Appendix 9C

Reclamation Salmon Mortality Model Analysis Documentation

This appendix provides information about the methods and assumptions used for the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Environmental Impact Statement (EIS) analysis using the Bureau of Reclamation (Reclamation) Salmon Mortality Model. It is organized in two main sections that are briefly described below:

- Section 9C.1: Reclamation Salmon Mortality Model Methodology and Assumptions
  - The EIS Salmon Mortality analysis uses the Reclamation Salmon Mortality model to quantify salmon early life stage (pre-spawned eggs, fertilized eggs, and pre-emergent fry) losses on the Trinity, Sacramento, Feather, American, and Stanislaus Rivers. This section briefly describes the overall analytical approach and assumptions of the Reclamation Salmon Mortality model.
- Section 9C.2: Reclamation Salmon Mortality Model Results
  - This section presents the salmon early life stage (pre-spawned eggs, fertilized eggs, and pre-emergent fry) mortality percentage of Trinity River Fall-Run, Sacramento River fall-run, late fall-run, spring-run, and winter-run, Feather River fall-run, American River fall-run, and Stanislaus River fall-run Chinook Salmon. Statistics are presented in tabular format.

9.C.1 Reclamation Salmon Mortality Model Methodology and Assumptions

9.C.1.1 Reclamation Salmon Mortality Model Methodology

The Reclamation Salmon Mortality Model simulates the early life stage mortality of Chinook Salmon along reaches of the Trinity (below Lewiston Dam to Burnt Ranch), Sacramento (below Keswick Dam to Princeton), Feather (below the Fish Dam to the Sacramento River confluence), American (below Nimbus Dam to the Sacramento River confluence), and Stanislaus Rivers (below Goodwin Dam to Riverbank). The model sets an initial spawning distribution along the different river reaches (as a percentage) and uses water temperature data to simulate egg development and mortality based on temperature relationships specified in the model. Daily water temperature results for the Sacramento, American, and Stanislaus rivers come from the HEC5Q models; and monthly water temperature results for the Trinity and Feather rivers come from the Reclamation Temperature Model are used as an input to Reclamation Salmon Mortality Model. The final output from the Reclamation Salmon Mortality Model used in this analysis is the resulting annual percent mortality. Operations Criteria and Plan (OCAP)

Biological Assessment (BA) Appendix L (Reclamation 2008) provides detailed description of the Reclamation Salmon Mortality Model structure, assumptions, and processes.

9.C.1.2 Reclamation Salmon Mortality Model Analysis Scenario Assumptions

This section describes the assumptions for the Reclamation Salmon Mortality Model analysis for the No Action Alternative, Second Basis of Comparison, and other alternatives.

The following CalSim II model simulations were performed as the basis of evaluating the impacts of the other alternatives:

- No Action Alternative
- Second Basis of Comparison

The following model simulations of other alternatives were performed:

- Alternative 1 – for simulation purposes, considered the same as Second Basis of Comparison
- Alternative 2 – for simulation purposes, considered the same as No Action Alternative
- Alternative 3
- Alternative 4 – for simulation purposes, considered the same as Second Basis of Comparison.
- Alternative 5

Assumptions for each of these alternatives were developed with the surface water modeling tools and are described in Appendix 5A, Section B.

Alternative 1 modeling assumptions are the same as the Second Basis of Comparison, and Alternative 2 modeling assumptions are the same as the No Action Alternative; therefore, the assumptions for those alternatives are not discussed separately in this document.

Assumptions for each of these alternatives are reflected to monthly CalSim II flow data that are used in the HEC5Q and Reclamation Temperature Models to generate flow and water temperature data that are then used in the Reclamation Salmon Mortality Model. Table 9C.1 provides the assumed spawning distributions for fall-, late fall-, winter-, and spring-Run Chinook Salmon on the Sacramento River in simulating various scenarios in this EIS. The OCAP BA Appendix L (Reclamation 2008) Tables L-2 to L-5 provide the assumed spawning distributions for Trinity River, Feather River, American River, and Stanislaus River fall-run Chinook Salmon.

Table 9C.1 Upper Sacramento River Spawning Distributions

Reach	No.	River Reach	Spawning Distribution (%)			
			Fall	Late Fall	Winter	Spring
UPPER	1	Keswick Dam – ACID Dam	16.28%	67.6%	45.03%	12.43%
	2	ACID Dam – Hwy 44	5.48%	5.0%	42.09%	32.77%
	3	Hwy 44 – Upper Anderson Bridge	12.26%	3.7%	12.23%	27.66%
	4	Upper Anderson Bridge – Balls Ferry	16.19%	7.9%	0.26%	10.90%
	5	Balls Ferry – Jellys Ferry	23.08%	8.0%	0.28%	8.75%
	6	Jellys Ferry – Bend Bridge	6.61%	1.0%	0.06%	2.58%
	7	Bend Bridge – Red Bluff Pumping Plant (previously Red Bluff Diversion Dam)	3.48%	0.5%	0.00%	0.83%
	Total – Upper Salmon Reach		**83.37%**	**93.8%**	**99.95%**	**95.92%**
MIDDLE	8	Red Bluff Pumping Plant – Tehama Bridge	10.82%	3.1%	0.05%	4.08%
	9	Tehama Bridge – Woodson Bridge	3.07%	1.2%	0.00%	0.00%
	10	Woodson Bridge – Hamilton City	1.82%	1.1%	0.00%	0.00%
	Total – Middle Salmon Reach		**15.71%**	**5.4%**	**0.05%**	**4.08%**
LOWER	11	Hamilton City – Ord Ferry	0.82%	0.6%	0.00%	0.0%
	12	Ord Ferry – Princeton	0.10%	0.2%	0.00%	0.0%
	Total – Lower Salmon Reach		**0.92%**	**0.8%**	**0.0%**	**0.0%**

NOTE:
Sacramento River salmon spawning distributions were revised based on average 2003-2014 redd survey data, provided by David Swank at National Marine Fisheries Service in April 2015.

9.C.2 Reclamation Salmon Mortality Model Results

Results are provided for each of the following runs separately:

- No Action Alternative
- Second Basis of Comparison
- Alternative 1
- Alternative 3
- Alternative 5

In addition, the same statistics are provided for the following comparisons to establish changes of the alternative with respect to one of the bases of comparison:

- Alternative 1 compared to No Action Alternative
- Alternative 3 compared to No Action Alternative
- Alternative 5 compared to No Action Alternative

- No Action Alternative compared to Second Basis of Comparison
- Alternative 1 compared to Second Basis of Comparison
- Alternative 3 compared to Second Basis of Comparison
- Alternative 5 compared to Second Basis of Comparison

The results are provided as tables summarizing the annual losses with long-term averages over the 82-year CalSim II simulation period. Averages are also provided by water year type.

The following results are presented in this section:

- B.1. Sacramento River Percent Salmon Loss Summary – Fall-Run Chinook Salmon
- B.2. Sacramento River Percent Salmon Loss Summary – Late Fall-Run Chinook Salmon
- B.3. Sacramento River Percent Salmon Loss Summary – Spring-Run Chinook Salmon
- B.4. Sacramento River Percent Salmon Loss Summary – Winter-Run Chinook Salmon
- B.5. Trinity River Percent Salmon Loss Summary – Fall-Run Chinook Salmon
- B.6. American River Percent Salmon Loss Summary – Fall-Run Chinook Salmon
- B.7. Feather River Percent Salmon Loss Summary – Fall-Run Chinook Salmon
- B.8. Stanislaus River Percent Salmon Loss Summary – Fall-Run Chinook Salmon

9.C.3 References

Reclamation (Bureau of Reclamation). 2008. *2008 Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessment*, Appendix L Reclamation Salmon Mortality Model.

Table B-1. Sacramento River Percent Mortality - Fall-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	17.0	---	-0.1
Wet	10.7	---	-0.8
Above Normal	10.5	---	-1.3
Below Normal	15.3	---	0.1
Dry	17.3	---	-0.1
Critical	37.9	---	2.4
Second Basis of Comparison			
Long-term Average	17.1	0.1	
Wet	11.5	0.8	---
Above Normal	11.9	1.3	---
Below Normal	15.2	-0.1	---
Dry	17.4	0.1	---
Critical	35.5	-2.4	---
Alternative 3			
Long-term Average	16.8	-0.2	-0.3
Wet	11.3	0.6	-0.2
Above Normal	11.6	1.0	-0.3
Below Normal	14.7	-0.7	-0.6
Dry	16.9	-0.4	-0.5
Critical	35.6	-2.3	0.1
Alternative 5			
Long-term Average	16.9	-0.1	-0.2
Wet	10.6	0.0	-0.8
Above Normal	10.4	-0.1	-1.4
Below Normal	15.0	-0.3	-0.2
Dry	17.0	-0.3	-0.5
Critical	38.5	0.6	3.0

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-2. Sacramento River Percent Mortality - Late Fall-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	3.1	---	0.4
Wet	3.1	---	0.8
Above Normal	2.4	---	0.5
Below Normal	2.5	---	-0.1
Dry	2.7	---	0.1
Critical	4.8	---	0.2
Second Basis of Comparison			
Long-term Average	2.7	-0.4	
Wet	2.2	-0.8	---
Above Normal	1.9	-0.5	---
Below Normal	2.6	0.1	---
Dry	2.5	-0.1	---
Critical	4.6	-0.2	---
Alternative 3			
Long-term Average	2.7	-0.4	0.0
Wet	2.3	-0.8	0.0
Above Normal	1.8	-0.6	-0.1
Below Normal	2.6	0.1	0.0
Dry	2.6	-0.1	0.1
Critical	4.6	-0.2	-0.1
Alternative 5			
Long-term Average	3.1	0.0	0.4
Wet	3.0	0.0	0.8
Above Normal	2.4	0.0	0.5
Below Normal	2.4	-0.1	-0.1
Dry	2.7	0.0	0.2
Critical	4.9	0.1	0.2

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-3. Sacramento River Percent Mortality - Spring-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	21.9	---	0.7
Wet	6.3	---	-2.4
Above Normal	4.8	---	-2.4
Below Normal	13.3	---	0.8
Dry	19.4	---	0.7
Critical	84.8	---	10.4
Second Basis of Comparison			
Long-term Average	21.1	-0.7	
Wet	8.6	2.4	---
Above Normal	7.2	2.4	---
Below Normal	12.5	-0.8	---
Dry	18.6	-0.7	---
Critical	74.3	-10.4	---
Alternative 3			
Long-term Average	21.1	-0.7	0.0
Wet	8.4	2.1	-0.3
Above Normal	7.3	2.4	0.0
Below Normal	10.8	-2.5	-1.6
Dry	17.5	-1.9	-1.1
Critical	78.1	-6.6	3.8
Alternative 5			
Long-term Average	21.9	0.1	0.8
Wet	6.3	0.0	-2.4
Above Normal	4.9	0.0	-2.4
Below Normal	13.3	0.0	0.8
Dry	18.1	-1.3	-0.6
Critical	87.4	2.6	13.1

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-4. Sacramento River Percent Mortality - Winter-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	5.0	---	0.7
Wet	0.6	---	-0.1
Above Normal	0.1	---	0.0
Below Normal	0.2	---	-0.8
Dry	0.3	---	0.0
Critical	31.4	---	5.4
Second Basis of Comparison			
Long-term Average	4.3	-0.7	
Wet	0.6	0.1	---
Above Normal	0.1	0.0	---
Below Normal	1.0	0.8	---
Dry	0.3	0.0	---
Critical	26.0	-5.4	---
Alternative 3			
Long-term Average	4.2	-0.8	-0.1
Wet	0.6	0.1	0.0
Above Normal	0.1	0.0	0.0
Below Normal	1.0	0.7	0.0
Dry	0.3	-0.1	0.0
Critical	25.3	-6.0	-0.7
Alternative 5			
Long-term Average	4.6	-0.4	0.3
Wet	0.6	0.0	-0.1
Above Normal	0.1	0.0	0.0
Below Normal	0.3	0.0	-0.8
Dry	0.3	0.0	0.0
Critical	28.9	-2.5	2.9

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-5. Trinity River Percent Mortality - Fall-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	4.0	---	0.2
Wet	1.3	---	-0.6
Above Normal	1.5	---	0.2
Below Normal	3.8	---	0.5
Dry	2.5	---	0.2
Critical	14.8	---	1.8
Second Basis of Comparison			
Long-term Average	3.7	-0.2	
Wet	1.9	0.6	---
Above Normal	1.2	-0.2	---
Below Normal	3.4	-0.5	---
Dry	2.3	-0.2	---
Critical	13.0	-1.8	---
Alternative 3			
Long-term Average	3.7	-0.2	0.0
Wet	1.9	0.5	-0.1
Above Normal	1.2	-0.2	0.0
Below Normal	3.2	-0.6	-0.2
Dry	2.2	-0.3	-0.1
Critical	13.3	-1.5	0.3
Alternative 5			
Long-term Average	3.9	0.0	0.2
Wet	1.3	0.0	-0.6
Above Normal	1.4	0.0	0.2
Below Normal	3.6	-0.2	0.3
Dry	2.5	0.0	0.2
Critical	14.9	0.1	1.9

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-6. American River Percent Mortality - Fall-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	23.2	---	0.2
Wet	22.6	---	-0.6
Above Normal	23.2	---	0.6
Below Normal	23.5	---	2.0
Dry	22.9	---	-0.1
Critical	25.0	---	0.1
Second Basis of Comparison			
Long-term Average	23.1	-0.2	
Wet	23.2	0.6	---
Above Normal	22.7	-0.6	---
Below Normal	21.5	-2.0	---
Dry	23.0	0.1	---
Critical	24.9	-0.1	---
Alternative 3			
Long-term Average	23.2	-0.1	0.1
Wet	23.2	0.6	-0.1
Above Normal	22.6	-0.6	0.0
Below Normal	21.8	-1.7	0.3
Dry	22.9	0.0	-0.1
Critical	25.4	0.4	0.6
Alternative 5			
Long-term Average	23.0	-0.3	-0.1
Wet	22.7	0.1	-0.5
Above Normal	22.5	-0.7	-0.2
Below Normal	22.5	-1.0	1.0
Dry	22.9	0.0	-0.1
Critical	24.7	-0.3	-0.2

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-7. Feather River Percent Mortality - Fall Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	7.2	---	0.2
Wet	4.6	---	2.8
Above Normal	3.4	---	0.2
Below Normal	8.4	---	-0.9
Dry	7.7	---	-0.9
Critical	14.5	---	-3.0
Second Basis of Comparison			
Long-term Average	7.0	-0.2	
Wet	1.7	-2.8	---
Above Normal	3.1	-0.2	---
Below Normal	9.2	0.9	---
Dry	8.6	0.9	---
Critical	17.4	3.0	---
Alternative 3			
Long-term Average	6.0	-1.1	-0.9
Wet	1.9	-2.7	0.1
Above Normal	2.9	-0.4	-0.2
Below Normal	6.8	-1.6	-2.4
Dry	7.8	0.0	-0.8
Critical	14.6	0.2	-2.8
Alternative 5			
Long-term Average	6.9	-0.2	-0.1
Wet	4.5	0.0	2.8
Above Normal	3.2	-0.2	0.1
Below Normal	10.6	2.3	1.4
Dry	7.4	-0.3	-1.1
Critical	13.9	-0.6	-3.6

Notes: All results are based on the 82-year simulation period. The water year types are defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.

Table B-8. Stanislaus River Percent Mortality - Fall-Run Chinook Salmon

	Percent Mortality	Difference from No Action Alternative	Difference from Second Basis of Comparison
	%	%	%
No Action Alternative			
Long-term Average	7.0	---	-0.4
Wet	1.6	---	0.1
Above Normal	5.3	---	-0.1
Below Normal	4.4	---	0.3
Dry	4.9	---	-0.3
Critical	14.4	---	-1.5
Second Basis of Comparison			
Long-term Average	7.4	0.4	
Wet	1.5	-0.1	---
Above Normal	5.4	0.1	---
Below Normal	4.1	-0.3	---
Dry	5.1	0.3	---
Critical	15.9	1.5	---
Alternative 3			
Long-term Average	6.2	-0.8	-1.2
Wet	1.6	0.0	0.1
Above Normal	4.0	-1.3	-1.4
Below Normal	3.8	-0.6	-0.3
Dry	4.2	-0.7	-0.9
Critical	13.4	-1.0	-2.5
Alternative 5			
Long-term Average	8.5	1.5	1.0
Wet	1.8	0.2	0.3
Above Normal	6.4	1.1	1.0
Below Normal	6.1	1.6	2.0
Dry	7.0	2.2	1.9
Critical	16.9	2.5	1.0

Notes: All results are based on the 82-year simulation period. The water year types are defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030.