Benefit Calculation, Monetization, and Resiliency Tab

Attachment 3: Physical and Monetized Benefits

Attach the analysis of all public and non-public monetized benefits. Identify at least one Program ecosystem or water quality priority for any ecosystem or water quality public benefit quantified. For each public and non-public benefit, describe the methods used to derive the physical and economic benefits and impacts at a level of detail that allows reviewers to verify your analysis.

Description must include:

- *The physical changes that are being monetized, consistent with information requested in the Physical Public Benefits Tab, and describing linkages between physical benefits and monetized benefits. See regulations sections 6004(a)(3) and 6004(a)(4); and*
- *The monetization method and sources for data used. See regulations section 6004(a)(4).*

WSIP Application Instructions, March 2017

Response

Table of Contents

Attachment 3: Physical and Monetized Benefits 1
Benefits Summary 4
Ecosystem Improvement (WSIP Public Benefits) 7
Anadromous Fish 7
Incremental Level 4 Refuge Water Supply 9
Lake Oroville Coldwater Pool 11
Yolo Bypass Flows 12
Recreation (WSIP Public Benefit) 14
Physical Quantification 14
Monetized Benefits 14
Flood Damage Reduction (WSIP Public Benefit) 15
Physical Quantification 15
Monetized Benefits 15
Water Supply (Non-Proposition 1 Eligible Benefit) 16
Physical Quantification 16
Monetized Benefits 17
Hydropower (Non-Proposition 1 Eligible Benefit) 17
Physical Quantification 17
Monetized Benefits 17

Tables

Table A3-1. Summary of Quantified Physical Benefits and Monetization Approaches 4
Table A3-2. Summary of Quantified Water Use by Purpose (TAF/year) 5
Table A3-3. Summary of Monetized Benefits by Purpose (2015$; $1,000s) 6
Table A3-4. Ecosystem Physical Benefits Quantified and Monetized 7
Table A3-5. SALMOD Results for 2030 and 2070 (TAF/year) 8
Table A3-6. Anadromous Fish Benefits: Least-Cost Alternative (2015$; $1,000s) 9
Table A3-7. Incremental Level 4 Refuge Water Supply Increases (2030 and 2070) (TAF/year) 10
Table A3-8. Incremental Level 4 Refuge Benefits: WSIP Unit Water Values (2015$; $1,000s) 10
Table A3-9. Lake Oroville Storage Increases for 2030 and 2070 (TAF/year) 11
Table A3-10. Lake Oroville Coldwater Pool Benefits: WSIP Unit Water Values (2015$; $1,000s) 12
Table A3-11. Yolo Bypass Flow Increases for 2030 and 2070 (TAF/year) 13
Table A3-12. Yolo Bypass Supply Benefits: WSIP Unit Water Values (2015$; $1,000s) 13
Table A3-13. Annual Recreation Visitation by Primary Activity 14
Table A3-14. Estimated Annual Recreation Benefits (2015$; $1,000s) 15
Table A3-15. Flood Reduction Benefits (2015$; $1,000s) 16
Table A3-16. Increase in Water Supply Deliveries (TAF/year) 16
Table A3-17. Total Water Supply Benefits: CWEST Results and WSIP Unit Water Values (2015$; $1,000s) 17
Table A3-18. Hydropower Benefits (2015$; $1,000s) 18

Figures

Figure A3-1.Percentage Increase in Fish Species Average Production for 2030 and 2070 8

Acronyms and Abbreviations

AS	ancillary services
cfs	cubic feet per second
CVP	Central Valley Project
DWR	California Department of Water Resources
GIS	geographic information system
JPA	Joint Powers Authority
M&I	municipal and industrial
NED	National Economic Development
NODOS	North-of-the-Delta Offstream Storage
O&M	operations and maintenance
PARO	Power and Risk Office (DWR)
PLEXOS	PLEXOS® Integrated Energy Model
project	Sites Reservoir Project
RPS	Renewable Portfolio Standard
RUVD	Recreation Use Values Database
SWP	State Water Project
TAF	thousand acre-feet
TR	Technical Report
WSIP	Water Storage Investment Program

Benefits Summary

In accordance with the Water Storage Investment Program (WSIP) Technical Report (TR) recommendations, CALSIM II modeling was used to determine the Sites Reservoir Project's (project) future water supply deliveries for 2030 and 2070 for each water-delivery-dependent purpose (e.g., municipal and industrial [M&I] deliveries, Incremental Level 4 deliveries) (CWC 2016). Other purposes were monetized based on other quantifications of their future operational performance (e.g., increased visitation for Recreation, supported habitat units for anadromous fish).

Table A3-1 shows the benefits quantified and monetized for the WSIP Application.

Table A3-1. Summary of Quantified Physical Benefits and Monetization Approaches

Benefit Type	Quantified Use	Physical Benefit Quantified	Monetization Method
WSIP Public Benefits	Ecosystem Improvement – Anadromous Fish	Habitat Units	Alternative Cost
	Ecosystem Improvement – Incremental Level 4 Refuge Water	Increased Deliveries	WSIP Unit Water Values
	Ecosystem Improvement – Oroville Coldwater Pool	Stored Water	WSIP Unit Water Values
	Ecosystem Improvement – Yolo Bypass	Delivered Water	WSIP Unit Water Values
	Recreation	Visitation	Facilities Assessment and Unit Day Values
	Flood Control	Flood Damage Reduction	Avoided Cost Savings
Non-Proposition 1 Eligible Benefits	Water Supply – M&I, Agricultural and Recaptured	Increased Deliveries	CWEST Modeling (M&I and Recaptured); WSIP Unit Water Values (Agricultural)
	Hydropower	Generated Power	PARO/PLEXOS Modeling

M&I = municipal and industrial
PARO = Power and Risk Office (DWR)
PLEXOS = PLEXOS® Integrated Energy Model
WSIP = Water Storage Investment Program

For each applicable project purpose, the CALSIM II operational analysis quantified its future water deliveries by water-year type and location. Corresponding physical benefits were estimated on an annual basis for the interim 2031 to 2069 period by interpolating individually (i.e., for each specific purpose by location, water-year type, and incidence rate). The 2070 physical benefit quantities were applied for the post-2070 study period (2071 to 2122). Each year's individual quantified water values were then used to determine a corresponding average expected water use amount. An average annual quantification was then estimated for the entire period of operations (2030 to 2122).

The majority of the benefits from the project purposes are expected to start producing their full benefits at the beginning of the project operations in 2030. The project's hydropower and recreation operations are the only facilities expected not to attain their full operating levels in 2030. Instead, a short initial ramp-up period is expected for those facilities before they achieve their full operating and benefit levels, in 2032. In a few other cases, the project facilities are expected to generate additional limited benefits before 2030. As a result, partial anadromous fish, Yolo Bypass, and flood damage reduction benefits are expected to be obtained before the end of construction.

The annualized benefit values for the 2030 to 2122 operating period were included the reduced benefits during the initial hydropower and recreation facilities' 2030 to 2031 ramp-up period. The project's pre-2030 additional benefits were not included in the annualized (2030 to 2122) values. However, the additional pre-2030 benefits are incorporated into the project's total net benefit value, benefit-cost ratio, and public benefit ratio calculations.

When applicable for the other project purposes, annual quantifications were similarly interpolated for the interim 2031 to 2069 period. The 2070 physical benefit quantities were also applied for the post-2070 study period (2071 to 2122).

Table A3-2 shows the estimated water supply deliveries and other quantified physical benefits by project purpose for 2030 and 2070, with the annualized average for the entire 2030 to 2122 operating period. More detailed information and discussion of each purpose's physical benefit quantification is provided in Sites_A5 Documentation under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB.

Table A3-2. Summary of Quantified Water Use by Purpose (TAF/year)

Period	WSIP Public Benefits			Non-Proposition 1 Eligible Benefits			Total Water
	Coldwater Pool [a]	**Yolo Bypass**	**Incremental Level 4 Refuge**	**Agricultural Water Supply**	**M&I Water Supply**	**Recaptured Water Supply**	
2030	109	39	35	137	106	11	437
2045	102	39	33	148	110	11	443
2070	90	39	31	167	117	11	455
Average (2030–2122)	**94**	**39**	**32**	**161**	**114**	**11**	**451**

[a] Includes coldwater pool improvements for both Shasta Lake and Lake Oroville.
M&I = municipal and industrial
TAF = thousand acre-feet
WSIP = Water Storage Investment Program

Each project purpose benefit was monetized based on its quantified physical benefits. As shown in Table A3-1, a variety of monetization approaches were used to estimate the economic benefit values for the project's purposes. The benefit monetizations for each project purpose are summarized below in Table A3-3. More detailed information and discussion of each purpose's physical benefit quantification is provided in Sites_A5 Documentation under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB.

Table A3-3 shows the estimated monetized benefits by purpose in 2030, 2045, 2070, and the annual average for the entire 2030 to 2122 study period. More detailed information and discussion of each purpose's physical benefit quantification is provided in Section A.5.

Table A3-3. Summary of Monetized Benefits by Purpose (2015$; $1,000s)

Year	WSIP Public Benefits								Non-Prop. 1 Eligible Benefits			Total Benefits
		Total Ecosystem Improvement										
	Total WSIP Public Benefits	Total Ecosystem Improvement	Anadromous Fish & Other Aquatic	Incremental Level 4 Refuge	Lake Oroville Coldwater Pool	Yolo Bypass	Recreation	Flood Control	Total Non-Prop.1 Eligible Benefits	Total Water Supply	Hydropower (System)	
2030	$73,717	$62,343	$25,637	$16,047	$11,814	$8,845	$6,997	$4,377	$109,207	$89,024	$20,183	$182,925
2045	$119,700	$108,325	$48,505	$27,644	$22,986	$9,190	$6,997	$4,377	$177,417	$157,234	$20,183	$297,116
2070	$156,824	$145,449	$86,619	$24,634	$24,976	$9,220	$6,997	$4,377	$271,704	$251,521	$20,183	$428,527
Annualized (2030-2122) [a]	**$122,033**	**$110,900**	**$56,985**	**$23,811**	**$20,987**	**$9,117**	**$6,755**	**$4,377**	**$194,902**	**$175,418**	**$19,483**	**$316,934**

[a] Annualized benefit value was calculated using net present value over 93 years at a 3.5% discount rate. Annualized benefits assume interpolated annual physical benefits between 2030 and 2070, and then constant annual benefits after 2070. WSIP unit water values were interpolated between 2030 and 2045, after which 2045 unit water values were used.

Ecosystem Improvement (WSIP Public Benefits)

Sites Reservoir would provide a variety of ecosystem benefits. Four distinct ecosystem benefits were analyzed. Table A3-4 summarizes the physical benefits that were quantified and monetarized for the WSIP Application.

Table A3-4. Ecosystem Physical Benefits Quantified and Monetized

Benefit Category	Location	Physical Benefit Monetized
Anadromous Fish	Sacramento River watershed between Keswick Dam and Red Bluff	Increase in habitat units as determined by SALMOD
Incremental Level 4 Refuge Water Supply	National Wildlife Refuges, State Wildlife Areas, and privately managed wetlands	Increase in Incremental Level 4 refuge water supplies to achieve optimum habitat management
Lake Oroville Coldwater Pool	Lake Oroville	Additional water stored in Lake Oroville provides temperature and flow improvements for anadromous fish
Yolo Bypass Flows	Yolo Bypass discharging to the Sacramento River	August through October releases from Sites Reservoir to Yolo Bypass

Anadromous Fish

Physical Quantification

Sites Reservoir provides a variety of benefits to anadromous fish. SALMOD modeling results were used to evaluate the cost of an alternative project to raise the dam at Shasta Lake to estimate the benefits to anadromous fish. The SALMOD model combines flow and temperature information to forecast the population of Chinook salmon in the Sacramento River watershed between Keswick Dam and Red Bluff. Table A3-5 presents the projected increases in future fish population and habitat units by type of fish for 2030, 2070, and the annual average in the 2030 to 2122 study period.

Table A3-5. SALMOD Results for 2030 and 2070 (TAF/year)

Run	No Action (# of fish/yr)	Average Increase (# of fish/yr)	Habitat Units	Dry Year Increase (# of fish/yr)	Critical Year Increase (# of fish/yr)	Dry & Critical Year Increase (# of fish/yr)
2030 SALMOD Results						
Fall-Run Chinook	32,275,104	435,138	435	19,893	1,493,430	609,308
Late Fall-Run Chinook	7,911,118	70,188	70	57,277	208,800	117,886
Winter-Run Chinook	3,892,177	20,627	21	-62,557	207,285	45,380
Spring-Run Chinook	866,601	13,331	13	14,088	40,324	24,582
Total All Runs	—	**539,284**	**539**	**28,701**	**1,949,839**	**797,156**
2070 SALMOD Results						
Fall-Run Chinook	27,506,156	1,454,968	1,455	2,574,746	3,427,234	2,915,741
Late Fall-Run Chinook	7,525,505	235,595	236	169,866	1,137,267	556,826
Winter-Run Chinook	3,711,513	84,433	84	-12,471	673,467	261,904
Spring-Run Chinook	688,048	47,068	47	69,601	42,975	58,951
Total All Runs	—	**1,822,604**	**1,822**	**2,801,742**	**5,280,943**	**3,793,422**
Average (2030–2122)						
Long-Term Average	—	1,539,301	1,539	2,190,480	4,546,667	3,132,955

Figure A3-1 shows the percentage growth in population increase projected for each fish type population in both 2030 and 2070.

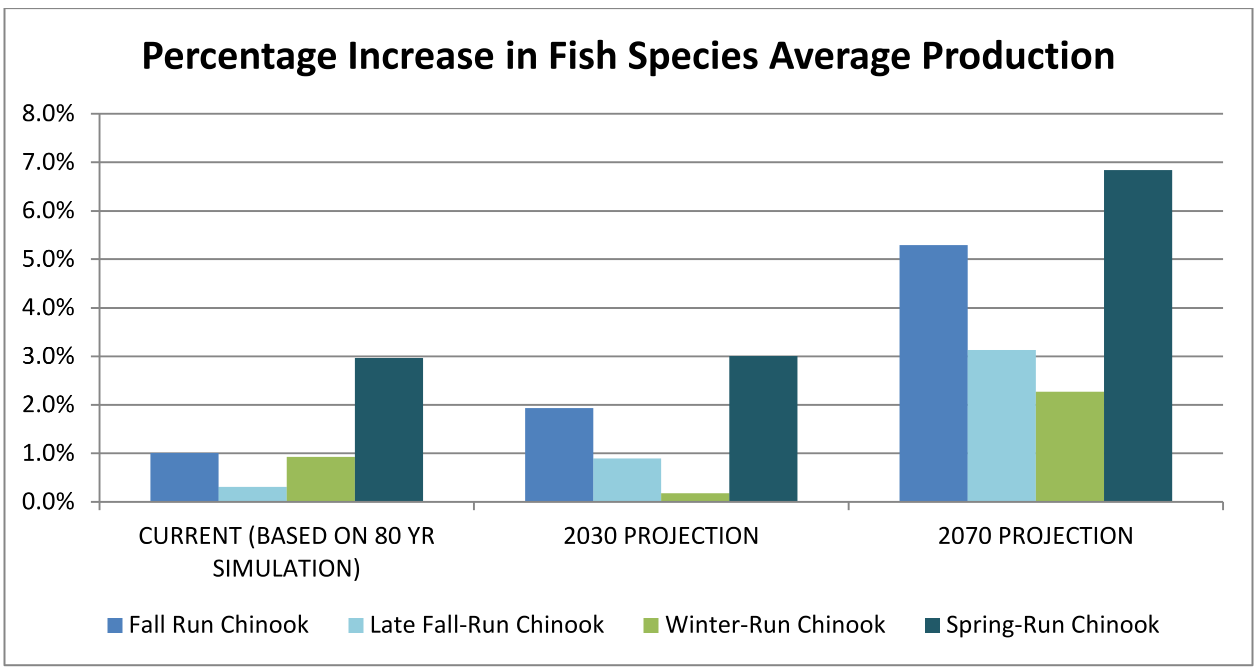

Figure A3-1.Percentage Increase in Fish Species Average Production for 2030 and 2070

Monetized Benefits

Sites Reservoir would enhance future water temperature and flow conditions in the Sacramento River as a means of improving the riverine ecosystem. The economic benefits of the project's contributions to anadromous fish survival were estimated based on the alternative cost approach. The cost of the most likely alternative is based on various Shasta Dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River.

The Shasta Lake dam raise is considered a reasonable and feasible alternative source due to not only its potential capability to provide the necessary quantities of new water supplies but also its location, which ensures that it can benefit the same anadromous fish population locations and therefore result in the same ecosystem improvement outcomes. Furthermore, recent extensive planning and analysis has been completed for the Shasta Dam raise, which provides more confidence in the accuracy of both its construction cost estimate and its potential implementation viability.

Table A3-6 shows that Sites Reservoir's anadromous water supply benefits were estimated based on the least-cost alternative of expanding Shasta Lake's storage with a 12.5-foot raise of Shasta Dam as a single-purpose water storage project that would result in increased future habitat units. The base construction cost for the Shasta Lake Raise was obtained from the 2015 Shasta Lake Water Resource Investigation Feasibility Study. The costs were adjusted into current dollar terms and annualized using a 3.5 percent discount rate in accordance with the WSIP TR requirements.

Analysis of the numerous Shasta Dam Raise alternatives determined that the 12.5-foot dam raise was not only the most productive alternative, with 988 new habitat units, but also the most cost-effective alternative, with a unit cost of $47,539 per habitat unit. From this finding, the $47,539 per habitat unit benefit value was applied to the project's expected future habitat improvement to estimate Sites Reservoir's anadromous fish benefits. This estimate is conservative because it does not account for deteriorating river conditions that would likely result from the longer timeframe required to implement a raise of the Shasta Dam.

Table A3-6. Anadromous Fish Benefits: Least-Cost Alternative (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$25,637	$86,619	**$56,985[a]**

[a] Based on 12.5-foot raise of Shasta Dam as the alternative cost for achieving the ecosystem improvement.
[b] Annualized benefits interpolated annual physical benefits between 2030 and 2070 and were then constant after 2070. Net present value over 93 years at a 3.5% discount rate.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's anadromous fish benefits were estimated to increase from $25.6 million in 2030 to approximately $86.6 million in 2070. The corresponding average annual benefit for the future 2030 to 2122 operating period was estimated to be $57.0 million.

Incremental Level 4 Refuge Water Supply

Physical Quantification

Table A3-7 shows improved deliveries to National Wildlife Refuges, State Wildlife Areas, and privately managed wetlands projected in 2030, 2070, and the annual average in the 2030 to 2122 study period. The distribution of water between north and south of Delta refuges was assumed and can be modified; however, additional infrastructure would be needed to significantly increase deliveries to north of Delta refuges.

Table A3-7. Incremental Level 4 Refuge Water Supply Increases
(2030 and 2070) (TAF/year)

Period	North-of-the-Delta	South-of-the-Delta	Total
2030 Results			
Long-Term Average	1	34	35
Wet	1	52	53
Above Normal	1	46	47
Below Normal	1	38	38
Dry	0	20	21
Critical	0	1	1
2070 Results			
Long-Term Average	1	30	31
Wet	1	50	51
Above Normal	1	40	41
Below Normal	1	29	30
Dry	0	16	17
Critical	0	1	1
2030–2122 Results			
Long-Term Average	**1**	**31**	**32**

Source: CALSIM II.

The changes in incremental Level 4 refuge supply deliveries were interpolated between 2030 and 2070 to project the future refuge water supplies on an annual basis. In accordance with WSIP TR guidance, post-2070 deliveries were assumed to remain at 2070 levels.

Monetized Benefits

Sites Reservoir would increase water deliveries for incremental Level 4 refuge needs. The economic benefits of the project's contributions to incremental Level 4 refuge needs were estimated using the WSIP unit water values to determine the value of its supplied water. It was also assumed that the incremental Level 4 refuge water would otherwise likely be used for south-of-the-Delta deliveries.

Therefore, the estimated total benefit value is estimated based on the expected future average hydrological year type and the expected use location of the water supplies. Furthermore, the WSIP unit water values were adjusted to include the additional conveyance energy cost associated with its future use. Table A3-8 presents the estimated benefit values for the projected future increases in incremental Level 4 refuge water.

Table A3-8. Incremental Level 4 Refuge Benefits: WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$16,047	$24,634	$23,811

[a] Based on WSIP unit water values adjusted by water-year type, expected delivery location, and conveyance energy costs.
[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant annual benefits after 2070. WSIP unit water values interpolated between 2030 and 2045, after which 2045 unit water values were used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's incremental Level 4 refuge water supply benefits were estimated to increase from $16.0 million in 2030 to approximately $24.6 million in 2070. The corresponding average annual benefit for the future 2030 to 2122 operating period was estimated to be $23.8 million, which is equal to an estimated average unit benefit value of $781 per acre foot for the incremental Level 4 refuge benefits. This valuation reflects the comparatively high benefit values for future south-of-the-Delta water uses.

Lake Oroville Coldwater Pool

Physical Quantification

Improvements to the coldwater pool and downstream releases to assist migrating fish would be beneficial to salmon, steelhead, and other fish in the lower Feather River. The benefits were anticipated to be less than the benefits downstream from Shasta Lake, but nevertheless significant. The SALMOD model does not include the Feather River area. The improvements in fish habitat in the Feather River watershed were therefore evaluated using an opportunity cost to secure an equivalent amount of storage in Lake Oroville. The storage increase based on CALSIM modeling is characterized below.

Table A3-9 shows the projected future increase in annual water storage for Lake Oroville.

Table A3-9. Lake Oroville Storage Increases for 2030 and 2070 (TAF/year)

Water-Year Type	Quantity
2030 Results	
Full	26
Dry	38
Critical	83
2070 Results	
Full	31
Dry	39
Critical	111
Average (2031–2122)	
Long-Term	30

Source: CALSIM II.
TAF = thousand acre-feet

Monetized Benefits

Sites Reservoir would enhance future water temperature and flow conditions in the American River as a means of improving the riverine ecosystem. Sites would achieve these ecosystem improvements by enabling Lake Oroville to delay some of its water deliveries, which would increase its coldwater pool conditions and lower the water temperatures of its subsequent water releases.

The economic benefits of the project's contributions to anadromous fish survival were estimated based on use of the WSIP unit water values to determine the value of the water that would otherwise be needed to be withheld in Lake Oroville to improve its coldwater pool and the temperature conditions of its water releases. Based on Lake Oroville general water supplies, for the purposes of the benefit valuation it is assumed that the water supply that would otherwise need to be retained (and therefore not delivered) would be south-of-the-Delta deliveries.

Therefore, the estimated total benefit value is estimated based on the expected future average hydrological year type and the expected use location of the water supplies. Furthermore, the WSIP unit water values were also adjusted to include the additional conveyance energy cost associated with its future use. Table A3-10 presents the estimated benefit values for the projected future increases in the coldwater pool at Lake Oroville.

Table A3-10. Lake Oroville Coldwater Pool Benefits: WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$11,814	$24,976	$20,987

[a] Based on WSIP unit water values adjusted by water-year type, expected delivery location, and conveyance energy costs.
[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant annual benefits after 2070. WSIP unit water values interpolated between 2030 and 2045, after which 2045 unit water values were used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The Lake Oroville coldwater benefits of the project were estimated to increase from approximately $11.8 million in 2030 to nearly $25.0 million in 2070. The corresponding average annual benefit for the future 2030 to 2122 operating period was estimated to be $21.0 million, which is equal to an estimated average unit benefit value of $781 per acre-foot.

Yolo Bypass Flows

Physical Quantification

In 2016, the California Department of Water Resources (DWR) performed a North Delta Food Web Study in collaboration with Federal and local water agencies. The study addressed the *Delta Smelt Resiliency Strategy* (DWR July 2016) recommendation for North Delta food web adaptive management projects. The resulting fall flows in the Yolo Bypass successfully produced a phytoplankton bloom, the major food source for endangered Delta smelt.

The Cache Slough area that receives water from the Yolo Bypass is the only place in the Delta estuary where the Delta smelt population is increasing. The purpose of this action is to help increase desirable food sources for Delta smelt in the lower Cache Slough and lower Sacramento River areas. This increase in food sources should improve Delta smelt growth and condition as they mature into adults, thereby increasing Delta smelt abundance.

The Sites Reservoir Project would provide two pulses of flow of at least 400 cubic feet per second (cfs) each over a two- to three-week period into the Yolo Bypass (via the Colusa Basin Drain, past the Wallace Weir and Ridge Cut, and into the Tule Drain) that will flow through the toe drain and out to the Sacramento River. Each flow pulse made into the Colusa Basin Drain would total about 20 thousand acre-feet (TAF) in each of the two- to three-week periods, resulting in an average total flow of 39 TAF per year. The flow pulses would be adaptively managed, but are currently thought to occur in late summer and early fall (e.g., August and September). The water deliveries would not have to occur every year, but would be desirable in most years.

Table A3-11 shows the projected future increase in annual water flows for Yolo Bypass for 2030, 2070, and the annual average in the 2030 to 2122 study period.

Table A3-11. Yolo Bypass Flow Increases for 2030 and 2070 (TAF/year)

Water-Year Type	Quantity
2030 Results	
Full	39
Dry	33
Critical	5
2070 Results	
Full	39
Dry	33
Critical	8
Average (2031–2122)	
Long-Term	**39**

TAF = thousand acre-feet

Monetized Benefits

Sites Reservoir would increase water deliveries to the Yolo Bypass. The economic benefits of the project's contributions to Yolo Bypass needs were estimated using the WSIP unit water values to determine the value of its supplied water. The Sacramento Valley WSIP unit water values were used to determine the benefit values of the water supplies used for the Yolo Bypass. These values do not include any conveyance cost benefit adjustment and were used because it was presumed that the necessary water supplies would otherwise be obtained from Sacramento Valley agricultural water users. Therefore, the estimated total benefit value is estimated based on the expected future average hydrologic year type and the expected use location of the supplies.

Table A3-12 presents the estimated benefit values for the projected future increases in Yolo Bypass deliveries.

Table A3-12. Yolo Bypass Supply Benefits: WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$8,845	$9,220	$9,117

[a] Based on WSIP unit water values adjusted by water-year type and expected delivery location.
[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant annual benefits after 2070. WSIP unit water values interpolated between 2030 and 2045, after which 2045 unit water values were used.
[c] Average over the entire hydrologic sequence (1922 to 2003).

The project's Yolo Bypass supply benefits were estimated to increase from $8.8 million in 2030 to $9.2 million in 2070. The corresponding average annual benefit for the future 2030 to 2122 operating period was estimated to be $9.1 million, which is equal to an estimated average unit benefit value of $237 per acre-foot for the future ecosystem benefits from Yolo Bypass. This valuation reflects the comparatively lower benefit values for future north-of-the-Delta water uses.

Recreation (WSIP Public Benefit)

Physical Quantification

Recreation benefits were valued using visitation estimates for the new recreational areas planned for the Sites project. Annual visitation was estimated using a facilities-based approach that accounts for Sites planned facilities, carrying capacity, the regional population of potential users, the surface acreage of the reservoir, fluctuations in storage throughout the year, and the amenities and visitation levels of substitute reservoirs in the region.

Table A3-13 presents the annual visitor-day estimates and unit day values by activity type. The estimated total annual visitor-days assumed in this analysis was approximately 187,000.

Table A3-13. Annual Recreation Visitation by Primary Activity

Activities	Annual Visitor-Days
Shore fishing	16,254
Boat fishing	8,407
Picnicking	15,457
Sightseeing	27,514
Swimming / beach use	36,992
Walking	42,223
Bicycling/Motorcycling	5,418
Horseback riding	2,429
Boating / water-skiing	29,145
Hunting	560
Other	2,429
Total	186,829

Monetized Benefits

Recreation benefits were quantified using unit day values from Rosenberger, Recreation Use Values Database (RUVD) for North America (2016) and from Loomis, Updated Outdoor Recreation Use Values on National Forests and Other Public Lands for U.S. Forest Service (2005). These values were applied to the visitation projections for Sites Reservoir. It was also determined that 80 percent of the visitor-days at Sites Reservoir would represent new recreational visits, and that the remaining 20 percent of visits would reflect recreational visitor-days that, in the absence of Site Reservoir's development, would otherwise have occurred at nearby reservoirs. Table A3-14 presents the results of the recreation benefits analysis.

Table A3-14. Estimated Annual Recreation Benefits (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$6,997	$6,997	$6,754

[a] Annual benefits reflect consumer surplus value for various recreational activities supported by Sites Reservoir and water operation scenarios under year 2030 and year 2070 levels of development. Benefits were attributed for only 75 percent of future visitation expected as new recreational use after accounting for potential substitution effects on other reservoirs in the region.

[b] Annualized benefits represent avoided costs relative to the Future No Project conditions over the planning horizon (2030 to 2122). Annual average is less than 2030 and 2070 values due to initial short ramp-up period before full benefits are generated.

[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's future recreation benefits were estimated to be approximately $7.0 million in 2030. Although future population growth might be expected to increase future recreation demand and visitation, it was conservatively assumed that the 2030 level of benefits would remain constant throughout the future 2030 to 2122 operating period. As a result, the average annual benefit for the future 2030 to 2122 operating period was estimated to be $6.8 million (slightly reduced due to an assumed 50 percent operation during its first two operating years).

Flood Damage Reduction (WSIP Public Benefit)

Physical Quantification

Development of the Sites project would reduce the magnitude of flood events in the area along Funks Creek and Stone Corral Creek, specifically for the town of Maxwell's residential, commercial, and public structures and contents. In addition, the project would reduce flood damage to adjacent agricultural lands and flood-related closures to Interstate 5 and State Route 20.

Hydraulic analysis (HEC-RAS 2-D) was used to quantify the project-related reduction in flood-impacted areas and flooding severity for six different flood event types (ranging from 5-year to 500-year flood events). Geographic information system (GIS) land use analysis inventoried the impacted areas. Flood reduction benefits were estimated for current hydraulic conditions to represent the expected 2030 conditions. No adjustments in the hydraulic modeling or other analytic methods were used to project 2070 conditions (including climate change) because the flood damage benefits are relatively limited and due to difficulty in quantifying the magnitude of changes in future flood events.

Additional details on flood damage reduction benefits are provided under the Sites_A1 Flood Control under the PHYSICAL PUBLIC BENEFITS TAB.

Monetized Benefits

The value of flood damage reduction benefits was estimated based on the average annual cost of flood damages under No Action conditions and the projected reduction in flooded area and damage costs for "with Project" conditions. The resulting Expected Annual Damages savings from the project-related reduction in flood impact incidence and severity were calculated for a comprehensive range of different flood event types (5 year to 500 year) and adjusted for their expected incidence rate. This approach corresponds to the "avoided cost" approach described in the WSIP TR report.

Table A3-15 presents the estimated benefit value of the project-related flood damage reduction.

Table A3-15. Flood Reduction Benefits (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$4,377	$4,377	$4,377

[a] Based on the project-related reduction in expected annual damages from future flood events.
[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant annual benefits after 2070.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's future flood reduction benefits were estimated to be approximately $4.4 million in 2030. It was conservatively assumed that 2030 benefit values would remain constant throughout the future 2030 to 2122 operating period. As a result, the average annual benefit for the future 2030 to 2122 operating period was estimated to be $4.4 million.

Water Supply (Non-Proposition 1 Eligible Benefit)

Physical Quantification

Increases in water supply were monetized based on the increase in deliveries. Increases in deliveries for 2030 and 2070 were estimated using CALSIM II. CALSIM II determined future water deliveries for each applicable project purpose by water-year type and location. Corresponding physical benefits were estimated on an annual basis for the interim 2031 to 2069 period by interpolating individually (i.e., for each specific purpose, location, water-year type, and incidence rate). Each year's individual quantified values were then used to determine a corresponding average expected water use amount. Table A3-16 shows the estimated water supply deliveries by water-year type projected in 2030, 2070, and the annual average in the 2030 to 2122 study period. Sites is expected to reduce the flood area by 9,570 acres. Additional details on flood damage reduction benefits are provided in Sites_A1 Flood Control under the PHYSICAL PUBLIC BENEFITS TAB.

Table A3-16. Increase in Water Supply Deliveries (TAF/year)

Period	NOD Agriculture	SOD Agriculture	SOD M&I	SOD Recaptured	Total
2030 Results					
Long-Term Average	110	25	106	11	254
Wet	62	5	15		82
Above Normal	86	68	52		144
Below Normal	125	28	121		273
Dry	157	56	213		426
Critical	153	53	185		391
2070 Results					
Long-Term Average	137	30	117	11	295
Wet	110	5	15		130
Above Normal	146	12	72		230
Below Normal	152	26	116		294
Dry	161	69	257		488
Critical	133	41	145		319
Average (2030–2122)					
Long-Term Average	**131**	**29**	**114**	**11**	**286**

Source: CALSIM II.
M&I = municipal and industrial
NOD = north-of-the-Delta
SOD = south-of-the-Delta

Monetized Benefits

Sites Reservoir would improve water supply reliability to both M&I water users (primarily south of the Delta) and agricultural waters (both north and south of the Delta). CWEST modeling was used to estimate the project's future M&I water supply benefits. The CWEST values were also applied to the small quantity of recaptured water that the Sites Joint Powers Authority (JPA) intends to use as a revenue source to cover the future operations and maintenance (O&M) cost-share for the project's agricultural water supply benefits for ecosystem and other public benefit purposes based on the WSIP-recommended unit water values. The total benefit value was estimated based on the expected future average hydrological year type and the expected use location of the water supplies. The WSIP unit water values were also adjusted to include the additional conveyance energy cost associated with its future use.

Table A3-17 shows the project's total water supply reliability benefits.

Table A3-17. Total Water Supply Benefits: CWEST Results and WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$89,024	$251,521	$175,418

[a] Based on CWEST and WSIP unit water values adjusted by water-year type, expected delivery location, and conveyance energy costs.
[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant annual benefits after 2070. WSIP unit water values interpolated between 2030 and 2045, after which 2045 unit water values were used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

Based on the assumed water use split between agricultural, M&I, and recaptured water deliveries and their use location, the project's future water supply benefits are estimated to increase from $89.0 million in 2030 to approximately $251.5 million in 2070. The corresponding average annual benefit for the future 2030 to 2122 operating period is estimated to be $175.4 million, which is equal to an estimated average unit benefit value of $760 per acre-foot for water supply use.

Hydropower (Non-Proposition 1 Eligible Benefit)

Physical Quantification

Hydropower benefits were modeled by both DWR's Power and Risk Office (PARO) and United States Bureau of Reclamation contractors. These non-public benefits are difficult to forecast due to a rapidly changing market for valuing ancillary and systemwide capacity benefits due to the rapid and extensive new development of wind and solar resources. The fluctuation in revenue from hydropower generation over the last decade can be seen by looking at the variability in revenue from generation that has occurred for the State Water Project (SWP).

Hydropower analysis performed by Toolson and Zhang (2013) generally corroborated PARO's direct net energy benefits. Toolson and Zhang's PLEXOS modeling analysis also evaluated Sites Reservoir ancillary services (AS) and systemwide capacity performance and benefits. Sites is expected to increase the hydropower (system) by 215,542 MWh per year.

Monetized Benefits

The proposed Sites Reservoir Project includes new hydropower capacity and the ability to provide AS at Shasta Dam and other hydropower facilities throughout the Central Valley Project (CVP) and SWP systems. Estimates of net changes in hydropower capacity, generation, and AS in western interconnection electrical power grid were estimated using both DWR's PARO modeling and the PLEXOS® Integrated Energy Model (PLEXOS).

The PARO model is used to estimate the costs and revenues of hydropower facilities' operations. Power benefits were also valued by PLEXOS, a power market simulation model, to forecast energy and AS power market prices for the year 2022, when the 33 percent Renewable Portfolio Standard (RPS), mandated by California law, will have been implemented. The assumption is that power market prices stabilize once the RPS is achieved.

DWR's PARO analysis modeled future optimized pumping, generation, and pump-back operations to estimate the future energy use cost and power generation benefits optimized between peak and off-peak periods. The PARO analysis determined that the estimated net energy cost for Sites Reservoir operations would be $1.7 million, which was assigned to the facility's O&M costs.

The PLEXOS hydropower analysis confirmed DWR's direct net energy benefits and costs. The PLEXOS analysis also estimated annual AS benefits of approximately $2.4 million and systemwide capacity benefits of $17.8 million per year. As a result, the combined AS and systemwide capacity National Economic Development (NED) benefits potentially attributable to the hydropower facilities would be $20.2 million per year. Table A3-18 shows the projected future AS and systemwide capacity benefits projected for Sites Reservoir's hydropower operations. As discussed above, the reservoir's projected energy costs are recognized in its O&M cost and therefore were not included in hydropower system benefits shown in Table A3-18.

Table A3-18. Hydropower Benefits (2015$; $1,000s)

Alternative	Annual Benefits a		Annualized Benefit b
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$20,183	$20,183	$19,483

[a] Based on projected ancillary service and systemwide capacity benefits. Facility pumping costs and generation revenues are included in the facilities' annual O&M costs.

[b] Annualized benefits assume interpolated annual physical benefits between 2030 and 2070 and then constant benefits after 2070. Annual average is less than 2030 and 2070 values due to initial short ramp-up period before full benefits are generated.

[c] Averaged over the entire hydrologic sequence (1922 to 2003).

Combined AS and systemwide capacity benefits of $20.2 million were determined for the project's hydropower operations in 2030. It was conservatively assumed that the project's 2030 level of benefits would remain constant throughout the future 2030 to 2122 operating period. As a result, the average annual hydropower benefit for the future 2030 to 2122 operating period was estimated to be $19.5 million (slightly reduced due to an assumed 50 percent operation during its first two operating years).