The potential for water quality improvements in the Delta was evaluated in terms of the position of X2 and the resulting Delta outflows. Shifting X2 downstream improves the habitat for Delta smelt and reduces water quality stress for other species, including salmonids. X2 is a Delta management tool; it is defined as the distance in kilometers from the Golden Gate Bridge to the location where the tidally averaged near-bottom salinity in the Delta measures 2 parts per thousand (ppt). East of X2, water becomes progressively fresher, and west of X2 the water becomes more saline, until it reaches the ocean, which has a salinity of approximately 35 ppt.

Habitat quality in the Delta is degraded when the salinity in the Delta increases. The highest salinities occur during the fall and early winter, when Delta outflow is at its lowest. Water quality degradation is most pronounced in Dry and Critical years. Figure 7-8 shows the change in the average X2 positions during September and October in Dry and Critical years for each of the alternatives. Alternative C performs best in terms of the shift in the location of X2 by 0.3 to 1.0 kilometer (km) seaward, followed by Alternative B and then Alternative A. Alternative D provides the least water quality benefit, with an average shift of 1 km to the east in July through August, and a 0.3 km shift in September through November. Shifting X2 requires a significant quantity of water. Releases from Sites Reservoir to improve Delta environmental water quality range from 174 TAF/yr under Alternative D up to 242 TAF/yr under Alternative C. The modeled benefits assume that all water is released from the Delevan Pipeline to the Sacramento River. It is also possible to release water via the Colusa Basin Drain to the Yolo Bypass and into the Delta. Releasing water in this way may provide additional benefits to salmonids and Delta smelt.

Water Quality for Agricultural and M&I Water Uses

Improved water quality in the Delta would benefit the Delta export water quality. Exporters using water for M&I purposes would experience a reduction in water treatment costs. Agricultural users, particularly in the San Joaquin River Basin, would benefit from reduced salt loads.

Water quality improvements that would result from the NODOS project alternatives for agricultural and M&I water uses were evaluated using salinity concentrations for the four action alternatives (Figure 7-9). Alternative C provides the greatest improvements, followed by Alternatives A, B, and D in decreasing order.

Sustainable Hydropower Generation (Secondary Objective)

The intent is to integrate the operation of the Sites hydropower facilities with the operation of renewable energy (i.e., wind and solar). This integration is maximized when the hydropower generated is fully dispatchable. The capability for pump-back storage with Holthouse Reservoir as a forebay/afterbay supports hydropower generation when it is beneficial to the grid, not just when Sites Reservoir is making water releases for customers.

Table 7-3 presents the dispatchable power generated and rated generating capacity for each of the facilities under each alternative and the range of hydropower generation (not accounting for the energy consumed in the system by pumping) over the 30-year analysis period in the NODOS Power Optimization Scheme.

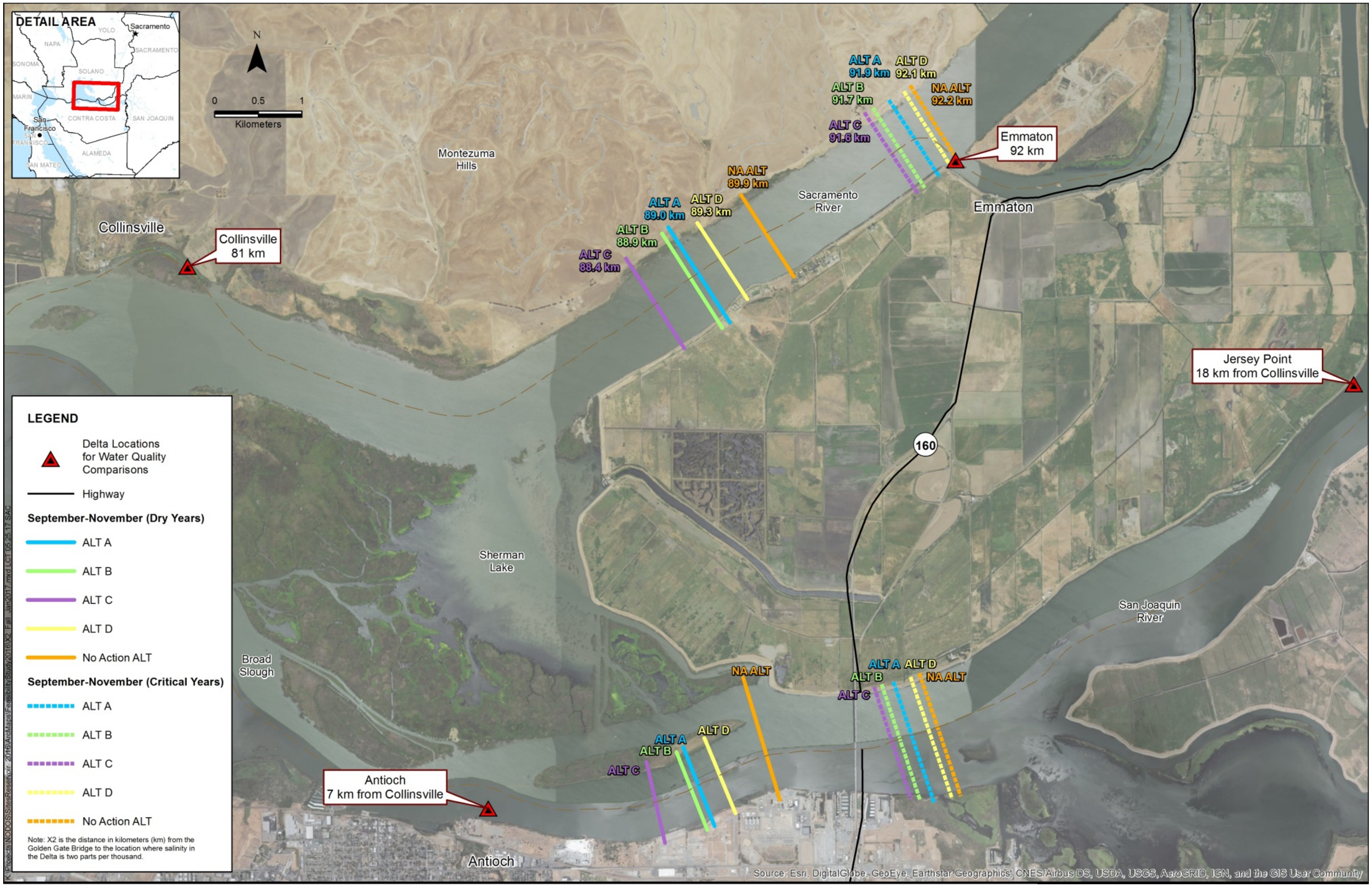

Figure 7-8. Position of X2 During September – November in Dry and Critical Years

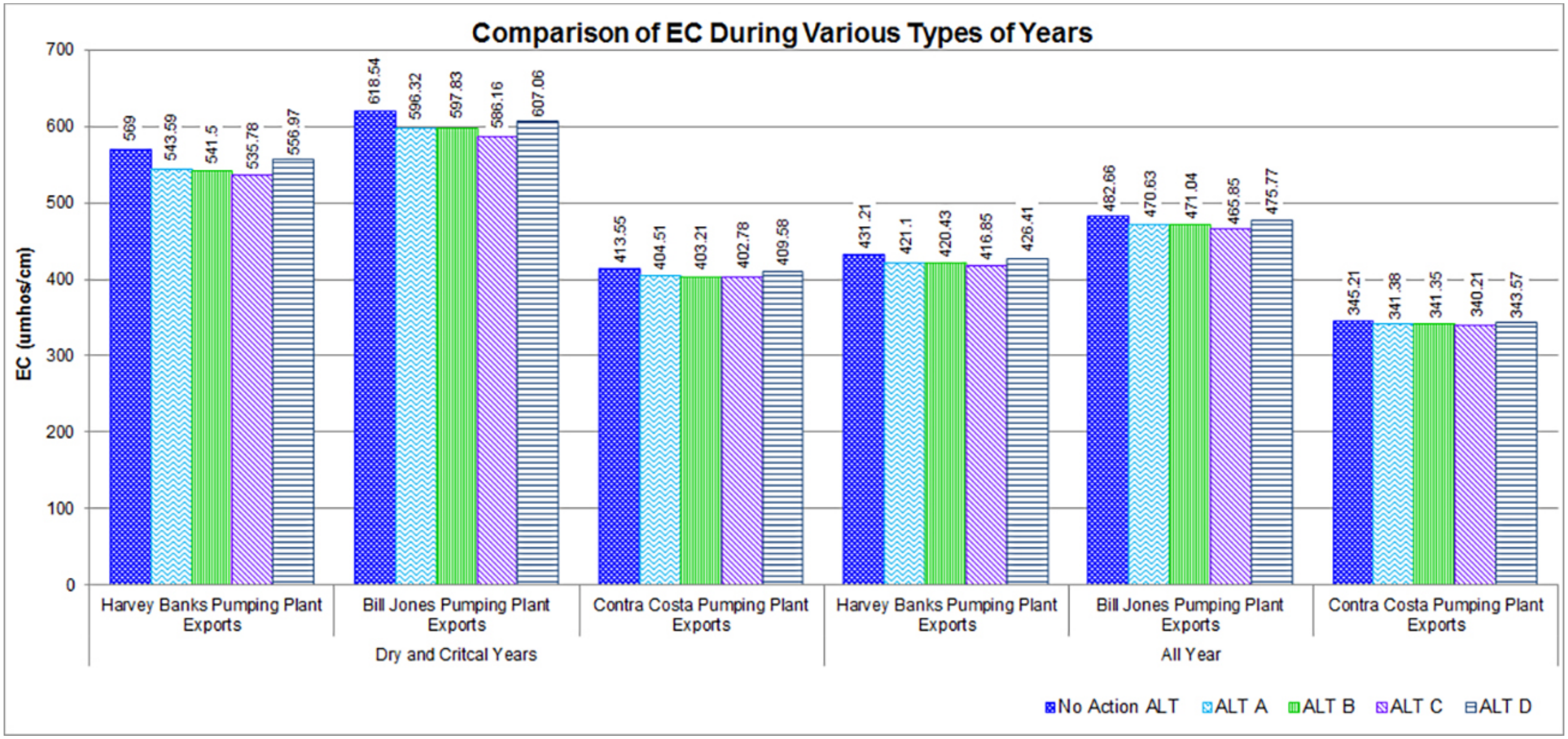

Figure 7-9. Improvements in Electrical Conductivity

Table 7-3. Hydropower Generation

Generation Capacity	Alternative A	Alternative B	Alternative C	Alternative D
Sites-rated generation capacity (MW)	96.3	109.7	109.7	109.7
Terminal Regulating Reservoir–rated generation capacity (MW)	4.9	4.9	4.9	4.9
Sacramento River–rated generation capacity (MW)	12	N/A	12	12
Long-term average dispatchable power generated through pump-back operation (GWh)	60.4	43.8	42.0	47

GWh = gigawatt-hours
MW = megawatt
N/A = not applicable

Alternative A has lower dams than the other three alternatives; and as a result, the Sites Pumping/Generating Plant for Alternative A has a lower generation capacity, although the opportunity for generating dispatchable power is high, because it would maintain a more constant water surface elevation. Alternatives B, C, and D have the same dam heights. Alternatives C and D have more generating capacity due to the inclusion of the Delevan Intake Pumping/Generating Plant. The TRR Pumping/Generating Plant is identical for all three alternatives.

Power generation is typically highest in the spring and early summer. Under all alternatives, the reservoir is maintained at a higher level throughout all seasons in wet and average years. Under these conditions, power generation at the Sites Pumping/Generating Plant can occur deeper into the summer. Releases occur in summer and fall that result in power generation at the TRR and Sacramento River facilities, as well.

Hydropower generation is also affected by the water-year type. Under extended drought conditions, there may not be sufficient water in the reservoir for pump-back operation; and releases, which contribute to power generation, would be diminished. As a result, there is a notable range of power generation over the 30-year analysis period corresponding to year-type.

As discussed in Chapter 2, Problems, Needs, and Opportunities, there is an opportunity for pumped-storage hydropower to firm renewable energy (solar and wind) resources to provide stable grid operation and reliable supplies for energy customers. Environmental benefits from reductions in GHG emissions are provided through the replacement of fossil fuel with hydropower generation to follow loads. The economics for these ancillary benefits are difficult to monetize, but are generally discussed in the section titled “Benefits,” below.

Recreation (Secondary Objective)

The action alternatives would provide new opportunities at Sites Reservoir for surface-water recreation, such as boating and fishing. New facilities would be developed on the shore of the reservoir to support other recreational activities, such as camping, hiking, picnicking, and sightseeing.

Alternatives A, B, and C would develop three new recreation areas in a phased approach to meet the local demand for recreation. It is assumed that each project alternative would provide recreational development and types of recreational opportunities comparable to those available at

Black Butte Reservoir. The three new recreation areas would be at Stone Corral, Lurline Headwaters, and Antelope Island. Future facilities would include boat launch sites, picnic areas and tables, developed campsites, restrooms, trails, and parking. Up to 112 overnight campsites would be added at each recreation area if it were fully developed.

Alternative D includes two recreation areas (Stone Corral and Peninsula Hills). The design for these areas was developed with input from Colusa County. Although this alternative has fewer recreation areas, the sites selected provide superior public access from the eastern and western ends of the new bridge. The facilities in these areas may also be phased in over time.

Overall usage of the recreational facilities is not expected to vary appreciably between the different alternatives.

As discussed previously, the Sites Reservoir alternatives would provide important benefits to anadromous fish, including important game fish. The benefits to fisheries, including salmonids, may result in higher catch rates and greater fish sizes. These benefits were not quantified.

Flood-Damage Reduction (Secondary Objective)

A portion of the area along Funks Creek downstream of Holthouse Reservoir is in the 100-year floodplain for Funks Creek. Under current No Project conditions, Funks Reservoir is not a flood control reservoir; therefore, it can be overwhelmed with runoff and send peak flows downstream on Funks Creek. The construction of Golden Gate and Sites Dams would essentially eliminate the potential for flooding in Funks Creek, Stone Corral Creek, and various other unnamed streams.

All alternatives would provide a similar reduction in flood damages. Of the 22,200 acres of land prone to flooding in these watersheds, approximately 43 percent (9,570 acres) would experience a reduction in flood-related damages under a 100-year flood event. This area includes the northern portion of the town of Maxwell, Interstate 5 adjacent to Maxwell, and State Highway 20 to the east. These areas are subject to frequent flooding. In addition to increasing the level of protection in the Funks Creek and Stone Corral Creek watersheds, a 100-year level of protection would be achieved for approximately 4,025 acres in the Colusa Basin. Additional flood damage benefits are likely from the diversions off of the Sacramento River that would occur during major storm events. The greatest benefits would be in the vicinity of the Red Bluff and Hamilton City diversions.

Benefits

Project benefits were evaluated in accordance with the basic guidelines for water development projects at the Federal level, as specified in the P&Gs (WRC 1983). This study was initiated before the release of the Principles, Requirements, and Guidelines (PR&Gs) (WRC 2015). Under the P&Gs, the Federal objective for water contributions is to maximize the contribution to NED consistent with protection of the environment.

Accurate representation and comparison of the project alternatives’ future benefits and costs requires that all future benefits and costs are discounted to current dollars to reflect the time value of money. Benefits are provided in 2015 dollars so that the benefits are more comparable with the benefits under WSIP and the feasibility reports for other CALFED storage projects. However, it should be noted that benefits for the State of California WSIP application differ from the NED benefits presented in this report. Benefits in the WSIP application were estimated with climate change assumptions and methodologies specific to the WSIP requirements; and as a result, vary from the benefits presented in this report. The conclusions from the two independent analyses (NED analysis using Federal guidelines and WSIP analysis using State guidelines) are consistent. Table 7-4 shows the methodologies that were used in the analysis of benefits.

Table 7-4. Economic Benefit Methodology

Benefit Type	Primary Method	Sensitivity Method	Rationale for Selection of Primary Method
Water Supply M&I	Water Transfer Pricing	LCPSIM, OMWEM	Transfer model reviewed by Reclamation for recent feasibility reports
Water Supply Agriculture	SWAP model	WSIP unit values for water supply	SWAP model used for other feasibility reports, more conservative
Incremental Level 4 Refuge Water Supply	Alternative Project Cost – Shasta Raise	WSIP unit values for water supply	Long-term dedicated water supply
Anadromous Fish	Alternative Project Cost – Shasta Raise	WSIP unit values	Uses SALMOD model to produce equivalent number of habitat units
Delta Environmental Water Quality	SWAP model	Alternative Project Cost – Auburn Dam	More conservative approach
M&I Water Quality	LCRBWQM and BAWQM	N/A	Only model results available
Agricultural Water Quality	SWAP model and LCRBWQM	WSIP unit values and LCRBWQM	SWAP model used for other feasibility reports and more conservative
Hydropower	PARO and PLEXOS Modeling	N/A	Availability
Recreation	Visitation	N/A	Availability
Flood Damage Reduction	Expected annual damages	N/A	Availability

BAWQM = Bay Area Water Quality Model
LCPSIM = Least Cost Planning Simulation Model
LCRBWQM = Lower Colorado River Basin Water Quality Model
M&I = municipal and industrial
N/A = not available
OMWEM = Other Municipal Water Economics Model
PARO = Power and Risk Office
PLEXOS = Plexos Integrated Energy Model – a registered trademark of Energy Exemplar
SWAP = Statewide Agricultural Production
WSIP = Water Storage Investment Program
— = not applicable

Federal regulation requires use of the Federal discount rate as specified by the DOI. In accordance with agency regulation, the Federal discount rate of 2.875 percent was used for fiscal year 2017 to calculate the present value of the project's future benefits and costs for this study (Federal Register 2016). Table 7-5 provides a summary of the potential features and benefits of the alternatives.

Table 7-5. Summary of Potential Features and Benefits of Alternatives (Compared to No Action Alternative)

Item	Alternative A 1.3 MAF Reservoir New Intake	Alternative B 1.8 MAF Reservoir No New Intake	Alternative C 1.8 MAF Reservoir New Intake	Alternative D 1.8 MAF Reservoir New Intake
Water Supply and Water Supply Reliability				
Long-term average water supply increases (TAF/yr) [a]	169	141	172	224
Dry and Critical year water supply increases (TAF/yr) [b]	333	271	346	419
Incremental Level 4 Refuge Water Supply				
Incremental Level 4 water supply increases (TAF/yr)	44	72	74	48
Anadromous Fish				
Additional End-of-September Storage in Shasta (TAF)	101	106	108	132
Winter-run Chinook fish production increase (thousand fish – SALMOD) [c]	936	683	756	986
Delta Environmental Water Quality Improvement [a]				
X2 position July to August (km)	-1.2	-1.2	-1.3	-1.0
Hydropower generated annually (in GWh)				
Long-term dispatchable power generation (Gwh)	60.4	43.8	42.0	47.1
Recreation (Reservoir)				
Maximum # recreation areas	3	3	3	2
Flood Damage Reduction				
Reduction on Funks Creek	Yes	Yes	Yes	Yes

[a] Water supply increases that are above the No Project Alternative; total supplies for agriculture and M&I.
[b] Dry and Critical period is the average quantity for the combination of the SWRCB D-1641 40-30-30 Dry and Critical years for the period October 1921 to September 2003. Average annual is for that same period.
[c] Numbers were derived from SALMOD and represent an index of production increase, based on the estimated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Pumping Plant.

D-1641 = Water Rights Decision 1641 Revised (SWRCB 2000)
GWh = gigawatt-hours
km = kilometer(s)
M&I = municipal and industrial
MAF = million acre-feet
SALMOD = a computer model that simulates the dynamics of freshwater salmonid populations
SWRCB = State Water Resources Control Board
TAF/yr = thousand acre-feet per year
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand

The project benefits and costs have been analyzed over a 100-year planning horizon based on the expected project completion in 2030, with 2 years to fill the reservoir, and full operation beginning in 2032. Partial deliveries should begin in 2031. Consequently, the end of the Federal planning horizon is 2130. Annualized benefits for each beneficiary are presented in Table 7-6 (note that the corresponding quantities of water associated with these benefits are shown in Table 7-1).

Table 7-6. Summary of Estimated NED Annual Benefits for NODOS Alternatives ($ millions, 2015)

Beneficiary	Alternative A	Alternative B	Alternative C	Alternative D
Water supply	$135.5	$136.5	$149.3	$137.9
Agricultural	$13.9	$7.7	$13.0	$20.8
M&I	$121.6	$128.8	$136.2	$117.1
Incremental Level 4 refuge	$22.2	$35.8	$37.3	$24.2
Anadromous fish & other aquatic	$45.7	$33.3	$36.9	$48.1
Water quality	$59.5	$59.9	$71.1	$41.6
Agricultural	$1.3	$1.4	$1.6	$1.0
M&I	$18.9	$20.8	$25.2	$14.0
Delta environmental	$39.3	$37.8	$44.2	$26.6
Hydropower (system)	$19.9	$14.8	$22.0	$20.2
Recreation (Reservoir)	$2.2	$2.2	$2.3	$2.3
Flood damage reduction	$4.3	$4.3	$4.3	$4.3
Total benefits	**$288.4**	**$285.5**	**$323.2**	**$278.6**

M&I = municipal and industrial
NED = National Economic Development
NODOS = North-of-the-Delta Offstream Storage

Appendix C, Economics, provides details about the estimation of benefits and the results of the sensitivity analysis. Annual benefit estimates varied considerably depending on the estimating methodology that was applied. Annual benefits ranged from $272 million to $505 million for Alternative A, from $285 million to $500 million for Alternative B, from $319 million to $556 million for Alternative C, and from $254 million to $445 million for Alternative D. The largest factor contributing to the range observed was the methodology used to estimate Delta environmental water quality benefits. The preferred method conservatively used the opportunity cost to shift water from agriculture to releases to the Delta. The sensitivity method looked at the cost to develop an alternative water project (in this case a raise of Shasta Dam) to achieve an equivalent amount of water for release to the Delta. Additional modeling to support the Final Feasibility Report may further alter the benefits; however, the benefit-cost ratio is still expected to remain positive.

Climate change was not included in these analyses; however, climate change is qualitatively addressed in Chapter 9, Risk and Uncertainty. Additional analysis with climate change scenarios for 2030 and 2070 was performed in support of the WSIP application process (Authority 2017).

Water Supply and Water Supply Reliability Benefits (Primary Objective)

CALSIM II operational studies were used to estimate the additional water provided by the NODOS project alternatives for agricultural and M&I uses. For agricultural benefits, these CALSIM II water deliveries were applied to the Statewide Agricultural Production (SWAP) model. The model was then run with demands based on 2025 and 2060 level of development for the future No Action and action alternatives.

Table 7-6 shows the estimated annual benefits for agricultural water supplies provided by each alternative. Alternative B provides lower benefits to agricultural users as a result of its inability to recapture water without the Delevan Intake. Recaptured water is reused under the other alternatives to increase the agricultural benefits. Alternative D has the highest agricultural benefits due to its increased emphasis on water supply for the Sacramento Valley.

M&I water uses include municipal, domestic, commercial, educational, and public safety applications. The M&I benefits derived from the NODOS project alternatives were estimated based on the assumption that the next increment of water supply to M&I users would likely be obtained through water transfers. This analysis relies on a water transfer pricing model developed for the Shasta Lake Water Resources Investigation (Reclamation 2015). This method is consistent with the “cost of the most likely alternative” method recommended by the P&Gs.

The action alternatives would increase water supplies to M&I water users across the state, especially during Dry/Critical years. The M&I water supply benefits would largely accrue to SWP contract holders south of the Delta. M&I water supply increases would generate economic benefits in the form of avoided water supply costs and reductions in shortage-related costs and losses.

Table 7-6 shows the estimated annual benefits for M&I water supplies provided by each alternative. Alternative C generates the greatest benefits to M&I users, followed by Alternative B and then Alternative A. Alternative D has the lowest M&I benefits because of its retention of more water in the Sacramento Valley for local use.

Benefits to Incremental Level 4 Water Supply for Refuges (Primary Objective)

Incremental Level 4 refuge water supply benefits were estimated based on the least-cost alternative of expanding Shasta Lake’s storage with a 6.5-foot raise of Shasta Dam as a single-purpose water storage project. The benefits for each alternative were then determined on a pro rata basis. The results show the highest benefits for Alternative C, followed by Alternatives B, D, and A, in decreasing order.

Benefits to Anadromous Fish (Primary Objective)

The greatest benefits to anadromous fish would occur in the Sacramento River watershed between Keswick Dam and Red Bluff, where the additional potential to store water in Shasta Reservoir provides lower water temperatures and improved flows that benefit anadromous fish, including Chinook salmon and steelhead.

The economic benefits derived from changes in anadromous fish populations were estimated through an alternative project cost approach (benefits are estimated using the cost of an alternative project that would provide the same physical accomplishment). SALMOD results for the Sites Reservoir alternatives were correlated with SALMOD results for a single-purpose raise of Shasta Dam that would result in the same increase in the production of anadromous fish.

As shown in Table 7-6, Alternative D provides the greatest benefit associated with anadromous fish. This alternative emphasized improving conditions in Shasta Reservoir to a greater extent than the other alternatives. It is followed by Alternative A, then Alternative C, and finally Alternative B in terms of the estimated anadromous fish benefits.

The potential benefits of water released for anadromous fish after it has served its coldwater pool purpose have not been evaluated in this Draft Feasibility Report. Additional benefits could be achieved if this water were applied to other project purposes.

Delta Water Quality Benefits (Primary Objective)

Three types of benefits associated with water quality improvements were considered to estimate the alternative benefits.

- Agricultural benefits that result from using less saline irrigation water
- Benefits derived from reductions in M&I water supply treatment costs and avoided damages to equipment and distribution systems
- Environmental benefits resulting from improved water quality conditions in the Delta, including improved X2 conditions and supporting habitat for Delta smelt

Agricultural Water Quality Benefits: Improvements in irrigation water quality to exporters would affect crop production in both the short term and the long term. Reduced salinity in irrigation water improves production by reducing crop root zone salinity. Potential benefits of improved irrigation water quality for agriculture can be categorized according to specific crop and/or irrigation management effects, such as:

- Increased yield of existing crops
- Ability to grow more salt-sensitive crops
- Reduced leaching requirements and other irrigation management costs
- Reduced drainage and disposal costs
- Avoided losses in crop acreage

Growers can take advantage of some or all of these benefits, depending on their irrigation and cropping decisions. The SWAP model was used to estimate the unit value (or marginal value) of an additional unit of water available for irrigation for each alternative. In addition, the Lower Colorado River Basin Water Quality Model was used to estimate the agricultural water quality benefits for the South Coast region. Alternative C offers the highest agricultural water quality benefits, followed by Alternative B, Alternative A, and then Alternative D.

M&I Water Quality Benefits: Improvements in Delta water quality are also important for urban exporters using the water for M&I purposes. Two models were used to assess the economic benefits of M&I water supplies. Each model represents a different geographic region. The Lower Colorado River Basin Water Quality Model covers water users in the service area of the Metropolitan Water District of Southern California, and the Bay Area Water Quality Economics Model covers Southern Bay Area water users. Both models estimate the benefits of salinity reduction in terms of avoided costs and damages from water quality improvements.

Alternative C offers the greatest water quality benefits to exporters for M&I purposes, followed by Alternative B and then Alternative A. Alternative D provides the lowest water quality benefits to exporters because it devotes less water to M&I use.

Delta Environmental Water Quality Benefits: The economic benefits derived from Delta water quality improvements were estimated using the SWAP model to approximate the opportunity cost of shifting water from agriculture to Delta water quality (see Appendix C, Economics).

Sensitivity analysis was performed through an alternative project cost approach. The alternative project considered was the construction of Auburn Dam as a water supply project without hydropower generation. The previously studied water deliveries from Auburn Dam are similar to the amount of water released from Sites Reservoir to improve water quality in the Delta (this amount excludes releases for export). Securing a long-term improvement in Delta water quality without a new water supply like Auburn Dam is unlikely to occur.

Alternative C provides the greatest environmental water quality benefit. Alternative D provides the least Delta water quality benefit due to its greater emphasis on anadromous fish benefits in the Sacramento watershed north of the Delta and increased use of its water in the Sacramento Valley.

Hydropower Generation Benefits (Secondary Objective)

The DWR Power and Risk Office (PARO) developed an optimization scheme for NODOS project operations to take advantage of the opportunities and price differentials that the energy market offers to estimate the hydropower generation benefits. PARO used CALSIM II model results to identify a median-case 30-year time-series for project operations. Daily pump-back operations were superimposed (where and when possible) to better use excess capacities of project facilities, and to capture energy market opportunities. Pump-back operations would enhance the project's economics by capturing opportunities offered by the energy market (energy price differentials between on-peak and off-peak hours) and providing opportunities to support and integrate renewable energy production (e.g., wind, solar).

The Electric Power Research Institute's Energy Portfolio Model was used to monetize the probabilistic value of the NODOS project power portfolio for each of the project alternatives under both incidental and optimized operational scenarios. Overall, modeling results show that if NODOS project pumping and generation operations are managed to address peak demand and energy pricing considerations, the increased revenues from the optimized operations would have an important beneficial impact on the project's economics. Additional hydropower analysis was performed (Toolson and Zhang 2013) to estimate annual ancillary service benefits and systemwide capacity benefits.

It should be noted that market conditions for dispatchable hydropower have changed significantly over the last decade. Future market conditions are difficult to predict. As a result, there is a degree of uncertainty in the estimated hydropower benefits. Furthermore, it has not yet been determined if transmission capacity is available and if power agreements would be through the WAPA/CVP or through CAISO. The estimated benefits assume CAISO oversight.

The total net revenues are similar (within 10 percent of each other) for Alternatives A, C, and D. Alternative B has an appreciably reduced energy generation capacity because it does not include the pumping/generating facility associated with the Delevan Intake.

Recreation Benefits (Secondary Objective)

Alternatives A, B, and C include three potential recreation areas (Stone Corral, Lurline Headwaters, and Antelope Island). Alternative D has two recreation areas (Stone Corral and modified Peninsula Hills), which collectively provide recreational capacity and opportunity at a level similar to or exceeding that of the three combined recreation areas for Alternatives A, B, and C. Boat ramps, trails, day use, and overnight facilities (see Table 6-2) would be constructed to support the recreational activities. The economic values (as measured by consumer surplus) of the different recreational activities anticipated at Sites Reservoir were developed using a benefits-transfer approach. The values for outdoor recreational activities are derived from published estimates for specific outdoor activities across distinct regions of the U.S. The recreation activity values used for the analysis are average values derived from individual studies conducted between 1967 and 2003, updated to 2015 dollars (Loomis 2005).

Based on the previous recreational activity studies for other regions of the country, the weighted-average value per activity expected at Sites Reservoir is estimated to be $52.33 per day. Based on a maximum of 200,000 visitor-days per year across a range of activities, the maximum annual value of the future recreational use at a NODOS project is estimated to be nearly $10.5 million for Alternatives A, B C, and D.

Due to expected fluctuations in the reservoir's surface area resulting from Dry year conditions, recreational activity at Sites might be expected to be slightly reduced, and average between 179,000 and 186,850 annual visitor-days for Alternatives A, B, C, and D. However, a large share of Sites Reservoir's future recreational use may be expected to result from visitors relocating their recreational activity from other locations in the region. Furthermore, it is likely that the recreation areas would be phased in over time, rather than all constructed initially. Stone Corral Recreation Area is the most accessible, and is included in all alternatives. It would likely be constructed first. Therefore, it is conservatively estimated that only 25 percent of the recreational use would represent net new recreation benefits. Consequently, Alternatives C and D are projected to result in the greatest recreation benefits ($2.3 million). Alternatives A and B would have similar, but slightly lower, benefits of approximately $2.2 million.

Flood-Damage Reduction Benefits (Secondary Objective)

The area along Funks Creek downstream of the existing Funks Reservoir is subject to flooding. Funks Reservoir is not a flood control reservoir. Constructing Sites Reservoir would appreciably reduce the risk of flooding at Funks Creek, Stone Corral Creek, and various other unnamed streams. Additional reductions in flooding would be realized in some portions of the downstream Colusa Basin. The reduction in flood damages can be estimated by comparing the estimated average annual cost of flooding under the No Action Alternative with the predicted average annual flooding costs following the construction of Sites Reservoir.

For the land parcels within the 100-year floodplain related to Funks and Stone Corral Creeks, rice production is the primary crop, followed by dryland pasture. Irrigated production in the area is predominantly tomatoes (for processing), wheat, and alfalfa. Crop budget data were used to calculate a weighted average annual flood damage estimate, based on income, variable costs not expended, probability of flooding in each month, and percent of damages that would occur if there was a flood. Land cleanup and rehabilitation costs were added as a fixed cost to each estimate. Under the NODOS project alternatives, up to 9,570 acres of farmland would experience a reduction in flood-related damages during a 100-year flood event.[1] Apart from irrigated production in the floodplain, most of the land uses would not be substantially affected by the short-term flooding that the area periodically experiences.

In addition, the NODOS project would also potentially reduce the likelihood of flood damage to some of the homes at the northern end of Maxwell. Approximately a quarter of the town of Maxwell is in the 100-year flood area of Funks Creek, although no businesses are within the 100-year floodplain area. The total potential flood control benefit of Alternatives A, B, C, and D are estimated to be approximately $4.3 million per year.

Alternative Costs

Table 7-7 provides the construction, OM&R, and total costs for each of the project alternatives. Costs are based on October 2015 price levels. Annualized costs are based on a 100-year period of analysis with a 2.875 percent interest discount rate. Construction costs were escalated to an NOP date in mid-2022. An escalation of 15 percent over 7 years was also as applied for each alternative for the purpose of estimating the potential necessary budgetary approval request.

Table 7-7. Estimated Construction and Annual Costs of NODOS Alternatives

Item	Alternative A	Alternative B	Alternative C	Alternative D
Construction Cost ($ millions)				
Field Costs (October 2015)	$3,689	$3,723	$4,028	$4,046
Non-Contract Costs (October 2015)	$581	$589	$643	$651
Construction Cost (October 2015 price level) (Field Costs + Non-Contract Costs)	**$4,270**	**$4,312**	**$4,671**	**$4,697**
Escalation to Notice to Proceed (2022)	$641	$647	$700	$705
Escalation from Notice to Proceed (2022) to Mid-Point of Construction (2026)	$413	$412	$447	$449
Total Escalated Construction Cost (2026) (Construction Costs + Escalation to 2022 + Escalation to 2026)	**$5,381**	**$5,369**	**$5,816**	**$5,848**
Permits and Water Rights (2022)	$25	$25	$25	$25
Investment Cost ($ millions)				
Interest During Construction (October 2015 price level)	$555	$561	$607	$611
Total Investment Cost (October 2015 price level) (Construction Cost +Interest During Construction)	**$4,825**	**$4,873**	**$5,278**	**$5,308**
Annual Cost ($ millions – October 2015)				
Interest and Amortization	$147	$149	$161	$162
Operation, Maintenance, and Replacement	$26	$27	$26	$26
Total Annual Cost	**$174**	**$175**	**$187**	**$188**

Totals may not sum exactly due to rounding.
NODOS = north-of-the-Delta offstream storage

[1] The specific locations and related agricultural production in the floodplain that would be less affected by flood events are not known.

Feasibility Analysis

The evaluation of feasibility for the NODOS project alternatives is presented through four accounts established by the P&Gs (WRC 1983). Specifically, the NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE) accounts are used to consider beneficial and adverse effects of the alternatives.

National Economic Development Account

The P&Gs (WRC 1983) define the NED plan as the alternative that reasonably maximizes the net NED benefits. Table 7-8 summarizes the annualized benefits and costs, and presents the net NED benefits for each alternative.

Table 7-8. Summary of Annual Benefits, Annual Costs, and NED Benefits ($ millions, 2015)

Costs/Benefits	Alternative A	Alternative B	Alternative C (NED)	Alternative D (LPA)
Total NED Benefits	**$288.4**	**$285.5**	**$323.2**	**$278.6**
Capital Amortization (100 yr, 2.875%) [a]	$147.4	$148.9	$161.2	$162.1
Operation, Maintenance, and Replacement	$26.4	$26.5	$26.2	$26.2
Total Cost	$173.7	$175.4	$187.4	$188.3
BCR	1.66	1.63	1.72	1.48
Annual Net NED Benefits	$114.7	$110.2	$135.8	$90.4
Total Net Benefit (NPV)	**$3,754**	**$3,607**	**$4,446**	**$2,958**

[a] The amortization period is from 2031 to 2130.
BCR = benefit-cost ratio
LPA = Locally Preferred Alternative
NED = National Economic Development
NPV = net present value
yr = year(s)

As shown in Table 7-8, Alternative C has the highest annual net NED benefits, and is therefore the NED Plan. The annual net NED benefits for Alternative C are approximately $136 million, based on a projected annual total cost of $187.4 million, of which $161.2 million would be required for capital amortization.

As noted previously, depending on the economic method used, the BCR would vary for each alternative. The range in BCR for each alternative is as follows:

- Alternative A: BCR ranges from 1.56 to 2.90.
- Alternative B: BCR ranges from 1.62 to 2.85.
- Alternative C: BCR ranges from 1.70 to 2.97.
- Alternative D: BCR ranges from 1.35 to 2.36.

Regional Economic Development Account

The RED account tracks changes in regional economic activity that result from each alternative. In accordance with the P&Gs, regional income and regional employment were considered as measures of regional or local effects that would result from implementing one of the alternatives.

For Sites Reservoir, two regions were considered in the RED analysis. The first region covers Colusa and Glenn Counties, the two counties in which most construction and maintenance activities associated with the project would be located. Statewide effects were also considered as a second region to capture the large geographic extent of benefits anticipated under the NODOS/Sites Reservoir Project.

For this analysis, the following drivers of regional economic effects are evaluated:

- Construction expenditures
- OM&R expenditures
- Recreation spending
- Agricultural production

Development of the NODOS project would require substantial capital investment, including land acquisition, construction, and mitigation-related costs. The total construction cost of the project, accounting for contingencies, is estimated at approximately $4.4 billion to $4.9 billion (depending on project alternative) over the 8-year construction period (2022 to 2030). Project costs include payments for construction labor and the procurement of construction-related goods and services. To the extent that construction spending occurs locally, the project would generate regional economic benefits in the Local Study Area (i.e., Colusa and Glenn Counties). However, based on the small size of the local economy, it is anticipated that substantial expenditures would include labor and commodities imported into the region. These regional economic benefits associated with construction of the NODOS project would be temporary, coinciding with the estimated 8-year construction period.

The annual workforce serving the project is estimated to range between 30 and 330 workers annually, with an average of approximately 143 to 159 jobs (see Table 7-9 for Direct Jobs: Construction) supported over the construction period. The corresponding construction payroll is estimated at $44.5 million to $49.7 million annually.

Other expenditures consist primarily of purchases of construction materials (e.g., concrete and steel) and construction equipment required to develop project facilities. In addition, large capital equipment, such as power generating turbines, would need to be purchased and installed at the site. Estimated non-labor construction expenditures would total $3.6 billion to $4.1 billion, of which $537 million to $683 million are allocated to capital equipment assumed to be imported into the region. RED effects associated with land acquisition were assumed to be one-time effects occurring in a single year at the commencement of project development.

Table 7-9 summarizes the expected increase in employment throughout the region that would result from the NODOS project comprehensive plans.

Table 7-9. Summary of Annual Employment Impacts to the Local Region for RED Account

Employment	Alternative A	Alternative B	Alternative C	Alternative D
Short-Term Employment [a]				
Direct Jobs: Agriculture	-44	-44	-44	-44
Direct Jobs: Construction	143	144	156	159
Indirect and Induced Jobs: Agriculture	-18	-18	-18	-18
Indirect and Induced Jobs: Construction	367	371	402	406
Total Direct, Indirect, and Induced Employment	448	453	496	503
Long-Term Employment: Direct Jobs				
Operations and Maintenance	35	30	35	35
Agriculture	-5	-5	-5	-5
Recreation	15	15	16	16
Total Direct Jobs	45	40	46	46
Long-Term Employment: Indirect and Induced Jobs				
Operations and Maintenance	13	12	13	15
Agriculture	-5	-5	-5	-5
Recreation	2	2	2	2
Total Long-Term Indirect and Induced Jobs	10	9	10	12
Long-Term Total Direct, Indirect and Induced Employment	56	49	56	57

[a] Approximately 14.5 direct jobs would also be created locally by project-related land acquisition during the 1-year period before project construction begins. In addition, land acquisition would create approximately 3 indirect and induced jobs locally.
Totals may not add up exactly due to rounding.
RED = Regional Economic Development

Table 7-10 shows the increases in income that are expected to accompany the regional increase in employment during construction. Because economic benefits are typically reported in annual terms, costs were converted to average annual expenditures for the duration of the construction period.

Table 7-10. Summary of Annual Income Effects to the Local Region for RED Account: During Construction ($ millions, 2015)

Income	Alternative A	Alternative B	Alternative C	Alternative D
Direct	$43.8	$44.2	$47.9	$49.0
Indirect and induced jobs	$15.9	$16.4	$17.5	$17.6
Total income	**$59.7**	**$60.6**	**$65.4**	**$66.6**

Totals may not add up exactly due to rounding.
RED = Regional Economic Development

Table 7-11 shows the income increases that would result from long-term operation of a new reservoir. It is assumed that all employees would reside in the local area. Project operations would incur wheeling and pumping costs to fill the reservoir. It would also require ongoing OM&R expenditures on miscellaneous goods and services to primarily support hydropower operations, but also maintenance of recreational facilities at the reservoir. The average annual OM&R spending associated with the project is estimated to be up to $25 million annually.

Table 7-11. Summary of Annual Income Effects to the Local Region for RED Account: Long Term ($ millions, 2015)

Income	Alternative A	Alternative B	Alternative C	Alternative D
Direct	$2.1	$1.8	$2.1	$2.1
Indirect and induced jobs	$0.3	$0.3	$0.3	$0.3
Total Income	**$2.4**	**$2.1**	**$2.4**	**$2.4**

Long-term RED income effects include project operations and maintenance and recreation.
Totals may not add up exactly due to rounding.
RED = Regional Economic Development

Table 7-12 presents the results of the RED analysis associated with changes in agricultural production and prices with the NODOS project. The direct effects represent impacts in the agricultural sector, and total effects account for changes across all industries with economic linkages to agricultural production. Future agricultural output statewide is expected to increase between $6.0 million and $15.3 million per year as a result of the project.

Table 7-12. Annual RED Effects to the State: Agricultural Production and Price Effects ($ thousands, 2015 Dollars)

	Labor Income		Employment (FTEs)		
Alternative	**Direct**	**Direct**	**Total**	**Direct**	**Total**
Alternative A	$4,134	$922	$2,169	44.7	72.1
Alternative B	$3,311	$816	$1,856	36.6	59.6
Alternative C	$4,560	$998	$2,365	47.3	77.3
Alternative D	$4,683	$998	$2,365	47.3	77.3

Average annual effect based on average water-year conditions.
Results represent change relative to future No Project conditions.
Based on changes in agricultural production (irrigated acreage) and agricultural commodity prices. Does not fully represent potential benefits to the agricultural sector of improved water supply reliability.
FTE = full-time equivalent
RED = Regional Economic Development

Environmental Quality Account

The EQ account provides an analytical framework to integrate environmental review, coordination, and consultation requirements into the planning process. The EQ account displays both positive and negative non-monetary effects on ecological, cultural, and aesthetic resources. The monetary impacts of a project on environmental resources are included in the NED account, but are also included in the descriptions in this section to provide a comprehensive overview of the environmental impacts and benefits of the alternatives.

Table 7-13 summarizes the potential environmental effects for all resource categories. Environmental effects are comprehensively evaluated in the EIR/EIS for the NODOS/Sites Reservoir Project (Reclamation and Authority 2017). All alternatives would be similar in terms of their potential environmental effects, although some effects would be increased by the construction of higher dams or the construction of a new Delevan Intake.

Table 7-13. Summary of Potential Environmental Effects

Resource Area and Potential Effects	No Action	Alt A	Alt B	Alt C	Alt D
Surface Water Resources: Beneficial effect of increasing water supply in Dry and Critical years. No negative impacts.	▲	●	●	●	♦
Surface Water Quality: Less-than-significant impact on water temperatures. Potentially beneficial effect on temperature in the Sacramento River between Keswick Dam and Red Bluff. No impact to mercury, nutrients, salinity, or dissolved oxygen. Potentially beneficial effect of reducing salinity in the Delta. Less than significant impact on the Yolo Bypass. Less-than-significant impact from construction activities.	▲	♦	♦	♦	●
Fluvial Geomorphology and Riparian Habitat: Less-than-significant impact in the Primary and Secondary Study Areas to riverine processes, river meander, bank erosion, alteration of riparian vegetation, and aquatic habitat. No impact in the Extended Study Area.	■	■	■	■	■
Flood control: No impact in the Secondary or Extended Study Areas. Less-than-significant impact in the Primary Study Area. Potentially beneficial effect of reducing flooding in the Stone Corral and Funks Creeks watersheds, including downstream benefit in Colusa Basin Drain.	■	●	●	●	●
Groundwater Resources: Potential benefits in the Extended and Secondary Study Areas, including improvements to the quantity and quality of riparian and floodplain habitats for aquatic and terrestrial species. Potentially beneficial effects of providing water supply for groundwater banking and in-lieu recharge. Less-than-significant impacts in the Primary Study Area from construction activities.	▲	●	●	●	♦
Groundwater Quality: Potential benefits in the Extended Study Areas for incremental Level 4 refuge water quality. Less-than-significant impacts in the Primary and Secondary Study Areas.	▲	●	●	●	♦
Aquatic Biological Resources: Less-than-significant impacts in the Extended and Secondary Study Areas. Potentially beneficial effects from providing cold water at times and locations to increase the survival of salmonid eggs and fry, and improve conditions for the migration of juveniles. Helps maintain flows to minimize dewatering of salmonid redds and reduce stranding. Potential to increase upstream attraction flows. Potential to provide lower-salinity habitat for Delta smelt, longfin smelt, and other estuarine fishes. Significant impacts in the Primary Study Area to the Stone Corral and Funks Creek watershed can be mitigated to less-than-significant levels. Significant impacts from the Delevan Pipeline Intake/Discharge Facility can be mitigated to less-than-significant levels.	▲	●	●	●	♦
Botanical Resources: Less-than-significant impacts in the Extended Study Area. Potentially beneficial effects in the Secondary Study Area. Significant impact to vegetation communities in the inundation, recreation, and buffer areas can be mitigated to less-than-significant levels. Significant impact to freshwater marsh and riparian vegetation along the Delevan Pipeline can be mitigated to less-than-significant levels. Significant impacts to Fremont cottonwood forest at the Delevan Intake can be mitigated to less-than-significant levels. Potential impacts from construction to special-status plants can be mitigated to less-than-significant levels. Significant impacts from invasive or noxious species can be mitigated to less-than-significant levels. Indirect impacts from human disturbance can be mitigated to less-than-significant levels.	■	■	■	■	■

Resource Area and Potential Effects	No Action	Alt A	Alt B	Alt C	Alt D
Terrestrial Biological Resources: Impacts are less than significant in the Extended and Secondary Study Areas. In the Primary Study Area, adverse effects, including alteration of habitat suitability and mortality, on any wildlife habitat identified in local or regional plans, policies, and regulations or identified by CDFW or USFWS can be mitigated to less-than-significant levels, with the exception of golden eagle. Significant and unavoidable impact to golden eagle habitat. Significant impacts to the movement of wildlife species can be mitigated to less-than-significant levels. Less-than-significant impact to common wildlife from human disturbance. No impacts from conflicts with conservation plans, local policies, or ordinances.	■	▲	▲	▲	▲
Wetlands and Other Waters of the U.S.: Less-than-significant effects in the Extended and Secondary Study Areas. In the Primary Study Area, significant impacts to the use or quality of waters could be reduced to less-than-significant levels with mitigation. Adverse effects to Federally protected wetlands can be reduced to less-than-significant levels with mitigation.	■	■	■	■	■
Geology, Minerals, Soils, and Paleontology: No impact in the Extended or Secondary Study Areas. Within the Primary Study Area, adverse impacts to paleontological resources could be reduced to less-than-significant levels with mitigation.	■	■	■	■	■
Faults and Seismicity: No impacts in the extended or secondary study areas. Impacts in the Primary Study Area are less than significant.	■	■	■	■	■
Cultural Resources: Less-than-significant impact in the Extended and Secondary Study Areas. In the Primary Study Area, significant impact to archaeological resources can be mitigated to less-than-significant levels. If possible, historic resources will be avoided, but there is a potential for significant and unavoidable impact to historical properties. Disturbance of cultural properties and tribal resources can be mitigated to less-than-significant levels. Significant and unavoidable impact from disturbance of human remains.	■	▲	▲	▲	▲
Indian Trust Assets: Less-than-significant impact to Indian Trust assets.	■	■	■	■	■
Land Use: No impacts in the Extended or Secondary Study Areas. In the Primary Study Area, significant and unavoidable impact from physical division of an established community. Construction would result in significant and unavoidable conflicts or incompatibilities with designated land uses, existing zoning, and conversion of land with Williamson Act contracts.	■	▲	▲	▲	▲
Recreation: No impacts to recreation in the Extended and Secondary Study Areas. Impacts in the Primary Study Area are less than significant. Potential benefit from newly constructed recreation areas. Potential benefit to water levels in existing reservoirs (Shasta, Folsom, Oroville, and Trinity).	■	●	●	●	●
Socioeconomics: All impacts are considered to be less than significant. Potentially beneficial effect to recreation economics.	■	■	■	■	■
Environmental Justice: No impacts.	■	■	■	■	■
Air Quality: No impacts in the Extended or Secondary Study Areas. Significant and unavoidable impacts from particulate and vehicle exhaust emissions (NOx and ROG) during construction in the Primary Study Area.	■	▲	▲	▲	▲
Climate Change and Greenhouse Gas Emissions: Significant and unavoidable impact from generation of cumulative GHG emissions.	■	▲	▲	▲	▲
Navigation, Transportation, and Traffic: All impacts are at less-than-significant levels.	■	■	■	■	■
Noise: No impact in the Extended or Secondary Study Areas. All impacts in the Primary Study Area are at less-than-significant levels.	■	■	■	■	■

Resource Area and Potential Effects	No Action	Alt A	Alt B	Alt C	Alt D
Public Health and Environmental Hazards: All impacts are at less-than-significant levels.	■	■	■	■	■
Public Services and Utilities: No impacts in the Extended or Secondary Study Areas. Impacts in the Primary Study Area are at less-than-significant levels.	■	■	■	■	■
Visual Resources: Significant and unavoidable impacts from the proposed TRR facilities. All other impacts are less than significant.	■	▲	▲	▲	▲
Power Production and Energy: Potential benefit from hydropower generation that could support the development of renewable wind and solar energy. Potential impacts could be mitigated to less-than-significant levels.	■	●	●	●	●

CVP = Central Valley Project
NOx = nitrous oxides
ROG = reactive organic gases
TRR = Terminal Regulating Reservoir
▲ = negative impact
■ = neutral to mitigated impact
● = beneficial effect
♦ = highly beneficial effect

Table 7-14 summarizes the environmental accomplishments of the four alternatives.

In support of WSIP, CDFW has recently developed priorities for ecosystem improvement to “improve California’s ecosystem resources for the benefit of people, fish and wildlife, and plants” (CWC 2016). The CDFW ecosystem priorities for the WSIP are based on existing environmental laws and regulations, species recovery plans and strategies, initiatives, and conservation plans. The NODOS project alternatives address several of these priorities by providing benefits to anadromous fish in the Sacramento River watershed and ecological and water quality benefits in the Delta. Priorities that would be addressed by the NODOS project alternatives are described below.

- **Provide cold water at times and locations to increase the survival of salmonid eggs and fry:** All alternatives would result in improvement in egg-to-fry survival for endangered winter-run Chinook salmon. For Sacramento River winter-run Chinook salmon, modeling results indicate reductions in annual early-life-stage mortality of approximately over 50 percent, when compared to the No Action Alternative over the entire cumulative frequency distribution. Model results also indicate lower probabilities of exceeding specified water temperature index values, and therefore, more suitable water temperatures—particularly during months with relatively warm water temperature conditions (i.e., July and August). Other salmon runs and steelhead would also benefit from more favorable water temperatures, especially at important spawning habitat between Keswick Dam and Bend Bridge. In addition, salmonids would benefit from improvements in coldwater pool conditions in Trinity Lake, Lake Oroville, and Folsom Lake.

Table 7-14. Summary of Environmental Effects Considered in EQ Account

	Alternative A Average/Dry and Critical	Alternative B Average/Dry and Critical	Alternative C Average/Dry and Critical	Alternative D Average/Dry and Critical
Incremental Level 4 Incremental Refuge Water Supply				
Level 4 Deliveries (TAF/yr)	44/21	71/38	74/37	48/24
Anadromous Fish and Other Aquatic Species: Increase in Storage Associated with Cold-Water Pool Improvement				
Shasta, End of September (TAF)	101/139	106/180	108/175	132/198
Anadromous Fish and Other Aquatic Species: Chinook (all runs)				
Average Increase (habitat units/yr): SALMOD results for winter-run, spring-run, fall-run, and late-fall-run Chinook [a]	936	683	756	986
Anadromous Fish and Other Aquatic Species: Sacramento River Flows Below Keswick				
Monthly Flow (% Increase December–February)	6.8%/17.1%	6.8%/17.2%	6.4%/15.9%	7.6%/16%
Water Quality: Delta Environmental				
July through August Improvement in X2 (km)	-1.2/-0.9	-1.2/-1.1	-1.3/-1.3	-1.0/-0.7
September through November Improvement in X2 (km)	-0.5/-0.6	-0.6/-0.9	-0.8/-1.1	-0.3/-0.4

[a] Numbers were derived from SALMOD and represent an index of production increase, based on the estimated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the Red Bluff Pumping Plant.

EQ = Environmental Quality
km = kilometer(s)
SALMOD = a computer model that simulates the dynamics of freshwater salmonid populations
TAF = thousand acre-feet
TAF/yr = thousand acre-feet per year
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand

- **Enhance flows to improve habitat conditions for in-river rearing and downstream migration of juvenile salmonids:** Improvements in flow and flow patterns for both the American River and the Sacramento River would benefit juvenile salmonids in the Sacramento River. Juvenile fish would benefit from the extended opportunity to exit inundated rearing habitats, which would contribute to increased survival of smolts during emigration periods.
- **Maintain flows and appropriate ramping rates at times and locations that would minimize dewatering of salmonid redds and prevent stranding of juvenile salmonids in side channel habitat:** Connectivity between main and side channels is an important parameter to reduce stranding risk, and at the same time, increase habitat and food availability for rearing juvenile fish. Also, appropriate ramping rates would help trigger and contribute to the success of downstream movement of juvenile fish by preventing fish from being stranded when flow decreases. All alternatives would result in increased flows in Average, Dry, and Critically Dry water-year types, which would benefit early life stages of salmon. Seasonal schedules for NODOS project operations would stabilize flows in the lower American River to minimize the dewatering of salmon and steelhead spawning habitats, which would in turn reduce isolation events for juvenile fish.
- **Increase flows to improve ecosystem water quality:** Releases from Sites Reservoir would increase flows during times when flows are generally low, and unsuitable for fish (i.e., July and August). Increased summer flows would help improve ecosystem water quality by preventing extreme water temperatures, which impede fish migration for both juvenile downstream movement and adult upstream migration to spawning grounds. Additional storage in Shasta Lake resulting from Sites Reservoir operations would facilitate the ramping-up of flows in the Sacramento River from Shasta and Trinity Reservoirs when ambient temperatures are generally high. Such flows would have an ecosystem-wide benefit to water quality because the waters from these reservoirs are typically cooler than the existing water temperatures in the Sacramento River. Releases from Sites Reservoir would also reduce Delta salinity, to the benefit of both Delta smelt and longfin smelt.
- **Increase flows to support anadromous fish passage by providing adequate dissolved oxygen and lower water temperatures:** Although dissolved oxygen conditions would not be appreciably affected by the NODOS project alternatives, increased flows from the end of May to the end of September, when flows are generally low and temperatures are generally high, may support fish passage.
- **Increase attraction flows during the upstream migration period to reduce the straying of anadromous species into non-natal tributaries:** Increased flows could function as attraction flows for a number of Chinook spawners. Although straying may be less likely to occur by fish in the Sacramento River compared to the San Joaquin River Basin, release of flow from coldwater pools upstream would contribute to an increase in the number of Chinook salmon spawners reaching their natal spawning grounds.
- **Increase Delta outflow to provide low-salinity habitat for Delta smelt, longfin smelt, and other estuarine fishes in the Delta, Suisun Bay, and Suisun Mars**h: For each alternative, the conceptual model shows that X2 shifts west near Collinsville from May to

December improve and enhance estuarine habitats, reduce entrainment risks, and improve food availability for salmon and Delta smelt.

- **Maintain groundwater and surface water interconnections to support instream benefits and groundwater-dependent ecosystems:** Increasing flows during summer months would benefit interconnection between groundwater and surface water. Although there are no quantitative data available, groundwater would most likely be recharged from water released to either the Sacramento River, or possibly, to Funks Creek.
- **Enhance flow regimes to improve the quantity and quality of riparian and floodplain habitats for aquatic and terrestrial species:** Increased flow and improvements of flow patterns for both the American River and the Sacramento River would improve a variety of habitats bordering the Sacramento and American Rivers.
- **Enhance floodplains by increasing the frequency, magnitude, and duration of floodplain inundation to enhance primary and secondary productivity and the growth and survival of fish:** Suitable aquatic edge habitats (fish territories with cover features that act as current breaks to provide safety from predators) in close proximity to food sources are important to the growth and survival of juvenile fish. Slower velocities in shallow floodplain areas would result in increased food availability for fish in edge habitats. All alternatives would be expected to provide these types of habitats in the Sacramento River.
- **Enhance the temporal and spatial distribution and diversity of habitats to support all life stages of fish and wildlife species:** Juvenile fish would benefit from extended access to inundated rearing habitats, contributing to increased survival of smolts during emigration periods. Wildlife species that would be supported by the enhanced and diversified habitats (i.e., inundated rice fields north of the Delta) include giant garter snake (*Thamnophis gigas*), greater sandhill crane (*Grus Canadensis*), long-billed curlew (*Numenius americanus*), western pond turtle (*Actinemys marmorata*), purple martin (*Progne subis*), tricolored blackbird (*Agelaius tricolor*), and yellow-headed blackbird (*Xanthocephalus xanthocephalus*).
- **Enhance access to fish spawning, rearing, and holding habitat by eliminating barriers to migration:** Reduced water temperatures could better support migrating salmon in reaching their historical spawning grounds (i.e., eliminate thermal barriers).
- **Provide water to enhance seasonal wetlands, permanent wetlands, and riparian habitat for aquatic and terrestrial species on Federal and State wildlife refuges and on other public and private lands managed for ecosystem values:** The seasonal schedule of NODOS project operations would increase water supply, which would help riparian habitats in the Sacramento River watershed. Increasing water supply during Dry and Critically Dry water-year types would benefit willows and aesthetics. All alternatives provide incremental Level 4 water supply to south-of-the-Delta National Wildlife Refuges, State Wildlife Areas, and privately managed wetlands in the San Joaquin River Valley.
- **Develop and implement non-native invasive species management plans using proven methods to enhance habitat and increase the survival of native species:** Mitigation activities include the development and implementation of non-native species

management, primarily the removal of yellow starthistle (*Centaurea solstitialis*) on mitigation property with conversion to a native plant conservation easement.

- **Enhance habitat for native species that have commercial, recreational, scientific, and educational value:** All alternatives would enhance habitat for native species that are Federal- and/or State-listed, State species of concern, and species with commercial value. The alternatives can be adaptively managed to benefit a wide variety of species, but especially anadromous fish, Delta species, and waterfowl.

In accordance with Water Code Section 79754, the SWRCB has identified water quality priorities that could be realized by water storage projects. The NODOS project alternatives would address the priorities described below.

- **Improve water temperature conditions in surface water bodies that are not meeting water quality standards for temperature:** Temperature issues in the Sacramento River vary by season and river reach. Basin Plan Water Quality Objectives (RWQCB 2016) require that the Keswick Dam to Hamilton City reach of the Sacramento River have a temperature of 56°F or colder, and that the reach of the Sacramento River from Hamilton City to the I Street Bridge have a temperature of 68°F or colder. Temperature modeling results show improvements in the temperature in the Sacramento River at Bend Bridge (Appendix A, Plan Formulation).
- **Improve salinity conditions in surface water bodies that are not meeting water quality standards for sodium, total dissolved solids, chloride, or specific conductance/electrical conductivity:** Sites Reservoir operations would improve the position of X2 during summer and fall months (Figure 7-8). There may also be some additional salinity benefits in the interior Delta waterways for ecosystem benefits and potential water supply diversions at interior Delta intakes, including possible improvements at the City of Antioch intake and other intakes for Delta exports.
- **Protect, clean up, or restore groundwater resources in high- and medium-priority basins designated by DWR.** Sites Reservoir is in the Sacramento Valley Groundwater Basin, Colusa Sub-Basin, and is classified as a medium-priority basin. Groundwater basin reports describe high EC, total dissolved solids (TDS), nitrate, and manganese groundwater impairments near Colusa; high TDS and boron levels near Knights Landing; and high nitrate concentrations near Arbuckle, Knights Landing, and Willows. In preliminary planning efforts, Colusa County has identified in-lieu recharge efforts as one of the potential management practices to improve groundwater quality and groundwater supplies.
- **Provide water for basic human needs, such as drinking, cooking, and bathing, in disadvantaged communities, where those needs are not being met.** Sites Reservoir would provide slight improvements in the quality of M&I water supplies in Dry and Critical years. The City of Antioch’s intake is on the San Joaquin River; however, fingerprinting studies indicate that the intake mostly captures Sacramento River water. The chloride concentrations at the intake periodically exceed the United States Environmental Protection Agency’s (EPA) secondary Maximum Contaminant Level (MCL) of 250 milligrams per liter (mg/L). There are several severely disadvantaged or disadvantaged communities in the city of Antioch.

EQ Account Summary: Alternative D would produce the most benefits for anadromous fish, followed by Alternative C. Alternative D provides the greatest end-of-September coldwater pool increase in Shasta Reservoir, provides the most water on average to stabilize Sacramento River fall flows, and has the highest increase in Chinook salmon production between Keswick Dam and Red Bluff, as estimated by SALMOD. Alternative B is considered to be slightly superior to Alternative A.

Alternative C would release the most water for Delta environmental quality benefits, followed by Alternative B, then Alternative A, and finally Alternative D. Impacts from construction are somewhat higher for Alternatives C and D, but these specific impacts could be mitigated and do not change the overall ranking of EQ account benefits.

Overall, Alternatives C (better for Delta water quality) and D (better for anadromous fish in the Sacramento River) are expected to result in the most EQ account benefits.

Other Social Effects Account

The OSE account collects effects that are not reflected in the other accounts, including community impacts, public safety, displacement, long-term productivity, and energy conservation.

Drought Preparedness: The vulnerability of California's water system to drought is one of the primary challenges identified in the *California Water Action Plan 2016 Update* (NRA, CDFA, and Cal EPA n.d.). Climate change increases the likelihood and severity of future droughts. An improvement in the ability of the State to manage scarce surface water supplies and over-stressed groundwater basins is needed for both economic and environmental sustainability.

Sites Reservoir would improve both water supply reliability and water system flexibility to achieve a greater level of drought preparedness for the statewide water system. Water supply reliability can be characterized by increases in water deliveries for agriculture, M&I, and environmental purposes in Dry and Critical water-years. The flexibility of the water system is a function of the water that is available in storage for delivery. Improvements associated with the Sites Reservoir alternatives are presented in Table 7-15. Alternative D provides the greatest improvement in water supply reliability, and Alternative C provides the greatest long-term improvement in storage.

Table 7-15. Water System Improvements

Improvements	Alternative A	Alternative B	Alternative C	Alternative D
Water Supply Reliability				
Increase in Dry and Critical year water supply (TAF/yr)	333	271	346	419
Water System Flexibility				
Increased average end-of-September Storage (TAF)	867	1,127	1,304	1,278

TAF = thousand acre-feet
TAF/yr = thousand acre-feet per year

Water Supply for Disadvantaged Communities: Water provided from Sites Reservoir for M&I purposes would supply basic human needs, including drinking, cooking, and bathing, in disadvantaged communities where those needs are not adequately being met. California Water Code (Division 1, Section 106.3) establishes the right of every human being to safe, clean, affordable, and accessible water for human consumption, cooking, and sanitary purposes.

Sustainable Groundwater Management: The Sites Reservoir alternatives were also evaluated to assess their ability to support the implementation of the Sustainable Groundwater Management Act. Groundwater accounts for more than one-third of California's water supply on average, and groundwater approaches two-thirds of water supply in dry years when surface water supplies are reduced. The lack of flexibility in the statewide water system contributes to groundwater basin overdraft, seawater intrusion, land subsidence, and water quality degradation. Pumping more groundwater than is recharged lowers groundwater levels and increases energy costs.

Water supplied by Sites Reservoir could support both in-lieu recharge and provide a dedicated supply for conjunctive use. Specific opportunities that could be supported by Sites Reservoir include the following:

- Support conjunctive use efforts to manage groundwater by the Orland-Artois Water District (a board member of the Sites Project Authority) (Davids Engineering and Orland-Artois Water District 2002)
- Support in-lieu recharge in Colusa County to address subsidence in the vicinity of Arbuckle, California
- Provide water for Delta environmental commitments to facilitate the success of the American River Basin Regional Conjunctive Water Project (the Placer County Water Agency and the City of Roseville are Sites Project Authority Board members supporting the development of this project)
- Provide approximately 26 TAF for groundwater replenishment to the Coachella Valley Water District (a member of the Sites Project Agreement Committee)
- Provide approximately 6.5 TAF for groundwater replenishment to the Desert Water Agency

Capacity for Emergency Response: The Sites Reservoir alternatives would provide additional capacity in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake, in addition to new storage at Sites Reservoir, to respond to a levee failure. This additional capacity would improve the ability of the system to temporarily increase Delta inflow to reduce the impact of seawater intrusion on water operations. Furthermore, Sites Reservoir is well south of Shasta Lake, and would be able to make a special release of water with reduced travel time to the Delta. Table 7-16 shows the increase in emergency response capacity for each alternative under different year-types. Water supplied directly from Sites Reservoir could also be used for fighting forest fires in the general vicinity of Sites Reservoir.

OSE Account Summary: The ability of the alternatives to support drought preparedness, disadvantaged community water supply, and sustainable groundwater management is proportional to their improvements in water supply reliability and flexibility. Alternative C would provide a slightly greater benefit than Alternative D, and an appreciably greater benefit than Alternative B. Alternative A would provide the least OSE benefits.

Table 7-16. Emergency Water Supply Storage

Storage	Alternative A	Alternative B	Alternative C	Alternative D
May (TAF)				
Average annual	1,100	1,376	1,584	1,546
Dry	1,037	1,236	1,505	1,461
Critical	817	851	1,101	960
September (TAF)				
Average annual	867	1,127	1,304	1,278
Dry	753	932	1,113	1,113
Critical	537	575	814	611

Combined end-of-month storage for Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir.
TAF = thousand acre-feet

Summary of Four Accounts

The results of the evaluation of the four accounts are as follows:

- **NED account**: Alternative C has the highest net NED benefits and is therefore the NED Plan.
- **RED account:** Alternative D, developed by the Authority, has the highest RED benefits and is the Locally Preferred Alternative.
- **EQ account:** Alternatives C and D provide the greatest net environmental benefits. Alternative C provides greater benefits to Delta environmental water quality, and Alternative D provides greater benefits to anadromous fish. This difference in benefits is due to how the alternatives are operated. Either alternative could be adaptively managed to emphasize benefits to the north (anadromous fish) or south (Delta water quality).
- **OSE account:** Alternative C provides the greatest OSE benefits, followed by Alternative D.

Comparison of Alternatives

The P&Gs provide four criteria for consideration in evaluating alternatives: effectiveness, efficiency, acceptability, and completeness (WRC 1983).

Effectiveness

Effectiveness is the extent to which an alternative plan addresses the problems and needs and satisfies the planning objectives. The NODOS Investigation objectives and the effectiveness of each alternative in achieving the objectives are listed in Table 7-17. In developing a combined ranking, primary objectives were weighted twice as much as secondary objectives. A lower level of effectiveness does not mean an alternative would be infeasible or that is does not address the specified problems and opportunities.

Table 7-17. Ranked Effectiveness of Alternatives (1 = Highest, 5 = Lowest)

Objective	Rationale	No Action	Alternative A	Alternative B	Alternative C	Alternative D
Primary Objectives						
Water supply	Ranked by increase in deliveries	5	3	4	2	1
Incremental Level 4 refuge supply	Ranked by increase in deliveries	5	4	2	1	3
Anadromous fish	Ranking based on SALMOD results	5	3	4	2	1
Delta water quality	Ranking based on shift in X2	5	2	2	1	4
Secondary Objectives						
Hydropower generation	Ranking based on pump-back generation	5	1	2	3	4
Recreation	Ranking based on visitor-days	Lowest	Equal	Equal	Equal	Equal
Flood damage reduction	Ranking based on acreage	Lowest	Equal	Equal	Equal	Equal
Combined ranking		5	3	4	1	2

SALMOD = a computer model that simulates the dynamics of freshwater salmonid populations
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand

As shown in Table 7-17, Alternative C has the highest effectiveness in meeting all project objectives. It especially excels at delivering water to refuges and releases to the Delta for environmental water quality. Alternative D has a relatively low effectiveness for Delta environmental water quality, but outperforms Alternative C for water supply and providing benefits to salmonids in the Sacramento River.

Efficiency

Efficiency is an evaluation of the cost-effectiveness of each alternative's ability to address the specified problems and opportunities, consistent with protecting the environment. The most efficient measures address the objectives with the least cost. The ranking is consistent with the benefit-cost ratios presented in Table 7-8. In descending order, the alternatives' efficiency in meeting the project objectives are ranked as follows:

- Alternative C (highest)
- Alternative B
- Alternative A
- Alternative D
- No Action

Acceptability

Acceptability considers the acceptability of an alternative to Federal, State, and local entities and the public, as well as its compatibility with existing laws, regulations, and public policies. A measure with less support is not infeasible, but it is less preferred. All alternative plans are compatible with existing laws, regulations, and public policies. No harm to the CVP or SWP is a requirement for acceptability. The ranking of acceptability would be completed after public comments are received during circulation of the Draft Feasibility Report and EIR/EIS. Acceptability will be presented in the Final Feasibility Report, but there is ongoing opportunity for public input throughout the Final EIR/EIS and NOD/ROD process. In addition, acceptability is contingent on a cooperative operating agreement between the Authority, Reclamation, and DWR, with an approved water right from the SWRCB.

Completeness

Completeness is a determination of whether an alternative accounts for all necessary investments or other actions to ensure the realization of the planned benefits.

Table 7-18 provides an evaluation of the completeness of each alternative. One measure of completeness is the ability of the alternatives to respond to drought and climate change without requiring actions by others to maintain the level of benefits. Alternatives C and D are the most complete, reflecting the flexibility of these alternatives to adapt to changing conditions. Alternative C provides more resilience for water quality. Alternative D has more resilience for water supply and anadromous fish.

Table 7-18. Relative Completeness of Alternatives (1 = Highest, 5 = Lowest)

Objective	Rationale	No Action	Alternative A	Alternative B	Alternative C	Alternative D
Primary Objectives						
Dry and Critical year water supply	Ranking based on deliveries	5	3	4	2	1
Dry and Critical year anadromous fish benefits	Ranking based on SALMOD results	5	3	4	2	1
Dry and Critical year water quality benefits	Ranking based on X2 results	5	3	2	1	4
Resilience to climate change	Ranking based on increase in storage	5	2	3	1	1
Combined ranking		5	3	4	1	2

SALMOD = a computer model that simulates the dynamics of freshwater salmonid populations
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand

The alternatives were evaluated and ranked with regard to the four criteria. The score assigned to acceptability will be updated after receiving feedback during the review of the Draft Feasibility Report and the Draft EIR/EIS.

Table 7-19 provides a summary comparison of the No Action Alternative and the action alternatives.

Table 7-19. Summary Comparison of No Action Alternative and Action Alternatives

Alternative	Effectiveness	Efficiency	Completeness	Acceptability	Combined
No Action	5	5	5	TBD	18
A	3	2	3	TBD	11
B	4	3	4	TBD	14
C (NED Plan)	1	1	1	TBD	6
D (Authority)	2	4	2	TBD	9

Alternatives are ranked from 1 to 5, with the best performer receiving a 1.
NED = National Economic Development
TBD = To be determined in the future following public review

Alternative C, the NED Plan, has the best (lowest) combined score. Alternative D has the next best score, primarily due to the support from local interests and consistency with the California Water Bond.

The review of the Draft Feasibility Report will inform the forthcoming acceptability rating.