Attachment 1-4 Scenario Related Changes to CalSim II and DSM2

1 Introduction

This document describes assumptions for scenario related changes to CalSim II and DSM2 utilized in this EIR. Scenario related changes include:

- Application of Summer/Fall Suisun Marsh Salinity Control Gate (SMSCG) Operations
- Old and Middle River flows

2 Application of Summer/Fall SMSCG Operations

The ~~proposed project~~ Proposed Project and Refined Alternative 2b Summer/Fall Delta Smelt Habitat Action includes a measure to operate SMSCG for up to 60 days in June – October of below normal, above normal years, and, possibly wet years. For more detailed description of the action, see Section 3.3 of the main document. This document describes the changes to CalSim II and DSM2 to model effect of ~~proposed project~~ SMSCG operations.

2.1 Representation in CalSim II

CalSim II uses artificial neural networks (ANNs) to calculate the salinity at select compliance locations in the Delta. However, the CalSim II ANNs do not account for effect SMSCG operations, which increase salinity intrusion in the Sacramento and San Joaquin Rivers. To ensure modeled operations from CalSim II meet D1641 water quality standards, a buffer was applied to the compliance threshold.

Therefore, CalSim II was adjusted to meet water quality standards in the Delta. To model the effect of gate operations, a buffer to D1641 water quality standards at Sacramento River at Emmaton and San Joaquin River at Jersey Point during assumed periods of SMSCG operations. The buffer value represents the increase in Delta Outflow required meet water quality standards when SMSCG are operating. Therefore, operating to a salinity buffer would provide the same operational response as would a simulation that included SMSCG operations explicitly. Methodology for determining CalSim II buffer values is described in Section 2.3.

2.2 Representation in DSM2

DSM2 dynamically models SMSCG operations. Therefore, DSM2 model input were adjusted to match the description in the ~~proposed project~~Proposed Project and Refined Alternative 2b.

2.3 Calculation of CalSim II Buffer

Impact of SMSCG operations on salinity at select compliance locations was studied using the DSM2. DSM2 was run with and without July – August SMSCG operations. Tidally averaged salinity results were then compared at D-1641 regulation stations modeled in CalSim II. Scatter plots, of tidally averaged monthly salinity with and without July – August SMSCG operations are presented in Figure 1. Salinity during the months of January – June and November – December, when modeled SMSCG operations are consistent, are shown in blue. The blue scatter points make a 1:1 line, indicating salinity results during these months are equal. Salinity during the months of July and August are shown in orange. As these points are above the 1:1 line (in blue), monthly average July and August salinity at these locations increases. Salinity results during September and October are represented as grey point. Even though SMSCG are not operating, the salinity impact of July – August operations require about two months to disperse. As changes to salinity follow a linear trend, salinity impacts of SMSCG operations are estimated with a linear regression.

The result of applying linear regressions for the month of July-September at the major regulatory locations (Jersey Point, Emmaton, Contra Costa Canal and Clifton Court) are summarized in Table 1.

Table 1. Regression Coefficients Representing Salinity Effects of SMSCG Operations

–	Jersey Point	Emmaton	Old River at Rock Slough	Clifton Court Forebay
Intercept	24.0	32.3	-46.8	-60.6
Slope	1.12	1.09	1.20	1.22

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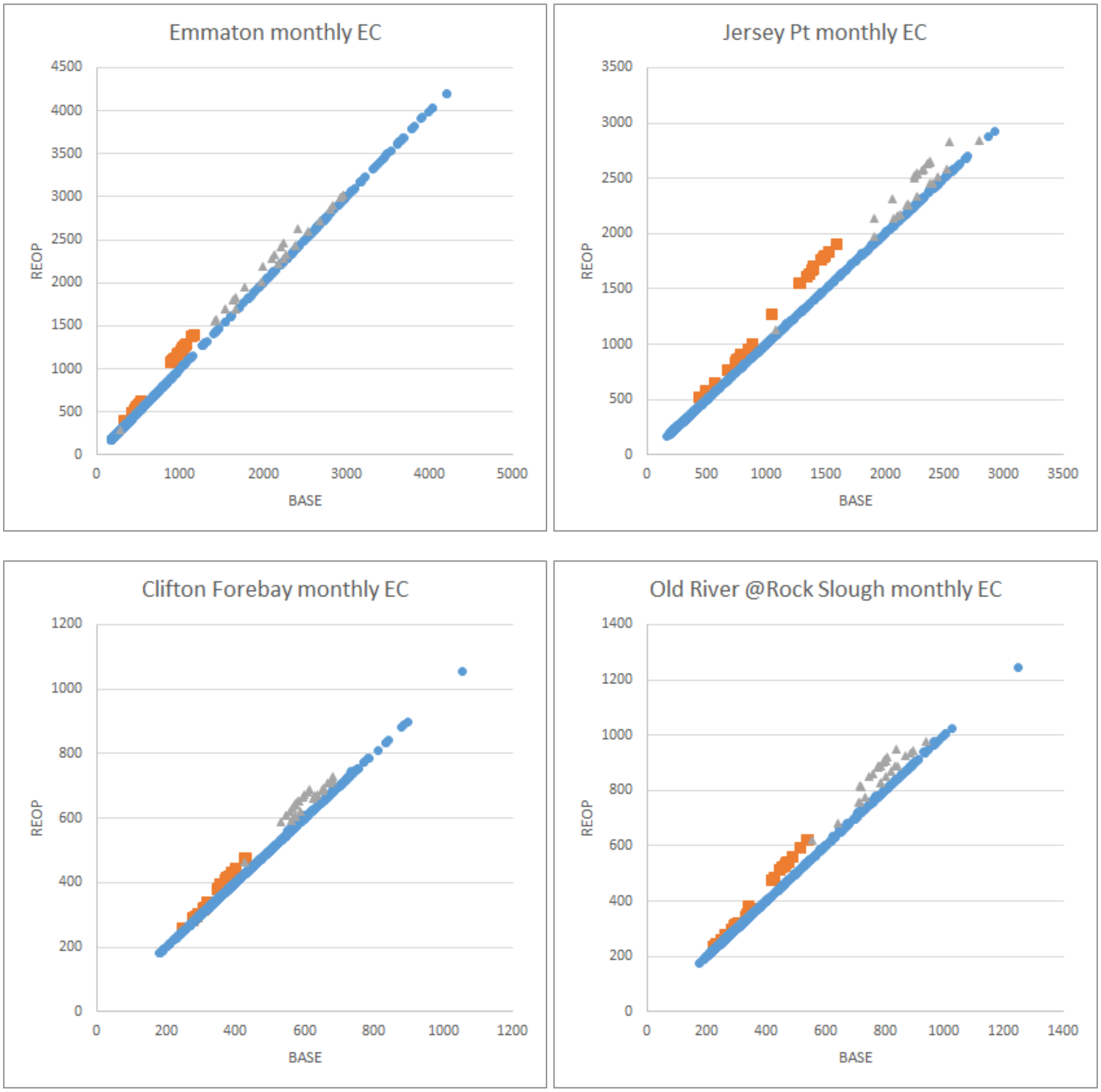

Figure 1. Scatter Plot of With and Without SMSCG Operations, Monthly Averaged EC

- orange square is for Jul-Aug, the SMSCG summer re-operation time
- grey triangle is for Sep-Oct, to show the lingering effect
- blue circles is for all the other months, when both scenarios are almost identical

3 Old and Middle River Flows

3.1 Existing

Calculations of the Net Tidal Flow in Old and Middle River (OMR) have been used in recent years as a surrogate for determining the relative influence of water project export rates on Bay-Delta aquatic species listed for Endangered Species Act protection under both Federal and State law.

The U.S. Fish and Wildlife Service and National Marine Fisheries Service issued Biological Opinions for Delta smelt and Central Valley salmonids in 2008 and 2009 (08/09 BiOps), respectively. The 08/09 BiOps included OMR restrictions to minimize potential loss of sensitive fish species due to the water project exports.

Previous Approach Used for CalSim Studies (2009 CalSim II Assumptions)

After the issuance of the 08/09 BiOps, there was a multi-agency effort to develop representations of these new criteria in CalSim II for the purpose of estimating the operations of the SWP and CVP for water supply and ~~CECA~~CEQA/NEPA processes. Many of the assumptions were based on best guesses and limited data at the time. At the time of development, it was expected that the Delta smelt would be the primary driver in the determination of the OMR for the export operations. Salmonids were expected to provide a consistent timing with the explicit onset starting January 1, but otherwise expected to be covered by the Delta smelt criteria.

The methods used in estimating the OMR requirements are detailed in "Representation of U.S. Fish and Wildlife USFWS Biological Opinion Reasonable and Prudent Alternative Actions for CalSim II Planning Studies" and "Representation of National Marine Fisheries Service Biological Opinion Reasonable and Prudent Alternative Actions for CalSim II Planning Studies" included at the end of Appendix H Attachment 1-4 Scenario Related Changes to CalSim II and DSM2.

Proposed New Approach for CalSim Studies

As part of ~~the~~ assumptions development ~~of the baseline assumptions~~ for the ~~proposed project~~Existing Conditions, previous assumptions that were developed almost 10 years ago prior to the implementation of the 08/09 BiOps, were reevaluated for consistency with current understanding of OMR management. This review is especially necessary considering a known shift in how OMR is determined in real-time for Delta smelt and a recognition that Salmonid protections have been the determining factor on setting OMR more often than originally expected.

Historical OMR determinations, as shown in Figure 2, were used to assess the general representation of the OMR in CalSim II based on assumptions developed roughly 10 years ago. As shown in the figure, there are periods with significant deviations. This comparison demonstrates the need for updated OMR assumptions for appropriate reflection of the ~~existing conditions~~Existing Conditions in the CalSim II model.

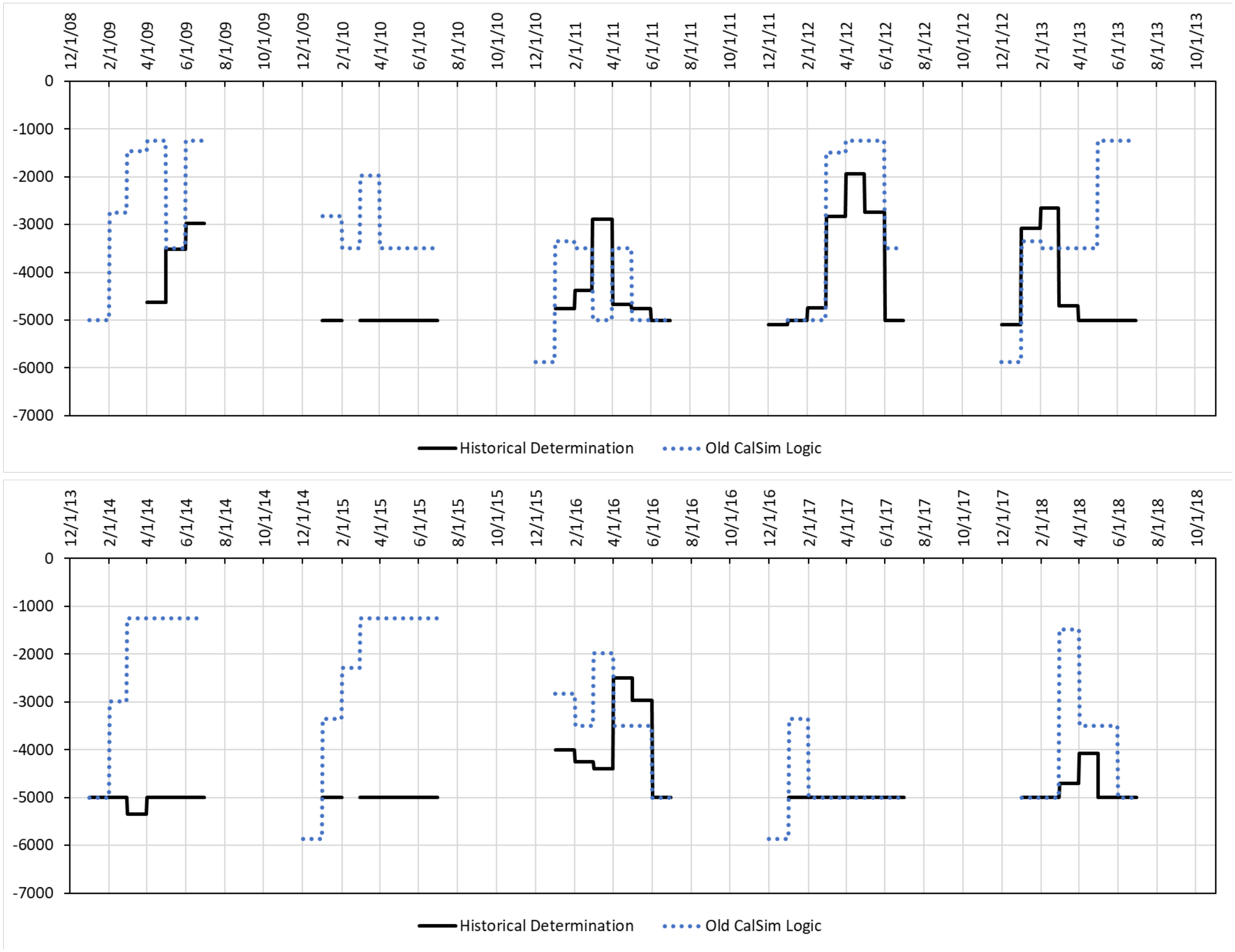

Figure 2: Comparison of the Old CalSim logic to the actual historical OMR determinations.

Method for Estimating the First Flush in CalSim for the Baseline

In modeling the ~~existing condition~~Existing Conditions, 2008 USFWS BiOp Action 1 or "First Flush" was assumed to be implemented under the following conditions:

- December when the unimpaired Sacramento River Runoff (SRR) is greater than 20,000 cfs
- January if no First Flush occurred in December and when the SRR is greater than 20,000 cfs

This action is consistent with the methodology used in the 2009 CalSim II assumptions but reduces the timeframe during which this action trigger in the model to December and January. This reduction in timeframe was based on the general understanding that the action would likely not occur after January.

Method for Estimating the Calendar based 2009 NMFS BiOp Action 4.2.3

The implementation of the 2009 NMFS BiOp Action 4.2.3 is a calendar-based OMR that begins on January 1 and ends June 30. An OMR restriction of -5,000 cfs is applied as a background level for this period.

Method for Estimating OMR for Smelt Entrainment Protection in CalSim

The 2008 USFWS BiOp Action 2 CalSim assumptions were updated from using an X2 based measure in the 2009 implementation to a turbidity-based protection measure reflecting the recent OMR determinations. As mentioned above, most recent historical OMR determinations have been based on turbidity-based indicators, rather than strictly fish presence. Instead of an X2 surrogate, this action uses a flow surrogate to indicate central Delta turbidity triggering an Adult Delta smelt entrainment protective OMR action. Old River at Bacon Island (OBI) was chosen to represent the southern part of the central Delta and to trigger an entrainment protection action.

When triggered the modeling assumes a -2,000 cfs for 5 days when the following conditions occur:

- Timeframe under which a turbidity avoidance action may occur
  - January to March – if First Flush occurs in December
  - February to March – if First Flush occurs in January or not at all
- SRR > 20,000 cfs

Like other turbidity related actions, this one requires the use of a surrogate to determine when an action is triggered. The turbidity station at OBI is in the interior Delta south of the San Joaquin River, which makes it difficult to predict with any great accuracy. However, the SRR is and has been used as a surrogate for other turbidity-based actions in CalSim II. To determine an appropriate flow level, number of days with historical daily average OBI data above 12 NTU, from 2008 to 2019, were summed for each month from January to March. The resulting number of days per month exceeding 12 NTU were compared to the SRR for the same month (Figure 3). The red line indicates the SRR value that captures most instances when daily average OBI turbidity greater than 12 NTU.

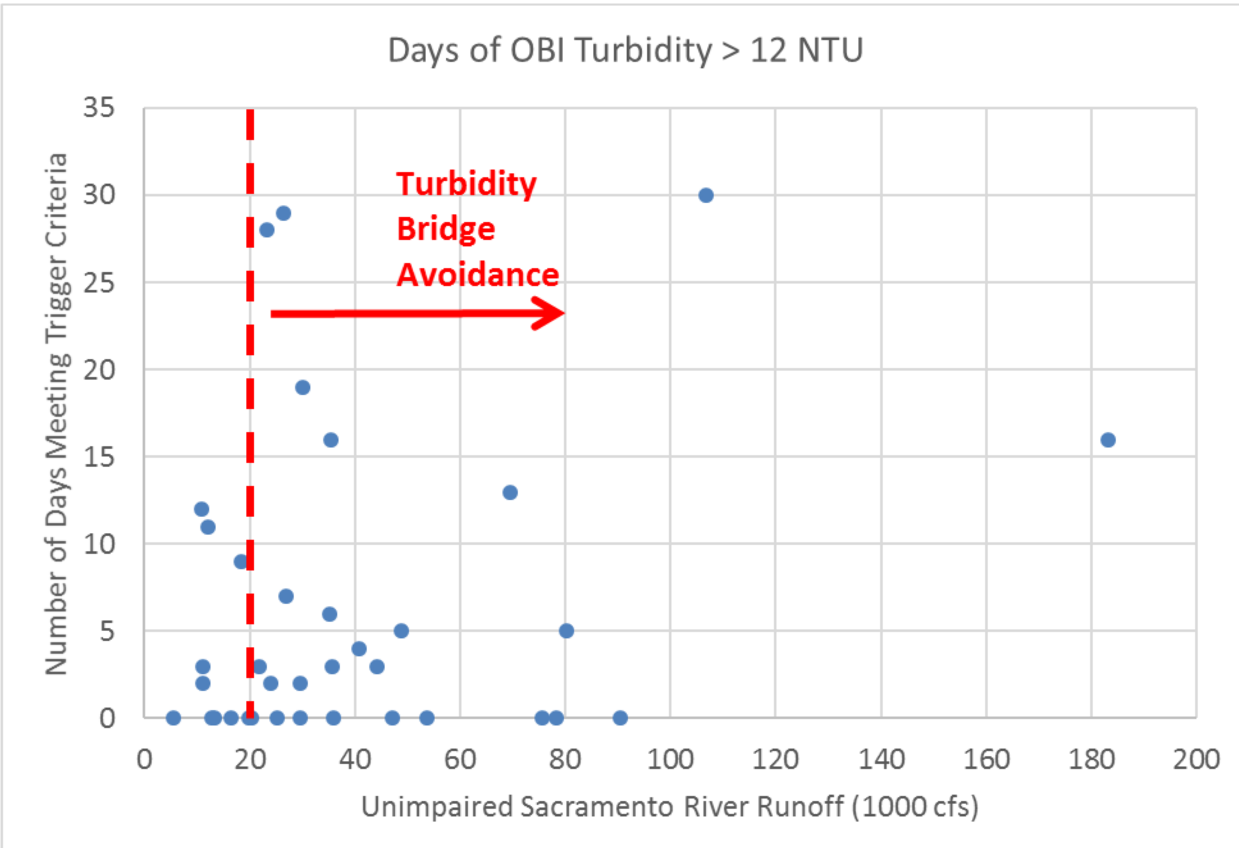

Figure 3: Relationship between Sacramento River Runoff and the number of days of turbidity at Old River at Bacon Island exceeding 12 NTU. Where the red line at an SRR of 20,000 cfs shows the rough transition point of the data.

This relationship could be stronger, but it should be recognized that because of its location, OBI turbidity is subject to many variables, including but not limited to wind driven turbidity and lower turbidity due to proactive Project operations that is embedded in the OBI turbidity data presented here, and may not be representing a true turbidity bridge formation. In general, the historic OBI turbidity data resulted in a 72% frequency of triggering an event. Using an SRR surrogate of 20,000 cfs results in a 61% triggering frequency. Given that in CalSim II the OMR requirements are applied on a monthly timestep, this is a reasonable surrogate for reflecting potential duration of this OMR action in CalSim II.

Representation of OMR due to Salvage Density in CalSim

As described above, the ~~existing conditions~~Existing Conditions modeling was updated to estimate the OMR restrictions based more on the Salmon and Steelhead density triggers rather than the larval and juvenile smelt using the location of X2 consistent with recent historical operations. Based on the historical salvage data a generalized relationship was developed and applied in all year types where:

- March assumed 3 days at Stage 1 (OMR = -3,500 cfs), and 5 days at Stage 2 (OMR = -2,500 cfs)
- April assumed 9 days at Stage 1 (OMR = -3,500 cfs)
- May assumed 5 days at Stage 1 (OMR = -3,500 cfs)

The number of days at each *Stage* were determined using salvage data for winter run, based on length at date, and for steelhead from 2010 to 2019. Daily density was determined for each species by dividing the daily fish loss by the volume of pumping at the SWP and CVP export facilities. Calculated daily densities were then compared to triggers levels, which are determined at the beginning of each year for winter run. Historical winter run trigger levels have ranged 2.5 fish/TAF to 12 fish/TAF for Stage 1 and 5 fish/TAF to 24 fish/TAF for Stage 2. Steelhead triggers were consistently 8 fish/TAF for Stage 1 and 12 fish/TAF for Stage 2.

For each triggering event, a minimum of 5 days of required OMR was assumed, but, if an event continues or another event is triggered immediately, the number of days at a specific OMR level could be greater, or could transition to another *Stage.* Table 2 reports the total number of days determined by the historic data that resulted in Stage 1, and Table 3 reports the total number of days at Stage 2.

Table 2: Number of days of OMR at Stage 1 levels based on historical salvage that exceeded the fish density triggers for Stage 1 for winter run and steelhead.

–	Jan	Feb	Mar	Apr	May	Jun
2010	0	5	0	5	2	0
2011	5	1	3	5	10	10
2012	0	5	5	10	5	0
2013	0	0	12	13	5	0
2014	0	0	0	0	0	0
2015	0	5	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	5	15	11	0
2019	0	0	0	11	0	0
Average	1	2	3	6	3	1

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Table 3: Number of days of OMR at Stage 2 levels based on historical salvage that exceeded the fish density triggers for Stage 2 for winter run and steelhead.

–	Jan	Feb	Mar	Apr	May	Jun
2010	0	0	0	0	0	5
2011	0	10	28	2	0	0
2012	0	7	26	6	0	0
2013	0	0	0	12	10	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	0	5	5	0
2019	0	0	0	0	0	0
Average	0	2	5	3	2	1

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For implementation in CalSim, the combined monthly averages for Stage 1 and Stage 2 were used to determine months with an average of 5 more days, which would indicate on average one or more triggering events occurred. Only months with combined averages over 5 were assumed in development of OMR restrictions based on salvage density. Table 4 shows the number of days assumed in the CalSim II logic for Stage 1 and Stage 2 salvage density salmonid protections.

Table 4: Resulting number of days for each trigger stage assumed in the CalSim model under the Existing Conditions.

–	Jan	Feb	Mar	Apr	May	Jun
Stage 1 (-3,500 cfs)	0	0	3	9	5	0
Stage 2 (-2,500 cfs)	0	0	5	0	0	0

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Rollup of OMR Methodology in CalSim

Implementation of the updated assumptions in CalSim, as described above, better represent both the fish species that has been dictating the OMR requirements as well as the restriction level under the recent historic conditions. Figure 4 compares the updated CalSim assumptions to both the historical OMR requirements and the previous (old) CalSim assumptions used in CalSim, where the updated logic appears to better represent the actual historical determinations better.

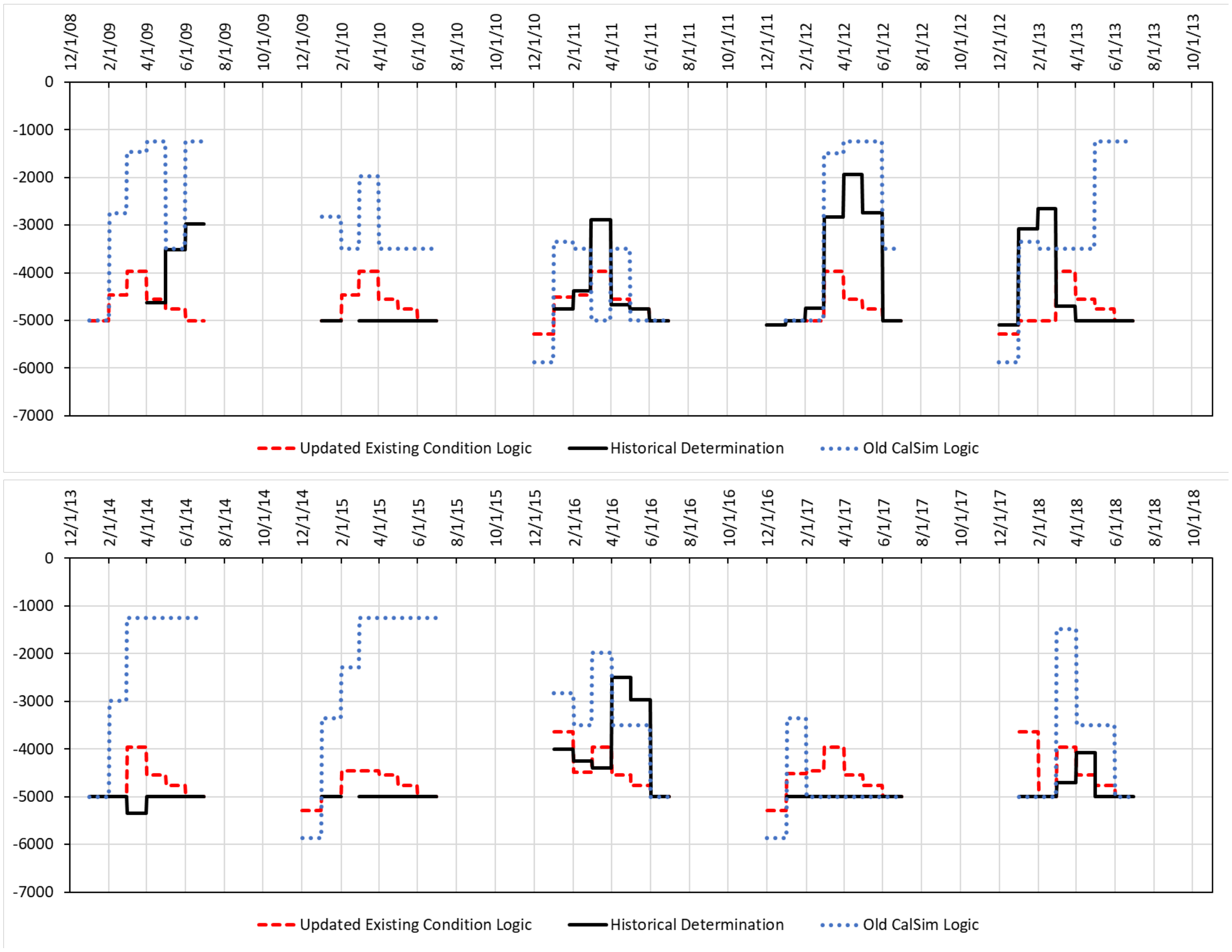


Figure 4: Comparison of the Updated CalSim logic to the actual historical OMR determinations and the Old CalSim logic.

3.2 Proposed Project

The following OMR criteria were implemented in the Proposed Project CalSim II model.

Integrated Early Winter Pulse Protection (First Flush) Trigger and Criteria

In modeling the ~~proposed project~~Proposed Project, the Integrated Early Winter Pulse Protection or "First Flush" (described in Section 3.3.1 of the main document) was assumed to be implemented under the following conditions:

- December when the unimpaired Sacramento River Runoff (SRR) is greater than 20,000 cfs
- January if no First Flush occurred in December and when the SRR is greater than 20,000 cfs

The First Flush action is assumed to restrict OMR to -2,000 cfs for 14 days. Since CalSim utilizes a monthly timestep this 14 day action is implemented using a weighted average with a background level. For December the background level is -8,000 cfs and for January the background level is -5,000 cfs.

These assumptions were developed using Sacramento River at Freeport flow and turbidity data from 2008 to 2019. In addition, turbidity data from Sacramento River at Hood was used to fill-in and confirm turbidity data at Freeport. Since the first flush is limited to the December to January period, the data analyzed was also limited to this timeframe. Turbidity is a parameter that is not simulated in CalSim, and so a flow surrogate was used and consistent with past practice. The SRR represents the unimpaired flow from the major tributaries to the Sacramento River. As shown in Figure 5 the approximate transition where Freeport flow and turbidity levels would trigger a first flush is around an SRR of about 20,000 cfs.

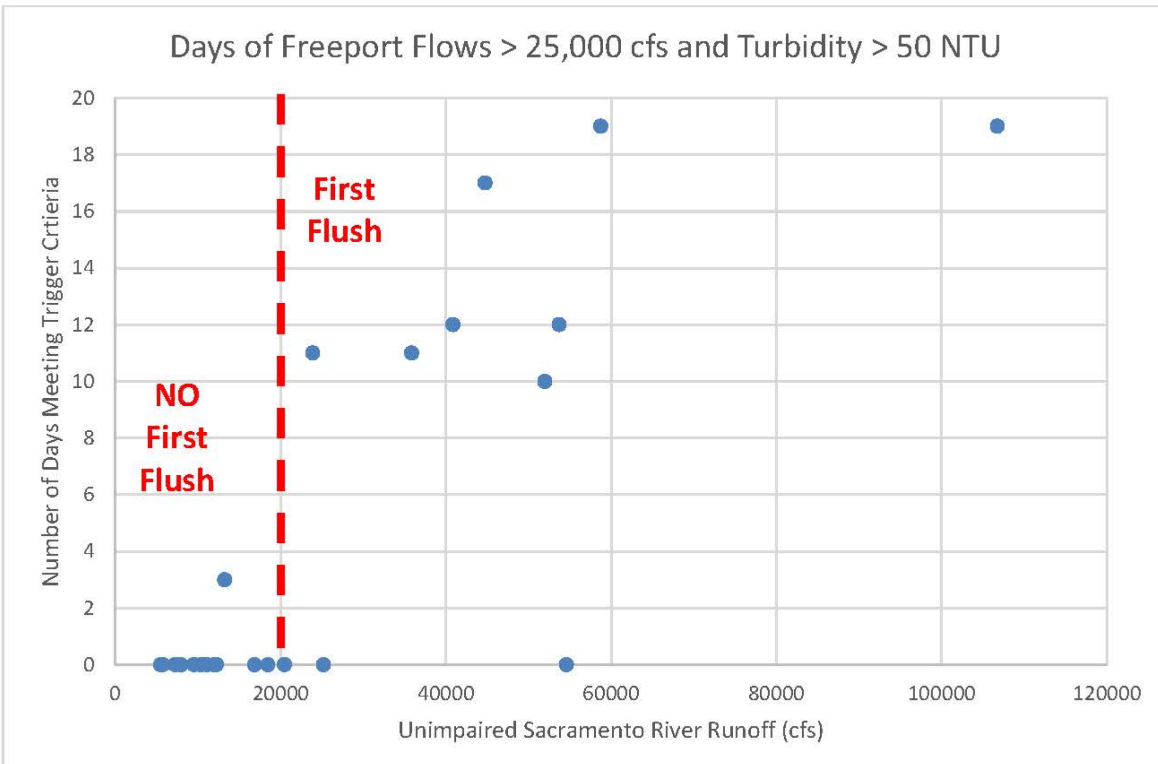
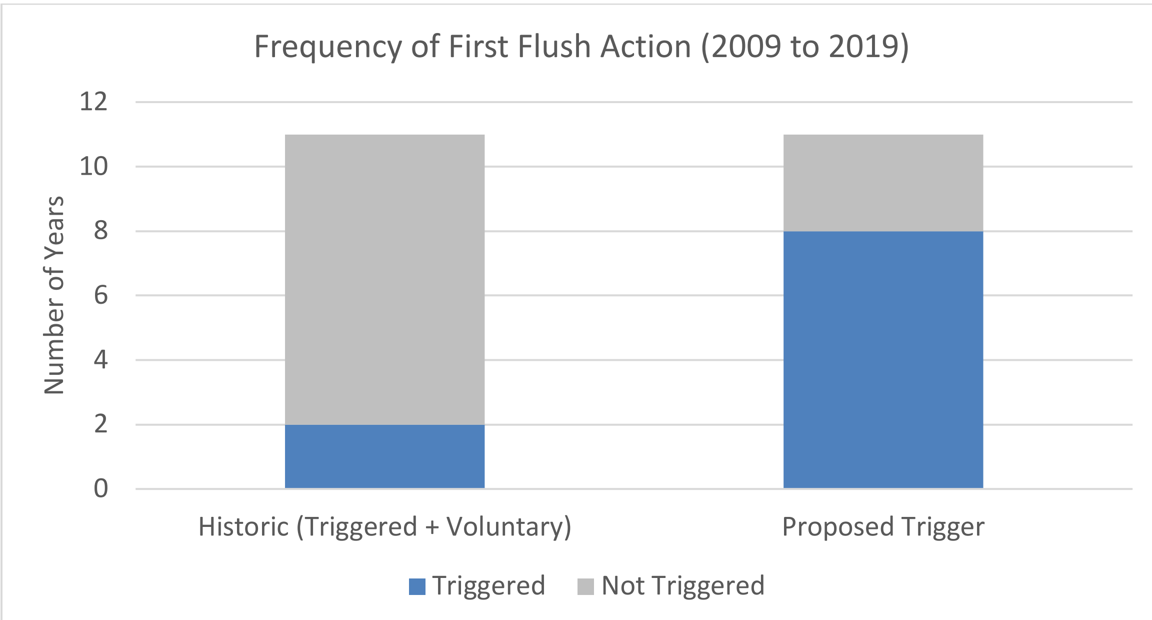


Figure 5: Relationship between Sacramento River Runoff and the flow and turbidity at Freeport exceeding 25,000 cfs and 50 NTU.

Using the SRR is consistent with what was used in the modeling of the Existing Condition which represents a different triggering criterion – Section 3.1 of this attachment describes how the assumptions for the Existing Conditions were developed). As described, the Existing Condition modeling uses an SRR of 20,000 cfs as a surrogate of reaching 12 NTU in the interior Delta. Even though these separate analyses have indicated similar levels of SRR to represent the triggering of the First Flush, the action in the Proposed Project is expected to be triggered more often. Evaluating the historical First Flush actions from the 2008/2009 BiOps (water years 2009 to 2019) has shown that the action was only triggered once, in 2013. However, there was an additional period where the Projects proactively took an action before a trigger could occur, and so in the 11 years of historical operations, the First Flush conditions, as described by the action in the Existing Conditions, occurred twice. Under the newer definition using flow and turbidity at Freeport, this would occur much more frequently. Figure 6 shows that the frequency of the First Flush occurring increases from roughly 20% under Existing Conditions to over 70% with the Proposed Project.



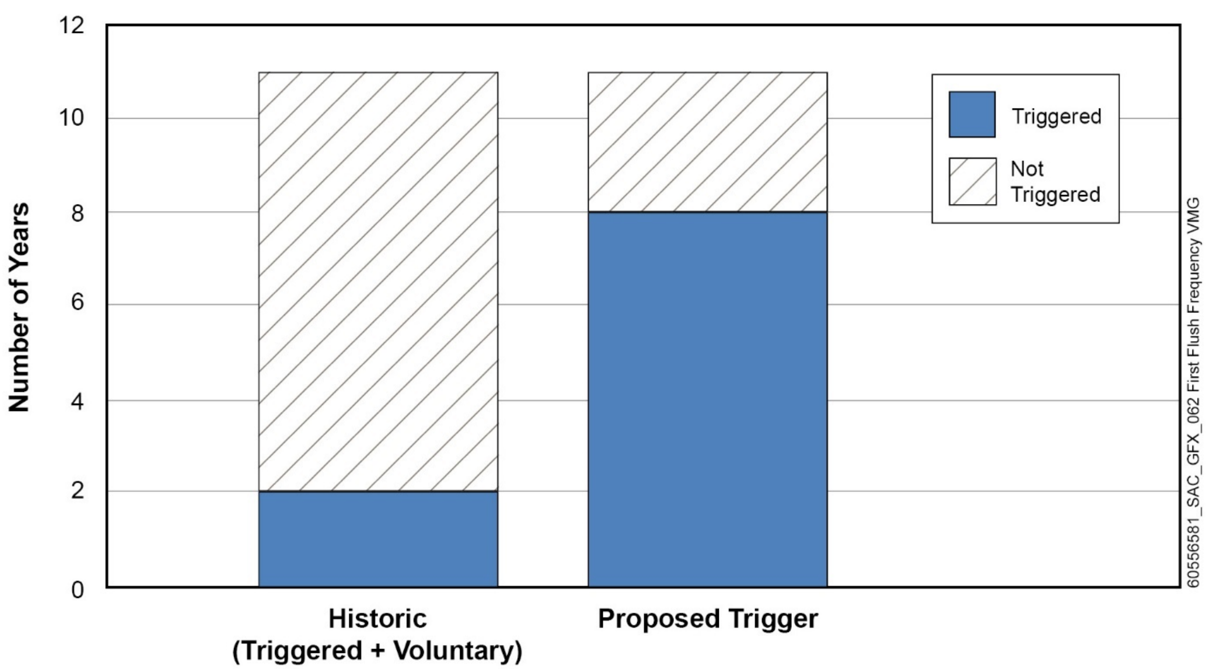


Figure 6: Comparison of the historical triggering of the First Flush action under the 2008/2009 BiOps and the new proposed triggering under the Proposed Project.

It is important to note, that the CalSim assumptions between the Existing Condition and the Proposed Project are the same, however as shown in Figure 6, the frequency of triggering the First Flush action is expected to be higher under the Proposed Project.

Turbidity Bridge Avoidance Trigger and Criteria

In modeling the ~~proposed project~~Proposed Project, the turbidity bridge avoidance (described in Section 3.3.1 of the main document) was assumed to apply an additional OMR requirement of -2,000 cfs for 5 days when the following conditions occur:

- Timeframe under which a turbidity avoidance action may occur
  - January to March – if First Flush occurs in December
  - February to March – if First Flush occurs in January or not at all
- SRR > 20,000 cfs

Like other turbidity related actions, this one requires the use of a surrogate to determine when an action is triggered. The turbidity station at Old River at Bacon Island (OBI) is in the interior Delta south of the San Joaquin River, which makes it difficult to predict with any great accuracy. However, the SRR is and has been used for other turbidity based actions. Using historical OBI data from 2008 to 2019, daily average values above 12 NTU were summed for months January to March. The resulting number of days per month exceeding 12 NTU were compared to the SRR for the same month (Figure 7). The red line indicates the rough transition point using the SRR.

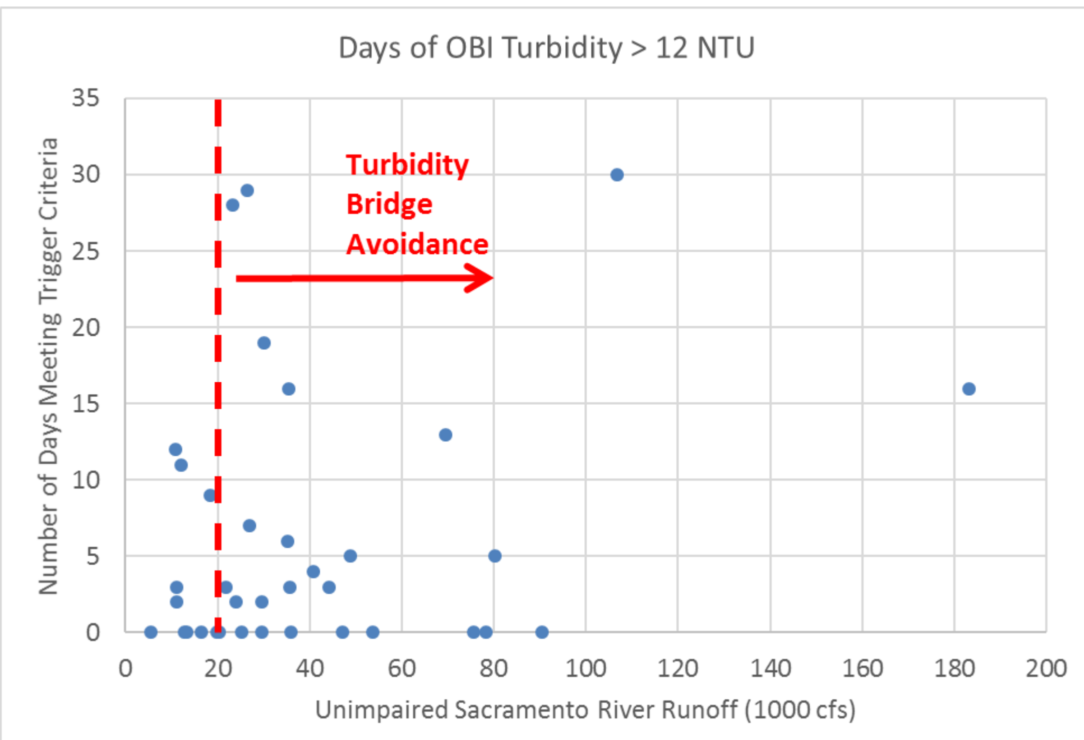


Figure 7: Monthly Comparison of Number of Days in Month Exceeding 12 NTU at OBI and SRR

This relationship could be stronger, but it should be recognized that because of its location, OBI, is subject to many variables, including but not limited to wind driven turbidity and lower turbidity due to proactive Project operations that is embedded in the data. In general, the historic data resulted in a 72% frequency of a triggering event. Using an SRR surrogate of 20,000 cfs results in a 61% triggering frequency.

OMR Flex Trigger and Criteria

In modeling the ~~proposed project~~Proposed Project, OMR Flex (described in Section 3.3.1 of the main document) was assumed to be implemented under the following conditions:

- Wet water years – no OMR flex was assumed,
- Above normal and below normal water years – 7 days at -6,000 cfs in January and February,
- Dry water years – 7 days at -6,000 cfs in either January or February, and
- Critical water years – no OMR flex was assumed.

These assumptions were developed using historical data from 2009 to 2018 were used to develop a generalized OMR flex implementation in the CalSim model. There are many conditions which need to be met before an OMR flex can occur, however not all conditions are available in the historical data. For estimating the OMR flex in the model the following data and conditions were used:

- Excess condition – Daily historical determinations of excess conditions was used to indicate periods where the first condition under which OMR flex may occur,
- First Flush not occurring – the method for estimating first flush in CalSim (described above) was used to determine periods where a first flush was not occurring,
- Turbidity bridge avoidance not occurring – the method for estimating turbidity avoidance in CalSim (described above was used to determine periods where a turbidity bridge avoidance action was not occurring.
- Salvage threshold not occurring – the method for estimating salvage threshold triggers in CalSim (described above) was used to determine periods when a salvage threshold trigger would not have been active.
- No other risk fishery related concerns – to address the potential for other fishery related concerns, the historical OMR level more negative than -4,000 cfs was assumed, for this purpose, to indicate the low general risk to fish and capture the other conditions described in described in Section 3.3.1 of the main document.

If all conditions above were met, then OMR flex was assumed to be possible. Table 5 reports the number of days that were determined to have potential for OMR flex using the method described.

Table 5: Number of days in each month and water year that had the potential for OMR flex.

Year	Dec	Jan	Feb	Mar	Apr	May	Jun
2009	0	0	7	20	2	0	0
2010	0	1	0	0	0	3	28
2011	17	22	8	0	0	0	23
2012	0	24	0	0	0	14	0
2013	2	3	6	12	0	0	0
2014	0	0	6	13	11	0	0
2015	5	3	15	5	0	0	0
2016	0	9	9	23	0	0	0
2017	8	1	5	0	0	0	23
2018	0	31	11	6	0	0	0

Further aggregating the estimated OMR flex days into a generalized CalSim representation, the water years were consolidated into two groups of 1) wet, above normal, and below normal, and 2) dry and critical. These groups roughly split the available water years into six samples and four samples respectively. Table 6 shows the results of the water year grouping.

Table 6: Average number of days with potential OMR flex, grouped by critical and dry water years and wet, above normal, and below normal water years. Based on historical analysis of water years 2009 to 2018.

Condition	Dec	Jan	Feb	Mar	Apr	May	Jun
C & D	2	2	9	13	3	0	0
W, AN & BN	4	15	6	5	0	3	12

Table 6 was used to further develop the generalized assumptions for CalSim. The timeframe of OMR flex for modeling purposes was limited to January and February because December in the model would only be activated with a first flush event which would eliminate the ability for OMR flex. Months later in the spring were also not included because of the potential for additional OMR due to larval and juvenile Delta smelt and longfin smelt. In addition, as Table 5 (the annual one) indicates, there is considerable variability in the potential OMR flex days and so for the CalSim implementation only above normal, below normal and dry years were assumed to utilize OMR flex.

Salvage Loss Thresholds Trigger and Criteria

The Proposed Project includes real-time OMR management actions based on percent of Winter-Run Chinook Salmon and Central valley Steelhead salvaged relative to proposed Single Year Loss Thresholds (described in Section 3.3.1 of the main document). The proposed Single Year Loss Thresholds were based on the 90% of the greatest loss observed for each species during water years 2010 through 2018. For Winter-Run loss thresholds were identified for Dec – Mar period. For steelhead, separate loss thresholds were identified for Dec – Mar and Apr – Jun. In modeling the proposed project, the real-time OMR management based on Single Year Loss Thresholds was assumed to be implemented as follows:

- In March and April of wet, above-normal, below-normal and dry years, it is assumed that the 50% of the proposed single year loss thresholds for one or more of the species will be exceeded, which triggers an OMR flow requirement of -3,500 cfs.

Historic salvage data at the fish facilities at Banks and Jones Pumping Plants and fish catch data at Chipps Island trawl during water years 2010 – 2018 were analyzed. Historic salvage data provides the potential timing of triggering the 50% and 75% levels of the proposed single year loss thresholds. The Chipps Island catch data provides the migration timing and estimates for when the 95% of Winter-Run and Steelhead have migrated out of the Delta, which is the proposed offramp for the real-time OMR management for these species.

Figures 8, 9 and 10 show the historical loss of Winter-Run, Steelhead for Dec – Mar and Steelhead for April – Jun, respectively. The historical loss in the figures is expressed as a percent of the proposed single year loss threshold values. Figure 11 and 12 show the migration timing based on the fish catch data at the Chipps Island trawls for Winter-Run and Steelhead. Information from Figures 8 through 12 is summarized below in Table 7, which shows the timing of when 50% and 75% of the proposed loss thresholds are triggered for water years 2010 through 2018, and when 95% of listed salmonid species are estimated to leave the Delta.

The information summarized in Table 7 was used to select the generalized assumptions for implementation of real-time management based on Single Year Loss Thresholds CalSim. It is important to recognize that the historical salvage and fish distribution data are reflective historical hydrologic and environmental conditions and not necessarily reflect of future conditions. However, since the proposed operations are tied to the historical loss at the SWP and CVP pumping facilities, it is appropriate to use historical data to estimate the generalized assumptions for use in CalSim in this case.

Table 7: Historical timing of natural Winter-Run and Steelhead loss at SWP and CVP south Delta pumping facilities. 50% and 75% losses are percentages of "90% of maximum annual loss during 2010-2018 period" – Table 7a – 7b.

WY	WYT	50% Dec-Mar Loss Timing	75% Dec-Mar Loss Timing	95% past Chipps
2010	BN	--	--	May
2011	W	Feb 16 - 28	Mar 1 - 15	May
2012	BN	Mar 1 - 15	Mar 16 - 31	May
2013	D	--	--	May
2014	C	--	--	May
2015	C	--	--	May
2016	BN	--	--	May
2017	W	--	--	May
2018	BN	--	--	May

Table 7b: Historical timing of natural Steelhead loss at SWP and CVP south Delta pumping facilities. 50% and 75% losses are percentages of "90% of maximum annual loss during 2010-2018 period".

WY	WYT	50% Dec-Mar Loss Timing	75% Dec-Mar Loss Timing	50% Apr-Jun Loss Timing	75% Apr-Jun Loss Timing	95% past Chipps
2010	BN	Feb	Mar	--	--	May
2011	W	Mar	--	May	Jun	Apr
2012	BN	Mar	--	--	--	Apr
2013	D	Mar	--	May	Jun	Apr
2014	C	--	--	--	--	May
2015	C	--	--	--	--	Apr
2016	BN	--	--	--	--	Mar
2017	W	--	--	--	--	Apr
2018	BN	Mar	Mar	Apr	Apr	May

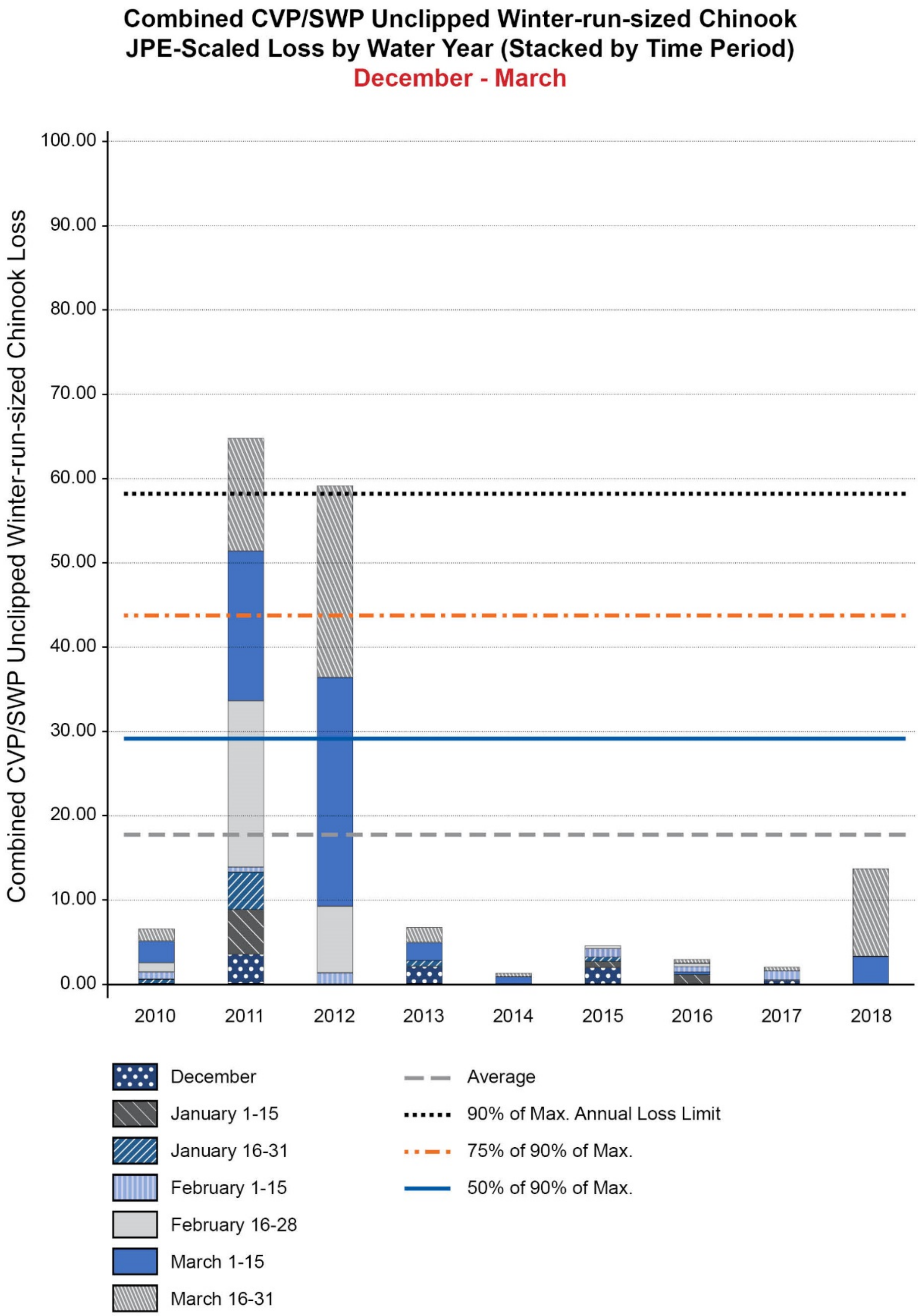


Figure 8: Combined CVP/SWP unclipped winter-run-sized Chinook loss, as a percentage of the winter-run Juvenile Production Estimate (JPE), for WY 2010 through WY 2018. Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management. (Source: July 2019 ROC Peer Review Draft NMFS Biological Opinion)

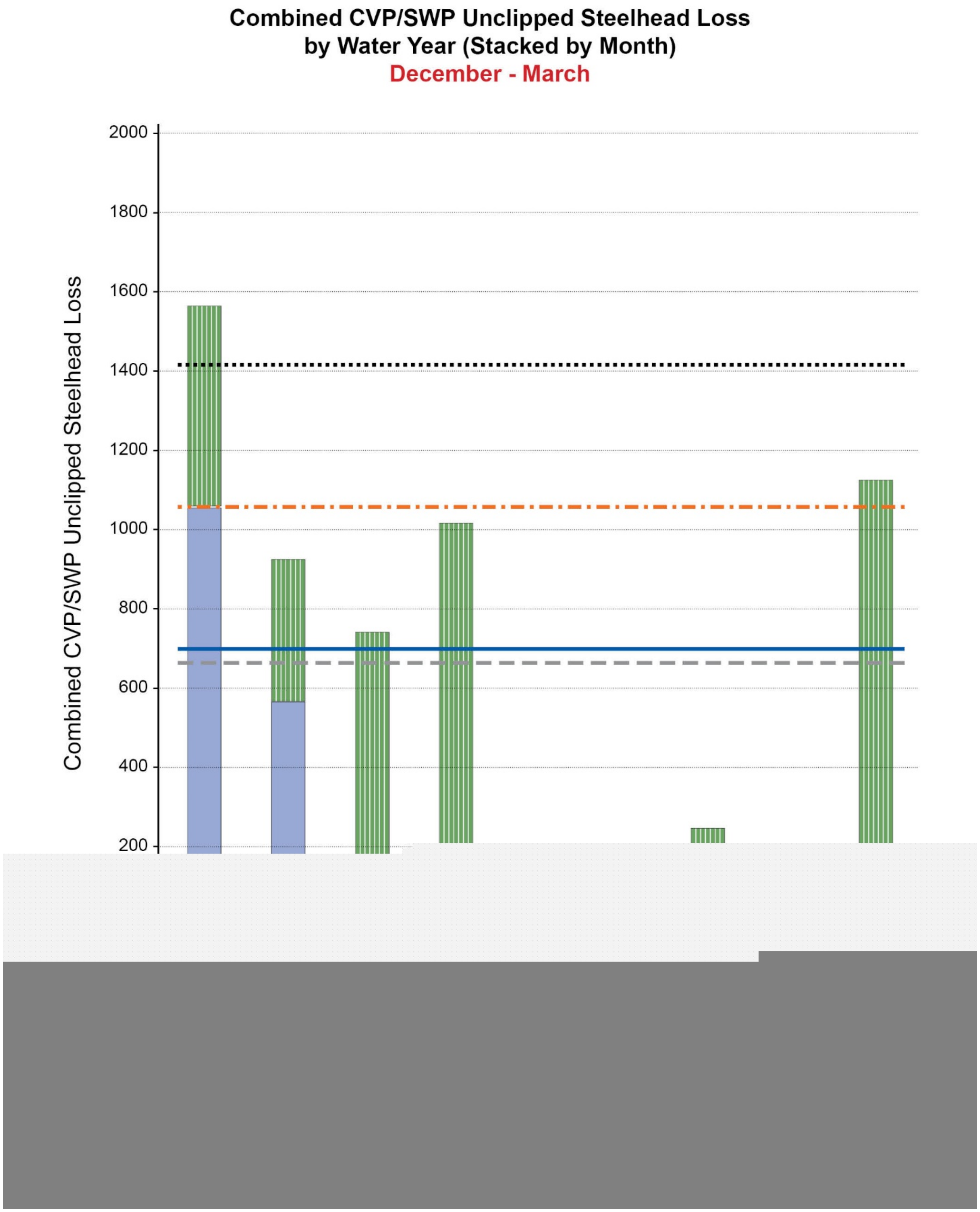


Figure 9: Combined CVP/SWP wild steelhead loss for WY 2010 through WY 2018. Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management. (Source: July 2019 ROC Peer Review Draft NMFS Biological Opinion)

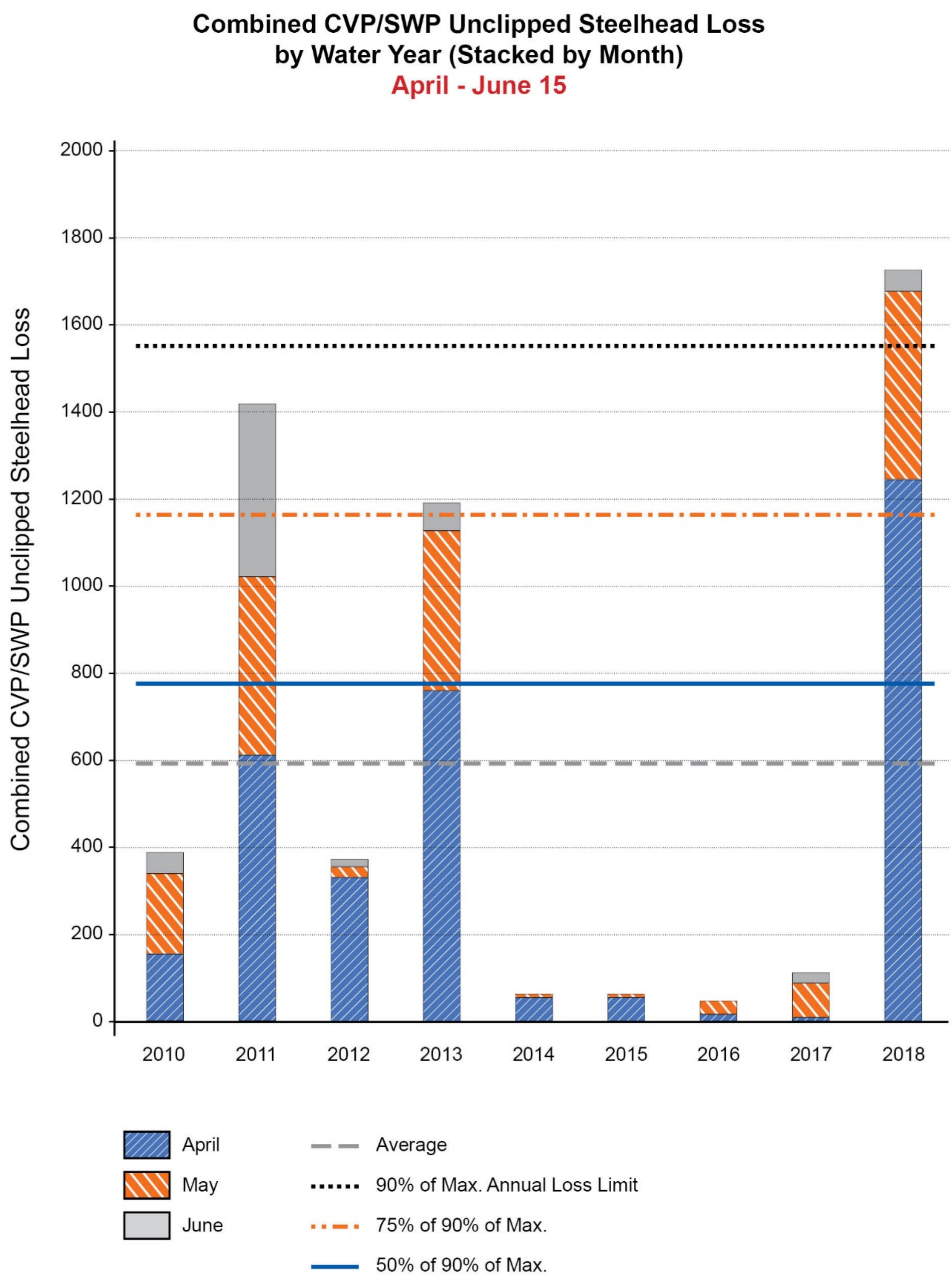


Figure 10: Combined CVP/SWP wild steelhead loss for WY 2010 through WY 2018. Bars represent cumulative loss from April through June 15, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management. (Source: July 2019 ROC Peer Review Draft NMFS Biological Opinion)

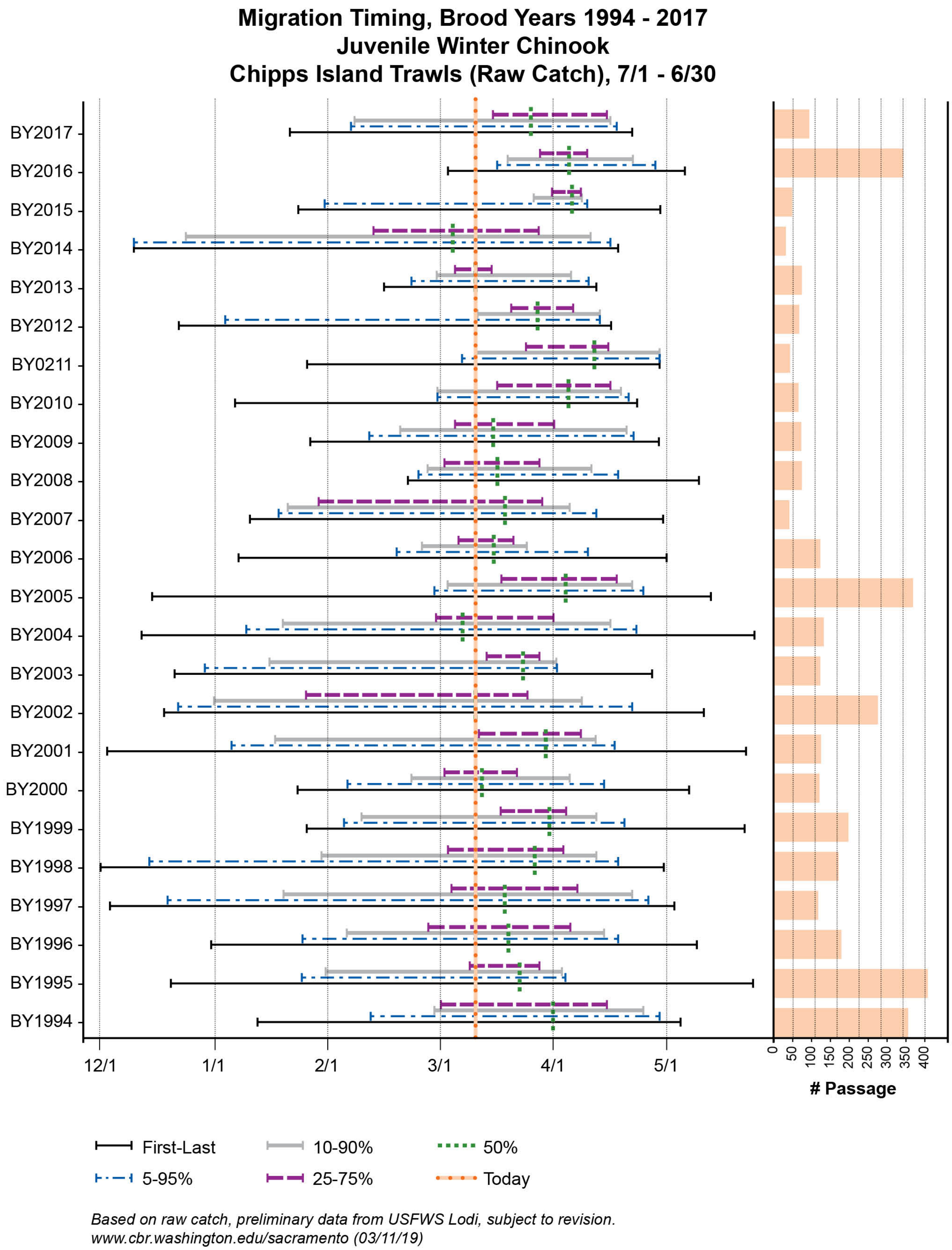


Figure 11: Juvenile winter-run Chinook salmon migration timing past the Chipps Island Trawl location for Brood Years 1994-2017 or Water Years 1995-2018. (Source: January 2019 ROC BA Appendix F)

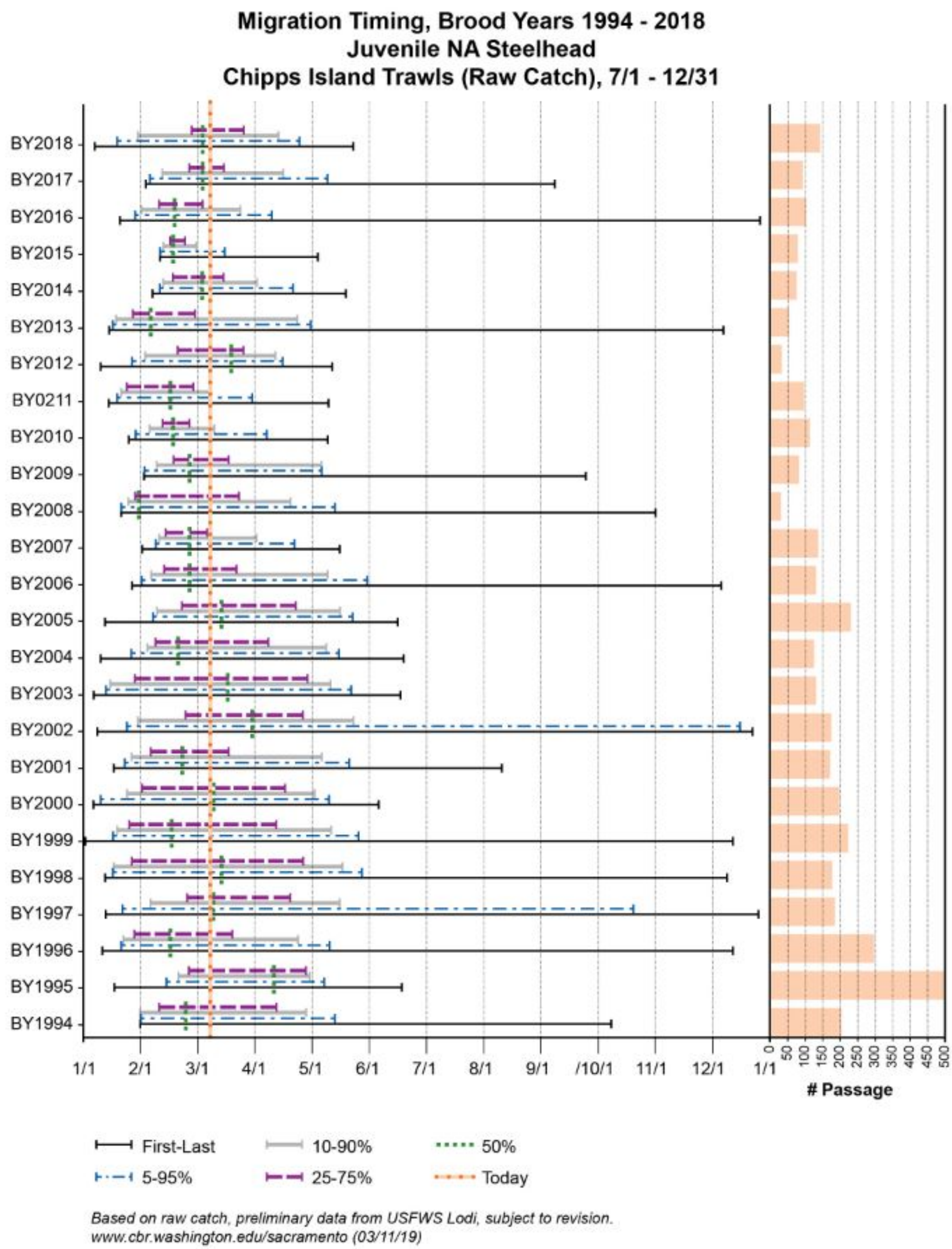


Figure 12: Juvenile unclipped CCV steelhead migration timing past the Chipps Island Trawl location for Brood Years 1994-2017 or Water Years 1995-2018. (Source: January 2019 ROC BA Appendix F)

3.3 Refined Alternative 2b

The following OMR criteria were implemented in the Refined Alternative 2b CalSim II model.

Integrated early winter pulse protection (first flush) trigger and criteria

Same as the Proposed Project.

Turbidity bridge avoidance trigger and criteria

Same as the Proposed Project.

OMR flex trigger and criteria

In modeling the Refined Alternative 2b, OMR Flex (described in Section 3.3.1 of the main document) was assumed to be implemented under the following conditions:

- Wet water years – no OMR flex was assumed,
- Above normal and below normal water years – 6 days at -6,250 cfs in January and February,
- Dry water years – 6 days at -6,250 cfs in either January or February, and
- Critical water years – no OMR flex was assumed.

Assumptions were developed based on the information provided in the "OMR flex trigger and criteria" sub-section of Section 3.2, "Proposed Project," of this attachment. These OMR flex modeling assumptions were revised to better reflect the OMR flex description in Chapter 3.3.1, "OMR Management," of the main document. Therefore, Refined Alternative 2b OMR flex assumptions slightly differ from Proposed Project OMR flex assumptions.

As opposed to 7 days of OMR flexibility action under the Proposed Project, OMR flexibility action under the Refined Alternative 2b occurs for 6 days. Appendix H Attachment 2-4 presents a sensitivity analysis of OMR flexibility actions under the Proposed Project.

Although historical data indicate that OMR flexibility may occur for more than 6 days (Table 5), these data are representative of operations under the Existing Conditions. It should be noted that the Existing Conditions do not operate to the OMR flexibility action. Delta flows and water quality would dynamically respond to the OMR flexibility action, amongst other operations of the Refined Alternative 2b. It is expected that the onset of the OMR flexibility action would draw more turbid water to Old and Middle Rivers, increasing turbidity at Old River at Bacon Island (OBI). Per Turbidity Bridge Avoidance, discussed in Chapter 3.3.1, "OMR Management," OBI turbidity cannot exceed 12 NTU. Therefore, to meet Turbidity Bridge Avoidance, the OMR flexibility action would conclude.

A wide variation of OMR flexibility days is presented in Table 5. With assumptions described above, the number of potential OMR flexibility days is expected to decrease, especially in months with a high number of OMR flexibility days (e.g. January 2012). Given the expected conditions under Refined Alternative 2b, long-term average of the OMR flexibility action is assumed to occur for 6 days.

Salvage loss thresholds trigger and criteria

Same as the Proposed Project.

4 Referenced Material

Representation of U.S. Fish and Wildlife USFWS Biological Opinion Reasonable and Prudent Alternative Actions for CalSim II Planning Studies

The U.S. Fish and Wildlife Services's (USFWS) Delta Smelt Biological Opinion (BiOp) was released on December 15, 2008, in response to the U.S. Bureau of Reclamation's (Reclamation) request for formal consultation with the USFWS on the coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP) in California.

To develop CalSim II modeling assumptions for reasonable and prudent alternative actions (RPA) documented in this BiOp, the California Department of Water Resources (DWR) led a series of meetings that involved members of fisheries and project agencies. The purpose for establishing this group was to prepare the assumptions and CalSim II implementations to represent the RPAs in Existing and Future Condition CalSim II simulations for future planning studies.

This memorandum summarizes the approach that resulted from these meetings and the modeling assumptions that were laid out by the group. The scope of this memorandum is limited to the December 15, 2008 BiOp. Unless otherwise indicated, all descriptive information of the RPAs is taken from Appendix B of the BiOp.

Table 5.A.A.6-1 lists the participants that contributed to the meetings and information summarized in this document.

The RPAs in the USFWS's BiOp are based on physical and biological phenomena that do not lend themselves to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPAs. The group believes the logic put into CalSim II represents the RPAs as best as possible at this time, given the scientific understanding of environmental factors enumerated in the BiOp and the limited historical data for some of these factors.

Table 5.A.A.6-1 Meeting Participants

Aaron Miller/DWR Steve Ford/DWR Randi Field/Reclamation Gene Lee/Reclamation Lenny Grimaldo/Reclamation	Derek Hilts/USFWS Steve Detwiler/USFWS Matt Nobriga/CDFW Jim White/CDFW Craig Anderson/NMFS
Parviz Nader-Tehrani/DWR Erik Reyes/DWR Sean Sou/DWR	Robert Leaf/CH2M HILL Derya Sumer/CH2M HILL

Notes:
CDFW = California Department of Fish and Wildlife
NMFS = National Marine Fisheries USFWS

The simulated Old and Middle River (OMR) flow conditions and CVP/SWP Delta export operations, resulting from these assumptions, are believed to be a reasonable representation of conditions expected to prevail under the RPAs over large spans of years (refer to CalSim II modeling results for more details on simulated operations). Actual OMR flow conditions and Delta export operations will differ from simulated operations for numerous reasons, including having near real-time knowledge and/or estimates of turbidity, temperature, and fish spatial distribution that are unavailable for use in CalSim II over a long period of record. Because these factors and others are believed to be critical for smelt entrainment risk management, the USFWS adopted an adaptive process in defining the RPAs. Given the relatively generalized representation of the RPAs, assumed for CalSim II modeling, much caution is required when interpreting outputs from the model.

Action 1: Adult Delta Smelt Migration and Entrainment (RPA Component 1, Action 1 –First Flush)

Action 1 Summary:

Objective: A fixed duration action to protect pre-spawning adult delta smelt from entrainment during the first flush, and to provide advantageous hydrodynamic conditions early in the migration period.

Action: Limit exports so that the average daily Combined OMR flow is no more negative than -2,000 cubic feet per second (cfs) for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25%).

Timing:

Part A: December 1 to December 20 – Based upon an examination of turbidity data from Prisoner's Point, Holland Cut, and Victoria Canal and salvage data from CVP/SWP (see below), and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, the Fall Midwater Trawl Survey (FMWT), and river flows; the Smelt

Working Group (SWG) may recommend a start date to the USFWS. The USFWS will make the final determination.

Part B: After December 20 – The action will begin if the 3-day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTU). However the SWG can recommend a delayed start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment.

Triggers (Part B):

Turbidity: Three-day average of 12 NTU or greater at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal.

OR

Salvage: Three days of delta smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value ≥ 0.5 (daily delta smelt salvage > one-half prior year FMWT index value).

The window for triggering Action 1 concludes when either off-ramp condition described below is met. These off-ramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered, unless the USFWS concludes on the basis of the totality of available information that Action 2 should be implemented instead.

Off-ramps:

Temperature: Water temperature reaches 12 degrees Celsius (°C) based on a three station daily mean at the temperature stations: Mossdale, Antioch, and Rio Vista

OR

Biological: Onset of spawning (presence of spent females in the Spring Kodiak Trawl Survey [SKT] or at Banks or Jones).

Action 1 Assumptions for CalSim II Modeling Purposes:

An approach was selected based on hydrologic and assumed turbidity conditions. Under this general assumption, Part A of the action was never assumed because, on the basis of historical salvage data, it was considered unlikely or rarely to occur. Part B of the action was assumed to occur if triggered by turbidity conditions. This approach was believed to tend to a more conservative interpretation of the frequency, timing, and extent of this action. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25% of the monthly criteria).

Timing: If turbidity-trigger conditions first occur in December, then the action starts on December 21; if turbidity-trigger conditions first occur in January, then the action starts on January 1; if turbidity-trigger conditions first occur in February, then the action starts on February 1; and if turbidity-trigger conditions first occur in March, then the action starts on March 1. It is assumed that once the action is triggered, it continues for 14 days.

Triggers: Only an assumed turbidity trigger that is based on hydrologic outputs was considered. A surrogate salvage trigger or indicator was not included because there was no way to model it.

Turbidity: If the monthly average unimpaired Sacramento River Index (four-river index: sum of Sacramento, Yuba, Feather, and American Rivers) exceeds 20,000 cfs, then it is assumed that an event, in which the 3-day average turbidity at Hood exceeds 12 NTU, has occurred within the month. It is assumed that an event at Sacramento River is a reasonable indicator of this condition occurring, within the month, at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal.

A chart showing the relationship between turbidity at Hood (number of days with turbidity is greater than 12 NTU) and Sacramento River Index (sum of monthly flow at four stations on the Sacramento, Feather, Yuba and American Rivers, from 2003 to 2006) is shown on Figure 5.A.A.6-1. For months when average Sacramento River Index is between 20,000 cfs and 25,000 cfs a transition is observed in number of days with Hood turbidity greater than 12 NTU. For months when average Sacramento River Index is above 25,000 cfs, Hood turbidity was always greater than 12 NTU for as many as 5 days or more within the month in which the flow occurred. For a conservative approach, 20,000 cfs is used as the threshold value.

Salvage: It is assumed that salvage would occur when first flush occurs.

Off-ramps: Only temperature-based off-ramping is considered. A surrogate biological off-ramp indicator was not included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought for use as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (see Figure 5.A.A.6-2). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, estimated daily water temperatures are estimated from the 82-year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CalSim. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure 5.A.A.6-2.

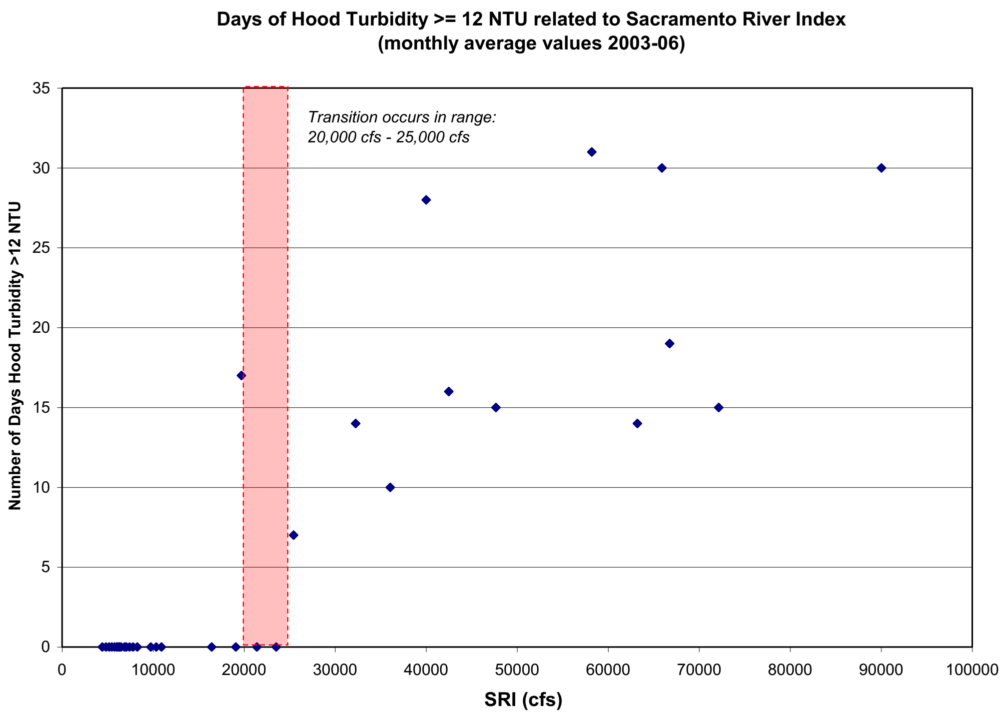


Figure 5.A.A.6-1 Relationship between Turbidity at Hood and Sacramento River Index

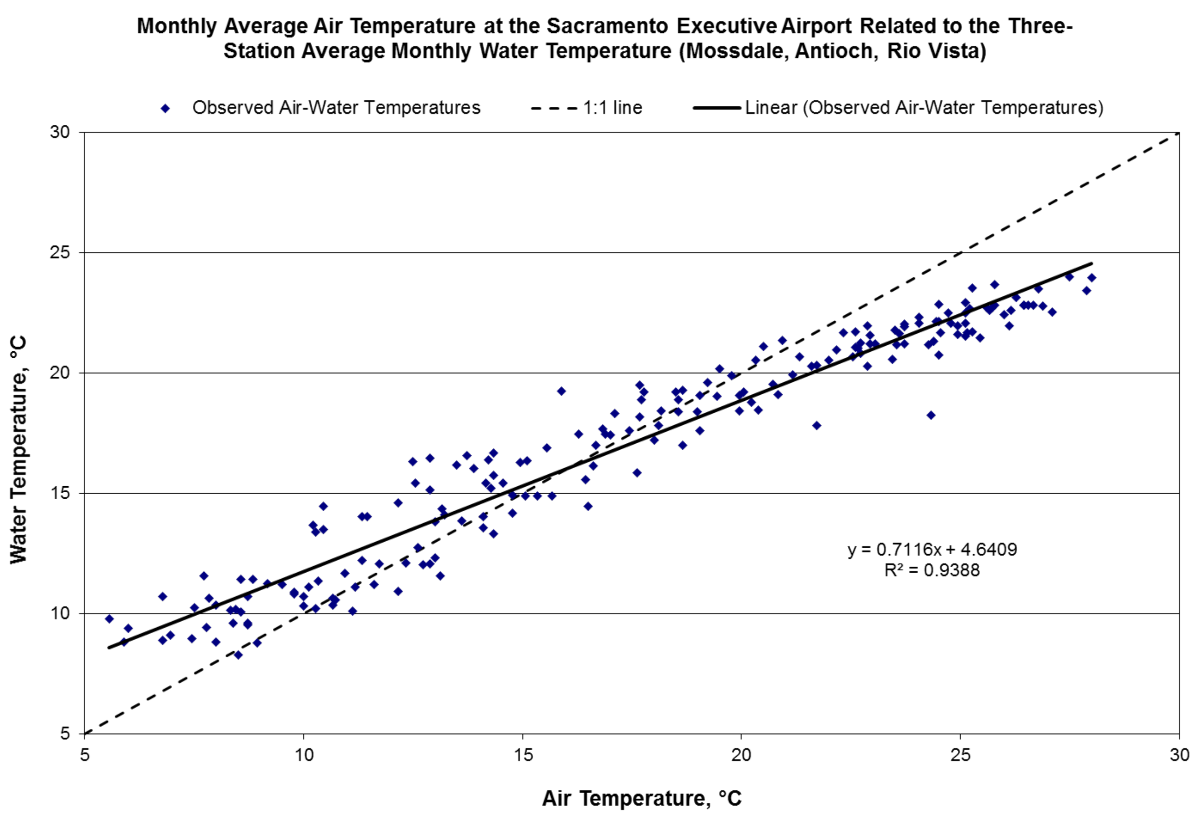


Figure 5.A.A.6-2 Relationship between Monthly Average Air Temperature at the Sacramento Executive Airport and the Three-station Average Monthly Water Temperature

Other Modeling Considerations: In the month of December in which Action 1 does not begin until December 21, for monthly analysis, a background OMR flow must be assumed for the purpose of calculating a day-weighted average for implementing a partial-month action condition. When necessary, the background OMR flow for December was assumed to be -8,000 cfs.

For the additional condition to meet a 5-day running average no more negative than -2,500 cfs (within 25%), Paul Hutton's equation[1] is used. Hutton concluded that with stringent OMR standards (1,250 to 2,500 cfs), the 5-day average would control more frequently than the 14-day average, but it is less likely to control at higher flows. Therefore, the CalSim II implementation includes both a 14-day (approximately monthly average) and a 5-day average flow criteria based on Hutton's methodology (see Attachment 1).

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 1.

December 1 to December 20 for initiating Action 1 is not considered because seasonal peaks of delta smelt salvage are rare prior to December 20. Adult delta smelt spawning migrations often begin following large precipitation events that happen after mid-December.

Salvage of adult delta smelt often corresponds with increases in turbidity and exports. On the basis of the above discussion and Figure B-2, Sacramento River Index greater than 25,000 cfs is assumed to be an indicator of turbidity trigger being reached at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal. Most sediment enters the Delta from the Sacramento River during flow pulses; therefore, a flow indicator based on only Sacramento River flow is used.

The 12°C threshold for the off-ramp criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

Results: Using these assumptions, in a typical CalSim II 82-year simulation (1922 through 2003 hydrologic conditions), Action 1 will occur 29 times in the December 21 to January 3 period, 14 times in the January 1 to January 14 period, 13 times in the February 1 to February 14 period, and 17 times in the March 1 to March 14 period. In 3 of these 17 occurrences (1934, 1991, and 2001), Action 3 is triggered before Action 1 and therefore Action 1 is bypassed. Action 1 is not triggered in 9 of the 82 years (1924, 1929, 1931, 1955, 1964, 1976, 1977, 1985, and 1994), typically critically dry years. Refer to CalSim II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest.

---

[1]Hutton, Paul/Metropolitan Water District of Southern California (MWDSC). Water Supply Impact Analysis of December 2008 Delta Smelt Biological Opinion, Appendix 5. February.

Action 2: Adult Delta Smelt Migration and Entrainment (RPA Component 1, Action 2)

Action 2 Summary:

Objective: An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions.

Action: The range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions (and the general guidelines below), specific OMR flows within this range are recommended by the USFWS's Smelt Working Group (SWG) from the onset of Action 2 through its termination (see Adaptive Process description in the BiOp). The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP/SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The USFWS will make the final determination.

Timing: Beginning immediately after Action 1. Before this date (in time for operators to implement the flow requirement) the SWG will recommend specific requirement OMR flows based on salvage and on physical and biological data on an ongoing basis. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt.

Suspension of Action:

Flow: OMR flow requirements do not apply whenever a 3-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of the Action are again in place.

Off-ramps:

Temperature: Water temperature reaches 12°C based on a three-station daily average at the temperature stations: Rio Vista, Antioch, and Mossdale.

OR

Biological: Onset of spawning (presence of a spent female in SKT or at either facility).

Action 2 Assumptions for CalSim II Modeling Purposes:

An approach was selected based on the occurrence of Action 1 and X2 salinity conditions. This approach selects from between two OMR flow tiers depending on the previous month's X2 position and is never more constraining than an OMR criterion of -3,500 cfs. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -3,500 or -5,000 cfs depending on the previous month's ending X2 location (-3,500 cfs if X2 is east of Roe Island, or -5,000 cfs if X2 is west of Roe Island), with a 5-day running average within 25% of the monthly criteria (no more negative than -4,375 cfs if X2 is east of Roe Island, or -6,250 cfs if X2 is west of Roe Island).

Timing: Begins immediately after Action 1 and continues until initiation of Action 3. In a typical CalSim II 82-year simulation, Action 1 was not triggered in 9 of the 82 years. In these conditions it is assumed that OMR flow should be maintained no more negative than -5,000 cfs.

Suspension of Action: A flow peaking analysis, developed by Paul Hutton[2], is used to determine the likelihood of a 3-day flow average greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and a 3-day flow average greater than or equal to 10,000 cfs in San Joaquin River at Vernalis occurring within the month. It is assumed that when the likelihood of these conditions occurring exceeds 50%, Action 2 is suspended for the full month, and OMR flow requirements do not apply. The likelihood of these conditions occurring is evaluated each month, and Action 2 is suspended for one month at a time whenever both of these conditions occur.

The equations for likelihood (frequency of occurrence) are as follows:

Frequency of Rio Vista 3-day flow average > 90,000 cfs:

> 0% when Freeport monthly flow < 50,000 cfs, OR
>
> (0.00289 × Freeport monthly flow – 146)% when 50,000 cfs ≤ Freeport plus Yolo Bypass monthly flow ≤ 85,000 cfs, OR
>
> 100% when Freeport monthly flow >85,000 cfs

Frequency of Vernalis 3-day flow average > 10,000 cfs:

> 0% when Vernalis monthly flow < 6,000 cfs, OR
>
> (0.00901 × Vernalis monthly flow – 49)% when 6,000 cfs ≤ Vernalis monthly flow ≤ 16,000 cfs, OR
>
> 100% when Vernalis monthly flow >16,000 cfs

Frequency of Rio Vista 3-day flow average > 90,000 cfs equals 50% when Freeport plus Yolo Bypass monthly flow is 67,820 cfs and the frequency of Vernalis 3-day flow average > 10,000 cfs equals 50% Vernalis monthly flow is 10,988 cfs. Therefore these two flow values are used as thresholds in the model.

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[2] Hutton, Paul/MWDSC. 2009. Water Supply Impact Analysis of December 2008 Delta Smelt Biological Opinion, Appendix 4. February.

Off-ramps: Only temperature-based off-ramping is considered. A surrogate biological off-ramp indicator was not included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought for use as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (Figure 5.A.A.6-2). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, daily water temperatures are estimated from the 82-year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CalSim II. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure 5.A.A.6-2.

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 2.

Action 2 requirements are based on X2 location that is dependent on the Delta outflow. If outflows are very high, fewer delta smelt will spawn east of Sherman Lake; therefore, the need for OMR restrictions is lessened.

In the case of Action 1 not being triggered, CDFW suggested OMR > -5,000 cfs, following the actual implementation of the BiOp in winter 2009, because some adult delta smelt might move into the Central Delta without a turbidity event.

Action 2 is suspended when the likelihood of a 3-day flow average greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and a 3-day flow average greater than or equal to 10,000 cfs in San Joaquin River at Vernalis occurring concurrently within the month exceeds 50%, because at extreme high flows the majority of adult delta smelt will be distributed downstream of the Delta, and entrainment concerns will be very low.

The 12°C threshold for the off-ramp criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

Results: Using these assumptions, in a typical CalSim II 82-year simulation (1922 through 2003 hydrologic conditions), Action 1, and therefore Action 2, does not occur in 11 of the 82 years (1924, 1929, 1931, 1934, 1955, 1964, 1976, 1977, 1985, 1991, 1994, and 2001), typically critically dry years. The criteria for suspension of OMR minimum flow requirements, described above, results in potential suspension of Action 2 (if Action 2 is active) 6 times in January, 11 times in February, 6 times in March (however Action 2 was not active in 3 of these 6 times), and 2 times in April. The result is that Action 2 is in effect 37 times in January (with OMR at -3,500 cfs 29 times, and at -5,000 cfs 8 times), 43 times in February (with OMR at -3,500 cfs

25 times, and at -5,000 cfs 18 times), 31 times in March (with OMR at -3,500 cfs 14 times, and at -5,000 cfs 17 times), and 80 times in April (with OMR at -3,500 cfs 46 times, and at -5,000 cfs 34 times). The frequency each month is a cumulative result of the action being triggered in the current or prior months. Refer to CalSim II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest.

Action 3: Entrainment Protection of Larval and Juvenile Delta Smelt (RPA Component 2)

Action 3 Summary:

Objective: Minimize the number of larval delta smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval delta smelt, e.g., by using a VAMP-like action. Because protective OMR flow requirements vary over time (especially between years), the action is adaptive and flexible within appropriate constraints.

Action: Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25% of the applicable requirement for OMR. Depending on extant conditions (and the general guidelines below), specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination (see Adaptive Process in Introduction). The SWG would provide these recommendations based upon weekly review of sampling data, from real-time salvage data at the CVP/SWP, and expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The USFWS will make the final determination.

Timing: Initiate the action after reaching the triggers below, which are indicative of spawning activity and the probable presence of larval delta smelt in the South and Central Delta. Based upon daily salvage data, the SWG may recommend an earlier start to Action 3. The USFWS will make the final determination.

Triggers:

<u>Temperature:</u> When temperature reaches 12°C based on a three-station average at the temperature stations: Mossdale, Antioch, and Rio Vista.

OR

<u>Biological:</u> Onset of spawning (presence of spent females in SKT or at either facility).

Off-ramps:

<u>Temporal:</u> June 30;

OR

Temperature: Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay.

Action 3 Assumptions for CalSim II Modeling Purposes:

An approach was selected based on assumed temperature and X2 salinity conditions. This approach selects from among three OMR flow tiers depending on the previous month's X2 position and ranges from an OMR criteria of -1,250 to -5,000 cfs. Because of the potential low export conditions that could occur at an OMR criterion of -1,250 cfs, a criterion for minimum exports for health and safety is also assumed. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -1,250, -3,500, or -5,000 cfs, depending on the previous month's ending X2 location (-1,250 cfs if X2 is east of Chipps Island, -5,000 cfs if X2 is west of Roe Island, or -3,500 cfs if X2 is between Chipps and Roe Island, inclusively), with a 5-day running average within 25% of the monthly criteria (no more negative than -1,562 cfs if X2 is east of Chipps Island, -6,250 cfs if X2 is west of Roe Island, or -4,375 cfs if X2 is between Chipps and Roe Island). The more constraining of this OMR requirement or the VAMP requirement will be selected during the VAMP period (April 15 to May 15). Additionally, in the case of the month of June, the OMR criterion from May is maintained through June (it is assumed that June OMR should not be more constraining than May).

Timing: Begins immediately upon temperature trigger conditions and continues until off-ramp conditions are met.

Triggers: Only temperature trigger conditions are considered. A surrogate biological trigger was included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought to be used as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (Figure 5.A.A.6-2). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, estimated daily water temperatures are estimated from the 82-year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CalSim. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure 5.A.A.6-2.

Biological: Onset of spawning is assumed to occur no later than *May* 30.

Clarification Note: This text previously read "Onset of spawning is assumed to occur no later than April 30", where the CalSim II lookup table has May 30 as the date. Based on RPA team discussions in August 2009, it was agreed upon that onset of spawning could not be modeled in CalSim. This trigger was actually coded as a placeholder in case in future this trigger was to be used; and the date was selected purposefully in a way that it wouldn't affect modeling results. Temperature trigger for Action 3 does occur before end of April. Therefore it does not matter whether the document is corrected to read May 30 or the model lookup table is changed to April 30.

Off-ramps:

Temporal: It is assumed that the ending date of the action would be no later than June 30.

OR

Temperature: Only 17 years of data are available for Clifton Court water temperature. A similar approach as used in the temperature trigger was considered. However, because 3 consecutive days of water temperature greater than or equal to 25°C is required, a correlation between air temperature and water temperature did not work well for this off-ramp criterion. Out of the 17 recorded years, in one year the criterion was triggered in May (May 31), and in 3 years it was triggered in June (June 3, 21, and 27). In all other years it was observed in July or later. With only four data points before July, it was not possible to generate a rule based on statistics. Therefore, temporal off-ramp criterion (June 30) is used for all years.

Health and Safety: In CalSim II, a minimum monthly Delta export criterion of 300 cfs for SWP and 600 cfs (or 800 cfs depending on Shasta storage) for CVP is assumed. This assumption is suitable for dry-year conditions when allocations are low and storage releases are limited; however, minimum monthly exports need to be made for protection of public health and safety (health and safety deliveries upstream of San Luis Reservoir).

In consideration of the severe export restrictions associated with the OMR criteria established in the RPAs, an additional set of health and safety criterion is assumed. These export restrictions could lead to a situation in which supplies are available and allocated; however, exports are curtailed forcing San Luis to have an accelerated drawdown rate. For dam safety at San Luis Reservoir, 2 feet per day is the maximum acceptable drawdown rate. Drawdown occurs faster in summer months and peaks in June when the agricultural demands increase. To avoid rapid drawdown in San Luis Reservoir, a relaxation of OMR is allowed so that exports can be maintained at 1,500 cfs in all months if needed.

This modeling approach may not fit the real-life circumstances. In summer months, especially in June, the assumed 1,500 cfs for health and safety may not be sufficient to keep San Luis drawdown below a safe 2 ft/day; and under such circumstances the projects would be required to increase pumping in order to maintain dam safety.

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 3.

The geographic distribution of larval and juvenile delta smelt is tightly linked to X2 (or Delta outflow). Therefore, the percentage of the population likely to be found east of Sherman Lake is also influenced by the location of X2. The X2-based OMR criteria were intended to model an expected management response to the general increase in delta smelt's risk of entrainment as a function of increasing X2.

The 12°C threshold for the trigger criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

The annual salvage "season" for delta smelt typically ends as South Delta water temperatures warm to lethal levels during summer. This usually occurs in late June or early July. The laboratory-derived upper lethal temperature for delta smelt is 25.4°C.

Results: Action 3 occurs 30 times in February (with OMR at -1,250 cfs 9 times, at -3,500 cfs 11 times, and at -5,000 cfs 10 times), 76 times in March (with OMR at -1,250 cfs 15 times, at -3,500 cfs 27 times, and at -5,000 cfs 34 times), all times (82) in April (with OMR at -1,250 cfs 17 times, at -3,500 cfs 29 times, and at -5,000 cfs 35 times), all times (82) in May (with OMR at -1,250 cfs 19 times, at -3,500 cfs 37 times, and at -5,000 cfs 26 times), and 70 times in June (with OMR at -1,250 cfs 7 times, at -3,500 cfs 37 times, and at -5,000 cfs 26 times). Refer to CalSim II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest. (Note: The above information is based on the August 2009 version of the model and documents the development process, more recent versions of the model may have different results.)

Action 4: Estuarine Habitat During Fall (RPA Component 3)

Action 4 Summary:

Objective: Improve fall habitat for delta smelt by managing of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal. This will help return ecological conditions of the estuary to that which occurred in the late 1990s when smelt populations were much larger. Flows provided by this action are expected to provide direct and indirect benefits to delta smelt. Both the direct and indirect benefits to delta smelt are considered equally important to minimize adverse effects.

Action: Subject to adaptive management as described below, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 kilometers in the fall following wet years and 81 kilometers in the fall following above normal years. The monthly average X2 position is to be maintained at or seaward of these location for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall X2 target. The action will be evaluated and may be modified or terminated as determined by the USFWS.

Timing: September 1 to November 30.

Triggers: Wet and above normal water-year type classification from the 1995 Water Quality Control Plan that is used to implement D-1641.

Action 4 Assumptions for CalSim II Modeling Purposes:

Model is modified to increase Delta outflow to meet monthly average X2 requirements for September and October and subsequent November reservoir release actions in Wet and Above Normal years. No off-ramps are considered for reservoir release capacity constraints. Delta exports may or may not be reduced as part of reservoir operations to meet this action. The Action is summarized in Table 5.A.A.6-2.

Table 5.A.A.6-2. Summary of Action 4 implementation in CalSim II

Fall Months following Wet or Above Normal Years	Action Implementation
September	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
October	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
November	Add reservoir releases up to natural inflow as needed to continue to meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)

Rationale: Action 4 requirements are based on determining X2 location. Adjustment and retraining of the ANN was also completed to address numerical sensitivity concerns.

Results: There are 38 September and 37 October months that the Action is triggered over the 82-year simulation period.

Action 5: Temporary Spring Head of Old River Barrier and the Temporary Barrier Project (RPA Component 2)

Action 5 Summary:

Objective: To minimize entrainment of larval and juvenile delta smelt at Banks and Jones or from being transported into the South and Central Delta, where they could later become entrained.

Action: Do not install the Spring Head of Old River Barrier (HORB) if delta smelt entrainment is a concern. If installation of the HORB is not allowed, the agricultural barriers would be installed as described in the Project Description. If installation of the HORB is allowed, the Temporary Barrier Project (TBP) flap gates would be tied in the open position until May 15.

Timing: The timing of the action would vary depending on the conditions. The normal installation of the spring temporary HORB and the TBP is in April.

Triggers: For delta smelt, installation of the HORB will only occur when particle tracking modeling results show that entrainment levels of delta smelt will not increase beyond 1% at Station 815 as a result of installing the HORB.

Off-ramps: If Action 3 ends or May 15, whichever comes first.

Action 5 Assumptions for CalSim II and DSM2 Modeling Purposes:

The South Delta Improvement Program (SDIP) Stage 1 is not included in the Existing and Future Condition assumptions being used for CalSim II and DSM2 baselines. The TBP is assumed instead. The TBP specifies that HORB be installed and operated during April 1 through May 31 and September 16 through November 30. In response to the USFWS BiOp, Action 5, the HORB is assumed to not be installed during April 1 through May 31.

Appendix 4: Approach to Suspend Actions During High Flows

MEMO

Date: December 16, 2008

To: File

From: Paul Hutton

Subject: Modeling Delta Smelt High Flow Action Temporary Suspensions

This memo summarizes an approach that was developed to represent high flow periods when Delta smelt flow actions are temporarily suspended. The actions of interest include the following:

- Wanger Actions – The winter pulse flow action (on or after December 25) is temporarily suspended if the 3-day average flow at Freeport exceeds 80,000 cfs. Similarly, the pre-spawning adult flow action (January and February) is temporarily suspended if the 3-day average flow at Freeport exceeds 80,000 cfs.
- Delta Smelt Biological Opinion Actions – Action 2 is temporarily suspended if the 3-day average flows at Rio Vista and Vernalis exceed 90,000 cfs and 10,000 cfs, respectively.

Methodology

Given that (1) the actions are written in terms of 3-day flow averages and (2) typical water supply impact analyses are conducted assuming monthly average flows, a method is needed to characterize the action in terms of monthly average flows. Historical flows information from DAYFLOW was used to characterize relationships between 3-day flows and monthly flows. The desired product is to determine a frequency of exceeding the 3-day flow target as a function of a monthly flow value. This frequency will be used to proportionally reduce calculated water supply impacts in high flow months.

Results for Wanger Actions

Figure 4-1 plots the frequency that 3-day Freeport flows exceed 80,000 cfs as a function of monthly average Freeport flows (Q_F). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_F < 50{,}000$ cfs

$0.0126 * \exp(0.000105*Q_F)$ when $50{,}000 \text{ cfs} \leq Q_F \leq 85{,}000$ cfs

100% when $Q_F > 85{,}000$ cfs

Results for BO Actions

Figure 4-2 plots the frequency that 3-day Rio Vista flows exceed 90,000 cfs as a function of monthly average Freeport flows (Q_F). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_F < 50{,}000$ cfs

$-146 + 0.00289*Q_F$ when $50{,}000 \text{ cfs} \leq Q_F \leq 85{,}000$ cfs

100% when $Q_F > 85{,}000$ cfs

Figure 4-3 plots the frequency that 3-day Vernalis flows exceed 10,000 cfs as a function of monthly average Vernalis flows (Q_V). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_V < 6{,}000$ cfs

$-49 + 0.00901*Q_V$ when $6{,}000 \text{ cfs} \leq Q_V \leq 16{,}000$ cfs

100% when $Q_V > 16{,}000$ cfs

The BO requires Rio Vista and Vernalis flows to simultaneously exceed the targets to temporarily suspend the flow action. For modeling purposes, it is assumed that these flows are statistically independent. Hence, the suspension frequency is calculated as the product of the individual frequencies. Since Rio Vista and Vernalis flows are modestly correlated, the proposed approach may somewhat understate the true suspension frequency. However, a cursory paired data evaluation suggested that the assumption will provide reasonable results.

Paul Hutton 2/2/09

Figure 4-1. Frequency of Wanger Freeport Flow Trigger as a Function of Monthly Freeport Flow

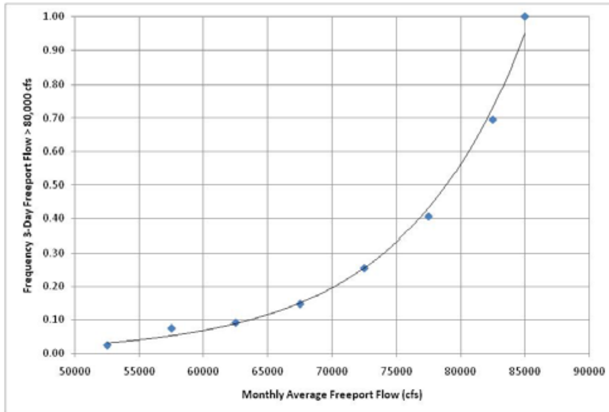
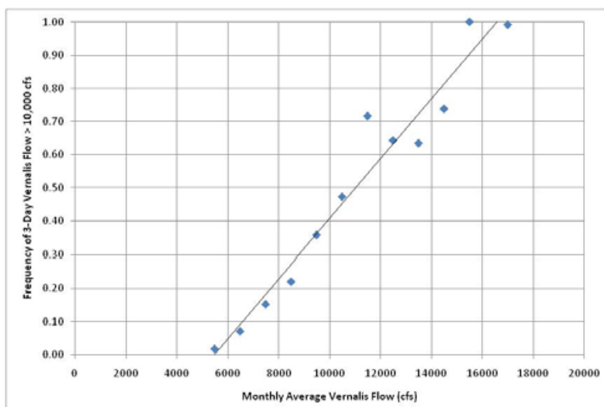


Figure 4-3. Frequency of BO Vernalis Flow Trigger as a Function of Monthly Vernalis Flow



Paul Hutton 2/2/09

Appendix 5: Approach to Relate 5-Day & 14-Day OMR Flows

MEMO

Date: January 2, 2009

To: File

From: Paul Hutton

Subject: How Frequently Will 5-Day OMR Flows (Rather than 14-Day OMR Flows) Control Project Operations Under New Delta Smelt Biological Opinion?

Background

Several flow actions specified in the December 2008 Delta Smelt biological opinion place limits on reverse flows in Old and Middle Rivers. Limits are given as 14-day averages, but the simultaneous 5-day averages are to be within 25% of the 14-day averages. This memo summarizes an investigation to answer the question "How frequently will 5-day OMR flows, rather than 14-day OMR flows, control project operations under the new Delta smelt biological opinion?"

Water supply impact studies assume the 14-day average flow controls. Such an approach would not be conservative if 5-day flows frequently control project operations. Based upon a recent meeting with SWP and CVP operators, the CVP operators believe that fishery agencies will accept violations of the 5-day flow limit provided that project operators maintain relatively stable pumping operations. Is this belief that 5-day flows will not control operations valid? Will the courts or environmental groups accept such an operation? An investigation into the potential frequency of 5-day flow control seems prudent, given that we don't know the answers to such questions.

Methods

The following methods were employed:

- Review historical Delta flow and operations data for the period between January 1990 and May 2008.
- Identify periods when (1) pumping operations were relatively stable and (2) 5-day OMR flows were more negative than 14-day OMR flows. For periods prior to

5-day OMR flows are more negative than 14-day OMR flows by nearly 1000 cfs (679 cfs + 297 cfs = 976 cfs). At two standard errors, or about 95% confidence, 5-day OMR flows are more negative than 14-day OMR flows by nearly 1300 cfs (679 cfs + 2*297 cfs = 1273 cfs).

By solving the Figure 5-1 regression equation for a condition when the 5-day OMR flow is 25% more negative than the 14-day OMR flow, the following limits are identified when 5-day OMR flows will control:

14-day OMR flow = -2980 cfs at a 50% confidence interval

-4280 cfs at a 67% confidence interval

-5580 cfs at a 95% confidence interval

Conclusions

This memo summarizes an investigation to answer the question "How frequently will 5-day OMR flows, rather than 14-day OMR flows, control project operations under the new Delta smelt biological opinion?" An analysis of historical flow and project operations data suggests that 5-day OMR flows will often control operations when the 14-day flow target is in the most stringent range of -1500 cfs to -2500 cfs. When the projects are operating to less stringent OMR flows in the range of -3000 cfs to -5000 cfs, 5-day OMR flows will occasionally be at least 25% more negative than 14-day OMR flows and might control project operations.

If the projects are required to strictly meet the 5-day OMR flow criteria, (1) the current water supply impact assumption of 14-day OMR flow control is not conservative and (2) it would be prudent to incorporate a factor of safety to address the 5-day flow criteria.

Figure 5-1. Average 5d OMR flows as a function of average 14d OMR flows during periods when pumping operations were stable and 5d flows were more negative than 14d flows.

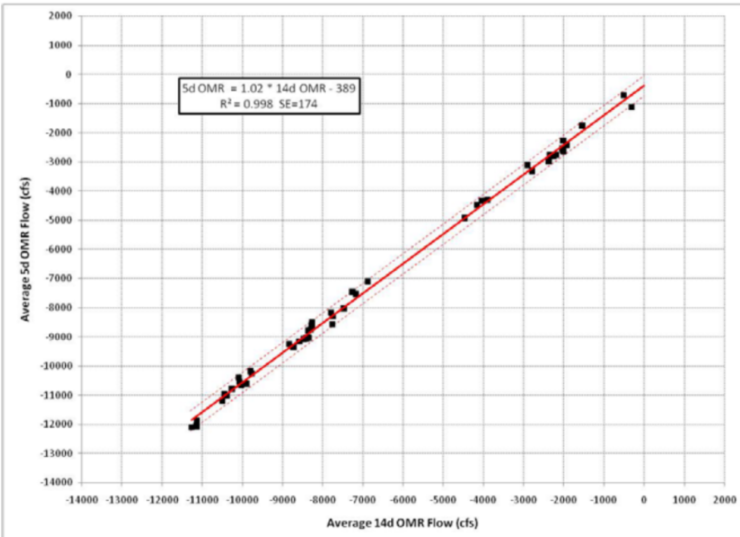


Figure 5-2. Peak 5d OMR flows as a function of peak 14d OMR flows during periods when pumping operations were stable and 5d flows were more negative than 14d flows.

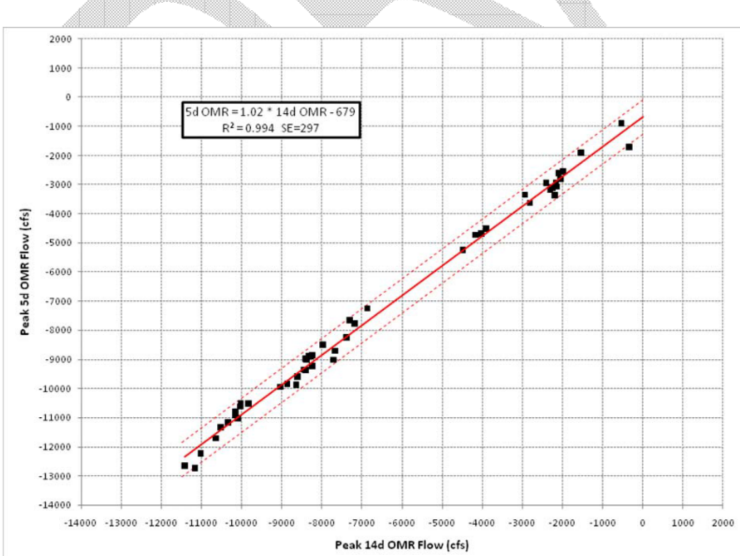


Table 5-1. Fifty periods were identified when pumping operations were relatively stable and 5-day OMR flows were more negative than 14-day OMR flows.

Period			Daily Export Range (cfs)			14d Export Range (cfs)			Average OMR Difference (cfs)				Peak OMR Difference (cfs)				
Start Date	End Date	Duration (days)	Min	Max	Range	Min	Max	Range	14d	5d	Diff	%Diff	Date	14d	5d	Diff	%Diff
24-Jan-90	1-Feb-90	9	10000	10700	700	10400	10500	100	-8300	-8760	-460	6%	30-Jan-90	-8390	-9010	-620	7%
9-Feb-90	17-Feb-90	9	9900	10600	700	10400	10400	0	-8270	-8590	-320	4%	12-Feb-90	-8280	-8900	-620	7%
24-Feb-90	3-Mar-90	8	10000	10600	600	10400	10500	100	-8270	-8690	-420	5%	27-Feb-90	-8240	-8870	-630	8%
10-Mar-90	19-Mar-90	10	10000	10800	800	10300	10400	100	-8260	-8510	-250	3%	18-Mar-90	-8340	-8890	-550	7%
24-Mar-90	1-Apr-90	9	10300	10600	300	10300	10500	200	-8830	-9250	-420	5%	31-Mar-90	-9040	-9950	-910	10%
1-Apr-91	8-Apr-91	8	9300	10200	900	10200	10300	100	-7470	-8020	-550	7%	4-Apr-91	-7390	-8260	-870	12%
16-Mar-92	24-Mar-92	9	10000	10700	700	10300	10400	100	-8410	-9060	-650	8%	22-Mar-92	-8640	-9880	-1240	14%
20-Aug-93	27-Aug-93	8	10400	10900	500	10600	10700	100	-8730	-9350	-620	7%	24-Aug-93	-8870	-9850	-980	11%
4-Sep-93	10-Sep-93	7	10900	10900	0	10600	10700	100	-8360	-8790	-430	5%	9-Sep-93	-8420	-8990	-570	7%
18-Sep-93	23-Sep-93	6	10300	10900	600	10800	10900	100	-8370	-9030	-660	8%	20-Sep-93	-8450	-9360	-910	11%
1-Oct-93	9-Oct-93	9	10800	11100	300	10600	10900	300	-8340	-9040	-700	8%	3-Oct-93	-8240	-9240	-1000	12%
17-Oct-93	22-Oct-93	6	10800	10900	100	10900	10900	0	-7790	-8170	-380	5%	18-Oct-93	-7980	-8500	-520	7%
22-Nov-95	30-Nov-95	9	4300	4800	500	4400	4400	0	-2780	-3300	-520	19%	25-Nov-95	-2810	-3640	-830	30%
7-Dec-95	13-Dec-95	7	4200	4400	200	4300	4400	100	-2900	-3100	-200	7%	12-Dec-95	-2930	-3360	-430	15%
22-Dec-95	28-Dec-95	7	4200	4400	200	4200	4300	100	-2370	-2980	-610	26%	26-Dec-95	-2250	-3130	-880	39%
12-Aug-99	22-Aug-99	11	8700	11600	2900	10900	11300	400	-9800	-10180	-380	4%	20-Aug-99	-10040	-10630	-590	6%
28-Aug-99	5-Sep-99	9	10900	11600	700	11100	11400	300	-10260	-10790	-530	5%	1-Sep-99	-10350	-11180	-830	8%
13-Sep-99	19-Sep-99	7	11400	11500	100	11500	11500	0	-10090	-10390	-300	3%	17-Sep-99	-10030	-10530	-500	5%
3-May-00	9-May-00	7	1700	2200	500	2100	2300	200	-1930	-2410	-480	25%	8-May-00	-1980	-2560	-580	29%
5-May-01	13-May-01	9	1500	1700	200	1500	1500	0	-2000	-2630	-630	32%	11-May-01	-2190	-3380	-1190	54%
22-May-01	29-May-01	8	800	1600	800	1500	1500	0	-2020	-2590	-570	28%	27-May-01	-2140	-3080	-940	44%
22-Jul-01	29-Jul-01	8	7900	8800	900	8100	8300	200	-8580	-9160	-580	7%	25-Jul-01	-8610	-9610	-1000	12%
20-Aug-01	26-Aug-01	7	7700	8900	1200	8100	8400	300	-8470	-9080	-610	7%	23-Aug-01	-8410	-9370	-960	11%
6-Sep-01	12-Sep-01	7	7200	8300	1100	7500	7600	100	-7760	-8580	-820	11%	8-Sep-01	-7720	-9030	-1310	17%
19-Sep-01	25-Sep-01	7	7200	8200	1000	7700	7800	100	-7750	-8310	-560	7%	22-Sep-01	-7680	-8720	-1040	14%
27-Apr-02	3-May-02	7	1400	1500	100	1500	2000	500	-2190	-2750	-560	26%	30-Apr-02	-2160	-2960	-800	37%
12-May-02	18-May-02	7	1500	1500	0	1500	1500	0	-2030	-2540	-510	25%	16-May-02	-2040	-2810	-770	38%
26-May-02	31-May-02	6	1600	1600	0	1600	1600	0	-2010	-2260	-250	12%	31-May-02	-2100	-2620	-520	25%
1-May-03	7-May-03	7	1400	1500	100	1500	1500	0	-2340	-2760	-420	18%	3-May-03	-2400	-2950	-550	23%
15-May-03	22-May-03	8	1500	2300	800	1400	1700	300	-2250	-2800	-550	24%	20-May-03	-2300	-3190	-890	39%
15-Aug-03	22-Aug-03	8	11300	11600	300	11200	11400	200	-11260	-12100	-840	7%	20-Aug-03	-11430	-12670	-1240	11%
31-Aug-03	6-Sep-03	7	11200	11500	300	11400	11500	100	-11140	-12070	-930	8%	3-Sep-03	-11170	-12750	-1580	14%
13-Sep-03	21-Sep-03	9	10000	11600	1600	11200	11400	200	-11130	-11880	-750	7%	16-Sep-03	-11030	-12240	-1210	11%
25-Jul-05	31-Jul-05	7	11500	11600	100	11500	11500	0	-10020	-10670	-650	6%	28-Jul-05	-10110	-11040	-930	9%
7-Aug-05	15-Aug-05	9	10900	11700	800	11500	11600	100	-10390	-11020	-630	6%	13-Aug-05	-10530	-11350	-820	8%
22-Aug-05	28-Aug-05	7	11600	11700	100	11500	11600	100	-10500	-11190	-690	7%	25-Aug-05	-10650	-11720	-1070	10%
13-Aug-06	18-Aug-06	6	11500	11600	100	11500	11600	100	-10070	-10560	-490	5%	15-Aug-06	-10170	-10930	-760	7%
26-Aug-06	3-Sep-06	9	11300	11600	300	11500	11500	0	-9760	-10260	-500	5%	1-Sep-06	-9840	-10520	-680	7%
10-Sep-06	16-Sep-06	7	11000	11600	600	11500	11600	100	-9900	-10610	-710	7%	14-Sep-06	-10090	-11040	-950	9%
5-Nov-06	13-Nov-06	9	8600	10000	1400	9200	9400	200	-6880	-7100	-220	3%	7-Nov-06	-6870	-7260	-390	6%
15-Nov-06	23-Nov-06	9	9200	10000	800	9200	9500	300	-7260	-7460	-200	3%	20-Nov-06	-7310	-7660	-350	5%
2-Dec-06	6-Dec-06	5	8400	10200	1800	9600	9800	200	-7170	-7530	-360	5%	4-Dec-06	-7180	-7780	-600	8%
27-Jan-07	1-Feb-07	6	6300	6900	600	6500	6800	300	-3890	-4300	-410	11%	28-Jan-07	-3900	-4530	-630	16%
7-Feb-07	13-Feb-07	7	6400	6900	500	6800	6800	0	-4160	-4490	-330	8%	10-Feb-07	-4170	-4730	-560	13%
22-Feb-07	28-Feb-07	7	6600	6900	300	6800	6900	100	-4030	-4330	-300	7%	25-Feb-07	-4020	-4700	-680	17%
3-Apr-07	9-Apr-07	7	5600	7100	1500	6200	6600	400	-4460	-4920	-460	10%	7-Apr-07	-4480	-5250	-770	17%
15-May-07	20-May-07	6	1200	1500	300	1400	1500	100	-1540	-1750	-210	14%	18-May-07	-1540	-1920	-380	25%
14-Aug-07	24-Aug-07	11	11600	11600	0	11500	11600	100	-10450	-10960	-510	5%	17-Aug-07	-10160	-10810	-650	6%
3-May-08	9-May-08	7	1500	1500	0	1500	1600	100	-310	-1110	-800	258%	6-May-08	-330	-1720	-1390	421%
18-May-08	22-May-08	5	1400	1700	300	1500	1500	0	-500	-710	-210	42%	20-May-08	-530	-900	-370	70%

Paul Hutton 2/2/09

4.1 Representation of National Marine Fisheries Service Biological Opinion Reasonable and Prudent Alternative Actions for CalSim II Planning Studies

The National Marine Fisheries Service's (NMFS) Biological Opinion (BiOp) on the Long-term Operations of the Central Valley Project and State Water Project was released on June 4, 2009.

To develop CalSim II modeling assumptions to represent the operations related reasonable and prudent alternative actions (RPA) required by this BiOp, the California Department of Water Resources (DWR) led a series of meetings that involved members of fisheries and project agencies. The purpose for establishing this group was to prepare the assumptions and CalSim II implementations to represent the RPAs in both Existing- and Future-Condition CalSim II simulations for future planning studies.

This memorandum summarizes the approach that resulted from these meetings and the modeling assumptions that were laid out by the group. The scope of this memorandum is limited to the June 4, 2009 BiOp. All descriptive information of the RPAs is taken from the BiOp.

Table 5.A.A.6-1 lists the participants that contributed to the meetings and information summarized in this document.

The RPAs in NMFS's BiOp are based on physical and biological processes that do not lend themselves to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPAs. The group believes the logic put into CalSim II represents the RPAs as best as possible at this time, given the scientific understanding of environmental factors enumerated in the BiOp and the limited historical data for some of these factors.

Given the relatively generalized representation of the RPAs assumed for CalSim II modeling, much caution is required when interpreting outputs from the model.

Table 5.A.A.7-1 Meeting Participants

Aaron Miller/DWR Randi Field/Reclamation Lenny Grimaldo/Reclamation Henry Wong/Reclamation	Derek Hilts/USFWS Roger Guinee/ USFWS Matt Nobriga/CDFW Bruce Oppenheim/ NMFS
Parviz Nader-Tehrani/ DWR Erik Reyes/ DWR Sean Sou/ DWR Paul A. Marshall/ DWR Ming-Yen Tu/ DWR Xiaochun Wang/ DWR	Robert Leaf/CH2M HILL Derya Sumer/CH2M HILL

Notes:
CDFW = California DWR of Fish and Wildlife
NMFS = National Marine Fisheries Service
USFWS = U.S. Fish and Wildlife Service

4.2 Action Suite 1.1 Clear Creek

Suite Objective: The RPA actions described below were developed based on a careful review of past flow studies, current operations, and future climate change scenarios. These actions are necessary to address adverse project effects on flow and water temperature that reduce the viability of spring-run and CV steelhead in Clear Creek.

Action 1.1.1 Spring Attraction Flows

Objective: Encourage spring-run movement to upstream Clear Creek habitat for spawning.

Action: Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem.

Action 1.1.1 Assumptions for CalSim II Modeling Purposes

Action: Model is modified to meet 600 cfs for 3 days twice in May. In the CalSim II analysis, Flows sufficient to increase flow up to 600 cfs for a total of 6 days are added to the flows that would have otherwise occurred in Clear Creek.

Rationale: CalSim II is a monthly model. The monthly flow in Clear Creek is an underestimate of the actual flows that would occur subject to daily operational constraints at Whiskeytown Reservoir. The additional flow to meet 600 cfs for a total of 6 days was added to the monthly average flow modeled.

Action 1.1.5. Thermal Stress Reduction

Objective: To reduce thermal stress to over-summering steelhead and spring-run during holding, spawning, and embryo incubation.

Action: Reclamation shall manage Whiskeytown releases to meet a daily water temperature of: (1) 60°F at the Igo gauge from June 1 through September 15; and (2) 56°F at the Igo gauge from September 15 to October 31.

Action 1.1.5 Assumptions for CalSim II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: A temperature model of Whiskeytown Reservoir has been developed by Reclamation. Further analysis using this or other temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model.

4.3 Action Suite 1.2 Shasta Operations

Objectives: To address the avoidable and unavoidable adverse effects of Shasta operations on winter-run and spring-run:

- Ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning between Balls Ferry and Bend Bridge in most years, without sacrificing the potential for cold water management in a subsequent year. Additional actions to those in the 2004 CVP/SWP operations Opinion are needed, due to increased vulnerability of the population to temperature effects attributable to changes in Trinity River ROD operations, projected climate change hydrology, and increased water demands in the Sacramento River system.
- Ensure suitable spring-run temperature regimes, especially in September and October. Suitable spring-run temperatures will also partially minimize temperature effects to naturally-spawning, non-listed Sacramento River fall-run, an important prey base for endangered Southern Residents.
- Establish a second population of winter-run in Battle Creek as soon as possible, to partially compensate for unavoidable project-related effects on the one remaining population.
- Restore passage at Shasta Reservoir with experimental reintroductions of winter-run to the upper Sacramento and/or McCloud rivers, to partially compensate for unavoidable project-related effects on the remaining population.

Action 1.2.1 Performance Measures

Objective: To establish and operate to a set of performance measures for temperature compliance points and End-of-September (EOS) carryover storage, enabling Reclamation and NMFS to assess the effectiveness of this suite of actions over time. Performance measures will help to ensure that the beneficial variability of the system from changes in hydrology will be measured and maintained.

Action: To ensure a sufficient cold water pool to provide suitable temperatures, long-term performance measures for temperature compliance points and EOS carryover storage at Shasta Reservoir shall be attained. Performance measures for EOS carryover storage at Shasta Reservoir are as follows:

- 87% of years: Minimum EOS storage of 2.2 MAF
- 82% of years: Minimum EOS storage of 2.2 MAF and end-of-April storage of 3.8 MAF in following year (to maintain potential to meet Balls Ferry compliance point)
- 40% of years: Minimum EOS storage 3.2 MAF (to maintain potential to meet Jelly's Ferry compliance point in following year)

Performance measures (measured as a 10-year running average) for temperature compliance points during summer season are:

- Meet Clear Creek Compliance point 95% of time
- Meet Balls Ferry Compliance point 85% of time
- Meet Jelly's Ferry Compliance point 40% of time
- Meet Bend Bridge Compliance point 15% of time

Action 1.2.1 Assumptions for CalSim II Modeling Purposes

Action: No specific CalSim II modeling code is implemented to simulate the performance measures identified. System performance will be assessed and evaluated through post-processing of various model results.

Rationale: Given that the performance criteria are based on the CalSim II modeling data used in preparation of the Biological Assessment, the system performance after application of the RPAs should be similar as a percentage of years that the end-of-April storage and temperature compliance requirements are met over the simulation period. Post-processing of modeling results will be compared to various new operating scenarios as needed to evaluate performance criteria and appropriateness of the rules developed.

Action 1.2.2 November through February Keswick Release Schedule (Fall Actions)

Objective: Minimize impacts to listed species and naturally spawning non-listed fall-run from high water temperatures by implementing standard procedures for release of cold water from Shasta Reservoir.

Action: Depending on EOS carryover storage and hydrology, Reclamation shall develop and implement a Keswick release schedule, and reduce deliveries and exports as needed to achieve performance measures.

Action 1.2.2 Assumptions for CalSim II Modeling Purposes

Action: No specific CalSim II modeling code is implemented to simulate the Performance measures identified. Keswick flows based on operation of 3406(b)(2) releases in OCAP Study 7.1 (for Existing) and Study 8 (for Future) are used in CalSim II. These flows will be reviewed for appropriateness under this action. A post-process based evaluation similar to what has been explained in Action 1.2.1 will be conducted.

Rationale: Performance measures are set as percentage of years that the end-of-September and temperature compliance requirements are met over the simulation period. Post-processing of modeling results will be compared to various new operating scenarios as needed to evaluate performance criteria and appropriateness of the rules developed.

Action 1.2.3 February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)

Objective: To conserve water in Shasta Reservoir in the spring in order to provide sufficient water to reduce adverse effects of high water temperature in the summer months for winter-run, without sacrificing carryover storage in the fall.

Action:

- Reclamation shall make its February forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin at least as conservative as the 90% probability of exceedance. Subsequent updates of water delivery commitments must be based on monthly forecasts at least as conservative as the 90% probability of exceedance.
- Reclamation shall make releases to maintain a temperature compliance point not in excess of 56 degrees between Balls Ferry and Bend Bridge from April 15 through May 15.

Action 1.2.3 Assumptions for CalSim II Modeling Purposes

Action: No specific CalSim II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: Temperature models of Shasta Lake and the Sacramento River have been developed by Reclamation. This modeling reflects current facilities for temperature controlled releases. Further analysis using this or another temperature model can further verify that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably at each of the compliance points. In the future, it may be that adjusted flow schedules may need to be developed based on development of temperature model runs in conjunction with CalSim II modeled operations.

Action 1.2.4 May 15 through October Keswick Release Schedule (Summer Action)

Objective: To manage the cold water storage within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat temperatures for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the Sacramento River between Keswick Dam and Bend Bridge, while retaining sufficient carryover storage to manage for next year's cohorts. To the extent feasible, manage for suitable temperatures for naturally spawning fall-run.

Action: Reclamation shall manage operations to achieve daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows:

- Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and not in excess of 56°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31 for protection of mainstem spring run, whenever possible.

- Reclamation shall operate to a final Temperature Management Plan starting May 15 and ending October 31.

Action 1.2.4 Assumptions for CalSim II Modeling Purposes

Action: No specific CalSim II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flows included in model. During the detailed effects analysis, temperature modeling and post-processing will be used to verify temperatures are met at the compliance points. In the long-term approach, for a complete interpretation of the action, development of temperature model runs are needed to develop flow schedules if needed for implementation into CalSim II.

Rationale: Temperature models of Shasta Lake and the Sacramento River have been developed by Reclamation. This modeling reflects current facilities for temperature controlled releases. Further analysis using this or another temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably at each of the compliance points. It may be that alternative flow schedules may need to be developed based on development of temperature model runs in conjunction with CalSim II modeled operations.

4.4 Action Suite 1.3 Red Bluff Diversion Dam (RBDD) Operations

Objectives: Reduce mortality and delay of adult and juvenile migration of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon caused by the presence of the diversion dam and the configuration of the operable gates. Reduce adverse modification of the passage element of critical habitat for these species. Provide unimpeded upstream and downstream fish passage in the long term by raising the gates year-round, and minimize adverse effects of continuing dam operations, while pumps are constructed replace the loss of the diversion structure.

Action 1.3.1 Operations after May 14, 2012: Operate RBDD with Gates Out

Action: No later than May 15, 2012, Reclamation shall operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish.

Action 1.3.1 Assumptions for CalSim II Modeling Purposes

Action: Adequate permanent facilities for diversion are assumed; therefore, no constraint on diversion schedules is included in the Future condition modeling.

Action 1.3.2 Interim Operations

Action: Until May 14, 2012, Reclamation shall operate RBDD according to the following schedule:

- September 1 - June 14: Gates open. No emergency closures of gates are allowed.
- June 15 - August 31: Gates may be closed at Reclamation's discretion, if necessary to deliver water to TCCA.

Action 1.3.2 Assumptions for CalSim II Modeling Purposes

Action: Adequate interim/temporary facilities for diversion are assumed; therefore no constraint on diversion schedules is included in the No Action Alternative modeling.

4.5 Action 1.4 Wilkins Slough Operations

Objective: Enhance the ability to manage temperatures for anadromous fish below Shasta Dam by operating Wilkins Slough in the manner that best conserves the dam's cold water pool for summer releases.

Action: The Sacramento River Temperature Task Group (SRTTG) shall make recommendations for Wilkins Slough minimum flows for anadromous fish in critically dry years, in lieu of the current 5,000 cfs navigation criterion to NMFS by December 1, 2009. In critically dry years, the SRTTG will make a recommendation.

Action 1.4 Assumptions for CalSim II Modeling Purposes

Action: Current rules for relaxation of NCP in CalSim II (based on BA models) will be used. In CalSim II, NCP flows are relaxed depending on allocations for agricultural contractors. Table 5.A.A.7-2 is used to determine the relaxation.

Table 5.A.A.7-2 NCP Flow Schedule with Relaxation

CVP AG Allocation (%)	NCP Flow (cfs)
<10	3,250
10–25	3,500
25–40	4,000
40–65	4,500
>65	5,000

Rationale: The allocation-flow criteria have been used in the CalSim II model for many years. The low allocation year relaxations were added to improve operations of Shasta Lake subject to 1.9 MAF carryover target storage. These criteria may be reevaluated subject to the requirements of Action 1.2.1

4.6 Action 2.1 Lower American River Flow Management

Objective: To provide minimum flows for all steelhead life stages.

Action: Implement the flow schedule specified in the Water Forum's Flow Management Standard (FMS), which is summarized in Appendix 2-D of the NMFS BiOp.

Action 2.1 Assumptions for CalSim II Modeling Purposes

Action: The AFRMP Minimum Release Requirements (MRR) range from 800 to 2,000 cfs based on a sequence of seasonal indices and adjustments. The minimum Nimbus Dam release requirement is determined by applying the appropriate water availability index (Index Flow). Three water availability indices (i.e., Four Reservoir Index (FRI), Sacramento River Index (SRI), and the Impaired Folsom Inflow Index (IFII)) are applied during different times of the year, which provides adaptive flexibility in response to changing hydrological and operational conditions.

During some months, Prescriptive Adjustments may be applied to the Index Flow, resulting in the MRR. If there is no Prescriptive Adjustment, the MRR is equal to the Index Flow.

Discretionary Adjustments for water conservation or fish protection may be applied during the period extending from June through October. If Discretionary Adjustments are applied, then the resultant flows are referred to as the Adjusted Minimum Release Requirement (Adjusted MRR).

The MRR and Adjusted MRR may be suspended in the event of extremely dry conditions, represented by "conference years" or "off-ramp criteria". Conference years are defined when the projected March through November unimpaired inflow into Folsom Reservoir is less than 400,000 acre-feet. Off-ramp criteria are triggered if forecasted Folsom Reservoir storage at any time during the next twelve months is less than 200,000 acre-feet.

Rationale: Minimum instream flow schedule specified in the Water Forum's Flow Management Standard (FMS) is implemented in the model.

Action 2.2 Lower American River Temperature Management

Objective: Maintain suitable temperatures to support over-summer rearing of juvenile steelhead in the lower American River.

Action: Reclamation shall develop a temperature management plan that contains: (1) forecasts of hydrology and storage; (2) a modeling run or runs, using these forecasts, demonstrating that the temperature compliance point can be attained (see Coldwater Management Pool Model approach in Appendix 2-D); (3) a plan of operation based on this modeling run that demonstrates that all other non-discretionary requirements are met; and (4) allocations for discretionary deliveries that conform to the plan of operation.

Action 2.2 Assumptions for CalSim II Modeling Purposes

Action: The flows in the model reflect the FMS implemented under Action 2.1. It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: Temperature models of Folsom Lake and the American River were developed in the 1990's. Model development for long range planning purposes may be required. Further analysis using a verified long range planning level temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably

4.7 Action Suite 3.1 Stanislaus River / Eastside Division Actions

Overall Objectives: (1) Provide sufficient definition of operational criteria for Eastside Division to ensure viability of the steelhead population on the Stanislaus River, including freshwater migration routes to and from the Delta; and (2) halt or reverse adverse modification of steelhead critical habitat.

Action 3.1.2 Provide Cold Water Releases to Maintain Suitable Steelhead Temperatures

Action: Reclamation shall manage the cold water supply within New Melones Reservoir and make cold water releases from New Melones Reservoir to provide suitable temperatures for CV steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam.

Action 3.1.2 Assumptions for CalSim II Modeling Purposes

Action: No specific CalSim II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flow operations resulting from the minimum flow requirements described in action 3.1.3.

Rationale: Temperature models of New Melones Lake and the Stanislaus River have been developed by Reclamation. Further analysis using this or another temperature model can further verify that temperature operations perform reasonably well with flows included in model and temperatures are met reliably. Development of temperature model runs is needed to refine the flow schedules assumed.

Action 3.1.3 Operate the East Side Division Dams to Meet the Minimum Flows, as Measured at Goodwin Dam

Objective: To maintain minimum base flows to optimize CV steelhead habitat for all life history stages and to incorporate habitat maintaining geomorphic flows in a flow pattern that will provide migratory cues to smolts and facilitate out-migrant smolt movement on declining limb of pulse.

Action: Reclamation shall operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed in NMFS BiOp Appendix 2-E and generally described in figure 11-1. When operating at higher flows than specified, Reclamation shall implement ramping rates for flow changes that will avoid stranding and other adverse effects on CV steelhead.

Action 3.1.4 Assumptions for CalSim II Modeling Purposes

Action: Minimum flows based on Appendix 2-E flows (presented in Figure 5.A.A.7-1) are assumed consistent to what was modeled by NMFS (5/14/09 and 5/15/09 CalSim II models provided by NMFS; relevant logic merged into baselines models).

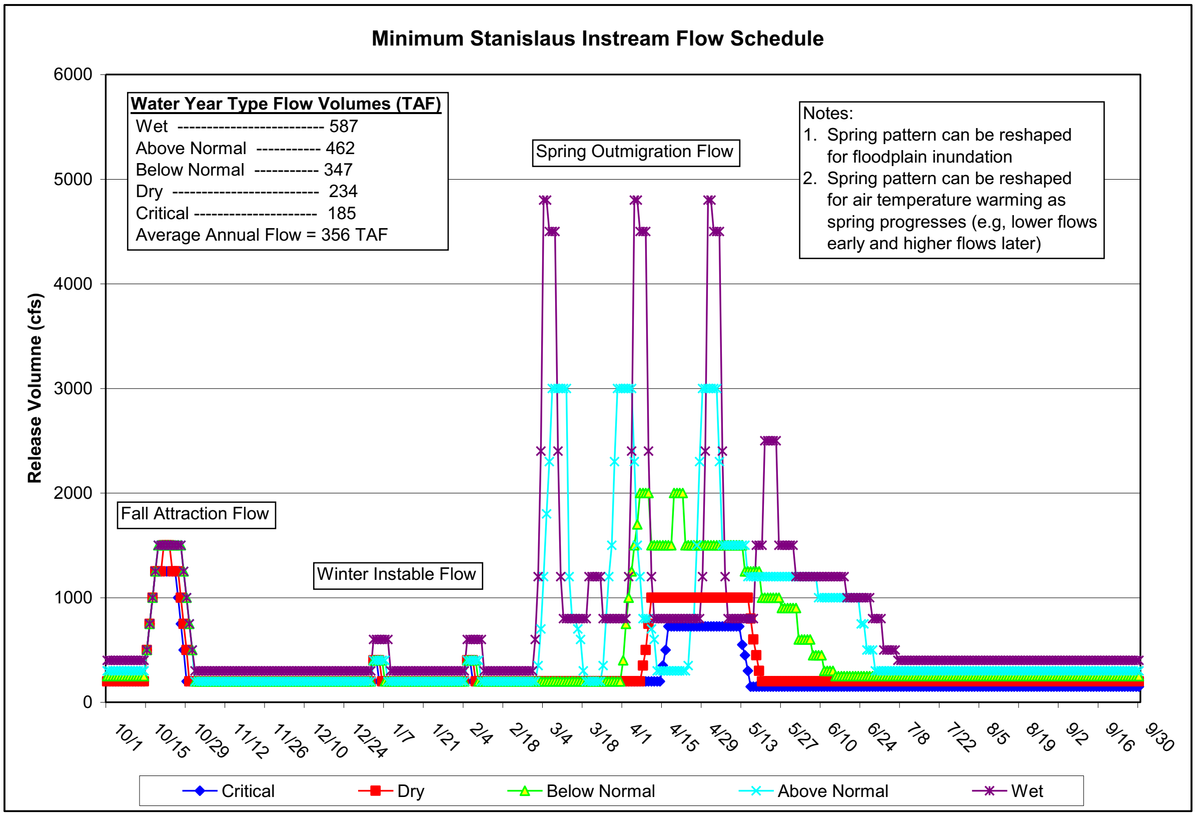


Figure 5.A.A.7-1 Minimum Stanislaus instream flow schedule as prescribed in Appendix 2-E of the NMFS BiOp (06/04/09)

Annual allocation in New Melones is modeled to ensure availability of required instream flows (Table 5.A.A.7-3) based on a water supply forecast that is comprised of end-of-February New Melones storage (in TAF) plus forecasted inflow to New Melones from March 1 to September 30 (in TAF). The "forecasted inflow" is calculated using perfect foresight in the model. Allocated volume of water is released according to water year type following the monthly flow schedule illustrated in Figure 5.A.A.7-1.

Table 5.A.A.7-3 New Melones Allocations to Meet Minimum Instream Flow Requirements

New Melones index (TAF)	Annual Allocation Required for Instream Flows (TAF)
< 1,000	0 to 98.9
1,000 to 1,399	98.9
1,400 to 1,724	185.3
1,725 to 2,177	234.1
2,178 to 2,386	346.7
2,387 to 2,761	461.7
2,762 to 6,000	586.9

Rationale: This approach was reviewed by NOAA fisheries and verified that the year typing and New Melones allocation scheme are consistent with the modeling prepared for the BiOp.

4.8 Action Suite 4.1 Delta Cross Channel (DCC) Gate Operation, and Engineering Studies of Methods to Reduce Loss of Salmonids in Georgiana Slough and Interior Delta

Action 4.1.2 DCC Gate Operation

Objective: Modify DCC gate operation to reduce direct and indirect mortality of emigrating juvenile salmonids and green sturgeon in November, December, and January.

Action: During the period between November 1 and June 15, DCC gate operations will be modified from the proposed action to reduce loss of emigrating salmonids and green sturgeon. From December 1 to January 31, the gates will remain closed, except as operations are allowed using the implementation procedures/modified Salmon Decision Tree.

Timing: November 1 through June 15.

Triggers: Action triggers and description of action as defined in NMFS BiOp are presented in Table 5.A.A.7-4.

Table 5.A.A.7-4 NMFS BiOp DCC Gate Operation Triggers and Actions

Date	Action Triggers	Action Responses
October 1 – November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) are greater than 3 fish per day but less than or equal to 5 fish per day.	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
October 1 – November 30	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
October 1 – November 30	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.
December 1 – December 14	Water quality criteria are met per D-1641.	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (e.g., Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS' prior approval of the study.
December 1 – December 14	Water quality criteria are not met but both the KLCI and SCI are less than 3 fish per day.	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
December 1 – December 14	Water quality criteria are not met but either of the KLCI or SCI is greater than 3 fish per day.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5
December 15 – January 31	December 15 – January 31	DCC Gates Closed.
December 15 – January 31	NMFS-approved experiments are being conducted.	Agency sponsoring the experiment may request gate opening for up to 5 days; NMFS will determine whether opening is consistent with ESA obligations.
December 15 – January 31	One-time event between December 15 to January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions.	Upon concurrence of NMFS, DCC Gates may be opened one hour after sunrise to one hour before sunset, for up to 3 days, then return to full closure. Reclamation and DWR will also reduce Delta exports down to a health and safety level during the period of this action.
February 1 – May 15	D-1641 mandatory gate closure.	Gates closed, per WQCP criteria
May 16 – June 15	D-1641 gate operations criteria	DCC gates may be closed for up to 14 days during this period, per 2006 WQCP, if NMFS determines it is necessary.

Action 4.1.2 Assumptions for CalSim II Modeling Purposes

Action: The DCC gate operations for October 1 through January 31 were layered on top of the D-1641 gate operations already included in the CalSim II model. The general assumptions regarding the NMFS DCC operations are summarized in Table 5.A.A.7-5.

Timing: October 1 through January 31.

Table 5.A.A.7-5 DCC Gate Operation Triggers and Actions as Modeled in CalSim II

Date	Modeled Action Triggers	Modeled Action Responses
October 1 – December 14	Sacramento River daily flow at Wilkins Slough exceeding 7,500 cfs; flow assumed to flush salmon into the Delta	Each month, the DCC gates are closed for number of days estimated to exceed the threshold value.
October 1 – December 14	Water quality conditions at Rock Slough subject to D-1641 standards	Each month, the DCC gates are not closed if it results in violation of the D-1641 standard for Rock Slough; if DCC gates are not closed due to water quality conditions, exports during the days in question are restricted to 2,000 cfs.
December 15 – January 31	December 15-January 31	DCC Gates Closed.

Flow Trigger: It is assumed that during October 1 – December 14, the DCC will be closed if Sacramento River daily flow at Wilkins Slough exceeds 7,500 cfs. Using historical data (1945 through 2003, USGS gauge 11390500 "Sacramento River below Wilkins Slough near Grimes, CA"), a linear relationship is obtained between average monthly flow at Wilkins Slough and the number of days in month where the flow exceeds 7,500 cfs. This relation is then used to estimate the number of days of DCC closure for the October 1 – December 14 time period (Figure 5.A.A.7-2).

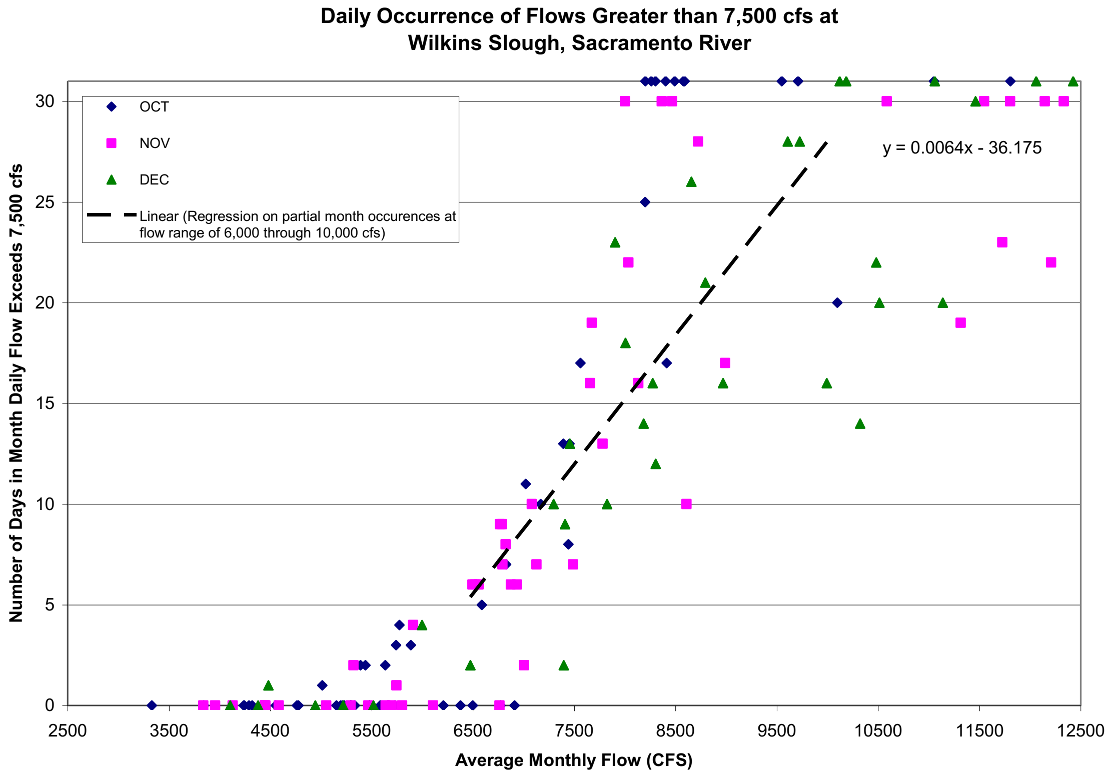


Figure 5.A.A.7-2 Relationship between monthly averages of Sacramento River flows and number of days that daily flow exceeds 7,500 cfs in a month at Wilkins Slough

It is assumed that during December 15 through January 31 that the DCC gates are closed under all flow conditions.

Water Quality: It is assumed that during October 1 – December 14 the DCC gates may remain open if water quality is a concern. Using the CalSim II-ANN flow-salinity model for Rock Slough, current month's chloride level at Rock Slough is estimated assuming DCC closure per NMFS BiOp. The estimated chloride level is compared against the Rock Slough chloride standard (monthly average). If estimated chloride level exceeds the standard, the gate closure is modeled per D1641 schedule (for the entire month).

It is assumed that during December 15 through January 31 that the DCC gates are closed under all water quality conditions.

Export Restriction: During October 1 – December 14 period, if the flow trigger condition is such that additional days of DCC gates closed is called for, however water quality conditions are a concern and the DCC gates remain open, then Delta exports are limited to 2,000 cfs for each day in question. A monthly Delta export restriction is calculated based on the trigger and water quality conditions described above.

Rationale: The proposed representation in CalSim II should adequately represent the limited water quality concerns were Sacramento River flows are low during the extreme high tides of December.

4.9 Action Suite 4.2 Delta Flow Management

Action 4.2.1 San Joaquin River Inflow to Export Ratio

Objectives: To reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta, by increasing the inflow to export ratio. To enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: For CVP and SWP operations under this action, "The Phase II: Operations beginning is 2012" is assumed. From April 1 through May 31, 1) Reclamation shall continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action 3.1.3 and Appendix 2-E of the NMFS BiOp); and 2) Combined CVP and SWP exports shall be restricted to the ratio depicted in table B-44 below based on the applicable San Joaquin River Index, but will be no less than 1,500 cfs (consistent with the health and safety provision governing this action.)

Action 4.2.1 Assumptions for CalSim II Modeling Purposes

Action: Flows at Vernalis during April and May will be based on the Stanislaus River flow prescribed in Action 3.1.3 and the flow contributions from the rest of the San Joaquin River basin consistent with the representation of VAMP contained in the BA modeling. In many years this flow may be less than the minimum Vernalis flow identified in the NOAA BiOp.

Exports are restricted as illustrated in Table 5.A.A.7-6.

Table 5.A.A.7-6. Maximum Combined CVP and SWP Export during April and May

San Joaquin River Index	Combined CVP and SWP Export Ratio
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1

Rationale: Although the described model representation does not produce the full Vernalis flow objective outlined in the NOAA BiOp, it does include the elements that are within the control of the CVP and SWP, and that are reasonably certain to occur for the purpose of the EIS/EIR modeling.

In the long-term, a future SWRCB flow standard at Vernalis may potentially incorporate the full flow objective identified in the BiOp; and the Merced and Tuolumne flows would be based on the outcome of the current SWRCB and FERC processes that are underway.

Action 4.2.3 Old and Middle River Flow Management

Objective: Reduce the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. Enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. Refer to NMFS BiOp document for the negative flow objective decision tree.

Action 4.2.3 Assumptions for CalSim II Modeling Purposes

Action: Old and Middle River flows required in this BiOp are assumed to be covered by OMR flow requirements developed for actions 1 through 3 of the FWS BiOp Most Likely scenario (Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CalSim II Planning Studies – DRAFT, 6/10/09).

Rationale: Based on a review of available data, it appears that implementation of actions 1 through 3 of the FWS RPA, and action 4.2.1 of the NOAA RPA will adequately cover this action within the CalSim II simulation. If necessary, additional post-processing of results could be conducted to verify this assumption.

4.10 References

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Attachment 1-5 Estimation of SWP Proportion of Effects

The scope of current project is to secure coverage for the long-term operations of the SWP under CESA. The CalSim modeling performed to analyze the proposed long-term SWP operations simulate the joint SWP and CVP operations. Therefore, following approach was used to isolate potential SWP proportion of any effects that may be a result of joint operation of SWP and CVP.

The approach is based on premise that under excess Delta conditions the joint operations are typically governed by the exports at the SWP and CVP pumping facilities, and under balanced conditions the SWP and CVP responsibility are defined in the Coordinated Operations Agreement (COA). COA identifies two types of balanced conditions: In basin use (IBU) and Unstored water for export (UWFE). In estimating the SWP proportion of effects, following principles were used:

- For months with IBU balanced conditions, the sharing ratio assigned to SWP in the COA is the SWP's proportion of an effect.
- For months with UWFE balanced conditions and excess conditions, the proportion of exports at Banks Pumping Plant of the total exports at Banks and Jones Pumping Plants is the SWP's proportion of an effect. All exports including any CVP wheeling and water transfers at the Banks Pumping Plant are used in this estimation.

These principles were applied to each month in the Proposed Project and Refined Alternative 2b 82-year CalSim simulation period, and the SWP's proportions were identified for each month. The monthly proportions were averaged over the long-term planning period and by Sacramento 40-30-30 water year types~~ and long-term~~. Tables 1 and 2 show~~s~~ the estimated SWP proportion of an effect that is a result of joint operations of SWP and CVP ~~based on~~for the Proposed Project and Refined Alternative 2b, respectively. The proportions shown in Table 1 are based on the ~~proposed project~~Proposed Project CalSim modeling performed to support the Proposed Project effects analysis. The proportions shown in Table 2 are based on the Refined Alternative 2b CalSim modeling performed to support the Refined Alternative 2b effects analysis. These proportions are only for use in the effects analysis ~~included in the current project~~ of their respective alternatives.

Table 1: Estimated SWP proportion of an effect that may be a result of joint operation of SWP and CVP based on the Proposed Project CalSim simulation. The proportions presented are averaged by water year type and long-term by month.

Month	Wet	Above-Normal	Below-Normal	Dry	Critical	Long-term Average
OCT	49%	47%	44%	43%	42%	45%
NOV	64%	51%	57%	54%	48%	56%
DEC	50%	56%	56%	54%	49%	53%
JAN	50%	43%	43%	44%	43%	45%
FEB	56%	48%	46%	41%	40%	48%
MAR	57%	46%	49%	41%	39%	48%
APR	49%	47%	51%	45%	47%	48%
MAY	46%	44%	40%	37%	37%	42%
JUN	42%	31%	29%	35%	40%	36%
JUL	39%	20%	25%	35%	40%	33%
AUG	43%	20%	25%	30%	36%	33%
SEP	28%	23%	52%	40%	39%	36%
Annual Average	48%	40%	43%	42%	42%	44%

Table 2: Estimated SWP proportion of an effect that may be a result of joint operation of SWP and CVP based on the Refined Alternative 2b CalSim simulation. The proportions presented are averaged by water year type and long-term by month.

Month	Wet	Above-Normal	Below-Normal	Dry	Critical	Long-term Average
OCT	48%	43%	48%	43%	42%	45%
NOV	62%	52%	60%	57%	47%	57%
DEC	50%	56%	57%	54%	53%	53%
JAN	51%	43%	43%	43%	45%	46%
FEB	56%	47%	46%	41%	38%	47%
MAR	57%	45%	44%	41%	37%	47%
APR	37%	21%	22%	24%	37%	29%
MAY	28%	19%	18%	24%	33%	25%
JUN	42%	31%	28%	35%	40%	36%
JUL	37%	20%	25%	35%	40%	32%
AUG	53%	55%	25%	28%	36%	41%
SEP	28%	23%	51%	40%	38%	35%
Annual Average	46%	38%	39%	39%	41%	41%