.4, demands for storage under non-consumptive water rights and claims have been incorporated into the demand dataset only during the wet season.

registrations and stockponds, were assumed to constitute a negligible amount of the water diversion and use within the Delta watershed.[24]

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 originally excluded from the analysis. 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 2.2.10 below). During the dry season, the potential impact of these non-consumptive diversions on the timing of flows is not assumed to be significant given the negligible amount of hydropower-related storage assumed to be occurring during the dry season. As discussed below in section 2.2.5 (Wet Season Demand Adjustments), during the wet season non-consumptive water right records that divert water to storage can make water unavailable for other users for periods of time greater than the temporal resolution of the analysis (e.g., weekly or longer). Therefore, diversions to storage under non-consumptive rights such as hydropower rights are included in the demand dataset only during the wet season to accurately reflect where these diversions make water unavailable within a month.

This initial selection of water right records resulted in a demand dataset consisting of approximately 12,000 total post-1914 appropriative water rights (excluding minor appropriative water right types) and statements of diversion and use. Of these, approximately 5,000 were post-1914 appropriative water rights and 7,000 were statements of diversion and use. The demand dataset also includes approximately 4,000 additional minor water rights, such as stockponds and registrations; the demand values for these records is assumed to be negligible and have been set to zero in the demand dataset.

As discussed in section 2.2.4, demands for storage under non-consumptive water rights and claims were later incorporated into the demand dataset during the wet season. After incorporating these demands, the demand dataset includes approximately 17,000 total water right records, including 6,000 appropriative water rights (excluding minor appropriative water right types), 7,000 statements of diversion and use, and 4,000 additional minor water rights (such as stockponds and registrations).

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

[24] Exclusion of the demands for these minor right types from the methodology represents a conservative assumption because it underestimates overall demand and may thus result in fewer curtailments. These diverters are still issued notices of water unavailability and curtailment orders in keeping with the principles of the water rights priority system.

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 post-1914 appropriative water rights and statements of diversion and use 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 approximately 580 water right records, including approximately 360 post-1914 appropriative rights and approximately 220 Statements of Diversion and Use, which could be reviewed within a limited timeframe. 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.[25] 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.

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

[25] 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).

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 post-1914 appropriative water rights and statements of diversion and use 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 and applying corrections to rectify errors as discussed above, 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.

State Water Board staff have initiated an expanded quality control effort encompassing appropriative water rights with a face value (maximum diversion amount) of 1,000 AF or greater and statements of diversion and use with reported diversions of 1,000 AF or greater in either calendar year 2018 or 2019. This quality control expansion added approximately 800 water right records for review and includes the water rights and claims identified as non-consumptive that were previously excluded from review.

In addition to the above, 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.

Further refinements to the demand dataset used in the Water Unavailability Methodology may also 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.

2.2.4 Enhanced Reporting Forms

Enhanced reporting information submitted by water users in accordance with the emergency regulation may also inform future refinements to the demand dataset. Pursuant to the emergency regulation, on August 20, 2021, the Board issued curtailment and reporting orders to water right holders and claimants throughout the Delta watershed. The orders require monthly reporting of water diversion and use for water rights and claims in the Delta watershed that have a face value or recent annual reported diversion volume of 5,000 AF or greater. For these water rights and claims, diverters are required to provide monthly reports of water diversion and use information for prior months and monthly reporting of projected water demand by completing the Delta Watershed Enhanced Reporting of Actual Diversions and Projected Demand Form (Enhanced Reporting Form). The Enhanced Reporting Forms are required monthly during the effective period of the emergency regulation unless otherwise specified by the State Water Board.

Staff are currently evaluating the water diversion and use information submitted in the Enhanced Reporting Forms. Projected demand data supplied in these forms is being compared to the 2018 diversion information contained within the demand dataset to identify any instances where the demand dataset may be overestimating demands. This comparison of 2018 diversion information and the enhanced reporting of projected demand will be generated on a monthly basis and consulted prior to curtailment implementation. In addition, the projected demand data is being consulted during the evaluation of specific curtailment exception proposals that have been submitted by water right holders and claimants.

Beginning during summer 2022, staff will implement modifications to enhanced reporting processes under the emergency regulation as discussed above. Specifically, water right holders and claimants in the Delta watershed with a face value or recent annual reported diversion volume of 1,000 AF or greater may submit projected monthly demand information if the diverter determines that the quality controlled 2018 demand data for that right should be updated. Reliable updated data will then be incorporated into the Methodology as corrected demand values to be used in determining curtailments.

Additionally, water diversion and use information already supplied through the Enhanced Reporting Forms is being evaluated and may be used to inform future updates of the demand dataset. Prior month reporting now comprises an additional year of dry year diversion data for 2021, providing a relevant comparison to the 2018 diversion data contained in the demand dataset. The prior diversion data may also be used to inform other refinements to the water unavailability methodology, such as stream depletion effects.

2.2.5 **Wet Season Demand Adjustments**

Prior versions of the demand dataset were intended primarily to identify when available data indicated that natural and abandoned water supplies were unavailable for water users in the Delta watershed during the dry season. This section describes adjustments to the demand dataset for application during the wet season.

As noted in section 2.2.1, water right records identified as non-consumptive based on their beneficial use type (e.g., hydropower generation or fish and wildlife preservation and enhancement) were previously excluded from the analysis due to its prior focus on dry season operations. During the dry season these non-consumptive uses of water do not typically significantly alter the timing of flows or change the amount of water available downstream. However, during the wet season water right records with non-consumptive beneficial use types such as hydropower generation can significantly alter the timing of flows when water is diverted to storage. These diversions can make water unavailable for diversion by other users within a month. The demand dataset has been adjusted to incorporate approximately 500 additional post-1914 appropriative water rights and statements of diversion and use with non-consumptive beneficial use types that were originally excluded from the demand dataset (see Appendix B and the Water Unavailability Methodology Spreadsheet). For these records, the diversion values contained in the demand dataset reflect only diversion to storage volumes. Non-consumptive direct diversions do not alter the timing of flows or change the amount of water available downstream and are therefore not included in the demand dataset.

A wet season adjustment quality control review effort was conducted following selection of the additional water right records with non-consumptive beneficial use types. Similar to the previous quality control review effort, the scope of the review was narrowed to produce a manageable subset of records to review within a limited timeframe. For this

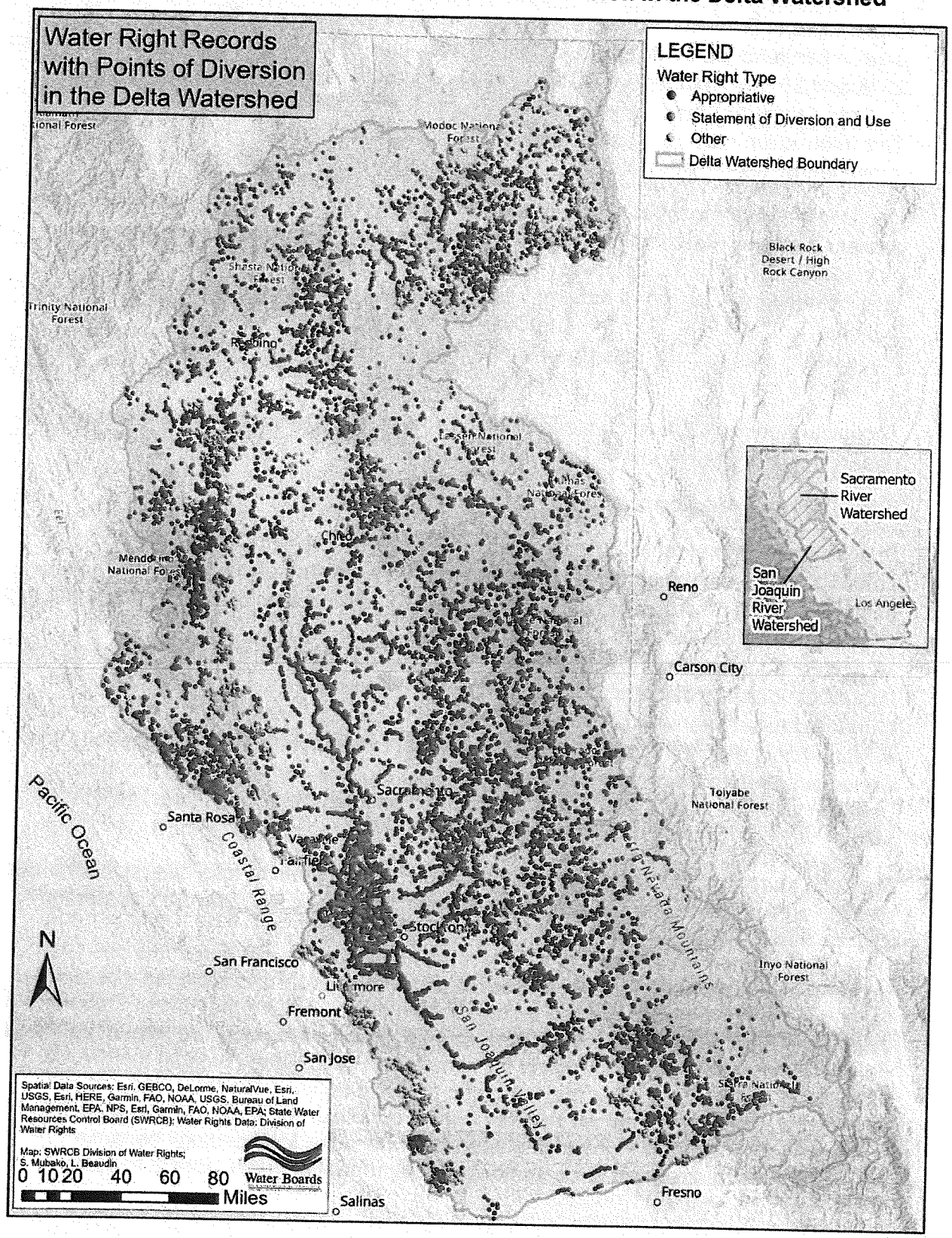
quality control review, post-1914 appropriative water rights and statements of diversion and use with a reported diversion to storage volume of 5,000 AF or greater in either 2018 or 2019 were selected. Approximately 75 records were included in this quality control review effort. Additional non-consumptive records were added when the quality control effort was expanded to encompass diversions of 1,000 AF or greater. The 2018 and 2019 annual reports of water diversion and use for these records were reviewed to identify and correct potential inaccuracies in the diversion to storage data.

In addition, this quality control review addressed occurrences of duplicative reporting of diversions to storage under overlapping consumptive and non-consumptive use rights. Staff compiled 2018 and 2019 reported diversion to storage volumes for all water right records, including those associated with consumptive uses, held by the same primary owners of the approximately 75 largest water right records with non-consumptive beneficial use types. When identical diversion to storage volumes were reported for consumptive and non-consumptive water right records held by the same primary owner and associated with the same location, the reported diversion to storage volumes were assumed to be duplicative and the demand value for the non-consumptive water right record was changed to zero to avoid overreporting of diversion to storage volumes. Staff also reviewed information regarding overlapping reporting between consumptive and non-consumptive water right records submitted in the September 2021 Enhanced Reporting Forms, which were required pursuant to the emergency regulation. Staff's review of information regarding overlapping water rights and claims contained in the September 2021 Enhanced Reporting Forms identified additional occurrences of overlapping reporting of diversions under consumptive and non-consumptive water right records. In these cases, the demand value for the non-consumptive water right record was changed to zero.

Further refinements to the demand values for non-consumptive use rights included in the demand dataset may occur. Diverters who are aware of reporting issues, including, but not limited to overlapping reporting of diversions to storage between consumptive and non-consumptive water right records, should contact the State Water Board at Bay-Delta@waterboards.ca.gov.

Points of diversion for all water right records included in the demand dataset at this time are shown in Figure 9 below. The figure has been updated since the August 20, 2021 version of this report and now includes points of diversion for the approximately 500 non-consumptive water right records described above. Figure 9 displays points of diversion for approximately 17,000 water right records in the Delta watershed, including 6,000 Appropriative water rights, 7,000 Statements of Diversion and Use, and 4,000 additional minor rights (e.g., stockponds and registrations).

Figure 8. Water Right Records with Points of Diversion in the Delta Watershed



2.2.6 Disaggregation of Statements of Diversion and Use

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 or 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 or Pre-1914." For the purposes of assigning priority within the Methodology, those water right records categorized as "Riparian or Pre-1914" or Other were assumed to have the more senior priority of right, i.e., Riparian.[26]

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

2.2.7 Disaggregation of Total Diversion Amounts

Prior versions of the demand dataset included monthly and annual total diversion amounts, which combined the reported direct diversions and diversions to storage for each water right record. The total diversion amounts have now been disaggregated into discrete direct diversion and diversion to storage amounts based on information submitted in annual reports for calendar years 2018 and 2019. The disaggregation of total diversions into discrete direct diversion and diversion to storage amounts in the demand dataset informed refinements to the methodology, including the different spatial assignment of demand based on POD type (direct diversion or storage reservoir), the exclusion of return flows from availability to meet storage demands, and the application of return flow factors to direct diversion demand only (as described in section 2.2.11 below).

Previous quality control review efforts focused on corrections to total diversion amounts and did not apply specific corrections to the direct diversion and diversion to storage

[26] For the purpose of curtailment, diverters who claim both a riparian and a pre-1914 appropriative water right to serve the same place of use (or have reported diversion pursuant to a combination of such unadjudicated claims among their Initial Statement of Water Diversion and Use and their 2018 and 2019 annual reports) are treated solely as riparian claimants. Assuming, solely for curtailment determinations, that the diverter has a valid riparian right, they may continue to divert under that right, subject to its restrictions, unless and until the riparian right is curtailed. In nearly all scenarios this represents a conservative simplifying approach within the Methodology because riparian rights are assumed to be senior to all appropriative rights absent specific evidence to the contrary.

components of the total diversion. Accordingly, a supplemental quality control review effort was conducted with a focus on the water right records for which a correction to the total diversion amount was previously applied, and both direct diversion and diversion to storage amounts were reported for 2018. Approximately 200 records were included in this supplemental quality control review effort. For these records, the 2018 and 2019 annual reports were reviewed and appropriate adjustments to the direct diversion and diversion to storage amounts were applied.

2.2.8 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-three water right records in the Delta watershed have PODs that span multiple subwatersheds. Of these, nine 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 2.2.9 below, the Water Unavailability Methodology treats these demands differently because of the unique circumstances of the Projects' diversions. For the rights that have PODs within multiple subwatersheds, demands for direct diversion and storage under each water right record were split among the applicable subwatersheds based on the proportion of the total active PODs diverting natural flow located within each subwatershed. No demand was split to PODs which are inactive or which are solely points of rediversion. 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. These water rights are only curtailed in the methodology if water is unavailable within all of the subwatersheds where they have demands. If all of a water right's PODs within a subwatershed are points of rediversion or inactive, these PODs are not factored into curtailment decisions (i.e., curtailment is only determined based on unavailability in subwatersheds where a water right has active demands that are met by natural flow).

For rights with PODs in multiple subwatersheds that reported both direct diversions and diversions to storage in 2018 or 2019, demands were split differently based on the nature of each POD associated with the right; direct diversion demands are only split among PODs that divert directly, while storage demands are only split among PODs which divert to storage. For example, a right associated with an upstream storage reservoir in the Upper Feather River subwatershed and a downstream point of direct diversion in the Sacramento Valley Floor subwatershed would have all of its storage demand assigned to the reservoir POD and all of its direct diversion demand assigned to the direct diversion POD in Sacramento Valley Floor. An apportionment of demand based on the actual amounts 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. However, these proration amounts may be updated based on more specific information for specific water rights as appropriate.

2.2.9 **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.[27] 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. Given the extreme dry conditions and associated limited exports out of the Delta watershed by the Projects in 2022, this assumption may be modified to only assign the portion of Project demand that is exported out of basin a lower priority date and to assign the remaining diversions for inbasin purposes the water right priority date. However, changes to Project priority dates do not have a significant effect on the analysis given the Projects' relatively junior water right priority. Since two of three of the New Melones Project water rights (A014858A and A014858B) are not authorized for export out of the Delta watershed, these demands are all assumed to be met in accordance with the original priority date of the rights.

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[27] Wat. Code, §§ 11128, 11460.

In accordance with the State Water Board's April 4, 2022 Order Approving Temporary Urgency Changes to Water Right License and Permit Terms Relating to Delta Water Quality (TUCO), Project demands within the Legal Delta were reduced in May and June. CVP diversions in the Legal Delta were limited to 900 cfs of direct diversion under the most senior CVP right, and SWP diversions in the Legal Delta were limited to 600 cfs of direct diversion under the most senior SWP right. Legal Delta demands under all other CVP and SWP water rights were set to zero. Further adjustments may be made to CVP and SWP demands if the Board acts to further modify Project operations in the future.

2.2.9.1 *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 natural flow supplies in the watershed.

2.2.9.2 *Settlement Contractor Demands*

As discussed above, there are various water users in the Delta watershed that have settlement type 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 possible 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 curtailment orders under their own water rights and would then need to rely upon contractual supplies to the extent those supplies are available.

Demands of Sacramento River Settlement Contractors and Feather River Contractors

As discussed above, as a result of the very dry hydrologic conditions this year, DWR has reduced allocations to FRC (that have a settlement type contract) in accordance with their respective contract deficiency provisions. This can generally be classified as a 50 percent reduction compared to full contract amounts, though diversions to riparian parcels are not subject to reduction under the contract deficiency provisions and

allocations may exceed 50 percent of the full contract amount depending on the individual contractor. In addition, pursuant to Reclamation's operations plan for the CVP, deliveries to the SRSC have been reduced to 18 percent of their full contractual allocation. Accordingly, the demands associated with these water rights and claims have been modified to reflect the reduction in contractual allocations.

April to September demands associated with water rights and claims underlying FRC contracts were adjusted to reflect the monthly volumes identified in DWR's 2022 Operations Outlook, submitted as required by Condition 5 of the TUCO. April to September diversions identified in the Operations Outlook account for approximately 85 percent of contract diversions under the reduction. The remaining 15 percent was apportioned to water rights underlying the FRC contracts in accordance with the individual allocations and irrigation seasons identified in the contract deficiency provisions. These volumes were apportioned to the remaining months of each contract's allowable irrigation season by month (January to March and October to December) based on 2018 monthly diversion patterns.

Demands for water rights and claims underlying the SRSC contracts were adjusted to reflect 2022 diversion schedules accounting for the 18 percent contractual allocation when such schedules were available. In cases where a single contractor holds multiple water rights or claims, reduced contractual allocations were apportioned in order of water right priority, with demands assigned to the senior-most right or claim first. Demands for SRSCs without identified diversion schedules were reduced to 25 percent of their 2018 demands, which is equal to approximately 18 percent of their full contract amount.

Demands for water rights and claims underlying the FRC and SRSC contracts will be adjusted as appropriate if the proposed emergency regulation provision discussed above is adopted or based on additional Operations Outlooks or other reliable and public information consistent with adopted provisions of the emergency regulation.

Exchange Contractors

In most years, the Exchange Contractors receive replacement supplies exported from the Legal Delta in exchange for use of water from the San Joaquin River under the Exchange Contractors' underlying rights as part of settlement-type contracts related to the development of the Friant Project by Reclamation. Accordingly, until April 2022 all Exchange Contractor demands were assumed to be met with previously stored CVP supplies rather than San Joaquin River water diverted under the Exchange Contractors' underlying water right claims. Starting in April 2022 the Exchange Contractors are expected to be receiving a significant portion of their demand from the San Joaquin River. The Exchange Contractor demand assumptions are being adjusted accordingly.

2.2.10 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 may be considered in the future as appropriate.

2.2.11 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.

Monthly return flow factors were calculated for the Sacramento and San Joaquin watersheds using model results from a CalSim 3 public release. For each watershed, the sum of return flows from all valley floor demand units (DU) was divided by the sum of surface water diversions to all valley floor DUs to obtain a return flow factor. Demand factors, which demands are multiplied by to produce reduced demand values accounting for return flows, are simply one minus the return flow factor for the respective watershed and month. For example, if the return flow factor for a watershed in a given month is 0.2, or 20%, the demand factor applied in that watershed for that month would be 0.8, or 80%. Within CalSim 3, return flows result from all sources of water delivered to a given DU, including directly diverted surface water, previously stored surface water, and pumped groundwater. During drier years modeled surface water deliveries are lower than in wetter years, but modeled return flows remain similar due to the contribution of larger quantities of groundwater. As a result, return flow factors calculated from results for critically dry years are larger and likely overestimate the availability of water for diversion. A spreadsheet containing the calculation of return flow factors as described above is available upon request.

Prior versions of this report as applied during water year 2021 relied upon return flow factors based on CalSim 3 model results for water year 2014 due to similar hydrology and land use. As discussed above in section 2.2.9.2, land use in the Sacramento Valley is likely to be substantially reduced relative to a typical irrigation season and reuse of tailwater is likely to be maximized. In particular, rice agriculture dominates modeled return flows in the Sacramento Valley and is likely to be substantially reduced in areas drained by the Colusa Basin Drain. Consequently, return flow assumptions used in the methodology during water year 2022 may be informed by supplementary modeling analyses incorporating the best available information regarding land use, recycling of applied water, and actual gaged return flows where available. These supplementary analyses may be conducted using CalSim 3, SacWAM, or other quantitative tools. Future curtailment status updates will specify any changes made to return flow assumptions and disclose the technical basis to water right holders and the public.

During the wet season, diversion to storage may account for a significant portion of total diversions. Because diversions to storage do not produce return flows until stored

water is released and rediverted for consumptive use, demands for diversion to storage should not be scaled to account for return flows. At the time of publication of prior versions of this report, the demand data had not been fully disaggregated between diversions to storage and direct diversions. The disaggregation of direct diversion and diversion to storage, described above in section 2.2.8, has allowed elimination of return flow factors for all diversions to storage. Starting in July 2022 the application of return flow factors to direct diversion demands in headwater subwatersheds will also be considered, using the same factors calculated for the respective watershed unless better data is available on return flows in individual subwatersheds. In the Legal Delta, return flows are applied based on the watershed in which a particular diversion is located (see map in Figure 4).

While return flow factors are not applied to diversions to storage, the CalSim-derived return flow data itself does incorporate return flows associated with demands met from previously stored water. It is unclear whether a more explicit incorporation of these return flows into the methodology would be appropriate given comments the Board received from Reclamation in late 2021 claiming residual control of return flows from its deliveries of stored water, and accordingly asserting that these return flows should not be incorporated into the water unavailability analysis as they are not abandoned and available for diversion by other parties. Assuming these flows contribute to return flows is a conservative assumption.

2.2.12 Exclusion of Curtailment Exceptions

Pursuant to the emergency regulation, water users can seek an exception to curtailment for several purposes. These purposes include diversions for minimum human health and safety needs, diversions for non-consumptive uses that do not decrease downstream flows in the watershed, alternative water sharing agreements that achieve the same results as curtailment, and other proposals that curtailment is inappropriate and would not make water available to serve senior downstream water rights and claims.

Of these exceptions to curtailment, generally only those for minimum human health and safety needs represent a net consumptive use of water. Staff have analyzed the quantity of water associated with the minimum human health and safety exceptions received to date and have found that they represent a negligible quantity of water for the most part. The demand resulting from this exception is not incorporated into the demand dataset or larger methodology due to this largely negligible quantity and because its exclusion favors fewer curtailments. Demands associated with the exceptions will continue to be evaluated and substantial, significant exceptions may be incorporated into the methodology's demand dataset in the future, if appropriate.

2.3 Adjustments to the Supply and Demand Datasets

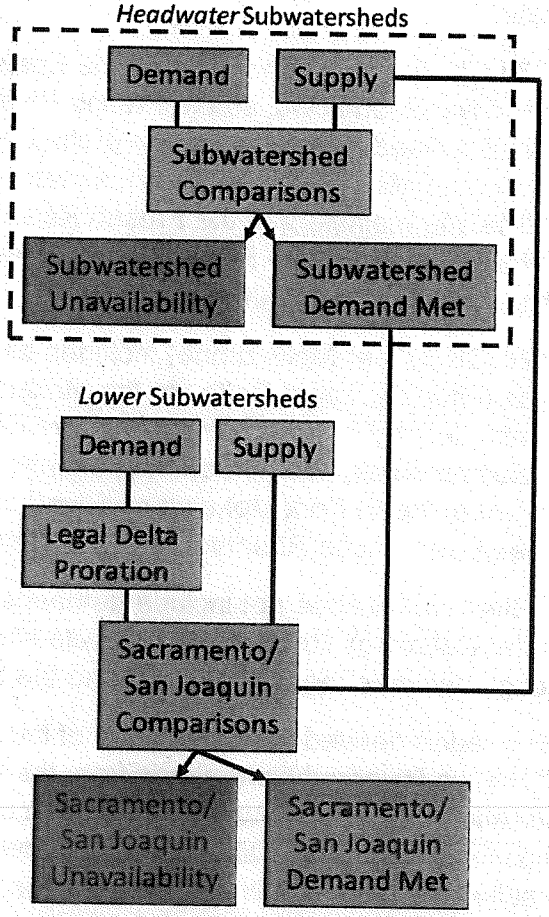
2.3.1 Elimination of Unmet Demand

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 Upper 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 9 below is a schematic showing how this analysis was performed using the supply and demand data previously described.

As shown in Figure 9, 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 its 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 4). The headwater subwatersheds in the San Joaquin River watershed are the Chowchilla River, Upper San Joaquin River above Friant Dam, Fresno River, Merced River, Tuolumne River, Stanislaus River, Calaveras River, Mokelumne River, and the Cosumnes River. Figure 10 below shows a schematic of the subwatersheds previously mapped in Figure 4. A small number of rights in the headwater Putah Creek, Stanislaus River, Calaveras River, Mokelumne 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).

Figure 9. Schematic of Supply and Demand Analysis at the Subwatershed and Watershed Levels



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 Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and Upper San Joaquin River subwatersheds.

Some headwater subwatersheds in the San Joaquin River watershed were delineated based on a combination of smaller HUC10 watersheds and stream buffers because their HUC8 boundaries (see section 2.1.3 above) contain demands that are not met exclusively by supplies from within the subwatershed. The Chowchilla River HUC8 (Middle San Joaquin-Lower Chowchilla) also includes minor east side tributaries and the mainstem of the San Joaquin River from Friant Dam to the confluence with the

Merced River, so the Chowchilla River headwater subwatershed was instead defined as a combination of two HUC10s representing only the Chowchilla River drainage (Upper Chowchilla River and Lower Chowchilla River), as well as a buffer along Ash Slough below Berenda Reservoir.

The Fresno River HUC8 includes diversion points on the Eastside Bypass that are supplied by San Joaquin River flood flows, so the Fresno River headwater subwatershed was instead defined as a combination of three HUC10s (Upper Fresno River, Coarse Gold Creek, and Middle Fresno River), as well as buffers along Dry Creek below Avenue 16 ½, the mainstem of the Fresno River between Road 16 and the Eastside Bypass, and the mainstem of the Fresno River between the Road 9 diversion structure and the confluence with the San Joaquin River.

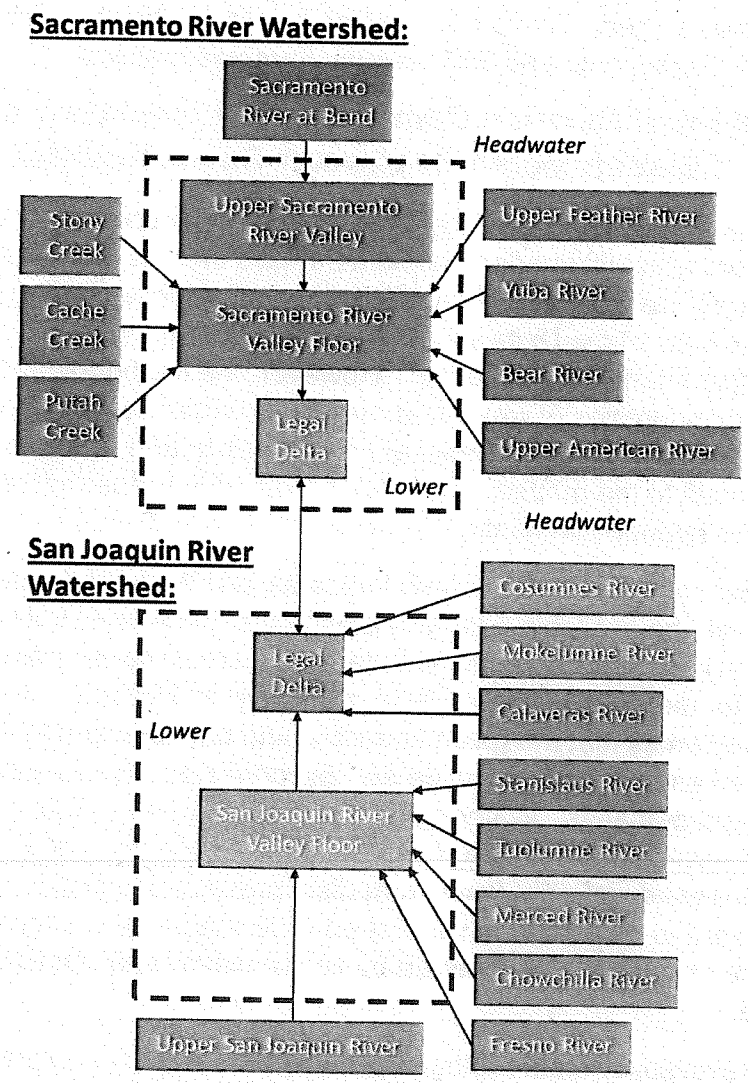
The Mokelumne River HUC8 (Upper Mokelumne) includes demands on the mainstem of the San Joaquin River within the Legal Delta, so the Mokelumne River headwater subwatershed was instead defined as a combination of five HUC10s (Upper Mokelumne River, South Fork Mokelumne River, Middle Fork Mokelumne River, Upper North Fork Mokelumne River, and Lower North Fork Mokelumne River) and a buffer along the Mokelumne River between Camanche Reservoir and the confluence with Dry Creek.

Finally, the Calaveras River HUC8 does not include demands along Mormon Slough that are supplied from the Calaveras River, so its subwatershed boundary was modified to include Mormon Slough between the Bellota Weir and the Stockton Diverting Canal.

Previous versions of this report derived the delineation of the Mokelumne River, Chowchilla River, and Fresno River subwatersheds from the HUC8 boundaries, which resulted in their classification as lower subwatersheds. By deriving the delineations from the HUC10 boundaries as described above, these subwatersheds are able to be treated as headwater subwatersheds within the analysis; thereby enabling a headwater subwatershed-level analysis to be conducted in these areas. As discussed in more detail below, this enables headwater subwatershed level analyses to be conducted in these areas and for any unmet demand to be eliminated from the wider watershed-level analysis (of which the lower reaches of these subwatersheds are now a part).

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 10. 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 or curtailment orders based on the headwater subwatershed-level analysis. Currently, rights and claims are only curtailed if there is zero supply available to meet their demands (i.e., a right or claim is currently not curtailed even if a portion of its demand cannot be met by available supply). However, this assumption may be refined in the future. 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 unavailability at the headwater subwatershed scale is only part of the evaluation of water unavailability. 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 unavailability 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.[28] 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 the period of analysis (e.g., 7 days or 31 days). 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. Water rights and claims within a disconnected headwater subwatershed would not be curtailed based on the watershed-wide unavailability analysis. Abandoned instream flows from disconnected headwater subwatersheds may still be considered to contribute to watershed-wide supply (see section 2.1.6 above) unless they are assumed to be diverted by senior water right claimants within the subwatershed.

The Water Unavailability Methodology Spreadsheet, available on the State Water Board's Delta Water Unavailability Methodology webpage, contains a table in the 'Supply Final' tab that summarizes which headwater subwatersheds were assumed to be disconnected from the Delta watershed during the analyzed period .

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 Legal Delta from both the Sacramento and San Joaquin River watersheds. To

[28] Demands by Riparian-priority claims 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.

account for this, appropriative demands within the Legal Delta are prorated between the two watersheds based on the 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 during the analysis period, 80 percent of Legal Delta appropriative demand is charged against Sacramento River watershed supply for that period 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. Water rights and claims with points of diversion within the Legal Delta that claim only appropriative water rights will only receive notices of water unavailability or curtailment orders if both the Sacramento River watershed analysis and the San Joaquin River watershed analyses 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 unavailability to appropriators in the Legal Delta during this critically dry period.

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 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 (see section 2.2.6 above).[29]

Supply ratios for the Sacramento and San Joaquin River watersheds are calculated using the exceedance forecast selected for use in determining water unavailability for each watershed (see section 3.1.1 below). 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).

[29] 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 Legal Delta and available on the website of the Office of the Delta Watermaster (Overlap Memo).

Although the methodology has the flexibility to evaluate water unavailability over sub-monthly timesteps to consider short-term precipitation and runoff events, water unavailability analyses for the purpose of issuing curtailments in the Legal Delta are not currently performed on a timestep any shorter than 30 days (i.e., monthly). The methodology does not assume there is supply available longer than a month in the Legal Delta such that water unavailability would be affected based on the analyses discussed in Appendix D. The methodology also only accounts for freshwater natural flows from the Sacramento and San Joaquin Rivers as part of 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 via tidal action is assumed to be of insufficient quality to be usable for agricultural or municipal purposes. Technical Appendix D explains the technical analysis that supports these assumptions.

2.4 Water Unavailability Visualizations

The Water Unavailability Methodology includes two major types of water unavailability visualizations: the headwater subwatershed visualizations (17 in total) and the watershed-wide visualizations,[30] consisting of one for the Sacramento River watershed and one for the San Joaquin River watershed. Samples of these graphs are provided below in Figure 11, Figure 12, and Figure 13. 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 2.2.9 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. When conditions in the Delta watershed were 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.[31] During the wet season when precipitation conditions were dynamically evolving, the 50 percent FNF exceedance forecast was used. Other scenarios, such as the 75 percent FNF exceedance forecast, have also been used as appropriate (see section 3.1.1 below). The watershed-wide visualizations display a single supply scenario that has been adjusted to account for disconnection at the

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

[31] Section 3.1.1 below describes how daily FNF may be used to determine which monthly FNF exceedance forecast most closely represents actual conditions. From May through September 2021, the water supply forecasts used in the visualizations were the 90 percent exceedance forecast from DWR's May B-120. Beginning in October 2021, B-120 forecasts are not available; therefore, CNRFC forecasts have been used since October.

subwatershed scale. The sample watershed-wide visualizations below display the adjusted 50 percent exceedance forecast.

Figure 11. Sample Headwater Subwatershed Water Unavailability Visualization (Yuba River)

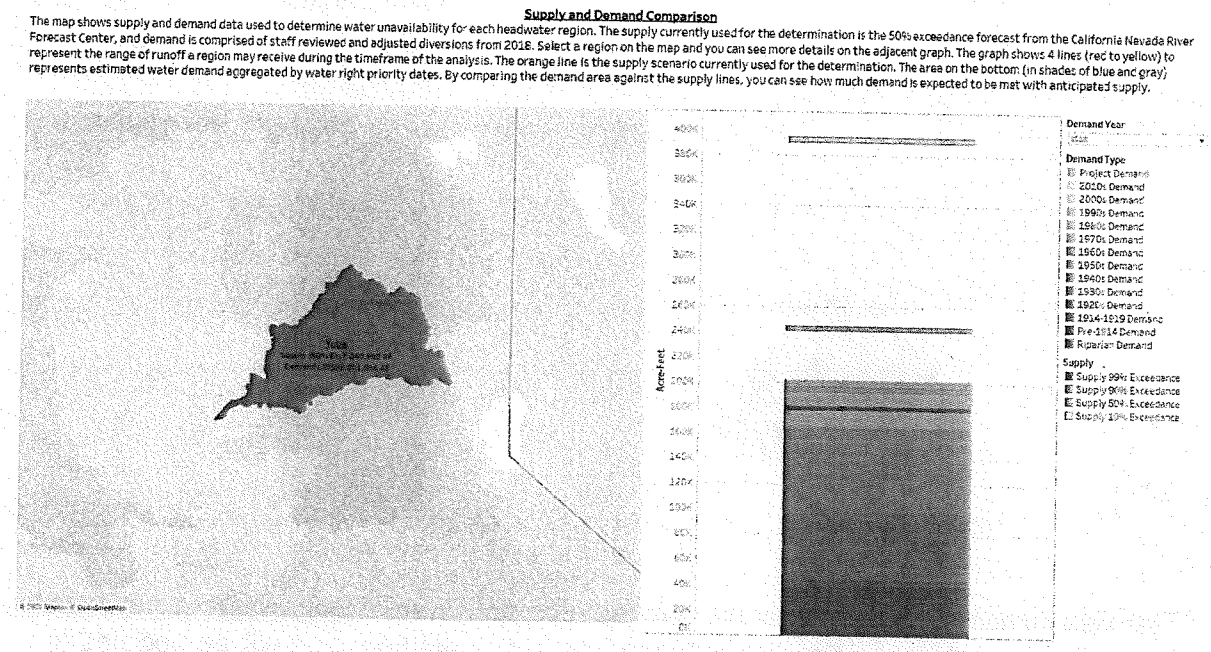


Figure 12. Sample Sacramento River Watershed Water Unavailability Visualization

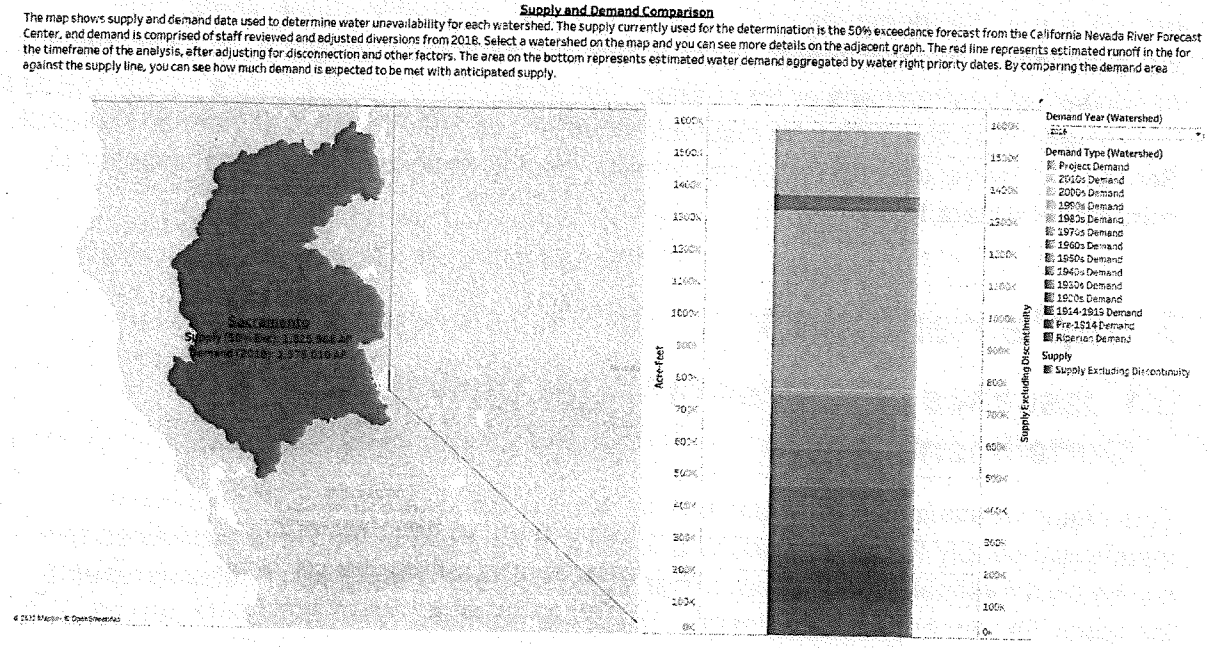
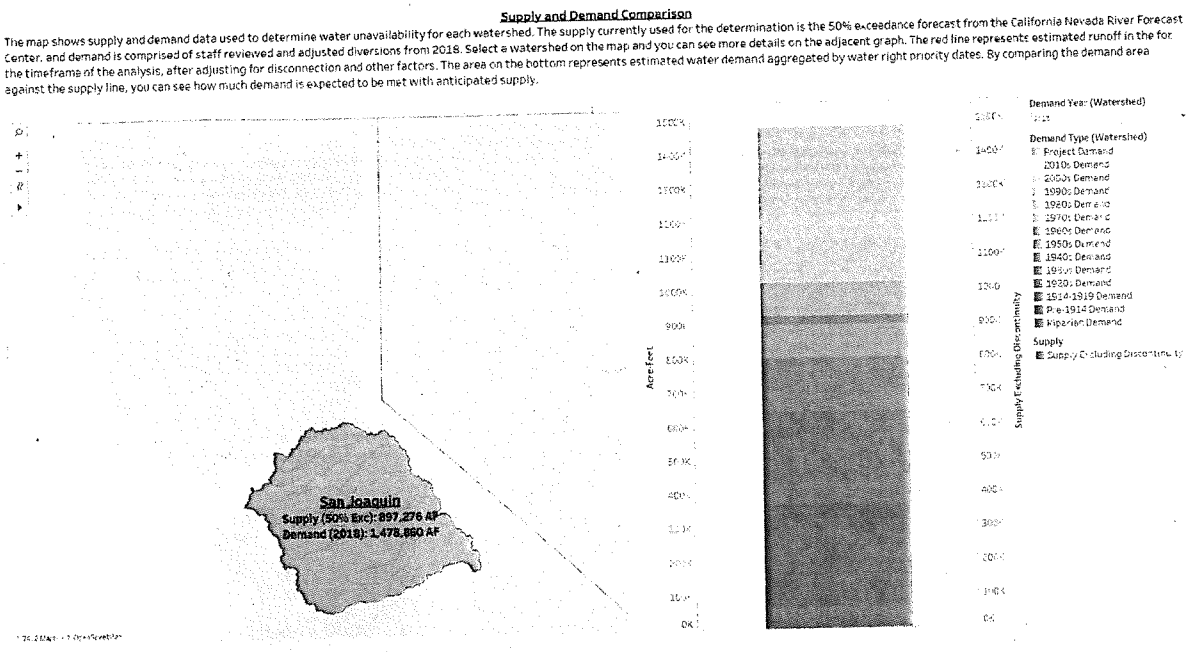


Figure 13. Sample San Joaquin River Watershed Water Unavailability Visualization



The visualizations have been made available on the Board's Delta Water Unavailability Methodology webpage using the Tableau interactive platform and will be updated 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 insufficient water available to meet all riparian demands. Section 3.1 below describes the process for issuing notices of water unavailability or curtailment orders to diverters.

3 Implementation

3.1 Issuance of Notices of Water Unavailability and Curtailment Orders

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 prior outputs of the

methodology, on June 15 and July 23, 2021, the State Water Board issued notices of water unavailability (also referred to simply as "notices") to water right holders and/or claimants in the Delta watershed indicating that water supplies are not available for their use. Notices, unlike curtailment orders, are not directives to stop diverting. 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.

Given the dire water supply conditions in the Delta watershed, on August 20, 2021, based on the output of the methodology and the authority granted to the Board under the emergency regulation, the Board issued curtailment orders to all post-1914 appropriative water right holders in the Delta watershed, many pre-1914 appropriative claimants, as well as some riparian claimants. Unlike notices of water unavailability, curtailment orders are directives to stop diverting. The curtailment orders, which will continue to be updated as conditions change, require affected right holders and claimants to cease diversions when water is not available under a water right holder's or claimant's priority of right unless and until (1) they have authorization to continue diverting pursuant to one of the exceptions enumerated in the regulation or (2) they receive notice that the curtailment order has been temporarily suspended or permanently lifted. In addition, the emergency regulation authorizes the State Water Board to require enhanced reporting of some larger water users to provide additional information on past diversion and use, and future projected use. That information is planned to be used to better inform future curtailment decisions.

During exceptionally dry conditions in the fall of 2021, curtailments were issued when the methodology determined that any portion of a water right or claim's demand was unavailable. Despite large precipitation events early in the water year, 2022 has remained critically dry. Nevertheless, due to continued needs to refill storage reservoirs and capture precipitation and snowmelt from short duration events, the methodology was modified to only issue curtailments when zero supply is available to meet a water right or claim's demand (i.e., if any portion of a right's demand can be met by available supply, then it is not curtailed). Further adjustments may be made to this assumption to reflect limited availability, particularly for larger rights.

In recognition of the provisions of the Coordinated Operations Agreement (COA) between the SWP and CVP that identifies how to distribute available supplies and responsibilities for meeting Delta requirements, curtailment of Project rights in the Sacramento River watershed and the Legal Delta are not being implemented when water is found to be unavailable for only Project rights. Implementation of curtailment of these Project rights will be limited to periods of time when the Project's operations have the potential to injure other water right holders and claimants. That is, at times when any non-Project water rights or claims would be curtailed, the Sacramento River

watershed and Legal Delta Project rights would still be subject to curtailment. This ensures that curtailments will not interfere with the effective coordination of the Projects pursuant to the COA while also ensuring that other water right holders are not impacted.

As discussed above, appropriative diverters in the Legal Delta will only be curtailed 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. Implementation of this methodology will operate separately from issuance of curtailments pursuant to standard water right Term 91, which was reimposed in June and expected to be in effect through the summer and early fall.

3.1.1 Period of Analysis and Exceedance Forecast Selection

To evaluate water unavailability, water demands are evaluated against an appropriate supply forecast (e.g., 10%, 50%, 90%, or other exceedance forecast) for a specified period of analysis (e.g., 7 days or 31 days). The most appropriate values for these two variables, exceedance forecast and period of analysis, are selected based on the best available data.

During the initial implementation of the Water Unavailability Methodology in summer 2021, a static calendar month timestep was used for the analysis due to the relatively stable hydrology at this time of year. As conditions during the fall and winter became more dynamic different averaging periods were applied that had the effect of generally reducing curtailments. This includes a shorter averaging period (7 days) that was used for curtailments of rights and claims outside the Legal Delta that provided for more dynamic suspension of curtailment orders if forecasted or actual precipitation events were expected to generate sufficient runoff during a particular week. A rolling 31-day averaging period was also used that provided for greater suspension of curtailments during the winter and spring. Because the hydrology has stabilized in late spring, beginning in June 2022 the Board has returned to a static calendar month timestep that better reflects the shift from predominately precipitation-driven reservoir storage demands to more static direct diversion demands for agricultural purposes.

Demand values, instream flows, and gap-filling factors used in the analysis are prorated to the same averaging period as supply. Due to issues related to transit times and the duration of supply availability, the issuance of curtailments within the Legal Delta continues to be considered based on an analysis using a monthly (i.e., no shorter than 30 days) timestep. However, shorter term expected precipitation and runoff data can still be considered as appropriate in determining whether to temporarily suspend curtailments in the Legal Delta.

The selected supply data source and averaging period help to inform the selection of the most appropriate exceedance forecast for the analysis. For example, CNRFC forecasts have the highest confidence in predicting precipitation and resulting runoff within the next 7 days. Within those 7 days there is a possibility of outlying conditions (i.e., a particularly strong or weak precipitation event), but a median forecast (50%

exceedance) is expected to be the most likely predictor of supply over that period. The use of CNRFC forecasts, which are updated daily, also incorporates observed and forecasted conditions that may affect water supplies in the future. These include precipitation (or a lack thereof), snowpack levels, temperature changes that may cause snowmelt, antecedent soil moisture conditions, wind, and other factors.

Over longer periods, general climatic trends have a greater influence over the forecast. Therefore, for a longer averaging period during a critically dry year, a drier forecast such as the 75 or 90 percent exceedance forecast may be more appropriate. It may also be appropriate to select a higher exceedance when using a forecast that is updated less frequently or looks several months into the future, such as DWR's B-120. During the initial implementation of the Water Unavailability Methodology in summer 2021, a 90% exceedance supply forecast was used for the analysis because the most recent B-120 forecasts had been issued several months earlier in May 2021 and conditions had generally become drier since that time.

Weekly curtailment status updates from the Board have described the exceedance forecast and averaging period used in the analysis. As described above, earlier updates used a static calendar month period of analysis. Due to variable conditions throughout the Delta watershed, different exceedance forecasts may be used for the Sacramento River watershed, the San Joaquin River watershed, and individual subwatersheds, if appropriate.

Additional available datasets that may be used to monitor and forecast precipitation and runoff include qualitative Area Forecast or Hydrometeorological Discussions from NOAA and CNRFC, 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.

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.).[32] Currently, notices of water unavailability or curtailment orders 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.

[32] 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.

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 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. This version of the report includes report updates in response to topics raised during the October 20, 2021 technical staff workshop, those raised in petitions for reconsideration of the August 20, 2021 curtailment and reporting orders, as well as information and input provided during the May 12, 2022 staff workshop and corresponding written comment period ending May 19, 2022 (see section 1.6).

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 other issues. The methodology itself may also change as appropriate to address issues that may arise. Regular updates regarding issues related to water unavailability will be provided to the public during Board meetings. Regular updates will also be provided on the Board's Delta Drought and Delta Water Unavailability Methodology webpages, including updated water unavailability visualizations.

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, the emergency regulation provides that the submittal of demand projections may be required and these projections may 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 emergency regulation.

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 2.2.8 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: 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. While the spreadsheet posted on the Delta Drought webpage represents a single "snapshot" analysis conducted to determine water unavailability on a given day, it contains multiple interactive elements which allow the user to run a similar analysis with different input data. Each tab that contains static data (e.g., multipliers, streamflows, or water right records) indicates in the top-left cell the date that data was last updated. Archived spreadsheets containing the analyses supporting curtailments are available for each specific day that a weekly update was issued. These spreadsheets are available on the Water Board's File Transfer Protocol (FTP) site; see the Delta Drought webpage for instructions to request credentials to access the FTP site.

NOTE: The spreadsheet is a large file with links to external online files and many complex formulas. It performs best with automatic formula calculation turned off so that recalculations can be done manually rather than each time a single value is changed.

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

Field Name(s)	Definition & Methodology	Data Source(s)
Subwatershed	An area encompassing one or more HUC8 watersheds, determined based on geospatial mapping of stream and diversion locations and the unavailability of full natural flow (FNF) supply locations ("gages"). Subwatershed is the smallest area over which water unavailability is determined.	Staff-determined
Subwatershed Type	Subwatersheds are categorized as either "Headwater" or "Lower" for the purpose of this analysis: - A headwater subwatershed contains water demands that can only be met by water supplies in the subwatershed (i.e., there are no tributaries flowing into the subwatershed from another subwatershed). - A lower subwatershed can receive water supplies from outside its boundaries (i.e., it is located downstream of the headwaters).	Staff-determined
HUC8[1]	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. Yellow tabs contain data fields that can be updated or revised to change the analysis; cells with modifiable data are highlighted yellow in those tabs. Blue tabs contain data related to water supply, green tabs contain data related to water demand, and orange tabs contain analyses of water unavailability at various scales that are used to determine water right curtailments.

[1] As described in Section 2.3.1 of the main report, any records assigned to the Upper Mokelumne, Middle San Joaquin-Lower Chowchilla, Fresno River, or Upper Calaveras California HUC8s (headwater subwatersheds) in the spreadsheet were based on a closer analysis of Hydrologic Unit Code Level 10 (HUC10) boundaries and other criteria. Points of Diversion (PODs) located in these HUC8s that did not meet these criteria are assigned to the Lower San Joaquin River or San Joaquin Delta HUC8s (lower subwatersheds) in this spreadsheet.

Supply Past

This tab contains past supply data for the current water year, which is only used in the water unavailability analyses if the user-specified date range (see Supply Forecast section) contains dates in the past. Water supply observations are obtained from the California Nevada River Forecast Center (CNRFC) and consist of full natural flow (FNF, also known as "unimpaired flow") estimates in thousand acre-feet (TAF). Values must be manually entered into this tab; direct links to individual datasets for each site are provided in the spreadsheet.

Supply Forecast

This tab contains forecasted supply data for a user-specified date range. Water supply forecasts are obtained either from the Department of Water Resources (DWR) Bulletin 120 Water Supply Forecast (B-120) or from CNRFC and consist of FNF estimates. Direct links to individual forecast datasets are provided in the spreadsheet. Supply volumes are provided in units of TAF.

This tab is grouped vertically into five tables separated by gray rows. The top table contains user-specified start and end dates (inclusive) over which water supply and demand are calculated. The dates entered in these cells may range from the start date of the current water year (see Supply Past section) to one year from the current date (e.g., if the spreadsheet is modified on February 1, 2022, any date between October 1, 2021 and February 1, 2023 could be entered). To compute supply for the specified period using CRNFC data, daily past and/or forecasted supply values are added for dates within the period. To compute supply using B-120 data, monthly forecasts are converted to an average daily demand for each month, which is multiplied by the number of days in each month that fall within the specified period to calculate a total volume of water.

The top table also allows the user to select a supply forecast data source; selecting "CNRFC" will use those forecasts for all subwatersheds, while selecting "B120" will use those forecasts for the ten major subwatersheds and CNRFC for the smaller ones. Finally, in the top table the user can select the calendar year of quality-controlled demand data from 2018 or 2019 (see Appendix B) to use in the analysis. Finally, the top table allows the user to select a demand scenario (i.e., which diversions will contribute to demand evaluated): only direct diversions, only storage diversions, or the sum of direct and storage diversions, which was the basis for all previous analyses (see Final Demand section for more information on disaggregated direct and storage diversions).

The second table allows the user to select one of seven supply exceedance probabilities for each subwatershed: 99% (equivalent to the minimum forecast), 90%,

75%, 50% (equivalent to the median forecast), 25% 10%, and 1% (equivalent to the maximum forecast). Alternatively, a "Custom" forecast can be selected to use user-specified volumes entered in the second row.

The third table contains forecasted FNF values for the user-specified time period for each CNRFC gage in each subwatershed. The row of gage names includes direct links to each forecast comma-separated value (CSV) file on the CNRFC website, which are updated daily; to update the forecasts in the spreadsheet, the user must click these links (or use Excel's Edit Links window in the Data toolbar) to open all forecast CSVs, then recalculate these formulas. Forecasts are presented as volumes over the user-specified timer period for each of the seven forecast exceedance probabilities. Each forecast exceedance is calculated from the 41 different "traces" for the respective gage in the fourth table; the 75% through 10% exceedances are calculated using Excel's exclusive percentile function, which is equivalent to computing plotting positions with the Weibull formula.

The fourth table contains forecasted FNF values for each CNRFC gage. Forecasts are presented in the form of 41 different "traces" for each gage each day; this table contains the total forecasted supply volume over the user-specified time period in the top table, referencing the online forecast CSV file for each gage. CNRFC forecast CSVs contain daily average FNF values in thousand cubic feet per second (TCFS), which are converted to volumes of TAF in the spreadsheet.

The fifth table contains B-120 forecasted FNF values for the ten major subwatersheds, as published in monthly Water Supply Index (WSI) or weekly Distribution (DIST) products released January through June. These values must be entered manually, and the far-left column contains links to forecast data sources for each subwatershed. While monthly WSI products provide monthly forecasts for all six exceedance probabilities, weekly DIST products provide only 50% monthly forecasts. DIST products also include forecasts for the Mokelumne and Cosumnes subwatersheds, which are not provided in WSI products. The third column in this table contains the calculated B-120 forecast for the user-specified period based on daily averages, including both forecasted and past values; B-120 values for past months are calculated FNF, which are equal for all forecast exceedances. While CNRFC forecasts are available up to one year from the current date, B-120 forecasts are only available until the end of September of the current water year.

Final Supply

This tab contains water supply data from the Supply Forecast tab that is reformatted and computed to represent available supply data for each of the Delta watershed's 20 subwatersheds. This tab also contains intermediate supply calculations which are used

in water unavailability analyses at the headwater and subwatershed scales. All supply volumes in this tab are provided in units of acre-feet (AF).

This tab is grouped vertically into four tables separated by gray rows. The top table contains water supply forecasts for seven exceedance probabilities for each subwatershed: 99% (equivalent to the minimum forecast), 90%, 75%, 50% (equivalent to the median forecast), 25% 10%, 1% (equivalent to the maximum forecast), or a user-specified Custom forecast (see Supply Forecast section). The top row is populated with forecasts based on the user-specified exceedance forecast for each subwatershed (see Supply Forecast section). Water supply computations for each subwatershed based on the forecasted values in the Supply Forecast tab are explained in the table below. Some subwatersheds are computed using Gap Filling (GF) factors that are explained in the next section.

Field Name(s)	Definition & Methodology	Data Source(s)
Exceedance	The probability of the water supply over the user-specified period exceeding the given volume.	--
Sacramento Bend	Supply forecasts for the Sacramento River at Bend subwatershed: - CNRFC gage BDBC1. - B-120 SRWSI or DIST (50% only).	CNRFC, B-120
Stony	Supply forecasts for the Stony Creek subwatershed (at East Park Reservoir): - Augmented, CNRFC gage EPRC1 * GF Stony Increase Factor.	CNRFC w/ staff adjustments
Cache	Supply forecasts for the Cache Creek subwatershed (above Rumsey): - Extrapolated, Stony * GF Cache-Stony Ratio.	Staff estimates
Upper Feather	Supply forecasts for the Upper Feather River subwatershed (at Lake Oroville): - CNRFC gage ORDC1. - B-120 SRWSI or DIST (50% only).	CNRFC, B-120
Yuba	Supply forecasts for the Yuba River subwatershed (at Englebright Reservoir or near Smartville plus Deer Creek): - CNRFC gage HLEC1. - B-120 SRWSI or DIST (50% only).	CNRFC, B-120

Field Name(s)	Definition & Methodology	Data Source(s)
Bear	Supply forecasts for the Bear River subwatershed (near Wheatland): - Extrapolated, Upper Feather * GF Bear-Yuba Ratio.	Staff estimates
Upper American	Supply forecasts for the Upper American River subwatershed (at Folsom Lake): - CNRFC gage FOLC1. - B-120 SRWSI or DIST (50% only).	CNRFC, B-120
Putah	Supply forecast for the Putah Creek subwatershed (near Winters): - Extrapolated, Stony * GF Putah-Stony Ratio.	Staff estimates
Upper Sacramento Valley	Supply 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): - Augmented, CNRFC gages (EDCC1+TCRC1) * GF Elder-Thomes Increase Factor + (MLMC1+DCVC1+BKCC1) * GF Mill-Deer-Butte Increase Factor.	CNRFC w/ staff adjustments
Sacramento Valley Floor	Supply 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): - Extrapolated, (Sacramento Bend+Upper Feather+Upper American) * GF Sacramento Valley Ratio.	Staff estimates
Sacramento Total	The sum of all subwatershed supplies in the Sacramento River watershed for the given forecast exceedance over the user-specified time period.	Calculated
Chowchilla	Supply forecasts for the Chowchilla River subwatershed (at Buchanan Reservoir): - CNRFC gage BHNC1.	CNRFC

Field Name(s)	Definition & Methodology	Data Source(s)
Upper San Joaquin	Supply forecasts for the Upper San Joaquin River subwatershed (at Millerton Reservoir): - CNRFC gage FRAC1. - B-120 SJWSI or DIST (50% only).	CNRFC, B-120
Fresno	Supply forecasts for the Fresno River subwatershed (at Hensley Lake): - CNRFC gage HIDC1.	CNRFC
Merced	Supply forecasts for the Merced River subwatershed (at Exchequer Reservoir or below Merced Falls): - CNRFC gage EXQC1. - B-120 SJWSI or DIST (50% only).	CNRFC, B-120
Tuolumne	Supply forecasts for the Tuolumne River subwatershed (at New Don Pedro Reservoir or below La Grange Reservoir): - CNRFC gage NDPC1. - B-120 SJWSI or DIST (50% only).	CNRFC, B-120
Stanislaus	Supply forecasts for the Stanislaus River subwatershed (at New Melones Reservoir or below Goodwin Reservoir): - CNRFC gage NMSC1. - B-120 SJWSI or DIST (50% only).	CNRFC, B-120
Calaveras	Supply forecasts for the Calaveras River subwatershed (at New Hogan Reservoir): - CNRFC gage NHGC1.	CNRFC
Mokelumne	Supply forecasts for the Mokelumne River subwatershed (at Pardee Reservoir): - CNRFC gage CMPC1. - B-120 DIST (50% only).	CNRFC
Cosumnes	Supply forecasts for the Cosumnes River subwatershed (at Michigan Bar): - CNRFC gage MHBC1. - B-120 DIST (50% only).	CNRFC

Field Name(s)	Definition & Methodology	Data Source(s)
San Joaquin Valley Floor	Supply forecasts for the San Joaquin River Valley Floor subwatershed (minor east and west side tributaries between the Chowchilla and American Rivers, including Mariposa, Owens, and Bear Creeks): - Extrapolation, CNRFC gages MPAC1+OWCC1+MEEC1 + (Upper San Joaquin+Merced+Tuolumne+Stanislaus)* GF San Joaquin Valley Ratio + (Mokelumne+Cosumnes) * GF San Joaquin-Mokelumne-Cosumnes Ratio.	CNRFC, staff estimates
San Joaquin Total	The sum of all subwatershed supplies in the San Joaquin River watershed for the given forecast exceedance over the user-specified time period.	Calculated
Delta Watershed Total	The sum of all supplies in the Delta watershed for the given forecast exceedance over the user-specified time period.	Calculated
% Sacramento/ San Joaquin	The percent of total Delta watershed supply for the given forecast exceedance over the user-specified time period which came from the respective watershed.	Calculated

The second table in this tab contains calculations related to the contributions of each subwatershed to watershed-wide supply. The first row indicates if any Riparian-priority claims in each subwatershed faced water unavailability over the user-specified period (see Headwaters section). In other words, these cells identify if each subwatershed's supplies and demands should be excluded from the Watershed unavailability analysis due to lack of connectivity with the Delta watershed; they have conditional formatting to highlight red if the subwatershed lacks connectivity. Lower subwatersheds have static values that indicate they are never disconnected from the watershed. The second row computes the total Riparian-priority demand within each headwater subwatershed that would be unmet by local supplies (see Headwaters section); this value will only be nonzero if the subwatershed is assumed to be disconnected from the watershed. These calculations do not include unmet demands of Riparian-only claims (i.e., Water Right Type = Statement of Div and Use (Riparian)).

The second table's third row indicates if any subwatershed's supply is less than its abandoned instream flow requirement for the user-specified period (see Instream Flows section), with conditional formatting to highlight red if the instream flow is greater. The fourth row calculates the volume of instream flow in excess of the FNF supply for each

subwatershed; these volumes are not available to Riparian-only claims in the Watershed-scale analysis (see Watersheds section). Finally, the fifth row calculates the supply from each subwatershed that contributes to the Watershed-scale analysis: if the subwatershed is disconnected its contributing supply is equal to the difference between its Instream Flow in Excess of Supply and its Headwater Riparian Demand Unmet (i.e., the amount of abandoned instream flow not diverted by Riparian-priority claims in the subwatershed), otherwise its Total Supply is equal to its Selected Supply Forecast value plus its Instream Flow in Excess of Supply value. Supply ratios for the Delta watershed are calculated based on total supply volumes for each watershed for the purpose of Legal Delta demand proration (see Watersheds section).

The third table in this tab indicates the priority date of the most senior right or claim in each subwatershed, as well as the Sacramento and San Joaquin watersheds and the Legal Delta as a whole, that would be under curtailment for the user-specified time period with the user-specified supply forecasts (see Final Supply section). Values are provided for both the Headwater Subwatershed-scale unavailability analysis (see Headwaters section below) and the Watershed-scale unavailability analysis (see Watersheds section below). These cells will only display "Riparian" priority if the supply in the given headwater subwatershed is forecasted to be zero; they will display "All Pre-14" if all pre-1914 appropriative water right claims are under curtailment. Values of "Project" mean that one or more Project water rights (assumed to be the most junior in the Delta watershed) are under curtailment. These cells display "-" if no water rights or claims are under curtailment for the given subwatershed/watershed. In some cases, these cells may display the priority of a right that has no water available in that subwatershed but is not curtailed because it diverts from additional subwatershed(s) or is located in the Legal Delta; these rights are only curtailed if water is unavailable from all sources (see Curtailments section). The third table also contains calculations of the total unmet demand and excess local supply in each subwatershed; unmet demand would be zero if no rights or claims in the subwatershed face water unavailability, while excess supply would be zero if some rights or claims face water unavailability. Excess supplies from individual headwater subwatersheds may meet demands further downstream in the watershed, so the total excess supply for each watershed is less than the sum its subwatersheds. The fourth table in this tab contains a reformatted and simplified version of the third table for discussion purposes, with priority dates of first curtailments displayed as years only.

Gap Filling

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 outside the Methodology spreadsheet based on past supply data, and detailed methods for each subwatershed are described in the table below. Outlying

values (outside the range of the overall mean plus or minus three times the overall standard deviation) are not included in the calculated monthly mean factors shown in this tab. The bottom Supply Forecast Period row contains average calculated factors for the user-specified time period (see Supply Forecast section) based on the number of days in each month that fall within the specified period.

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)	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 and averaged by month. - GF Cache = CSR*(EPRC1*SIF) for WY 2015-Present and Forecasts.	Calculated
Stony Increase Factor (SIF)	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 gage EPRC1 is located upstream of several tributaries): - SIF = DWR subbasin UF4 / CNRFC gage EPRC1 for WYs 2013-2014, removed outlying values and averaged by month. - GF Stony = SIF*EPRC1 for WY 2015-Present and Forecasts.	Calculated
Bear-Yuba Ratio (BYR)	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 gage YRS for WY -1922-2014, removed outlying values and averaged by month. - GF Bear = BYR*YRS for WY 2015-Present and Forecasts.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Elder-Thomes Increase Factor (ETIF)	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 gages EDCC1 and TCRC1 do not include all west side tributaries): - ETIF = DWR subbasin UF5 / (CNRFC gages EDCC1+TCRC1) for WYs 2013-2014, removed outlying values 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)	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 gages MLMC1, DCVC1, and BKCC1 do not include all east side tributaries): - MDBIF = DWR subbasin UF7 / (CNRFC gages MLMC1+DCVC1+BKCC1) for WYs 2013-2014, removed outlying values and averaged by month. - GF Upper Sacramento Valley East = MDBIF*(MLMC1+DCVC1+BKCC1) for WY 2015-Present and Forecasts.	Calculated
Putah-Stony Ratio (PSR)	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 and averaged by month. - GF Putah = PSR*(EPRC1*SIF) for WY 2015-Present and Forecasts.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Sacramento Valley Ratio (SRVR)	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 gages SBB+FTO+AMF for WY 1922-2014, removed outlying values 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)	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 gages MKM+CSN for WY -1922-2014, removed outlying values and averaged by month. - GF San Joaquin Valley Floor East = SJMCR*(MKM+CSN) for WY 2015-Present and Forecasted.	Calculated
San Joaquin-Merced-Tuolumne-Stanislaus Ratio (SJMTSR)	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 gages SJF+MRC+TLG+SNS for WY -1922-2014, removed outlying values and averaged by month. - GF San Joaquin Valley Floor West = SJMTSR*(SJF+MRC+TLG+SNS) for WY 2015-Present and Forecasted.	Calculated

Instream Flows

This tab contains 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 State Water Board's Sacramento Valley Water Allocation Model (SacWAM) and Water Supply Effects (WSE) model. Only requirements which cross subwatershed boundaries or end near the bottom of a subwatershed (less than about 50 river miles from its mouth) are included. If the instream flow reach ends higher up in the subwatershed, such that it may meet demand in that subwatershed itself, the abandoned instream flow is not considered in the analysis. The source of each instream flow requirement is detailed in the Note column.

Flow values in the Instream Flows table are given in average cubic feet per second (CFS) by month, which the Supply Forecast Period column converts to a volume in acre-feet (AF) for the user-specified time period (see Supply Forecast section) using daily averages and the number of days in each month that fall within the specified period. The supply contribution of each subwatershed to the Watershed-scale analysis is represented by the greater of either the forecasted full natural flow (FNF) or the abandoned instream flow in this table for the respective subwatershed (see Final Supply section). In other words, during very dry conditions instream flows are assumed to consist of supplemental reservoir releases which would replace available natural flows when abandoned below their intended reach. During wet conditions instream flows are assumed to consist of bypassed natural flows, which would not contribute abandoned water in excess of FNF below their intended reach.

Demand

This tab contains monthly water diversion (demand) data for water right records in the Delta watershed. This data originates 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 reported water diversions for a single water right or claim in each month of the 2018 and 2019 calendar years, which are used as proxies for current water demand in this analysis. Demand data are further distributed to individual points of diversion (PODs) and adjusted to account for return flows in the Final Demand tab (see Final Demand section).

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Water Right Application ID; each water right record on file with the State Water Board (Board) is assigned a unique Application ID.	eWRIMS database
Water Right Type	Water right or claim 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 or Pre-1914): A riparian and/or 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. - Statement of Div[ersion] and Use (Pending): A statement filed to document diversions while an appropriative water right application is pending. - Stockpond or Federal Stockpond: A water right for a small livestock watering impoundment constructed before 1969 (Water Code §1226). - Registration (Domestic, Livestock, or Cannabis): Water rights issued for certain small projects (Water Code §§1228-1229). - Federal Claims: A claim of federal reserved water rights filed before July 1, 1984 (Water Code §1227).	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
	- Section 12 File: A specific type of water right, similar to a pre-1914 appropriative water right claim.	
Water Right Status	Status of the water right or claim: - 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. - Certified: A Stockpond, Federal Stockpond, or Section 12 File water right for which the Board has issued a certificate. - Registered: A Domestic, Livestock, Cannabis, or other small water right Registration which has been approved by the Board.	eWRIMS database
Primary Owner	Name of the primary owner of the water right record.	eWRIMS database
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 or claim (YYYY/MM/DD): - Appropriative, Federal Stockponds, Cannabis/Domestic/Livestock Registration: The earlier of the Application Acceptance Date and Application Received Date values. - Statements (Riparian): "Riparian" and assumed to have a more senior priority date than all appropriative water rights and claims. - Statements (Pre-1914, "Riparian or Pre-1914," Pending, Unclassified, or Other): Assumed to be January 1 of the earliest claimed Year Diversion Commenced attribute, which is present in both Initial Statements of Diversion and Use and annual Supplemental Statements of Diversion and Use. - Stockpond: The earlier of the Application Acceptance Date or Application Received Date values, if this date is after 1977. Otherwise,	eWRIMS database

Field Name(s)	Definition & Methodology	Data Source(s)
	assumed to be January 1 of the Year Diversion First Commenced value. - Federal Claims: Assumed to be January 1 of the Year Diversion First Commenced value if this date is before 1914. Otherwise, the earlier of the Application Acceptance Date and Application Received Date values. - Section 12 File: The Priority Date value.	
Assumed Priority Date	The date which carries over to all other parts of the spreadsheet. Equal to the Priority Date except for certain rights and claims: - Statements ("Riparian or Pre-1914" or Other): Assumed to be "Riparian" because the statement does not contain sufficient information to designate a volume of demand to each type of claim. Conservatively assumed to have a more senior priority date than all appropriative water rights and claims. [2] - Statements (Pre-1914 or Unclassified) with a Priority Date after 1914: In 1914 but with the relative order of dates preserved by assigning sequential dates to each starting with 1914/01/02. - Statements (Pending): "Pending" and assumed to be the most junior of all records, because the statement was only filed to document diversions while an appropriative water right application is pending. - Appropriative Project water rights listed in Board Decision 1641 (excepting 2 New Melones Project rights, per Board Decision 1422): "Project" and assumed to be junior to other appropriative water rights and claims.	Staff-determined
Face Value (AFA)	The maximum volume of water authorized for diversion annually under an appropriative	eWRIMS database

[2] For claims in 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)
	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.	
2018/2019 Total Direct (AFA)	The total reported direct diversion of the water right record in calendar year 2018 or 2019. Values for select water right records were manually reviewed by staff and corrected as necessary (see Direct Review columns).	eWRIMS database w/ staff adjustments
2018/2019 Total Storage (AFA)	The total reported diversion to storage of the water right record in calendar year 2018 or 2019. Values for select water right records were manually reviewed by staff and corrected as necessary (see Storage Review columns).	eWRIMS database w/ staff adjustments
2018/2019 Total Diversion (AFA)	The total reported diversion of the water right record in calendar year 2018 or 2019 (sum of Total Direct and Total Storage columns).	eWRIMS database w/ staff adjustments
2018/2019 Direct/Storage 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 the annual report. - Some rights or claims contain more specific comments with additional information.	Staff-determined
2018/2019 Jan-Dec Direct (AF)	The total reported direct diversion of the water right record in each month of calendar year 2018 or 2019. Values for select water right records were manually reviewed by staff and corrected as necessary (see Direct Review columns).	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
2018/2019 Jan-Dec Storage (AF)	The total reported diversion to storage of the water right record in each month of calendar year 2018 or 2019. Values for select water right records were manually reviewed by staff and corrected as necessary (see Storage Review columns).	eWRIMS database w/ staff adjustments

Return Flows

This tab contains factors which are used to adjust demand data to account for return flows in each subwatershed. Return Flow factors are calculated for each month in the Sacramento and San Joaquin River watersheds as the percent of diversion which returned as flow in the same month (Factor = Total Diversions / Total Return Flows). Data used to determine the factors were sourced from CalSim3 results published by DWR and include return flows resulting from both agricultural and municipal water uses sourced from surface water natural flows, rediversions of previously stored water, and pumped groundwater.

All values in the Return Flows table are given as multipliers (i.e., a value of 0.6 means that the analysis will reduce demands in the given subwatershed in the given month by 40%). Demand values in the analysis are adjusted by multiplying monthly direct diversion demand for a given water right or claim by the monthly factor for the appropriate subwatershed where it diverts; return flows are not applied to reduce demands for diversions to storage. Demand adjustments are done in the Final Demand tab of the spreadsheet (see next section).

Final Demand

This tab contains monthly demand data for water rights and claims in the Delta watershed, modified from the Demand tab (see previous section) to account for return flows and the distribution of demand to individual points of diversion (PODs). 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 record rather than each POD. While the data necessary to separate demands to each POD originated from the eWRIMS database, some staff judgement is required to develop the Direct and Storage 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 Return Flows tab of the spreadsheet. Each row quantifies monthly demands from a single water right or claim's POD. This tab also contains demands calculated for the user-specified period using daily averages multiplied by the number of days in each month that fall within the specified period (see Supply Forecast section).

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Application ID of the water right or claim, sourced from the Demand tab. Water rights or claims with multiple PODs are split into multiple rows, one for each POD.	eWRIMS database
Water Right Type	Water right or claim type, sourced from the Demand tab.	eWRIMS database w/ staff adjustments
Primary Owner	Name of the primary owner of the water right record.	eWRIMS database
POD ID	Unique numeric identifier for the POD.	eWRIMS database
Latitude/ Longitude	Latitude and longitude coordinates of the POD location (NAD83).	eWRIMS database
HUC8	The name of the Hydrologic Unit Code Level 8 watershed where demand from the POD. Water right or claim PODs are automatically assigned a HUC8 value in eWRIMS based on their location. HUC8 values for some PODs in the Upper Mokelumne, Middle San Joaquin-Lower Chowchilla, and Fresno River were manually assigned to other HUC8s so that PODs in these subwatersheds represent headwater demands that can only be met by local supply.	eWRIMS database, USGS WBD
Subwatershed	Subwatershed where demand from the POD is 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 that POD is located in the Legal Delta (TRUE/FALSE). Assigned in the eWRIMS database based on the location of the POD.	eWRIMS database w/ staff adjustments
Priority Date	The priority date of a water right or claim, sourced from the Assumed Priority Date field in the Demand tab (YYYY/MM/DD).	eWRIMS database w/ staff adjustments
Priority Year	The year of the priority date, sourced from the previous column. Riparian, Project, or Pending priorities are shown as such.	eWRIMS database w/ staff adjustments
Direct Weight	The percent of a given water right or claim's direct diversion demand which was assumed to occur from a given POD: - Direct Weight = (1 if an Active point of Direct Diversion, 0 if Inactive or Point of Rediversion) / (total number of Active Points of Diversion in the Delta watershed for the given record). - Equal to one for any records with only one POD. - Equal to zero for PODs associated only with storage (as long as the water right record has additional PODs associated with direct diversions). - The sum of Direct Weights for most water rights or claims is equal to one (see exception in Demand Comment column).	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Storage Weight	The percent of a given water right or claim's diversion to storage demand which was assumed to occur from a given POD: - Storage Weight = (1 if an Active point of Diversion to Storage, 0 if Inactive or Point of Rediversion) / (total number of Active Points of Diversion to Storage in the Delta watershed for the given record). - Equal to one for any records with only one POD. - Equal to zero for PODs associated only with direct diversions (as long as the water right record has additional PODs associated with storage). - The sum of Storage Weights for most water rights or claims is equal to one (see exception in Demand Comment column), regardless of whether they have reported diversions to storage.	Staff-determined
Demand Comment	Additional detail about the Direct or Storage Weights or other aspects of the demand: - POD(s) outside Delta watershed: The water right or claim has one or more associated PODs which divert from streams outside the Delta watershed (sum of Direct and/or Storage Weights is less than one). - Inactive: The POD is not actively used (Direct and Storage Weights are zero). - Rediversion: The POD does not divert natural flow (Direct and Storage Weights are zero). - Project: The water right is listed in Board Decision 1641 and its Priority Date is set to "Project." Indicates the associated project (e.g., Shasta).	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Storage Comment	The name of a storage reservoir that appears to be associated with a given POD, with terms like "Reservoir," "Lake," "Pond," or "Dam" removed.	eWRIMS database, staff-determined
2018/2019 Jan-Dec Direct/Storage (AF)	Monthly demands of a given water right or claim from a given POD for a given demand year for direct diversion. Calculated as follows: (Application ID Demand for month of demand year, sourced from Demand tab) * (Return Flow Factor for subwatershed and month, sourced from Return Flows tab) * (Direct Weight)	Calculated
2018/2019 Jan-Dec Storage (AF)	Monthly demands of a given water right or claim from a given POD for a given demand year for storage. Calculated as follows: (Application ID Demand for month of demand year, sourced from Demand tab) * (Storage Weight)	Calculated
2018/2019 Period Direct/Storage/ Demand (AF)	Monthly demands (direct, storage, or the sum of both) of a given water right or claim POD for a given demand year for the user-specified period in the Supply Forecast tab, calculated based on a daily average for each month and the number of days in each month that fall within the period.	Calculated
Selected Period Demand (AF)	Monthly demand based on the user-specified Demand Scenario for the user-specified Demand Year for a given water right or claim POD over the user-specified period.	Calculated

Headwaters

This tab contains tabular water unavailability analyses for the 17 headwater subwatersheds in the Delta watershed. In each, forecasted water supplies are used to determine water unavailability for each water right or claim in order of priority date. Rights or claims which are not expected to have water available to meet their demands

due to limited local supplies are flagged for the potential receipt of a notice of water unavailability or curtailment order based on the Headwater Subwatershed-scale analysis, and these unmet demands are excluded from the Watershed-scale analysis (see next section). If the Headwaters Analysis indicates that any Riparian claims of right (senior demands) would face water unavailability, supplies and demands from that subwatershed are excluded from its respective Watershed analysis (see calculations in Final Supply section). 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 and claims listed in the Final Demand tab of the spreadsheet are grouped by subwatershed.
2. Any rights or claims 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, Mokelumne River, and Cosumnes River headwater subwatersheds. Water unavailability for these rights or claims is only analyzed in the Watershed analyses, 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 records (i.e., with the same Application ID, Subwatershed, and Legal Delta? values) are merged; this occurs for any records with multiple PODs in the same subwatershed. All Riparian-priority claims in each subwatershed are also merged since water unavailability is not determined for individual Riparian-priority claims; they are merged into two distinct categories based on their Water Right Type.
4. Any records with total Direct and Storage Weight (see Final Demand section) sums of zero for the given Application ID, Subwatershed, and Legal Delta? values (i.e., with only inactive PODs or points of rediversion in the given area) are removed to ensure that water availability for these rights or claims is analyzed only based on where they divert natural flow (in the Headwater Subwatershed-scale analysis this does not affect any rights or claims).
5. Rights and claims in each subwatershed are sorted by priority date, with the most senior rights or claims first: Riparian, Pre-1914 Appropriative, Appropriative, Project, and Pending (see the description of Assumed Priority Dates for certain Statements in the Demand section). 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.
6. For each right or claim in a subwatershed, each of the following parameters is calculated or determined: demand, cumulative supply available, water

unavailability (i.e., will this right or claim potentially receive a notice of water unavailability or curtailment order?), demand met, and demand unmet. Demands are calculated, and thus water unavailability is evaluated, only for the user-specified time period in the Supply Forecast tab.

This tab is grouped into seventeen tables separated by black rows. Each contains the analysis for a headwater subwatershed: Sacramento River above Bend, Stony Creek, Cache Creek, Upper Feather River, Yuba River, Bear River, Upper American River, Putah Creek, Chowchilla River, Upper San Joaquin River, Fresno River, Merced River, Tuolumne River, Stanislaus River, Calaveras River, Mokelumne River, and Cosumnes River.

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 Final Demand tab.	USGS WBD
Subwatershed	Smallest area over which water unavailability is determined, based on one or more HUC8s. This tab contains data for only headwater subwatersheds (see Subwatersheds tab), sourced from the Final Demand tab.	Staff-determined
Application ID	Application ID of a given water right or claim, sourced from the Final Demand tab. Any duplicate Application IDs in a single subwatershed are merged.	eWRIMS database
Primary Owner	Name of the primary owner of the water right or claim, sourced from the Demand tab.	eWRIMS database
Water Right Type	Water right or claim type, sourced from the Demand tab.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Priority Date	The priority date of a water right or claim, sourced from the Assumed Priority Date field in the Demand tab (YYYY/MM/DD). Statements with "Riparian" priority are grouped together as two demands (either Riparian-only or "Riparian or Pre-1914" and Other) at the top of each subwatershed, both of which are assumed to have equal senior priority. With the exception of 2 New Melones water rights, Project rights listed in Board Decision 1641 are denoted as "Project" priority and are assumed to be junior to other appropriative demands. Statements with "Pending" priority are assumed to be junior to all other water rights and claims and are listed at the bottom of each subwatershed.	eWRIMS database w/ staff adjustments
Demand (AF)	Demands by a given water right or claim in the respective subwatershed for the user-specified Demand Year over the user-specified time period in the Supply Forecast tab, summed from the Selected Period Demand column of the Final Demand tab. Excludes any demands in the Legal Delta.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Supply Cumulative (AF)	Available supply to meet a given water right or claim's Demand over the user-specified time period based on the user-specified Forecast Source. Calculated as follows: - For the first group of Riparian-only claims in each subwatershed, equal to the subwatershed's Selected Supply Forecast value from the first table in the Final Supply tab. - For the next water right or claim, the Supply Cumulative available to the previous right or claim minus the previous right or claim's Demand Potentially Met in Subwatershed (see below). - Continued for each next junior water right or claim, until all Demands are accounted for or there is no remaining water supply available.	CNRFC, B-120, staff estimates
Water Unavailable in Headwater Subwatershed?	If water is anticipated to be unavailable to a given water right or claim for the user-specified time period (TRUE/FALSE). Water is only considered unavailable if Supply Cumulative is zero (i.e., water is available even if only a portion of demand can be met by available supply). These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Demand Potentially Met in Subwatershed (AF)	Amount of a given right or claim's Demand which can be met by available supply over the user-specified time period, calculated as follows: - If Supply Cumulative > Demand, equal to Demand. - If 0 < Supply Cumulative < Demand, equal to Supply Cumulative (i.e., only a portion of Demand can be met). - If Supply Cumulative = 0, equal to zero (i.e., Water Unavailable in Subwatershed).	Calculated
Demand Unmet in Subwatershed (AF)	Amount of a given right or claim's Demand which cannot be met by available water supply over the user-specified time period, calculated as follows: - If Demand Potentially Met = Demand, equal to zero. - If Demand Potentially Met < Demand, equal to Demand - Demand Potentially Met in Subwatershed. - If Demand Potentially Met in Subwatershed = 0, equal to Demand.	Calculated

Watersheds

This tab contains tabular water unavailability analyses for the Sacramento and San Joaquin River watersheds. In each watershed, total forecasted supplies are used to determine water unavailability for each right or claim 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 in the Legal Delta. Rights or claims which are not expected to have water available to meet their demands are flagged for the potential receipt of a notice of water unavailability or curtailment order based on the Watershed-scale analysis. This is in addition to those flagged for potential receipt of a notice of water unavailability or curtailment order based on the Headwater Subwatershed-scale 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 or claims further downstream in the watershed. Headwater subwatersheds where not all senior demands (Riparian priority) can be met by available supplies have their FNF supplies

and demands removed from the Watershed Analysis (see Final Supply and Headwaters sections).

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

1. The water rights and claims listed in the Final Demand tab of the spreadsheet are grouped by watershed. Rights or claims in the Legal Delta (Legal Delta? = TRUE), with the exception of Riparian-only claims (Water Right Type = Statement of Div and Use (Riparian)), are present in both watersheds so that they can be prorated to each based on available supplies.
2. Any duplicate records (i.e., with the same Application ID, Subwatershed, Watershed, and Legal Delta? values) are merged; this occurs for any records with multiple PODs in the same subwatershed. All Riparian-priority claims in each watershed are also merged since water unavailability is not determined for individual Riparian-priority claims; they are merged into four distinct categories based on their Water Right Type and location outside or within the Legal Delta.
3. Any records with total Direct and Storage Weight (see Final Demand section) sums of zero for the given Application ID, Subwatershed, and Legal Delta? value (i.e., with only inactive PODs or points of rediversion in the given area) are removed to ensure that water availability for these rights or claims is analyzed only based on where they divert natural flow. In the Watershed-scale analysis this affects only four rights owned by the U.S. Bureau of Reclamation for Black Butte Reservoir on Stony Creek, New Melones Reservoir on the Stanislaus River, and Hensley Lake on the Fresno River.
4. Rights and claims in each watershed are sorted by priority date, with the most senior rights or claims first: Riparian, Pre-1914 Appropriative, Appropriative, Project, and Pending (see the description of Assumed Priority Dates for certain Statements in the Demand section). 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. For each right or claim in 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 unavailability (i.e., will this right or claim potentially receive a notice of water unavailability or curtailment order?), demand met, and demand unmet. Demands are calculated, and thus water unavailability is evaluated, only for the user-specified time period in the Supply Forecast tab.

This tab is grouped into two tables separated by black rows, one for each watershed (Sacramento and San Joaquin).

NOTE: Though this tab evaluates water unavailability for any user-specified time period entered in the Supply Forecast tab, water unavailability analyses for the purpose of

issuing curtailments in the Legal Delta will not be performed on a timestep any shorter than one month.

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 Final Demand tab. Legal Delta demands (Legal Delta? = TRUE, with the exception of Water Right Type = Statement of Div and Use (Riparian)) are present in both watersheds, with their demands prorated between them.	USGS WBD
Subwatershed	Smallest area over which water unavailability is determined, based on one or more HUC8s. Sourced from the Final Demand tab.	Staff-determined
Application ID	Application ID of a given water right or claim, sourced from the Final Demand tab. Any duplicate Application IDs in a single subwatershed with the same Legal Delta? value are merged.	eWRIMS database
Primary Owner	Name of the primary owner of the water right or claim, sourced from the Demand tab.	eWRIMS database
Water Right Type	Water right or claim type, sourced from the Demand tab.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Priority Date	The priority date of a water right or claim, sourced from the Assumed Priority Date field in the Demand tab (YYYY/MM/DD). Statements with "Riparian" priority are grouped together as four demands (Riparian-only or "Riparian or Pre-1914" and Other, either within or outside of the Legal Delta) at the top of each watershed, all of which are assumed to have equal senior priority. With the exception of two New Melones water rights, Project rights listed in Board Decision 1641 are denoted as "Project" priority and are assumed to be junior to other appropriative demands. Statements with "Pending" priority are assumed to be junior to all other water rights and claims and are listed at the bottom of each watershed.	eWRIMS database w/ staff adjustments
Legal Delta?	If demand for that row occurs in the Legal Delta (TRUE/FALSE), sourced from the Final Demand tab. Each water right or claim located in the Legal Delta (with the exception of Water Right Type = Statement of Div and Use (Riparian)) is present in both the Sacramento and San Joaquin Watershed Analyses.	eWRIMS database
Headwater Subwatershed?	If demand for that row occurs in a headwater subwatershed (TRUE/FALSE), sourced from the Subwatersheds tab based on the Subwatershed value.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Demand (AF)	Demands by a given water right or claim in the respective subwatershed for the user-specified Demand Year over the user-specified time period in the Supply Forecast tab, summed from the Final Demand tab. If the right or claim is located in the Legal Delta (Legal Delta? = TRUE, with the exception of Water Right Type = Statement of Div and Use (Riparian)), the demand is multiplied by the respective watershed's supply ratio (see Total Supply values in the second table in the Final Supply tab) in order to prorate these demands between both watersheds.	eWRIMS database w/ staff adjustments
Water Unavailable in Headwater Subwatershed?	If water is anticipated to be unavailable in a headwater subwatershed (TRUE/FALSE): - If located in a headwater subwatershed and outside the Legal Delta, equal to the Water Unavailable in Subwatershed? value in the Headwaters tab for the respective right or claim. - FALSE if located in a lower subwatershed and/or in the Legal Delta. These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Demand Potentially Met in Subwatershed (AF)	Demand by a given water right or claim which could be met by available supply in the respective subwatershed: - If supply is less than the total demand of Riparian-priority Statements in the given headwater subwatershed (see Disconnected? value in the second table in the Final Supply tab), equal to zero. - If located in a headwater subwatershed and outside the Legal Delta, equal to the Demand Potentially Met in Subwatershed value in the Headwaters tab for the respective right or claim. - If located in a lower subwatershed and/or in the Legal Delta, equal to Demand.	Calculated

Field Name(s)	Definition & Methodology	Data Source(s)
Supply Cumulative (AF)	Available supply to meet a given water right or claim's Demand Potentially Met in Subwatershed over the user-specified time period based on the user-specified Forecast Source. Calculated as follows: - For the first group of Riparian-only claims outside the Legal Delta in each watershed, equal to the watershed's Total Supply value minus its Instream Flow in Excess of Supply value from the second table in the Final Supply tab. - For the second group of claims, the previous group's Supply Cumulative minus the previous group's Demand Met in Watershed (see below). - For the third group of "Riparian or Pre-1914" or Other claims outside the Legal Delta, the previous Supply Cumulative minus the previous Demand Met in Watershed plus the watershed's Instream Flow in Excess of Supply value from the second table in the Final Supply tab. - For the fourth group of claims, the previous Supply Cumulative minus the previous Demand Met in Watershed. - Continued for each next junior water right or claim until all Demands are accounted for or Supply Cumulative is zero.	CNRFC, B-120, staff estimates
Water Unavailable in Watershed?	If water is anticipated to be unavailable to a given water right or claim for the user-specified time period (TRUE/FALSE). Water is only considered unavailable if Supply Cumulative is zero (i.e., water is available even if only a portion of demand can be met by available supply). Subwatersheds where Riparian-priority demand exceeds supply (see Disconnected? value in the second table in the Final Supply tab) are marked as "FALSE." These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Demand Met in Watershed (AF)	Amount of a given right or claim's Demand Potentially Met in Subwatershed which can be met by available supply in the watershed, calculated as follows: - If Supply Cumulative > Demand Potentially Met in Subwatershed, equal to Demand Potentially Met in Subwatershed. - If 0 < Supply Cumulative < Demand Potentially Met in Subwatershed, equal to Supply Cumulative (i.e., only a portion of Demand can be met). - If Supply Cumulative = 0, equal to zero (i.e., Water Unavailable in Watershed).	Calculated
Demand Unmet in Watershed (AF)	Amount of a given right or claim's Demand which can be physically met by local supply but is unavailable, calculated as follows: - If Demand Met = Demand Potentially Met in Subwatershed, equal to zero. - If Demand Met < Demand Potentially Met in Subwatershed, equal to Demand Potentially Met in Subwatershed - Demand Met. - If Demand Met = 0, equal to Demand Potentially Met in Subwatershed.	Calculated
Water Unavailable?	If water is anticipated to be unavailable to the given water right or claim over the user-specified time period either in the Headwater Subwatershed-scale analysis (Water Unavailable in Subwatershed?) and/or the Watershed-scale analysis (Water Unavailable in Watershed?) (i.e., will this right or claim potentially receive a notice of water unavailability or curtailment order?). These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Legal Delta

This tab contains information on water rights and claims located in the Legal Delta. Because these rights and claims are assumed to have access to supplies from both the Sacramento and San Joaquin Rivers to meet their demands (see Demand column in Watersheds section), this tab quantifies total demands and demands met from each watershed to identify which rights or claims may potentially receive notices of water unavailability or curtailment orders. Riparian-priority claims in the Legal Delta are merged into two rows (one for Riparian-only claims, one for "Riparian or Pre-1914" and Other claims) since water unavailability is not determined for individual Riparian-priority claims. 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 demand proration between watersheds.

Water rights or claims in the Legal Delta will only face water unavailability if water is unavailable from both watersheds. This tab does not contain any new analysis, it only compiles values from the Watersheds tab for rights or claims located in the Legal Delta (Legal Delta? = TRUE in the Final Demand tab). Duplicate rights are merged in this tab, so each row represents a single water right's total demand. Water rights that have PODs both within and outside the Legal Delta are not included in this tab because they will only face water unavailability if water is unavailable from all potential sources; these rights can be found in the Curtailments tab (see next section).

NOTE: Though this tab evaluates water unavailability for any user-specified time period entered in the Supply Forecast tab, water unavailability analyses for the purpose of issuing curtailments in the Legal Delta will not be performed on a timestep any shorter than one month.

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Application ID of a given water right or claim, sourced from the Final Demand tab.	eWRIMS database
Primary Owner	Name of the primary owner of the water right or claim, sourced from the Demand tab.	eWRIMS database
Water Right Type	Water right or claim type, sourced from the Demand tab.	eWRIMS database w/ staff adjustments

Field Name(s)	Definition & Methodology	Data Source(s)
Priority Date	The priority date of a water right or claim, sourced from the Assumed Priority Date field in the Demand tab (YYYY/MM/DD).	eWRIMS database w/ staff adjustments
Sacramento/ San Joaquin Demand (AF)	Demands by a given water right or claim in the respective watershed for the user-specified Demand Year over the user-specified time period, sourced from the Demand column of the Watersheds tab.	eWRIMS database w/ staff adjustments
Sacramento/ San Joaquin Supply (AF)	Water supply available to a given water right or claim in the respective watershed over the user-specified time period based on the user-specified Forecast Source, sourced from the Supply Cumulative column of the Watersheds tab.	Staff-determined
Water Unavailable in Sacramento/ San Joaquin?	If the water right or claim is anticipated to face water unavailability from the respective watershed, sourced from the Water Unavailable in Watershed? Column of the Watersheds tab. These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined
Sacramento/ San Joaquin Demand Met (AF)	Amount of a given right or claim's Demand in the respective watershed which can be met by available supplies, sourced from the Watersheds tab.	Staff-determined
Water Unavailable?	If the water right or claim is anticipated to face water unavailability in both the Sacramento and San Joaquin River watersheds over the user-specified time period (i.e., will this right or claim potentially receive a notice of water unavailability or curtailment order based on the Watershed-scale analysis?). These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Curtailments

This tab contains information on the potential curtailment status of all water rights and claims in the Delta watershed. It does not contain any new analysis, it only compiles values from the Watersheds tab to determine which rights or claims face water unavailability over the user-specified time period in the Supply Forecast tab. Information presented for each right or claim includes ownership, location, total demands, and potential curtailment status based on either Headwater Subwatershed or Watershed-scale water unavailability. Rights and claims only face unavailability if there is zero supply available to meet their demands (either based on local supply in the Headwater Subwatershed-scale analysis or watershed-wide conditions in the Watershed-scale analysis). Any rights with multiple PODs are merged into single rows in this tab, including rights and claims in the Legal Delta that are assumed to have access to supplies from both the Sacramento and San Joaquin River watersheds or any other rights or claims with PODs in multiple subwatersheds that are assumed to have access to water from all of them (with the exception of subwatersheds with zero demand, as described in the Headwaters and Watersheds sections). These rights and claims will only face water unavailability if water is unavailable from all potential water sources (i.e., all subwatersheds where demands occur or both the Sacramento and San Joaquin River watersheds).

NOTE: Though this tab contains water unavailability determinations for any user-specified time period entered in the Supply Forecast tab, water unavailability analyses for the purpose of issuing curtailments in the Legal Delta will not be performed on a timestep any shorter than one month.

Field Name(s)	Definition & Methodology	Data Source(s)
Application ID	Application ID of a given water right or claim, sourced from the Final Demand tab.	eWRIMS database
Primary Owner	Name of the primary owner of the water right or claim, sourced from the Demand tab.	eWRIMS database
Water Right Type	Water right or claim type, sourced from the Demand tab.	eWRIMS database w/ staff adjustments
Priority Date	The priority date of a water right or claim, sourced from the Assumed Priority Date field in the Demand tab (YYYY/MM/DD.	eWRIMS database w/ staff adjustments

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 Final Demand tab; water rights with multiple PODs that fall in both watersheds are denoted as "Both."	USGS WBD
Subwatershed	Smallest area over which water unavailability is determined, based on one or more HUC8s. Sourced from the Final Demand tab; water rights with PODs in multiple subwatersheds are denoted as "Multiple."	Staff-determined
Legal Delta?	If demand for that row occurs in the Legal Delta (TRUE/FALSE), sourced from the Final Demand tab; water rights with multiple PODs both within and outside the Legal Delta are denoted as "Partial."	eWRIMS database w/ staff adjustments
Demand (AF)	Total demands by a given water right or claim for the user-specified Demand Year over the user-specified time period, sourced from the Watersheds tab.	eWRIMS database w/ staff adjustments
Demand Met (AF)	Amount of each right or claim's Demand which can be met by available supply, sourced from the Demand Met in Watershed column in the Watersheds tab. NOTE: This column does not compute partially met demands for Riparian-priority claims; these claims will either appear as having all of their demand met (if some supply is available) or having zero demand met (if there is zero supply available in their respective subwatershed or watershed).	

Field Name(s)	Definition & Methodology	Data Source(s)
Water Unavailable in Subwatershed?	If the water right or claim is anticipated to face water unavailability due to limited local supplies, as evaluated in the Headwater Subwatershed-scale analysis. Sourced from the Water Unavailable in Subwatershed? column of the Watersheds tab; will only equal TRUE if there is zero supply available at a given record's priority of right. Riparian claims will only equal TRUE if zero supply is available in their respective subwatershed. Rights or claims in the Legal Delta or rights with PODs in multiple subwatersheds will only equal TRUE if water is unavailable from all potential sources. These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined
Water Unavailable in Watershed?	If the water right or claim is anticipated to face water unavailability due to limited supplies in its respective watershed, as evaluated in the Watershed-scale analysis. Sourced from the Water Unavailable in Watershed? Column of the Watersheds tab; will only equal TRUE if there is zero supply available at a given record's priority of right. Riparian claims will only equal TRUE if zero supply is available in their respective watershed. Rights or claims in the Legal Delta or rights with PODs in multiple subwatersheds will only equal TRUE if water is unavailable from all potential sources. These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined

Field Name(s)	Definition & Methodology	Data Source(s)
Water Unavailable?	If the water right or claim is anticipated to face water unavailability from all potential sources due to insufficient supplies in the Headwater Subwatershed-scale analysis and/or the Watershed-scale analysis (i.e., will this right or claim potentially receive a notice of water unavailability or curtailment order?). These cells have conditional formatting to highlight red if water is unavailable for a given right or claim.	Staff-determined
Curtailment Status	If the water right or claim is curtailed for the user-specified time period. Depending on discretion exercised by the Deputy Director for Water Rights in the issuance of curtailments, this value may be based on the Water Unavailable in Headwater Subwatershed?, Water Unavailable in Watershed?, or Water Unavailable? value (TRUE = Curtailed, FALSE = Not Curtailed) and may be based on additional criteria. Certain types of water rights may have a more specific status: - Pending Statements are marked as "Not Authorized to Divert" at all times. - Cannabis Registration rights are marked as "Not Authorized to Divert" if the user-specified time period (based on the Start Date in the Supply Forecast tab) is during the dry season forbearance period of April 1-October 31.	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 Resources Control Board (State Water Board or 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 Board's 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).[1] The eWRIMS database system can be accessed at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/

[1] Watermasters may report the diversion and use of water within their areas of oversight to the Board via various means other than the eWRIMS RMS; as a result, this data is not currently incorporated into the eWRIMS database except to the extent that individual diverters may have also reported their diversions to the Board via the eWRIMS RMS. Data from watermaster reports may be incorporated into the demand dataset in the future after assessment of the extent of duplicative reporting between the reports and the eWRIMS database.

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. The current copy of the eWRIMS datasets were downloaded on October 6, 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[2] 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 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:

- Active
- 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.

[2] The beneficial uses of water pertaining to water rights are defined in the California Code of Regulations, title 23, §§ 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.

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 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 Number	HUC4 Name
1802	Sacramento
1804	San Joaquin

A small number of water right records are missing latitude and longitude information for their associated POD and were not captured by the geographic selection. A limited number of records were updated with spatial information prior to the October 6, 2021 update that had previously been excluded from the Delta Watershed selection.

Identification of Non-Consumptive Water Right Records in the Delta Watershed

Water right records that contain only the following non-consumptive beneficial use types and combinations were identified:

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

In previous iterations of the demand dataset, all water right records with the above beneficial use types were excluded. However, water right records with the above beneficial use types have been incorporated into the demand dataset as a wet season adjustment (discussed further below under *Wet Season Demand Adjustments*). 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. However, non-consumptive water right records that divert water to storage during the wet season can make water unavailable for other users within a month.

A small number of water right records did not contain beneficial use information in the eWRIMS flat files. These water right records were included in the demand dataset. However, many of these were identified as 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
- Section 12 File
- Temporary Permit
- Registration Cannabis
- Registration Domestic
- Registration Irrigation
- Registration Livestock
- Federal Claims
- Federal Stockponds
- Stockpond

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. The diversion demands from Appropriative water rights and Statements of Diversion and Use claims are included in the analysis. Other water right types (e.g., registrations, stockponds) are included in the issuance of notices of water unavailability and curtailment orders in keeping with the principles of the water rights priority system, but their demand values are set to zero.

By limiting the demand analysis to Appropriative water rights and Statements of Diversion and Use, minor water right types such as Stockponds, Registrations, Temporary Permits, and other types of water right records were 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 from the analysis 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 Appropriative water rights and Statements of Diversion and Use claims in the demand dataset after initial selection[3] were subdivided to approximately 580 water right records that include the largest consumptive diversions in

[3] Approximately 500 Statements of Diversion and Use and Appropriative water rights with solely non-consumptive beneficial use types were excluded from the initial selection but have now been incorporated into the demand dataset as discussed under *Wet Season Demand Adjustments*.

the Delta watershed. Criteria used to identify this selection of water right records include:

- 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 approximately 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 classified 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.

Originally, these records were removed entirely from the demand dataset. However, the current version of the demand dataset retains these records. For these records, the amount directly diverted is set to zero and the amount diverted to storage was left unchanged in 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 indicate 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 (e.g., diverting 1,000 gallons but reporting having diverted 1,000 acre-feet). 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 these records was conducted. In these cases, the reported diversion amounts within the demand dataset were updated to equal the face value of the water right.

Wet Season Demand Adjustments

Water right records identified as non-consumptive based on their beneficial use type (e.g., power only) were previously excluded from the demand dataset. During the dry season, these non-consumptive uses of water do not typically significantly alter the timing of flows or change the amount of water available downstream. However, during the wet season, water right records with non-consumptive beneficial use types can significantly alter the timing of flows when water is diverted to storage. These diversions can make water unavailable for diversion by other users within a month.

Accordingly, the demand dataset has been adjusted to incorporate the approximately 500 Appropriative water rights and Statements of Diversion and Use with non-consumptive beneficial use types that were previously excluded from the demand dataset. For these records, the direct diversion values contained in the demand dataset were set to zero and the diversion values for these records effectively reflect only diversion to storage volumes. Each water right record in the Delta watershed demand dataset consists of a direct and a storage diversion component. The direct diversion component of a water right with non-consumptive beneficial uses is not considered consumptive use and is excluded from the demand dataset by setting the direct

diversion component to zero. The diversion to storage component is included in the demand dataset.

A wet season adjustment quality control review effort was conducted following selection of these additional water right records. For this quality control review, Appropriative water rights and Statements of Diversion and Use with a reported diversion to storage volume of 5,000 AF or greater in either 2018 or 2019 were selected. Approximately 75 records were included in this quality control review effort. The 2018 and 2019 annual reports of water diversion and use for these records were reviewed to identify and correct potential inaccuracies in the diversion to storage data, such as diversion data entry and reporting issues.

In addition, this quality control review addressed occurrences of duplicative reporting of diversions to storage under overlapping consumptive and non-consumptive use rights. When identical diversion to storage volumes were reported for consumptive and non-consumptive water right records held by the same primary owner and associated with the same location, the reported diversion to storage volumes were assumed to be duplicative and the demand value for the non-consumptive water right record was changed to zero. Staff also reviewed information regarding overlapping reporting between consumptive and non-consumptive water right records submitted in the September 2021 Enhanced Reporting Forms[4], which were required pursuant to the emergency regulation. Staff's review of information regarding overlapping water rights and claims contained in the September 2021 Enhanced Reporting Forms identified additional occurrences of overlapping reporting of diversions under consumptive and non-consumptive water right records. In these cases, the demand value for the non-consumptive water right record was changed to zero.

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 and the further use of this data are described in Appendix A.

[4] The August 20, 2021 curtailment and reporting orders require monthly reporting of water diversion and use for water rights and claims in the Delta watershed that have a face value or recent annual reported diversion volume of 5,000 acre-feet or greater. For these water rights and claims, diverters are required to provide monthly reports of water diversion and use information for prior months of the current year and monthly reporting of projected water demand by completing the Delta Watershed Enhanced Reporting of Actual Diversions and Projected Demand Form (Enhanced Reporting Form).

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 (approximately 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 October 6, 2021 copy of the eWRIMS datasets to produce a demand dataset that reflects updates to eWRIMS database information that occurred between January 15 and October 6, 2021. For example, a small number of diverters submitted new or revised 2018 or 2019 annual reports between January 15 and October 6, 2021. These new or revised diversion values were incorporated into the demand dataset. In addition, several 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 October 6, 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 using multiple data fields contained within the eWRIMS flat files:

- The Priority Date for the Appropriative, Federal Claims, Cannabis Registration, Domestic Registration, Irrigation Registration, Livestock Registration, Federal Stockponds, and Temporary Permit 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 or were assigned a "project" designation.

- The Priority Date for the Section 12 water right type was copied from the 'Priority Date' field in the eWRIMS database.
- 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" or "Pending" 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. Statements of Diversion and Use categorized as 'Pre-1914' or 'Unclassified' with 'year diversion first commenced' values greater than 1914 were assigned a priority datetime with a date of 1914/01/01 and a time stamp between 00:00 and 23:59 scaled according to the relative position of the 'year diversion first commenced' value between 1914 and 2022.The Priority Date for Federal Claims was based on the 'year diversion first commenced' if the 'year diversion first commenced' was prior to 1914. Otherwise, the Priority Date 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 Stockpond Certificates was based on the 'Application Acceptance Date' or 'Application Received Date' if the earlier of these dates was after the year 1977. Otherwise, the priority date was based on the 'year diversion first commenced' field.

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 direct diversion and monthly direct diversion amounts for both 2018 and 2019 and total annual storage diversion and monthly storage diversion amounts for both 2018 and 2019. Previous versions of the demand dataset included monthly and annual total diversion amounts for each record that combined the direct diversion and diversion to storage amounts (discussed further under *Disaggregation of Demand Data: Total Diversions to Direct Diversions and Diversions to Storage*). Some water right records divert from multiple PODs 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 Final Demand 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 (Supplemental 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 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 or 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 or 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. **Non-Demand** – 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 or Pre-1914' category contain keywords for both the Riparian and Pre-1914 categories.

Priority dates were assigned to each record in the 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. For the purposes of evaluating water unavailability, Statements of Diversion and Use in the 'Riparian or Pre-1914' category are assigned a non-priority date value of "Riparian" and are assumed to have senior priority over all appropriative water rights.[5] Statements in the Riparian and Other categories are similarly assigned a "Riparian" priority and assumed to all have equal senior priority. Statements of Diversion and Use in the "Pending" category are assigned a "Pending" priority and are assumed to be junior in priority to all other water rights and demands in the Delta watershed.

Disaggregation of Reported Diversions: Total Diversions split into Direct Diversions and Diversions to Storage

Rather than combine the direct and storage diversion values into a single total diversion value, the current version of the demand dataset includes monthly and annual amounts for both direct diversions and diversions to storage for each Application ID using the "DIRECT" and "STORAGE" diversion values reported in the eWRIMS Annual Water Use Report Flat File. Prior versions of the demand dataset summed these monthly values to produce a single set of monthly and annual diversion amounts for each Application ID.

A quality control review effort of disaggregated reported diversions was conducted, with a focus on the water right records for which a correction to the total diversion amount was previously applied and with both direct diversion and diversion to storage amounts reported in 2018. Approximately 200 records were included in this supplemental quality control review effort. For these records, the 2018 and 2019 annual reports were reviewed and appropriate adjustments to the direct diversion and diversion to storage amounts were applied.

[5] 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 regarding the Water Unavailability Methodology that were received prior to the release of the July 23, 2021 version of the report that was incorporated by reference into the emergency regulation, as well as the section of the July 23, 2021 version 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

Technical Appendix D: Assessment of Water Unavailability Issues Within the Legal Delta

This appendix provides additional background information used to evaluate water unavailability in the Legal Delta portion of the Sacramento-San Joaquin Delta (Delta) Watershed.

Introduction

The evaluation of water unavailability for diversion in the Legal Delta is complex due to a number of factors, including (1) the considerations of tidal influence on freshwater residence time and location in the Legal Delta and on water quality (e.g., its suitability for agricultural use), (2) the operations of the State Water Project (SWP) and Central Valley Project (CVP) (collectively the Projects) that release previously stored water from upstream reservoirs for use upstream and in the Legal Delta, over which water they retain claim and control for various beneficial uses, and (3) depletions of water in the Legal Delta due to evaporation from open water and transpiration of aquatic, riparian, and irrigated vegetation, which there are challenges measuring and estimating.

Notwithstanding the inherent challenges of administering the water rights system within those complex circumstances, the Division of Water Rights (Division) has continued to seek and accept input on how to refine the Water Unavailability Methodology for the Delta Watershed (Methodology) and to apply the Methodology within the Legal Delta. While those efforts to refine and fairly apply the Methodology will continue, as authorized under the drought emergency regulations currently in place and proposed for readoption, this revised appendix provides the latest and refined response to feedback and suggested improvements of the Methodology as applied within the Legal Delta.

In evaluating valuable critiques of the Methodology, the State Water Resources Control Board (State Water Board or Board) recognizes that not all challenges in application can be resolved based on currently available data. The State Water Board is also continuing to support long-term initiatives to improve Legal Delta water use data to address lingering drought response challenges. Under current circumstances of persistent drought within the Delta watershed, however, this appendix is appropriate to support implementation of the drought emergency regulations.

Since the beginning of June 2022, the Projects have been required to release previously stored water to meet water quality objectives in the Legal Delta. Based on

current and forecasted drought, precipitation, and storage conditions, such storage releases are expected to be necessary through at least the remainder of the current water year (through September 30, 2022) to maintain water quality in the Delta as required by State Water Board Decision 1641 (D-1641). Thus, it is vital to protect such storage releases from unlawful, unreasonable, or out-of-priority diversions that would interfere with protecting water quality in the Delta. The Methodology supports significantly deeper curtailments within the Delta watershed starting in July of 2022, not only to protect water quality but also to fairly administer the water rights priority system and the correlative shortage-sharing required among riparian claimants.

The Methodology accounts only for freshwater natural flows from the Sacramento and San Joaquin watersheds as part of the considered supplies and excludes any water supplies from tidal inflows to the Delta. The reason for that exclusion, which has been challenged by numerous comments, is that saline water entering the Delta from the San Francisco Bay via tidal action is assumed to be of insufficient quality to be usable for agricultural or municipal purposes.

Although the drought emergency regulation allows for further refinement to the Methodology and, potentially, consistent refinements to this technical appendix, this revision supports use of the Methodology to address the continuing drought.

The Delta Watermaster will convene a meeting among parties who have offered both critiques of this appendix and suggestions for further refinements. The purpose of the meeting will be to consider implementation strategies that respond to the current drought and protect Delta water quality. The meeting is tentatively scheduled for July 14, 2022, so that any such strategies can be communicated and evaluated in conjunction with the State Water Board's consideration of the revised emergency regulation for readoption.

The analysis in this appendix has been updated from earlier versions in the following ways: (1) the Legal Delta consumptive use estimates have been updated to be consistent with the demands in the Methodology, including consistent return flow assumptions; (2) the natural and abandoned Legal Delta inflow has been updated to include forecasted data consistent with the information in the Methodology; and (3) other observed conditions have been updated to reflect conditions in 2022 where available.

Appropriate Use of Hydrodynamic Models

Hydrodynamic models may provide useful insights into the complex movement of water within the Legal Delta when appropriately applied and validated. However, hydrodynamic models do not provide a sufficient answer to the basic mass balance problem of water unavailability for diversion. Hydrodynamic models such as the Department of Water Resources (DWR) Delta Simulation Model II (DSM2) may provide

fingerprinting results showing that some water diverted in the Legal Delta entered the Legal Delta months prior; however, these results do not provide useful guidance on when water is available or not available for users to divert, which must be informed by mass balance accounting. Additionally, it is not feasible to complete hydrodynamic model simulations for every update of the forecasted hydrology and analyze the results for each of the thousands of water rights and specific points of diversion in the Legal Delta.

Residence Time

Simple flow volumes and estimates of residence times based on inflow that are applied broadly to the Legal Delta also may not provide a sufficient answer to inform determinations regarding water unavailability because they do not account for mixing from tidal action and consumptive water use within the Legal Delta. Mixing of water, particularly in Suisun Bay, makes the mixed water from that source too salty for beneficial use far earlier than simple residence times and fingerprinting may suggest because they may not correctly consider the effects of even small volumes of very saline water. For example, half of the water at a particular location could come from water that entered from the Sacramento River spanning several months, but if the other half came from Suisun Bay, with an electrical conductivity (EC) of 20,000 microsiemens per centimeter (µs/cm), the water would have an EC of just over 10,000 µs/cm and would be unusable for almost all purposes.

Fortunately, bathymetry data available as a result of recent improvements in digital elevation models (USGS 2017) can be used to better understand the effects of extremely low Delta outflow on water unavailability and water quality in the Legal Delta. To improve hydrodynamic models in the Delta, the U.S. Geological Survey (USGS) and Inter-Agency Ecological Program (IEP) sponsored the development of a 10-meter horizontal grid of bathymetry in the Legal Delta region (USGS 2007). The survey determined the volume and area for the various regions of the Legal Delta shown in Figure 1 below.

Figure 1. Map of Legal Delta Regions and Suisun Bay (USGS 2007), with D-1641 Delta Outflow Compliance Locations (red), Relevant CDEC Gages (blue), and Other Points of Interest Added

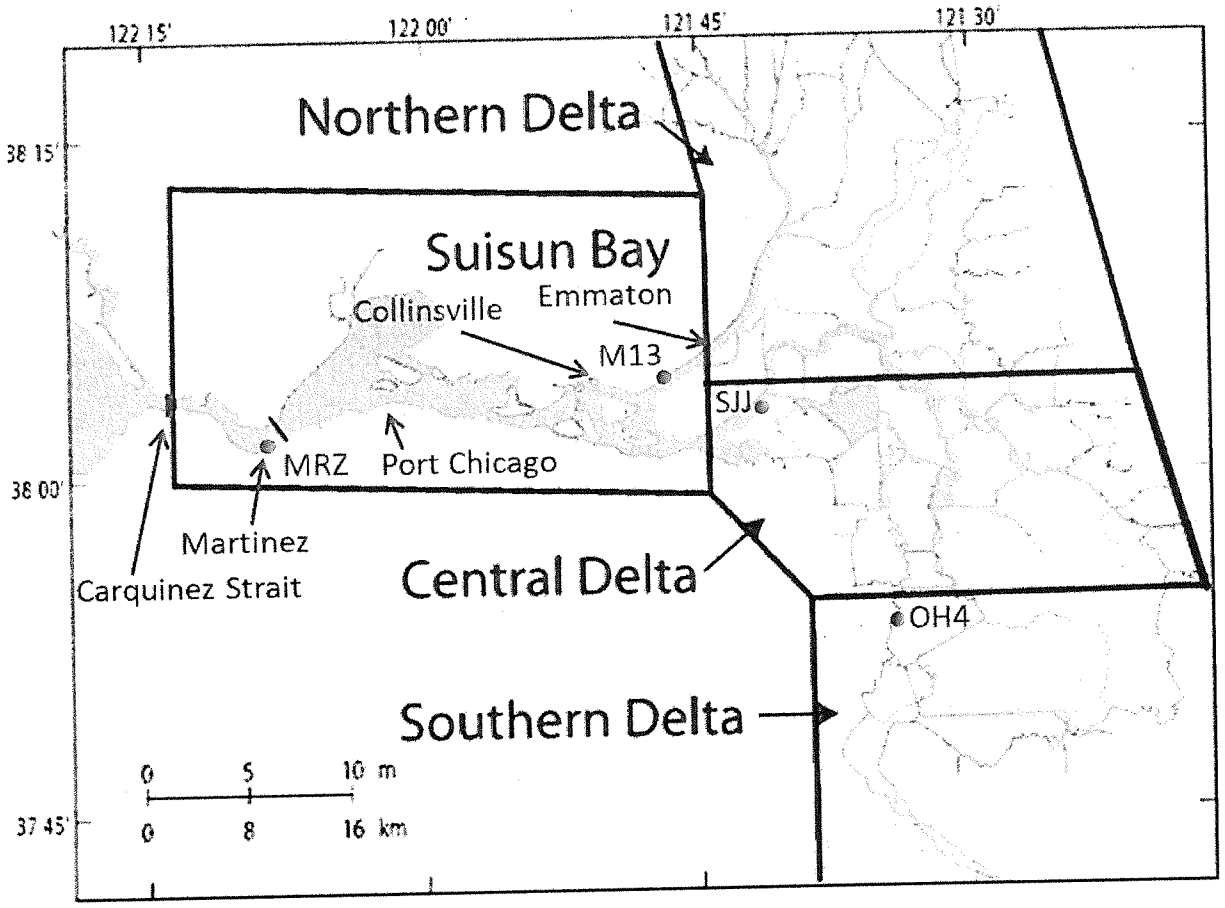


Table 1 contains the summary areas and volumes from the USGS report, with a conversion to volumes in thousand acre-feet (TAF). Table 1 also contains tidal flux volumes based on variable tidal ranges for the four regions from California Data Exchange Center (CDEC) river stage gages for July 2021. The tidal variation is greatest to the west in Suisun Bay and decreases in the Northern, Central, and Southern regions of the Legal Delta.

Table 1. Legal Delta and Suisun Bay Channel Volumes and Tidal Flux

Region	Water Surface Area (million meters^2)	Volume (million meters^3)	Water Surface Area (acres)	Volume (TAF)	Tidal Range (feet)	Tidal Flux* (TAF/day)	Tidal Mixing Time** (days)
Suisun Bay	165	954	40,772	773	3.6	297	2.6
Northern Delta	74	407	18,286	330	2.9	108	3.1
Central Delta	66	267	16,309	216	2.4	78	2.8
Southern Delta	10	28	2,471	23	2.4	12	2.0
Total	***316***	***1,656***	***78,085***	***1,343***		***494***	***2.7***
Total without Suisun Bay	***150***	***702***	***37,066***	***569***		***197***	***2.9***
Areas and volumes from USGS (2007).							
Tidal ranges from CDEC river stage data for gages MRZ, M13, SJJ, and OH4 (see Figure 1): https://cdec.water.ca.gov/dynamicapp/wsSensorData							

*Tidal flux is the volume of water exchanged each day, which is calculated by multiplying water surface area by the tidal range multiplied by the frequency (i.e., twice per day).
**The tidal mixing time is calculated by dividing the channel volume by the tidal flux.

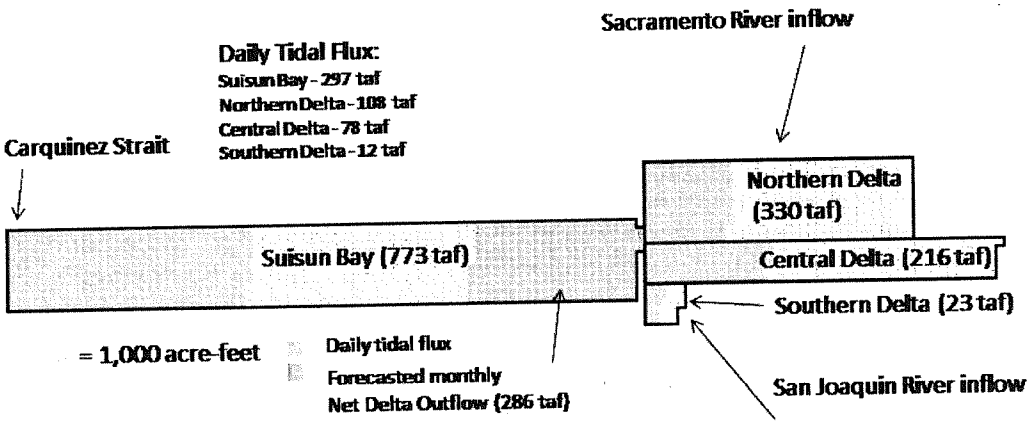
The Stockton and Sacramento Deep Water Ship Channels were deepened and widened for navigation, altering Delta hydrodynamics by increasing tidal flow volumes and therefore increasing seawater dispersion into the Delta (CCWD 2010). These large channels, not present in the early part of the century, are part of the reason that channel volumes are so much bigger in the Northern and Central Delta than the Southern Delta.

Table 1 may suggest, based on volume alone, that a pool of water in Suisun Bay and the Delta could provide a prolonged water supply in the Legal Delta. However, Table 1 also shows that an amount of water equal to the entire volume of Suisun Bay is exchanged by the tides over less than three days. Similarly, in each of the Legal Delta regions an amount of water greater than the total channel volume is exchanged by the tides every three days (less than two days in the Southern Delta). The large tidal influence greatly reduces the residence time of fresh water in the Legal Delta and the mixing has a large effect on the water quality (as discussed in the next section).

Figure 2 shows the four regions of the Legal Delta scaled according to their channel volumes. Superimposed on the graphic are scaled representation of each region's tidal flux and U.S. Bureau of Reclamation (Reclamation) forecasted net Delta outflow to Suisun Bay in July 2022 to maintain water quality; it is this positive net outflow that inhibits saltwater from flowing into the Delta. This schematic shows how large the daily tidal flux is in comparison to the volume of the regions of the Legal Delta. For example, the daily tidal flux in the Southern Delta is equal to approximately half its channel volume. Figure 2 makes three things visually clear:

1. The diurnal ebb and flow of the tides is overwhelmingly larger than the net freshwater outflow,
2. The tidal flux is significantly larger than the total volume of water in Suisun Bay and regions of the Legal Delta, and
3. The volume of water in Southern Delta channels is modest compared to the volume of water in Suisun Bay and other regions of the Legal Delta.

Figure 2. Schematic of Suisun Bay and Legal Delta Regions with Scaled Channel Volumes, Daily Tidal Flux, and Forecasted Net Delta Monthly Outflow, July 2022



Irrigated, riparian, and aquatic vegetation consumes a large volume of water from Delta channels. Consumptive use of water applied to crops in the Legal Delta can be estimated using the 2018 reports of diversion and use filed by diverters in the Legal Delta, as represented by demand data in the Methodology. To account for return flows, a reduction factor based on CalSim 3 results has been applied to demands throughout the Delta watershed (see Section 2.2.11 of the Methodology report). Legal Delta reported diversions in 2018 are summarized in Table 2 below. Table 2 shows that demand for consumptive water use in the Southern Delta is very large, especially in comparison to the corresponding channel volumes in Table 1.

Table 2. Demand for Consumptive Use Distributed by Legal Delta Region, May-October 2022

2018 Demand (TAF)	Suisun Bay (TAF)	Northern Delta (TAF)	Central Delta (TAF)	Southern Delta (TAF)	*TOTAL (TAF)*
May	1	75	36	59	*171*
June	0	121	56	81	*258*
July	0	142	63	83	*288*
August	0	109	46	63	*218*
September	0	74	24	40	*138*
October	0	44	16	16	*76*

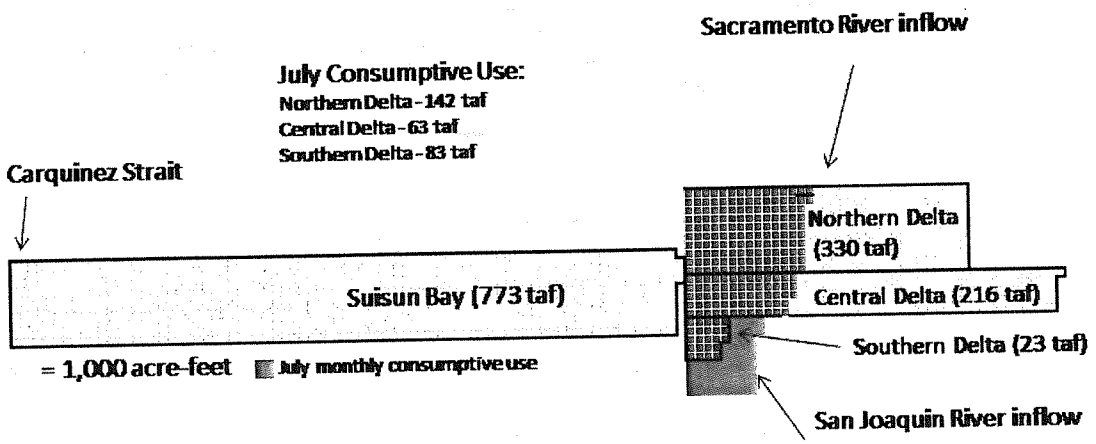
Monthly water demands within each Legal Delta region are shown as a percent of channel volume in Table 3 below. Table 3 shows that demand for consumptive water use in the Southern Delta is more than three times (360%) the volume of water in the Southern Delta channels in the months of June and July and just under that in May and August. Therefore, without considering the twice daily tidal flux discussed above, and without considering diversions by the Projects from Clifton Court Forebay and the Jones Pumping Plant, there are three full exchanges of water in the Southern Delta that are attributable to consumptive use if no diversions are curtailed. Without considering tidal flux, the total volume of water in the Southern Delta channels would be consumed in about 10 days throughout May, June, July, and August.

Table 3. Monthly Depletions as a Percent of Channel Volume, May-October 2022

Month	Reported Total Delta Demand for Consumptive Use (TAF)	Northern Delta	Central Delta	Southern Delta
May	171	23%	17%	257%
June	258	37%	26%	351%
July	288	43%	29%	360%
August	218	33%	21%	273%
September	138	22%	11%	175%
October	76	13%	7%	68%

Figure 3 shows the July consumptive use from Table 3 for different regions of the Legal Delta in relation to their channel volumes. Figure 3 clearly shows how the volume of consumptive use in the Southern Delta greatly exceeds the volume of water that can be stored in Southern Delta channels.

Figure 3. Schematic of Suisun Bay and Legal Delta Regions with Scaled Channel Volumes and Consumptive Use, July 2022

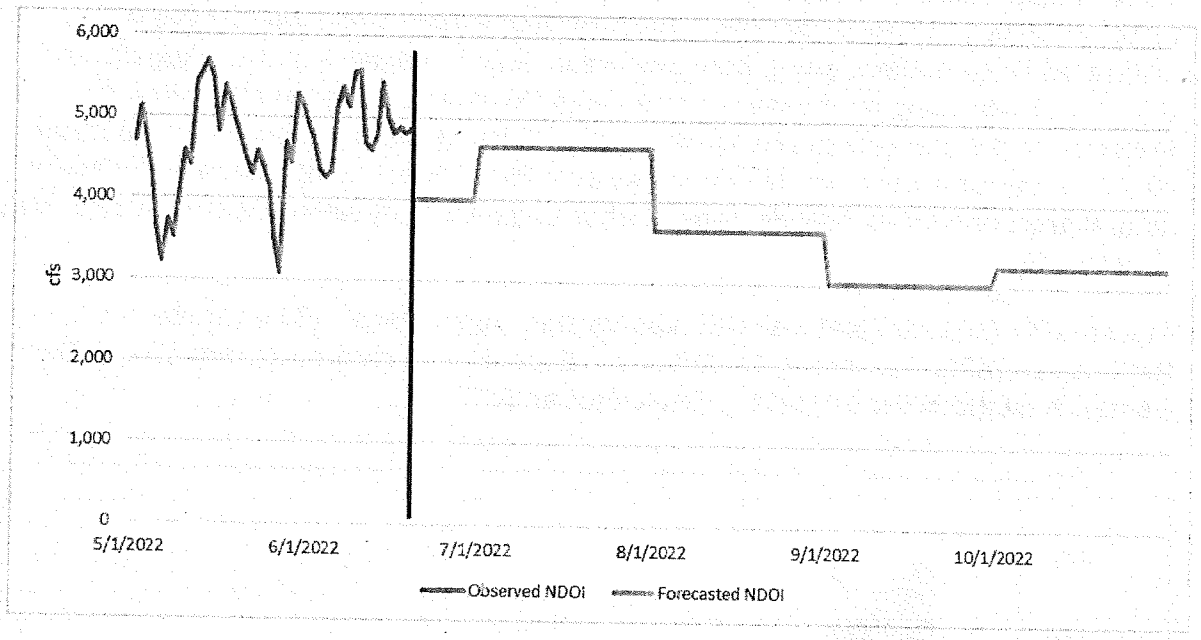


Simple estimates of residence time that only consider the total volume of the Legal Delta and inflow overestimate the residence time because they do not consider the enormous twice daily tidal flux, the variable channel volumes in different regions of the Delta, or consumptive water use.

Water Quality

In addition to decreased residence times attributable to tidal flux and consumptive use, the effects of reduced Delta outflow on water quality must also be considered for determining water unavailability. Although there would always be water present in the channels of the Delta, in the absence of releases of water from reservoir storage by the Projects the water in the Delta channels would not necessarily be of suitable quality for agricultural or municipal use. One of the principal purposes of the Projects is to release adequate water to maintain Delta outflow at levels sufficient to impede water in Suisun Bay from entering the Delta. During low flow conditions, the typical minimum flow needed to maintain a freshwater barrier to repel salinity from entering the Delta is a calculated net Delta outflow of 3,000 to 5,000 cubic feet per second (cfs). Flows in this range and higher have been maintained to prevent salinity intrusion during May and June of 2022 and are forecasted to be maintained for this purpose in July through October of 2022 (see Figure 4). Flows approaching and lower than 3,000 cfs, even for short periods, can result in salinity intrusion into the Delta.

Figure 4. Net Delta Outflow, May 1-June 19 Recorded Values and June 20-October 31 Forecasted Values by the U.S. Bureau of Reclamation



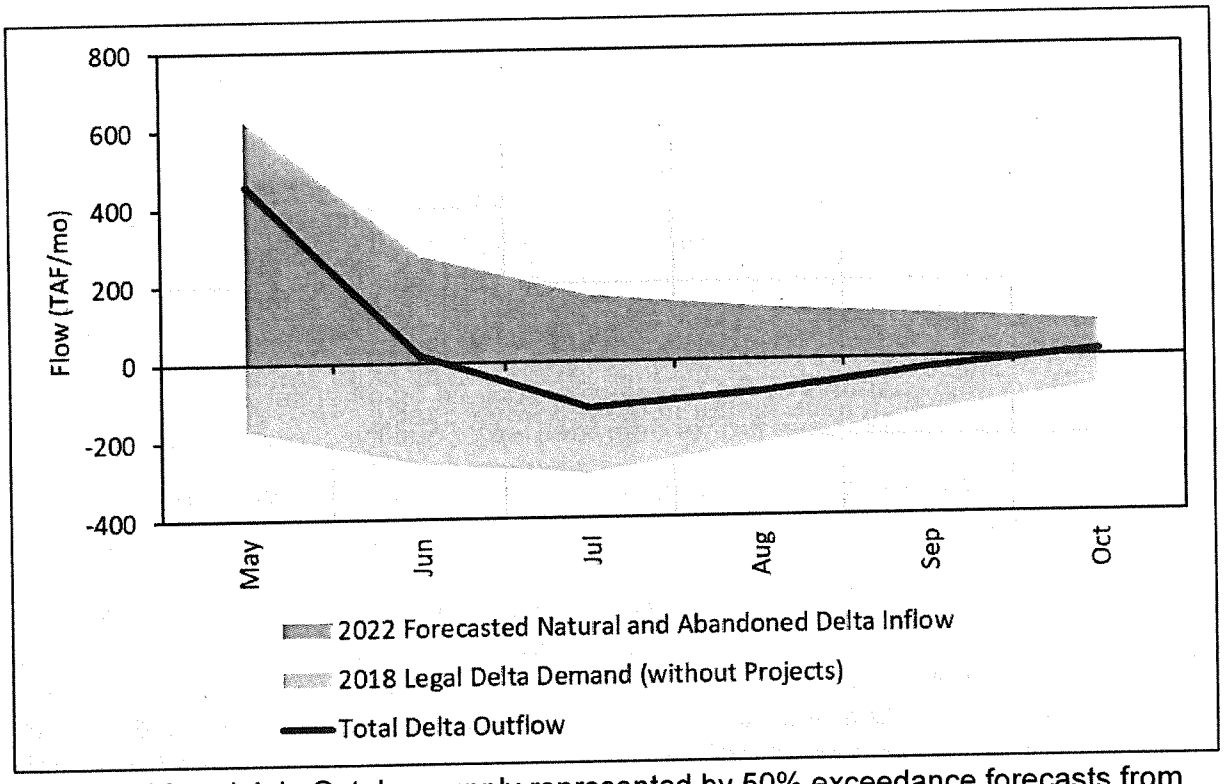
Absent Project storage releases, water quality in much of the Delta would be of a quality unsuitable for agriculture throughout much of the summer. While historical records of similarly dry periods may show that water was of sufficient quality for use throughout the summer, these periods did not include changes to the geography such as the deepening of ship channels or the increase in demand by other senior water users upstream, both of which have further degraded water quality.

The Methodology estimates water supply available to meet demand throughout the watershed. To determine the water supply available in the Legal Delta, the supply required to meet upstream demands senior to Legal Delta diverters is subtracted from the total watershed supply. While supply estimates are available on a daily timestep from the California Nevada River Forecast Center (CNRFC), the reported demand data is only available on a monthly timestep. If curtailments are issued based on watershed-wide unavailability in both the Sacramento and San Joaquin River watersheds based on the allocation priorities embedded in the Methodology, then the calculated Delta outflow met by natural and abandoned flows is zero. Because the Methodology first allocates water to meet any existing water right demands, the only time there is any excess natural and abandoned flow to contribute to calculated Delta outflow is when all demands are satisfied based on the watershed-scale analysis in at least one watershed (either the Sacramento or San Joaquin).

Without the release of Project water from storage, the only Legal Delta inflow would be from remaining natural and abandoned flows after upstream demands senior to Legal

Delta users have been met. If Legal Delta depletions remained the same, they would be met by natural and abandoned flows until those are fully consumed, and calculated Delta outflow would decrease to zero and then go negative if demands were not curtailed. Figure 5 shows the effect that removing Project water would have on calculated Delta outflow, going from positive in June to negative in July, August, and September assuming no diverters in the Legal Delta were curtailed other than the Projects. In the absence of previously stored Project water, calculated Delta outflow becomes negative (reverse Delta outflow) over these three months because inflow of natural and abandoned flow decreases while Legal Delta depletions increase from May through July.

Figure 5. Forecasted Natural and Abandoned Legal Delta Inflow for May-September 2022, Assuming CNRFC 50% Exceedance Hydrology and Legal Delta Demands without the Projects, May-October 2022*



*June 18-30 and July-October supply represented by 50% exceedance forecasts from CNRFC issued on June 18, 2022.

As shown in Table 4 below, Legal Delta inflow from natural and abandoned flows exceed Legal Delta consumptive use in May and June. Therefore, these inflows could have provided the water consumptively used in the Legal Delta. In July, August, and September, however, consumptive use in the Legal Delta is forecasted to exceed natural and abandoned inflows by upwards of 100 TAF/month.

Table 4. Calculated Net Delta Outflow without Project Inflows, May-October 2022

Month	Natural and Abandoned Legal Delta Inflow* (TAF)	Legal Delta Consumptive Use** (TAF)	Calculated Net Delta Outflow (TAF)	Calculated Net Delta Outflow (cfs)
May	626	171	455	7,405
June	277	258	19	325
July	168	288	-120	-1,955
August	134	218	-84	-1,368
September	111	138	-27	-448
October	89	76	13	220

*June 18-30 and July-October supply represented by 50% exceedance forecasts from CNRFC issued on June 18, 2022.
**Excluding Project demands.

Without Project storage releases, there will not be enough natural and abandoned Legal Delta inflow in July through September 2022 to prevent the net inflow of water from Suisun Bay into the Delta. Instead of the net Delta outflow of 4,652 cfs forecasted by Reclamation for July (see Figure 4), there would be a negative calculated net Delta outflow in July through September. Inflow of higher saline water from the west would be particularly large in the Southern Delta because it has disproportionately small channel volumes relative to its depletions. Table 5 shows that specific effect in the Southern Delta, where consumptive use exceeds natural and abandoned inflows from the San Joaquin River in June through October. The combined net inflow into the Southern Delta from the Central Delta and Suisun Bay for these five months, absent Project water from the San Joaquin River, would be 212 TAF – nearly ten times the 23 TAF volume of Southern Delta channels.

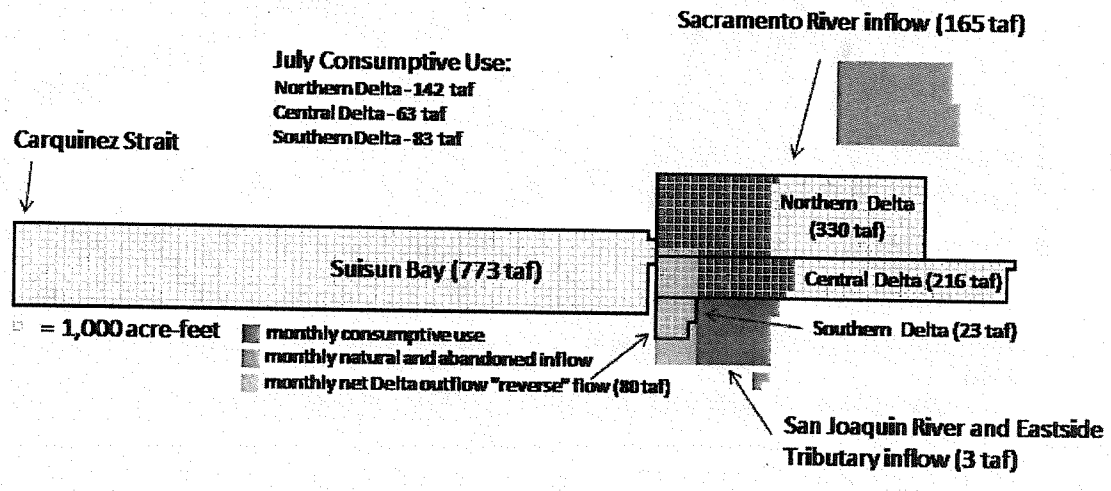
Table 5. Calculated Southern Delta Replacement Water with No Previously Stored Project Releases, May-October 2022

Month	Natural and Abandoned San Joaquin River Inflow to Legal Delta* (TAF)	Southern Delta Consumptive Use** (TAF)	"Replacement" Inflow to Southern Delta (TAF)
May	69	59	-10
June	50	81	30
July	3	83	80
August	3	63	60
September	2	40	39
October	3	16	12
Sum	129	341	212

*June 18-30 and July-October supply represented by 50% exceedance forecasts from CNRFC issued on June 18, 2022.
**Excluding Project demands.

Figure 6 shows forecasted conditions for July 2022 without Project water entering the Legal Delta. The figure shows consumptive use in the three Legal Delta regions relative to their channel volumes, the volume of natural and abandoned Legal Delta inflow, and calculated net (reverse) Delta outflow in July. The forecasted volume of Sacramento River natural and abandoned flow (165 TAF) is less than the combined Northern and Central Delta consumptive use (142 + 63 = 205 TAF). The volume of San Joaquin River natural and abandoned flows (3 TAF) is a small fraction of Southern Delta consumptive use (83 TAF). This shows that, with continued uncurtailed Legal Delta diversions and in the absence of Project water, the Northern, Central, and Southern Delta channels would be pulling water from Suisun Bay. Figure 6 shows that there would be calculated negative net Delta outflow from the Central and Southern Delta because consumptive use would be disproportionately higher than freshwater inflow.

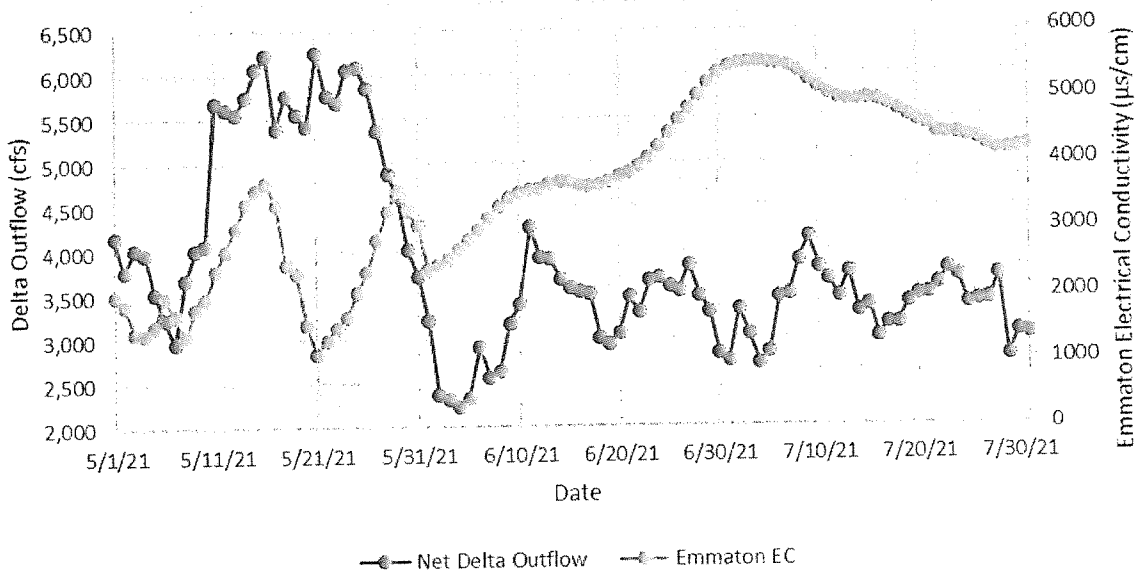
Figure 6. Schematic of Suisun Bay and Legal Delta Regions with Scaled Channel Volumes, Consumptive Use, Forecasted Natural and Abandoned Legal Delta Inflow, and Calculated Net Delta Outflow Reverse Flow, July 2022



Estimation of Water Quality in the Legal Delta Without Previously Stored Project Water

This section presents a discussion of Legal Delta water quality absent Project operations. Without the presence of upstream Project storage releases, diversions in the Southern Delta that exceed inflows from upstream would cause water from Suisun Bay and the Central Delta to enter the Southern Delta. For example, the average EC in the far western boundary of the Delta, at Emmaton (see Figure 1), was approximately 2,200 µs/cm in May 2021, when the calculated average net Delta outflow was over 5,000 cfs. The EC increased to an average of over 4,000 µs/cm in June and July 2021, when the calculated average net Delta outflow dropped to an average 3,300 cfs (see Figure 7 below). This relatively large increase in salinity occurred in response to a relatively small reduction in calculated net Delta outflow from 5,000 to 3,300 cfs. This minimal Delta outflow was still enough to maintain a freshwater barrier between Suisun Bay and the Delta, but salinity increased at Emmaton due to more water from Suisun Bay being mixed with Sacramento River water.

Figure 7. Historical Recorded Net Delta Outflow and Electrical Conductivity at Emmaton, May-July 2021



The EC at the eastern boundary of Suisun Bay, downstream of Emmaton, would have been far higher if there had been no Delta outflow to freshen water in Suisun Bay. Further west in Suisun Bay, the average EC from May through July 2021 was 11,000, 20,000, and 31,000 µs/cm at Collinsville, Port Chicago, and Martinez, respectively (east to west, see Figure 1).

Without previously stored Project releases, higher natural and abandoned flows in May 2022 would have started the season with sufficient water quality; however, without the benefit of Project water flowing into the Delta, the high EC water from Suisun Bay would intrude into the Delta in June and July. It does not take much of this high salinity water to have a large effect on water quality: a 50/50 mix of 20,000 µs/cm water from central Suisun Bay would result in a mixed water quality of over 10,000 µs/cm, assuming there was no salt in the other components of the mix.

Without Project water, conditions in the Southern Delta in July-September 2022 would be far worse than a 50/50 mix of Martinez-quality water because there would be very little low-salinity water present to mix with. Only 3 TAF of natural and abandoned San Joaquin River water is forecasted to be available in the Southern Delta in July 2022 (see Table 5), while consumptive use is 83 TAF (see Table 2). Only 4 percent of the monthly consumptive use would have been met by low-salinity water from the San Joaquin River. The other 96 percent would have to have been met with water that flowed into the Southern Delta through the Central Delta from Suisun Bay. A 90/10 mix of Martinez and San Joaquin River water could approach 18,000 µs/cm.

Although some salt-tolerant crops can continue to be grown with relatively saline water, doing so requires very high leaching fractions to move the salts through the root zone. The types of soils in the Southern Delta do not provide the high leaching requirements needed to support high salinity irrigation water, and salt-tolerant crops are not generally grown in the Southern Delta. Even if such crops were grown in the Southern Delta and such leaching were possible, there is nowhere for the leached water to go except back into the Southern Delta channels. With no net Delta outflow, the Southern Delta is a closed system where the salt levels would continue to rise.

Slight to moderate restrictions on use are generally considered for irrigation water with salinity between 700 and 3,000 µs/cm, with severe restrictions for salinity over 3,000 µs/cm (Ayers and Westcot, 1985). Determining the sensitivity of crops to highly saline water is not a simple matter because the effect on the crop is based on the salinity in the root zone, which can be higher than the salinity of applied irrigation water. This is because soil salinities generally increase as water is consumed by the plant and salts are left behind in the soil.

Sensitive crops start showing declines in yield for soil-water salinities (soil extract EC) over 2,000 µs/cm, with 100 percent yield reduction at 8,000 µs/cm. Moderately sensitive crops start showing reductions at 3,000 µs/cm, with 100 percent reduction at 16,000 µs/cm. Moderately tolerant and tolerant crops start showing reductions at 7,000 and 10,000 µs/cm, with 100 percent reduction at 24,000 to 32,000 µs/cm (Hoffman 2010). These effects would occur at lower thresholds of applied water salinity depending on initial soil salinity and leaching fractions of the soils, among other things. In 2007, less than ten percent of the crops grown in the Southern Delta were moderately tolerant or tolerant (Hoffman 2010).

An additional problem associated with applying highly saline water to crops is that salts will eventually have to be flushed from the root zone before yields can be restored. When that occurs, the salts will continue to impair the use of the receiving water as an agricultural supply until such time as all the salts are flushed from channels in the Delta.

Conclusions

Although there will always be water in the Legal Delta channels that are at or below sea level, by July 2022 the quality of the water in those channels would be too salty for agricultural or municipal beneficial uses absent the releases of previously stored water by the Projects as required by D-1641. This analysis shows that when tidal flux, consumptive use, Delta outflow, the operations of the Projects, and water quality are considered, the assumptions regarding Legal Delta residence time and water quality in the Water Unavailability Methodology are reasonable.

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