Appendix 11E Reservoir Fish Species Analysis

Appendix 11E Reservoir Fish Species Analysis

11E.1 Introduction

This appendix describes analysis used to evaluate potential impacts on aquatic species occupying reservoirs that may be affected by changes in the operation of the State Water Project (SWP) and Central Valley Project (CVP) facilities as a result of implementing the Sites Reservoir Project (Project).

Several reservoir fish species are sensitive to changes in reservoir storage (cold-water species) and water surface elevation (WSE; warm-water species) throughout the year. Because the Project is anticipated to result in changes in reservoir storage and WSEs in reservoirs, the fisheries impact assessment focused on these changes, along with other habitat-based elements. Taking into account species- and life stage–specific habitat requirements, operational components of alternatives were assessed to evaluate potential impacts on reservoir fish species.

Reservoirs evaluated include:

- Sites Reservoir
- Shasta Lake
- Lake Oroville
- Folsom Lake
- San Luis Reservoir

There would be negligible changes among alternatives in the operation of Trinity Reservoir (Appendix 5B2, *River Operations*, Table 5B2-1-1a to Table 5B2-1-4c; Figure 5B2-1-1 to Figure 5B2-1-12), and there would be negligible differences in Trinity Reservoir storage and WSE reductions among alternatives. Therefore, no Trinity Reservoir storage or WSE results are provided in this appendix. Further, because no other CVP or SWP reservoirs (e.g., Millerton and New Melones Reservoirs) would be affected by the Project, there would be no effect of any alternative on these reservoirs.

It is important to note that storage volume and elevations of the reservoirs listed above have experienced high variation within the year under historical operations. Therefore, this analysis focuses on the comparison of model outputs for each alternative relative to the No Action Alternative (NAA).[1]

[1] The term *NAA*, which is identical to the No Project Alternative, is used throughout Chapter 11, *Aquatic Biological Resources*, and associated aquatic resources appendices in the presentation of modeled results and represents no material difference from the No Project Alternative, as discussed in Chapter 3, *Environmental Analysis*.

11E.2 Methods

For a description of the impact assessment methodology, assumptions, and indicator variables used in the fisheries and aquatic impact assessment for operational impacts, refer to Appendix 11B, *Upstream Fisheries Impact Assessment Quantitative Methods*. The following summarizes the potential impacts on fish species based on changes in the indicator variables for each species/life stage evaluated. Detailed information and results of modeling tools relevant to the impact analyses for fisheries and aquatic resources are presented in the following appendices.

As described in Appendix 11B, it was determined that incremental changes of 5% or less in an indicator variable such as flow or other indicators based on flow (e.g., weighted usable area) were related to the uncertainties in the model processing. Therefore, changes of 5% or less are considered to be not substantially different, or “similar” in this comparative analysis. Differences between alternatives and the NAA of less than these levels are described below as being similar or only slightly different.

Because there would be negligible changes among alternatives in the operations of New Melones Reservoir and Millerton Lake, there would be negligible differences in reservoir storage volumes or WSEs among alternatives. As described in Chapter 2, *Project Description and Alternatives*, the Project would not affect or result in changes in the operation of the CVP Trinity River Division facilities (including Clear Creek), and thus Trinity River resources are not discussed or analyzed further in this appendix. The results of evaluations for these reservoirs are not presented.

This section presents a summary of potential mechanisms for impact and the analytical methods used to assess potential impacts on reservoir fish species.

Changes in CVP and SWP operations under Alternatives 1, 2, and 3 could result in changes in reservoir storage volume, WSE, and water temperature in associated reservoirs. Variation in reservoir storage, elevation, and water temperature is a function of water demand, water quality requirements, and inflow; these attributes also change based on the water year type.

11E.2.1. Reservoir Storage Volume

To evaluate potential effects of each alternative on cold-water reservoir fish species, differences between each alternative and the NAA in modeled monthly average reservoir storage were calculated during April through November. Although aquatic habitat within the CVP and SWP water supply reservoirs is not thought to be limiting, and reservoir cold-water fish species are not considered state or federal special-status species, storage volume is presented as an indicator of how much habitat may be available to fish species inhabiting these reservoirs.

Because San Luis Reservoir is an offstream storage reservoir that is filled each year with water exported from the Delta, the temperature stratification in the reservoir is usually eliminated by the pumping of relatively warm water into the reservoir through the inlet that is located near the bottom of the reservoir. The releases from San Luis Reservoir are also made through the intake/outlet structure near the bottom of the reservoir so that the coldest water is released during the spring and summer. Therefore, there is no cold-water habitat in the reservoir; San Luis

Reservoir is dominated by warm-water fish (largemouth bass and striped bass). As a result, no analysis of cold-water habitat was conducted for San Luis Reservoir.

11E.2.2. Reservoir Water Surface Elevation

Seasonal temperature stratification is a dominant feature of these reservoirs. There are relatively distinct fish assemblages within the upper (warm water) and lower (cold water) habitat zones, with different feeding and reproductive behaviors. Flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm-water fishes such as bass and catfish. Deeper layers are cooler and are suitable for cold-water species. Drawdown of reservoir storage from June through October can diminish the volume of cold water, reducing the amount of habitat for cold-water fish species within these reservoirs during these months. Reservoir storage and surface water elevations in the reservoirs from the CALSIM II model were used to analyze potential effects on reservoir fishes. WSE in each reservoir was calculated from storage values and is presented as average end-of-month elevation by water year type.

Warm-water fish species that inhabit the upper layer of these reservoirs may be affected by fluctuations in storage through changes in reservoir WSEs. Stable or increasing WSE during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm-water species, including the black basses. Conversely, reduced or variable WSE due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm-water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding behaviors. Increases in WSE are not thought to result in adverse effects on these species unless there is a corresponding decrease in water temperatures that can result in nest abandonment. Review of the available literature suggests many self-sustaining black bass populations in North America experience a nest success (i.e., the nest produces swim-up fry) rate of 21% to 96%, with many reporting survival rates in the 40% to 60% range (Latta 1963:17, Forbes 1981:3-4, Philipp et al. 1997:561–562, Friesen 1998:36, Knotek and Orth 1998:289, Hunt and Annett 2002:1204, Steinhart 2004:81). This would suggest that much less than 100% survival is required to have a self-sustaining population. Based on the literature review, bass nest survival probability in excess of 60% is assumed to be sufficient to provide for a self-sustaining bass fishery.

A conceptual approach was used to evaluate the effects of WSE reductions on bass nests based upon a relationship between black bass nest success and WSE reductions developed by California Department of Fish and Wildlife (Lee 1999:7). Lee (1999:7) examined the relationship between WSE reduction rates in five California reservoirs and nesting success for black bass and suggested that a month-over-month reduction rate of approximately 6 feet or less would result in 60% nest success for largemouth bass and smallmouth bass. Therefore, a month-over-month reduction in reservoir WSE of 6 feet or more per month was selected as the threshold beyond which an adverse impact on spawning success of nest-building, warm-water fish could occur. To evaluate impacts on largemouth bass, smallmouth bass, and warm-water fish in general, the frequency of simulated month-over-month reservoir reductions of 6 feet or more was compared between the NAA and each alternative.

Criteria to evaluate potential effects of reservoir WSE *increases* (nest flooding events) have not been developed by the California Department of Fish and Wildlife. Because of overall reservoir fishery benefits (e.g., an increase in the availability of littoral habitat for warm-water fish rearing), greater reservoir elevations that would be associated with rising water levels would offset negative impacts due to nest flooding. Therefore, the likelihood of spawning-related impacts from nest flooding is not addressed for reservoir fisheries.

The warm-water fish spawning period was assumed to be March through June. This period encompasses the majority, if not the entire, primary warm-water fish spawning and rearing period for the reservoirs included in this impact analysis (Lee 1999:2-3; Moyle 2002:400, 403, 406).

CALSIM II reports end-of-month (EOM) WSEs; therefore, WSEs from February to June were used in this analysis (i.e., March fluctuation rate = March EOM elevation – February EOM elevation). WSEs used in this analysis are outputs from the monthly CALSIM II model, and incremental changes of 5% or less are related to the uncertainties in the model processing; therefore, changes in the number of years that have monthly drawdowns of 6 feet or more of less than 2 years are considered to be not substantially different, or "similar" in this comparative analysis. Changes in the frequency of drawdown exceeding 4 years are considered substantial and may have a potentially significant impact on warm-water fish species in the reservoirs.

11E.2.3. Reservoir Water Temperature

Water temperatures in the reservoirs potentially affected by the Project could change as a result of altered operations. However, the small changes in lake temperatures that could occur would not be expected to adversely affect the lakes' warm-water fisheries. Any changes in water temperatures in the reservoirs are not anticipated to affect spawning warm-water game fish nesting success due to the wide water temperature ranges in which they spawn. For example, black basses reportedly spawn between approximately 54°F and 75°F (Graham and Orth 1986:701; Moyle 2002:400, 403, 406). Due to their wide range in water temperature tolerance, it is anticipated that during the nesting season (March through June) there would be enough habitat with suitable water temperatures in which warm-water game fish could successfully spawn, and, therefore, no evaluation of water temperatures in the SWP and CVP reservoirs was conducted for warm-water game fishes.

11E.3 Results

11E.3.1. Reservoir Storage

Reservoir storage model results were examined for Sites Reservoir, Shasta Lake, Lake Oroville, Folsom Lake, and San Luis Reservoir during April through November for cold-water fish species; reductions in average monthly surface elevations of 6 feet or more were examined during March through June for warm-water species.

11E.3.1.1. Sites Reservoir

Sites Reservoir long-term average storage volume for each alternative for April through November are presented in Table 11E-1. Because Sites Reservoir does not exist under the NAA, no comparison could be made for Sites Reservoir. Reservoir storage at Sites Reservoir would be greatest under Alternative 1A (Table 11E-1). However, all alternatives would benefit cold-water reservoir species relative to the NAA because Sites Reservoir, and the new habitat it would create, would not exist under the NAA.

Table 11E-1. Sites Reservoir Long-Term Average Storage Volume under Each Alternative (TAF)[1]

Water Year Type	Alt 1A	Alt 1B	Alt 2	Alt 3
April				
Wet	1,427	1,405	1,224	1,371
Above Normal	1,188	1,152	1,067	1,079
Below Normal	911	857	769	776
Dry	984	906	828	778
Critically Dry	508	471	438	384
All	1,072	1,028	922	952
May				
Wet	1,434	1,412	1,231	1,378
Above Normal	1,182	1,147	1,062	1,074
Below Normal	903	831	762	746
Dry	972	871	817	724
Critically Dry	470	433	403	338
All	1,064	1,012	914	930
June				
Wet	1,425	1,403	1,223	1,369
Above Normal	1,175	1,093	1,056	1,010
Below Normal	886	798	745	676
Dry	915	807	761	632
Critically Dry	405	366	341	278
All	1,035	972	887	877
July				
Wet	1,412	1,388	1,211	1,354
Above Normal	1,154	1,059	1,032	895
Below Normal	847	765	708	608
Dry	825	719	674	533
Critically Dry	336	295	273	208
All	992	927	844	812
August				
Wet	1,378	1,351	1,177	1,318
Above Normal	1,103	1017	977	804
Below Normal	804	730	663	556
Dry	729	630	579	450
Critically Dry	275	235	215	167
All	936	875	788	754
September				
Wet	1,345	1,322	1,144	1,289

Water Year Type	Alt 1A	Alt 1B	Alt 2	Alt 3
Above Normal	1,053	975	921	758
Below Normal	779	713	639	538
Dry	663	564	516	393
Critically Dry	234	198	179	153
All	894	836	746	720
October				
Wet	1,321	1,299	1,119	1,270
Above Normal	1,025	964	907	791
Below Normal	750	686	609	514
Dry	602	505	458	344
Critically Dry	213	183	162	139
All	860	808	716	702
November				
Wet	1,336	1,318	1,134	1,289
Above Normal	1,035	974	917	803
Below Normal	752	684	611	511
Dry	579	488	439	337
Critically Dry	205	175	154	133
All	861	810	717	707

[1] No values are presented for the NAA because Sites Reservoir would not yet be constructed.
Alt = alternative; TAF = thousand acre-feet.

11E.3.1.2. Shasta Lake

Differences in Shasta Lake storage volume between the NAA and each alternative during April through November are presented in Table 11E-2. Differences in reservoir storage under Alternatives 1A, 1B, and 2 generally would be small relative to the NAA. Storage would be consistently >5% higher under Alternative 3 in Critically Dry Water Years between June and September, representing a minor beneficial effect on cold-water reservoir species.

Table 11E-2. Percent Difference in Shasta Lake Storage Volume between Each Alternative and the NAA[1]

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
April				
Wet	0.0	0.0	0.0	0.1
Above Normal	0.0	0.0	0.0	0.1
Below Normal	0.0	0.1	-0.1	0.2
Dry	0.6	0.8	0.6	1.5
Critically Dry	1.8	1.7	1.5	3.1
All	0.3	0.4	0.3	0.8
May				
Wet	0.0	-0.2	0.0	-0.1
Above Normal	0.0	-0.1	0.0	-0.2
Below Normal	0.0	0.5	-0.1	0.7
Dry	0.5	1.2	0.5	2.3

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Critically Dry	2.3	2.3	2.2	4.3
All	0.4	0.5	0.3	1.0
June				
Wet	0.0	-0.2	0.0	-0.1
Above Normal	0.0	0.9	0.0	1.1
Below Normal	0.0	0.9	-0.1	2.3
Dry	0.5	1.4	0.6	3.5
Critically Dry	3.5	3.8	3.3	6.1
All	0.4	0.9	0.4	1.9
July				
Wet	0.0	-0.2	0.0	0.0
Above Normal	0.2	1.5	0.3	3.3
Below Normal	0.3	1.2	0.2	3.6
Dry	0.6	1.6	0.7	4.4
Critically Dry	4.0	4.6	3.9	7.7
All	0.6	1.1	0.6	2.7
August				
Wet	0.0	-0.1	0.0	0.0
Above Normal	0.7	1.9	0.9	5.2
Below Normal	0.8	1.5	0.6	4.7
Dry	0.7	1.9	0.8	5.2
Critically Dry	2.9	3.7	2.8	7.2
All	0.7	1.2	0.7	3.4
September				
Wet	0.0	0.1	0.0	0.2
Above Normal	1.3	2.1	1.5	5.4
Below Normal	0.9	1.5	0.8	5.0
Dry	0.7	1.8	0.8	5.2
Critically Dry	1.9	2.7	1.9	6.6
All	0.7	1.3	0.7	3.5
October				
Wet	0.0	0.1	0.0	0.2
Above Normal	1.0	1.5	1.2	3.8
Below Normal	1.0	1.4	0.8	3.7
Dry	0.9	2.0	1.0	4.9
Critically Dry	1.5	2.2	1.3	6.0
All	0.7	1.1	0.7	2.9
November				
Wet	0.1	0.2	0.1	0.3
Above Normal	0.8	1.3	1.1	3.0
Below Normal	0.6	0.7	0.5	1.9
Dry	0.9	1.6	1.0	4.1
Critically Dry	1.7	2.5	1.6	6.4
All	0.6	1.0	0.6	2.4

[1] A positive value indicates an increase in storage under the alternative relative to the NAA; a negative value indicates a reduction in storage under the alternative relative to the NAA.
Alt = alternative; NAA = No Action Alternative.

11E.3.1.3. Lake Oroville

Differences in Lake Oroville storage between the NAA and each alternative during April through November are presented in Table 11E-3. Differences in storage volume between the NAA and each alternative would be minimal in all months and water year types analyzed.

Table 11E-3. Percent Difference in Lake Oroville Storage Volume between Each Alternative and the NAA[1]

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
April				
Wet	0.0	0.0	0.0	0.0
Above Normal	0.0	0.0	0.0	0.0
Below Normal	0.3	0.2	0.3	0.4
Dry	0.1	0.2	0.1	0.3
Critically Dry	0.1	0.2	0.0	0.0
All	0.1	0.1	0.1	0.1
May				
Wet	0.0	0.0	0.0	0
Above Normal	0.0	0.0	0.0	0.0
Below Normal	0.3	0.2	0.3	0.4
Dry	0.0	0.4	0.0	0.5
Critically Dry	0.1	0.2	0.0	0.2
All	0.1	0.1	0.1	0.2
June				
Wet	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.0	0.2
Below Normal	0.5	0.5	0.5	0.5
Dry	2.0	2.3	2.0	2.5
Critically Dry	2.1	2.1	1.9	1.7
All	0.6	0.6	0.5	0.7
July				
Wet	0.0	0.0	0.0	0.0
Above Normal	0.0	0.1	0.0	0.8
Below Normal	1.2	1.2	1.2	1.1
Dry	3.6	3.8	3.4	3.5
Critically Dry	3.1	3.1	2.7	2.5
All	1.0	1.0	0.9	1.0
August				
Wet	0.0	-0.1	0.0	-0.1
Above Normal	0.0	0.1	0.0	0.8
Below Normal	1.6	1.5	1.5	1.3
Dry	3.2	3.6	3.0	3.4

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Critically Dry	2.2	2.3	1.7	1.2
All	0.9	0.9	0.8	0.9
September				
Wet	-0.2	-0.5	-0.2	-0.4
Above Normal	0.0	0.0	0.0	0.9
Below Normal	1.1	0.7	1.0	0.1
Dry	3.0	3.4	2.9	3.1
Critically Dry	2.3	2.2	1.8	1.2
All	0.7	0.6	0.7	0.6
October				
Wet	-0.2	-0.5	-0.2	-0.4
Above Normal	0.0	0.0	0.0	1.0
Below Normal	1.2	0.9	1.1	0.5
Dry	1.6	1.6	1.5	2.0
Critically Dry	1.7	2.0	1.3	1.4
All	0.5	0.3	0.4	0.5
November				
Wet	-0.2	-0.5	-0.2	-0.5
Above Normal	0.0	0.0	0.0	1.3
Below Normal	1.0	0.8	0.9	0.2
Dry	0.7	1.3	0.6	1.5
Critically Dry	1.1	1.4	0.7	0.8
All	0.3	0.2	0.2	0.3

[1] A positive value indicates an increase in storage under the alternative relative to the NAA; a negative value indicates a reduction in storage under the alternative relative to the NAA.
Alt = alternative; NAA = No Action Alternative.

11E.3.1.4. Folsom Lake

Differences in Folsom Lake storage between the NAA and each alternative during April through November are presented in Table 11E-4. Storage would generally be similar between each alternative and the NAA in all months and water year types analyzed.

Table 11E-4. Percent Difference in Folsom Lake Storage Volume between Each Alternative and the NAA[1]

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
April				
Wet	0.0	0.0	0.0	0.0
Above Normal	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	-0.1
Dry	0.0	0.2	0.0	0.4
Critically Dry	-0.4	-0.8	1.1	-0.4
All	0.0	0.0	0.1	0.0
May				
Wet	0.0	0.0	0.0	0.0

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Above Normal	0.0	0.0	0.0	0.0
Below Normal	0.0	0.0	0.0	0.0
Dry	-0.1	0.5	-0.1	0.8
Critically Dry	0.4	0.0	0.8	-0.6
All	0.0	0.1	0.1	0.1
June				
Wet	0.0	-0.1	0.0	0.0
Above Normal	-0.1	0.6	-0.1	0.5
Below Normal	0.0	0.2	0.0	0.3
Dry	-0.2	0.6	-0.2	1.3
Critically Dry	0.4	-0.1	0.8	-1.1
All	0.0	0.2	0.0	0.3
July				
Wet	0.0	0.0	0.0	0.0
Above Normal	-0.1	1.4	-0.1	2.9
Below Normal	0.0	0.4	-0.2	2.6
Dry	-0.2	0.7	-0.2	1.7
Critically Dry	-0.2	-0.3	0.7	-1.5
All	-0.1	0.4	0.0	1.1
August				
Wet	0.0	0.0	0.0	0.0
Above Normal	0.0	1.3	0.1	4.4
Below Normal	0.1	0.6	-0.3	3.7
Dry	-0.8	-0.2	-0.8	0.5
Critically Dry	2.8	2.5	3.7	1.8
All	0.1	0.5	0.1	1.6
September				
Wet	0.0	-0.5	0.0	-0.3
Above Normal	0.2	1.8	0.5	7.8
Below Normal	0.0	0.5	-0.1	5.0
Dry	-0.9	-0.2	-0.9	0.5
Critically Dry	3.0	2.6	4.0	1.9
All	0.1	0.3	0.2	2.1
October				
Wet	0.0	-0.5	0.0	-0.2
Above Normal	0.2	1.8	0.7	7.7
Below Normal	-0.1	0.3	0.0	4.5
Dry	-0.8	-0.1	-0.8	0.4
Critically Dry	3.2	2.7	4.1	2.0
All	0.2	0.3	0.3	2.0
November				
Wet	0.0	-0.1	0.0	-0.4
Above Normal	0.1	0.9	0.3	2.1
Below Normal	-0.2	0.2	0.0	2.7
Dry	0.0	0.2	-0.3	-0.7

Water Year Type	Alt 1A vs. NAA	Alt 1B vs. NAA	Alt 2 vs. NAA	Alt 3 vs. NAA
Critically Dry	2.1	1.5	2.6	0.3
All	0.2	0.3	0.2	0.5

[1] A positive value indicates an increase in storage under the alternative relative to the NAA; a negative value indicates a reduction in storage under the alternative relative to the NAA.
Alt = alternative; NAA = No Action Alternative.

11E.3.2. Reservoir Water Surface Elevation Reductions

11E.3.2.1. Sites Reservoir

Sites Reservoir WSE reductions of ≥6 feet for each alternative during March through June are presented in Table 11E-5. Because Sites Reservoir does not exist under the NAA, no quantitative comparison was made for Sites Reservoir. Reservoir WSE reductions would occur less frequently under Alternatives 1A and 2 and more frequently under Alternatives 1B and 3. However, all alternatives would provide a benefit to warm-water reservoir species relative to the NAA because Sites Reservoir, and the new habitat it would create, would not exist under the NAA.

Table 11E-5. Sites Reservoir Water Surface Elevation Reductions for Each Alternative (Difference in Number of Years)[1]

Alternative	Water Surface Elevation Reductions of 6 feet or More for Each Alternative over the 82-Year Period of Record			
	March	April	May	June
Alternative 1A	0	4	4	19
Alternative 1B	0	4	11	28
Alternative 2	0	3	4	20
Alternative 3	0	3	20	38

1 No values are presented for NAA because Sites Reservoir would not yet be constructed.

11E.3.2.2. Shasta Lake

For Shasta Lake, WSE reductions for each alternative for March through June are presented in Table 11E-6. Comparisons of WSE reductions between the NAA and each alternative for March through June are presented in Table 11E-7. Under each alternative, reservoir warm-water fish species habitat conditions in Shasta Lake generally would be similar to or more suitable than those under the NAA.

Table 11E-6. Shasta Lake Water Surface Elevation Reductions for Each Alternative (Number of Years)

Alternative	Water Surface Elevation Reductions of 6 feet or more for each alternative over the 82-year period of record			
	March	April	May	June
NAA	4	2	20	58
Alternative 1A	4	1	20	58
Alternative 1B	4	0	18	57
Alternative 2	4	1	20	58
Alternative 3	4	0	17	55

Table 11E-7. Comparison of Shasta Lake Water Surface Elevation Reductions between Alternatives (Difference in Number of Years)

Comparison	Water Surface Elevation Reductions of 6 feet or more for each comparison over the 82-year period of record			
	March	April	May	June
Alternative 1A Relative to NAA	0	-1	0	0
Alternative 1B Relative to NAA	0	-2	-2	-1
Alternative 2 Relative to NAA	0	-1	0	0
Alternative 3 Relative to NAA	0	-2	-3	-3

11E.3.2.3. Lake Oroville

For Lake Oroville, WSE reductions for each alternative for March through June are presented in Table 11E-8. Comparisons of WSE reductions between the NAA and each alternative for March through June are presented in Table 11E-9. Under each alternative, reservoir warm-water fish species habitat conditions in Lake Oroville generally would be similar to the NAA.

Table 11E-8. Lake Oroville Water Surface Elevation Reductions for Each Alternative (Number of Years)

Alternative	Water Surface Elevation Reductions of 6 feet or more for each alternative over the 82-year period of record			
	March	April	May	June
NAA	2	1	13	46
Alternative 1A	2	1	13	46
Alternative 1B	2	2	13	46
Alternative 2	2	1	13	46
Alternative 3	2	2	13	47

Table 11E-9. Comparison of Lake Oroville Water Surface Elevation Reductions between Alternatives (Difference in Number of Years)

Comparison	Water Surface Elevation Reductions of 6 feet or more for each comparison over the 82-year period of record			
	March	April	May	June
Alternative 1A Relative to NAA	0	0	0	0
Alternative 1B Relative to NAA	0	1	0	0
Alternative 2 Relative to NAA	0	0	0	0
Alternative 3 Relative to NAA	0	1	0	1

11E.3.2.4. Folsom Lake

For Folsom Lake, WSE reductions for each alternative for March through June are presented in Table 11E-10. Comparisons of WSE reductions between the NAA and each alternative for March through June are presented in Table 11E-11. Under each alternative, reservoir warm-water fish species habitat conditions in Folsom Lake generally would be similar to those under the NAA.

Table 11E-10. Folsom Lake Water Surface Elevation Reductions for Each Alternative (Number of Years)

Alternative	Water Surface Elevation Reductions of 6 feet or more for each alternative over the 82-year period of record			
	March	April	May	June
NAA	0	2	2	26
Alternative 1A	0	1	2	26
Alternative 1B	1	2	2	26
Alternative 2	0	1	2	26
Alternative 3	1	1	2	27

Table 11E-11. Comparison of Folsom Lake Water Surface Elevation Reductions between Alternatives (Difference in Number of Years)

Comparison	Water Surface Elevation Reductions of 6 feet or more for each comparison over the 82-year period of record			
	March	April	May	June
Alternative 1A Relative to NAA	0	-1	0	0
Alternative 1B Relative to NAA	1	0	0	0
Alternative 2 Relative to NAA	0	-1	0	0
Alternative 3 Relative to NAA	1	-1	0	1

11E.3.2.5. San Luis Reservoir

For San Luis Reservoir, WSE reductions for each alternative for March through June are presented in Table 11E-12. Comparisons of WSE reductions between the NAA and each alternative for March through June are presented in Table 11E-13. Under each alternative, reservoir warm-water fish species habitat conditions in San Luis Reservoir generally would be similar to those under the NAA.

Table 11E-12. San Luis Reservoir Water Surface Elevation Reductions for Each Alternative (Number of Years)

Alternative	Water Surface Elevation Reductions of 6 feet or more for each alternative over the 82-year period of record			
	March	April	May	June
NAA	0	22	62	82
Alternative 1A	0	22	62	82
Alternative 1B	0	22	62	82
Alternative 2	0	22	62	82
Alternative 3	0	22	62	82

Table 11E-13. Comparison of San Luis Reservoir Water Surface Elevation Reductions between Alternatives (Difference in Number of Years)

Comparison	Water Surface Elevation Reductions of 6 feet or more for each comparison over the 82-year period of record			
	March	April	May	June
Alternative 1A Relative to NAA	0	0	0	0
Alternative 1B Relative to NAA	0	0	0	0
Alternative 2 Relative to NAA	0	0	0	0
Alternative 3 Relative to NAA	0	0	0	0

11E.4 Impact Conclusions

Reservoir storage model results were examined for Shasta Lake, Lake Oroville, Folsom Lake, and San Luis Reservoir during April through November for cold-water fish species; reductions in average monthly surface elevations greater than 6 feet were examined during March through June for warm-water species.

11E.4.1. Impacts Associated with Alternatives 1A-3 at Sites Reservoir

11E.4.1.1. Cold-Water Fish Species

Long-term average monthly storage and average monthly storage by water year type during all months at Sites Reservoir (Table 11E-1) would be expected to be greatest under Alternative 1A and would be less for Alternatives 1B-3.

However, under the NAA, there would be no habitat for cold-water fish species and it is likely that the construction of Sites Reservoir under Alternatives 1, 2, and 3 would create habitat that benefits cold-water fish species.

11E.4.1.2. Warm-Water Fish Species

Alternatives 1A and 2 would be expected to have the fewest WSE reductions, whereas Alternatives 1B and 3 would be expected to have the greatest number of WSE reductions (Table 11E-5).

However, under the NAA, there would be no habitat for warm-water fish species and it is likely that the construction of Sites Reservoir under Alternatives 1, 2, and 3 would create habitat that benefits warm-water fish species.

11E.4.2. Impacts Associated with Alternative 1A Relative to the NAA

11E.4.2.1. Shasta Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions, indicating similar long-term average monthly storage and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-2).

It is unlikely that cold-water fish habitat is limiting in Shasta Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 1A would have a population-level effect on cold-water fish species in Shasta Lake relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-7).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1A would have a population-level effect on bass and other warm-water fish in Shasta Lake relative to the NAA.

11E.4.2.2. Lake Oroville

Cold-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-3).

It is unlikely that cold-water fish habitat is limiting in Lake Oroville; therefore, it is unlikely that changes in reservoir storage under Alternative 1A would have a population-level effect on cold-water fish species in Lake Oroville, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-8).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1A would have a population-level effect on bass and other warm-water fish in Lake Oroville, relative to the NAA.

11E.4.2.3. Folsom Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions (Table 11E-4) indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period.

It is unlikely that cold-water fish habitat is limiting in Folsom Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 1A would have a population-level effect on cold-water fish species in Folsom Lake relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-10).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1A would have a population-level effect on bass and other warm-water fish in Folsom Lake, relative to the NAA.

11E.4.2.4. San Luis Reservoir

Warm-Water Fish Species

Relative to the NAA, Alternative 1A would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Tables 11E-12 and 11E-13).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1A would have a population-level effect on bass and other warm-water fish in San Luis Reservoir, relative to the NAA.

11E.4.3. Impacts Associated with Alternative 1B Relative to the NAA

11E.4.3.1. Shasta Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-2).

It is unlikely that cold-water fish habitat is limiting in Shasta Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 1B would have a population-level effect on cold-water fish species in Shasta Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar or slightly lower frequencies of monthly WSE reductions of 6 feet or more (Table 11E-7).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1B would have a population-level effect on bass and other warm-water fish in Shasta Lake, relative to the NAA.

11E.4.3.2. Lake Oroville

Cold-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-3).

It is unlikely that cold-water fish habitat is limiting in Lake Oroville; therefore, it is unlikely that changes in reservoir storage under Alternative 1B would have a population-level effect on cold-water fish species in Lake Oroville, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-8).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1B would have a population-level effect on bass and other warm-water fish in Lake Oroville, relative to the NAA.

11E.4.3.3. Folsom Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-4).

It is unlikely that cold-water fish habitat is limiting in Folsom Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 1B would have a population-level effect on cold-water fish species in Folsom Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-10).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1B would have a population-level effect on bass and other warm-water fish in Folsom Lake, relative to the NAA.

11E.4.3.4. San Luis Reservoir

Warm-Water Fish Species

Relative to the NAA, Alternative 1B would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Tables 11E-12 and 11E-13).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 1B would have a population-level effect on bass and other warm-water fish in San Luis Reservoir, relative to the NAA.

11E.4.4. Impacts Associated with Alternative 2 Relative to the NAA

11E.4.4.1. Shasta Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-2).

It is unlikely that cold-water fish habitat is limiting in Shasta Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 2 would have a population-level effect on cold-water fish species in Shasta Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-7).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 2 would have a population-level effect on bass and other warm-water fish in Shasta Lake, relative to the NAA.

11E.4.4.2. Lake Oroville

Cold-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-3).

It is unlikely that cold-water fish habitat is limiting in Lake Oroville; therefore, it is unlikely that changes in reservoir storage under Alternative 2 would have a population-level effect on cold-water fish species in Lake Oroville, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-8).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 2 would have a population-level effect on bass and other warm-water fish in Lake Oroville, relative to the NAA.

11E.4.4.3. Folsom Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-4).

It is unlikely that cold-water fish habitat is limiting in Folsom Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 2 would have a population-level effect on cold-water fish species in Folsom Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-10).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 2 would have a population-level effect on bass and other warm-water fish in Folsom Lake, relative to the NAA.

11E.4.4.4. San Luis Reservoir

Warm-Water Fish Species

Relative to the NAA, Alternative 2 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Tables 11E-12 and 11E-13).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 2 would have a population-level effect on bass and other warm-water fish in San Luis Reservoir, relative to the NAA.

11E.4.5. Impacts Associated with Alternative 3 Relative to the NAA

11E.4.5.1. Shasta Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-2). Storage would be consistently >5% higher under Alternative 3 in Critically Dry Water Years between June and September.

However, itis unlikely that cold-water fish habitat is limiting in Shasta Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 3 would have a population-level effect on cold-water fish species in Shasta Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-7).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 3 would have a population-level effect on bass and other warm-water fish in Shasta Lake, relative to the NAA.

11E.4.5.2. Lake Oroville

Cold-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period (Table 11E-3).

It is unlikely that cold-water fish habitat is limiting in Lake Oroville; therefore, it is unlikely that changes in reservoir storage under Alternative 3 would have a population-level effect on cold-water fish species in Lake Oroville, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-8).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 3 would have a population-level effect on bass and other warm-water fish in Lake Oroville, relative to the NAA.

11E.4.5.3. Folsom Lake

Cold-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar amounts of habitat for cold-water fish species based on modeling results for reservoir storage conditions (Table 11E-4) indicating similar long-term average monthly storage, and similar average monthly storage by water year type during all months of the evaluation period.

It is unlikely that cold-water fish habitat is limiting in Folsom Lake; therefore, it is unlikely that changes in reservoir storage under Alternative 3 would have a population-level effect on cold-water fish species in Folsom Lake, relative to the NAA.

Warm-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Table 11E-10).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 3 would have a population-level effect on bass and other warm-water fish in Folsom Lake, relative to the NAA.

11E.4.5.4. San Luis Reservoir

Warm-Water Fish Species

Relative to the NAA, Alternative 3 would be expected to provide similar warm-water fish nesting conditions, based on modeling results indicating similar frequencies of monthly WSE reductions of 6 feet or more (Tables 11E-12 and 11E-13).

It is unlikely that a small difference in the number of years with monthly WSE reductions of greater than 6 feet under Alternative 3 would have a population-level effect on bass and other warm-water fish in San Luis Reservoir, relative to the NAA.

11E.5 References Cited

Forbes, A. M. 1981. Review of Smallmouth Bass (*Micropterus dolomieui*) Spawning Requirements and First Year Survival in Lakes. Wis. Dep, Nat. Resour. Res. Rep. No. 133.

Friesen, T. G. 1998. *Effects of Food Abundance and Temperature on Growth, Survival, Development and Abundance of Larval and Juvenile Smallmouth Bass*. University of Guelph, Ontario.

Graham, R., and D. Orth. 1986. Effects of Temperature and Streamflow on Time and Duration of Spawning by Smallmouth Bass. *Transactions of the American Fisheries Society* 115:693–702.

Hunt, J., and C. A. Annett. 2002. Effects of Habitat Manipulation on Reproductive Success of Individual Largemouth Bass in an Ozark Reservoir. *North American Journal of Fisheries Management* 55:1201–1208.

Knotek, W. L., and D. J. Orth. 1998. Survival for Specific Life Intervals of Smallmouth Bass, *Micropterus dolomieu*, during Parental Care. *Environmental Biology of Fishes* 51:285–296.

Latta, W. C. 1963. The Life History of the Smallmouth Bass, *Micropterus d. dolomieui*, at Waugoshance Point, Lake Michigan. Ann Arbor, MI: Institute for Fisheries Research (Michigan Department of Conservation) and the University of Michigan.

Lee, D. P. 1999. *Water Level Fluctuation Criteria for Black Bass in California Reservoirs*. Reservoir Research and Management Project: Information Leaflet No. 12.

Moyle, P. B. 2002. *Inland Fishes of California*. 2nd Edition. Berkeley, CA: University of California Press.

Philipp, D. P., C. A. Toline, M. F. Kubacki, D. B. F. Philipp, and F. J. S. Phelan. 1997. The Impact of Catch-and-Release Angling on the Reproductive Success of Smallmouth Bass and Largemouth Bass. *North American Journal of Fisheries Management* 17:557–567.

Steinhart, G. B. 2004. *Exploring Factors Affecting Smallmouth Bass Nest Success and Reproductive Behavior*. Dissertation. Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Graduate School of The Ohio State University.