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## State Water Resources Control Board

June 1, 2020

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### ORDER 90-5 SACRAMENTO RIVER TEMPERATURE MANAGEMENT

Dear Mr. Conant:

This letter responds to the U.S. Bureau of Reclamation's (Reclamation) May 20, 2020 submittal of a final 2020 Sacramento River Temperature Management Plan (TMP) pursuant to State Water Resources Control Board (State Water Board or Board) Water Right Order 90-5. Additionally, the attached appendix addresses certain issues raised in Reclamation's May 11, 2020 comment letter to the State Water Board related to the draft TMP.

Order 90-5 requires Reclamation to take actions reasonably within its control to protect winter-run Chinook salmon and other native species from elevated temperatures and other adverse conditions created by Reclamation's operations on the Sacramento River. State Water Board staff repeatedly requested that Reclamation provide information on operational scenarios other than those proposed in Reclamation's TMP that could allow for better temperature control. Unfortunately, Reclamation has failed to provide the requested information. This information is needed to inform adequate temperature management. Since Reclamation has declined to provide the information, the State Water Board does not have sufficient information to make a well-informed decision on Reclamation's final TMP. We are therefore unable to approve the TMP, and object to the plan.<sup>1</sup>

In the spirit of cooperative federalism, we expect that Reclamation will provide the information we requested. In order to be in a position to potentially improve temperature conditions this year, the State Water Board needs the requested analyses within 20 days from the date of this letter. If this information is provided timely, we will reevaluate the TMP and consider approval at that time.

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<sup>1</sup> The decision on Reclamation's TMP is made pursuant to authority delegated to the Executive Director of the State Water Board, and does not necessarily reflect the views of all of the State Water Board Members.

E. JOAQUIN ESQUIVEL, CHAIR | EILEEN SOBECK, EXECUTIVE DIRECTOR

## *Background*

Operations of Shasta Reservoir and associated facilities are not only critically important to California's water supply but also to the protection of winter-run Chinook salmon, which is one of the state's most endangered salmon species. Prior to construction of Shasta Dam, winter-run Chinook salmon spawning and early rearing habitat encompassed approximately 200 miles of snow-fed cold water streams in the upper reaches of the Sacramento River and its tributaries. These stream systems remained cold throughout the year, which protected salmon eggs and emergent fry from heat-induced mortality. With the construction and operation of Shasta and Keswick Dams, winter-run Chinook salmon no longer have access to this historic cold water habitat and are instead limited to a small stretch of the Sacramento River below Keswick Dam, where cooler temperatures are dependent on reservoir releases.

A number of controllable and uncontrollable factors contribute to temperatures below Keswick Dam, including the volumes of cold water that are affected by runoff and the timing and volume of releases from Shasta Reservoir, imports of water from the Trinity River system, temperature control device and side gate operations, power supply operations, air temperatures, and tributary inflow volumes and temperature in downstream reaches.

For the last several decades, winter-run Chinook salmon have teetered on the verge of extinction, due in large part to elevated temperature conditions in their sole remaining habitat, which is below Keswick Dam. The winter-run Chinook salmon population declined from over 100,000 fish in the late 1960s to fewer than 200 in the early 1990s (Yoshiyama et al. 1998).<sup>2</sup> These dramatic population declines led to the State Water Board's adoption of Order 90-5 that requires Reclamation to take actions reasonably within its control to protect winter-run and other native species from elevated temperatures and other adverse conditions created by Reclamation's operations on the Sacramento River.

In 2014 and 2015, temperatures were not maintained at protective levels below Shasta and Keswick Reservoirs, resulting in near total mortality of winter-run in those years and the near extinction of the species. Extinction of the winter-run was likely only avoided by maintaining high levels of hatchery production. In those years, adequate reservoir storage and cold water pool levels in Shasta Reservoir needed for temperature control were not maintained. Reclamation's modeling and monitoring was also inadequate to inform regulatory agency decision making and adjustments to operations that could have allowed for adequate temperature management.

This year's hydrology is very similar to the hydrology the region faced in 2013, the year before temperature control was lost. Over the last 21 years, every year with similar

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<sup>2</sup> Yoshiyama, R. M., Fisher, F. W., & Moyle, P. B. (1998). Historical abundance and decline of chinook salmon in the Central Valley region of California. *North American Journal of Fisheries Management*, 18(3), 487-521.

hydrology to this year was followed by another dry year. This observed pattern supports the importance of planning for and maintaining carryover storage levels this year. The operations proposed by Reclamation in its TMP are very similar to Reclamation's 2013 operations. And in fact, Reclamation's cold water pool estimates are already diverging from Reclamation's modeling. The volumes of coldest water in Shasta Reservoir are more than 10 percent lower than what was modeled less than two weeks ago. In addition, the current volumes of coldest water less than 48 degrees F in Shasta Reservoir are similar to the low levels experienced in 2014. This raises concerns that temperature conditions could already be deteriorating relative to Reclamation's TMP and could continue to do so. Recent science from the National Marine Fisheries Service (NMFS) (Daniels and Danner, 2020)<sup>3</sup> shows that dam discharge temperature from Shasta Reservoir has a greater effect on Sacramento River temperature than discharge volume, which suggests that reduced releases may be an effective tool in extending cold water pool resources, particularly if accurate information regarding cold water pool volumes and supporting modeling are available to inform regulatory decisions.

Given the conditions this year, the State Water Board asked Reclamation to evaluate scenarios that may improve temperature control and carryover storage going into next year, including reduced water deliveries under Reclamation's water rights, allowing Reclamation to retain more water in storage for the protection of cold water pool. Modifications to the volume and timing of imports from the Trinity River, and adjustments to power operations could also be considered.

Since this information is needed to inform adequate temperature management, and Reclamation failed to provide it, the State Water Board cannot approve the TMP. In the interim, although the State Water Board objects to the current plan, we do not expect, recommend, or require that Reclamation meet 56 degrees Fahrenheit (F) at the Red Bluff Diversion Dam (RBDD), as that would not be the best use of the limited Shasta Reservoir cold water pool. Instead, Reclamation should take every action in its reasonable control to protect native fish in the Sacramento River with an emphasis on actions that optimize protection of the winter-run Chinook salmon fishery downstream of Keswick Dam and provide for improved storage conditions going into next year. We also encourage Reclamation to work with the Sacramento River Settlement Contractors and other watershed stakeholders to implement voluntary measures that could improve fishery conditions, such as adjusting the timing of fall diversions.

### *Regulatory Background*

Order WR 90-5 requires Reclamation to operate Keswick Dam, Shasta Dam, and the Spring Creek Power Plant to meet a daily average water temperature of 56 degrees F on the Sacramento River at RBDD during periods when higher temperatures will be detrimental to fish. If there are factors beyond Reclamation's reasonable control that

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<sup>3</sup> Daniels, M. E., & Danner, E. M. (2020). The Drivers of River Temperatures Below a Large Dam. *Water Resources Research*, 56(5), e2019WR026751.

prevent Reclamation from meeting 56 degrees F at RBDD, Reclamation, in consultation with staff from the State Water Board, fisheries agencies, and the Western Area Power Administration, may develop a plan and propose that the compliance point be moved upstream. The State Water Board has 10 days to consider the TMP (which is June 1 this year due to the 10 day period ending on the weekend).

Under the 2019 Reclamation Biological Assessment and associated 2019 NMFS Biological Opinion, Reclamation proposes to operate to meet a temperature between 53.5 degrees F and 56 degrees F or higher at a compliance point 41 miles upstream of RBDD at Clear Creek (CCR). In the TMP, Reclamation is identifying a compliance location in addition to CCR for meeting 56 degrees F at times that 56 degrees F is not proposed at CCR as the compliance location for Order 90-5. Water temperatures generally increase incrementally downstream of Keswick Dam until an equilibrium temperature is reached. Accordingly, providing a temperature of 56 degrees F at a downstream location like RBDD provides cooler temperatures upstream. Meeting a temperature of 56 degrees F at RBDD would generally provide cooler temperatures than 53.5 at CCR.

#### *Reclamation's 2020 TMP*

This year, Reclamation is proposing to meet the following temperature compliance points:

- End of May through end of June, 2020: 53.5 degrees F at CCR and 56 degrees F at Balls Ferry
- End of June through middle of September, 2020: 54 degrees F at CCR and 56 degrees F at Balls Ferry
- Middle of September to the end of October, 2020: 56 degrees F at CCR

Reclamation submitted estimates of temperature dependent mortality indicating that these operations would be expected to result in stage independent temperature dependent mortality of 28 percent (with stage dependent temperature dependent mortality of 15 to 16 percent).<sup>4</sup> Estimates of temperature dependent mortality provided

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<sup>4</sup> While State Water Board staff recognizes the efforts of Anderson (2018) in adapting the temperature dependent model from Martin et al. (2017) to develop stage dependent mortality estimates for optimizing use of cold water during the temperature management season, this model may underestimate temperature dependent mortality. Martin et al. (2017) shows that temperature related mortality of eggs can occur earlier than the critical age used in Anderson (2018), and that lower temperatures for only a portion of the incubation period may not be sufficiently protective. Together with a historical reduction in the length of the temperature management reach and a lack of protection for fish that emerge after October 31 through mid-November, underestimating temperature mortality during the early stages of egg development could lead to management actions that further impact wild winter-run Chinook salmon stock and its genetic diversity. (Martin, B. T., Pike, A., John, S. N., Hamda, N., Roberts, J., Lindley, S. T., & Danner, E. M. (2017). Phenomenological vs. biophysical models of thermal stress in aquatic eggs. *Ecology letters*, 20(1), 50-59; Anderson, J. J. (2018). Using river temperature to optimize fish incubation metabolism and survival: a case for mechanistic models. *bioRxiv*, 257154).

by Reclamation on May 27, 2020 (Table 1), show similar results for mean/median stage independent mortality with a possible lower and upper range of less than 1 percent to nearly 70 percent.

Table 1: Estimated temperature-dependent egg mortality under different scenarios assuming a 2012-2019 spatial and temporal redd distribution using output from RAFT and interpolated HEC-5Q water temperature models.

Scenario	MODEL	Mean (%)	Median (%)	Lower (%)	Upper (%)
MAY_26_2020_INPUT_90_OUTPUT_90_25L3MTO	RAFT	30.63	27.57	0.08	69.6
MAY_26_2020_INPUT_90_OUTPUT_90_25L3MTO	HEC-5Q	26.46	22.16	0.11	67.22

While the mortality levels expected from the TMP are generally consistent with that expected for a Tier 3 year described in the 2019 Biological Opinion (median mortality of 24 percent)<sup>5</sup>, the projected temperature dependent mortality rate of approximately 28 percent is concerning to State Water Board staff considering the poor condition of winter-run Chinook salmon and other natural and anthropogenic causes of mortality that will affect these fish. Uncertainties concerning mortality rates and operations could also result in higher levels of mortality. Accordingly, approaches that could lower mortality and improve carryover storage conditions for next year merit consideration.

#### *Evaluation of Alternative Operational Scenarios*

Reclamation evaluated many scenarios in developing the initial draft TMP; however, Reclamation only evaluated possible modifications to temperature shutter operations that all included similar levels of mortality, or scenarios that would not be recommended due to uncertainties with the ability to provide temperature control throughout the temperature control season. Reclamation did not evaluate any other actions that could improve temperature conditions, including possible changes to the timing or volume of releases, modifications to Trinity River imports, or power production operations to evaluate the possibility for more protective temperature conditions.

In response to an earlier draft of the TMP, State Water Board staff requested that Reclamation evaluate scenarios in which volumes of water equivalent to reductions in deliveries to exchange contractors and refuges that occur under the current Shasta Critical year conditions are backed up in to storage in Shasta Reservoir. The purpose of Board staff's request was multi-fold: to evaluate whether conservation of water in Shasta Reservoir would improve temperature management this year; to avoid the higher end of possible temperature dependent mortality estimates; to evaluate whether the additional stored water would benefit carryover storage conditions going into next year; and to better understand the supply side and system management tradeoffs that would result from additional Shasta storage. Recognizing the interconnected nature of

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<sup>5</sup> The 2017 NMFS proposed Biological Opinion amendments, although never finalized, recommended that temperature dependent mortality not exceed 8 percent in this type of year.

the water supply system and the potential for unintended consequences of modifying project operations, State Water Board staff also asked Reclamation to include information regarding the tradeoffs associated with lower releases and information regarding why Reclamation does not recommend such operations.

Reclamation has declined to evaluate additional operational scenarios. Reclamation's position is that scenarios with different operational assumptions would be inconsistent with its contractual obligations, and are therefore beyond Reclamation's reasonable control. The State Water Board disagrees. To the extent that Reclamation delivers water under its own water rights, Reclamation's obligation to deliver water to its contractors does not take precedence over its permit obligations. Order WR 90-5 requires Reclamation to reduce releases to the extent reasonable and necessary to control water temperature. This permit condition is not and cannot be nullified by a contractual obligation. Reclamation's water supply contractors are not entitled to more water under their contracts than Reclamation is authorized to deliver consistent with the terms and conditions of its water right permits and licenses. (See *United States v. State Water Resources Control Bd.* (1986) 182 Cal.App.3d 82, 145-148; *State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674, 806, fn. 54; see also Order WR 92-02, p. 9, fn. 3 [compliance with Order WR 90-5 may require adjustments to water deliveries, which are controllable factors, and water should not be considered available for delivery if it is needed as carryover to maintain an adequate cold water pool].)

Reclamation's May 11 letter also suggested that the Board intends "to evaluate or take action on water rights held by parties other than Reclamation, in particular the Sacramento River Settlement Contractors, the San Joaquin River Exchange Contractors, and wildlife refuges . . . ." That is not the case. The Board's April 29, 2020 letter was intended to clarify that none of the operational scenarios the Board seeks to evaluate would impact the natural or abandoned flows to which senior riparian or appropriative water right holders may be entitled, including the settlement and exchange contractors.

The Board appreciates the willingness of Reclamation and the Sacramento River Settlement Contractors to continue to discuss this and other legal issues pertaining to compliance with Order WR 90-5. For purposes of compliance this year, however, it may not be necessary to resolve this issue because, due to the improvements in hydrology that occurred in early April, the Board is not seeking to evaluate any operational scenarios that may be inconsistent with Reclamation's contractual obligations to settlement or exchange contractors. Specifically, the Board's April 29, 2020 letter asked Reclamation to evaluate a scenario that stores water that is not delivered to settlement and exchange contractors due to the Shasta Critical year determination. There is reason to believe that this action may improve both temperature conditions in the fall and carryover storage. If the Shasta Critical year determination changes, evaluation of a scenario that reduces exports for service contractor deliveries is also requested.

These operations would be consistent with the settlement and exchange contracts, which provide for 75 percent allocations in a Shasta Critical year. These operational scenarios are also consistent with the shortage provisions contained in Central Valley Project (CVP) service contracts, which generally provide for reduced annual deliveries to service contractors when CVP water is unavailable due to hydrology or other legal requirements, which would include obligations under Order WR 90-5. (See *State Water Resources Control Board Cases, supra*, 136 Cal.App.4th at pp. 805-806 [discussing shortage provision in CVP service contract].) The State Water Board recognizes that such a scenario would have significant tradeoffs, however, and would therefore also like information on those tradeoffs.

#### *Drought and Carryover Storage*

Storage conditions this year are very similar to conditions in 2013. That year was the beginning of California's most recent drought, when low storage at the end of water year 2013 contributed to reduced storage in 2014 and 2015. The low storage levels in 2014 and 2015 led to the loss of temperature control and near extinction of winter-run Chinook salmon. Given the parallels this year to hydrologic conditions in 2013, the State Water Board continues to be concerned with preventing temperature dependent mortality and providing for carryover storage in the event that this is the first year in a series of drought years. One of the significant lessons learned from the recent drought was the need to plan for such contingencies. As such, Reclamation's proposal to operate this year similar to 2013 needs to be carefully considered. Recent information from Reclamation provided on May 27 indicates that the volume of coldest water in Shasta Reservoir (water less than 48 degrees F) is tracking very close to cold water volumes observed in 2014, and that the volumes of water less than 49 degrees F is more than 10 percent lower than what was modeled less than 2 weeks prior. The fact that cold water pool estimates are already diverging from Reclamation's model raises concerns that temperature conditions could already be deteriorating relative to the May 20<sup>th</sup> TMP. Further, it is possible that this year's Shasta Critical year determination (in which water supply allocations are reduced to various contractors) could change resulting in changes in operations that could affect temperatures. Reclamation, however, has not provided information regarding how such a change would affect operations this year.

#### *State Water Board Renewed Request for Information*

As stated above, the State Water Board currently does not have sufficient information to make a well-informed decision on Reclamation's final TMP. If the following information is provided within 20 days of the date of this letter, we will consider approval of the TMP at that time:

- Evaluation of operational scenarios that improve temperature protection this year, including extending temperature protection beyond October 31 if eggs are still in the redds at that time, and carryover storage going into next year. Assuming this remains a Shasta Critical year, this should include evaluation of

improving temperature management and carryover storage with water not allocated to settlement and exchange contractors and refuges under the contractual shortage provisions of the associated contracts. In the event it is not a Shasta Critical year following the recent storm event, a scenario in which exports for service contractors are reduced to provide 100 thousand acre-feet (TAF) of additional storage in Shasta Reservoir and up to 250 TAF if feasible should be evaluated.

- An evaluation of other possible adjustments to other operations to improve temperature conditions, including adjustments to power operations and Trinity River imports.
- The State Water Board recognizes that at this point in the water year, such scenarios could have significant water supply and economic impacts so also requests an evaluation of the tradeoffs associated with the above scenarios.

In addition to providing this information, Reclamation should notify the State Water Board immediately if any conditions (monitoring, modeling, operations, etc.) or projections indicate that conditions will be any less protective than identified in the May 20<sup>th</sup> TMP. This includes, but is not limited to, lower than projected reservoir storage levels or cold water pool volumes, higher than projected reservoir releases, higher than projected water temperatures at CCR or Balls Ferry, increases to estimated winter-run Chinook salmon mortality levels, or other indications that conditions for protection of winter-run and other native species are degrading this year.

#### *Transparency and Collaboration Moving Forward*

The State Water Board wants to work cooperatively with Reclamation and watershed stakeholders on collaborative science and planning to further improve our shared understanding of temperature management actions that can best achieve water supply and fish protection goals. Climate change, increased population growth, increased water demand will continue to put additional stressors on an already overburdened system, and could lead to endangered species going extinct when coupled with other stressors on these fish. At the same time, the State Water Board recognizes that curtailments in water supply and deliveries may cause real economic effects. Decisions that deplete the cold water pool too early, or that require releases at the wrong time, could have disastrous effects for water users and species alike. The State Water Board is tasked with balancing competing demands, and relies on the best available science and data when making related decisions and recommendations. The Board relies on the expertise of our federal partners to help us make the best decisions. We cannot do this alone.

While Reclamation evaluated over 300 management scenarios in developing the TMP for this year, each scenario relied on the same basic set of assumptions related to releases and supplies. The result was each scenario forecasted similar mortality levels



of salmon. The alternative operational scenarios the Board has requested are needed to make the most informed temperature management decisions – not only for the Board, but for the numerous stakeholders who are directly involved in management and stewardship of California’s water resources. Most critically, voluntary efforts to develop a long-lasting and meaningful balance between water supply and ecosystem needs will ultimately rely on timely and accurate information. The information developed from the requested scenario evaluations, combined with a better understanding of how water supply changes propagate throughout the water supply system, is a necessary part of an ongoing collaborative process.

One of the most difficult elements in temperature management planning is the short decision-making window inherent to the current process. With a highly fluid hydrology, changes in temperature and supply can occur on a near weekly basis, particularly during the winter and spring. In 2018, State Water Board staff requested that Reclamation develop a temperature management and planning protocol, in part to help address the ongoing challenges associated with the short timelines of the existing process. Reclamation worked towards this effort in 2018, but ultimately requested to pause the development of the protocol as a new biological opinion was being developed. A revised biological opinion was adopted in 2019.

Given that the 2019 biological opinion is now complete, Board staff requested in our April 3, 2020 letter that Reclamation develop a draft protocol for submittal to the State Water Board and fisheries agencies for comment by September 15, 2020. In public comments on the TMP, the State Water Board received helpful recommendations from Reclamation’s contractors, fisheries agencies, and non-governmental organizations (NGOs) on possible improvements to the temperature management process that should be considered related to early planning, voluntary measures, and collaboration. The protocol should consider these recommendations, as the recommended improvements could help all stakeholders involved. The State Water Board also recognizes that Reclamation plans to develop a drought tool kit of actions that can be taken during drought conditions to improve temperature management. The State Water Board is very supportive of those efforts and encourages Reclamation to include information regarding the drought tool kit in the draft protocol. Prior to development of the protocol, State Water Board staff will be sending a letter outlining additional issues it believes are important to consider, and we would like to meet with Reclamation to share ideas that would meet our collective needs and objectives.

The draft protocol requested above will be a good first step in establishing an earlier and ongoing collaborative process. Looking forward, efforts already underway may provide additional opportunities for temperature management collaboration. A science partnership with agencies, water users, and NGOs like that being proposed by the Northern California Water Association, could be a promising opportunity for identifying key temperature management questions and solutions in a collaborative forum. We look forward to seeing additional information and outcomes from that process, and are available for discussions as helpful.

If you have any questions regarding this letter, please contact Diane Riddle at [diane.riddle@waterboards.ca.gov](mailto:diane.riddle@waterboards.ca.gov). Please be aware that due to the public health concerns regarding the COVID-19 virus and the resulting pandemic, many State Water Board staff are telecommuting; therefore, the best avenue of communication at this time is via email.

Sincerely,

*ORIGINAL SIGNED BY*

Eileen Sobeck  
Executive Director  
State Water Resources Control Board

## Appendix: Clarifications and Corrections to Issues Raised in Reclamation's May 11, 2020 Letter to the State Water Resources Control Board.

### 1. Prior Drought

Reclamation raises a number of comments in their May 11, 2020 letter to the State Water Board regarding conditions during the prior drought and technical issues related to temperature management that require clarification. The description provided in the May 11<sup>th</sup> letter offers an incomplete analysis of the complicated temperature management issues that developed during the drought. We wish to provide additional context to statements made in the May 11<sup>th</sup> letter related to loss of temperature control and modeling efforts.

Reclamation attributes the loss of temperature control during the drought years of 2014 and 2015 entirely to decisions by the regulatory agencies, including the State Water Board. As Reclamation has acknowledged, depleted storage conditions in 2013 contributed to low storage in 2014 and associated temperature concerns. Regulatory agencies relied on temperature modeling provided by Reclamation in 2014 as part of the temperature planning process, and based regulatory decisions on that modeling information. Unfortunately, as described in the *Sacramento River Temperature Task Group Annual Report and Activities*, water temperatures from October 1, 2013 through September 30, 2014 were about 4 degrees F higher than modeled. These high temperature levels resulted in the loss of nearly all of the 2014 cohort of winter-run Chinook salmon due to temperature dependent mortality.

In 2015, delayed reporting by Reclamation on limited cold water storage conditions left limited options for improving temperature conditions, particularly without significant loss of already dedicated economic resources, and little time to analyze what options remained. By the time state and federal regulatory agencies were aware of the limited cold water volumes there were few actions that could be taken.

Reclamation seems to attribute 2014-2015 winter-run Chinook salmon mortality to the actions of regulatory actions, but clearly there are numerous factors that affected poor outcomes in those years. A collaborative multi-agency and stakeholder approach will help future temperature planning efforts – although without timely and accurate information such collaborative efforts will be constrained. The experience of the 2014-2015 drought years, and the resulting loss of nearly all the 2014 and 2015 cohorts of winter-run Chinook salmon, have informed the Board's subsequent temperature management planning efforts. Likewise, Reclamation has also taken the lessons learned during the most recent drought as an opportunity to evaluate drought responses and improve its temperature planning and management processes. Continuing (and potentially expanding) this working relationship will provide for better outcomes during dry conditions in the future.

## 2. Releases from Shasta, Allocations, and Decision Making

Reclamation's May 11<sup>th</sup> comment letter states that there is little difference in March through April releases from Shasta Reservoir between a zero allocation to water service contractors and a 100 percent allocation to water service contractors in a dry year. Reclamation further indicates that requirements for early water supply planning would only impact planting decisions without benefiting the available cold water pool, since the majority of deliveries to water service contractors begin in May when the hydrology and stratification of the available cold water-pool is better known. The Board acknowledges that changes in hydrology can be rapid and have significant effects on temperature management planning, as evidenced by this water year in particular. But the challenges associated with hydrologic uncertainty make early planning efforts more critical, not less. Reclamation may begin the majority of its deliveries to water service contractors in May; however, water supply allocation and associated planting decisions related to deliveries are made earlier in the season making it important to start planning processes early when conditions are dry. Early discussions on hydrology could facilitate voluntary efforts to identify reasonable options for improving cold water pool volumes and related temperature induced mortality.

## 3. Temperature Relationship to Shasta Releases and Fall Carryover

Reclamation indicates that lower releases from Shasta Reservoir during the spring through fall would not benefit temperature operations. Reclamation cites Daniels and Danner (2020), who evaluated the relationship of river temperatures to discharge over a wide range of flows and geographic scales. Daniels and Danner (2020) found that "discharge temperature often had a larger effect compared to discharge volume," particularly in the upper reach of the Sacramento River near CCR where Reclamation intends to manage temperatures. According to Daniels and Danner (2020), the river temperature in the upper Sacramento River (between Keswick Dam and upstream of Bend Bridge) responded primarily to changes in discharge temperature, with the exception of flows below 5,300 cfs. (Reclamation's forecasted releases during June and July are about 12,000 cfs.) Thus, when releases are above 5,300 cfs, greater discharge volumes may not be necessary to control river temperatures in the locations where temperature management currently occurs, and higher releases may deplete stored cold water resources.

Reclamation's May 11 comment letter also indicates that there is not a significant correlation between end of September storage levels and the next year's cold-water pool. Yet at the same time, Reclamation's analysis of historical prior storage, inflow, and releases for May 1 cold water capabilities states that "lower release in the fall of 2013 could have improved conditions for 2014." As discussed above, this year is very similar to 2013. Accordingly, improvements to carryover storage levels this year merit further consideration to address the types of challenges encountered during 2014 and 2015.

#### 4. Releases to Maintain Delta Water Quality

Reclamation indicates that State Water Board Decision 1641 (D-1641) required high releases from Shasta storage this winter to meet Delta outflow requirements, despite low precipitation. The D-1641 Delta outflow requirements are based on the prior month's hydrologic conditions to provide more operational certainty. The outflow requirements include significant flexibility to reduce water supply impacts, including three different methods of compliance and the ability to carry over excess compliance days from one month to the next. Although daily outflow from Shasta Reservoir exceeded inflow intermittently during the period from December through mid-March, approximately twenty percent of inflow to the reservoir was stored on a net basis during February and March. Although it is more typical to store upwards of fifty percent of inflow during these months, outflow from Shasta is well within the range observed during the prior twenty years of implementation of D-1641, on the basis of both absolute volume and fraction of inflow to the reservoir.