Benefit Calculation, Monetization, and Resiliency Tab

Attachment 5: Physical and Monetized Benefits

Provide additional information that supports the physical and monetary quantification of the public and non-public benefits and impacts of the project as required by subsection 6004(a)(4) of the regulations. This includes data, assumptions, analytical methods and modeling results, calculations and relevant sources of information. For reference documents or studies relied upon, applicants may provide links to an existing website in lieu of attaching those documents to the application.

WSIP Application Instructions, March 2017

Table of Contents

Tables

Figures

Acronyms and Abbreviations

$/AF	dollar value per acre-foot
AS	Ancillary Services
AS WSIP	Water Storage Investment Program
CEC	California Energy Commission
CP4A	Comprehensive Plan 4A
CPI-U	consumer price index for California
CPUC	California Public Utilities Commission
CVP	Central Valley Project
CWC	California Water Commission
CWEST	California Water Economics Spreadsheet Tool
DWR	California Department of Water Resources
EAD	Expected Annual Damages
EPM	Energy Portfolio Model
EPRI	Electric Power Research Institute's
F-RAM	Flood Rapid Assessment Model
I-5	Interstate 5
IEPR	Integrated Energy Policy Report
LRS	Loads and Resources Subcommittee
LTO EIS	Coordinated Long Term Operation of the Central Valley Project and State Water Project Environmental Impact Statement
LTPP	Long Term Procurement Plan
M&I	municipal and industrial
NOD	north of the Delta
O&M	operation and maintenance
PARO	Power and Risk Office (DWR)
PLEXOS	PLEXOS® Integrated Energy Model
project	Sites Reservoir Project
Reclamation	United States Bureau of Reclamation
RPS	Renewable Portfolio Standard
RUVD	Recreation Use Values Database
SALMOD	Salmon Population Model
SGMA	Sustainable Groundwater Management Act

SLWRI	Shasta Lake Water Resource Investigation
SOD	south of the Delta
SWAP	Statewide Agricultural Production
SWP	State Water Project
TAF	thousand acre-feet
TEPPC	Transmission Expansion Planning Policy Committee
TM	Technical Memorandum
TR	Technical Reference
UWMP	Urban Water Management Plan

A5.1 All Benefits

This section provides an overview of the analytic approaches, data, and calculations used for two or more of the benefit purposes to quantify their economic benefits. Subsequent sections discuss the analyses specific to the individual benefit purposes in more detail.

Table A5-1 shows the Sites Reservoir Project (project) purposes and benefits quantified and monetized for the Water Storage Investment Program (WSIP) Application. The key data, assumptions and analytical methods used to determine each project purpose's physical and monetary benefits are provided below. The following methodology discussion also describes the modeling results, calculations, and relevant information sources for the benefit analysis.

A5.1.1.a Analytic Methods

Table A5-1 shows (1) the analytic methods used to determine the monetized economic benefits for the WSIP Application and (2) the alternate methodologies considered for use for the economic benefit valuation analysis. In most cases, analyses using the alternate methodologies were also performed to evaluate their suitability for the WSIP Application's final benefit determination and to estimate the findings with their use.

The discussion of analytic methods in the following sections identifies and describes the analytic methods selected for use in the WSIP benefit value determination and those that were not selected.

Similarly, the discussion of the data, calculations, and modeling results below identifies and describes benefit valuation approaches that were selected and those that were not.

CALSIM II

The economic benefit analyses for project-provided water supply relied on CALSIM II modeling to quantify the project's expected future water deliveries under different water-year conditions. The California Water Commission's WSIP Technical Reference (November 2016) (TR) recognizes CALSIM II as "the model most capable of providing inter-regional or statewide analysis of water operations in the Central Valley of California." The WSIP TR also provides a detailed description of the CALSIM II model approach and use (TR, Section 4.3.8.9 and Appendix B).

Per WSIP TR recommendations, CALSIM II modeling was used to determine the project's future water supply deliveries under different water-year conditions to its expected water users and locations. The CALSIM II operational studies determined future water deliveries for both 2030 and 2070 conditions. The CALSIM II analysis also incorporated the WSIP TR required future climate change assumptions to determine its 2070 future water system operations and deliveries.

The CALSIM II analysis both accounts for water conveyance losses and recognizes water system operating constraints (both infrastructure and scheduling) to determine the water quantities that can be delivered to water users (whether municipal and industrial [M&I], agricultural, or for environmental improvement purposes).

Unless otherwise noted, CALSIM II was used to determine the water quantities that support the benefit valuation of the project purposes.

Table A5-1. Summary of Quantified Physical Benefits and Monetization Approaches

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

CWEST = California Water Economics Spreadsheet Tool
HEC-FDA = Hydrologic Engineering Center Flood Damage Reduction Analysis
M&I = municipal and industrial
PARO = Power and Risk Office (DWR)
PLEXOS = PLEXOS® Integrated Energy Model
WSIP = Water Storage Investment Program

Alternative Cost

The WSIP TR identified the Alternative Cost approach as an acceptable monetization approach for determining the economic benefit value for both WSIP public benefits and non-WSIP benefits. The Alternative Cost-benefit value for a project benefit is "the cost of the least-cost means of providing at least the same amount of physical benefit" (TR, Section 5.3).

In accordance with WSIP TR guidance, two alternative projects were identified and analyzed to provide comparable physical benefits as those that would be produced by Sites Reservoir: Shasta Lake Water Resource Investigation (SLWRI or "Shasta Raise") and the proposed Auburn Dam Project. Due to its location on the Sacramento River upstream of Sites Reservoir, Shasta could readily provide water to the same end users as Sites Reservoir. The Auburn Dam would be on the American River, which is a tributary to the Sacramento River and therefore could also serve most of the benefit purposes of the Sites Reservoir. In addition, both alternative projects are large water storage projects that would provide major quantities of new water supplies. Given the large magnitude of the necessary water supplies for the project's benefit purposes, it is highly unlikely that they could be obtained from existing water users, and if such long-term water transfers occurred, they would result in major adverse economic externalities (e.g., major reductions in agricultural-sector activity).

The United States Bureau of Reclamation (Reclamation) previously analyzed both alternative projects and determined them to be technically and economically feasible. Of the two, Shasta Raise has been most recently analyzed with its final feasibility study completed in 2015. Raising Shasta Lake Dam is projected to be substantially less costly to construct than Auburn Dam. In addition, there are major environmental concerns and other constraints to future construction of Auburn Dam. These concerns and constraints greatly reduce the likelihood that Auburn Dam would be authorized, funded, and constructed.

Consequently, Shasta Raise was determined to be the lower-cost and more-feasible alternative project. Enlargement of Lake Shasta was also determined to be the least-cost means to obtain similar ecosystem improvement and water supply outcomes. Therefore, the Shasta Raise was used as the basis for all Alternative Cost analyses for Sites Reservoir.

WISP Unit Water Values

The California Water Commission (CWC) provided unit values for water were used to estimate the willingness to pay for several of the project's ecosystem improvement benefit purposes in accordance with the Technical Memorandum (TM) guidance (TR, Appendix D). WSIP Unit Water Values were also used to determine the economic benefits from the project's future agricultural water supply increases. The unit values were then adjusted as appropriate to account for the delivered water's additional benefit value to its users represented by the conveyance costs expected to be incurred in addition to the water transfer cost. This approach is consistent with the benefit valuation methodologies recently used by the feasibility analyses for Reclamation's Draft Upper San Joaquin River Basin Storage Investigation (2015) and Shasta Lake Water Resource Investigation (2015). Both these analyses used a similar water transfer data set and model to develop base Unit Water Values that were then adjusted to include applicable conveyance costs and carriage losses to determine the full benefit value of the project's water supplies to its water users.

However, the Sites Reservoir benefits valuation analysis conservatively only increased the WSIP unit water benefit values to account for the additional conveyance energy costs. As discussed below, a majority of the project's expected water users are likely to be SWP water contractors that may be able to obtain their future deliveries through the SWP with minimal non-energy conveyance costs. The Cal-Sim 2 water modeling incorporates allowance for water system losses in its calculation of the delivery quantities. It was unclear from the WSIP TM whether and to what extent its unit water values (i.e. its transfer transactions) implicitly included any allowances for significant delivery water losses in their transactions and in the absence if information on the general nature of the transfers it was considered potentially speculative to apply any such adjustment. Consequently, the Sites Reservoir made no delivery water loss adjustment to increase the WSIP unit benefit value as a conservative assumption.

However, if a 25 percent adjustment to the unit water benefit value (similar to that used by the Shasta Lake Water Resource Water Investigation Feasibility Analysis), was applied the corresponding benefit values for the benefit-purpose would be similarly increased. This would result in higher benefit values for the project and increased benefit cost and public benefit ratio findings for the project.

The WSIP TM guidance also notes an important limitation to the use of its unit values:

> "(U)nit water values are appropriate for relatively small incremental amounts of water supply relative to the existing water uses available as feasible alternative sources. If an action or water supply will provide a large amount of water relative to available alternative sources, then the unit values in Table 5-5 may not be appropriate."

As the WSIP TM acknowledges, there are several reasons why, under certain circumstances, the WSIP unit values would undervalue the benefits for specific water uses. The WSIP unit values implicitly assume that there would be a sufficient number of willing sellers for the price and quantity of water that could supply the water being valued. This assumption may be difficult to meet for large quantities of water (especially those quantities required for the project's anadromous fish or M&I deliveries).

The project would provide long-term, reliable deliveries. Such deliveries would contrast with the current water transfer market, which predominantly consists of limited-term contracts and where the demand, supply, and prices vary considerably depending on the recent and projected water-year type. The Sites Reservoir has been designed to add more than 340 thousand acre-feet (TAF) in new long-term water supplies to California's water supply for ecosystem improvements and water users through the state. Consequently, the project's total quantity of new water and that provided for its individual benefit purposes generally exceed past water transfer quantities. Therefore, it is highly unlikely that the water transfers implicit in the WSIP unit water values could actually occur—or be achieved—in a manner that would result in comparable water quantities and reliability as that provided by the project.

Furthermore, as the WSIP TM also notes, there may be major third-party effects (e.g., externalities or related adverse effects on employees and other businesses in related economic sectors) that are not represented in the unit water values, which focus on the compensation to water sellers. Major and/or long-term reallocations of water use resulting from water transfers can be expected to potentially result in direct and indirect economic impacts to the region's workers, supporting businesses, and consumers. The WSIP unit water values are predominantly derived from past water transfers and are therefore solely based on the financial relationship between the water buyer and sellers. As a result, these values incorporate costs or losses to third-party entities or the larger economy. Inclusion of any additional third-party costs would be expected to increase the unit values and hence the benefit values of other water sources. As a result, the WSIP unit water values are considered conservative benefit valuations for the project's new water supply.

As discussed below, Alternative Cost analysis for benefit monetization reported considerably higher benefit water use benefit values. Nonetheless, to be conservative in its analysis and findings, the WSIP benefit value analysis has selected WSIP unit water values to monetize the benefits of several of its ecosystem improvement purposes and future increased agricultural water deliveries.

LTGEN/SWP

Conveyance energy costs for the majority of locations expected to receive water supply deliveries were calculated by using the LTGen/SWP power with the Sites CALSIM II operations model. Conveyance cost information from the California Department of Water Resources (DWR), as reported in 2016 unit costs for State Water Project (SWP) system deliveries, was also evaluated.

WSIP Technical Reference Guidelines

Generally, the Sites Reservoir benefit valuation analysis closely follows the WSIP TR guidelines. As shown in Table A5-1, WSIP unit water values were used to estimate the economic benefit values for several project purposes. As permitted by the guidelines, alternate benefit valuation approaches can also be used, provided they are technically sound and adequately justified.

The rationale for each selected benefit monetization approach is provided below. Generally, additional analyses using the alternate methodologies were also performed to better understand the sensitivity of the findings of each benefit analysis. Consequently, the findings for both the selected and the alternate benefit monetization approaches are presented and discussed below.

Other key WSIP requirements generally applied to the benefit analysis include:

- A planning horizon totaling 100 years (including the project construction period) (Consequently, future project benefits were determined for the 93-year operating period of 2030 to 2122.)
- A discount rate of 3.5 percent to determine annualized average benefit values, net present values, and applicable interest during construction costs (TR, Section 5.2.4)
- Analysis of benefits and costs in constant 2015 dollars and adjusted to 2015 price levels (TR, Section 5.2.5)
- Escalation of pre-2015 cost and benefit values into constant 2015 dollars using the yearly average consumer price index for California (CPI-U) (TR, Section 5.2.6)

Whenever possible, future real energy costs were escalated 1.7 percent annually to 2024 (TR, Section 5.2.7). In cases where this energy price escalation could not be incorporated into the model analysis, additional analysis was performed to determine adjustments to the analysis results to approximate the expected effects of the prescribed future escalation in real energy prices.

A5.1.1.b Data and Assumptions

Water Supply Quantities

The CALSIM II modeling analysis accounts for water conveyance losses in its quantification of delivered water supplies. Consequently, no water loss adjustments were applied to WSIP Unit Water Values. Table A5-2 shows the 2030 and 2070 water-year incidence rates for both the Sacramento River and the San Joaquin River Hydrologic Regions. The 2070 water-year frequencies have been adjusted to account for the WSIP-required climate change assumptions (TR, Section 2.12 and Appendix A).

Table A5-2. Water-Year Type Incidence Rates by Hydrologic Region: 2030 and 2070

Year Type	Hydrologic Region			
	Sacramento River		San Joaquin River	
	2030	2070	2030	2070
Wet	30%	32%	26%	18%
Above Normal	15%	13%	20%	21%
Below Normal	21%	16%	15%	11%
Dry	20%	24%	18%	16%
Critical	15%	15%	22%	34%
Total	100%	100%	100%	100%

Source: Calculated from historical hydrologic year type information.
Note: Total may not sum exactly due to rounding.

The Sacramento River Hydrologic Region water-year incidence rates were used in the CALSIM II modeling to determine the Sites Reservoir water delivery quantities.

Water Supply Benefit Values

Table A5-3 provides the WSIP-recommended unit water values, as discussed in Section 5.3.3 (and more extensively in Appendix D) of the WSIP TR. The WSIP Unit Water Values shown below were based for statistical analysis of past water transfers and application of the Statewide Agricultural Production Model (SWAP), including assumptions to account for the effects of future implementation of the Sustainable Groundwater Management Act (SGMA).

As discussed in the WSIP TR, the unit water values are also based on actual past water transfer transactions and sale prices, which generally require the buyer to also cover the conveyance costs for the deliveries. As a result, the full water price paid by the water buyer will be the combined sales price and the conveyance costs. This combined price also more accurately represents the water user's full willingness to pay for the supplied water.

Table A5-3. WSIP Unit Water Values by Water Year and Location ($/AF)

Water-Year Type	Sacramento Valley	Delta Export
2030 – Unit Water Values ($/AF)		
Wet	$145	$205
Above Normal	$190	$255
Below Normal	$255	$265
Dry	$275	$285
Critical	$345	$360
2045 – Unit Water Values ($/AF)		
Wet	$150	$415
Above Normal	$200	$520
Below Normal	$265	$635
Dry	$285	$675
Critical	$355	$1,055

Source: WSIP TR, Appendix D, Table D6, Page D-11.

The CALSIM II analysis also accounts for the ability of the state's water system to deliver the water supplies to the expected users. The majority of the project's water supply deliveries will be for either north-of-the-Delta (NOD) users or south-of-the-Delta (SOD) users through the SWP to its water contractors. The conveyance costs for NOD users will be minor, both in terms of wheeling costs and energy use. To be conservative in the attributed benefits, they were assumed to be zero and the WSIP values for Sacramento Valley users were not adjusted. However, as discussed in more detail below, the energy necessary to convey water to SOD users will be a significant expense and will indicate additional willingness-to-pay value to the WSIP Unit Water Values. As a result, to represent the full value of water supplied to end users, the expected conveyance energy costs to those end users are added to the WSIP Unit Water Values to represent their actual willingness to pay and full benefit value.

The SWP generally has considerable unused service capacity (which CALSIM II has accounted for in its operational modeling). The current annual fees and charges for SWP water contractors are determined to ensure full recovery of the SWP system's annual capital and operating costs. For a variety of reasons, the SWP generally cannot provide its contractors with their full Table A allocation. As a result, SWP water contractors are expected to incur only the marginal cost of their system use to convey deliveries because they already fully meet their annual required capital share. The marginal cost for SWP users will be predominantly the additional energy use because cost increases for other system operation and maintenance (O&M) components would be minor. As a result, the benefit analysis conservatively limits its adjustments of WSIP Unit Water Values to SOD users' expected energy costs for conveyance. The actual values are discussed further in Section A5.1.1.c.

Table A5-4 provides the expected benefit start date and the percentage of their 2030 levels. The majority of benefits are expected to start in 2030, except for anadromous fish, Yolo Bypass, and flood damage reduction, as partial benefits will begin before the end of construction. In the case of hydropower (system) and recreation, a short initial ramp-up period is expected before their operations reach their full 2030 benefit levels in 2032.

The additional benefits occurring before the project operations begin in 2030 are not included in the annualized (2030 to 2122) values calculated for each benefit category below and are not reported in their modeling result. Consequently, the pre-operation benefits are also not included in the Sites_A3 Physical Monetized under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB, results. This approach was used to facilitate comparisons both between the study-year results (i.e., 2030 and 2070) with the annualized value and between different benefit categories.

Although the pre-construction benefits are relatively minor, they nonetheless should be included when determining the project's total benefits. Consequently, the pre-construction benefits are shown in Future Economic Benefit in Sites_A6 Annual Benefits Table under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB, and factored into the project's total net benefit value, benefit-cost ratio, and public benefit ratio calculations in Sites_A10 Allocation under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB, and Physical and Economic Benefits Summary in Sites_A11 Benefits Table under the BENEFIT CALCULATION, MONETIZATION, AND RESILIENCY TAB.

Table A5-4. Benefit Start Dates with Percentage of 2030 Benefits

Year	Anadromous Fish	Incremental Level 4 Refuge	Oroville Coldwater Pool	Yolo Bypass	Recreation	Flood Control	Water Supply	Hydropower (System)	Total Benefits
2024	—	—	—	—	—	—	—	—	—
2025	—	—	—	—	—	—	—	—	—
2026	10%	—	—	10%	—	50%	—	—	10%
2027	15%	—	—	15%	—	50%	—	—	10%
2028	20%	—	—	30%	—	100%	—	—	24%
2029	30%	—	—	50%	—	100%	—	—	24%
2030	100%	100%	100%	100%	50%	100%	100%	50%	97%
2031	100%	100%	100%	100%	50%	100%	100%	50%	97%
2032	100%	100%	100%	100%	100%	100%	100%	100%	100%
2033	100%	100%	100%	100%	100%	100%	100%	100%	100%

A5.1.1.c Calculations

Water Supply Projections

The CALSIM II model results for 2030 and 2070 were used as the basis for determining both future annual water use quantities during the interim period (i.e., 2031 to 2069) and the subsequent post-2070 period.

For the interim period, straight-line interpolation between the 2030 and 2070 model results was used to determine the expected 2031 to 2069 annual values for applicable project purposes.

Annual averages for each intervening year were calculated based on appropriate weighting of the water-year type for the Sacramento River Hydrologic Region (Table A5-5). The weightings for the interim period are determined as straight-line interpolations between the 2030 and the 2070 model results. The 2070 water quantities are used for all years after 2070. The 2070 water-year frequencies have been adjusted to account for the WSIP-required climate change assumptions (TR, Section 2.12; Appendix A).

Table A5-5. Water-Year Type Incidence Rates: Sacramento River Hydrologic Region

Year	Wet	Above Normal	Below Normal	Dry	Critical	Avg. Water Year
2030	30%	15%	21%	20%	15%	100%
2031	31%	15%	21%	20%	15%	100%
2032	31%	15%	20%	20%	15%	100%
2033	31%	15%	20%	20%	15%	100%
2034	31%	15%	20%	20%	15%	100%
…	…	…	…	…	…	…
…	…	…	…	…	…	…
2066	32%	14%	16%	24%	15%	100%
2067	32%	14%	16%	24%	15%	100%
2068	32%	13%	16%	24%	15%	100%
2069	32%	13%	16%	24%	15%	100%
2070	32%	13%	16%	24%	15%	100%
2071	32%	13%	16%	24%	15%	100%
2072	32%	13%	16%	24%	15%	100%

Source: Based on historical hydrologic year type information.

Table A5-6 provides a representative calculation of the annual average based on the interpolation of the CALSIM II 2030 and 2070 water quantity projections for north-of-the-Delta agriculture water supplies.

Table A5-6. North-of-the-Delta Agricultural Water Deliveries (TAF/year)

Year	Wet	Above Normal	Below Normal	Dry	Critical	Avg. Water Year
2030	62	86	125	157	153	110
2031	63	87	125	157	152	111
2032	64	89	126	158	152	112
2033	65	90	127	158	151	112
2034	66	92	127	158	151	113
…	…	…	…	…	…	…
…	…	…	…	…	…	…
2066	105	140	149	161	135	135
2067	106	141	150	161	134	135
2068	107	143	151	161	134	136
2069	109	144	151	161	133	137
2070	110	146	152	161	133	137
2071	110	146	152	161	133	137
2072	110	146	152	161	133	137

Estimated Annual WSIP Unit Water Values

Unit Water Values were interpolated on a straight-line basis between 2030 and 2045 to derive water annual unit estimates for each year between 2031 and 2044. The 2030 unit values were used for all years before 2030. The 2045 unit values were used for all years after 2045.

The average water-year value is calculated based on hydrologic regions, with Sacramento Valley prices based on the Sacramento River Hydrologic Region and the Delta Export value based on the San Joaquin River Hydrologic Region. As the relative weightings during the interim period are determined by straight-line interpolation between the 2030 and the 2070 model results, the average annual value can vary through 2070. Table A5-7 provides a representative selection of these values.

Water sold to south-of-the-Delta water users will also necessarily incur the conveyance energy cost. This cost is in addition to the WSIP Unit Water Values, which were largely determined based on past water transfer transactions. Buyers typically negotiate purchase of the water from the seller's location. As a result, the buyer then incurs the wheeling and energy cost to convey the water to its location. As discussed previously, the conveyance energy costs estimates were based almost entirely on LTGEN/SWP energy use modeling. DWR data were used to project the conveyance energy cost only for American Canyon water district deliveries, which was not estimated by the LTGEN/SWP energy use models.

Table A5-7. Adjusted WSIP Unit Water Values ($/AF)

Year	WSIP Unit Water Value		Average Conveyance Energy Cost [a]	Adjusted WSIP Unit Water Value	
	Sacramento Valley	Delta Export		Sacramento Valley	Delta Export
2028	$229	$272	$185	$229	$457
2029	$230	$298	$185	$230	$483
2030	$229	$272	$185	$229	$457
2031	$230	$298	$185	$230	$483
2032	$230	$323	$185	$230	$508
2033	$231	$348	$185	$231	$533
2034	$231	$373	$185	$231	$558
…	…	…	…	…	…
…	…	…	…	…	…
2043	$235	$546	$185	$235	$731
2042	$236	$570	$185	$236	$755
2043	$236	$594	$185	$236	$779
2044	$237	$619	$185	$237	$804
2045	$238	$643	$185	$238	$828
2046	$238	$642	$185	$238	$827
2047	$238	$641	$185	$238	$826
…	…	…	…	…	…
…	…	…	…	…	…
2066	$238	$625	$185	$238	$810
2067	$238	$624	$185	$238	$809
2068	$238	$623	$185	$238	$808
2069	$238	$622	$185	$238	$807
2070	$238	$621	$185	$238	$806
2071	$238	$621	$185	$238	$806
2072	$238	$621	$185	$238	$806

Source: WSIP TR, Table D6, Page D-11 and LTGEN/SWP energy use modeling.
[a] Average conveyance cost for deliveries to south-of-the-Delta water contractors based on LTGEN/SWP energy use modeling.

- No conveyance adjustment was applied to north-of-the-Delta deliveries because the energy use for those water quantities would be limited.
- No conveyance cost adjustment was made for agricultural water supplied to north-of-the-Delta users (per discussion in Section A5.1.1.b, above).
- The estimated average conveyance energy cost for south-of-the-Delta agricultural water users was $185/AF.
- Unit Water Values were interpolated on a straight-line basis between 2030 and 2045. Constant Unit Water Values were applied after 2045. Note that average water values still change between 2045 and 2070 based on changing water supply quantities due to climate change.
- San Joaquin River Hydrologic Region water-year incidence rates are used to determine applicable unit values for Delta export deliveries.

The WISP Unit Water Values (see Table A5-3) were applied to the CALSIM II projected future water supply quantities (interpolated between 2030 and 2070). The WISP unit water values were also applied based on (1) expected water-year type frequencies and (2) use location. Based on these factors, weighted average unit prices were calculated specifically for each year in the study period. The WSIP Unit Water Values were also adjusted to include the additional conveyance energy cost required for its future use, as shown in Table A5-7.

A5.1.1.d Modeling Results

Table A5-8 shows the summary results of the average water quantities used by each project purpose. Several purposes are water non-consumptive and/or indirectly rely on project-related water (e.g., hydropower, recreation); consequently, they do not have any applicable assigned water use quantities.

Table A5-8. Summary of Quantified Water Use by Purpose (TAF/year)

Period	WSIP Public Benefits			Non-WSIP 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

The modeling results for each specific project purpose are reported and discussed under their corresponding section below.

A5.2 Ecosystem Improvement (WSIP Eligible Benefits)

Sites Reservoir would provide a variety of ecosystem benefits. Four distinct ecosystem benefits were quantified and monetized. Table A5-9 summarizes the physical benefits that were quantified and monetarized for the WSIP Application.

Table A5-9. 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 to provide 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

The specific analysis approach and results for each ecosystem improvement purpose are provided below.

A5.2.1 Anadromous Fish

Sites Reservoir provides a variety of benefits to anadromous fish. The Salmon Population Model (SALMOD) results were used to determine the cost of an alternative project to raise the dam at Shasta Lake to estimate the benefits to anadromous fish.

A5.2.1.a Analytic Methods

Salmon Population Model (SALMOD)

SALMOD simulates the dynamics of the freshwater life history of anadromous and resident salmonid populations using streamflow, water temperature, and habitat type. SALMOD combines flow and temperature information to forecast the population of Chinook salmon in the Sacramento River watershed between Keswick Dam and Bend Bridge, near Red Bluff. It provides potential fish production values reflecting the suitability of riverine habitat for Winter-run, Spring-run, Fall-run, and Late-Fall-run Chinook salmon. The model simulates salmon habitat conditions in the Sacramento River between Keswick Dam and Bend Bridge.

Alternative Cost – Shasta Lake Dam Raise (WSIP Benefit Monetization Approach)

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. As discussed in Section A5.1.1.a, this approach involves identifying the next-best (i.e., least-cost) alternative project to achieve the same outcomes (i.e., increasing salmon habitat) and using its development cost to represent the project's benefits.

Unlike other possible benefit valuation approaches (e.g., use of WSIP Unit Water Values), the Alternative Cost approach relies on direct comparisons of the two projects' expected fishery benefits for the Sacramento River as modeled by SALMOD. The Alternative Cost approach also represents a more permanent and reliable basis for the fish habitat improvement than that represented by reliance on future water transfers and changes in future water use.

Consequently, it was considered that the Alternative Cost of the Shasta Lake Dam raise would provide the most direct and reliable benefit valuation, and therefore this method was selected for use in the WSIP benefit valuation of the project's anadromous fish benefits.

WSIP Unit Water Values (Alternate Monetization Approach)

As previously discussed in Section A5.1.1.a, WSIP Unit Water Values modeling can also be used to determine the project's ecosystem benefits. However, to represent the project's anadromous fish benefits, the project's expected habitat unit improvements were not determined directly but instead were based on an estimated equivalent water quantity that would allow Shasta Lake to maintain its coldwater pool sufficiently and deliver the water supplies necessary to improve the fishery habitat conditions along the Sacramento River.

Based on the estimated water supply quantities, adjusted WSIP Unit Water Values can be applied to derive a corresponding anadromous fish benefit valuation. The appropriate Unit Water Values for the benefit valuation should be based on the expected likely source of the water to be "transferred" to replace the reduced Shasta deliveries.

WSIP Unit Fish Values (Alternate Monetization Approach)

The WSIP TR also provides guidance on benefit valuations for fishery recovery benefits based on escapement projections for winter-run and spring-run Chinook salmon (TR, Section 5.4.2.2; Appendix E). The WSIP TR indicates that a benefit of $100,000 per fish-year (one fish escaping one year) is reasonable. The TR recommended value for non-listed fall-run Chinook salmon is $2,500 per fish-year.

Although SALMOD and other fish models can be used to project future increases in smolt and juvenile salmon populations, no fish models are available to project the project-related future improvement in escapement for the Sacramento River. However, general estimates of expected juvenile fish survival rates were used to derive preliminary anadromous fish benefit values based on the WSIP Unit Fish Values.

A5.2.1.b Data and Assumptions

The cost of the most likely feasible alternative to the Sites Reservoir was based on various Shasta Lake Dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River. As discussed in Section A5.1.1.a, the Shasta Lake Dam raise is considered a feasible alternate source based on the key factor that its additional surface storage could ensure the availability of a greater and new supply of coldwater to reduce downstream water temperatures on the Sacramento River. The Shasta Lake Dam raise would benefit the same anadromous fish populations' locations and therefore result in the same ecosystem improvement outcomes. The Shasta Lake Dam raise could thereby also achieve the same benefits as Sites Reservoir would. Furthermore, recent extensive planning and analysis for the Shasta Lake Dam raise provides greater confidence in both the accuracy of its construction cost estimates and its potential implementation viability.

Nevertheless, the Shasta Lake Dam raise cost estimates are expected to result in conservative Alternative Cost-benefit valuations because the 2015 Final Feasibility Report construction cost estimates likely underestimate the actual full construction cost for its future storage expansion. Higher construction costs (or reduced ecosystem improvement outcomes) for the Shasta Lake Dam raise alternative would increase the Alternative Cost benefit values attributable for the Sites Reservoir project.

Key factors contributing to the Alternative Cost approach's underestimate of the project's benefit values include:

- The 2015 construction cost estimates do not factor in the full costs that would be necessary for project development. Given the project's unavoidable adverse wild and scenic river impacts and the current level of known opposition to the project, actual development of the project may be expected to be more costly and time-consuming than anticipated by the Feasibility Study analysis. The costs for overcoming the likely environmental and legal challenges to the project could significantly increase its overall future development cost.
- The schedule necessary to complete any expansion of Shasta Lake would be expected to be considerably longer than the schedule to complete Sites Reservoir not only because of the previously discussed environmental and legal challenges expected for a Shasta Lake Dam raise, but also because of the need to rely on Federal appropriations. On a present value basis, all else being equal, a 10-year delay in construction completion would result in nearly a 30 percent comparative reduction in the project's first year of benefits.

- Salmon populations within the Sacramento River and other related water systems are in decline and their future viability threatened by deterioration in river and habit conditions. Delayed development would result in further declines in fishery habitat and Chinook populations before any project-related ecosystem improvements would occur. The resulting habitat and population losses would reduce the comparative effectiveness of the eventual Shasta Lake expansion. In this case, the unit benefit cost of the Shasta Lake alternative would increase and result in a higher Alternative Cost benefit valuation for the project.
- The WSIP 2030 baseline scenario presumes overly optimistic Shasta Lake storage levels and coldwater conditions. It is equally probable that the future 2030 conditions at Lake Shasta will in fact have lower storage conditions. Past and current Federal government operation and management of the Central Valley Project (CVP) suggest that actual future 2030 conditions for Shasta Lake would be expected to have lower storage levels and reduced coldwater conditions. As a result, the project's comparative ecosystem improvement is underestimated, which reduces its quantified physical improvements and related benefit values. Furthermore, the near-term occurrence of this benefit diminishment results in a greater underestimate in the benefit valuation because the present value calculations give greater weight to the project's early-year benefits.

These factors indicate that the benefit value for Sites Reservoir as derived from the Alternative Cost approach applied to the Shasta Lake Dam raise should be recognized as conservative benefit valuations that likely understate the actual full benefit values of the ecosystem improvements resulting from Sites Reservoir.

A5.2.1.c Calculations

Fish Population Projections

Table A5-10 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. The SALMOD results show that the project would result in greatly increased future anadromous fish habitat improvements. This outcome is largely attributable to the projected deterioration in future water conditions for salmon species as a result of future climate change effects.

Table A5-10. SALMOD Results for 2030 and 2070 (TAF/year)

Run	No Action (# of fish/yr)	Average Increase (# of fish/yr)	Habitat Units	Dry Yr Increase (# of fish/yr)	Critical Yr Increase (# of fish/yr)	Dry & Critical Yr 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		**1,822,064**	**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 A5-1 shows the percentage growth in population increase projected for each fish-type population in both 2030 and 2070.

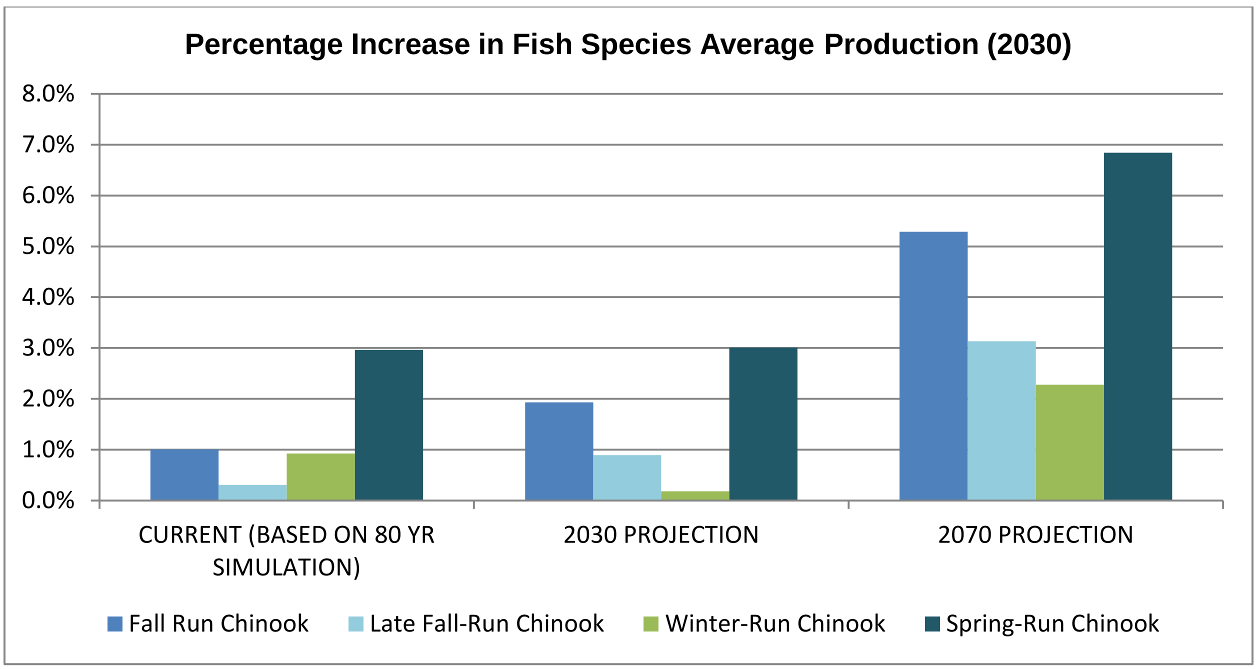

Figure A5-1. Percentage Increase in Fish Species Average Production for 2030 and 2070

As shown in Table A5-10, in 2030, 6.3 percent of the fish population increase would be composed of the Federal-protected Winter- and Spring-run Chinook, increasing to 7.2 percent in 2070. For the purposes of the WSIP Unit Fish Value approach, it was assumed 1 percent of the increased fish population would subsequently return as adults to spawn.

Alternative Cost (Selected Monetization Approach)

Sites Reservoir's anadromous fish benefits were estimated based on the least-cost alternative of expanding Shasta Lake's future storage with a 12.5-foot raise of Shasta Dam as a single-purpose water storage project that would provide increased habitat units.

The base construction cost for the Shasta Lake Dam raise was obtained from the 2015 Shasta Lake Water Resource Investigation Feasibility Study. The costs were adjusted into 2015 dollar terms and annualized using a 3.5 percent discount rate in accordance with the WSIP TR requirements. Table A5-11 shows the estimated single-purpose cost for six Shasta Lake Dam raise alternatives with their projected habitat unit improvement and the corresponding unit cost per habitat unit.

Table A5-11. Salmon Production and Annual Costs for Shasta Lake Dam Raise Scenarios

Dam Raise (feet)	Habitat Units (HU) [a]	2014$		2015$	
		Annual Cost ($1,000s)	Cost per Habitat Unit ($/HU)	Annual Cost ($1,000s) [b]	Cost per Habitat Unit ($/HU)
0.5	63	$35,585	$564,840	$36,103	$573,059
1.7	212	$36,407	$171,729	$36,936	$174,228
3.2	381	$37,771	$99,137	$38,321	$100,580
6.5	684	$40,831	$59,694	$41,425	$60,563
12.5	988	$46,295	$46,857	$46,968	$47,539
18.5	975	$51,761	$53,088	$52,514	$53,860

Source: Reclamation, Shasta Lake Water Resource Investigation Feasibility Study (2015).
[a] Each habitat unit equals 1,000 additional salmon produced.
[b] Costs have been adjusted into 2015 dollars and are based on a 3.5 percent annual discount rate.

Table A5-11 indicates that the 12.5-foot dam raise at Shasta Lake Dam is both the most-productive alternative, with 988 new habitat units, and the most cost-effective, with a unit cost of $47,539 per habitat unit. This unit value was applied as a conservative benefit value estimate for Sites Reservoir's anadromous fish benefit.

Table A5-12 shows the project's 2030, 2045, 2070, and annualized average over the project's entire 2030 to 2122 study period based on their corresponding SALMOD-projected increase in future habitat units. As shown in Table A5-12, the project's future increase in habitat units is projected to be up to 1,822 in 2070 and average 1,539 habitat units over the 93-year study period for the project.

Table A5-12. Estimated Anadromous Fish Benefits: Alternative Cost (2015$)

Year	Fishery Improvement Habitat Unit	Benefit Value	
		Unit Value $/Habitat Unit	Total ($1,000s)
2030	539	$47,539	$25,637
2045	1020	$47,539	$48,505
2070	1,822	$47,539	$86,619
Annualized (2030–2122) [a]	**1,539**	**-**	**$56,985**

[a] Annualized average benefit value is calculated using net present value over 93 years and a 3.5 percent discount rate.

The project's future habitat conditions would average 551 habitat units (56 percent increase) more than those provided by the 12.5-foot Shasta Lake Dam raise. The 2070 habitat conditions would be nearly 834 habitat units (84 percent increase) higher than the Shasta Lake Dam raise would achieve.

Nonetheless, the 12.5-foot Shasta Lake Dam raise benefit value was used because (1) no other alternative projects could be identified that would result in comparable higher habitat improvements for the Sacramento River; and (2) no other suitable project could be developed in conjunction with the 12.5-foot Shasta Lake Dam raise to provide the additional 834 habitat units in 2070. Furthermore, the fish habitat improvement results for the 18.5-foot raise suggest that any further economies of scale are unlikely to occur with higher raises of the Shasta Lake Dam.

As a result, it was considered reasonable and conservative to use the unit benefit value from the Shasta Lake Dam raise to estimate future anadromous fish benefits at Sites Reservoir.

WSIP Unit Water Values (Alternative Monetization Method)

Preliminary operational analysis determined that for 2030 conditions an approximately 83 TAF increase in end-of-September storage at Shasta Lake should be sufficient to result in the coldwater improvements necessary to achieve the corresponding 539 habitat unit increase. Under 2070 conditions, approximately a 59 TAF increase in end-of-September storage at Shasta Lake should be sufficient to result in the coldwater improvements necessary to achieve the corresponding 1,822 habitat unit increase. As discussed in Section A5.2.1.b, above, these values are expected to be conservative.

The economic benefits of the increase in anadromous fish were also estimated using the adjusted WSIP unit water values (see Table A5-7) applied to the projected average annual delivery quantities on a year-by-year basis over the project's entire 2030 to 2122 study period. WSIP unit water values are for Delta export and include conveyance energy adjustment because the water would otherwise be used in the south-of-the-Delta area. Table A5-13 shows the estimated annual benefit values of future anadromous fish in 2030, 2045, 2070 and as an annualized average over the project's entire 2030 to 2122 study period.

Table A5-13. Estimated Anadromous Fish Benefits: WSIP Unit Water Values (2015$)

	Fishery Improvement (Supply Equivalent)	Benefit Value	
		WSIP Unit Water Value	**Total**
Year	**TAF**	**$/AF**	**($1,000s)**
2030	83	$457	$38,042
2045	74	$828	$61,408
2070 [b]	59	$806	$47,684
Annualized (2030–2122) [a]	**65**	**—**	**$51,069**

[a] Annualized average benefit value is calculated using net present value over 93 years and a 3.5 percent discount rate.
[b] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

However, these benefit values do not account for any adverse economic effects of such a permanent and major shift in water use (e.g., for agricultural-dependent businesses and workers) that would increase the societal value of the continued use of the water for agricultural production. Allowances for that and other factors (e.g., difficulty and limited options for increasing habitat units) can be expected to explain the differential between the WSIP unit and Alternative Cost benefit value estimates.

WSIP Unit Fish Values (Alternative Monetization Method)

The project's anadromous fish economic benefits were also estimated using the WSIP Unit Fish Values (Section A5.2.1.a). Unit fish values for Fall-run, Winter-run, and Spring-run Chinook salmon were applied to their expected project-related increases in their 2030 and 2070 populations. Table A5-14 shows the estimated annual benefit values of future anadromous fish increases in 2030, 2045, 2070, and as an annualized average over the project's entire 2030 to 2122 study period.

Table A5-14. Estimated Anadromous Fish Benefits: WSIP Unit Fish Values (2015$)

Year	Fishery Improvement		Benefit Value	
			WSIP Unit Fish Value	Total
	Fall-Run Chinook	Winter- & Spring-Run Chinook	$1,000/Fish	($1,000s)
2030	5,053	340	$2.5/$100	$46,591
2045	9,498	705	$2.5/$100	$94,281
2070	16,906	1,315	$2.5/$100	$173,765
Annualized (2030–2122) [a]	**14,293**	**1,100**	**—**	**$111,966**

[a] Annualized average benefit value is calculated using net present value over 93 years at a 3.5 percent discount rate.

The WSIP Unit Fish Value approach resulted in much higher benefit value estimates than those obtained from the Alternative Cost approach. Therefore, as a conservative assumption and in accordance with WSIP TM guidance, WSIP Unit Fish Value approach was not used to estimate Sites Reservoir's anadromous fish benefits.

A5.2.1.d Modeling Results (Selected Monetization Approach)

Table A5-15 shows Sites Reservoir's anadromous water supply benefits as estimated based on the 12.5-foot raise of Shasta Dam as the least-cost alternative to the project.

Table A5-15. 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 are interpolated annual physical benefits between 2030 and 2070 and then constant after 2070. Annualized benefits calculated as net present value over 93 years at a 3.5 percent 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 annualized benefit for the future 2031 to 2132 operating period was estimated to be $57.0 million. As discussed above this was based on an estimated average unit benefit value of $47,539 per habitat unit.

A5.2.2 Incremental Level 4 Refuge Water Supply

Sites Reservoir will increase water deliveries for Incremental Level 4 Refuge needs located south-of-the-Delta.

A5.2.2.a Analytic Methods

CALSIM II

As previously discussed in Section A5.1, CALSIM II modeling was used to determine the project's 2030 and 2070 Incremental Level 4 water supply deliveries by location under different water-year conditions.

WISP Unit Water Values (Selected Monetization Approach)

As previously discussed in Section A5.1 All Benefits, WSIP Unit Water Value modeling is an approved benefit monetization approach and it was used to determine the project's 2030 and 2070 Incremental Level 4 Refuge water supply benefit values under different water-year conditions.

Alternative Cost (Alternate Monetization Approach)

As previously discussed in Section A5.1 All Benefits, the Alternative Cost method can be used to determine the project's 2030 and 2070 ecosystem improvement benefits of increased Incremental Level 4 Refuge deliveries under different water-year conditions. Shasta Lake Dam raise has been determined to be the least cost alternative for the project.

A5.2.2.b Data and Assumptions

Future increase in Incremental Level 4 Refuge supplies are not associated with any existing mitigation or compliance requirements per WSIP requirements (TR Section 8.1). Consequently, the project's ecosystem improvements represent new environmental benefits that would not otherwise be achieved.

A5.2.2.c Calculations

Project Water Use

Table A5-16 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.

Table A5-16. 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 the 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 Technical Reference guidance, post 2070 deliveries were assumed to occur at 2070 levels.

Consistent with the approach used to determine the benefit values for Yolo Bypass supply, the annual average water quantities were based on use of the Sacramento River Hydrologic Region's water-year incidence rates during the 2030 to 2070 study period.

WISP Water Unit Values (Selected Monetization Approach)

The economic benefits of the increase future water deliveries for Incremental Level 4 Refuges were estimated using the adjusted WSIP Unit Water Values (see Table A5-7) applied to the projected average annual delivery quantities on a year by year basis over the project's entire 2030 to 2122 study period. The Delta Export adjusted WSIP Unit Water Values were used for the Incremental Level 4 Water Refuge benefit because the majority of the Refuges are located south-of-the-Delta and the project supplied water would otherwise be used for south-of-the-Delta deliveries.

Table A5-17 shows the estimated annual benefit values of future Incremental Level 4 Refuge deliveries in 2030, 2045, 2070 and as an annualized average over the project's entire 2030 to 2122 study period.

Table A5-17. Incremental Level 4 Refuge Supply Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

Year	Incremental Level 4 Refuge Deliveries TAF	Benefit Value WSIP Unit Water Value [b] $/AF	Benefit Value Total ($1,000s)
2030	35	$457	$16,047
2045	33	$828	$27,644
2070 [c]	31	$806	$24,634
Annualized (2030–2122) [a]	**32**	**-**	**$23,811**

[a] Annualized benefit value is calculated using net present value for 93 years at a 3.5 percent discount rate.
[b] Adjusted WSIP Unit Water Values for Delta export supplies.
[c] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

Alternative Cost (Alternate Monetization Approach)

The economic benefits of the increase water deliveries to Incremental Level 4 Refuge were also estimated on an Alternative Cost basis. The Alternative Cost for achieving the Incremental Level 4 Refuge deliveries' ecosystem benefits is based on the cost of a Shasta Lake Dam raise developed and operated solely for the purpose of providing the water quantities necessary for the Incremental Level 4 Refuge supply purpose.

As discussed in Section A5.1.1.a, the Shasta Lake Dam raise was determined to be a reasonable and feasible alternate source due both to its potential ability to provide the necessary large quantities of new water supplies and its location which ensures that it could provide the same Incremental Level 4 Refuge supply deliveries and therefore result in the same ecosystem improvement outcomes. Furthermore, recent extensive planning and analysis has been completed for the Shasta Lake Raise which provides more confidence in both the accuracy of its construction cost estimates and its potential implementation viability.

The Alternative Cost was estimated on a per acre-foot unit basis using the 2015 Shasta Lake Water Resource Investigation Feasibility Study (2015) dam raise alternatives and cost estimates. The feasibility study evaluated six different dam raise alternatives and the Comprehensive Plan 4A (CP4A) alternative was selected as the National Economic Development Plan.

The CP4A alternative would construct an 18.5 foot Shasta Lake dam raise to provide 634,000 TAF in additional reservoir storage capacity, augmented spawning gravel and reserve 30 percent of the new storage capacity to increase its coldwater pool.

The per acre cost for both M&I and agricultural water supply purposes were determined by dividing each's single purpose cost estimated full annualized cost (i.e., including both O&M and construction) by its expected average water-year supply quantity.

The CP4A alternative's $9.4 million total annual O&M cost was allocated between its numerous benefit purposes proportionally based on their relative benefit values as shown in Table A5-18.

Table A5-18. Annual Benefits and Cost for Enlargement of Shasta Lake: CP4A (2014$; $millions)

CP4A	Anadromous Fish	Water Supply	Hydropower	Recreation	Total
Benefits	$33	$27	$14	$14	**$89**
O&M	$4	$3	$2	$2	**$9.4**

Source: Tables 4-7 and 4-8, SLWRI 2015.

The $3 million water supply O&M cost was further split proportionally between the agricultural and M&I uses based on their average annual water supply quantities. The resulting O&M costs were then added to the single purpose annualized construction costs. The resulting annual water supply cost estimates were then converted from their reported 2014 dollar cost estimates into 2015 dollar terms. No adjustment to the annualized costs was necessary since the Shasta Feasibility Study used the same 3.5 percent discount rate as that required by the WSIP TR guidelines.

Table A5-19 shows the annualized single purpose costs, the average year water deliveries, and the unit benefit value estimated for both agricultural and M&I water supply for the CP4A Shasta Lake 18.5 foot dam raise alternative. To be conservative, the Alternative Cost approach selected for Sites Reservoir was based on the lower water supply unit cost for Shasta Lake's agricultural supply. This alternate cost was used to value the economic benefits of Sites Reservoir's future 32 TAF of increased average annual Incremental Level 4 Refuge supply deliveries.

Table A5-19. Single Purpose Cost for Enlargement of Shasta Lake: CP4A ($1,000s)

Water Use	Deliveries (Average Year) (TAF/yr)	Annualized Cost (2014$)		Total Annualized Cost (2015$)	Alternative Cost: Unit Benefit Value ($/AF)
		Construction	O&M		
Agricultural	31.4	$43,600	$1,741	$46,001	$1,465
M&I	19.9	$44,500	$1,103	$46,267	$2,325

Source: Tables ES-7 and 4-5, SLWRI 2015.

The estimated annualized unit cost for the enlargement of Shasta Lake was determined to be $1,465 per acre foot. This annual cost represents the Alternative Cost for the Sites Reservoir and was then used to estimate the total benefit value for the future Incremental Level 4 Refuge deliveries in 2030, 2045, 2070 and the annualized average over the project's full 2030 to 2122 study period. Table A5-20 shows the resulting estimated benefit values of Sites Reservoir's future Incremental Level 4 Refuge deliveries using this Alternative Cost approach. The Alternative Cost approach resulted in much higher benefit value estimates than those obtained from the WSIP Unit Water Value approach. Therefore, as a conservative assumption and in accordance with WSIP TM guidance, the Alternative Cost approach was not used to estimate Sites Reservoir's Incremental Level 4 Refuge and similar Ecosystem Improvements.

Table A5-20. Incremental Level 4 Refuge Supply Benefit Valuation: Alternative Cost Approach (2015$; $1,000s)

Year	Incremental Level 4 Refuge Deliveries TAF	Benefit Value: Alternate Cost – Unit Value $/AF	Benefit Value: Total ($1,000s)
2030	35	$1,465	$51,418
2045	33	$1,465	$48,927
2070	31	$1,465	$44,774
Annualized (2030–2122) [a]	**32**	**—**	**$48,055**

[a] Annualized benefit value was calculated using net present value over 93 years at a 3.5 percent discount rate.

A5.2.2.d Modeling Results (Selected Monetization Approach)

Table A5-21 shows Sites Reservoir's Incremental Level 4 refuge water supply benefits as estimated based on WSIP Unit Water Values.

Table A5-21. Incremental Level 4 Refuge Benefits: WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a] 2030	Annual Benefits [a] 2070	Annualized Benefit [b]
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 values are 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 annualized benefit for the future 2030 to 2132 operating period was estimated to be $23.8 million. This 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.

A5.2.3 Lake Oroville Coldwater Pool

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 to Anadromous Fish were anticipated to be less than the benefits downstream from Shasta Lake, but nevertheless significant. The storage increase based on CALSIM II modeling is characterized below.

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

A5.2.3.a Analytic Methods

CALSIM II

As previously discussed in Section A5.1, CALSIM II modeling was used to determine the project's 2030 and 2070 water quantity increases to improve Lake Oroville Coldwater Pool conditions.

WSIP Unit Water Values (Selected Monetization Approach)

The SALMOD model does not include the Feather River area. No other fishery models for American River exist and therefore the habitat or fish population increase from future improvements in Lake Oroville's coldwater pool improvements cannot be directly evaluated. Consequently, the benefit value of fishery improvements within the Feather River watershed were evaluated based on an opportunity cost to secure an equivalent amount of storage in Lake Oroville.

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 temperature conditions of its water releases.

As previously discussed in Section A5.1 All Benefits, WSIP Unit Water Values modeling was used to determine the project's 2030 and 2070 water benefit values for the Lake Oroville Coldwater Pool under different water-year conditions.

The WISP unit value benefit method used to value the water supply necessary for the projected Lake Oroville coldwater pool improvements was the same as that used for the Incremental Level 4 Refuge supplies benefits (Section A5.2.2). The Lake Oroville benefit valuation analysis also similarly used the adjusted Unit Water Values for south-of-the-Delta supplies applied to the CALSIM II determined water quantities determined specifically necessary to achieve Lake Oroville's coldwater benefits.

Alternative Cost (Alternate Monetization Approach)

As previously discussed in Section A5.1 All Benefits and for Incremental Level 4 Refuge purposes (Section A5.2.2), an Alternative Cost method can be used to determine the project's 2030 and 2070 ecosystem improvement benefits under different water-year conditions. Furthermore, given the comparability of their estimated future water quantity needs (annual averages of 30 TAF for Oroville Coldwater Pool and 32 TAF for Incremental Level 4 Refuges); the Alternative Cost analysis for the Oroville Coldwater Pool benefits was very similar to that performed for the Incremental Level 4 Refuge supply increases.

A5.2.3.b Data and Assumptions

Lake Oroville's late spring and early summer water deliveries that would instead be met Sites Reservoir water releases would generally be for south-of-the-Delta water users. Consequently, south-of-the-Delta WSIP Unit Water Values were used to represent the benefit value of those releases which would otherwise need to be cancelled.

Similarly, based on Lake Oroville current 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. Consequently, south-of-the-Delta WSIP Unit Water Values were used to represent the benefit value of those releases which would otherwise need to be retained.

A5.2.3.c Calculations

Projected Water Use

Table A5-22 shows the projected future increase in annual end of May water storage for Lake Oroville projected by CALSIM II.

Table A5-22. 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 (2030–2122)	
Long-Term	30

Source: CALSIM II.

WISP Unit Water Values (Selected Monetization Approach)

The economic benefits of the increase future water deliveries for Lake Oroville coldwater pool were estimated using the adjusted WSIP Unit Water Values (see Table A5-7) applied to the projected average annual delivery quantities on a year by year basis over the project's entire 2030 to 2122 study period. Table A5-23 shows the estimated annual benefit values of future Lake Oroville coldwater pool improvements in 2030, 2045, 2070 and the annualized average over the project's full 2030 to 2122 study period.

Table A5-23. Lake Oroville Coldwater Pool Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

Year	Lake Oroville Coldwater Pool Deliveries	Benefit Value	
		WSIP Unit Water Value	Total
	TAF	$/AF	($1,000s)
2030	26	$457	$11,814
2045	28	$828	$22,986
2070 [b]	31	$806	$24,976
Annualized (2030–2122) [a]	**30**	-	**$20,987**

[a] Annualized benefit value was calculated using net present value over 93 years at a 3.5 percent discount rate.
[b] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

Alternative Cost (Alternate Monetization Approach)

As discussed above, the Alternative Cost approach for monetization of the project's future Incremental Lake Oroville Coldwater Pool deliveries was the same as that used for the project's Incremental Level 4 Refuge deliveries in Section A5.2.2. As a result, an estimated annualized per acre foot unit cost for the enlargement of Shasta Lake of $1,465/AF was used to estimate the total benefit value for the Lake Oroville coldwater pool deliveries in 2030, 2045, 2070 and the annualized average over the project's full 2030 to 2122 study period.

Table A5-24 shows the estimate the benefit values of Sites Reservoir's future Lake Oroville coldwater pool deliveries using the Alternative Cost approach.

Table A5-24. Lake Oroville Coldwater Pool Benefit Valuation: Alternative Cost Approach (2015$; $1,000s)

Year	Lake Oroville Coldwater Pool Deliveries TAF	Benefit Value	
		Alternate Cost – Unit Value $/AF	Total ($1,000s)
2030	26	$1,465	$37,857
2045	28	$1,465	$40,683
2070	31	$1,465	$45,394
Annualized (2030–2122) [a]	**30**	—	**$41,731**

[a] Annualized benefit value is calculated using net present value over 93 years and 3.5 percent discount rate.

A5.2.3.d Modeling Results (Selected Monetization Approach)

Table A5-25 presents the estimate benefits values for the projected future increases in Lake Oroville's coldwater pool.

Table A5-25. 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 values are used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's Lake Oroville coldwater pool benefits were estimated to increase from $11.8 million in 2030 to $25.0 million in 2070. The corresponding annualized benefit for the future 2030 to 2132 operating period was estimated to be $21.0 million. This is equal to an estimated average unit benefit value of $1,465 per acre foot. This valuation reflects the comparatively high benefit values for future south-of-the-Delta water uses.

A5.2.4 Yolo Bypass

Sites Reservoir will increase water deliveries to the Yolo Bypass which are expected to result in ecosystem improvements.

In 2016, DWR performed a North Delta Food Web Study in 2016 in collaboration with Federal and local water agencies. The study addressed the *Delta Smelt Resiliency Strategy* (California Department of Natural Resources, 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 should improve Delta smelt growth and condition as they mature into adults, thereby increasing Delta smelt abundance.

The Sites Reservoir Project will provide two pulses of flow of at least 400 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 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 TAF in each two to three week period 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.

A5.2.4.a Analytic Methods

CALSIM II

As previously discussed (see Section A5.1 All Benefits), CALSIM II modeling was used to determine the project's 2030 and 2070 water quantities for Yolo Bypass deliveries and ecosystem improvement under different water-year conditions.

WSIP Unit Water Values (Selected Monetization Approach)

The WISP unit value benefit method used to value the water supply necessary for the Yolo Bypass water supplies was the same as that used for both the Incremental Level 4 Refuge supplies benefits (Section A5.2.2) and Lake Oroville coldwater pool improvements. However, the Yolo Bypass benefit valuation analysis instead used the lower Unit Water Values for Sacramento Valley water supplies applied to the CALSIM II determined water delivery quantities.

Alternative Cost (Alternate Monetization Approach)

As previously discussed and applied to both the project's Incremental Level 4 Refuge supply and Lake Oroville coldwater purposes, an Alternative Cost method can be used to determine the project's 2030 and 2070 ecosystem improvement benefits from increased Yolo Bypass deliveries under different water-year conditions. Shasta Lake Dam raise has been determined to be least cost alternative. Furthermore, given the comparability of their estimated future water quantity needs (annual averages of 39 TAF for Yolo Bypass and 32 TAF for Incremental Level 4 Refuges), the Alternative Cost analysis for the Yolo Bypass benefits was very similar to that performed for the Incremental Level 4 Refuge supply increases.

A5.2.4.b Data and Assumptions

It was assumed that the water provided for the purpose of increasing Yolo Bypass flows would otherwise likely be delivered to south-of-the-Delta water contractors. Consequently, south-of-the-Delta unit values were used for the benefit valuation of the Yolo Bypass flows.

A5.2.4.c Calculations

Projected Water Supply Requirements

Table A5-26 shows the projected future increase in annual water flows for Yolo Bypass for 2030, 2070, and the annual average for the 2030 to 2122 study period.

Table A5-26. Yolo Bypass Flow Increases for 2030 and 2070 (TAF/year)

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

WSIP Unit Water Values (Selected Monetization Approach)

The economic benefits of the increase future water deliveries to the Yolo Bypass were estimated using the unadjusted WSIP Unit Water Values (see Table A5-7) applied to the projected average annual delivery quantities on a year by year basis over the project's entire 2030 to 2122 study period. The Sacramento Valley WSIP Unit Water Values are used. These values do not include any conveyance cost benefit adjustment and were used since it was presumed that the necessary water supplies would otherwise be expected to be obtained from Sacramento Valley agricultural water users.

Table A5-27 shows the estimated annual benefit values of future Yolo Bypass deliveries in 2030, 2045, 2070 and their annualized average quantity and benefit value over the project's entire 2030 to 2122 study period.

Table A5-27. Yolo Bypass Flows Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

Year	Yolo Bypass Deliveries TAF	Benefit Value: WSIP Unit Water Value $/AF	Benefit Value: Total ($1,000s)
2030	39	$229	$8,845
2045	39	$238	$9,190
2070	39	$238	$9,220
Annualized (2030–2122) [a]	**39**	—	**$9,117**

[a] Annualized benefit value was calculated using net present value over 93 years at a 3.5 percent discount rate.

Alternative Cost (Alternate Monetization Approach)

The Alternative Cost approach for monetization of the project's future Incremental Level 4 Refuge deliveries was also performed. As a result, an estimated annualized per acre foot unit cost for the enlargement of Shasta Lake of $1,465/AF was used to estimate the total benefit value for the Incremental Level 4 Refuge deliveries in 2030, 2045, 2070 and the annualized average over the project's entire 2030 to 2122 study period. Table A5-28 shows the results from use of the Alternative Cost approach to estimate the benefit values of Sites Reservoir's future Yolo Bypass deliveries.

Table A5-28. Yolo Bypass Flows Benefit Valuation: Alternative Cost Approach (2015$; $1,000s)

Year	Yolo Bypass Deliveries TAF	Benefit Value: Alternate Cost – Unit Value $/AF	Benefit Value: Total ($1,000s)
2030	39	$1,465	$56,577
2045	39	$1,465	$56,654
2070	39	$1,465	$56,783
Average (2030–2122) [a]	**39**	**—**	**$56,683**

[a] Annualized benefit value is calculated using net present value over 93 years at a 3.5% discount rate.

A5.2.4.d Modeling Results (Selected Monetization Approach)

Table A5-29 shows Sites Reservoir's Yolo Bypass water supply benefits as estimated based on the use of the applicable adjusted WSIP Unit Water Values (see Table A5-7).

Table A5-29. 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, 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 values are used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The project's Yolo Bypass supply benefits were estimated to remain relatively unchanged between 2030 ($8.8 million) and 2070 ($9.2 million). The corresponding annualized benefit for the future 2030 to 2132 operating period was estimated to be $9.1 million. This is equal to an estimated average unit benefit value of $237 per acre foot for the future ecosystem benefits from the Yolo Bypass. This valuation reflects the comparatively lower benefit values for future north-of-the-Delta water uses.

A5.3 Recreation (WSIP Eligible Benefit)

Development of the Sites Reservoir would provide new recreational facilities and opportunities.

A5.3.1.a Analytic Methods

Facilities-Based Visitation Model

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, surface acreage of the reservoir and fluctuations in storage throughout the year, as well as the amenities and visitation levels of substitute reservoirs in the region. Additional information and recreation analysis is available in Appendix C of the NODOS Draft Feasibility Study (USBR 2017). These variables for consideration are consistent with those outlined in the WSIP Technical Reference (TR Section 5.4.5). Annual visitation was calculated as a measure of total visitor days, which represents one person visiting for any part or all of a calendar day. This metric is commonly used to inform recreational benefits, and should not be confused with a recreational *visit*, which could last for more than one calendar day (e.g., camping).

WSIP Recreational Visitation Model

A sample WSIP Visitation Model was obtained from CWC and considerable efforts was made to apply the model in accordance with the technical guidance provided by the WSIP Technical Appendix (TR Section 5.4.5). The required inputs were obtained and run through the model, but the model results did not fall within the expected range. The WSIP Recreational Visitation model's visitation estimates were highly sensitive to a few of the model variables including; the number of boat lanes, the regional population of potential users, and the reservoir's surface acreage. Collectively, these factors indicated that Sites was too dissimilar from the other recreation facilities that were used to construct and benchmark the WSIP Visitation Model to permit the model's use. As a result, the facilities-based approach was instead used to project Sites Reservoir's future visitation levels.

User Day Values (Selected Monetization Approach)

Recreation benefits were quantified using unit day values from the Recreation Use Values Database (RUVD) for North America (Rosenberger 2016) and the U.S. Forest Service (Loomis 2005). Both of these resources provided a meta-analysis of hundreds of studies that estimated the use value of recreation activities in the U.S. over the past half-century. These recreation use value estimates reflect the average net willingness-to-pay or consumer surplus, in per person per activity day units for different activities and regions in the U.S. This benefit measure was considered to be consistent with the WSIP Technical Reference guidance (TR Section 5.4.5).

The WSIP Technical Report also suggests possible use of USACE Unit Day Values (TR Section 5.4.5.7) as unit day values for recreation. However, these unit values are national recreation use value estimates while the U.S. Forest Service values are for recreation use within the Western Pacific region. In addition, the USACE data identifies only four general recreational use categories while the U.S. Forest Service data provides specific use values for more than a dozen different recreation categories applicable to the project. Consequently, it was determined that the U.S. Forest would provide a more accurate estimate of Sites Reservoir's future recreation use benefits and were therefore used for the recreation benefit value analysis.

The selected U.S. Forest Service unit values were then applied to the visitation projections to determine the total annual user benefits for recreation at Sites Reservoir. The net recreational benefit for the project was then calculated by accounting for the potential substitution of recreational use from nearby reservoirs.

A5.3.1.b Data and Assumptions

Table A5-30 presents the annual visitor day estimates and unit day values by activity-type.

Table A5-30. Annual Recreation Visitation by Primary Activity

Activity	Annual Visitor-Days	Unit Day Values
Shore fishing	16,254	$86.23
Boat fishing	8,407	$86.23
Picnicking	15,457	$42.96
Camping	27,514	$47.51
Sightseeing	36,992	$51.29
Swimming / beach use	42,223	$44.11
Walking	5,418	$72.33
Bicycling/Motorcycling	2,429	$94.26
Boating / water-skiing	29,145	$52.48
Hunting	560	$72.29
Other	2,429	$40.77
Total	**186,829**	**$46.81** (avg.)

A majority of the unit day estimates that were incorporated in this analysis come from the most recent 2016 study (Rosenberger 2016), using Western Region values (as defined by U.S. Census regions). Only in a few cases the 2005 activity values (Loomis 2005) used, as the reported activity types more accurately reflected the planned recreational uses at Sites (e.g., horseback riding).

The databases informing the unit day value estimates do not contain information on marginal values for changes in site quality, condition or other factors that would allow for adjusting the net willingness to pay estimates with consideration of the unique attributes of Sites. However, these are average values, and have been endorsed for use by Federal actors such as the U.S. Bureau of Reclamation for estimating recreational benefits at reservoirs in California.

It is assumed that 80 percent of visitor days at Sites represent new recreational visits, and that the remaining 20 percent of visits reflect existing recreational visitor days that would have occurred at nearby reservoirs. This substitution factor is considered conservative given the limited number of reservoirs in the area, as well as results from the WSIP Visitation. As detailed in the WSIP Technical Reference (Appendix F), the acreage of nearby reservoirs did not significantly affect day visitation, except for a small, but measurable contribution in the fall months. In addition, even for those people who have recreated elsewhere (particularly at overcrowded facilities) and shift their trip to Sites, the quality of the recreational experience at Sites Reservoir may be higher, thereby generating additional recreation benefits that are not captured in this analysis.

A5.3.1.c Calculations

Table A5-31 presents the results of the recreation benefits analysis for both a scenario with no substitution and the assumed substitution level of 20 percent. The estimated annual visitor days assumed in this analysis is approximately 187,000.

Table A5-31. Annual Recreation Benefits (2015$; $1,000s)

Activity	Annual Visitor Days	Unit Day Values ($/day)	Annual Benefits ($1,000s)	
			0% Substitution	20% Substitution
Shore fishing	16,254	$86.23	$1,402	$1,121
Boat fishing	8,407	$86.23	$725	$580
Picnicking	15,457	$42.96	$664	$531
Camping	27,514	$47.51	$1,307	$1,046
Sightseeing	36,992	$51.29	$1,897	$1,518
Swimming / beach use	42,223	$44.11	$1,863	$1,490
Walking	5,418	$72.33	$392	$314
Bicycling/Motorcycling	2,429	$94.26	$229	$183
Boating / water-skiing	29,145	$52.48	$1,530	$1,224
Hunting	560	$72.29	$41	$32
Other	2,429	$40.77	$99	$79
Total	**186,829**	**$46.81** (avg.)	$8,746	$6,997

A5.3.1.d Modeling Results (Selected Monetization Approach)

Table A5-32 presents the results of the recreation benefits analysis.

Table A5-32. 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 $7.1 million in 2030. Although future population growth might be expected increase future recreation demand and visitation, it was conservatively assumed that 2030 level of benefits would remain constant throughout the future 2030 to 2132 operating period. As a result, the annualized benefit over the 2030 to 2132 operating period was estimated to be $6.9 million (slightly reduced due to an assumed 50 percent operation during its first two operating years).

A5.4 Flood Reduction (WSIP Eligible Benefit)

Development of the Sites project would reduce the magnitude of flood events in the area along Funks Creek and Stone Corral Creek, providing a direct public benefit. Flood damage reduction benefits were estimated based on avoided costs. In the case of the Sites project, flood damage costs would be reduced for the Town of Maxwell's residential, commercial and public structures and contents. In addition, the project would reduce flood damages to adjacent agricultural lands and flood-related closures to

Interstate 5 (I-5) and State Route (SR) 20. Other flood damage savings include avoided clean-up, emergency response, and disruption costs for workers and businesses.

A5.4.1.a Analytic Methods

The benefit value of the project-related flood damage reduction was estimated based on the annualized net cost savings of flood damages for the future “with Project” conditions compared to the existing “No Action” conditions. The resulting Expected Annual Damages (EAD) savings was estimated based on hydraulic analysis that quantified 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). GIS land use analysis inventoried the impacted areas. This approach corresponds to the “avoided cost” approach described in the WSIP Technical Reference report (TR Section 5.4.3).

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) since the flood damage benefits are relatively limited and difficulty in quantifying the changes in future flood events’ magnitude.

As a result, the 2030 flood reduction benefits are applied for 2070. This was considered a conservation assumption since the WSIP’s future climate changes conditions project more frequent and severe wet water years. This can be expected to result in more frequent flood events of greater magnitude.

Hydraulic Analysis

A HEC-RAS 2-D hydraulic model was used develop with and with-out project floodplains for the 5-, 10-, 25-, 50-, 100-, and 500-year flood events. A 50 percent capture scenario of runoff was used to inform the benefit analysis. While the HEC-RAS model was geographically constrained to lands west of I-5 (location of Maxwell), additional hydraulic modeling was conducted for the primarily agriculturally zoned lands east of the I-5.

Land Use Analysis

HEC-RAS floodplains were imported into GIS and overlaid on parcel data from Colusa County to identify lands, structures, and infrastructure exposed to flooding under with-project and without-project conditions. The acreage exposed to flooding was calculated for each event, and summarized by primary land use type. Further analysis was done to identify parcels and their respective land use characteristics to estimate avoided costs for each event.

Expected Annual Damages (Selected Monetization Approach)

The damage costs for each flood event were determined using cost-estimating approaches and data from USACE, FEMA and DWR’s Flood Rapid Assessment Model (F-RAM). Expected annual damages were estimated by calculating total avoided costs (i.e., without project damages minus with project damages) for each of the six events modeled, then multiplying the sum of each interval probability by the average damage in that interval, followed by summing over all interval probabilities. This approach is consistent with the WSIP Technical Reference guidance (TR Section 5.4.3).

HEC-FDA and Other Flood Damage Models (Alternative Monetization Approach)

More detailed and extensive flood analysis and modeling (such as HEC-FDA or similar models outlined in the WSIP Technical Reference Section 5.4.3) was not performed because: (1) there is not a substantial urban flood reduction and (2) the flood benefits are a relatively small proportion of the project’s total benefits. These more extensive and probabilistic analysis offered by these other models are generally used for more densely populated and urban areas and was not expected they would substantially change the benefit valuation for the project.

A5.4.1.b Data and Assumptions

Figure A5-2 shows the expected area of flooding for a 100-Year Flood Event. Three primary categories of avoided flood damage costs were analyzed: (1) agriculture; (2) structures and contents; and (3) transportation.

Agriculture

Agricultural damages were modeled based on crop loss estimates. Values were estimated for representative crop types in the Central Valley and account for both short-duration and long-duration flood events. The short duration (i.e., less than 5 days of inundation) per acre estimates, which include both weighted average crop income losses and land cleanup and rehabilitation costs, were applied to the equivalent crop types and acreage across the modeled flood events. The primary crop types in modeled floodplains include rice, pasture, tomatoes, and alfalfa.

Table A5-33 shows the acres at risk by crop type for a 100-yr flood event with their corresponding crop damage estimates used to estimate the agricultural flood damages.

Table A5-33. Projected Damages per Acre: 100-Year Flood Event (2015$; $1,000s)

Crop Type	Average Annual Damages ($/ac) [a]	Land Cleanup and Rehabilitation ($/ac)	Total Damage per Acre ($/ac) [b]	Reduced Flood Area (ac)	Total Damages ($1,000s)
Rice	$245	$262	$508	6,035	$3,066
Almonds	$1,746	$262	$2,008	266	$534
Tomatoes	$1,096	$253	$1,349	731	$986
Wine Grapes	$3,498	$253	$3,751	15	$55
Alfalfa	$269	$262	$532	731	$389
Pasture	-$16	$293	$277	1,779	$493
Other	$0	$265	$265	15	$4
Total				**9,570**	**$5,526**

Sources: DWR, *Flood Rapid Assessment Model (F-RAM)*. Developed by URS (November 2008); USACE, *National Economic Development Manual Series* (2010); USACE, *Sutter Basin Feasibility Report (*2013).
[a] Weight averages calculated based on expected crop income losses, variable costs not expended, and probability of flooding on a monthly basis.
[b] Represents a short-term flood event, which typically results in only limited damages to perennial crops.

Structures and Contents

Structures and content damages were modeled according to principles and guidelines prescribed by the USACE (USACE 2010). All structures intersecting with a floodplain in the Town of Maxwell were categorized as either residential or non-residential, based on the attribute data embedded in the Colusa County parcel file, and are assumed to have only one story. This taxonomy was used to assign specific damage functions to estimate both structures and content losses. Structure value was estimated by applying regional construction cost per square foot factors developed by Marshall & Swift to the reported structure size(s). The extent of damage (in this case, estimated replacement costs), were determined by multiplying the estimated structure value by depth damage curves and content-to-structure ratios used by USACE economists in the Sacramento District (USACE 2013). A constant flood depth of 5 feet above the first floor's elevation was assumed across all event types.

Indirect damages to account for cleanup costs, temporary housing, relocation assistance and other potential emergency costs were modeled as a proportion of direct damages, in this case 25 percent, according to estimates provided in the F-RAM model documentation.

It should be noted that damages to structures and contents represent full replacement value, not the depreciated value. This approach, used by FEMA, more accurately reflects the true cost to replace the damaged asset.

Only structures in the Town of Maxwell were included in this assessment of flood damages. There are additional structures scattered across the agriculturally zoned parcels outside of the Town center that would also be subject to damage but are not included to be conservative.

Table A5-34 shows the depth damage functions, indirect cost assumption, square footage of residential and non-residential structures that would avoid damage during a 100-year flood event from the without-project conditions compared to the with-project conditions. The damage estimates also include estimated avoided secondary damages (e.g., emergency response).

Table A5-34. Avoided Cost Assumptions and Estimates: 100-Year Flood Event (2015$; $1,000s)

Structure Type	Structure [a]	Content [a]	Indirect [b]	Square Feet [c]	Avoided Damage
Residential (1-story)	53%	29%	25%	76,584	$11,701
Non-Residential (1-story)	31%	100%	25%	52,666	$12,470
Total Avoided Costs					**$24,171**

Sources: DWR, *Flood Rapid Assessment Model (F-RAM)*. Developed by URS (November 2008); USACE, *National Economic Development Manual Series* (2010); USACE, *Sutter Basin Feasibility Report (*2013).
[a] Assumes 5-foot flood depth based on Sutter Basin Feasibility Report (USACE 2013).
[b] F-RAM indirect cost factor.
[c] The difference in building square feet impacted by the 100-year flood event between without-project and with-project conditions.

Transportation

The roads I-5, adjacent to the Town of Maxwell, and SR 20, between I5 and the City of Colusa, are subject to flood related closures. The damages stemming from transportation disruptions were modeled according to USACE guidance (USACE 1991), accounting for the value (i.e., opportunity cost) of time. Data on average daily trips at the identified transportation corridors, vehicle mileage costs, and median household income for adjacent counties were applied to assumptions on trip type (i.e., work, social, recreation, personal business, vacation) distributions by weekday and weekend, distance to reroute, and duration of delay. Collectively this information informed a daily weighted average damage estimate for both the I-5 and State Route 20. A one-day closure was assumed for all six flood events modeled.

Additional roadway repair damages were estimated using assumptions of the amount of roadway exposed, and cost-per-mile factors for different roadway classifications. Indirect damages to account for cleanup costs, emergency costs, and losses from disruption to employment and commerce were modeled as a proportion of direct damages, in this case 50 percent. Both repair and indirect damages were informed according to estimates provided in the F-RAM model documentation.

A5.4.1.c Calculations

Table A5-35 presents the estimated avoided costs across the primary damage categories for the six flood events modeled.

Table A5-35. Flood Benefits by Event and Impact Category (2015$; $1,000s)

Flood Type	Agriculture	Structure and Contents	Transportation	Total
500-Year	$4,856	$10,199	$1,365	$16,420
100-Year [a]	$5,526	$24,171	$1,552	$31,249
50-Year	$5,959	$23,337	$1,690	$30,986
25-Year	$6,323	$11,472	$1,767	$19,562
10-Year	$5,829	$7,912	$1,570	$15,311
5-Year	$5,211	$24,546	$1,410	$31,167

Sources DWR, *Flood Rapid Assessment Model (F-RAM)*. Developed by URS (November 2008); USACE, *National Economic Development Manual Series* (2010); USACE, *Sutter Basin Feasibility Report (*2013).
[a] Values shown in Tables A5-33 and A5-34.

Table A5-36 presents the steps that were taken to calculate the EAD (described above), integrating the damages across the six flood events modeled.

Table A5-36. EAD Calculation (2015$; $1,000s)

Frequency	Interval	Damages at Stage	Average	Interval	Summation
0.002		$16,420			EAD $4,377
	0.008		$23,835	$191	
0.01		$31,249			$4,187
	0.010		$31,118	$311	
0.02		$30,986			$3,876
	0.020		$25,274	$505	
0.04		$19,562			$3,370
	0.060		$17,437	$1,046	
0.1		$15,311			$2,324
	0.100		$23,239	$2,324	
0.2		$31,167			

A5.4.1.d Modeling Results (Selected Monetization Approach)

Table A5-37 presents the estimated benefit value of the project-related flood damage reduction.

Table A5-37. 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 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 $4.4 million in 2030. It was conservative assumed that 2030 benefit values would remain constant throughout the future 2030 to 2132 operating period. As a result, the annualized benefit for the future 2030 to 2132 operating period was estimated to be $4.4 million.

A5.5 Water Supply (Non-Proposition 1 Eligible Benefit)

Increased future water deliveries and improved water supply reliability are expected to be the project's largest non-public benefit. The project's water supply improvements are expected to ultimately serve both agricultural producers (located both north- and south-of-the-Delta) and south-of-the-Delta M&I users. The benefit valuation analysis assumes that the majority (approximately 58 percent) of the project water deliveries will be for agricultural use. This was considered a realistic characterization of the JPA current partnering water contractors and conservative assumption given the far higher value placed on M&I water supplies.

In addition, it is expected that Sites Reservoir will be able to recapture some quantities of the Shasta's future deliveries that are scheduled as a result of the project's coldwater pool benefits. It is currently envisioned that the reclaimed would be allocated to JPA and used to provide supplementary water deliveries for south-of-the-Delta M&I users. The sales revenues from the reclaimed water supplies would then be used to cover the O&M costs assigned to the project's various public benefits. The water supply benefit analysis therefore accordingly analyzed the project's future water deliveries separately and then combined the findings to report a single overall water supply benefit value.

A5.5.1 M&I Water Supply

Sites Reservoir will improve future water supply reliability for M&I water users predominantly located south of the Delta.

A5.5.1.a Analytic Methods

Two approaches that provide M&I water supply benefits at 2030 and 2070 conditions in average annual value (2015 dollars): Economic Model Approach: California Water Economics Spreadsheet Tool (CWEST) and Unit Value Approach using WISP provided Unit Water Values as dollar value per acre-foot.

The M&I water supply benefit analysis relies on CALSIM II modeling to quantify the project's expected future M&I deliveries under different water-year conditions. CWEST modelling to determine the project's future M&I water supply benefits. Consequently, the economic benefits of increased future M&I water deliveries were estimated on a "willingness to pay" basis.

CALSIM II

As previously discussed in Section A5.1, CALSIM II modeling was used to determine the project's 2030 and 2070 M&I water supply deliveries by location under different water-year conditions. The water quantities for the intervening years were interpolated individually by purpose, water-year type and location.

The WSIP 2030 and 2070 without Project CALSIM II model runs were compared to the WSIP 2030 and 2070 with Project CALSIM II model runs to quantify the annual deliveries to Sites Project Participants. Delivery is the calculated quantity at the location of each Sites Project Participant after accounting for conveyance losses, consistent with WSIP TR Guidelines (TM Section 4.12.3).

CWEST (California Water Economics Spreadsheet Tool) (Selected Monetization Approach)

CWEST was developed for the US Bureau of Reclamation's Coordinated Long Term Operation of the Central Valley Project and State Water Project Environmental Impact Statement (LTO EIS) Environmental Consequences analysis.

CWEST is an economic benefit valuation tool developed to provide consistent and transparent analysis of economic benefits of M&I water supplies for CVP contractors and SWP Table A contract holders. CWEST is an economic simulation and optimization tool that represents each individual CVP and SWP M&I water user's decision making under 2030 and 2070 conditions based on publicly available information. CWEST determines how CVP and SWP M&I water users will meet their 2030 and 2070 water demand levels at their minimum economic cost given their supply constraints and alternatives. Detailed technical discussion of the CWEST model is available from the Appendix 19A of the Draft Long Term Operation EIS (USBR 2015).

CWEST quantifies M&I water supply benefit by simulating the water management decisions made at the district or agency level. The model's objective is to select each Sites Project participant's set of management actions that meet their annual water demand at the lowest cost. The estimated cost difference between the with and without Sites Reservoir scenarios determines the project's M&I water supply benefit. Similar to the other existing California M&I water economics tools, CWEST minimizes the total costs of meeting annual M&I water demands subject to applicable operational and supply constraints. These costs include:

- Conveyance and operations costs;
- Existing and new permanent supplies, transfer or other option costs;
- Local surface and groundwater operations;
- Lost water sales revenues; and
- End-user shortage costs.

CWEST incorporates level of demand, quantity and type of local water supplies, and costs for both 2030 and 2070 development conditions into its benefit value estimates.

CWEST was selected to estimate M&I water supply benefits in the WSIP application based on the criteria in Technical Reference document Section 4.12 Water Supply Analysis (CWC, 2016). CWEST was updated for the WSIP benefit valuation analysis to evaluate nine representative participants for the M&I Sites Project. The updates to CWEST include 2030 and 2070 analysis using 2015 UWMP data, inclusion of only Sites Project participants, and all relevant assumptions outlined in the CWC Technical Reference document. Appendix 19A of the LTO EIS details the economic tool's development history, methodology, and assumptions (Reclamation, 2015).

WSIP Unit Water Values (Alternate Benefit Monetization Approach)

As previously discussed in Section A5.1 All Benefits, WSIP Unit Water Values modeling is an approved benefit monetization approach and it was used to determine the project's 2030 and 2070 M&I water supply benefit values under different water-year conditions.

This approach applies a dollar value per acre-foot ($/AF) values for water by region, water-year type, and future condition. Conveyance costs were included in the benefit calculation to better represent the full willingness to pay by south-of-the-Delta water contractors.

As the WSIP TM acknowledges, there are several reasons and factors that may ensure that the WSIP unit values would undervalue the M&I benefits. As previously discussed in Section A5.1.1.a, the WSIP unit values implicitly assume that there would be a sufficient number of willing sellers for the price and quantity of water that could supply the water being valued. This assumption may be difficult to meet for large quantities water (especially such as those required for the project's M&I deliveries).

The project would provide long-term and reliable deliveries. This contrasts with the current water transfer market which predominantly consists of limited term contracts and where the demand, supply and prices vary considerably depending on the recent and projected water-year type.

The third-party costs of water transfers are not included in the Unit Water Values. Major and/or long-term reallocations of water use resulting from water transfers can be expected to potentially result in direct and indirect economic impacts to the region's workers, supporting businesses and consumers. The WSIP Unit Water Values are predominantly derived from past water transfer and therefore based on the financial relationship solely between the water buyer and sellers. As a result, it does incorporate any costs or losses to third-party entities or the larger economy. Inclusion of any additional third-party costs would be expected to increase the unit values and hence the benefit values or other water sources.

A5.5.1.b Data and Assumptions

The major update to CWEST was removing non- Sites Project Participants from the model and including any Sites Project Participants that were not including in the existing version on the model. CWEST updates for the WSIP application allows for analysis at 2030 and 2070 and is in 2015 dollars. The main data source for the update was individual Sites Project participants Urban Water Management Plans (UWMPs).

A5.5.1.c Calculations

Water Supply Projections

Table A5-38 shows the estimated water deliveries by water-year type projected in 2030, 2070, and the annual average in the 2030 to 2122 operating period.

Table A5-38. 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
2030-2122 Results					
Long-Term Average	**131**	**29**	**114**	**11**	**286**

Source: CALSIM II.
Note: Values may not sum due to rounding.

CWEST Model Results (Selected Monetization Approach)

Tables A5-39 and A5-40 show the detailed CWEST modeling results for the project under the future 2030 and 2070 without Project CALSIM II model runs and the WSIP 2030 and 2070 with Project CALSIM II model runs. Similar to many impact models, CWEST generally evaluates the conditions and estimates outcomes for both a “with project” and “without project” scenarios. The project’s impacts are then determined by the differences between the two scenarios.

Both tables show the average annual delivery and conveyance cost for each of the representative M&I water users. The delivery cost is subtracted from the total estimated benefit for each M&I water user from their expected cost savings gained by using the project water supply rather than other alternate sources. The tables also show potential water supply quantity from their alternate water sources (e.g.,

Table A5-39. M&I Water Supply Benefits: 2030 CWEST Modeling Detailed Model Results (2015$; $1,000s)

Benefit Factor	Representative Water Districts and Agencies									Total
	Castaic Lake	Zone 7	Santa Clara Valley	Antelope Valley-East Kern	San Gorgonio Pass	Desert	Coachella Valley	San Bernardino Valley	City of American Canyon	
Average Deliveries (TAF/Yr)	4.0	16.2	19.4	1.6	11.3	5.3	21.4	24.3	2.6	106
Delivery Cost	-$602	-$1,041	-$1,219	-$300	-$2,097	-$974	-$3,969	-$4,494	-$197	-$14,892
New Supply (TAF/Yr)	0	-4.7	-3.4	0	-1.6	-0.5	-2.1	-1.5	0	-14
Annualized New Supply Costs	$0	$4,090	$1,106	$0	$1,469	$223	$981	$575	$2	$8,446
Surface/GW Storage Costs	$0	$81	$563	$0	$0	$0	$0	$0	$0	$644
Lost Water Sales Revenues	$221	$2,193	$1,469	$102	$335	$219	$900	$1,302	$112	$6,852
Transfer Costs	$359	$1,143	$175	$0	$926	$0	$0	$0	$223	$2,827
Shortage Costs	$300	$9,784	$7,175	$1,834	$1,553	$1,480	$3,467	$518	$53	$26,165
GW pumping savings	$665	$304	$0	$114	$0	$411	$5,336	$7,285	$0	$14,115
Excess Water Savings	$13	$48	$485	$105	$1,265	$517	$0	$0	$147	$2,580
Average Annual Cost	$957	$16,601	$9,754	$1,856	$3,451	$1,876	$6,715	$5,187	$340	$46,737

Table A5-40. M&I Water Supply Benefits: 2070 CWEST Modeling Detailed Model Results (2015$; $1,000s)

Benefit Factor	Representative Water Districts and Agencies									Total
	Castaic Lake	Zone 7	Santa Clara Valley	Antelope Valley-East Kern	San Gorgonio Pass	Desert	Coachella Valley	San Bernardino Valley	City of American Canyon	
Average Deliveries (TAF/Yr)	4.5	17.8	21.4	1.8	12.5	5.8	23.6	26.7	2.8	117
Delivery Cost	-$663	-$1,147	-$1,348	-$330	-$2,308	-$1,072	-$4,369	-$4,946	-$217	-$16,400
New Supply (TAF/Yr)	0	-3.9	-20.5	0	-2.8	-2.0	-18.1	-22.3	0	-70
Annualized New Supply Costs	$179	$5,344	$41,092	$0	$5,228	$1,924	$23,414	$30,178	$18	$107,376
Surface/GW Storage Costs	$0	-$119	$213	$0	$0	$0	$0	$0	$0	$94
Lost Water Sales Revenues	$350	$2,277	-$786	$85	$299	$141	$438	$2,738	$126	$5,668
Transfer Costs	$976	$3,445	-$225	$0	$810	$0	$0	$0	$903	$5,909
Shortage Costs	$127	$21,652	$7,085	$3,474	$1,460	$6,421	$17,818	$14,263	$177	$72,476
GW pumping savings	$626	$312	$0	$95	$0	$442	-$129	-$433	$0	$914
Excess Water Savings	$0	$0	$0	$20	$1,489	$110	$0	$0	$136	$1,756
Average Annual Cost	$1,596	$31,763	$46,031	$3,345	$6,978	$7,967	$37,171	$41,799	$1,143	$177,793

conservation, recycling, and desalination). These are the alternate supplies that can be adopted as management actions to reduce their future water shortage costs. The new supply quantity is a key decision variable in the CWEST model analysis.

As shown in Tables A5-39 and A5-40, the CWEST analysis projects that between 2030 and 2070, Sites Reservoir's annual M&I net supply benefits would increase from $46.7 million to $177.8 million. Unsurprisingly the majority of the M&I benefits would be gained by the four water agencies that would receive the largest M&I deliveries.

The largest share of the Sites Reservoir's projected 2030 M&I benefits would be expected to result from its avoided shortage costs which would total $26.2 million and would account for 42.5 percent of the total benefits. The other important sources of M&I benefits in 2030 would be savings in groundwater pumping costs ($14.1 million), avoided development costs for other new supply sources ($8.4 million) and reduced water purchase costs ($6.9 million). Together these additional three cost savings categories would account for 47.7 percent of the project's total M&I benefits.

In 2070 the project's benefits from avoided shortage costs are projected to increase to approximately $72.5 million but would account for only 37.3 percent of the $177.8 million in total benefits. Instead the avoided development of other new supply sources would result in $107.4 million cost savings and the largest share (55.3 percent) of the project's 2070 M&I benefits.

Table A5-41 summarizes M&I Water Supply benefit values from the CWEST modeling. The equivalent Unit Water Values for M&I are estimated to be $440 per acre foot in 2030 and $1,521 in 2070.

Table A5-41. M&I Water Supply Benefit Valuation: CWEST Water Values (2015$; $1,000s)

		Benefit Value	
Year	**M&I TAF**	**CWEST $/AF**	**Total ($1,000s)**
2030	106	$440	$46,737
2045	110	$874	$95,883
2070	117	$1521	$177,793
Annualized (2030 - 2122) [a]	**114**	-	**$114,107**

Note:
[a] Annualized benefit value is calculated using net present value over 93 years and 3.5% discount rate.

WSIP Unit Water Values (Alterative Monetization Approach)

The economic benefits of the increase future water deliveries for M&I were estimated using the adjusted WSIP Unit Water Values (see Table A5-7) applied to the projected average annual delivery quantities on a year by year basis over the project's entire 2030 to 2122 study period. Table A5-42 shows the estimated annual benefit values of future M&I water supply in 2030, 2045, 2070 and the annualized average over the project's full 2030 to 2122 study period.

Table A5-42. M&I Water Supply Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

		Benefit Value	
Year	**M&I Water Supply TAF**	**WSIP Unit Water Value $/AF**	**Total ($1,000s)**
2030	106	$457	$48,517
2045	110	$828	$90,761
2070 [b]	117	$806	$94,208
Annualized (2030–2122) [a]	**114**	-	**$81,742**

[a] Annualized benefit value is calculated using net present value over 93 years and 3.5 percent discount rate.

[b] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

A5.5.1.d Modeling Results (Selected Monetization Approach)

Table A5-43 shows the estimated future M&I water supply benefit values obtained from the CWEST for 2030 and 2070.

Table A5-43. M&I Water Supply Benefits: CWEST Modeling (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$46,737	$177,793	$114,107

Source: CWEST

[a] Based on CWEST Modeling adjusted by water-year type, expected delivery location and conveyance energy costs.

[b] Annualized benefits represent avoided costs relative to the Future No Project conditions over the planning horizon (2030 to 2122), and are adjusted for expected variations in surface area conditions.

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

The model results indicate an increase in M&I benefits from $46.7 million in 2030 to $177.8 million in 2070. The corresponding annualized benefit for the future 2030 to 2132 operating period is estimated to be $114.1 million. This is equal to an estimated average unit benefit value for M&I of $1,302 per acre foot.

The major increase in future M&I benefits is only partly the result of the 11 TAF (10.4 percent) increase in 2070 average annual M&I deliveries that are projected to occur as a result of future climate change conditions enabling greater diversions of Sacramento River flows.

Instead major factors driving the M&I benefit increase are increased water demand, reduced water availability from other water supplies (including groundwater depletion and climate change reductions in future Sierra snowpack levels) and the limited availability of alternate water sources.

A5.5.2 Agricultural Water Supply

Sites Reservoir will improve water supply reliability to agricultural water users, particularly during dry years. Over 80 percent of the future agricultural water deliveries are current expected to be for water contractors located within the Sacramento Valley. The remaining agricultural deliveries are expected to be for south-of-the-Delta agricultural water users.

A5.5.2.a Analytic Methods

CALSIM II

As previously discussed in Section A5.1 All Benefits, CALSIM II modeling was used to determine the project's 2030 and 2070 agricultural water supply deliveries by location under different water-year conditions.

WISP Unit Water Values (Selected Monetization Approach)

WSIP Unit Water Value modeling was used to determine the project's 2030 and 2070 agricultural water supply prices under different water-year conditions. The WISP unit value benefit approach used to value the project's future increases in agricultural water supplies was the same as that used for the Incremental Level 4 refuge, Lake Oroville coldwater pool and Yolo Bypass supply benefits (Sections A5.2.2-4). The agricultural benefit valuation analysis also similarly used the adjusted Unit Water Values (for the south-of-the-Delta deliveries) and the Sacramento Valley values (its future north-of-the-Delta deliveries) correspondingly applied to the CALSIM II determined future agricultural water supply quantities.

LTGEN/SWP

As previously discussed in Section A5.1 All Benefits, LTGEN/SWP was used to determine the project's 2030 and 2070 average conveyance energy costs and when appropriate adjust the water benefit values for south-of-the-Delta deliveries.

SWAP Model (Alternate Monetization Approach)

The SWAP model is a regional agricultural production and economic optimization model that simulates the decisions of farmers across 93 percent of agricultural land in California. The model assumes that farmers maximize profits (revenue minus cost) by choosing total input use (e.g., total crop acres) and input use intensity (e.g., applied water per acre) subject to market, resource, and technical constraints.

Although the SWAP model is not specifically recommended in the WSIP TM Section 5 – Monetizing the Value of Project Benefits, the CWC discussed the SWAP model in Appendix D – Unit Values for Water. The CWC also provided the SWAP version 6.1 model for public use. The Sites Reservoir his version of the SWAP model was used to provide an alternative benefit value of the project's agricultural benefits. As discussed in the WSIP TM (Appendix D), the model was calibrated using 2010 crop acreage and water use information. Crop prices and cost data from 2011 and 2012 were used to calibrate it is economic factors.

However, for reasons discussed below, it was determined that the SWAP Model majorly misrepresented and underestimated the project's future agricultural benefit values. As a result, the SWAP model was not selected as the monetization approach to determine Sites Reservoir's agricultural benefits for the WSIP application.

A5.5.2.b Data and Assumptions

In addition to the Appendix D discussion of the SWAP model and its relationship to the WSIP Unit Water Values, extensive discussion of the SWAP model's methodology, data sources and assumptions are available in agency technical reports and the technical appendices of several recent federal feasibility studies of proposed water storage project and water management programs in California. The SWAP Model Update and Application to Federal Feasibility Analysis provides a comprehensive overview of the SWAP model and its application (USBR/DWR 2012). The Final Modeling Appendix to the Shasta Lake Water Resources Investigation also provides extensive discussion of the SWAP Model and its use for economic valuation of agricultural water supply increases (USBR 2014).

A5.5.2.c Calculations

Water Quantities

Table A5-38 shows the estimated agricultural water deliveries by water-year type projected in 2030, 2070, and the annual average in the 2030 to 2122 operating period.

WSIP Unit Water Values

Future adjusted WSIP Unit Water Values by water-year type and location are previously shown in Table A5-7. As previously discussed in Section A5.1, future annual agricultural water supply quantities were interpolated based on water-year type and location.

The adjusted WSIP Unit Water Values were used for south-of-the-Delta use (i.e. including expected conveyance energy cost necessary to deliver the agricultural water) (Table A5-44). No conveyance energy cost adjustments were applied to the locally supplied agricultural water (i.e. for north-of-the-Delta agricultural water users) since the energy need for their deliveries will be minor.

Table A5-44. Agricultural Water Supply Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

	Agricultural Supply		Benefit Value	
			WSIP Unit Water Value [b]	Total
Year	**NOD (TAF)**	**SOD (TAF)**	**$/AF**	**($1,000s)**
2030	110	27	$229 / $457	$37,443
2045	121	28	$238 / $828	$51,732
2070 [b]	137	30	$238 / $806	$56,995
Annualized (2030–2122) [a]	**131**	**29**	**—**	**$50,188**

[a] Annualized benefit value is calculated using net present value over 93 years at a 3.5 percent discount rate.
[b] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

SWAP Model (Alternate Monetization Approach)

The Sites Reservoir SWAP analysis used the CWC provided SWAP version 6.1 model without any modifications to its model code or baseline data. Review of the CWC SWAP model concluded that the water supply portfolios in the Sacramento Valley, especially Tehama and Colusa Counties, were not consistent with their actual current and future conditions. The CWC SWAP model was not updated to more accurately quantify existing or future Sacramento Valley baseline water supply portfolios due to time constraints, data limitations, and fundamental concerns about SWAP's applicability for determining the project's agricultural supply benefits.

The uncorrected CWC SWAP model was nonetheless run to estimate the project's agricultural supply benefits. Tables A5-45 and A5-46 show the SWAP model results for 2030 and 2070 conditions.

Table A5-45. Agricultural Water Supply Benefit Valuation: 2030 SWAP Values (2010$; $1,000s)

	2030 Conditions (Average Water Year)		
Benefit Factor	**Without Project**	**With Project**	**Difference**
Total Surface Water Use (TAF)	14,099	14,127	27.9
Income Over Expenses	$12,337,876	$12,339,675	$1,799
Groundwater Total Cost [a]	$462,889	$462,889	$0
Groundwater Pumped (TAF)	4,384	4,384	0
Acres Irrigated (1,000s)	6,148	6,154	6.9
Variable Fallow Expenses [b]	na	na	($263)
Consumer Surplus Change			$7,451
NODOS NED Benefits			**$9,513**

[a] Decreased groundwater use and costs represent avoided cost benefits for the project.
[b] Decreased variable fallow expenses represent avoided cost benefits for the project.

Table A5-46. Agricultural Water Supply Benefit Valuation: 2070 SWAP Values (2010$; $1,000s)

	2070 Conditions (Average Water Year)		
Benefit Factor	**Without Project**	**With Project**	**Difference**
Total Surface Water Use (TAF)	13,532	13,661	129
Income Over Expenses	$13,250,159	$13,257,471	$7,312
Groundwater Total Cost [a]	$599,805	$598,563	($1,242)
Groundwater Pumped (TAF)	4,356	4,346	(10.3)
Acres Irrigated (1,000s)	5,946	5,973	27.5
Variable Fallow Expenses [b]	na	Na	($1,046)
Consumer Surplus Change			$22,211
NODOS NED Benefits			**$31,811**

[a] Decreased groundwater use and costs represent avoided cost benefits for the project.
[b] Decreased variable fallow expenses represent avoided cost benefits for the project.

Total surface water use reported in the tables were solved within the model and may not represent the total surface water available to agriculture calculated in CALSIM II. Therefore, the difference in total surface water use between the without project and with project does not match with the reported Sites water deliveries in Table A5-44. There are multiple influences on the quantity of surface water use within SWAP such as technology, crop prices, groundwater pumping constraints from SGMA, and the price of surface water deliveries. These results further resigned the use the CWC provided SWAP model to estimate the benefits of agricultural water supply.

The largest share of the agricultural water benefit estimated by SWAP is expected from the consumer surplus benefits from the increased agricultural production enabled by the project's water deliveries. This corresponds to the total net value for food consumers obtain from the increased food production (and includes the value above the market price that many consumers may possess).

The other major source of agricultural benefit results from gains in the "income over expenses" (or producer surplus) generated by the increase and/or change in the agricultural activity enabled by the additional agricultural water supplies.

The SWAP agricultural supply benefit estimates in Tables A5-45 and A5-46 are shown in 2010 dollar terms. These values were adjusted into 2015 dollar terms using the Consumer Price Index and their results are summarized in Table A5-47. Table A5-47 also shows the corresponding annualized average benefit value of the agricultural benefits based on the SWAP analysis.

Table A5-47. Incremental Agricultural Water Supply Benefit Valuation: SWAP (SGMA) Values (2015$; $1,000s)

		Benefit Value	
Year	**Agricultural Supply TAF**	**SWAP (SGMA) Water Value $/AF [b]**	**Total ($1,000s)**
2030	137	$76	$10,465
2045	148	$132	$19,664
2070	167	$209	$34,996
Annualized (2030–2122) [a]	**161**	**—**	**$23,075**

Note:
[a] Annualized benefit value is calculated using net present value over 93 years and 3.5 percent discount.
[b] Water value is based on total TAF; SWAP underestimates north-of-the-Delta water use.

The CWC SWAP model was determined inadequate to quantify agricultural water supply benefits largely due to its incorrect baseline Sacramento Valley water supply, use and pricing assumptions.

A5.5.2.d Modeling Results (Selected Monetization Approach)

The estimated total benefit value was estimated based on the expected future average hydrological year type and the WSIP Unit Water Values applicable based on the use location of the delivered agricultural water. Table A5-48 shows the estimated future agricultural water supply benefit values.

Table A5-48. Agricultural Water Supply Benefits: WSIP Unit Water Values (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit ($) [b]
	2030	2070	
Average Water Conditions [c]			
Sites Reservoir	$37,443	$56,995	$50,188

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

The agricultural supply analysis estimates that future agricultural benefits will increase from $37.4 million in 2030 to approximately $57.0 million in 2070. The corresponding annualized benefit for the future 2030 to 2132 operating period is estimated to be $50.2 million. This is equal to an estimated average unit benefit value of $337 per acre foot for agricultural water use. This benefit valuation reflects the high proportion of future north-of-the-Delta agricultural use envisioned by the project.

A5.5.3 Recaptured Water Supply

Sites Reservoir will also collect limited quantities of additional “Recaptured” water related to its releases supporting its anadromous fish deliveries. Rescheduled Shasta Lake deliveries that occur when Sacramento River flows exceed its required “maintenance” levels would add “surplus” supplies that Sites Reservoir would be entitled and able to divert without adversely affect the downstream river conditions or deliveries.

These recaptured water quantities are expected to average approximately 10 TAF per year and would be assigned to the JPA. The JPA would sell the recaptured water predominantly to south-of-the-Delta M&I water contractors. The recaptured water’s sales revenues will then be used to cover the future annual O&M expenses assigned to the public benefit uses.

A5.5.3.a Analytic Methods

CALSIM II

As previously discussed in Section A5.1 All Benefits, CALSIM II modeling was used to determine the project’s 2030 and 2070 recaptured water quantities and its supply deliveries by location under different water-year conditions.

CWEST Model Results (Selected Monetization Approach)

The recaptured water is expected to be predominantly delivered to south-of-the-Delta water contractors and will therefore represent supplemental M&I deliveries. Therefore, the M&I analyses and findings (Section A5.5.1) are similarly applicable to the recaptured water supplies.

WSIP Unit Water Values (Alternate Benefit Monetization Approach)

As previously discussed above, WSIP Unit Water Values modeling for the M&I analysis (Section A5.5.1) are similarly applicable to the recaptured water supplies.

A5.5.3.b Data and Assumptions

The data and assumptions for the M&I analysis (Section A5.5.1) are similarly applicable to the recaptured water supplies.

A5.5.3.c Calculations

Water Supply Projections

The future recaptured water supply quantities determined by CALSIM II are shown above in Table A5-44.

CWEST Model Results (Selected Monetization Approach)

Unit benefit values for the project's M&I deliveries were estimated based on the M&I supply's average quantities and CWEST benefit value estimates under future 2030, 2045 and 2070 conditions. Table A5-49 shows the estimated unit values. These unit M&I benefit values were applied to their corresponding project future water delivery quantity to determine benefit value estimates for the project's recapture water supplies under future 2030, 2045 and 2070 conditions. Table A5-49 shows the estimated benefit values for the project's future recaptured water supply.

Table A5-49. Recaptured Water Supply Benefit Valuation: CWEST Water Values (2015$; $1,000s)

Year	Recaptured Water Supply TAF	Benefit Value CWEST $/AF	Benefit Value Total ($1,000s)
2030	11	$440	$4,845
2045	11	$874	$9,619
2070	11	$1521	$16,733
Annualized (2030–2122) [a]	**11**	**-**	**$11,123**

[a] Annualized benefit value is calculated using net present value over 93 years at a 3.5 percent discount rate.

WSIP Unit Water Values (Alternative Monetization Approach)

The WSIP Unit Water Value analysis for the recaptured water supplies was the same as that applied to the project's M&I supplies. The recaptured water supply's economic benefits were estimated using the adjusted WSIP Unit Water Values (see Table A5-7) applied to the projected average annual delivery quantities on a year by year basis over the project's entire 2030 to 2122 study period.

Table A5-50 shows the estimated annual benefit values of future recaptured water supply in 2030, 2045, 2070 and the annualized average over the project's full 2030 to 2122 study period.

Table A5-50. Recaptured Water Supply Benefit Valuation: WSIP Unit Water Values (2015$; $1,000s)

Year	Recaptured Water Supply TAF	Benefit Value WSIP Unit Water Value $/AF	Benefit Value Total ($1,000s)
2030	11	$457	$5,029
2045	11	$828	$9,619
2070 [b]	11	$806	$8,866
Annualized (2030–2122) [a]	**11**	**—**	**$8,038**

[a] Annualized benefit value is calculated using net present value over 93 years at a 3.5 percent discount rate.
[b] The 2070 unit value is lower than the 2045 unit value because of the change in the hydrological year type incidence result in a wetter average year.

A5.5.3.d Modeling Results (Selected Monetization Approach)

Table A5-51 shows the estimated future recaptured water supply benefit values obtained based on the CWEST values for 2030 and 2070.

Table A5-51. Recaptured Water Supply Benefits: CWEST Modeling (2015$; $1,000s)

Alternative	Annual Benefits [a]		Annualized Benefit [b]
	2030	2070	
Average Conditions [c]			
Sites Reservoir	$4,845	$16,733	$11,123

Source: CWEST.
[a] Based on CWEST modeling adjusted by water-year type, expected delivery location, and conveyance energy costs.
[b] Annualized benefits represent avoided costs relative to the Future No Project conditions over the planning horizon (2030 to 2122) and are adjusted for expected variations in surface area conditions.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The model results indicate an increase in recaptured water supply benefits from $4.8 million in 2030 to $16.7 million in 2070. The corresponding annualized benefit for the future 2030 to 2132 operating period is estimated to be $11.1 million. This is equal to an estimated average unit benefit value for Recaptured Water Supply of $1,302 per acre foot.

Same as it is for M&I, the major increase in recaptured water supply benefits is driven by increased water demand, reduced deliveries from other water supplies (including groundwater depletion and climate change reductions in future Sierra snowpack levels) and the limited availability of alternate water sources.

A5.5.4 Total Water Supply

The project's total water supply reliability benefits are shown in Table A5-52. The total water supply benefit is the project's combined agricultural water supply benefits (estimated using adjusted WSIP Unit Water Values) and its M&I and recaptured water supply benefits (estimated by the CWEST model).

Table A5-52. 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 model results and WSIP Unit Water Values adjusted by water-year type, expected delivery locations, 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 values are used.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

Based on the assumed water use split between agricultural, M&I and recapture water use and their use location, the water supply analysis estimate that the project's future water supply benefits will increase from $89.0 million to $251.5 million in between 2030 and 2070. The corresponding annualized benefit over the entire future 2030 to 2132 operating period is estimated to be $175.4 million. This is equivalent to a $760 per acre foot average water supply unit benefit value.

Based on the benefit value differentials, the water supply analysis also indicates the project's total water supply benefits could be increased under different water use allocation that increase south-of-the-Delta and/or M&I water deliveries.

A5.6 Hydropower – System-wide (Non-Proposition 1 Benefit)

The proposed Sites Reservoir project will include new hydropower capacity, generation and pump-back facilities. The seasonal water diversions for the reservoir require power while subsequent water releases would generate power. A pump-back component of the project operations was also modeled and pump-back operations would occur throughout the year as conditions allow.

The hydropower facilities will enable the Sites Reservoir to generate power from its water releases to offset its pumping costs. The pump-back operations were designed to enhance the project's economic performance by capturing opportunities offered by the energy market (energy price differentials between on-peak and off-peak hours). The pump-back facilities also provide the support and products needed to integrate renewable energy (e.g., wind and solar) and thereby potential result in ancillary service[1] and system-wide capacity[2] benefits for the state's power system.

A5.6.1.a Analytic Methods

Future hydropower benefits were modeled by both DWR's Power and Risk Office (PARO) and by Bureau of Reclamation Contractors using the PLEXOS model. These non-public benefits are very difficult to forecast due to a rapidly changing market for valuing ancillary and system-wide capacity benefits due to the rapid and extensive new development of wind and solar resources. The revenue variability for hydropower generation over the last decade can be seen by looking at the fluctuations in the State Water Project past hydropower revenues (add source).

DWR PARO Analysis:

DWR's PARO analysis modeled Sites Reservoir's future incidental and optimized hydropower operation strategies. The incidental scenario that assumes that pumping and generation are scheduled according to expected demand for water deliveries. The optimization scheme maintains the alternatives' operations, constraints, and assumptions as envisioned by the water operations modeling team, but optimizes operations to maximize the Power Portfolio value of the assets.

PARO used two power portfolio models to estimate the costs and revenues from hydropower facilities' operations: Electric Power Research Institute's (EPRI) Energy Portfolio Model (EPM), Version 5; and the EPRI's Fast Fit model, Version 2.5.

Energy Portfolio Model (Selected Monetization Approach)

PARO used the EPRI (EPM, Version 5, as a power portfolio model to project the Reservoir future power costs and revenues. EPM is a computer software model designed to help businesses manage value and risk in the power and energy markets.

The EPM translates the facility operations and underlying commodity prices into a representative set of financial instruments and incorporated into the EPM to determine the probabilistic monetary value of the power portfolio under the study's operational scenario. The EPM provides a set of templates to facilitate describing and evaluating common types of power and fuel contracts (supply contracts,

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1 Ancillary services benefits are power facility functions that support the power system's generating capacity, energy supply, and delivery. Ancillary services include improved capabilities for the power "grid" to respond to electricity demand, supply, or other market imbalances.

2 System-wide capacity benefits include improvements to the energy planning capacity market that ensure better power system performance. These improvements include improved resource adequacy, renewable energy integration services and renewable energy generation.

standard and customized forward, and option contracts). The model characterizes each commodity market by a forward price curve and a term volatility structure. The model also uses a correlation matrix to characterize the behavior of pairs of commodity markets.

EPRI's Fast Fit Model

EPRI's Fast Fit Model (Version 2.5) was used to characterize the needed power, fuel price volatilities, pricing structures, and the correlations between the different energy markets in which the hydropower facility would participate, or would compete with.

PLEXOS (Selected Monetization Approach)

Toolson and Zhang's PLEXOS® Integrated Energy Model (PLEXOS) analysis also evaluated the project's expected net changes in hydropower capacity, generation, and ancillary services in Western Interconnection electrical power grid. PLEXOS is a power market simulation model that was used to estimate Sites Reservoir's future Ancillary Services (AS) and system-wide capacity performance and benefits.

In addition to projecting Sites Reservoir's future hydropower operations and benefits, PLEXOS also forecast energy and ancillary service power market prices for the year 2022 when the 33 percent Renewable Portfolio Standard (RPS), mandated by California law, will have been implemented.

A5.6.1.b Data and Assumptions

The PLEXOS hydropower benefit study used findings from the California Public Utilities Commission (CPUC) 2012 Long Term Procurement Plan (LTPP) proceedings as the basis for the majority of the assumptions. This study reflects the inputs from multiple resources and has been reviewed by multiple stakeholders in the California power sector. WECC's Transmission Expansion Planning Policy Committee (TEPPC) oversees and maintains a public database for production cost and related analysis. In the LTPP study the latest TEPPC 2022 base case, along with the 2012 WECC Loads and Resources Subcommittee (LRS)'s report, were used for the majority of the assumptions.

The assumptions for the California energy market were further updated with CPUC's inputs from 2010 LTPP assumptions, RPS, and scenario selection tool; with California Energy Commission (CEC)'s inputs on load forecast from Integrated Energy Policy Report (IEPR) and natural gas price forecast; with California ISO's inputs on generator data and operation data, etc.

The PLEXOS analysis used the 2012 LTPP Base Case's 2022 base energy monthly price projections. Their energy prices varied from $32.85 per MWh to $51.07 per MWh (in 2015 dollars) with a mean value of $41.60 per MWh.

The WSIP hydropower benefit analysis assumed that:

- The PLEXOS AS and Capacity values for 2025 can be applied as a conservative estimate of Sites Reservoir's future annual values
- PLEXOS assumes that future power market prices will stabilize once the RPS is achieved.
- Increases in future real energy prices (per WSIP energy escalation requirement) would be expected to increase ancillary service and system-wide value capacity benefit values.

A5.6.1.c Calculations

Energy Use and Hydropower Generation

Table A5-53 shows the PARO analysis estimates of Sites Reservoir's annualized average future pumping costs and hydropower revenues.

Table A5-53. Sites Reservoir Pumping Use and Power Generation

	Total Pumping (MWh)			**Generation (MWh)**	
	On-Peak	**Off-Peak**	**Pump-Back**	**On-Peak**	**Off-Peak**
Q1 Average	21,285	113,368	21,441	17,814	0
Q2 Average	5,296	15,650	56,563	71,244	351
Q3 Average	3,147	3,275	27,391	77,496	526
Q4 Average	8,957	22,982	31,323	48,111	0
Annual Average	38,685	155,275	136,718	214,665	877

Power Costs and Hydropower Revenues

Table A5-54 shows the PARO analysis estimates of Sites Reservoir's annualized average future pumping costs and hydropower revenues. The PARO analysis determined that the estimated net energy cost for the Site Reservoir future operations would average $1.7 million per year.

Table A5-54. Sites Reservoir Power Costs and Generation Revenues (2015$; $1,000s)

Facility	**Hydropower Operations**	
	Incidental	**Optimized**
Pumping Operations – Revenues (Costs)		
T-C Canal Pumping	($303)	($303)
GCID Pumping	($486)	($486)
Delevan Pipeline Intake Facilities	($1,628)	($1,628)
TRR Pumping	($603)	($603)
Sites Pumping	($8,675)	($7,975)
Subtotal	**($11,695)**	**($10,995)**
Generation – Revenues (Costs)		
Sites Generation	$5,960	$6,434
TRR Generation	$464	$464
Sacramento River Generation	$2,017	$2,017
Subtotal	**$8,442**	**$8,916**
Pump-Back Operations – Revenues (Costs)		
Pump-Back during Diversion Cycle	N/A	$127
Pump-Back during Release Cycle	N/A	$66
Pure Pump-Back Operations Cycle	N/A	$156
Subtotal		$349
Total Net Revenues (Costs)	**($3,253)**	**($1,730)**

GCID = Glenn-Colusa Irrigation District
N/A = not applicable
T-C = Tehama-Colusa
TRR = Terminal Regulating Reservoir

The reservoir's projected energy costs are recognized in its operating and maintenance cost, and were consequently not included in the hydropower system benefit values shown in Table A5-55.

A5.6.1.d Modeling Results (Selected Monetization Approach)

PLEXOS hydropower analysis confirmed DWR's direct energy benefit and cost results. The PLEXOS modeling also determined that the proposed hydropower facilities could be expected to result in substantial ancillary service and system-wide capacity benefits. Table A5-55 shows the estimated future combined ancillary service and system-wide capacity benefits from Sites Reservoir's hydropower operations.

Table A5-55. 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 system-wide capacity benefits. Note that facility pumping costs and generation revenues are included in the facilities' annual O&M costs.
[b] Annualized benefit is interpolated annual physical benefits between 2030 and 2070 and held constant after 2070. Annual average is less than 2030 and 2070 values due to the initial short ramp-up period before full benefits are generated.
[c] Averaged over the entire hydrologic sequence (1922 to 2003).

The PLEXOS analysis also estimated annual ancillary service benefits of approximately $2.4 million and system-wide capacity benefits of $17.8 million per year. As a result, combined ancillary services and system-wide capacity benefits of $20.2 million are potentially attributable to the project's hydropower operations.