North-of-the-Delta Offstream Storage Investigation

2013 Progress Report

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

December 2013

ERRATA

Errors in Table 7-1 on Page 7-2 were corrected on 9 January 2014 and the updated table has now been incorporated into this version of the report.

EXECUTIVE SUMMARY

Introduction

The purpose of this Progress Report is to present results to date of the North-of-the-Delta Offstream Storage (NODOS) feasibility studies that are underway by the United States (U.S.) Department of the Interior, Bureau of Reclamation (Reclamation) and State of California Department of Water Resources (DWR) to evaluate the potential benefits of new storage north of the Sacramento and San Joaquin River Delta (Delta) (Figure ES 1). New offstream storage offers the potential to improve the flexibility of the federal Central Valley Project (CVP) and State Water Project (SWP) systems to ensure these systems continue to contribute to the water supply and reliability, water quality, and environmental needs of California and the nation.

Reclamation and DWR are sharing in the costs of the studies and interruptions in state funding have delayed the completion of the feasibility studies. This report responds to the immediate congressional and state interest in the results to date.

The NODOS feasibility studies are being conducted consistent with the 1983 U.S. Water Resources Council (WRC) *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (WRC, 1983).

Study Authorization

Public Law 108-7 states "The Secretary of the Interior, in carrying out CALFED Bay-Delta Program (CALFED)-related activities, may undertake feasibility studies for Sites Reservoir, Los Vaqueros Reservoir Enlargement, and Upper San Joaquin Storage projects. These storage studies should be pursued along with ongoing environmental and other projects in a balanced manner." Public Law 108-361 authorized project-specific "planning and feasibility studies" for both surface and groundwater storage, including Sites Reservoir in Colusa County.

DWR received authorization to study NODOS beginning in 1996 under State of California Proposition 204, The Safe, Clean, Reliable Water Supply Act, which was approved in 1996 and provided funding for feasibility and environmental investigations of offstream storage projects upstream from the Delta.

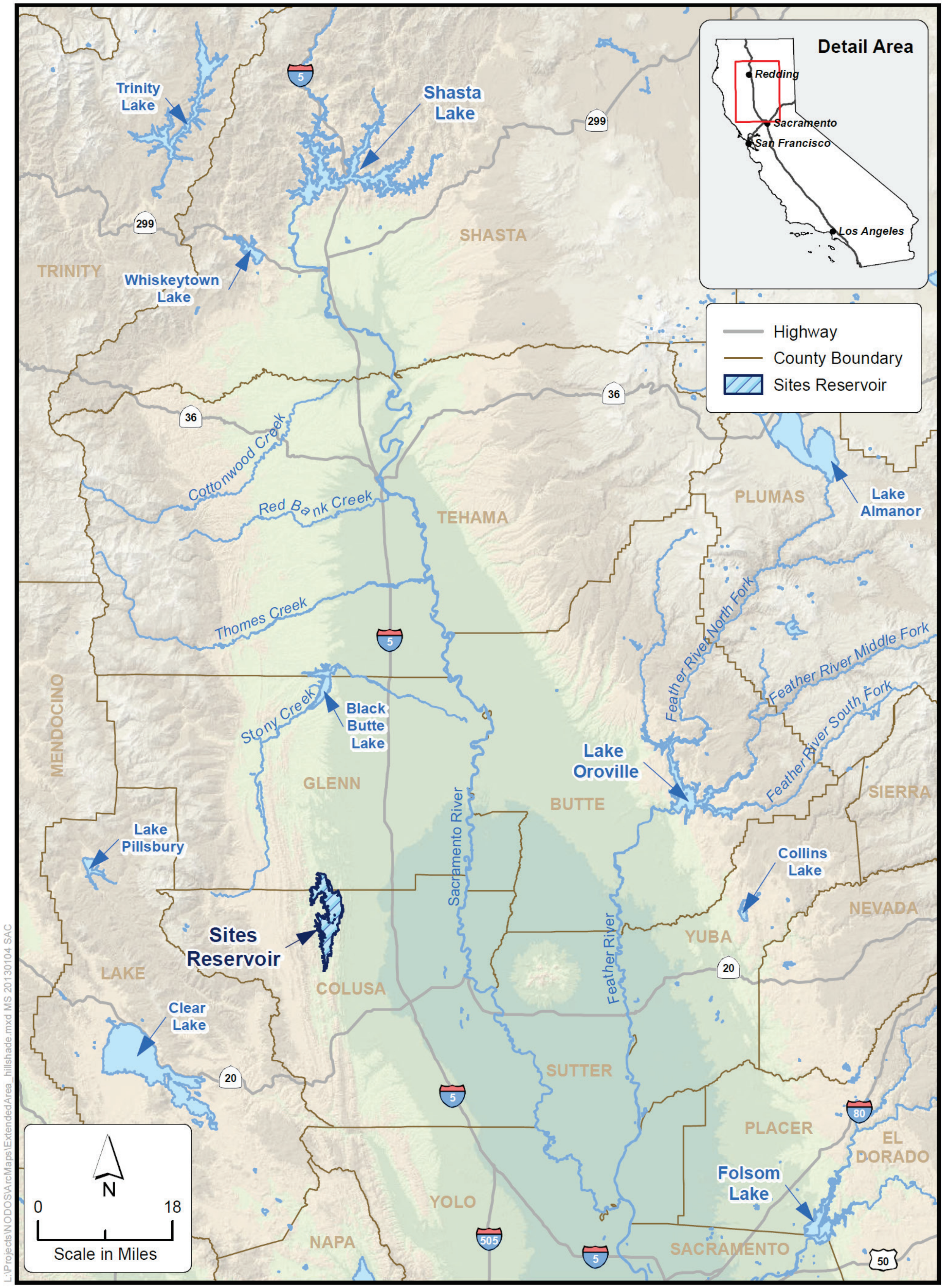


Figure ES-1. Setting for NODOS Feasibility Studies

In addition, the State Budget Act of 1998 authorized DWR to continue feasibility and environmental studies pertaining to the NODOS and alternatives. Subsequent funding was allocated as part of the CALFED Integrated Storage Investigations Program and in November 2002, Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach, Protection Act of 2002, was approved, authorizing funding for surface water storage planning and feasibility studies pursuant to CALFED. State of California Proposition 84, The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Act of 2006, as amended in 2009 and 2012, were approved to provide funding to: ensure that safe drinking water is available to all Californians; protect public from catastrophic floods; protect the rivers, lakes and streams of the state from pollution, loss of water quality, and destruction of fish and wildlife habitat; protect the beaches, bays and coastal waters of the state for future generations; and revitalizing our communities and making them more sustainable and livable by investing in sound land use planning, local parks, and urban greening. NODOS feasibility studies funding is provided from DWR's general fund and from California bond funds.

Limitations of This Report

This Progress Report is being provided to make current information about potential NODOS alternatives available to the public, stakeholders, and decision makers. The lead agencies recognize that several elements of the feasibility studies are incomplete and, thus, not ready for formal public release at this time and no alternative is recommended for implementation. Thus, comments are not being solicited and responses will not be provided on any comments that may be received on this progress report. In the future, when the public Draft Feasibility Report and the related Draft EIR/EIS are published, members of the public will have an opportunity to provide comments.

Project Purpose and Planning Objectives

Need for Study

According to the *California Water Plan Update 2005: A Framework for Action* (DWR, 2005)

> "The biggest challenge facing California water resources management remains making sure that water is in the right places at the right time. This challenge is greatest during dry years: When water for the environment is curtailed sharply, less water is available from rainfall for agriculture and greater reliance on groundwater results in higher costs for many users. In the meantime, those who have already increased water use efficiency may find it more challenging to achieve additional water use reductions."

The challenge is especially acute and consequences are exacerbated during multiple dry years, as evidenced by the 1976-77, 1987-92, and 2007-09 droughts. In 2009, the U.S. Department of Agriculture designated all counties within the San Joaquin River, Tulare Lake, and Central Coast Hydrologic Regions as either Primary Natural Disaster Areas (21 counties) or Natural Disaster Areas (29 counties) because of losses caused by drought.

This lack of water supply reliability is closely linked to a decrease in the flexibility of the operations for the CVP and SWP. The flexibility of the CVP and SWP system has become increasingly constrained by competing demands for water. This trend of increasing constraints threatens the ability of the system to meet water use needs while protecting ecosystems and water quality. The flexibility and adaptive capability of these systems was significant when the projects were first implemented. However, flexibility has diminished over time due to population growth and the recognition of the need for additional environmental water commitments. Additional impacts to flexibility are foreseen as a result of increasing population and potential climate change effects.

As a result of considerations like these, the Preferred Program Alternative in the CALFED Bay-Delta Programmatic Record of Decision (CALFED ROD) identified a need for up to 6 million acre-feet (MAF) of new storage in California, including up to 3 MAF of storage north of the Delta. This report focuses on problems and opportunities for fulfilling part of the recommended 3 MAF of storage north-of-the-Delta.

Purpose Statement for Feasibility Studies

The purpose of the NODOS feasibility studies is to evaluate new offstream surface storage located north of the Delta, consistent with the following planning objectives and constraints.

Improve Water Supply and Water Supply Reliability (Primary Objective)

The NODOS feasibility studies focus on the use of offstream storage to provide increased water supply and improve reliability of water deliveries for municipal, industrial, agricultural, and environmental uses. Water from NODOS can also serve as an alternate source of water to meet the incremental Level 4 refuge supply demands established in the Central Valley Project Improvement Act for maintenance of wildlife refuges. A new offstream reservoir could also supply water in the event of levee failures in the Delta to reduce the effect of highly saline water surging into the Delta.

Increase Populations of Anadromous Fish and Other Aquatic Species (Primary Objective)

Several environmental factors have negatively affected the populations of anadromous fish and other aquatic species in the Sacramento River watershed and throughout the Delta. New offstream storage north of the Delta could benefit anadromous fish and other aquatic species by:

- Improving the reliability of cold-water carry-over storage in Shasta Lake, Lake Oroville, Trinity Lake, and Folsom Lake.
- Providing more frequent releases from Shasta Dam of water with appropriate temperatures to benefit all species and life stages of anadromous salmonids between Keswick Dam and Red Bluff.

- Increasing the availability of coldwater pool storage at Folsom Dam to provide Reclamation with increased operational flexibility to provide suitable water temperatures in the Lower American River.

- Stabilizing fall flows in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD) to minimize dewatering of fall-run Chinook salmon redds.

- Providing increased flows from spring through fall in the lower Sacramento River by changing the seasonal pattern of diversions at Red Bluff to the Tehama-Colusa (T-C) Canal and at Hamilton City to the Glenn-Colusa Irrigation District (GCID) Canal.

- Stabilizing flows in the lower American River to minimize the stranding of fall-run Chinook salmon redds and steelhead redds.

- Providing supplemental Delta outflow during summer and fall months to increase estuarine habitat and improve food availability for anadromous fishes and other estuarine-dependent species. This additional seasonal outflow would result in a more favorable position for X2. (X2 is a Delta management tool, and defined as the distance in kilometers from the Golden Gate Bridge to the locations where the tidally averaged near-bottom salinity in the Delta measures 2 parts per thousand.)

Provide Sustainable Hydropower Generation (Primary Objective)

Hydropower generated at offstream reservoirs can play an important role in development of renewable energy with reduced greenhouse gas emissions. Equipping an offstream reservoir with pumped storage capability facilitates the integration of other forms of renewable energy into the power grid. The project could produce electricity to supply high-peak demands and pump water into the reservoir during periods of low demand when the energy cost is reduced.

Improve Water Quality (Primary Objective)

Agricultural runoff, acid mine drainage, treated wastewater discharges, and urban runoff all affect water quality in the lower Sacramento River. The Sacramento River from RBDD downstream to Knights Landing is listed as an impaired water body by the State Water Resources Control Board.

Improved water quality in the Delta is needed for drinking water, agriculture, and environmental restoration. The Delta system is the diversion point for drinking water for 25 million Californians, and it is critical to California’s agricultural economy. NODOS could improve water quality by providing increased flows of high-quality water during periods when water quality is impaired.

Provide Opportunities for Recreation (Secondary Objective)

The planning of any reservoir north of the Delta provides an opportunity to develop new recreational facilities. Recreation in the immediate vicinity of a new reservoir would include hiking, fishing, camping, boating, and mountain biking.

Provide Flood Damage Reduction (Secondary Objective)

The NODOS Project would provide an opportunity to reduce flooding in local watersheds.

Public Involvement and Outreach

A wide range of public involvement activities have been performed in support of the NODOS feasibility studies. These activities enrich the planning process and meet the requirements of the National Environmental Policy Act (NEPA), Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations), and Presidential memorandum regarding the engagement of federally recognized tribal governments.

Formal scoping was performed from November 2001 to February 2002 and a variety of briefings and tours have been provided periodically to agencies, groups, and individuals who have expressed interest in the project.

The Notice of Preparation (NOP) was filed with the State Clearinghouse, and on November 9, 2001, the federal Notice of Intent (NOI) was published in the Federal Register to inform the public about the feasibility studies and environmental documentation process, consistent with the California Environmental Quality Act and NEPA. The formal scoping process for the NODOS feasibility studiesbegan with the publication of the NOP and NOI and concluded on February 8, 2002. During the 2001-2002 scoping period, one tribal and three public scoping meetings were held. The study team received 57 comments that addressed program alternatives. Some comments were specific suggestions related to the types or range of alternatives, such as water-use efficiency, conjunctive use, land fallowing, wastewater reclamation and recycling, and Shasta Lake enlargement. Others discussed more generally about what alternatives should or should not be developed and the possible benefits/impacts of certain alternatives. The Scoping Report (Reclamation and DWR, 2002) includes a complete summary of the comments received during the scoping period.

Additional opportunities for public involvement and outreach will be provided throughout the remaining feasibility studies stages, including but not limited to:

- Draft Feasibility Report and EIR/EIS (rvw, cmp, hearings)
- Final Feasibility Report and EIR/EIS
- ROD/NOD
- Congressional and State Legislation Actions/ Decision Process

Plan Formulation

Table ES-1 summarizes the objectives for NODOS.

Table ES-1. NODOS Planning Objectives Summary

Primary Objectives
Improve Water Supply and Water Supply Reliability
Increase Populations of Anadromous Fish and Other Aquatic Species
Provide Sustainable Hydropower Generation
Improve Water Quality
Secondary Objectives
Provide Opportunities for Recreation
Provide Flood Damage Reduction

For the NODOS feasibility studies, an iterative planning process consistent with the P&Gs and NEPA/California Environmental Quality Act was used, as shown on Figure ES-2. Initially, feasibility studies efforts focused on defining problems, needs, opportunities, planning objectives, and constraints. The initial phase culminated in the release of the *North-of-the-Delta Offstream Storage Investigation Final Initial Alternatives Information Report* in 2006 (Reclamation and DWR, 2006a).

The second phase of the planning process emphasized identification of management measures and developing combinations of these measures to formulate and screen preliminary alternative plans. The second phase culminated with the release of the *North-of-the-Delta Offstream Storage Investigation Plan Formulation Report* (PFR) in 2008 (Reclamation and DWR, 2008).

The ongoing feasibility studies represent the third phase of the investigation and includes further technical, environmental, economic, and financial analyses. The forthcoming draft report will evaluate the technical, environmental, economic, and financial feasibility of NODOS. It is anticipated that these interim documents and the CALFED Program ROD and Programmatic EIR/EIS will be cited and included by refrence in the forthcoming Draft Feasibility Report and EIR/EIS for NODOS.

Management Measures. The NODOS feasibility studies consider a number of management measures. Management measures are project actions or features that address a specific planning objective. The management measures retained to support the primary and secondary planning objectives include:

- **Water Supply and Supply Reliability (Primary):** Develop new offstream storage (Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, or Newville Reservoir).
- **Water Supply and Supply Reliability (Primary):** Improve water use efficiency, implement additional recycling, and employ water transfers between users to satisfy unmet demands.

This page intentionally left blank

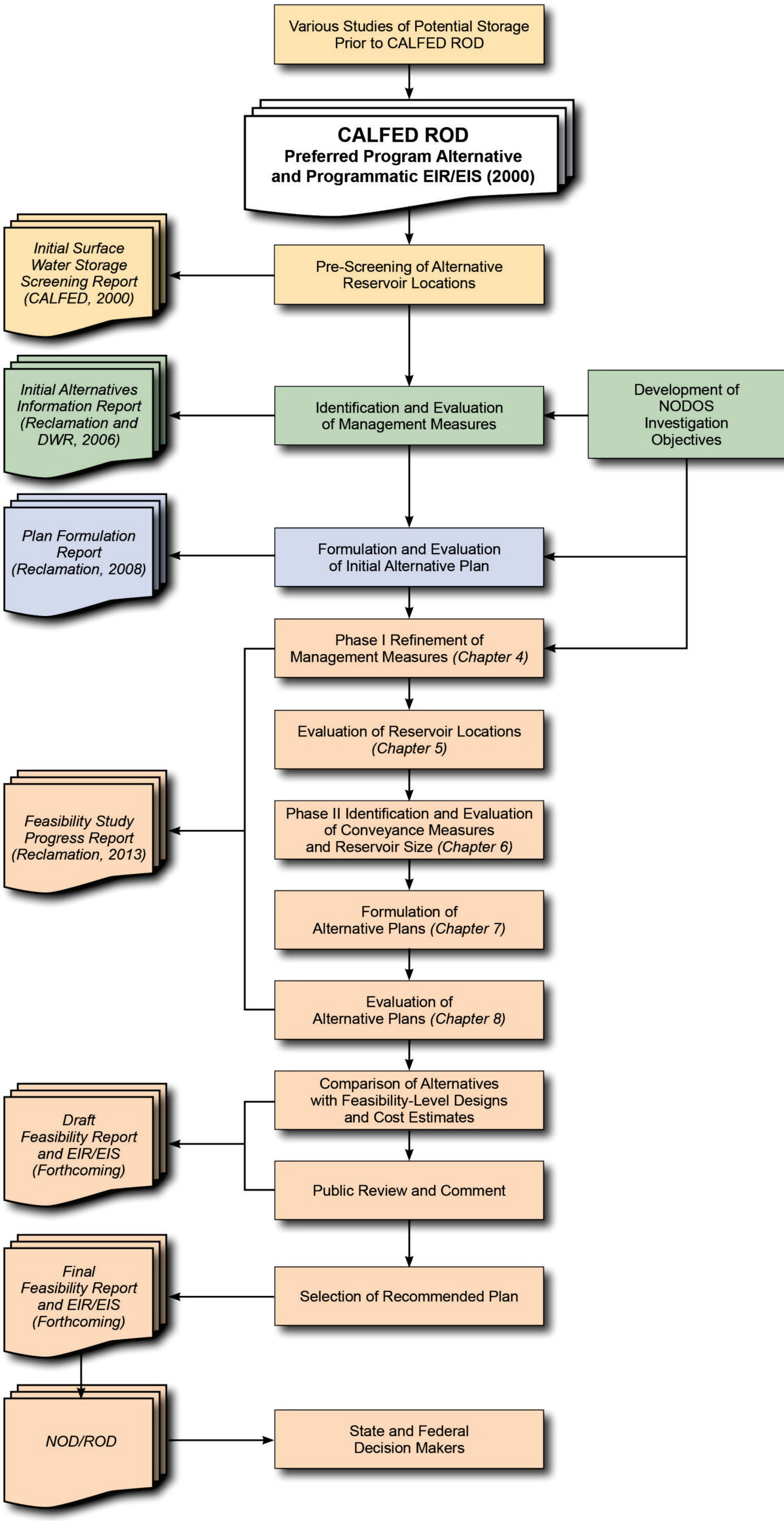


Figure ES-2. Iterative Alternative Formulation Process

This page intentionally left blank

- **Survivability of Anadromous Fish and Other Aquatic Species (Primary):** Improve system flows and temperatures by integrating offstream storage into CVP and SWP system operations.
- **Integrated, Flexible Hydropower Generation (Primary):** Equip offstream reservoir with facilities to enable pump storage operation.
- **Water Quality (Primary):** Increase flows of high-quality water in the lower Sacramento River and Delta through releases from new offstream storage.
- **Recreation (Secondary):** Provide new facilities for recreation adjacent to the new reservoir.
- **Flood Damage Reduction (Secondary):** Provide local flood damage reduction associated with ephemeral streams.

Development of Alternatives

The NODOS feasibility studies consider a wide range of alternatives. The management measures and alternative attributes were evaluated as follows:

- Determining a preferred reservoir location
- Determining the best conveyance system to fill the reservoir and release the water for beneficial uses
- Developing alternatives for the preferred reservoir location and conveyance system to determine the appropriate sizing of the reservoir and the preferred seasonal schedule for operations

These steps are described in further detail in the following sections.

Alternate Reservoir Locations

The geographic scope of analysis for the NODOS feasibility studies was narrowed from the CALFED Program ROD and EIR/EIS (CALFED, 2000a) scope which included an evaluation of 52 potential reservoir locations along with conservation measures and conjunctive use options for the system as a whole. When considering surface water storage, offstream facilities are recommended by CALFED as a way to provide additional storage without creating new barriers to the migration of anadromous fish. The NODOS feasibility studies identified four potential reservoir locations (Red Bank Project, Newville Reservoir, Colusa Reservoir Complex, and Sites Reservoir) located north of the Delta for offstream storage (Figure ES-3).

Evaluation of the four alternative reservoir locations (Table ES-1) determined that the Sites Reservoir location was most capable of meeting the project objectives and satisfies the project purpose for evaluating new offstream storage north-of-the-Delta. Criteria used in this calculation included divertible water supply, total storage, environmental impacts, and approximate cost per acre-foot for storage.

Evaluation of the four alternative reservoir locations (Table ES-2) determined that the Sites Reservoir location was more capable of meeting the project objectives than

Newville Reservoir or the Red Bank Project, largely because of its closer proximity to the Sacramento River and existing infrastructure (the T-C and GCID canals). Sites Reservoir has lower costs and fewer environmental impacts than the larger Colusa Reservoir Complex.

Table ES-2. Evaluation of Potential Reservoir Locations

Reservoir	Conclusions
Colusa Reservoir	• Approximately 3 MAF of storage • Four times the cost of Sites or Newville, but only a 25 percent increase in yield • Impacts more acreage, greater environmental impact
Newville Reservoir	• Approximately 1.9 MAF of storage • Greater impact to cultural resources • More than double the blue oak, wetland, and riparian acreage impacted than for Sites Reservoir • Fall and late fall runs for salmon and steelhead impacted in Thomes Creek
Red Bank Reservoir Complex	• Approximately 3.5 TAF of storage • Includes on-stream facilities, does not meet project purpose for providing offstream storage • Greater impacts to aquatic resources from introducing barrier to migration • Greatest habitat diversity • Potential for reservoir leakage

Table ES-2. (Continued)

Reservoir	Conclusions
Sites Reservoir	• Approximately 1.8 MAF of storage • Fewer environmental impacts than alternative locations • Cost per acre-foot of water is comparable to Newville Reservoir and much lower than Colusa Reservoir • Existing GCID and TCCA canals significantly reduce construction costs and environmental impacts associated with conveyance • Existing GCID and TCCA canals significantly improve the reliability of reservoir filling operations

GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TAF = thousand acre-feet
TCCA = Tehama-Colusa Canal Authority

Alternate Conveyance Systems

An array of 17 conveyance measures for filling and releasing water from Sites Reservoir were identified for consideration and evaluation. Conveyance measures originating from the Sacramento River include the GCID Canal, the T-C Canal, and a new pipeline (called the Delevan Pipeline), as illustrated in Figure ES-4. Tributary source conveyance measures include a new pipeline from the Colusa Basin Drain (CBD) and a new pipeline from Stony Creek originating at the Black Butte afterbay and connecting to the T-C Canal below the City of Orland.

Table ES-3 shows the conveyance management measures recommended for further consideration based on the initial evaluation of costs, ability to meet water quality objectives, and environmental impacts. Conveyance options that used existing conveyance (T-C and GCID canals) greatly reduced the associated environmental impacts. The ability to release water to the Sacramento River via the Delevan Pipeline was extremely important to achieving the primary objective for water quality improvement and significantly improved the performance with respect to all other primary objectives. Neither the CBD nor Stony Creek were as reliable as a source for filling the reservoir as the Sacramento River.

Table ES-3. Conveyance Measures Recommended for Further Consideration

Conveyance Measure	Size
T-C Canal (existing)	2,100 cfs capacity
GCID Canal (existing)	1,800 cfs capacity
Delevan Pipeline (new)	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa

Preliminary Alternatives

Nine initial alternatives (No Project Alternative and eight action alternatives) were developed to address the primary planning objectives, constraints, and criteria, as addressed in the PFR (Reclamation and DWR, 2008). The initial alternatives were based on different themes that incorporated different levels of accomplishing the primary objectives. The evaluation of the initial alternatives helped determine how changing the operations of the NODOS project affected its performance. An approach that balanced the operations to address each primary objective and enhance the project’s benefits was recommended for detailed evaluation.

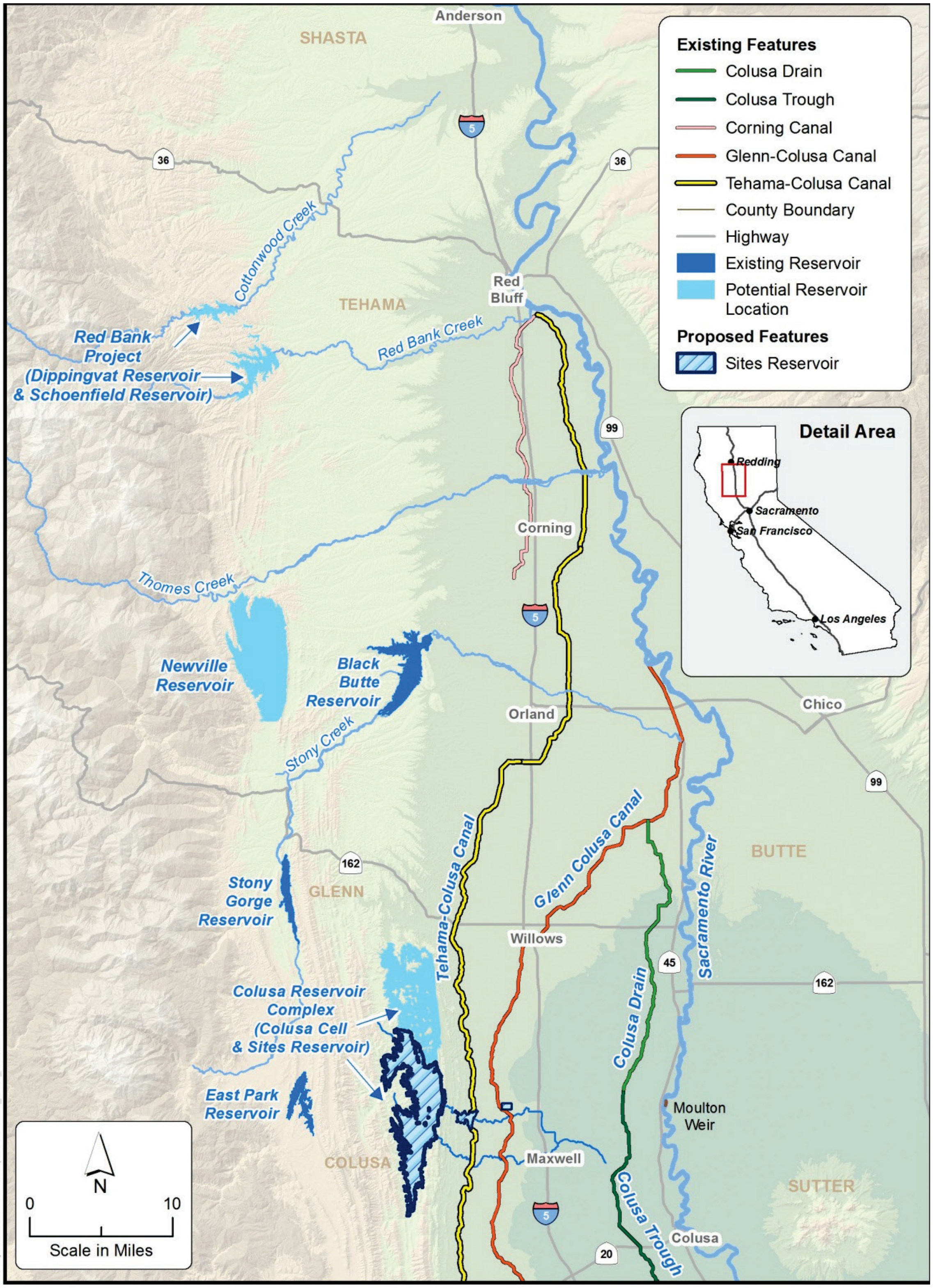


Figure ES-3. Alternative Offstream Locations for NODOS

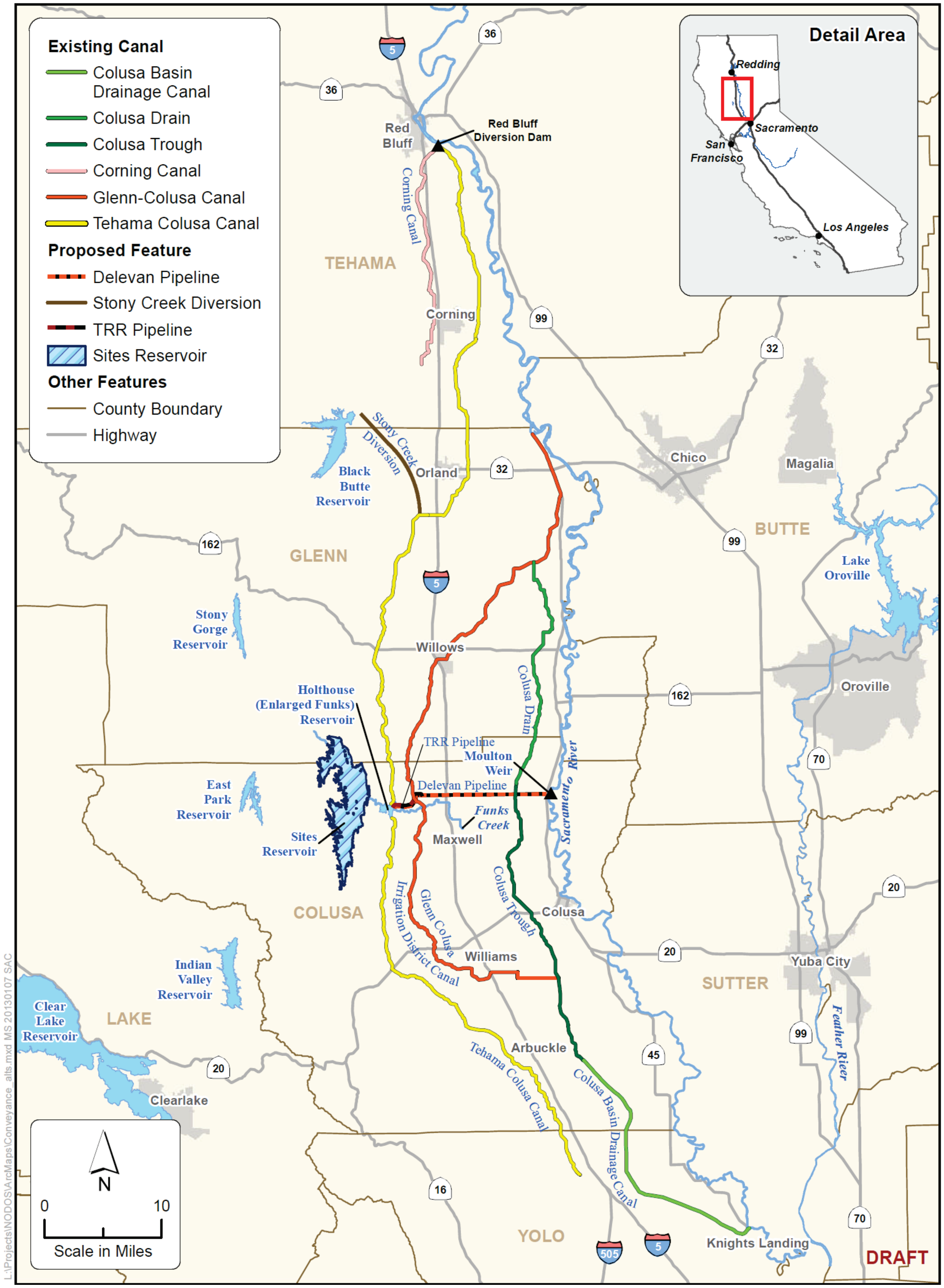


Figure ES-4. NODOS Conveyance Alternatives

No Project Alternative and Alternative Plans

Three plans considered in detail for the forthcoming Draft Feasibility Report and EIR/EIS alternatives and a No Project alternative were developed for detailed evaluation. Each plan addresses, in varying degrees, all of the NODOS planning objectives. The planning horizon for the future conditions is assumed to be 100 years. Each of the alternative plans includes the following measures:

- Developing new offstream storage at Sites Reservoir
- Improving system flows and temperatures by integrating offstream storage into CVP and SWP operations
- Providing an ecosystem enhancement fund to support gravel replenishment, habitat development, and other enhancements in the Sacramento River watershed between the Feather River and Keswick Dam
- Providing pump storage capability to support the integration of hydropower generated at the reservoir with renewable energy opportunities
- Increasing flows of high-quality water in the lower Sacramento River and Delta through releases from Sites Reservoir
- Providing new facilities for recreation adjacent to the new reservoir
- Providing local flood damage reduction associated with ephemeral streams

No Project Alternative: Under the No Project Alternative, reasonably foreseeable actions would be implemented, but new storage north of the Delta would not be developed to improve water supply, enhance the survivability of anadromous fish, improve drinking water quality in the Delta, or improve flexible hydropower generation. Reasonably foreseeable actions include actions that are currently authorized, have secured funding for design and construction, and for which environmental permitting and compliance activities are substantially complete (see Chapter 6). The No Project Alternative provides a basis of comparison for evaluating the potential benefits and effects of the alternative plans.

Small Reservoir with New Diversion (Alternative A): Alternative A includes a 1.27 MAF reservoir (Figure ES-5). The smaller reservoir requires fewer (six) saddle dams, and the two main dams (Sites Dam and Golden Gate Dam) would be smaller. Because the smaller reservoir would have a lower water surface elevation (WSE), less hydropower could be generated at the Sites Pumping/Generating Plant under Alternative A. Water would be conveyed to the reservoir using the existing T-C and GCID canals and through the Delevan Pipeline. The Delevan Pipeline Intake/Discharge Facilities include a new screened intake capable of pumping up 2,000 cubic feet per second (cfs) from the Sacramento River and releasing up to 1,500 cfs back to the river. The Delevan Pipeline Intake/Discharge Facilities also include hydropower generation capability. Alternative A also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Large Reservoir with Existing Diversions (Alternative B): Alternative B provides 1.81 MAF storage capacity (Figure ES-6). The larger reservoir requires more (nine) saddle dams, and the Sites Dam and Golden Gate Dam are larger than they are under Alternative A. The resulting higher surface water elevation supports a higher hydropower generation capacity for the Sites Pumping/Generating Plant. Water would be conveyed to the reservoir using only the T-C and GCID canals. The Delevan Pipeline allows the release of up to 1,500 cfs back to the Sacramento River, but no new intake facility is provided to divert water from the river at this location. As a result, more water would be diverted at the existing facilities near Red Bluff (T-C Canal) and Hamilton City (GCID Canal). With only two diversion points, the reservoir would be more challenging to fill and have a lower average WSE. Also, there is no hydropower generation at the Delevan Pipeline Discharge Facility. Alternative B also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Large Reservoir with New Diversion (Alternative C): Alternative C provides 1.81 MAF storage capacity. The larger reservoir requires more (nine) saddle dams, and the Sites Dam and Golden Gate Dam are larger than they are in Alternative A (Figure ES-7). The resulting higher surface water elevation supports a higher hydropower generation capacity for the Sites Pumping/Generating Plant. Water would be conveyed to the reservoir using the T-C and GCID canals and the Delevan Pipeline. The Delevan Pipeline Intake/Discharge Facilities include a new screened

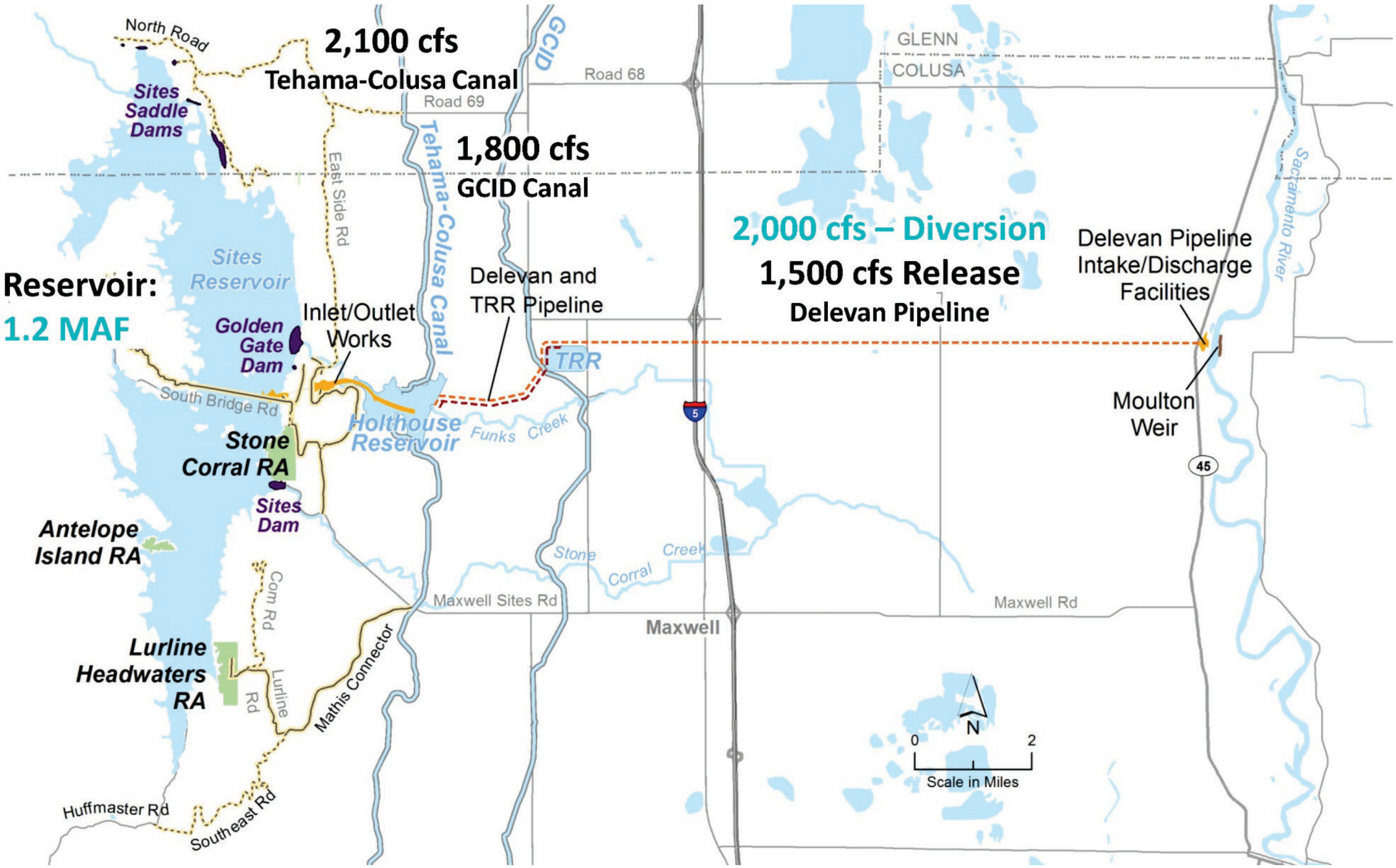


Figure ES-5. Features of NODOS Alternative A

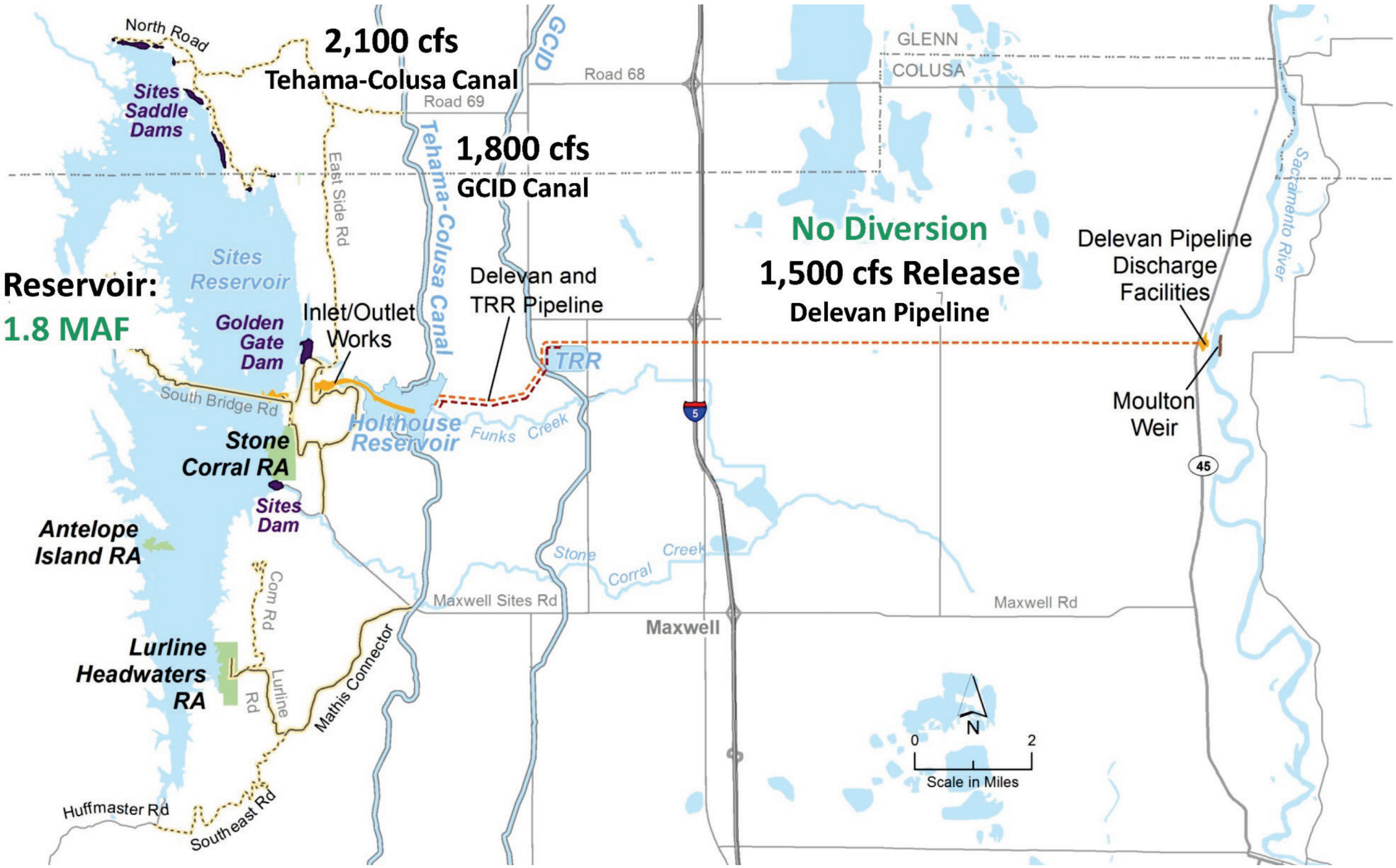


Figure ES-6. Features of NODOS Alternative B

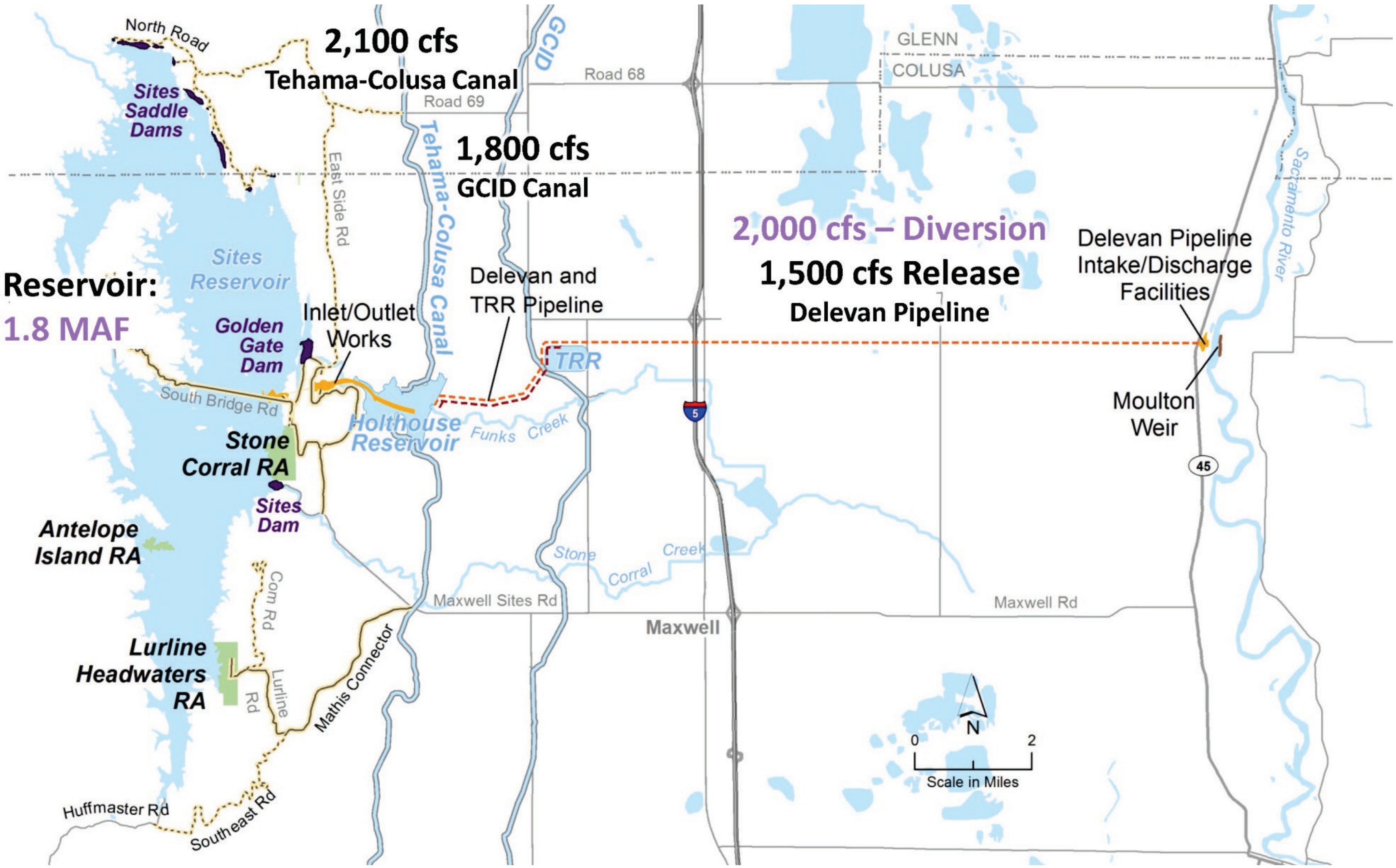


Figure ES-7. Features of NODOS Alternative C

intake capable of pumping up 2,000 cfs from the Sacramento River and releasing up to 1,500 cfs back to the river. The Delevan Pipeline Intake/Discharge Facilities also include hydropower generation capability. Alternative C also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Table ES-4 provides a summary of NODOS Alternatives A, B, and C.

Estimated of Potential Project Accomplishments

Each alternative would result in improvements, to varying degrees, to all of the primary and secondary objectives. Table ES-5 provides a summary of the potential benefits of the alternative plans. Figure ES-8 depicts how the additional water would be used to accomplish the various project purposes.

Integrating the additional water stored with Alternatives A, B, and C would significantly increase the flexibility of CVP and SWP system operations. More water could be stored on average in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Figure ES-9 shows the potential/estimated increases in long-term average (October through September) and driest periods average (October through September) storage in CVP and SWP reservoirs for the three alternative plans. The additional storage (800 to 1,400 thousand acre-feet) could significantly increase the flexibility of system operations to respond to system needs.

Figure ES-10 conceptually illustrates how the changes in operations under the NODOS alternatives, to varying degrees, would improve conditions for anadromous fish.

Table ES-4. Description of Alternative Plans

Alternative	A	B	C
Storage Capacity			
Sites Reservoir – Storage Maximum Water Surface Surface Area	1.27 MAF 480 feet msl 12,400 acres	1.81 MAF 520 feet msl 14,000 acres	1.81 MAF 520 feet msl 14,000 acres
Conveyance Capacities *(to Sites Reservoir)*			
Tehama-Colusa Canal	2,100 cfs	2,100 cfs	2,100 cfs
Glenn-Colusa Canal	1,800 cfs	1,800 cfs	1,800 cfs
Delevan Pipeline[a] Diversion Release	 2,000 cfs 1,500 cfs	 No Diversion 1,500 cfs	 2,000 cfs 1,500 cfs
Delevan Pipeline and Associated Intake or Discharge Facilities	Sacramento River Pumping/ Generating Plant pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.	Reinforced concrete structure, which would house a flow meter and cone valve and dissipate releases up to 1,500 cfs at the Sacramento River.	Sacramento River Pumping/ Generating Plant plant pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.
Hydropower Generation			
Sites Pumping/Generating Plant Generation Capacity	100 MWs	125 MWs	125 MWs
Operations Priorities *(Primary Planning Objectives)*			
Long-Term *(all years)*	EESA Power[b]	EESA Power[b]	EESA Power[b]
Driest Periods *(drought years)*	M&I	M&I	M&I
Average to Wet Periods *(non-drought years)*	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural
Anadromous Fish Measures *(nonoperational; in addition to ecosystem enhancement-associated operations changes)*			
Establish an Environmental Enhancement Fund	✔	✔	✔

[a] A pump station, intake, and fish screens are not included for the Delevan Pipeline for Alternative B. The Delevan Pipeline would be operated for releases only from Sites Reservoir to the Sacramento River year round.

[b] Includes dedicated pumping/generating facilities with dedicated afterbay/forebay of 6.5 TAF in Holthouse Reservoir (enlarged Funks Reservoir) used for managing conveyance of water between Sites Reservoir and river diversion locations.

cfs = cubic foot per second
EESA = ecosystem enhancement storage account
MAF = million acre-feet
MW = megawatt
M&I = municipal and industrial
msl = mean sea level
TAF = thousand acre-feet

Table ES-5. Summary of Potential Relative Accomplishments of Alternative Plans and Estimates of Preliminary Costs and Benefits

Item/Objective	ALT A	ALT B	ALT C
Reservoir Size (MAF)	1.27	1.81	1.81
New Sacramento River Diversion	Yes	No	Yes
Water Supply and Water Supply Reliability			
Water Supply Increase (TAF/year)	213	213	246
Total Releases from Sites Reservoir (TAF/year)	425	429	488
Increase Water NOD (TAF/year)	37	23	39
Increase Water SOD (TAF/year)	132	118	133
Level 4 Refuge Supply Contribution (TAF/year)	44	72	74
Water Quality			
Water Supply for Water Quality Improvement (TAF/year)	128	136	165
Delta Water Quality – Downstream shift in X2 (July/August) (kilometers)	1.4	1.4	1.7
Anadromous Fish and Other Aquatic Species			
Water Supply for EESA (Average/Dry Year) (TAF/year)	84/91	80/98	77/86
Winter-Run Chinook Egg – Fry Survivability (percent increase from No Project Alternative)	26%	21%	33%
Winter-Run Chinook Fish Production (percent increase from No Project Alternative)	3%	1%	3%
Fall-Run Chinook Fish Production (percent increase from No Project Alternative)	10%	9%	12%
Flexible Hydropower Generation			
Hydropower Generated Annually (in GWh)	184 to 301	143 to 336	169 to 353
Recreation			
Recreation	Low	Medium	Medium
Flood Damage Reduction			
Flood Damage Reduction (acres)	8,625	8,625	8,625
Benefits			
Annual Benefits ($M)	248	255	276

ALT = alternative
EESA = ecosystem enhancement storage account
GWh = gigawatt-hour
MAF = million acre-feet
NOD = North of Delta
SOD = South of Delta
TAF = thousand acre-feet
$M = 2013 dollars (millions)

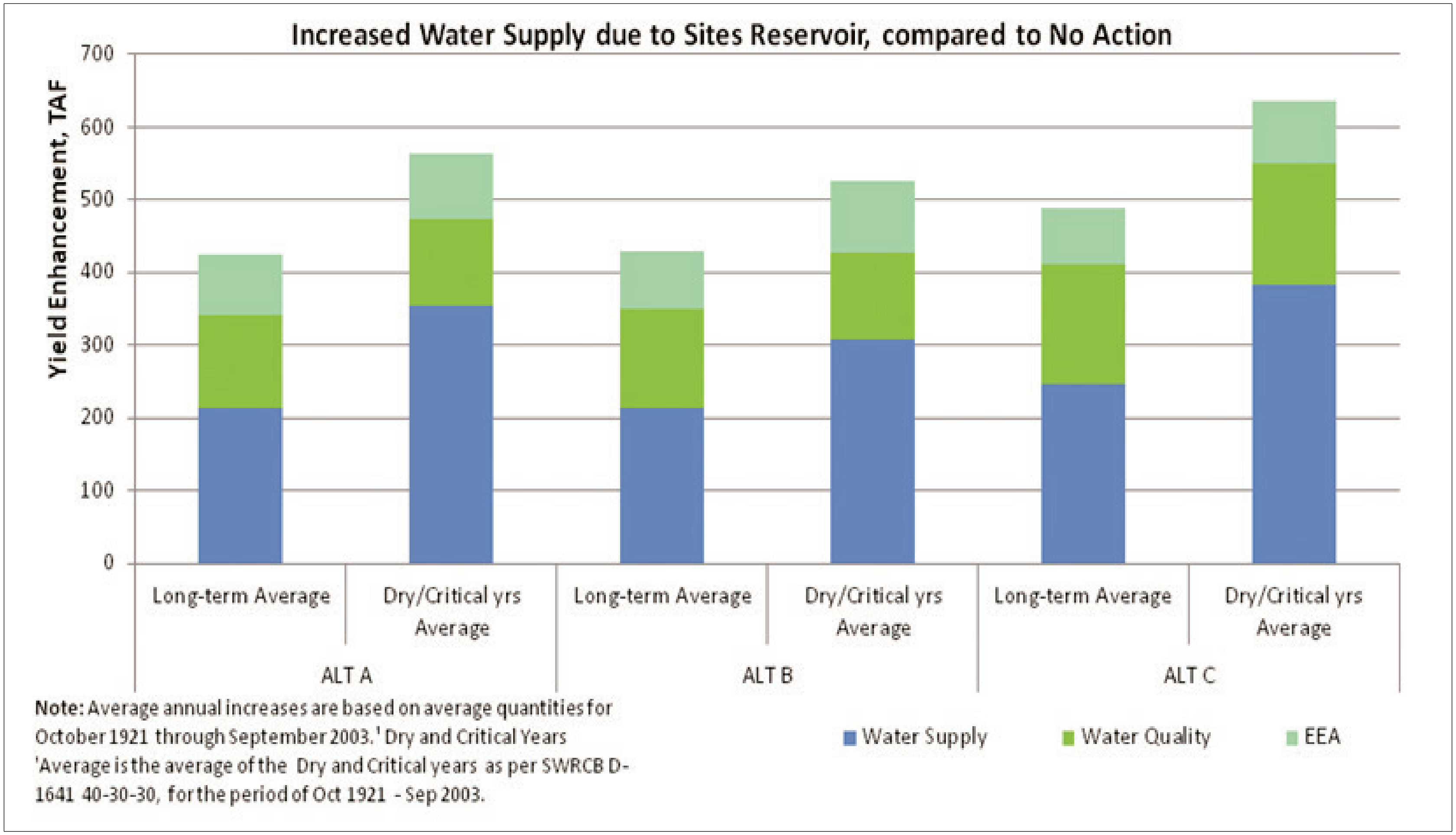
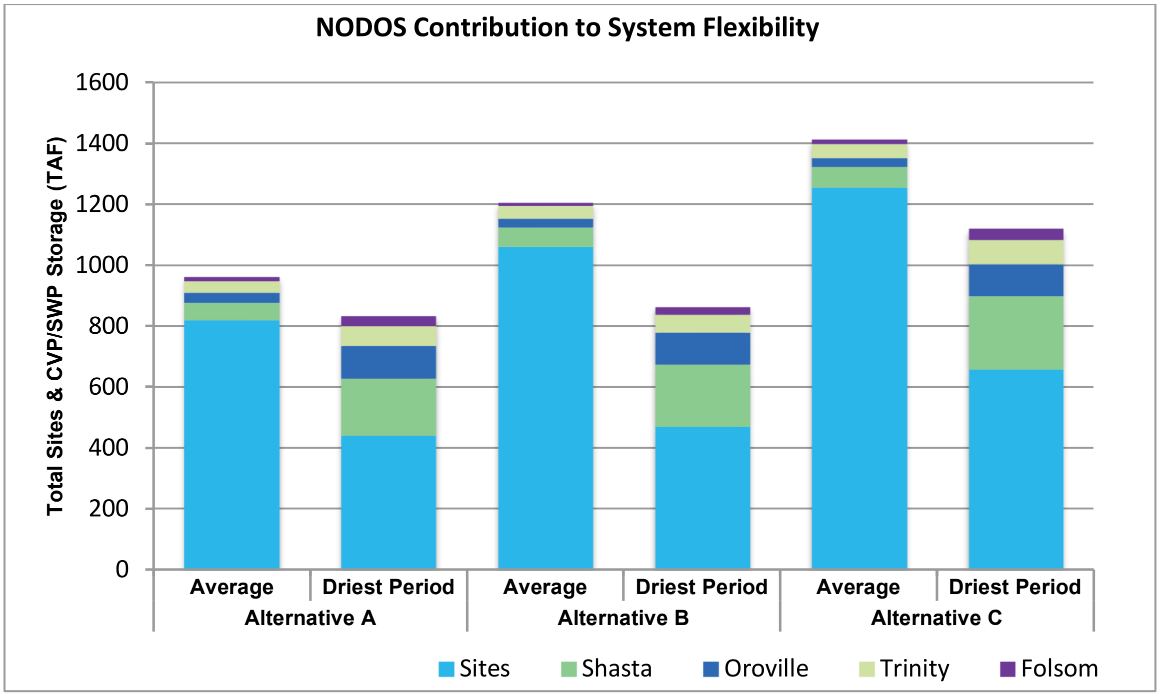


Figure ES-8. Enhancement of Water Supply for Project Purposes Compared to No Project Alternative



Driest periods are essentially the drought years in the 83-year full-simulation sequence (i.e., 1928 to 1934, 1976 to 1977, and 1987 to 1992). These years are designated as multiple year dry sequences, rather than each individual year, as designated by the Indices.

Figure ES-9. Increases in Average System Storage Compared to the No Project Alternative

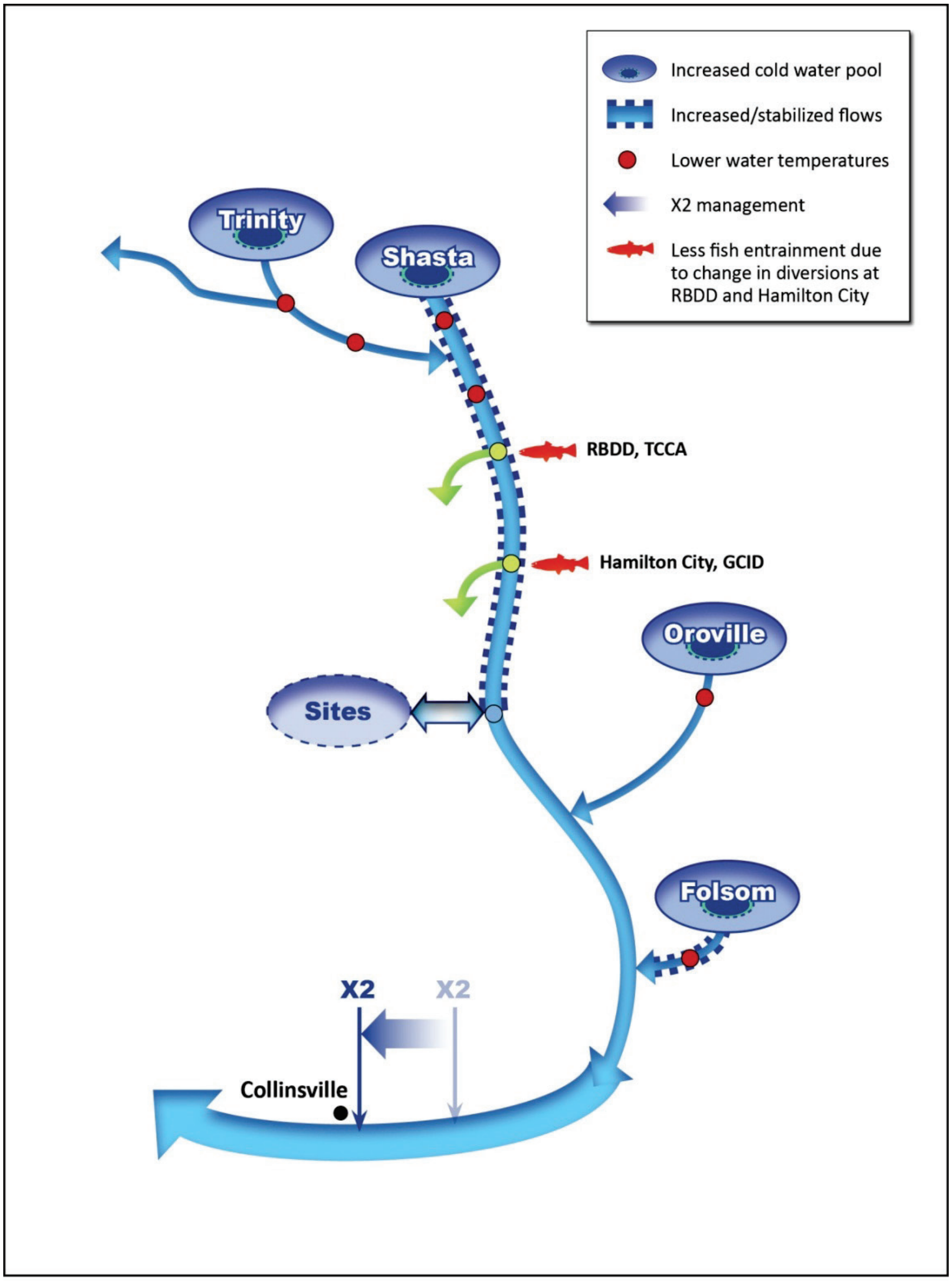


Figure ES-10. Potential Aquatic Enhancement at CVP and SWP Facilities from Implementation of NODOS Alternative Plans

Estimated Benefits

NODOS would provide a variety of benefits in accordance with the primary and secondary objectives. Table ES-6 summarizes the results of the economic benefit analysis.

Table ES-6. Summary of Estimated NED Benefits for NODOS Alternative Plans ($M, 2013 Dollars)[a]

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	$12.7	$7.1	$11.7
Urban	$157.6	$161.1	$167.6
Refuges	$12.5	$20.5	$21.1
Conveyance (CVP/SWP)	($22.9)	($22.3)	($24.8)
Total	$159.9	$166.4	$175.6
Water Quality			
Agricultural	$1.2	$1.4	$1.7
Urban	$18.1	$19.8	$24.0
Total	$19.3	$21.3	$25.7
Ecosystem Enhancement	$46.7	$50.1	$49.3
Hydropower (system)	$20.6[b]	$15.1[b]	$23.5
Recreation	$2.3	$2.3	$2.4
Flood Damage Reduction	$0.0	$0.0	$0.0
Total	***$248.8***	***$255.2***	***$276.2***

[a] Discounted at the federal discount rate of 3.75% over 100 years.
[b] Approximated benefits based on analysis of Alternative C by Toolson and Zhang (2013)

CVP = Central Valley Project
NED = national economic development
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project
$M = 2013 dollars (millions)

Estimated Costs

A feasibility-level design and estimate of probable construction cost is under development for the NODOS alternatives. The Draft Feasibility Report will include and engineering appendix and the estimate of probable construction cost.

This page intentionally left blank

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

LIST OF TABLES

LIST OF TABLES (Continued)

Page

LIST OF FIGURES

Page

LIST OF ACRONYMS

AF	acre-feet
Bay-Delta	San Francisco Bay-Sacramento River and San Joaquin River Delta
BDCP	Bay Delta Conservation Plan
BiOp	biological opinion
CALFED	CALFED Bay-Delta Program
CALFED ROD	CALFED Bay-Delta Programmatic Record of Decision
CALSIM	California Statewide Integrated System Model
CBD	Colusa Basin Drain
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
COA	Coordinated Operations Agreement (for the CVP and SWP)
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
Delta	Sacramento River-San Joaquin River Delta
DDT	dichloro-diphenyl-trichloroethane
District Court	United States District Court for the Eastern District of California
DOI	Department of Interior
DPS	distinct population segment
DWR	California Department of Water Resources
EC	electrical conductivity
ECw	electrical conductivity measurement
EEF	ecosystem enhancement fund
EESA	ecosystem enhancement storage account
EIR	environmental impact report
EIS	environmental impact statement
ELT	Early Long-Term
EQ	environmental quality
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
ESU	evolutionary significant unit
FIA	Flood Insurance Agency
fps	feet per second; foot per second

LIST OF ACRONYMS (Continued)

GCID	Glenn-Colusa Irrigation District
GHG	greenhouse gas
GCM	global climate model
IAIR	Initial Alternatives Information Report
IOS	interactive object-oriented simulation
km	kilometer
kV	kilovolt
LCPSIM	Least-Cost Planning Simulation Model
LLT	Late Long-Term
MAF	million acre-feet
MOU	Memorandum of Understanding
M&I	municipal and industrial
msl	mean sea level
MW	megawatt
NED	national economic development
NEPA	National Environmental Policy Act
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NODOS	North-of-the-Delta Offstream Storage
NOI	Notice of Intent
NOP	Notice of Preparation
OCAP	CVP and SWP Long-Term Operational Criteria and Plan
OMWEM	Other Municipal Water Economics Model
OSE	other social effects
Outreach Plan	NODOS Feasibility Studies Stakeholder Outreach Plan
O&M	operations and maintenance
P&Gs	principals and guidelines (Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies)
PCB	polychlorinated biphenyl
PFR	Plan Formulation Report
PG&E	Pacific Gas and Electric Company
ppt	parts per thousand
RBDD	Red Bluff Diversion Dam
Reclamation	Bureau of Reclamation
RED	regional economic development
RPA	reasonable and prudent alternative
ROD	Record of Decision
ROW	right-of-way

LIST OF ACRONYMS (Continued)

SWAP	Statewide Agricultural Production Model
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
T-C	Tehama-Colusa
TDS	total dissolved solids
TRR	terminal regulating reservoir
U.S.	United States
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VELB	valley elderberry longhorn beetle
Western	Western Area Power Administration
WRC	United States Water Resources Council
WSE	water surface elevation
WSFQ	water supply, fishery, and water quality benefits
X2	A Delta management tool, 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.
°F	degrees Fahrenheit

This page intentionally left blank

CHAPTER 1 INTRODUCTION

This Progress Report for the North-of-the-Delta Offstream Storage (NODOS) feasibility studies presents results to date of the ongoing United States (U.S.) Department of the Interior (DOI), Bureau of Reclamation (Reclamation) and State of California Department of Water Resources (DWR) evaluation of potential benefits of alternative offstream storage projects north of the Sacramento-San Joaquin River Delta (Delta). New offstream storage offers the potential to improve the flexibility of the federal Central Valley Project (CVP) and State Water Project (SWP) systems to ensure these systems continue to contribute to the water supply, water quality, and environmental needs of California and the nation.

This Progress Report is being provided to make current information about potential NODOS alternatives available to the public, stakeholders, and decision makers. The lead agencies recognize that several elements of the feasibility studies are not ready for formal public release at this time and no alternative is recommended for implementation. Thus, comments are not being solicited and responses will not be provided on any comments that may be received on this progress report. In the future, when the Public Draft Feasibility Report is published, all members of the public will have an opportunity to provide comments.

Purpose Statement for Study

The purpose of the NODOS feasibility studies is to evaluate new offstream surface storage located north of the Delta.

Study Authorizations

Congress provided NODOS feasibility studies authority to Reclamation in the Consolidated Appropriations Act of 2003 (Public Law 108-7) and reaffirmed this authority in the CALFED Bay-Delta Authorization Act of 2004 (Public Law 108-361). Public Law 108-7 states “The Secretary of the Interior, in carrying out CALFED Bay-Delta Program (CALFED)-related activities, may undertake feasibility studies for Sites Reservoir, Los Vaqueros Reservoir Enlargement, and Upper San Joaquin Storage projects. These storage studies should be pursued along with ongoing environmental and other projects in a balanced manner.” Public Law 108-361 authorized project-specific “planning and feasibility studies” for both surface and groundwater storage, including Sites Reservoir in Colusa County.

DWR received authorization to study NODOS beginning in 1996 under State of California Proposition 204, The Safe, Clean, Reliable Water Supply Act, which was approved in 1996 and provided funding for feasibility and environmental studies of offstream storage projects upstream from the Delta. In addition, the State Budget Act of 1998 authorized DWR to continue feasibility and environmental studies pertaining to the NODOS and alternatives. Subsequent funding was allocated as part of the CALFED Integrated Storage Investigations Program and in November 2002, Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, was approved, authorizing funding for surface water storage planning and feasibility studies under CALFED. State of California Proposition 84, The Safe Drinking Water, Water Quality and Supply, Flood Control, River and

Coastal Protection Act of 2006, were approved to provide funding to: ensure that safe drinking water is available to all Californians; protect public from catastrophic floods; protect the rivers, lakes and streams of the state from pollution, loss of water quality, and destruction of fish and wildlife habitat; protect the beaches, bays and coastal waters of the state for future generations; and revitalizing our communities and making them more sustainable and livable by investing in sound land use planning, local parks, and urban greening. California funding derives from DWR's general fund and from California bond funds.

NODOS Feasibility Studies Process

An iterative planning process consistent with the 1983 U.S. Water Resources Council (WRC) *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (WRC, 1983) was used to identify and evaluate potential storage alternatives. This process is illustrated in Figure 1-1. The evaluation includes the following:

1. Identify problems, needs, and opportunities (see Chapter 2)

2. Develop planning objectives, and identify planning principles and constraints (see Chapter 3)

3. Identify and evaluate management measures to meet planning objectives (see Chapter 3 and Appendix A)

4. Formulate an array of alternative plans (see Chapters 4, 5, and 6)

5. Evaluate action alternatives and compare to No Project Alternative (see Chapter 7)

6. Define implementation considerations (see Chapter 8)

7. Select a recommended plan, including rationale (still under development)

Scope of Planning Efforts

Previous results of the initial phase of the feasibility studies are documented in the *North-of-the-Delta Offstream Storage Investigation Final Initial Alternatives Information Report* (IAIR) (Reclamation and DWR, 2006a) and in *North-of-the-Delta Offstream Storage Investigation Plan Formulation Report* (PFR) (Reclamation and DWR, 2008).

As shown in Figure 1-1, the emphasis in the planning phases changes as the feasibility studies progress. Initially, emphasis is placed on defining problems, needs, and opportunities and compiling and forecasting future conditions in the Study Area to support the development of planning objectives. The emphasis then shifts to defining management measures and combining them to formulate and evaluate alternative plans.

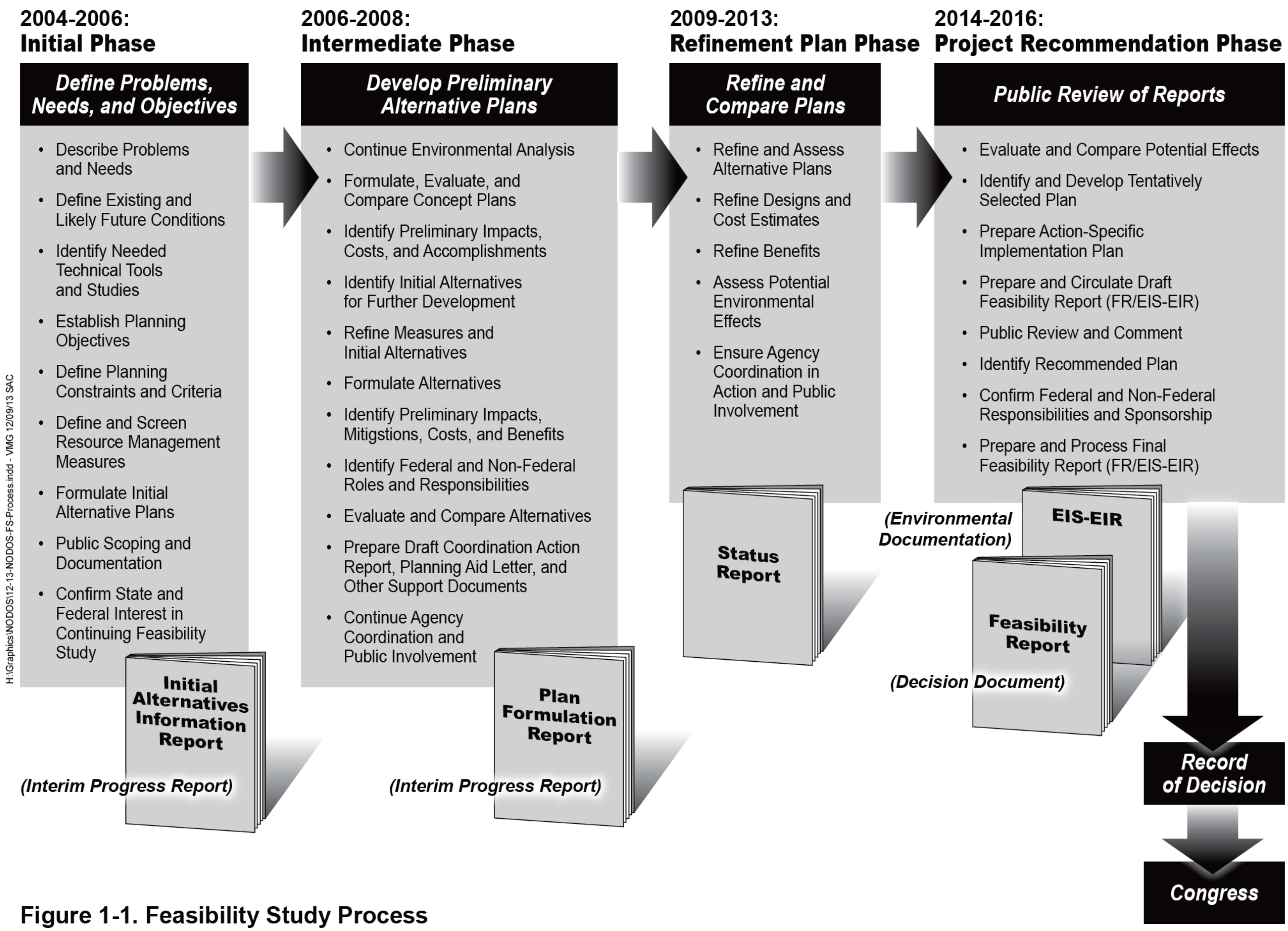


Figure 1-1. Feasibility Study Process

Planning Approach

The feasibility studies are being prepared in coordination with cooperating agencies, other resource agencies, stakeholders and the public. The studies are consistent with the 1983 WRC P&Gs (WRC, 1983). The study is also consistent with the *CALFED Bay-Delta Programmatic Record of Decision* (CALFED ROD) (CALFED, 2000a), which identified five potential surface-water storage projects for further consideration.

CHAPTER 2 PROBLEMS, NEEDS, AND OPPORTUNITIES

Many prior studies have suggested the potential benefits that could be obtained from new storage north of the Delta. In 2001, the CALFED ROD (CALFED, 2000a) identified several problems, needs, and opportunities, including a need to improve:

- Water supply and water supply reliability
- Survival of anadromous fish and other aquatic species
- Water quality

NODOS has the potential to address all of these needs. Levee system integrity for levees in the Delta was also identified as an issue to be addressed in the CALFED ROD; however, NODOS does not significantly affect levees within the Delta.

Public Scoping Process

The P&Gs (WRC, 1983) and the National Environmental Policy Act (NEPA) each require that interested and affected agencies, groups, and persons be provided opportunities to participate throughout the planning process, as stated in the P&Gs, Section IV.1.4.3—specifically, "planning should include an early and open process termed 'scoping' to identify the likely significant issues to be addressed and the range of those issues," as stated in the P&Gs, Section IV.1.4.8, which is complementary with the California Environmental Quality Act (CEQA)/NEPA regulations (40 Code of Federal Regulations Parts 1501.1-1501.8).

For the present study, the initial step in identifying problems, needs, and opportunities specific to the NODOS Project included a public scoping effort to solicit public and stakeholder input. On November 5, 2001, the Notice of Preparation (NOP) was filed with the State Clearinghouse, and on November 9, 2001, the federal Notice of Intent (NOI) was published in the *Federal Register*. The formal scoping process for NODOS began with the publication of the NOP and NOI and concluded on February 8, 2002. During the 2001-2002 scoping period, one tribal and three public scoping meetings were held.

The study team received 57 comments that addressed program alternatives. Some comments were specific suggestions related to the types or range of alternatives, such as water-use efficiency, conjunctive use, land fallowing, wastewater reclamation and recycling, and Shasta Lake enlargement. Others discussed more generally about what alternatives should or should not be developed and the possible benefits/impacts of certain alternatives. The Scoping Report (Reclamation and DWR, 2002) includes a complete summary of the comments received during the scoping period. Additional information on the resolution of scoping comments are available in the Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

Water Supply and Water Supply Reliability

The CVP and SWP are two of the largest water distribution systems in the world. By the time construction of the initial facilities for both systems concluded in the 1970s, the two systems combined to provide significant flexibility for water resources management in California. Much of this flexibility has been lost over the last 30 years due to:

- Increasing use of water within the source watersheds
- Increases in contract allocations
- Increasing requirements and commitments associated with environmental needs (e.g., water to meet the demands of endangered species and wildlife refuge supply commitments)

Potential climate change effects are anticipated to further diminish the ability of these systems to sustain their current levels of water supply.

According to the *California Water Plan Update 2005: A Framework for Action* (DWR, 2005)

> "The biggest challenge facing California water resources management remains making sure that water is in the right places at the right time. This challenge is greatest during dry years: When water for the environment is curtailed sharply, less water is available from rainfall for agriculture and greater reliance on groundwater results in higher costs for many users. In the meantime, those who have already increased water use efficiency may find it more challenging to achieve additional water use reductions."

The challenge is especially acute and consequences are exacerbated during multiple dry years, as evidenced by the 1976-77, 1987-92, and 2007-09 droughts. In 2009, the U.S. Department of Agriculture designated all counties within the San Joaquin River, Tulare Lake, and Central Coast Hydrologic Regions as either Primary Natural Disaster Areas (21 counties) or Natural Disaster Areas (29 counties) because of losses caused by drought.

As a result of considerations like these, the Preferred Program Alternative in the CALFED ROD identified a need for up to 6 million acre-feet (MAF) of new storage in California, including up to 3 MAF of storage north of the Delta.

Water Demand

The *California Water Plan Update 2009: Integrated Water Management* (DWR, 2009a) evaluated three scenarios for water demand changes between 2010 and 2050. The Current Trends and Expansive Growth scenarios without climate change indicate an additional 2 to 6 MAF/year of water would be needed by 2050 to stop groundwater overdraft statewide. The effects of potential climate change have been projected to increase the need for water by another 4 to 9 MAF/year. According to the Current Trends Scenario in the 2009 update, the population in California is expected to grow by 62 percent between 2010 and 2050. The ability of the SWP and CVP to respond to these demands likely would be constrained by existing conveyance facilities, area-of-origin issues, environmental impacts, and other third-party effects.

Table 2-1 provides details on the statewide water balance (surface and groundwater).

Water Supply

The Sacramento River basin's CVP contractors and settlement contractors are subject to dry-year deficiencies and are especially vulnerable to droughts. During extended droughts, decreased surface water deliveries eventually forces water users to use groundwater, if they have this capability, to replace surface water supply or to remove agricultural acreage from production (DWR, 2005). Additional use of groundwater supplies during droughts may result in adverse impacts such as reduced groundwater quality and ground subsidence. Additional adverse impacts on regular users may be caused due to groundwater shortages (DWR, 2005).

During extended periods of drought in the Sacramento River hydrologic region, local water districts that rely exclusively on surface-water supplies would encounter insufficient supplies. The reasons for this insufficiency include allocation cutbacks imposed by their CVP and SWP water contracts, direct diversions that often conflict with the needs of sensitive species, and reduction in the length of the diversion period.

There is growing concern among scientists and water managers regarding the potential impacts of global warming on California's water resources. One of the more considerable impacts identified is related to California's reliance on Sierra and Trinity snowpack storage. Estimates indicate that a rise of 3 degrees Celsius in California would result in the loss of snow at lower elevations, reducing the snowline elevation by as much as 1,500 feet, with a corresponding loss of up to 5 MAF of April 1 snowpack storage (DWR, 2005). As per the *Technical Memorandum Report on Progress on Incorporating Climate Change into Management of California's Water Resources* (DWR, 2006), the state's snowpack is estimated to contribute an average of approximately 15 MAF of runoff each year, approximately 14 MAF of which is estimated to occur in the Central Valley.

The CALFED ROD (CALFED, 2000b) specifically addressed the linkage of surface water storage to the successful implementation of all other elements of CALFED:

> "Expanding water storage capacity is critical to the successful implementation of all aspects of the CALFED Program. Not only is additional storage needed to meet the needs of a growing population, but, if strategically located, it would provide much needed flexibility in the system to improve water quality and support fish restoration efforts. Water supply reliability depends upon capturing water during peak flows and during wet years, as well as more efficient water use through conservation and recycling."

Table 2-1. California Water Balance Summary (MAF)

Statewide	Water Year (Percent of Average Precipitation)							
	1998 (171%)	**1999 (92%)**	**2000 (97%)**	**2001 (72%)**	**2002 (81%)**	**2003 (93%)**	**2004 (94%)**	**2005 (127%)**
Water Entering the Region								
Precipitation[a]	329.6	181.3	187.7	139.2	160.1	184.4	186.5	251.9
Inflow from Oregon/Mexico	2.3	2.4	1.7	1.1	1.1	1.1	1.1	1.0
Inflow from Colorado River	5.0	5.1	5.3	5.2	5.4	4.5	4.8	4.2
Total	**336.9**	**188.8**	**194.7**	**145.5**	**166.7**	**190.0**	**192.4**	**257.2**
Water Leaving the Region								
Consumptive Use of Applied Water (Agricultural, M&I, Wetlands)[b]	22.5	27.6	27.9	27.8	29.3	26.7	29.2	24.4
Outflow to Nevada/Oregon/ Mexico	1.6	1.7	0.9	0.7	0.8	1.1	0.8	1.4
Statutory Outflow to Salt Sink	43.8	51.8	28.0	13.9	29.6	39.8	36.7	37.3
Additional Outflow to Salt Sink	73.0	34.0	37.1	17.7	24.0	29.9	24.7	22.7
Other[c]	190.5	86.3	106.5	99.7	92.7	97.7	114.9	167.6
Total	**331.4**	**201.4**	**200.4**	**159.8**	**176.4**	**195.2**	**206.3**	**253.4**
Storage Changes								
Change in Surface Reservoir Storage	7.2	-4.1	-1.3	-4.6	0.1	3.7	-4.1	7.9
Change in Groundwater Storage[d]	-1.7	-8.5	-4.4	-9.7	-9.7	-8.7	-9.8	-4.1
Total	**5.5**	**-12.6**	**-5.7**	**-14.3**	**-9.6**	**-5.0**	**-13.9**	**3.8**
Applied Water[b]	33.9	41.3	41.8	41.2	43.9	40.6	44.1	38.2

Source: DWR 2009a, Table 4-2 (no data has been made available for subsequent years)

[a] The percent precipitation is based on a running 30-year average of precipitation for the region; discrepancies can occur between information calculated for Update 2009 and earlier published data.

[b] "Consumptive use" is the amount of applied water used and no longer available as a source of supply.

[c] "Other" includes evapotranspiration, evaporation, groundwater subsurface outflows, natural and incidental runoff, agriculture effective precipitation and other outflows.

[d] Change in groundwater storage is based on best available information. Basins in the north part of the state (North Coast, San Francisco, Sacramento River, and North Lahontan Regions and parts of the Central Coast and San Joaquin River Regions) were modeled – spring 1997 to spring 1998 for the 1998 water year and spring 1999 to spring 2000 for the 2000 water year. All other regions and years were calculated.

The Safe, Clean, and Reliable Drinking Water Supply Act of 2010, as stated in Senate Bill 2, Division 26.7, passed in November 2009, mandates the following objectives:

(a) Safeguarding supplies of clean, safe drinking water to California's homes, businesses, and farms is an essential responsibility of government, and critical to protecting the quality of life for Californians.

(b) Every Californian should have access to clean, safe, and reliable drinking water.

(c) Providing adequate supplies of clean, safe, and reliable drinking water is vital to keeping California's economy growing and strong.

(d) Encouraging water conservation and recycling are common sense methods to make more efficient use of existing water supplies.

(e) Protecting lakes, rivers, and streams from pollution, cleaning up polluted groundwater supplies, and protecting water sources that supply the entire state and crucial to providing a reliable supply of drinking water and protecting the state's natural resources.

Over the past decade, protective actions, including the Central Valley Project Improvement Act (CVPIA) and the *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (State Water Resources Control Board [SWRCB], 1995), as well as court decisions restricting water exported from the Delta, have constrained the ability of the CVP and SWP to contribute to statewide water supply reliability.

Water supply and water supply reliability benefits that can be supported directly by NODOS include:

Agricultural water supply reliability:

- Local agricultural water districts
- SWP water contractors
- CVP water contractors

Environmental water supply reliability:

- Sacramento and San Joaquin Valleys incremented Level 4 Refuge water supply

Municipal and industrial (M&I) water supply reliability:

- CVP water contractors
- SWP water contractors

Incremented Level 4 Water Supply for Wildlife Refuges

Each year, Reclamation, and the U.S. Fish and Wildlife Service (USFWS) endeavor to make progress toward the established requirement to supply 555,515 acre-feet (AF) of water to the refuges, pursuant to the CVPIA. This target quantity of water is referred to as full Level 4, and is the amount of water required for optimum habitat development on the refuges.

Full Level 4 water consists of two blocks of water—Level 2 water and incremental Level 4 water. Level 2 water equals 422,251 AF of water that is derived from CVP's annual yield and other sources, and is the average annual amount of water required to maintain wetland habitats at the refuges as they existed in 1989 (Reclamation, 1989). The Refuge Water Supply Program has delivered an average of 364,985 AF of Level 2 water annually since 1993.

Incremental Level 4 water equals 133,264 AF and is the difference between Level 2 and full Level 4. Incremental Level 4 water is supplemental water that is acquired from willing sellers. The amount of Incremental Level 4 water acquired varies from year to year, depending on annual hydrology, water availability, water market pricing, and funding. The Refuge Water Supply Program has acquired an average of 58,401 AF of incremental Level 4 water annually since 1993. After accounting for conveyance losses, the average amount of incremental Level 4 water delivered to the refuges annually is 51,047 AF. The NODOS Project can provide an alternative source for the incremental Level 4 water delivered to the refuges on a consistent basis.

Water Supply Reliability

Water supply reliability is defined as delivering a specific quantity of water with a determined frequency to a particular location at a particular time. It indicates an acceptable level of dependability (e.g., timing) of water delivery to the people receiving it. It is one of CALFED's four primary interrelated objectives. Water supply reliability integrates the water supply elements of storage, conveyance, and quality. Local, regional, California, and federal governments and water suppliers all have a role in assuring water resource sustainability and improving water supply reliability for the existing and future population and the environment.

Water supply reliability is complicated by the need for consistent and expedited delivery of water to downstream environmental, agricultural, and urban users. During prolonged drought, water supplies are less reliable, which increases competition and can lead to conflict between water users. The Delta serves as the diversion point for water supply for 27 million people (Delta Stewardship Council, 2010, http://deltacouncil.ca.gov/water-supply), but it is experiencing an ecosystem crisis where salmon, delta smelt, and other species are all at their lowest recorded levels. New offstream surface storage could provide a means of addressing the competition for water supply in the Delta by capturing water when it is available for use and then releasing it during drier periods.

As competition grows among water users, management of the highly constrained and regulated water system becomes more challenging and complex. The following situations can occur during long or extreme droughts:

- There is an increased reliance on out of basin water transfers.
- Water supplies are less reliable, heightening competition and sometimes leading to conflict among water users.
- Water quality is degraded, making it difficult and costly to bring raw water up to drinking water quality standards.
- Business and irrigated agriculture are adversely affected, jeopardizing California’s economy.
- Ecosystems are strained, putting sensitive and endangered plants, animals, and habitats at risk.
- Groundwater levels decline and many rural residents who are dependent on small water systems or wells cannot access water from their wells.
- The potential for water transfer to out-of-basin areas during times of drought are adversely affected.

Climate change potentially threatens to further reduce water supply reliability throughout California. The northern California mountain snowpack is melting earlier in the spring, and sea level rise along the coast imperils tidally connected fresh water supplies. As the surface storage provided by the natural snowpack decreases, existing reservoir operations would be less able to provide a reliable water supply.

The NODOS feasibility studies focus on the use of offstream storage to provide additional water supply and improve reliability. Water stored in the winter during higher flow conditions in the Sacramento River would be available for use throughout the year or by capturing the earlier runoff that might occur in the form of rainfall rather than snowmelt. In addition, increased storage allows more water to be carried over in storage from year to year. Additional water in an offstream storage reservoir, without additional federal flood capacity constraints, is especially helpful in mitigating the effects of drought or multiple dry years and the potential effects of climate change.

Flexible Water Supply Management

The existing state and federal water systems, SWP and CVP, respectively, are relatively rigid in terms of timing, location, and how water is pumped from the Delta. This lack of flexibility creates difficulty in addressing impacts to the aquatic ecosystem. Runoff varies both seasonally and annually. Urban, agricultural, and environmental water needs create conflicting demands for limited water supplies. Water management flexibility can provide a more rapid response to meeting these demands, but also for unexpected incidents such as Delta levee breaks. Such flexibility could also help meet flow standards for aquatic ecosystem restoration benefits in the Sacramento River and Delta, which is essential to adapt to changing conditions and demands. Strategically located surface storage would provide much needed flexibility in the system for agricultural, environmental, and M&I users.

Survival of Anadromous Fish and Other Aquatic Species

An anadromous fish which hatches and develops in freshwater matures and migrates to spend a large part of its lifecycle in brackish water or saltwater. Its lifecycle is marked by a return to freshwater where it spawns at the location of its origin. Sacramento River system anadromous fish include native species, such as steelhead, North American green sturgeon, and four runs of Chinook salmon, as well as introduced species, such as American shad. Loss of riparian habitat, introduction of non-native predatory fish, the operation of dams and pumping facilities, polluted runoff, and changes in geomorphology have negatively affected the populations of anadromous fish and other aquatic species in the Sacramento River hydrologic region. The following federal or state-listed endangered and threatened fish species are among those affected in the Sacramento River and Delta:

- Chinook salmon – Sacramento River winter-run (Federal and California Endangered Species)
- Chinook salmon – Central Valley spring-run (Federal and California Threatened Species)
- Chinook salmon – Sacramento River fall-run
- Chinook salmon – Sacramento River late fall-run
- Delta smelt (Federal and California Threatened Species)
- Steelhead – California Central Valley (evolutionary significant unit [ESU]) (Federal Threatened Species)
- North American green sturgeon – Southern Distinct Population Segment (DPS) – (Federal Threatened Species)

Biological opinions (BiOps) for the species listed above affect water supply operations.

Non-listed fish species that also may be affected by water operations include:

- Sacramento splittail
- River lamprey
- Pacific lamprey
- White sturgeon

- Striped bass
- American shad

Several non-fish species, such as the bank swallow (California Threatened Species) and western pond turtle (Federal Special Concern Species and California Species of Special Concern), may also be affected by systemwide water operations. These species depend on riparian habitat in the Delta and Sacramento River.

Populations of fish and other species are sensitive to flow. The CVPIA (DOI, 1999) redefined the purposes of the CVP and required the dedication of 800,000 AF annually to the Anadromous Fish Restoration Program, which includes a goal of doubling the population of anadromous fish and the restoration of fish, wildlife, and habitat purposes. In addition, between 368 thousand acre-feet (TAF) and 815 TAF of water normally diverted annually into the Central Valley were redirected to remain as instream flows on the Trinity River. The CVPIA also directed Reclamation to obtain water from willing sellers for use on wildlife refuges identified in the *Evaluation of Groundwater Potential for Incremental Level 4 Refuge Water Supply* (Reclamation, 2004) and the San Joaquin Basin Action Plan [CVPIA Section 340b(d)]. The water to be obtained amounted to approximately 422 TAF of Level 2 water (considered a firm supply to meet current management needs) and 133 TAF of Level 4 water (Reclamation, 2004). This water provides an additional refuge water supply to achieve an optimal supply for full habitat development.

Populations of fish and other species are also sensitive to water temperature. Initially, California reservoirs were kept relatively full, and the cold water released from the hypolimnion (the cold, non-circulating layer of water that lies below the thermocline in a thermally stratified lake) provided cooler water in the summer to downstream reaches. Since the early 1980s, reservoirs have been drawn down further because of increased water demands, resulting in warmer water releases and higher egg mortality rates. The warmer water temperatures have especially harmed winter-run Chinook salmon, which spawn in spring and summer. To address this problem, special modifications were made to Shasta Dam to allow for the release of cooler water from the hypolimnion, even when water levels in the reservoir are drawn down. The CALFED Ecosystem Restoration Program (ERP) included evaluating new sources of water to improve conditions for the spawning, rearing, and migration of myriad fish species in the Sacramento River and the Delta. Further needs exist to reduce the impacts of water diverted from the Sacramento River and to provide cooler water for fish spawning habitat.

Temperatures in the Sacramento River for spawning areas below Keswick Dam must be kept near 56 degrees Fahrenheit (°F) to allow salmon and steelhead incubation and smolt survival. Experts disagree on the range of temperatures that various ESUs of salmon need for survival in different life stages. These requirements are further complicated by the number of different species inhabiting the spawning area and the life stage of each of these species. As an example, Central Valley steelhead have different freshwater incubation and rearing requirements than do several salmon species because steelhead require longer periods in fresh water. Thus, juvenile steelhead may be present in the Sacramento River spawning grounds when fall-run Chinook salmon are beginning to spawn, and each may have independent water supply and water quality needs. Four seasonal runs of Chinook salmon occur in the Sacramento River drainage area, with each run being defined by a combination of adult migration timing and spawning, juvenile residency, and smolt migration periods.

Additionally, facilities, including screens, pumping plants, and forebays/ afterbays, constructed to support water diversions may cause straying or direct losses of fish and can increase the exposure of juvenile fish to predation.

NODOS would change systemwide operations, including operations associated with the Upper Sacramento River, to improve flows for anadromous fish migration and provide cooler water for fish spawning and rearing habitat.

Ecosystem Restoration

As part of CALFED, the ERP developed an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations by recognizing the natural forces that created historic habitats and using these forces to help regenerate habitats. The ERP identified more than 600 programmatic actions to improve ecological health. In addition to ERP, the National Marine Fisheries Service (NMFS) released a proposed Central Valley Salmon and Steelhead Recovery Plan in 2009, which states:

> "The goal of this recovery plan is to ensure the long-term viability of endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and threatened Central Valley steelhead using effective partnerships with regional stakeholders. Recovery plans are not regulatory documents and successful implementation and recovery of listed species would require the support, efforts and resources of many entities, from federal and state agencies to individual members of the public."

The Plan also states that 95 percent of historic spawning habitat has been lost due to dam construction and that there has been a 98 percent loss of riparian and floodplain habitat in the lower river and Delta. It also asserts that only 1 out of 4 historic populations of winter-run salmon remain, 3 out of 8 populations of spring-run salmon remain, and only a few of the 28 populations of steelhead remain. The recovery strategy in the proposed plan describes the following components:

- Prioritize and secure existing populations
- Reintroduce historic habitats
- Reduce ongoing threats to species and restore interconnected habitats

The proposed plan suggests that the following highest priority key actions are necessary for recovery of these species:

- Develop phased reintroduction plans for specific watersheds
- Restore ecological flows throughout the Sacramento and San Joaquin River basins and the Delta
- Develop and implement large-scale Delta Ecosystem Restoration
- Restore ecological function and reduce non-native fish predation
- Implement all phases of the Battle Creek Restoration Program
- Implement the San Joaquin Restoration Program
- Create incentives for statewide water conservation
- Change commercial fishery management to reduce harvest of listed species
- Implement steelhead monitoring

The ecosystem restoration measures considered for NODOS are not restricted to meeting ERP and NMFS objectives; however, implementing the measures in a way that achieves some of these objectives would notably enhance the benefits to fish and other aquatic species. The NODOS planning team identified ERP and NMFS objectives that can be supported by implementing a NODOS Project. The team prioritized actions with input from a Sacramento River Flow Regime Technical Advisory Group, which included environmental advocacy groups, academics, and representatives from federal and state water resource and wildlife agencies. NODOS can benefit anadromous fish and other aquatic species by providing additional flows in the Sacramento River for environmental purposes and increasing the coldwater storage pool at Shasta Lake. Ecosystem restoration actions supported by NODOS alternatives include the following:

- Improve the reliability of cold water carry-over storage at Shasta Lake.
- Increase supplemental flows for cold water releases to the Sacramento River for salmon and steelhead between Keswick Dam and Red Bluff Diversion Dam (RBDD).
- Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at Red Bluff to provide water into the Tehama-Colusa (T-C) Canal and at Hamilton City to provide water into the Glenn-Colusa Irrigation District (GCID) Canal, and by providing supplemental flows from NODOS.
- Improve the reliability of cold water carry-over storage at Folsom Lake and stabilize flows in the American River.

- Stabilize fall flows in the Sacramento River between Keswick Dam and RBDD to minimize dewatering of fall-run Chinook salmon redds, particularly during fall months.

- Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds and steelhead redds, and reduce isolation events of juvenile anadromous salmonids.

- Provide supplemental Delta outflow during summer and fall months to improve X2 (if possible, west of Collinsville, 81 kilometers [km] or approximately 50 miles) and increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fishes and other estuarine-dependent species. (X2 is a Delta management tool, and defined as the distance in km from the Golden Gate Bridge to where the tidally averaged near-bottom salinity measures 2 parts per thousand [ppt].)

- Improve the reliability of coldwater pool storage in Lake Oroville and stabilize flows in the lower Feather River.

Biological Opinions on Project Operations

In December 2008, USFWS issued a BiOp analyzing the effects of the long-term coordinated operation of the CVP and SWP in California (USFWS BiOp). The USFWS BiOp concluded that "the coordinated operation of the CVP and SWP, as proposed, was likely to jeopardize the continued existence of the Delta smelt" and "adversely modify Delta smelt critical habitat." The USFWS BiOp included a Reasonable and Prudent Alternative (RPA) for CVP and SWP operations designed to allow the projects to continue operating without causing jeopardy or adverse modification. On December 15, 2008, Reclamation provisionally accepted and then implemented the USFWS RPA.

In 2009, NMFS issued a BiOp on the effects of the coordinated federal and state project operation. It found that continued project operations would likely jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, Southern DPS of North American green sturgeon, and Southern Resident killer whales. Also, the NMFS BiOp concluded that the long-term coordinated operation of the CVP and SWP, as proposed, was likely to destroy or adversely modify critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead and the Southern DPS of North American green sturgeon. The NMFS BiOp included an RPA designed to allow the projects to continue operating without causing jeopardy to listed species or destruction or adverse modification of critical habitat. Reclamation provisionally accepted the RPAs in the BiOp, conditioned upon the further evaluation and development of the longer-term actions and the components included in those actions.

Both BiOps were legally challenged, and the U.S. District Court for the Eastern District of California (District Court) ruled that Reclamation violated NEPA by failing to conduct a NEPA review of the potential impacts to the human environment prior to provisionally accepting both the 2008 USFWS

RPA and the 2009 NMFS RPA. In separate rulings, the District Court found certain portions of both BiOps to be arbitrary and capricious, and remanded those portions of the BiOp to USFWS and NMFS. USFWS and NMFS have been ordered by the District Court to complete their final BiOps by December 1, 2013, and February 1, 2016, respectively. The District Court ordered Reclamation to complete a Final EIS reviewing the USFWS RPA by December 1, 2013. In a separate ruling, the District Court ordered Reclamation to complete a Final EIS reviewing the NMFS RPA by February 1, 2016.

Flexible Hydropower Generation

Increased hydropower production is needed to increase the production of clean, renewable energy while avoiding or reducing environmental impacts and enhancing the viability of ecosystems. Hydropower can play an important role in developing more sustainable energy supplies with reduced greenhouse gas (GHG) emissions. Policy initiatives promoting renewable energy include:

- Assembly Bill 32 – Requires reductions in carbon dioxide emissions to 1990 levels by 2020.
- Executive Order S-3-05 – Requires reductions in carbon dioxide emissions to 80 percent of 1990 levels by 2050.
- Senate Bill X1-2 – Requires one-third of the State of California's electricity to come from renewable sources by 2020.
- Memorandum of Understanding (MOU) for Hydropower among the Department of Energy, DOI, and the Department of the Army – Requires new hydropower development to be sustainable and take into account the need to maintain healthy river ecosystems. The intent is to harmonize the production of clean, renewable power with a reduction of environmental inputs and enhancement of the viability of ecosystems.
- Regional GHG Initiative and Western Climate Initiative.
- Western Governors' Association Clean and Diversified Energy Initiative.

Opportunities for pumped storage are especially attractive because they facilitate the integration of other forms of renewable energy into the grid. Fossil fuel-powered electrical generating facilities are widely used as peaking or load following resources. The intermittent nature of renewable energy from solar, wind, and some other green technologies often lacks the responsiveness to meet peak demand and follow loads. Peak production generally does not correspond to peak demand and the energy output is highly variable. Pumped storage hydropower complements the intermittent nature of most renewables, firming these resources to provide stable grid operation and reliable supply for customers. The environmental benefits from hydroelectric power primarily arise from the replacement (offset) of fossil fuel generation and the associated GHG emissions.

Pumped storage is a well-established technology. Pumped storage produces electricity to supply high-peak demands by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine. Pumped storage schemes currently provide the most commercially important means of large-scale grid energy storage and improve the daily capacity factor of the generation system. Pumped storage offers the benefits of:

- Capacity Value – Reliability
- Ancillary Services Value – Ability to shift power output or demand
- Avoided Carbon Costs – Reduced GHG emissions
- Clean peak power – Renewable generation (wind and solar power) easily integrated

Pumped storage provides the size (megawatts [MWs] capacity) and discharge duration required for large-scale energy storage. The adaptability and flexibility of pumped storage serves as an ideal operational tool to support the development of additional wind and solar power by:

- Providing reliability and stability of the electric system.
- Providing a quick-start reserve or spinning reserve for load. (Quick-start reserve refers to the ability to go from shut down to full load quickly, spinning reserves are used to meet sudden demands for power.)
- Providing operational area (control regulation).
- Using pumped storage for traditional peak shaving and load leveling. (Peak load leveling refers to the method for reducing the large fluctuations that occur in electricity demand, for example by storing excess electricity during periods of low demand for use during periods of high demand. Peak shaving refers to sending power back to the grid when demand is high.)
- Improving reactive power support, thereby reducing the need for temporary measures.
- Providing minute-by-minute load following.
- Providing fast pick-up, load shedding, and ramping.
- Improving voltage and frequency control within Northern California.
- Providing capacity to guard against future power interruptions from line faults, plant trips, and market forces.

As population increases in the Sacramento Valley and throughout California, demands for electricity will continue to grow. This demand for electricity drives the need for new electrical supplies, such as hydropower, or demand responsiveness programs, such as off-peak pumping at power generating facilities.

Hydropower is most abundant during winter and spring because its existence typically is tied to increased flows on major waterways. A NODOS Project would use power during times of relative abundance and produce relatively clean hydropower during times of high demand (pump back from the reservoir).

Water Quality

Many of California’s streams, lakes, and wetlands are impaired, reducing their ability to support beneficial uses such as municipal supply for drinking, agricultural supply for crop irrigation, habitat for aquatic life and wildlife, and recreation. Some water body impairments are due, in part or entirely, to a lack of adequate flows. Degraded water quality limits the uses of water supply and increases treatment costs.

Agricultural runoff, acid mine drainage, and urban runoff affect water quality in the lower Sacramento River. Flow in the river is generally sufficient to provide significant dilution to prevent excessive concentrations of contaminants except during the driest periods. Nevertheless, the Sacramento River downstream from RBDD to Knights Landing is listed as an impaired water body under Section 303(d) of the Clean Water Act (CWA) for dichloro-diphenyl-trichloroethane (DDT), dieldrin, mercury, polychlorinated biphenyls (PCBs), and unknown toxicity. Constituents of concern between Knights Landing and the Delta include chlordane, DDT, dieldrin, mercury, PCBs, and unknown toxicity (SWCRB, 2010).

Improved water quality in the Delta is needed for drinking water, agriculture, and environmental restoration. Seawater intrusion in the Delta and in coastal aquifers, agricultural drainage, and imported Colorado River water are considered potential causes of increased salinity in all types of water supplies, adversely affecting many beneficial uses. *Our Vision for the California Delta* (Delta Vision Blue Ribbon Task Force, 2008) emphasized the need for California to encourage equitable access to higher-quality water sources and to seek to reduce conflict among water users for diversion from the highest water quality locations. This report also emphasized the importance of meeting water quality standards in both storage and conveyance systems. The composition requirements of each end use vary, but the guiding elements of a Delta water quality “needs assessment” are mercury, selenium, dissolved oxygen, pesticides, toxicity of unknown origin, organic carbon, bromide, and nutrients.

The Delta system is the diversion point for drinking water for millions of Californians, and it is critical to California’s agricultural sector. Typically, the months of April through July are most favorable with respect to the Delta as a source of drinking water. Outflow from natural runoff is usually high enough during this period to push seawater out of the Delta toward the San Francisco Bay. This period is also outside of the peak loading time related to agricultural drainage. Addressing USFWS BiOp and NMFS BiOp requirements for flow and temperature has resulted in a shift in exports from the higher-quality spring months to the typically lower-quality fall months, with the corresponding degradation in delivered water quality.

All Delta fisheries are sensitive to a variety of water quality constituents. For example, delta smelt require a water source with an electrical conductivity measurement (ECw) of less than 12,000 ECw to reproduce, and there is strong opinion that the survival of delta smelt increases as X2 moves past Collinsville and downstream toward San Francisco Bay. SWRCB Decision 1641 (D-1641) requires X2 implementation from February to June to improve habitat protection for fish in the Delta. The intent of the X2 requirement is to maintain adequate transport flows to move delta smelt away from the influence of the CVP/SWP water diversions and into low-salinity rearing habitat in Suisun Bay and the lower Sacramento River. In addition to electrical conductivity (EC) and salinity requirements, the ideal water temperature for delta smelt is 71.6°F, but they cannot survive if water temperatures exceed 77°F. Accordingly, there is a need to provide fresh water of sufficient quality and temperature to meet biological needs, such as those of the delta smelt. The NODOS feasibility studies are evaluating methods to improve water quality by providing increased flows of high-quality water during periods when water quality is impaired. This goal would be achieved by increased releases from other reservoirs and/or releases directly from NODOS to the Sacramento River.

Recreation

The planning of any reservoir north of the Delta provides an opportunity to develop new recreational facilities. Recreation in the immediate vicinity of a new reservoir would include hiking, fishing, camping, boating, and mountain biking. Generally, large metropolitan areas, such as nearby Sacramento, have high demands for water-oriented recreational opportunities. Some of these demands are served by reservoirs on the western slope of the Sierra Nevada. However, as population increases in the Sacramento Valley, demands for flat water, river, and land-based recreation are expected to increase.

Flood-Damage Reduction

Improvements to the water management system may provide opportunities to increase flood protection through better coordination of the reservoirs in the Sacramento Valley region. Even as an offstream reservoir with substantial diversion capabilities, NODOS cannot remove enough water from the Sacramento River during high-flow events to meaningfully affect flood damage reduction efforts downstream. Rather, NODOS may allow for additional flood reservation storage at other onstream reservoirs within the region. The flood reservation space of Folsom Lake, Lake Oroville, and Shasta Lake could be increased, and the water supply commitments from those onstream reservoirs could be met by NODOS. The Folsom Dam Flood Management Study is currently evaluating the flood management capabilities of Folsom Dam.

Supplemental Flows for Emergency Response

Recent technical studies of the Delta, including the Delta Plan (Delta Stewardship Council, 2013) and *Envisioning Futures for the Sacramento San Joaquin Delta* (Public Policy Institute of California, 2012) indicate the Delta Region, as it exists today, is unsustainable. Seismic risk, high water conditions, sea level rise and land subsidence threaten levee integrity throughout the Delta.

A major earthquake could potentially result in as many as 20 islands in the Delta failing, and flooding simultaneously. While earthquakes pose the greatest risk to Delta Region levees, winter storms and related high water conditions are the most common cause of levee failures in the region. High water conditions have caused approximately 140 levee failures in the Delta over the past 100 years. By the year 2100, Delta levee failure risks due to high water conditions will increase by 800 percent. The risk of levee failure in the Delta due to an earthquake is expected to increase by 93 percent during the same period (DWR, 2009b). Climate change could cause more frequent high water conditions in the Delta [and potentially increase the risk of related levee failure] due to more winter precipitation falling as rain rather than snow. Sea level rise also increases the probability of levee failure.

In the event of a levee failure in the Delta, NODOS would be able to release additional water into the Sacramento River to help mitigate the potential water quality impacts of the levee failure by providing adequate freshwater flows into the Delta to move or help stabilize the intrusion of seawater from San Francisco Bay. The location of the NODOS reservoir equipped with a direct conduit to the Sacramento River would potentially allow the water released from NODOS to reach the Delta within 2 days (Reclamation and DWR, 2008) sooner than water released from Shasta Lake.

This page intentionally left blank

CHAPTER 3 PLANNING OBJECTIVES AND CONSTRAINTS, AND THE ALTERNATIVE DEVELOPMENT PROCESS

Objectives and Constraints

The NODOS feasibility studies include a series of both primary and secondary objectives. The primary objectives are considered essential to developing a viable project and alternatives must meet all of the primary objectives to advance in the evaluation process. Alternatives are developed to effectively and efficiently meet the primary objectives. The development of new offstream storage also provides an opportunity to provide other, secondary benefits. After developing alternatives to meet the primary objectives, the resulting opportunities to achieve the secondary benefits were evaluated.

Planning Objectives

The primary and secondary planning objectives for the NODOS feasibility studies are based on the identified problems, needs, and opportunities. These planning objectives incorporate national andCalifornia-specific goals.

The four primary objectives for the NODOS feasibility studies are:

- **Improve Water Supply and Water Supply Reliability:** By capturing water from the Sacramento River watershed during peak flows and wet years, NODOS would be able to provide additional water supply and improve the reliability of delivering water.

- **Increase the Survival of Anadromous Fish and Other Aquatic Species:** The NODOS alternatives would be managed in a manner that increases the cold water pool in other reservoirs in the Sacramento Basin. The water stored through NODOS would also facilitate increased flows during critical migration periods.

- **Provide Flexible Hydropower Generation:** Releases from a new reservoir would provide an opportunity to generate hydropower, thereby contributing to a more sustainable energy supply. The alternatives will be developed in a manner that facilitates their integration with renewable energy projects, including solar and wind generation.

- **Improve Water Quality:** NODOS would be able to release high-quality water from the Sacramento River watershed during months when flows are typically low and water quality in the Delta is impaired.

The NODOS alternatives are formulated to achieve these four primary objectives and evaluated to assess their effectiveness in achieving these objectives.

The two secondary objectives are:

- **Provide Opportunities for Recreation**: The new reservoir would provide opportunities for lakeside recreation.

- **Flood Damage Reduction**: The dams associated with the new reservoir would provide limited flood protection for the Stone Corral and Funks Creek watersheds, including improved protection for a portion of the City of Maxwell. NODOS would also provide a source for fresh water releases to improve water quality in the event of levee breaches in the Delta.

The NODOS alternatives are not formulated to maximize the secondary objectives, but opportunities to achieve them were included in the alternatives and evaluated to the extent that they are available.

National Goals

The Water Resources Development Act of 2007, specifies that federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

1. Seeking to maximize sustainable economic development
2. Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used
3. Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems

No hierarchal relationship can be specified for these three goals. As a result, tradeoffs among potential solutions need to be evaluated during the decision making process. Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs (WRC, 2013). Public benefits include environmental, economic, and social goals. Both monetary and non-monetary effects can be considered.

California Goals

In addition to the national goals and requirements, California's objective for the feasibility studies is to provide technical and financial information to implementing agencies. Key factors that agencies must consider are whether the NODOS Project can be implemented to assure public health and safety and whether it can provide statewide benefits (e.g., water supply reliability, water quality, ecosystem restoration) at a reasonable cost. In the California process, an EIR is required for project environmental compliance under CEQA and to identify permitting and mitigation requirements. Reclamation and DWR are preparing a joint EIR/EIS for the NODOS feasibility studies.

Planning Constraints

The scope of the feasibility studies process is limited by basic constraints specific to the NODOS feasibility studies, which include the following:

- **Offstream Storage** – By definition and consistent with the CALFED ROD, the NODOS feasibility studies are focused on offstream storage locations. The creation of reservoirs that would interrupt major watercourses and impede the migration of fish are not the subject of this investigation

- **Laws, Regulations, and Policies** – Laws, regulations, and policies that must be considered include, but are not limited to, NEPA, Fish and Wildlife Coordination Act, Clean Air Act, CWA, National Historic Preservation Act, Federal Endangered Species Act (ESA), and California ESA, CEQA, and the CVPIA. The CVPIA of 1992 (Public Law 102-575) influences water supply deliveries, river flows, and related environmental conditions.

- **CALFED ROD** – The CALFED ROD is a general framework for addressing CALFED. It includes program goals, objectives, and projects intended primarily to benefit the Delta system, its tributaries, and areas that receive water supplies exported from the Delta. In addition to the NODOS feasibility studies, the Preferred Program Alternative in the CALFED ROD includes four other surface water and various groundwater storage projects to help meet water supply needs, improve water quality, and improve the ecosystem functions of the Delta system. While the CALFED ROD does not identify NODOS as a specific project to be pursued, the ROD does identify NODOS (the proposed Sites Reservoir) as a project requiring further investigation. Developed plans should, therefore, incorporate the goals, objectives, and programs or projects of the CALFED ROD.

- **Coordinated Operations Agreement and Reallocation of Contract Water Supplies** – The Coordinated Operations Agreement (COA) is a settlement agreement allocating water between CVP and SWP. Federal authorizations for the NODOS feasibility studies focus on CALFED-related storage studies to provide additional supply reliability and water management flexibility to support CALFED objectives. Federal authorizations do not provide authority to reallocate CVP water supplies among the long-term contractual commitments.

Public Outreach Plan

Efforts to engage the public, stakeholders, federally recognized tribes, non-governmental organizations (NGOs), and public agencies in decisions affecting the NODOS Project continue to play an important role in the investigation. These efforts are currently guided by the NODOS Feasibility Studies Stakeholder Outreach Plan (Outreach Plan), and include a broad range of activities designed to accomplish both official and supplementary outreach goals.

The following describes the outreach and coordination approach for the NODOS feasibility studies, the progress of engaging the public in the investigation, and continuing Coordination Team activities in coordinating with stakeholders, federally recognized tribes, NGOs, cooperating agencies, environmental coordination action team, and the public throughout the investigation.

Consistent with CEQA/NEPA, and the federal planning principles, Reclamation and DWR are required to conduct specific outreach activities for NODOS. The Outreach Plan being utilized during the NODOS feasibility studies has relied on activities to support stakeholder engagement with a primary focus on the following objectives:

- Raising awareness of project progress and status, including information on the development of alternatives throughout the NODOS feasibility studies and those currently under consideration
- Clarifying and communicating complex issues associated with the NODOS feasibility studies, including how the project relates to other ongoing water programs
- Providing opportunities for public input at appropriate investigation milestones

Direct Meetings with Stakeholders and the Public

The Coordination Team has met directly with stakeholders, elected officials, NGOs, agencies, federally recognized tribes, and the public throughout the NODOS feasibility studies. This interaction has included formal public meetings, focused meetings with specific stakeholder groups, briefings to elected officials, and tours of the reservoir footprint area. The purpose of this engagement has, and continues to be, aimed at:

- Identifying and engaging the broadest number of stakeholders possible
- Creating and maintaining project transparency by providing project information in a timely and unbiased fashion

Resolving issues and concerns within the parameters of the CEQA/NEPA process

Alternative Development Process

The development of alternatives for the NODOS feasibility studies is an iterative process that was initiated with the CALFED ROD (CALFED, 2000b). The planning process for the NODOS feasibility studies includes three major phases and related milestone products: the NODOS IAIR (Reclamation and DWR, 2006a), the PFR (Reclamation and DWR, 2008), and the forthcoming feasibility studies documentation.

The IAIR documented the first stage in the planning process and identified several features and activities (structural and non-structural), called management measures, which met the planning objectives. The IAIR summarized the preliminary screening for the management measures that focused on the evaluation of potential reservoir locations. Recognizing the limited scope of the IAIR and the iterative nature of the planning process, the PFR developed a more complete evaluation of management measures and the evaluation of a series of initial alternatives. This NODOS Progress Report provides the results to date for the evaluation of refined alternatives.

Figure 3-1 shows the complete process for developing initial alternative plans and the final selection of the recommended plan.

CALFED Evaluation of Alternative Reservoir Locations

CALFED performed an initial evaluation of 52 potential reservoir sites within the larger CALFED solution area (Figure 3-2). Further evaluation took place and is documented as part of the NODOS IAIR.

Specifically, CALFED looked for sites that could contribute substantially to its multiple purpose objectives. These objectives included potential sites that could provide broad benefits for water supply, flood control, water quality, and the ecosystem. CALFED eliminated locations providing less than 0.2 MAF of storage and those that conflicted with CALFED solution principles, objectives, or policies.

Of the 52 surface storage sites, 40 were removed from CALFED's list during the initial evaluation process detailed in the *Initial Surface Water Storage Screening Report* (CALFED, 2000c).

The initial evaluation resulted in the selection of the following 12 surface storage sites for further CALFED consideration:

- Four NODOS alternatives, including the Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, and Newville Reservoir (also known as Thomes-Newville Reservoir)
- In-Delta storage and enlargement of Los Vaqueros Reservoir
- Four South-of-the-Delta storage alternatives, including Ingram Canyon Reservoir, Quinto Creek Reservoir, Panoche Reservoir, and Montgomery Reservoir
- Enlargement of Shasta Lake (Shasta Dam) and Millerton Reservoir (Friant Dam)

Identification and Evaluation of Measures to Address Primary Planning Objectives

Numerous management measures have been identified to address each of the primary planning objectives. The development of measures has been an iterative process. Measures were identified initially in the IAIR (Reclamation and DWR, 2006a) and subsequently refined in the PFR and subsequent feasibility studies process.

Table 3-1 identifies the measures that best address the primary and secondary planning objectives. Measures carried forward best address the objectives for the NODOS feasibility studies, given the consideration of planning constraints and criteria.

The evaluation of NODOS measures included modeling the ability of the system to meet demands under extended dry conditions. Under these conditions, three of the water supply measures (water use efficiency, additional recycling, and water transfers) were found to play a necessary and important role in combination with NODOS to improve water supply reliability. These three measures were evaluated through the use of the Least-Cost Planning Simulation Model (LCPSIM) to assess water supply benefits, rather than by building specific targets for these actions into the No Project Alternative hydrodynamic modeling effort.

Table 3-1. Retained Management Measures

Primary Objectives	Management Measures
Water Supply and Reliability	Colusa Reservoir Complex
	Red Bank Project
	Sites Reservoir
	Newville Reservoir
	Water-use efficiency methods
	Additional recycling
	Transfer water between water users, and source shift (use groundwater in lieu of surface water)
Anadromous Fish Survival	In-stream aquatic habitat downstream from Keswick Dam
	Replenish spawning gravel in Sacramento River
	Improve flows and temperature by integrating a new offstream storage facility into system operations
Integrated, Flexible Generation of Hydropower	Incorporate pumped storage into NODOS Project
Water Quality	Improve water quality by increasing flows to the Delta from new offstream surface storage
Secondary Objectives	**Management Measures**
Recreation	Construct recreation facilities at the new reservoir
	Additional storage in system would increase opportunities for recreation at existing reservoirs
Flood Damage Reduction	Provide local flood-damage reduction benefits

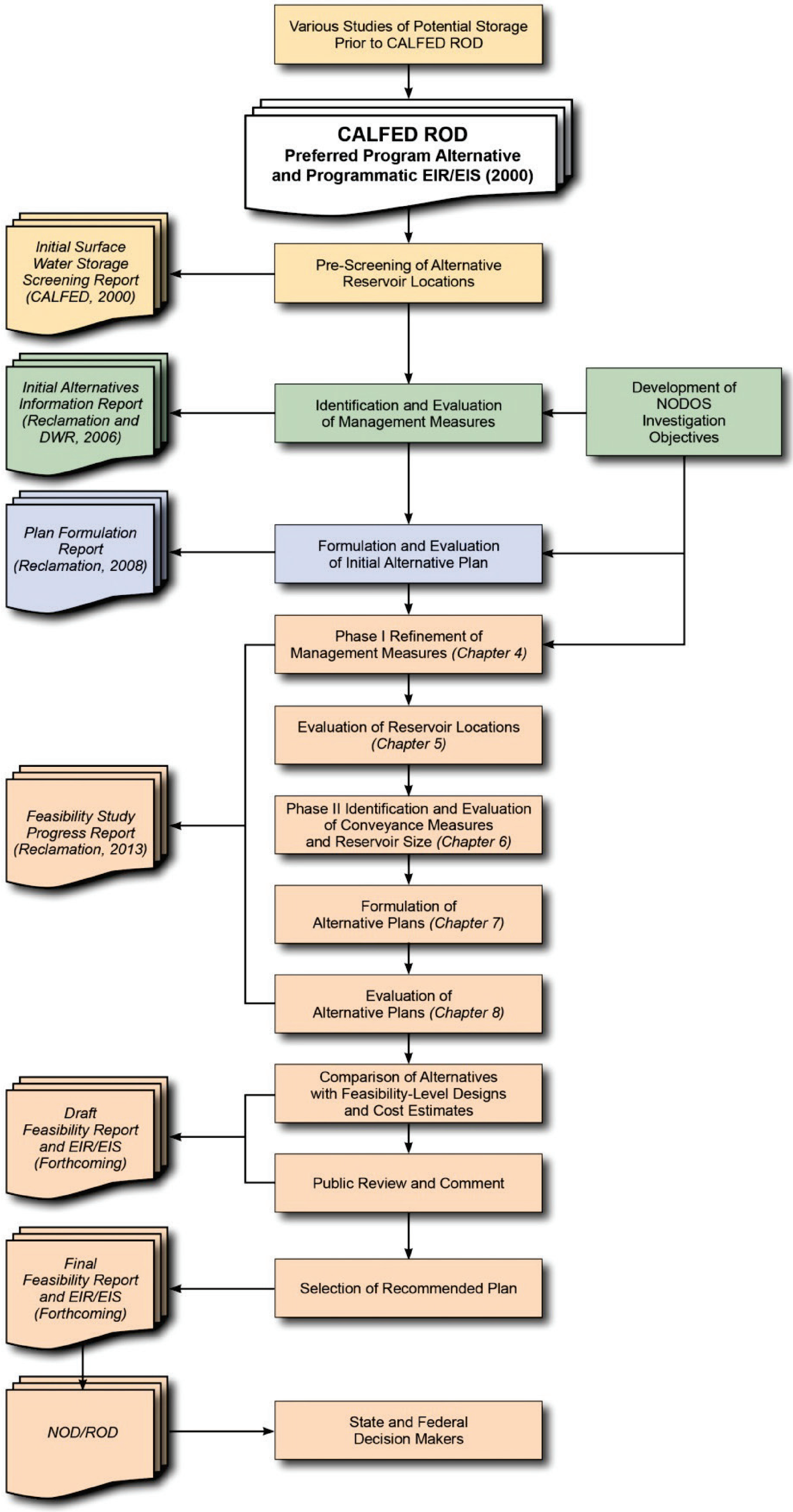


Figure 3-1. NODOS Feasibility Studies Process

This page intentionally left blank

L:\Projects\NODOS\PFR\ArcMaps\NODOSPFR_Figure42_SurfaceStorageComponent.mxd TNC 05.09.2011 SAC

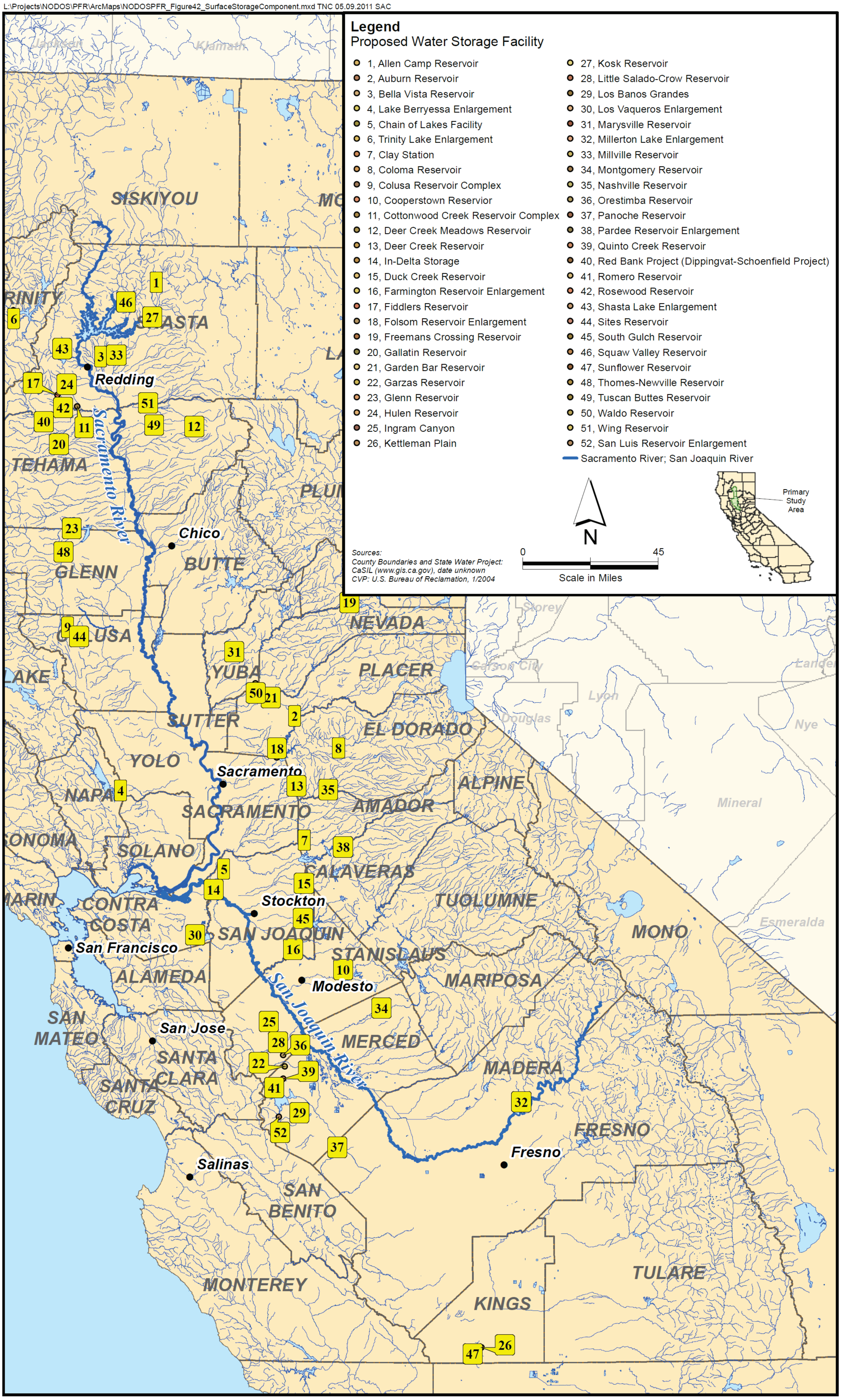


Figure 3-2. Surface Storage Component

This page intentionally left blank

CHAPTER 4 POTENTIAL OFFSTREAM STORAGE LOCATIONS

Initial evaluation activities associated with the CALFED Bay-Delta Program were described in Chapter 3, including an evaluation of 52 potential reservoir locations prior to the CALFED ROD. This section provides additional evaluation for offstream storage locations north of the Delta.

Twelve sites were previously identified by CALFED as promising locations for further evaluation, and the following four north-of-the Delta potential locations were identified as promising offstream storage for further evaluation:

- Red Bank Project
- Newville Reservoir
- Colusa Reservoir Complex
- Sites Reservoir

These proposed sites provide a range of potential water supply reliability benefits, and would also serve similar project purposes.

Reservoir Location Descriptions

Locations for offstream storage evaluated during the NODOS feasibility studies are described below and shown on Figure 4-1.

- **Red Bank Complex** – Red Bank Complex is in northwest Tehama County, approximately 17 miles west of the City of Red Bluff. This reservoir complex would include a diversion on South Fork Cottonwood Creek at Dippingvat Reservoir, two small reservoirs in the headwaters of North Fork Red Bank Creek (Blue Door and Lanyan Reservoirs), and a larger storage reservoir on Red Bank Creek (Schoenfield Reservoir). The South Fork Cottonwood Creek watershed is relatively large (81,900 acres), while the Red Bank Creek watershed is relatively small (27,300 acres). Dippingvat Reservoir would have a normal pool elevation of 1,205 feet and an inundation area of 1,800 acres. Schoenfield Reservoir, with a normal pool elevation of 1,017 feet, would inundate 2,770 acres and have a storage capacity of 0.25 MAF. Both Dippingvat Reservoir and Schoenfield Reservoir would be constructed on perennial streams and be considered onstream facilities.

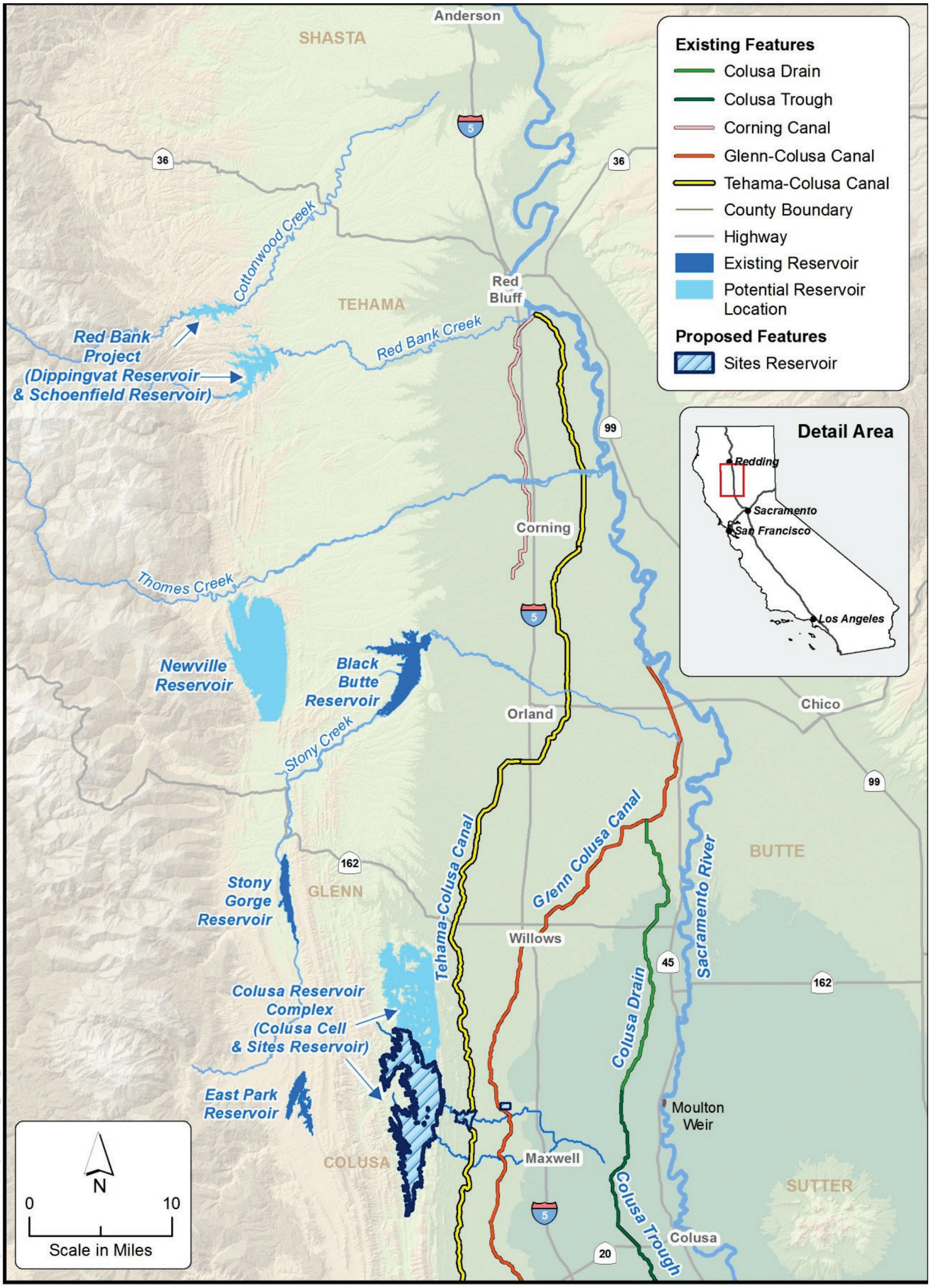


Figure 4-1. Alternative Offstream Locations for NODOS

- **Newville Reservoir** – Newville Reservoir would be situated within north-central Glenn County and south-central Tehama County, approximately 18 miles west of the City of Orland and 23 miles west-southwest of the City of Corning. This proposed reservoir project would be within portions of the North Fork Stony Creek watershed (51,200 acres) and Thomes Creek watershed (123,500 acres), as well as the associated U.S. Geological Survey (USGS) subbasins. A small diversion along Thomes Creek would transfer water to Newville Reservoir in the North Fork Stony Creek watershed. Alternative reservoir sizes of 1.9 and 3.0 MAF are being evaluated, with associated normal water surface elevations (WSEs) of 905 and 980 feet and corresponding reservoir surface areas of 14,500 and 17,000 acres. Newville Reservoir would be upstream from Black Butte Lake. Constructing a dam on North Fork Stony Creek and a small saddle dam at Burrows Gap would form the smaller proposed reservoir. Up to five additional saddle dams and a dike would be required for a 3.0-MAF reservoir alternative. Multiple conveyance options are possible using existing infrastructure, such as canals, new infrastructure, tunnels, and/or pipelines, or a combination of new and existing mechanisms to provide increased flexibility and reliability in the operation of existing and new infrastructure.

- **Colusa Reservoir Complex** – The Colusa Reservoir Complex is located in north-central Colusa County and south-central Glenn County, approximately 12 miles southwest of the community of Willows and 10 miles west of Maxwell. Colusa Reservoir Complex would include the area of the proposed Sites Reservoir and the Colusa Cell. The Colusa Cell would be due north of Sites Reservoir and could be constructed with Sites Reservoir facilities to form a single 28,000-acre reservoir. The inundation area of the Colusa Cell is within Logan Creek and Hunter Creek watersheds (35,000 acres), with the associated USGS subbasins. A mean full pool elevation of 520 feet would inundate approximately 14,000 acres within the Colusa Cell and could store an additional 1.2 MAF. The maximum storage of the Colusa Reservoir Complex would be 3.0 MAF. The Colusa Cell requires a total of 16 dams. It requires all dams for Sites Reservoir and four additional major dams along Logan ridge: one for Logan Creek and three for Hunters Creek and its tributaries. Colusa Reservoir Complex requires seven saddle dams, compared to the nine required for Sites Reservoir. The Colusa Reservoir Complex would provide greater total storage capacity (up to 64 percent greater storage capacity).

- **Sites Reservoir** – Sites Reservoir is in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the community of Maxwell. Water would be diverted from the Sacramento River to fill the reservoir. The proposed reservoir inundation area includes most of Antelope Valley and the small community of Sites. The reservoir is in the Funks Creek and Stone Corral Creek watersheds (59,700 acres), with the associated USGS subbasins. A mean full pool elevation of 520 feet would inundate 14,000 acres and could store a maximum of 1.81 MAF. Alternative reservoir sizes of 1.27 and 1.81 MAF are under consideration. At 1.27 MAF, six saddle dams and two major dams (Sites and Golden Gate Dams) would be required. At 1.81 MAF, Sites Reservoir would require the construction of two major dams (Sites and Golden Gate Dams) and nine saddle dams along the southern edge of the Hunters Creek watershed. Diversions from the Colusa Basin Drain (CBD), the Sacramento

River, Stony Creek, and local tributaries would provide potential sources of water supply for the Sites Reservoir project.

Initial Evaluation of Potential Locations

Potential reservoir sites for the NODOS feasibility studies were developed and reviewed during study team meetings, field inspections, and outreach for the NODOS feasibility studies.

Because all of the projects are upstream of the Delta and adjacent to the Sacramento River, the types of benefits (such as supplemental yield for various uses and reduced diversions from the Sacramento River during the peak local delivery period) would vary primarily in scale. Table 4-1 compares the project characteristics. Current studies have updated, as needed, to allow comparative evaluation of alternatives.

Physical Environment

All six of the proposed reservoir projects are within the Coast Range foothills along the western edge of the northern Sacramento Valley. Figure 4-1 shows delineation of USGS watersheds and subbasins containing the proposed offstream reservoirs. The acreage of the watersheds or subbasins associated with the reservoirs is shown in parentheses below. Table 4-1 shows the drainage area of the watersheds upstream of the dams. (Acreage of watersheds or subbasins associated with the reservoirs is shown in parentheses in the text following Table 4-1.)

Table 4-1. Comparison of Storage and Watershed Areas

Attribute	Colusa Reservoir Complex	Red Bank Project	Sites Reservoir	Newville Reservoir
Gross Storage (acre-feet)	3,300,000[a]	354,000[a]	1,200,000 to 1,900,000[a]	1,800,000 to 3,000,000[a]
Dead Storage (acre-feet)	100,000	N/A	40,000	50,000
Watershed (acres)	94,700	109,200	59,700	174,700

[a] From Initial Surface Water Storage Screening (CALFED, 2000c).

Topography

The physical topography of the watersheds draining the east side of the Coast Range toward the Sacramento Valley is diverse. The topography ranges from steep, rugged, mountainous terrain within the upper watersheds to rolling foothills in the study areas to relatively flat alluvial terrain as the watersheds enter the Sacramento Valley. Elevations range from less than 40 feet on the valley floor to over 8,000 feet along the Coast Range divide.

- **Colusa Reservoir Complex** – The Colusa Reservoir Complex area is between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. In addition to the inundation area of Sites Reservoir, the proposed Colusa Reservoir would also inundate the valleys associated with both Hunter and Logan Creeks upstream of Logan Ridge. Topographic relief within the inundation area of the Colusa Cell is more varied than within Sites Reservoir and numerous islands would be created from hills greater than 520 feet elevation. The Colusa Cell inundation area would be approximately 10 miles long and 3 miles wide, with a maximum depth of 260 feet. The foothills separating the Colusa Cell from the Sacramento Valley are substantially lower in elevation than those found near Sites, with only a single peak in excess of 1,000 feet elevation. Development of this project would require construction of numerous saddle dams, as a number of areas along the eastern edge of the project are less than the normal pool elevation of 520 feet.

- **Red Bank Project** – The Red Bank reservoir footprint area is highly dissected, rugged, mountainous terrain. The primary drainages (and associated valleys) run from west to east. Linear alluvial terraces are associated with the major drainages and stream gradients are much greater than those found in the other three proposed reservoirs. Topographical relief within the inundation area of the Red Bank Project varies from small areas of relatively flat alluvial terraces to gently rolling terrain to very steep hill slopes ranging in elevation from 780 to 1,200 feet.

- **Sites Reservoir** – The Sites Reservoir footprint area is situated between the Sacramento Valley to the east and the mountainous portion of the Coast Range to the west. A relatively narrow band of steep rolling foothills, approximately 2 to 3 miles wide, separates the proposed reservoir area from the Sacramento Valley. Antelope Valley, the primary inundation area of the proposed Sites Reservoir, lies between this narrow band of foothills and the more mountainous Coast Range. This relatively narrow north-south trending valley is approximately 13 miles long and up to 2 miles wide. Elevation of the Antelope Valley floor ranges from 320 to 400 feet above mean sea level (msl), while the foothills separating the valley from the Sacramento Valley reach a maximum elevation of 1,300 feet. Elevations along the west side of Antelope Valley increase rapidly with several peaks within 2 miles of the valley margin above 2,000 feet.

- **Newville Reservoir** – Newville Reservoir would be located in a large circular valley surrounding the North Fork Stony Creek. Topographical relief within the inundation area of Newville Reservoir is that of gently rolling terrain ranging in elevation from 630 feet to 975 feet elevation. A single steep ridge (Rocky Ridge) separates the Newville Reservoir site from low, rolling foothill areas to the east. Rocky Ridge runs north and south with several peaks above 1,300 feet elevation. Steep, rugged mountains form the western boundary of the reservoir area, with elevations up to 3,000 feet within 2 miles of the reservoir inundation area. The currently preferred diversion on Thomes Creek would be made at a low dam in a steep, narrow, confined reach below Thomes Creek Canyon at approximately 1,035 feet above msl.

Climate and Water Resources

The climate of the watersheds draining into the western Sacramento Valley is typical Mediterranean. Winters are rainy and relatively mild with only occasional freezing temperatures at the lower elevations; summers are comparatively dry and hot. The rainy season normally begins in September and continues through March or April. Rains may continue for several days at a time, but are usually gentle. Summer rains are rare, as are thunderstorms and hailstorms. Thunderstorms occur approximately

10 days per year in the Sacramento Valley, occasionally producing high intensity rainfall of short duration. Most precipitation is associated with migrant storms that move across the area during winter. Snow is the dominant form of precipitation above 5,000-foot elevation and persists on north- and east-facing slopes into the early summer.

Streams draining into the proposed Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, and Newville Reservoir are ephemeral with little or no flow from July through October. However, these streams tend to respond rapidly to significant rainfall events. Flash flooding with substantial overland flow has been observed. Flow recorded at the stream gage on Stone Corral Creek near Sites is representative of the flow variability in these small ephemeral streams. Annual discharge volume varied from zero in 1972, 1976, and 1977 to 39,930 AF in 1963 and averages 6,500 AF. Monthly flow volumes in excess of 15,000 AF have been documented.

The immediate area of the alternative projects has very few groundwater resources. The area is underlain by the Great Valley Sequence rocks and locally by Quaternary terrace deposits. Groundwater is found in fractures in the Great Valley Sequence and in the sands and gravels in the terrace deposits. Springs occur where the terrace deposits terminate or where water-bearing fractures encounter the surface. A number of springs also occur in the Great Valley Sequence rocks where faults create subsurface dams that cause groundwater to reach the surface. Not all fractures or faults contain groundwater. Nor do all terrace deposits have groundwater.

Hydrology of Optional Water Supplies

Flows of various nearby streams were evaluated to determine the quantity of water that could be diverted to storage in the four alternative project locations.

First, historical flows of streams were reviewed to provide a preliminary assessment of the relative scale of available water in a given stream.

Second, historical flows were subjected to local and downstream operational constraints to determine the divertible flow. Local operational constraints include instream flow requirements of the source stream, limitations related to the operations and water rights of existing local water supply projects, and existing or proposed diversion and conveyance facility capacities. Downstream operational constraints include lower Sacramento River flow requirements and requirements in the Delta.

Optional Water Supply Sources

Table 4-2 shows the optional water supply sources considered for the NODOS alternatives. Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, and Newville Reservoir each have a number of optional water supply sources. These sources may be packaged in various combinations to generate sufficient water supply for a specific project. The Red Bank Project is unique because there is only one major water supply source being considered for diversion and storage. The six optional sources are the same for Colusa Reservoir Complex and Sites Reservoir. Newville Reservoir has three optional water supply sources. Local inflow sources are not shown, but each offstream project would receive some local inflow from the relatively smaller ephemeral streams that flow directly to the offstream reservoirs.

Table 4-2. Optional Water Supply Sources for NODOS Projects

Colusa Reservoir Complex	Red Bank Project	Sites Reservoir	Newville Reservoir
• Colusa Basin Drain • Grindstone Creek • Little Stony Creek • Sacramento River • Stony Creek • Thomes Creek	• South Fork Cottonwood Creek	• Colusa Basin Drain • Grindstone Creek • Little Stony Creek • Sacramento River • Stony Creek • Thomes Creek • Funks Creek[a] • Stone Corral Creek[a]	• Sacramento River • Stony Creek • Thomes Creek

[a] These creeks do not provide significant flow to fill Sites Reservoir.

Streamflow records were reviewed to determine the relative quantity of water that has historically flowed in various streams. While existing local and downstream constraints were assumed, no analysis was made as to the availability of water rights (more thorough analysis is embedded in the subsequent modeling effort discussed in Chapters 7 and 8). Table 4-3 shows November through March streamflow volumes at representative locations for the period 1945-1994. Figure 4-2 shows the location of waterways listed in Table 4-3. The November through March period was chosen to avoid any operational conflicts with existing facilities and water rights. Local irrigation operations often begin in April and conveyance facilities are being used for deliveries. Most of the data shown are directly from gage station streamflow records. A number of the data records needed to be extended or adapted using basic hydrologic correlations. Correlations for the entire period of record were required for Grindstone Creek, inflow to East Park Reservoir, South Fork Cottonwood Creek, North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, Beegum Creek, Cold Fork Creek, Hensley Creek, Dry Creek, and Jerusalem Creek.

Table 4-3. November – March Streamflow Volumes, 1945-1994 of Optional Water Supply Source Streams

Source and Location	Minimum (MAF)	Maximum (MAF)	Average (MAF)
Sacramento River at Butte City	1.613	14.415	5.4607
Whiskeytown Reservoir at Keswick Reservoir[a]	0.541	1.297	0.937
Stony Creek below Black Butte Dam	0.001	1.052	0.2345
Colusa Basin Drain at Highway 20	0.039	0.759	0.2089
Inflow to Stony Gorge Reservoir	0.004	0.509	0.1513
Thomes Creek at Paskenta	0.007	0.359	0.1509
Inflow to Proposed Grindstone Reservoir	0.009	0.301	0.0854
Inflow to East Park Reservoir with Rainbow Diversion	0.001	0.222	0.0762
South Fork Cottonwood Creek at Dippingvat	0.005	0.259	0.0754
Clear Creek at Whiskeytown Reservoir[b]	0.021	0.206	0.063

Table 4-3. (Continued)

[a] Values computed based on 10 years of record, Bureau of Reclamation.
[b] Values computed based on 46 years of record, USGS gauging station, Clear Creek at Igo.

MAF = million acre-feet
SCS = Soil Conservation Service
USGS = United States Geological Survey

By far, the Sacramento River is the largest water supply source for the options considered. With an average historical 5-month flow volume at Butte City of nearly 5.5 MAF, the river's flow is more than 5 times the size of the second largest option, Whiskeytown Reservoir. The smallest optional water supply sources are Grindstone Creek, East Park Reservoir, South Fork Cottonwood Creek, and Clear Creek, each with an average November through March runoff of less than 0.1 MAF. The sources are not independent options. All of the tributary streams contribute to the flow of the Sacramento River. Outflow from East Park Reservoir becomes inflow to Stony Gorge and ultimately contributes to the flow below Black Butte.

Streamflow volumes are dependent upon diversion location. In general, volumes increase in the downstream direction. Optional diversion locations for the Sacramento River are at the existing T-C Canal diversion in Red Bluff, the existing GCID Canal diversion in Hamilton City, a new diversion at Chico Landing, and a new diversion opposite Moulton Weir. Diversion locations investigated for Stony Creek include Black Butte Lake, Stony Gorge Reservoir, and East Park Reservoir with additional water from the Rainbow Diversion, and at the GCID Canal crossing. The diversion location investigated for CBD is due west of Moulton Weir, approximately 10 miles north of Highway 20. Thomes Creek diversion locations include a number of options west of Paskenta and at the T-C Canal crossing. The Grindstone Creek diversion location is from a potential Grindstone Reservoir. The Grindstone Dam site is approximately 2.5 miles upstream from the confluence with Stony Creek. The diversion location for South Fork Cottonwood Creek is at the proposed Dippingvat Reservoir for the Red Bank Project.

Divertible Flow of Water Supply Sources

Divertible flow is computed by imposing local and downstream restrictions on the streamflow volume, including applicable instream flow requirements of tributary streams and the Sacramento River. Divertible flow is also limited by diversion and conveyance capacity of new or existing facilities. Table 4-4 shows a representative divertible flow for each individual water supply source for the purpose of comparison.

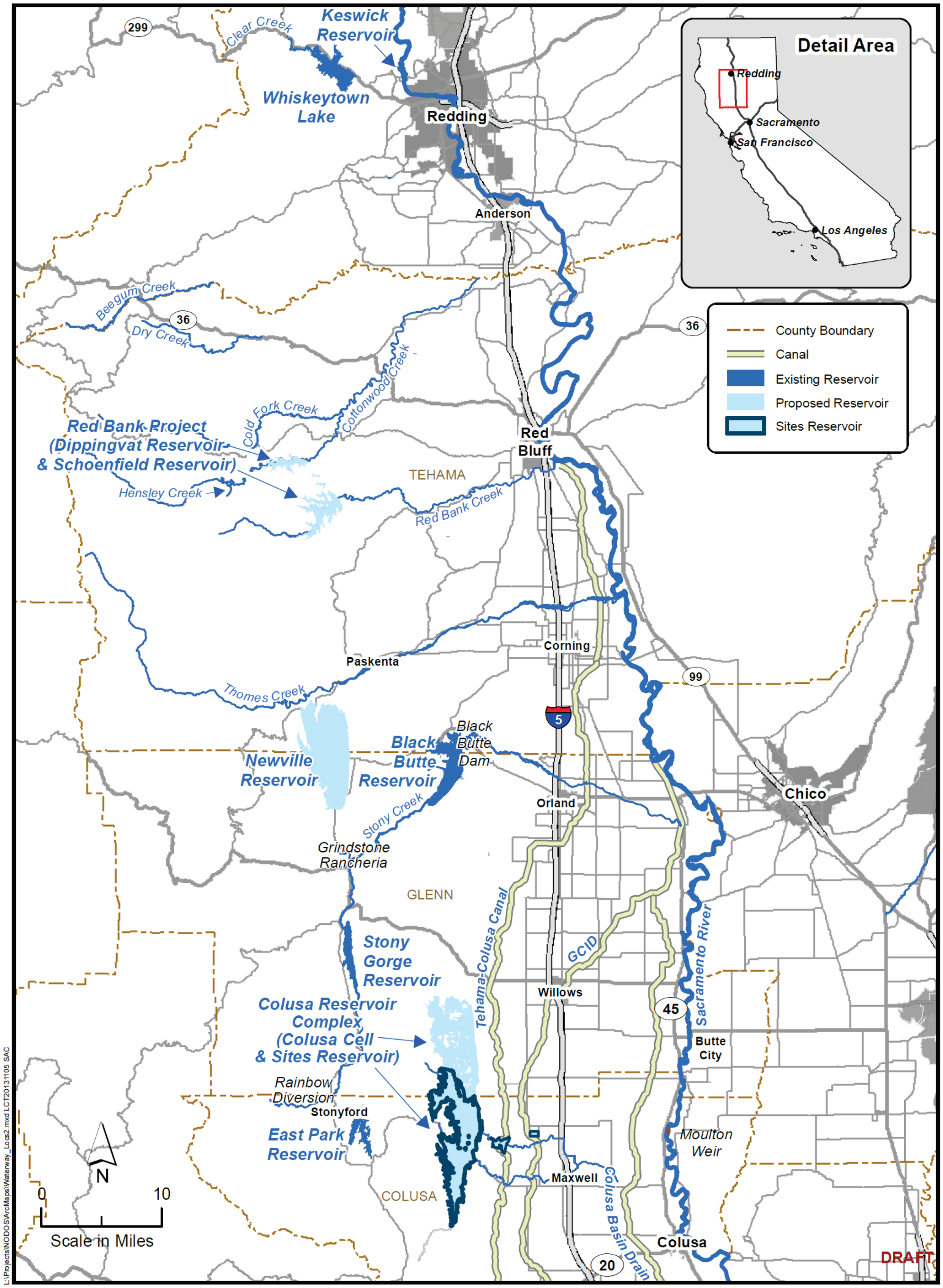


Figure 4-2. Location of Waterways in the NODOS Vicinity

Table 4-4. November – March Average Divertable Flow

Stream and Location	Conveyance Capacity (cfs)	Divertible Flow (MAF)
Sacramento River at Butte City	5,000	0.5873
Stony Creek Below Black Butte Dam	1,700	0.2345
Colusa Basin Drain	3,000	0.1365
Stony Gorge Reservoir	1,500	0.0702
Thomes Creek	2,100	0.1089
Grindstone Reservoir	750	0.0679
East Park Reservoir with 300 cfs Rainbow Diversion	1,200	0.0301
South Fork Cottonwood Creek at Dippingvat	800	0.0529

cfs = cubic feet per second
MAF = million acre-feet

Biological Resources

The following subsections summarize biological resources, such as vegetation, fish, and wildlife, found in the reservoir footprint areas.

Vegetation

The watersheds of Sacramento Valley west-side streams contain a variety of vegetative communities. These communities include white fir, Klamath mixed conifer, Douglas fir, ponderosa pine, closed-cone pine-cypress, montane hardwood conifer, montane hardwood, blue oak woodland, valley oak woodland, blue oak foothill pine, montane riparian, valley foothill riparian, montane chaparral, mixed chaparral, chamise-redshank chaparral, annual grassland, and cropland.

Vegetation within the reservoir footprint locations is varied due to the influence of local soils, geology, microclimate, hydrology, aspect, and elevation, as well as other physical and biological factors. All project sites contain at least some annual grassland habitat. This upland plant community of herbaceous annual grasses and herbs is characteristically composed of many non-native species and a limited number of native species. Species composition is highly variable among stands and throughout the growing season. Vernal pools and swales within the annual grassland community support unique assemblages of native wetland plant species.

Chaparral communities occur at or near each of the reservoir footprint locations in varying amounts. These stands frequently occur in a continuous canopy with little or no understory. Other shrub and tree species, including poison oak and manzanita, form a mosaic in some chaparral stands.

Riparian vegetation is associated with both intermittent and permanent streams. Common riparian overstory species include Fremont's cottonwood, willow, and Mexican elderberry.

Two types of oak woodland were identified within the six reservoir footprint locations: valley oak woodland and blue oak woodland. Valley oak woodlands are found along the major tributaries and valley bottoms in the reservoir sites. This vegetative community may include other native tree and shrub species. Blue oak woodland occurs at or near each of the alternatives. Blue oak is the dominant or sole canopy species in these woodlands. An annual grassland understory is common and a shrub layer comprised of manzanita and wedgeleaf ceanothus can occur. Blue oak woodlands primarily occur on moderately rocky to well-drained slopes. Limited amounts of wetlands occur within the reservoir footprint areas.

Ninety-nine percent of the Colusa Cell area is dominated by an annual grasslands community. The remaining one percent of the land area is divided between blue oak woodland, riparian, emergent wetlands, and non-vegetated areas. No chaparral, blue oak/foothill pine woodland, or cultivated grain is present within the reservoir footprint. As elevation increases above the western edge of the reservoir boundary, the blue oak savanna community becomes dominant.

Foothill pine woodland comprises 61 percent of the Red Bank reservoir footprint. Oak woodland habitat was identified and mapped in approximately 20 percent of the area. Annual grasslands are present on approximately 12 percent. Limited amounts of chaparral, riparian, and wetlands are also present.

Annual grasslands (approximately 94 percent of the surface area) dominate the proposed Sites Reservoir. Blue oak woodland occurs around the fringe of the reservoir area. Relatively small amounts of blue oak woodland, chaparral, riparian, wetlands, cultivated grain, and non-vegetated areas comprise the remainder of the inundation area. As elevation increases above the western edge of the reservoir boundary, the foothill pine community becomes dominant with large chamise chaparral stands present on shallow soils and southern exposures.

The Newville Reservoir area is dominated (85 percent) by annual grasslands. Oak woodland comprises an additional 11 percent of the inundation area. A limited amount of chaparral, emergent wetland, and riparian habitat were also mapped within Newville Reservoir. No foothill pine or cultivated grain was mapped within the reservoir footprint.

Fish and Wildlife Resources

Following is aquatic and fishery, and wildlife resources found in the reservoir footprint areas.

Aquatic and Fishery Resources

The watersheds of the North Coast Range draining east toward the Sacramento Valley contain native and non-native species, warm-water and coldwater species, and anadromous and resident fish species. At least 24 species of fish are present in these watersheds. Several state- or federally listed fish species occur in the region including steelhead, and various runs of Chinook salmon. Coldwater habitats are present in the upper watersheds of the major streams including Cottonwood Creek, Red Bank Creek, and Thomes Creek.

Fishery evaluations were performed on three ephemeral streams within the Colusa Cell footprint (Logan, Hunters, and Minton Creeks). Survey results indicate the presence of only one native species and several introduced warmwater species. All of these streams are ephemeral upstream from the proposed dam sites and do not provide coldwater habitat. No state- or federally listed fish species were identified within the reservoir area. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

A more recent survey on South Fork Cottonwood Creek and Red Bank Creek within the Red Bank reservoir footprint area located six species of resident game fishes and six species of non-resident game fishes. Steelhead were identified within the Red Bank Creek watershed.

Fishery evaluations performed at Antelope, Stone Corral, and Funks Creeks within the footprint of Sites Reservoir indicated the presence of several native and non-native species. All of these streams are ephemeral within the reservoir area and do not provide coldwater habitat. Most are degraded with extensive downcutting and little riparian vegetation. However, a single adult spring-run Chinook salmon was observed in Antelope Creek within the inundation area. Habitat surveys indicate that the stream reaches above the reservoir do not provide suitable rearing habitat for anadromous species.

Surveys from the 1980s of the ephemeral streams within the Newville Reservoir footprint resulted in capturing California roach, Sacramento pike minnow, Sacramento sucker, and green sunfish. Rainbow trout were present in the perennial headwater areas of Salt and Heifer Camp Creeks above the proposed reservoir inundation area. The lower Thomes Creek watershed contained a diverse fish assemblage that included runs of fall-run, late fall-run, and spring-run Chinook salmon and steelhead.

Wildlife

A wide variety of wildlife species utilize areas in and around the proposed reservoir areas either seasonally or year-round. Surveys are ongoing of the proposed reservoir sites for the presence of state- and federally listed species. However, substantially less information has been collected on non-listed species density and distribution.

Some general statements about relative wildlife species' diversities can be made based on the variety of habitat types and successional stages present within each of the proposed reservoir locations. The Colusa Cell includes all habitat associated with the smaller Sites Reservoir is strongly dominated by annual grasslands with little habitat or structural diversity. This monotypic habitat would not support the same diversity of wildlife species that would be expected at the other proposed reservoir locations where a greater diversity of habitats is present. The Red Bank Project and Newville Reservoir areas support a greater diversity of habitat type than the Sites and Colusa Cell areas. Although the Red Bank reservoir footprint area is the smallest of the six proposed reservoir locations, it contains the greatest diversity of habitats and several stages of habitats and should support the highest diversity of vertebrate wildlife.

State- or federally listed wildlife species have been studied and documented at or near each proposed reservoir location. Both wintering sandhill cranes (state-threatened) and a migrating bank swallow (state-threatened) have been detected at or near the proposed Colusa Cell. Extensive surveys of the proposed Sites and Colusa

Cell reservoir footprint areas have failed to detect any California tiger salamanders or red-legged frogs. Protocol for the field surveys requires that the study include areas around the proposed reservoirs where proposed facilities, roads, and utilities would be relocated. One red-legged frog (federally threatened) has been reported within the Red Bank reservoir footprint area. Numerous federally listed species of concern, California Species of Special Concern, federal Migratory Nongame Birds of Management Concern, or candidate species occur within each of the proposed reservoirs.

The Bald and Golden Eagle Protection Act of 2009 also has application. Wintering bald eagles (state endangered, federally threatened) occur in low numbers at each proposed reservoir location and golden eagles are one of the most common raptors throughout the study area.

Several California Department of Fish and Wildlife (CDFW) harvest species occur within the proposed reservoirs. Upland game includes black-tailed deer, black bear, feral pig, gray squirrel, wild turkey, California and mountain quail, and mourning dove. Waterfowl use is limited within each of the proposed reservoirs and generally restricted to winter use of stock ponds and small lakes. Limited wood duck and mallard nesting also occur within stock ponds and along the stream channels where adequate brooding water exists. Relatively high deer use of portions of the Newville Reservoir and Red Bank reservoir footprint areas during winter has been reported. Substantially less deer use has been observed within the Sites Reservoir area and no use has been noted within the Colusa Cell area. Observations indicate that feral pigs occur in low to moderate numbers within each of the proposed reservoirs, with the greatest use within the Red Bank reservoir footprint area. Wild turkeys are relatively common in portions of the Red Bank reservoir footprint area and Newville Reservoir area.

According to the Natural Diversity Database, several federally listed invertebrate species may occur within the four proposed reservoir sites. These species include vernal pool fairy shrimp, Conservancy fairy shrimp, and vernal pool tadpole shrimp.

Socio-Economic Resources

The following subsections discuss socio-economic resources encountered in the study area.

Land Use

The watersheds draining the east slope of the Coast Range are subject to a variety of land use practices. Upper elevations are primarily commercial forest lands and managed for timber production, outdoor recreation, and grazing. Foothill areas are currently managed primarily for livestock grazing. Some foothill valleys support dryland grain or orchard production. Extensive mineral extraction activities have historically occurred throughout foothill and mountain areas. Sacramento Valley portions of the watersheds support a wide variety of agricultural uses including livestock grazing, irrigated grain and truck-crops, and orchards.

Land use within the proposed Colusa Cell area is almost exclusively dedicated to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use. No other agricultural land use practices have been identified. Only one occupied ranch home site has been identified within the inundation area and no other residential or commercial developments are present.

Land use within the Red Bank reservoir footprint area is similar to that at the other three proposed reservoirs. Both year-round and winter/spring cattle grazing is the dominant land use. Other agricultural land uses include a small walnut orchard and a few acres of irrigated pasture. Several landowners operate hunting clubs, and at least one landowner operates a fee-for-fishing business.

Land use within the proposed Sites Reservoir area is dedicated primarily to livestock production. Both year-round and winter/spring cattle grazing is the dominant land use, while a small amount of both horse and sheep grazing also occurs. Other agricultural land uses include minor amounts (200 to 300 acres) of dryland grain production. Some residential land use also occurs within the small community of Sites (population 20) and on 10 to 14 scattered ranch sites. A small commercial rock quarry is present near the proposed Sites Dam site. Limited commercial firewood harvesting has occurred within and adjacent to the inundation area. There is also a local cemetery.

Seasonal and year-round livestock grazing dominates land use within the Newville Reservoir area. However, limited horse and sheep grazing also occurs. At least 20 occupied ranch sites are found within the reservoir area. Limited firewood harvest has occurred in some areas.

Cultural Resources

Results of the record search indicated that there were no site records in the files of the State database for the Colusa Cell. A field survey found greater scarcity of subsistence resources than in the Sites Reservoir area and the ephemeral nature of the water supply were not suitable for extensive use or habitation during the prehistoric past.

Three sites were recorded within the Colusa Cell, two historic ranches and one site with a prehistoric and an historic component. The significance of the sites is undetermined. The assessment of eligibility to the National Register could not be made on the basis of surface indications. Additional studies would be necessary to complete the evaluation.

Results of the record search for the Red Bank Study Area at the Northwest Information Center of the California Historical Resources Information System at California State University, Chico, indicated that the reservoir footprint area had not been surveyed for cultural resources and no cultural resources were previously recorded in the reservoir footprint area. The surveys completed in 1994 for the United States Army Corps of Engineers (USACE) Cottonwood Creek project were downstream of the project described here, with no overlap of the footprints.

A total of 31 sites were recorded within the Red Bank Study Area. Twenty-eight sites are prehistoric and three are historic. The prehistoric sites in the Red Bank reservoir footprint area were generally small and the artifact distribution relatively sparse. The sites were probably associated with seasonal upland hunting, fishing, and gathering activities. The larger permanent settlements were situated further downstream on the banks of the perennial streams and along the Sacramento River.

Much of the Sites Reservoir study area was surveyed in 2001-2003. Based on the results of this study and earlier surveys, 147 sites have been recorded within the Sites footprint. These include 67 prehistoric sites, 46 historic-era sites, and 34 sites that contain both prehistoric and historic-era components. An additional 419 isolates were recorded during a subsequent study, most of which consisted of historic-era items related to ranching and farming. At least 18 sites appeared to be significant. Prehistoric settlement in the study area was constrained by the limited food and fuel resources and the scarcity of water. However, the area would have been important for seasonal hunting and gathering forays. The larger and more permanent villages were situated along the lower reaches of the bigger streams and on the knolls and natural levees along the Sacramento River. To date, no sites have been evaluated for formal inclusion into the National Register.

The town of Sites is likely significant as a Historic District. Moving the cemetery associated with Sites, along with several smaller historic-era cemeteries, would present special consideration. Similarly, many of the large prehistoric village sites within the Sites study area have a high probability of containing burials, which would require considerable coordination with local Native American tribes.

A survey of prehistoric sites within Newville reservoir footprint area was completed in 1983. A total of 117 sites were recorded within the footprint of the proposed reservoir, representing a more complete prehistoric settlement pattern that includes evidence of permanent or semi-permanent villages, seasonal campsites, and special resource procurement and use sites. The presence of perennial streams and availability of fuel and subsistence resources accounts for the more intensive use of the study area during prehistoric times. As with the Sites study area, moving the historic cemeteries within the footprint of the Newville study area would be necessary.

Conclusions from Initial Evaluation of Potential Reservoir Locations

Three viable surface storage measures suitable for more detailed evaluation were identified through the initial evaluation process: Colusa Reservoir Complex, Sites Reservoir, and Newville Reservoir. Potential reservoir locations associated with the Red Bank were not recommended for additional evaluation.

Because it is an onstream reservoir, Dippingvat Reservoir has more extensive environmental impacts and is not considered consistent with the objective to increase the populations of anadromous fish and other aquatic species. Without Dippingvat Reservoir, the Red Bank Project would be limited to Schoenfield Reservoir, reducing the storage volume to 0.25 MAF. Furthermore, in spite of Red Bank having the smallest reservoir footprint area, it contains one of the greatest diversity of habitats and several stages of habitats and has considerable environmental and fishery impacts. The following impacts support the conclusion for not recommending Red Bank Project for further evaluation:

- The California red-legged frog, a federally threatened species, was observed in the reservoir footprint.
- To provide water supply to the reservoir, this measure would block a portion of the Cottonwood Creek watershed. The Cottonwood Creek watershed is a known anadromous fishery for Steelhead and fall-run and late-fall-run Chinook salmon.
- Cottonwood Creek is the largest undammed tributary to the Upper Sacramento River, and it is the Sacramento River's most important source of sediment.
- Constructing this facility would impact an area with a high diversity of habitat.
- Hydrologic conditions do not favor the Red Bank Project unless a diversion dam is constructed across Cottonwood Creek to divert the flow needed to fill the Schoenfield site, which would impede anadromous fish passage and spring-run salmon and steelhead.
- Initial geotechnical investigations indicate the potential for excessive reservoir leakage for this project, compared to other viable measures considered in this study.
- The project would reduce the release of sediment, gravel, and large woody debris needed for ecological function in the Sacramento River.

Detailed Evaluation of Colusa Reservoir Complex, Sites Reservoir, and Newville Reservoir Locations

To provide a preliminary economic assessment to compare the average annual cost per yield for the three surface storage measures, costs for the construction of the reservoirs were compared with yield and unit cost per deliverable volume. These costs are presented in Table 4-5. The estimated average annual cost per yield is similar in magnitude for Sites and Newville Reservoirs. The capital cost of Colusa Reservoir Complex would be approximately 4.4 times that of Sites Reservoir and 6 times that of Newville Reservoir, while the increase in yield over what would be produced by the Sites and Newville Reservoirs is approximately 10 to 25 percent. Because of this lack of efficiency, the Colusa Reservoir Complex measure was not recommended as a selected measure for inclusion in the alternatives for further consideration.

Table 4-5. Comparison of Storage, Yield, and Reservoir/Dam Screening Costs

Attribute	Measure		
	Colusa Reservoir Complex	Sites Reservoir	Newville Reservoir
Gross Storage (acre-feet)	3,000,000	1,810,000	1,900,000
Dead Storage (acre-feet)	100,000	40,000	50,000
PFR estimate of Capital Cost[b]	$1,496,500,000	$339,500,000	$249,250,000
PFR Estimated Average Annual Cost[c]	$77,000,000	$17,500,000	$13,000,000
Estimated Average Annual Yield[d] (acre-feet)	328,000	274,000	275,000
PFR Average Annual Cost/Yield (acre-feet)	$235/acre-foot	$64/acre-foot	$47/acre-foot

Table 4-5. (Continued)

[a] Preliminary cost estimate of major dam(s) from the PFR (Reclamation and DWR, 2008) includes only clearing and grubbing, foundation preparation, and embankment materials. It excludes other costs, such as lands, easements, rights-of-way, relocations, conveyance, or recreation. The basis year for costs is 2005.

[b] Average construction cost increase in California for 2004-2005 was 6.019%, rounded to the nearest $250,000 (California Construction Cost Index).

[c] A = average annual cost based on P = Project Life Cost ($2005), i = 5.125%, and n = 100 years (current amortization rate used by Reclamation).
Formula is:

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

Where:
- A = average annual cost
- P = present-day total capital investment (project life capital cost)
- i = annual amortization rate
- n = number of amortization periods

[d] Based on SWP/CVP only (excludes local) (CALFED, 2000c).

CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
DWR = California Department of Water Resources
PFR = Plan Formulation Report
SWP = State Water Project

It should be noted that the costs presented in Table 4-5 do not include mitigation.

Both the reservoir location and conveyance system to support Sites Reservoir would have significantly fewer environmental impacts than Newville Reservoir. Table 4-6 shows the ecological and cultural attributes of several environmental resources within the reservoir footprints. Potential effects of the two reservoirs on these resources are displayed using quantity indicators.

Table 4-6. Relative Reservoir Footprint Environmental Impacts Comparison

Preliminary Site Survey Results by Biological/Ecological Attributes	Sites Reservoir	Newville Reservoir
Wetland (acres)	249	**525**
Riparian (acres)	75	**476**
Blue oak woodland (acres)	924	**2,532**
Valley oak woodland (acres)	4	**104**
Number of elderberry stems greater than 1-inch diameter	684	**1,204**
Number of elderberry stems with emergence holes[a]	18	**222**
Total number of bird species	**160**	146
Number of California and Federal bird species of concern	**25**	19
Prehistoric cultural resource components	45	**117**
Historic cultural resource components	27	**65+**

The larger value of the two for each attribute considered is highlighted by **bold** text.

[a] Elderberry delisting is under consideration.

The review of potential environmental impacts within the footprints for the Sites Reservoir and Newville Reservoir indicates a much greater impact potential for the Newville Reservoir. With the exception of potential impacts to the number of California and federal bird species of concern, possible project-related impacts for all of the other biological/ecological attributes are higher for Newville Reservoir. In addition to the number of impacts within the reservoir footprints, the Sites Reservoir location offers the advantage of being able to use the existing T-C and GCID canals to significantly reduce the extent of excavation required for conveyance.

The Sites Reservoir location offers several advantages over the selection of Newville Reservoir, even though the construction of the dams for Newville would be less expensive. The most significant advantages include:

- Sites Reservoir is much closer to the Sacramento River, which has the largest supply of divertible flow.

- The existing T-C and GCID canals already divert 3,900 cubic feet per second (cfs) from the Sacramento River into close vicinity to Sites Reservoir. This diversion significantly reduces environmental impacts and costs associated with new conveyance. Although the reservoir cost for Sites Reservoir is higher, the conveyance is much less expensive. The total project costs were considered comparable for the two reservoirs.

- The construction of dams to create Newville Reservoir would have greater environmental impacts, including impacts to salmon in Thomes Creek.

Sites Reservoir would have fewer environmental impacts than Newville Reservoir. It also better meets the purpose of the feasibility studies because it is more consistent with the definition for offstream storage due to the impact of Newville Reservoir on the Thomes Creek watershed. The watersheds associated with Sites Reservoir are ephemeral and much smaller by comparison. The water supply available to fill Sites Reservoir is also more reliable. As a result, Sites Reservoir was selected for the development of detailed alternatives.

Conclusion

Based on the findings presented in this chapter, it was decided to develop a range of initial alternatives for NODOS using Sites Reservoir.

CHAPTER 5 EVALUATION OF CONVEYANCE AND RESERVOIR SIZE

A central element in the evaluation of the management measures used to formulate alternatives for the NODOS feasibility studies is the identification of a preferred reservoir location(s). Conveyance measures and potential reservoir size are dependent on the reservoir location selected. Therefore, the formulation and evaluation of potential conveyance measures and reservoir sizes was deferred until the evaluation of reservoir locations was completed, as detailed in Chapter 4. As described in that chapter, Sites Reservoir is the recommended offstream surface storage management measure of the NODOS feasibility studies. This section presents the formulation and evaluation of various conveyance packages and reservoir sizes that are used to formulate action alternatives for Sites Reservoir.

Development of Conveyance Measures

This section presents the evaluations and screening of various measures for conveying water to and from Sites Reservoir. Table 5-1 provides a list of potential conveyance management measures.

Table 5-1. Original Conveyance Measures Considered

Conveyance Facility	Source	Capacity Description
T-C Canal	Sacramento River at Red Bluff	Existing 2,100 cfs capacity Modify to 2,700 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
GCID Canal	Sacramento River at Hamilton City	Existing 1,800 cfs capacity Expand to 3,000 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
Stony Creek Pipeline	Stony Creek at existing Black Butte Afterbay	1,000 cfs capacity 2,100 cfs capacity
Delevan Pipeline	Sacramento River Opposite Moulton Weir	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity 4,000 cfs capacity 5,000 cfs capacity
Colusa Basin Pipeline	Colusa Basin Drain	1,000 cfs pipeline capacity 3,000 cfs pipeline capacity

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa

Conveyance is an especially important offstream surface storage element. Because Sites Reservoir is not located on a major stream, water must be delivered both to and from the reservoir. As a result, conveyance management measures must address several diversion and conveyance facilities to transport water to Sites Reservoir. The conveyance measures must also address the delivery of water from Sites Reservoir to service areas or locations with various water resources needs and uses.

Conveyance Measures Considered

Conveyance measures originating from the Sacramento River include the GCID Canal, the T-C Canal, and a new pipeline (called the Delevan Pipeline), as illustrated in Figure 5-1. Tributary source conveyance measures include a new pipeline from the CBD and a new pipeline from Stony Creek, originating at the Black Butte afterbay and connecting to the T-C Canal below Orland.

The conveyance measures include five different water source locations that can be combined in numerous ways to provide sufficient inflow to reliably fill Sites Reservoir. A complete alternative plan requires conveyance management measures to convey water to and from the reservoir. Preliminary operation simulations indicate that 3,000 to 6,000 cfs of total inflow capacity to Holthouse Reservoir (an expansion of the existing Funks Reservoir) on the T-C Canal is needed to fill Sites Reservoir reliably.

Each of these five proposed conveyance measures has a range of capacity sizes. As a result, 17 conveyance measures were identified for consideration and evaluation, as presented in Table 5-1 and preliminary designs and cost estimates were developed for each of the 17. Figure 5-2 shows a conceptual graphical representation of these original conveyance measures. The initial designs and cost estimates for each of the 17 original conveyance management measures were considered individually, without consideration of how measures could be combined or integrated with other conveyance measures into a plan.

Additional details for each of the conveyance measures, by facility, follow.

T-C Canal Measures

The T-C Canal is a concrete-lined canal with an existing capacity of 2,100 cfs to Funks Reservoir. T-C Canal measures assume that new fish screens and a pumping plant at the Sacramento River would be completed by the Fish Passage Improvement Project underway at the RBDD. In addition, designers found that the T-C Canal capacity could be increased up to 2,700 cfs using the existing canal prism near Funks; however, this effort would require several improvements along the length of the canal, such as modifications at road and water crossings to convey additional capacity. Expansion of the T-C Canal beyond 2,700 cfs would require substantial reconstruction and expansion of the canal prism. Preliminary designs were developed for 4,000 and 5,000 cfs.

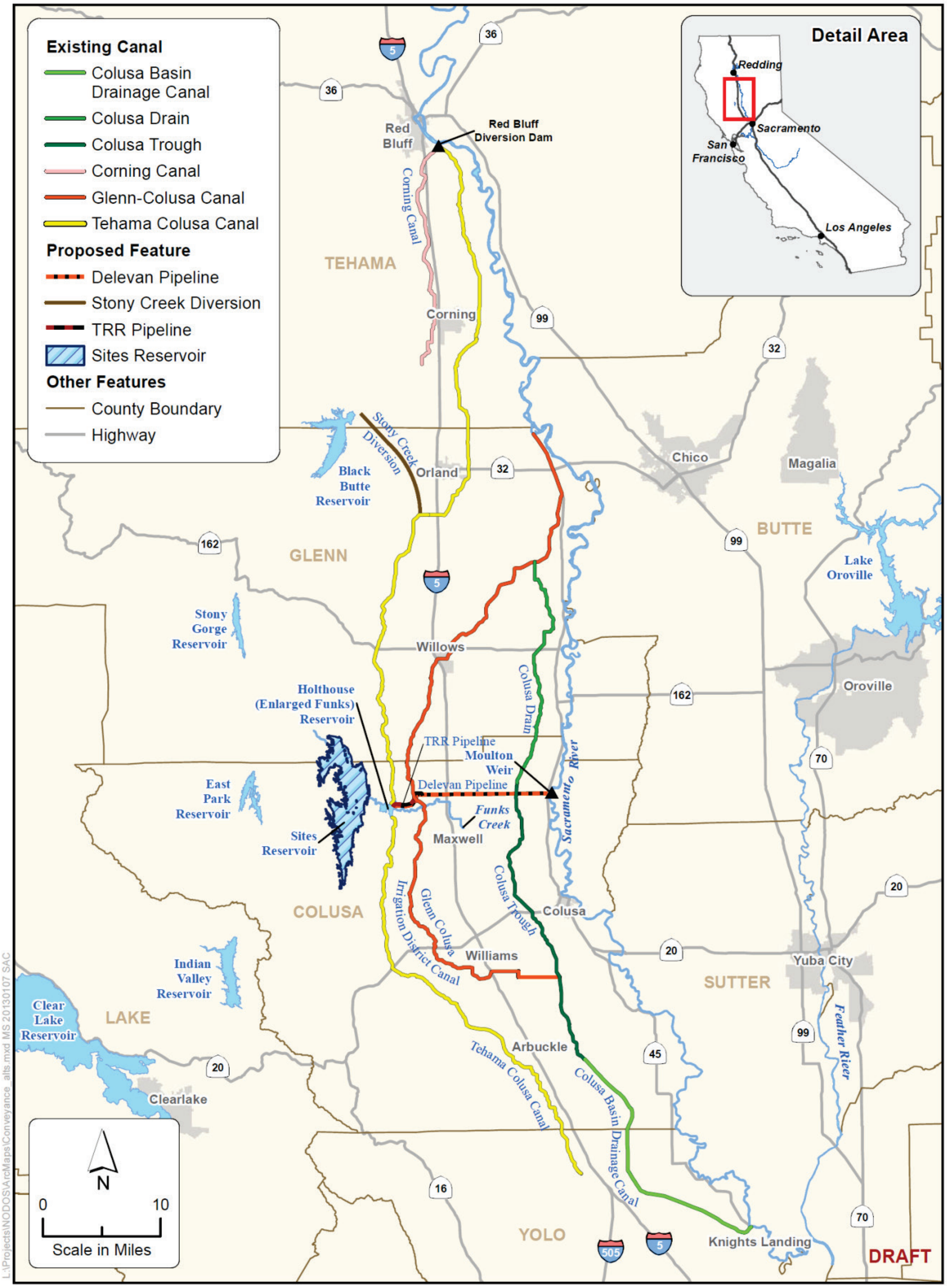


Figure 5-1. NODOS Conveyance Alternatives

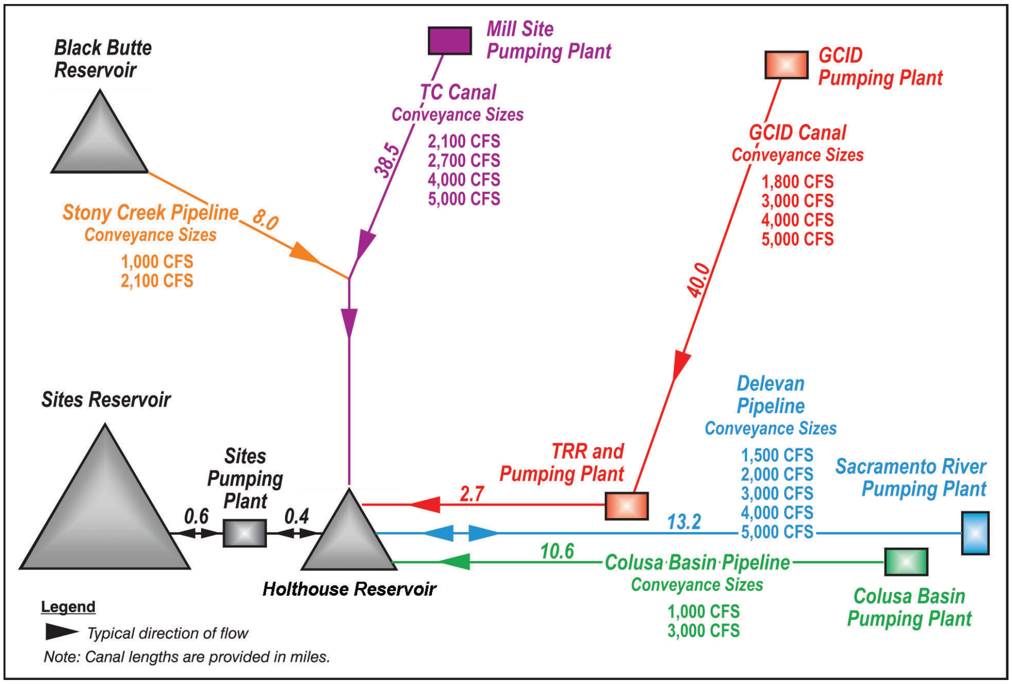


Figure 5-2. Original Conveyance Measures

GCID Canal Measures

The GCID Canal is an earth-lined canal with an existing capacity of 3,000 cfs near its diversion and approximately 1,800 cfs near a proposed terminal regulating reservoir (TRR). All GCID Canal conveyance measures require a TRR and a pipeline connecting to Holthouse Reservoir on the T-C Canal. The pipeline connecting the TRR and Holthouse Reservoir, the Delevan Pipeline, and the Colusa Basin Pipeline all use the same alignment. Only minor modifications to the pumping plant and fish screen on the Sacramento River are required for the 1,800 cfs and 3,000 cfs measures. The 3,000 cfs GCID Canal measure also would require substantial earthwork to expand the capacity of the canal to the TRR. The 4,000 cfs and 5,000 cfs conveyance management measures require major modifications to the GCID Canal, fish screen, and pumping plant. GCID Canal measures would facilitate delivery of Sites Reservoir water to the GCID service area, facilitating an integrated operation with the CVP.

Stony Creek Pipeline Measures

Stony Creek Pipeline is a proposed new pipeline that would convey flows from the existing Black Butte Afterbay on Stony Creek to the T-C Canal. The 1,000- and 2,000 cfs pipeline options would utilize existing conveyance space in the lower portion of the T-C Canal.

Delevan Pipeline Measures

The Delevan Pipeline was designed to provide the shortest conveyance distance from the Sacramento River to Holthouse Reservoir. A Delevan canal was also considered, but dismissed from detailed evaluation due to a variety of environmental effects. The

1,500 cfs Delevan Pipeline requires two 12-foot-diameter pipes. The remaining four Delevan Pipeline measures require one 12-foot-diameter pipe for each additional 1,000 cfs. Diversion facilities include pumps and fish screens. Delevan Pipeline measures also can be used to release water back to the Sacramento River to meet downstream needs directly or to facilitate an integrated operation with the CVP and SWP.

Colusa Basin Pipeline Measures

The 1,000- and 3,000 cfs Colusa Basin Pipeline measures rely on a similar design and use the same alignment as the Delevan Pipeline but divert water from CBD. The design and installation of fish screens and pumps would be required.

Important Considerations When Evaluating Conveyance Measures

The conceptual representation of the conveyance management measures shown on Figure 5-2 reveals several important attributes that must be considered. First, with the two exceptions, both the T-C Canal measures and Stony Creek Pipeline measures require increasing the capacity in the lower portion of the T-C Canal (from Orland to Holthouse Reservoir). When these two conveyance measures are combined, they cannot use the same capacity in the lower T-C Canal at the same time. Therefore, the cost to expand the capacity of the lower portion of the T-C Canal below Orland also has been estimated. These designs and estimates for expanding capacity in the portion of T-C Canal below Orland have been sized the same as the full expansions of the length of the canal (i.e., 2,700 and 4,000 cfs). This sizing provides an estimate of the cost to provide conveyance for T-C Canal measures and Stony Creek Pipeline measures at the same time.

All measures have been designed to convey water to Holthouse Reservoir. Consequently, they can be compared directly to determine their relative performance in conveying water to storage. By contrast, each measure’s ability to convey water from Sites Reservoir storage to areas of need or use, or directly to the Sacramento River, varies. Any conveyance measure plan would facilitate delivery of water to a portion of the T-C service area, as Sites Reservoir uses Holthouse Reservoir on the canal as an afterbay. Consequently, Stony Creek Pipeline and T-C Canal measures, for example, do not provide any additional conveyance to areas of need or use.

Table 5-2 presents an initial comparison of conveyance measures that includes a listing of the conveyance measure capacities at Holthouse Reservoir and the measure design costs. Costs are rounded to the nearest $100K. Table 5-2 also identifies if the conveyance measure has the ability to directly release water to the Sacramento River. This capability is noted because conveyance measures that can release water directly to the Sacramento River would facilitate the ability to meet additional needs throughout the San Francisco Bay-Sacramento River and San Joaquin River Delta (Bay-Delta) system. Water released directly to the Sacramento River could provide downstream benefits for Delta water quality and water supply reliability for CVP, SWP, and Level 4 refuge supply.

Table 5-2. Screening Cost Estimates and Other Considerations for Potential Conveyance Measures

Conveyance Facility	Capacity Description	PFR Cost Estimate[a] (millions)	Ability to Provide Direct Release to Sacramento River?
T-C Canal	Existing 2,100 cfs capacity[b]	$0	No
	Modify to 2,700 cfs capacity	$110.9	No
	Expand to 4,000 cfs capacity	$398.2	No
	Expand to 5,000 cfs capacity	$556.5	No
GCID Canal	Existing 1,800 cfs capacity	$178.5	No
	Expand to 3,000 cfs capacity	$302.3	No
	Expand to 4,000 cfs capacity	$463.8	No
	Expand to 5,000 cfs capacity	$552.3	No
Stony Creek Pipeline	1,000 cfs capacity	$87.9	No
	2,100 cfs capacity	$168.3	No
Delevan Pipeline	1,500 cfs capacity	$364.9	Yes
	2,000 cfs capacity	$421.4	Yes
	3,000 cfs capacity	$574.3	Yes
	4,000 cfs capacity	$747.2	Yes
	5,000 cfs capacity	$917.2	Yes
Colusa Basin Pipeline	1,000 cfs pipeline capacity	$145.9	No
	3,000 cfs pipeline capacity	$362.9	No

[a] Costs from the PFR (Reclamation and DWR, 2008) are 2007 preliminary construction costs for conveyance screening and do not include mitigation, engineering, or administrative costs.
[b] Although the Red Bluff Fish Screen has a capacity of 2,500 cfs, the current diversion capacity for the canal is 2,100 cfs.
cfs = cubic feet per second
DWR = California Department of Water Resources
GCID = Glenn-Colusa Irrigation District
PFR = Plan Formulation Report
T-C = Tehama-Colusa

Conveyance from Reservoir to Service Areas or Locations with Various Water Resource Needs and Uses

The following evaluation considers the ability of measures to convey water to service areas or locations with varying water resource needs and uses. Ultimately, the ability of a conveyance measure to transport water to needs and uses would be evaluated with an operations model.

For Sites Reservoir, three general methods can be used to facilitate the delivery of water to areas of need and use.

- Water can be delivered directly from Sites Reservoir to meet local needs in the vicinity of the existing GCID and T-C canals. Needs are defined as currently unmet uses for water.

- Sites Reservoir can deliver water locally in an integrated way (e.g., water supply exchanges) with CVP operations, thereby facilitating an ability to meet additional needs throughout the Bay-Delta system. Any Sites Reservoir plan would be connected to Holthouse Reservoir and, therefore, to the T-C Canal. This connection would facilitate some integration with the CVP, independent of the conveyance measures selected. Additional connection to and integration with the

CVP would be facilitated by the GCID Canal measures. The benefits resulting from this type of integrated exchange operation relate directly to the amount of water served to the local area by Sites Reservoir that was previously served by the CVP's other facilities. Sites Reservoir can serve CVP contractors that were previously served by other CVP facilities. In exchange, the CVP can serve the primary objectives of this project without affecting current uses.

- The Delevan Pipeline measures offer the unique ability to release water into the Sacramento River directly from Sites Reservoir. The Delevan Pipeline measures also would facilitate the ability to meet additional needs throughout the Bay-Delta system. Water released from the Delevan Pipeline could provide downstream benefits for Delta water quality and water supply reliability for CVP, SWP, and Level 4 refuge supply. These resource needs can be met directly by conveying water through the Delevan Pipeline to the Sacramento River for downstream uses and needs. The Delevan Pipeline measures could provide significant and unique benefits that may not be possible by either of the methods discussed above.

The release capacity of conveyance pipelines from Holthouse Reservoir to the Sacramento River is estimated to be 75 percent of the pipeline pumping capacity associated with pumping from the river to Holthouse Reservoir. This reduction in capacity results from pressure losses in the pipe. Table 5-3 shows the conveyance measures associated with direct conveyance to the Sacramento River and each measure's release capacity to the river.

Table 5-3. Conveyance Measures Associated with Direct Conveyance to the Sacramento River

Conveyance Management Measure (Capacity to Pump Water into Sites Reservoir)	Release Capacity (from Holthouse Reservoir to Sacramento River)
(A)	0.75 (A)
Delevan Pipeline – 1,500 cfs	1,125 cfs
Delevan Pipeline – 2,000 cfs	1,500 cfs
Delevan Pipeline – 3,000 cfs	2,250 cfs
Delevan Pipeline – 4,000 cfs	3,000 cfs
Delevan Pipeline – 5,000 cfs	3,750 cfs

cfs = cubic feet per second

Initial Evaluation of Environmental Considerations of the Conveyance Measures

The following environmental considerations also are noted for evaluating the various conveyance measures.

- ***Water Quality.*** The water from the CBD is considered to be of relatively poor quality when compared to Sacramento River water and it is, therefore, less desirable. The CBD is the single largest source of agricultural return flows to the Sacramento River. Flows from the CBD have elevated values for alkalinity, EC, and total dissolved solids. Nitrogen and phosphorus concentrations also are generally higher in the CBD. Water taken from the CBD into Sites Reservoir and then released back through the conveyance system could result in water quality impacts to local agricultural users and create a new source of relatively lower quality water if discharged from the Delevan Pipeline into the Sacramento River.

- ***Agricultural Land.*** California's desire to preserve agricultural land is reflected in the California Land Conservation Act, also known as the Williamson Act. The effectiveness of the Williamson Act is often measured by the amount of prime agricultural land (as defined in the Act) in the program. Expansion of the GCID Canal (4,000- and 5,000 cfs options) would require the acquisition of temporary and permanent rights-of-way (ROWs). The 4,000- and 5,000 cfs measures for the GCID Canal would require approximately 1,890 acres of land during construction. Permanent land area acquired for the canal expansion would be 940 acres, of which 727 acres are classified as prime agricultural land. Similar impacts to agricultural land are associated with the expansion of the T-C Canal: 2,468 acres of agricultural land were determined to be within 100 feet of the project footprint; of these, 1,244 acres are classified as prime agricultural land.

- ***Environmental Effects.*** As already noted, measures that expand the existing canals would affect large land areas, temporarily and permanently. Some environmental effects of land conversions associated with expanding the T-C Canal and the GCID Canal to 4,000 or 5,000 cfs have been identified preliminarily.

  Environmental reconnaissance surveys of T-C Canal expansion areas have identified vernal pools within 100 feet of the expansion project fence line. At least two vernal pools were found on each side of the T-C Canal at the same mile marker. Vernal pools were found east of Corning and near Funks Reservoir. Approximately 170 elderberry stems of a size suitable for valley elderberry longhorn beetle (VELB) use were found. Effects to salmon and steelhead related to siphon enlargements at some nearby streams are likely; their presence would affect construction timing and require mitigation. T-C Canal is partially within the range of the giant garter snake near Orland, and expansion of the existing canal beyond 2,700 cfs could result in the loss of giant garter snake habitat. Swainson's hawk nesting habitat also extends into a portion of the T-C Canal alignment; numerous nests have been recorded along the canal. Additional environmental impacts include roughly 64 acres of jurisdictional wetlands (including vernal pools) located primarily at the culvert crossings and siphon locations. Although ponds and toe drains also occur, they might require mitigation if the large expansions were implemented. These impacts could be avoided, minimized, and/or mitigated, but not without some degree of additional cost.

  The environmental reconnaissance of T-C Canal expansion areas also determined that midden soils are present in several locations; these are frequently associated with long-term occupation and human remains. There is a midden under T-C Canal, near State Route 162. As a rough estimate, up to 30 buildings are within 100 feet of the T-C Canal, and numerous farmhouses and buildings are within 100 feet of the T-C Canal between Orland and Red Bluff.

  Environmental reconnaissance surveys limited to within 100 feet of the potential GCID expansion project footprint, on both sides and at siphon locations, have indicated approximately 286 elderberry stems greater than 1 inch in diameter at ground level, which is considered habitat for VELB. Effects to salmon and steelhead related to siphon enlargements are likely on some nearby streams; their presence would affect construction timing and require mitigation. The GCID Canal alignment is entirely within the range of the giant garter snake; the canal itself and areas within 100 feet are considered habitat (at least 945 acres). A Swainson’s hawk nesting habitat exists in the vicinity of the GCID Canal; there are numerous records of nests along the canal. Additional environmental impacts include approximately 35 acres of jurisdictional wetlands (including vernal pools) located primarily at the culvert crossings and siphon locations. Although ponds and toe drains also occur, the jurisdictional wetlands might require mitigation if a canal expansion project were implemented.

The expansion study areas and adjacent lands have not been surveyed for cultural resources; however, the GCID Canal qualifies as an historic structure. Records searches indicate 11 historic sites within 1 mile of the GCID Canal and no recorded prehistoric sites. Several graves within a portion of the Willows Cemetery are within 100 feet of the existing GCID Canal footprint; expansion might require the relocation of a portion of this cemetery. As a rough estimate, 10 buildings are within 100 feet of the GCID Canal (mostly houses in Willows).

Table 5-4 provides a summary of the potential issues and impacts that might result from enlarging the GCID Canal or T-C Canal to 4,000 or 5,000 cfs.

Table 5-4. Summary of Potential Issues and Impacts from Enlarging T-C Canal or GCID Canal to 4,000 or 5,000 cfs

Environmental Permits/Documentation Potentially Required
NEPA Compliance
CEQA Compliance
Federal ESA or CESA Compliance (Consultation, Biological Assessment)
CDFW Streambed Alteration Agreement
Clean Water Act 404 Compliance
Clean Water Act 401 Compliance
RWQCB Storm Water Permit
Federal 106 (Cultural/Historic Resources) Compliance
Potential Environmental Issues
Impacts to Prime Farmland, Unique Farmland, or Farmland of Statewide Importance
Impacts to Lands Under Williamson Act Contracts
Impacts to Jurisdictional Wetland Habitats and Waters of the U.S.
Impacts to Wildlife Migration or Movement
Impacts Related to Short-Term Noise, Air Quality, or Traffic Increases
California- and Federally Listed Species Potentially Impacted
Bald eagle
Bank swallow
Swainson’s hawk
Mountain plover
Greater sandhill crane

Table 5-4. (Continued)

California- and Federally Listed Species Potentially Impacted (cont'd)
Giant garter snake
California tiger salamander
Central Valley spring-run Chinook salmon
Central Valley steelhead
Western yellow-billed cuckoo
Winter-run Chinook salmon
Green sturgeon
Conservancy fairy shrimp
Valley elderberry longhorn beetle
Vernal pool fairy shrimp
Vernal pool tadpole shrimp
Greene's tuctoria
Hoover's spurge
Hairy Orcutt grass
Slender Orcutt grass
Palmate-bracted birds beak
Other
Potential Impacts to Cultural and Historical Resources
Impacts to Housing (Necessitating Relocation)

CDFW = California Department of Fish and Wildlife
CEQA = California Environmental Quality Act
CESA = California Endangered Species Act
cfs = cubic feet per second
ESA = Endangered Species Act
GCID = Glenn-Colusa Irrigation District
NEPA = National Environmental Policy Act
RWQCB = Regional Water Quality Control Board
T-C = Tehama-Colusa

Construction of the Delevan Pipeline would also result in temporary land disturbance during construction along with new permanent ROW; however, significantly less land is affected than is needed to expand the canal capacity. A temporary easement of approximately 350 acres is required for the Delevan Pipeline (length is approximately 13.5 miles) with a permanent ROW of approximately 270 acres. Construction would occur in giant garter snake habitat.

Conveyance Management Measure Recommendations

Table 5-5 shows conveyance management measures recommended for further consideration based on the initial evaluation of costs (see Table 6-2), ability to meet the water quality objective by releasing water to the Sacramento River (see Table 6-2), and environmental considerations described in the previous section, as well as those not recommended for further consideration. The Colusa Basin Pipeline was not recommended due to quality concerns and its inability to release water to the Sacramento River to satisfy the primary objective of water quality improvement. The Stony Creek Pipeline could be used to convey water to the reservoir, but would not support releases for beneficial uses. The existing T-C Canal and GCID Canal can be used to fill the reservoir at a lower cost. The cost analysis and preliminary environmental analysis recommends the existing T-C Canal 2,100 cfs measure and the GCID 1,800 cfs measure. In addition, three Delevan Pipeline measures (1,500 cfs, 2,000 cfs, and 3,000 cfs) were recommended to allow further investigation of providing direct release capacity to the Sacramento River that could be accomplished uniquely with the Delevan Pipeline. If a Delevan Pipeline measure is included in a reservoir plan with existing capacity canals, total diversion capability would range from 5,400 to 6,900 cfs.

Table 5-5. Conveyance Measures Retained and Conveyance Measures Not Recommended for Further Consideration

Conveyance Measures Recommended for Further Consideration	
T-C Canal	Existing 2,100 cfs capacity
GCID Canal	Existing 1,800 cfs capacity
Delevan Pipeline	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity
Conveyance Measures Not Recommended for Further Consideration	
T-C Canal	Modify to 2,700 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
GCID Canal	Expand to 3,000 cfs capacity Expand to 4,000 cfs capacity Expand to 5,000 cfs capacity
Stony Creek Pipeline	1,000 cfs capacity 2,100 cfs capacity
Delevan Pipeline	4,000 cfs capacity 5,000 cfs capacity
Colusa Basin Pipeline	1,000 cfs pipeline capacity 3,000 cfs pipeline capacity

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
T-C = Tehama-Colusa

This recommendation leaves five conveyance measures for continuing consideration in the NODOS feasibility studies. These measures can be combined to provide a range of conveyance measures to Holthouse Reservoir, with up to 6,900 cfs total capacity, for use in initial alternative development. In addition, the conveyance measures retained would allow for an evaluation of benefits associated with various conveyance measures, as previously described.

Evaluation of Various Reservoir Sizes

Four sizes of Sites Reservoir have been considered: 800 TAF, 1.27 MAF, 1.81 MAF, and 2.1 MAF. The reservoir sizes studied were chosen to reflect a range of storage values that would allow for a useful comparison of the developed cost and quantity estimates, and provide for reasonably reliable interpolation for other reservoir sizes not specifically addressed by the four selected reservoir sizes.

Table 5-6 presents a summary of each reservoir storage alternative. Included in this table is the total number of dams required to impound Sites Reservoir and the total embankment volume (amount of material required to create the dams) for each of the four reservoir alternatives.

Table 5-6. Sites Reservoir Alternative Reservoir Size Summary

Reservoir Storage (MAF)	Maximum Water Surface Elevation (feet)	Reservoir Surface Area (acres)	Total Number of Dams[a] (main + saddle)	Total Embankment Volume (CY)
0.8	440	10,200	2 + 3	6,900,000
1.27	480	12,400	2 + 6	11,600,000
1.81	520	14,200	2 + 9	22,300,000
2.1	540	15,100	2 + 7[b]	33,800,000

[a] Total number of dams include the main dams, Sites and Golden Gate, and the saddle dams.
[b] Saddle dams 7, 8, and 9 become one continuous embankment in the 2.1-MAF reservoir alternative.

CY = cubic yards
MAF = million acre-feet

Based upon review of the reservoir rim topography, site geology, the presence of geologic features trending through the reservoir rim, and a cursory evaluation of the relationship between embankment volume and reservoir storage, it was determined that a 2.1-MAF reservoir may be infeasible. A review of the reservoir rim indicated that reservoir elevations at or above 540 feet would likely require grouting of the lower saddle areas along the relatively steep ridges of the eastern rim, to ensure the structural integrity of the project. This treatment, combined with the increasing proportion of required embankment material volume and to higher reservoir surface elevations, would result in larger unit costs (reservoir cost/AF of storage) for reservoir elevations above 540 feet. Therefore, the reservoir alternatives below elevation 540 feet were found to be more economical on a unit cost basis. In addition, detailed geologic and geotechnical evaluations have not been performed on lower elevation areas of the eastern rim. Therefore, a maximum elevation of 520 feet was selected to ensure that the proposed size of Sites Reservoir would be technically feasible. The maximum reservoir elevation was limited to 520 feet due to questionable conditions on the relatively steeper slopes of the eastern reservoir rim that could result in large increases in project costs during the later stages of design.

Therefore, reservoir sizes of 800 TAF, 1.27, MAF, and 1.81 MAF were considered for alternative development.

Evaluation of Various Conveyance and Reservoir Packages

Based on the initial screening of the conveyance measures and reservoir sizes described above, the following measures were further evaluated:

- Sites Reservoir Size:
  - 800 TAF
  - 1.27 MAF
  - 1.81 MAF

- Conveyance Measures:
  - Existing T-C Canal (2,100 cfs)
  - Existing GCID Canal (1,800 cfs)
  - Delevan Pipeline
    - 1,500 cfs
    - 2,000 cfs
    - 3,000 cfs

Preliminary costs and operations modeling were developed for these measures to help identify the appropriate reservoir size and conveyance packages. Table 5-7 identifies the reservoir size and conveyance packages evaluated.

Table 5-7. Storage and Conveyance Screening Scenarios

Reservoir Storage (TAF)	Conveyance				Screening Capital Cost ($Billion, 2007)[a]
	T-C+GCID (cfs)	Delevan Pipeline Diversion (cfs)	Delevan Pipeline Release (cfs)	Total Diversion Capacity	
800	3,900	0	0	3,900	1.96
800	3,900	1,500	1,125	5,400	2.92
800	3,900	2,000	1,500	5,900	3.13
800	3,900	3,000	2,250	6,900	3.56
1,270	3,900	0	0	3,900	2.22
1,270	3,900	1,500	1,125	5,400	3.15
1,270	3,900	0	1,500	3,900	3.09
1,270	3,900	2,000	1,500	5,900	3.36
1,270	3,900	3,000	2,250	6,900	3.79
1,810	3,900	0	0	3,900	2.64
1,810	3,900	1,500	1,125	5,400	3.56
1,810	3,900	0	1,500	3,900	3.50
1,810	3,900	2,000	1,500	5,900	3.77
1,810	3,900	0	2,250	3,900	3.82
1,810	3,900	3,000	2,250	6,900	4.19

[a] Costs from the PFR (Reclamation and DWR, 2008) are 2007 preliminary construction costs for screening of alternative reservoir sizes and do not include mitigation, engineering, or administrative costs.

cfs = cubic feet per second
DWR = California Department of Water Resources
GCID = Glenn-Colusa Irrigation District
PFR = Plan Formulation Report
TAF = thousand acre-feet
T-C = Tehama-Colusa

Modeling results from the PFR suggested that a 2,000 cfs Delevan Pipeline conveyance was adequate to meet the project objectives. Constructing a larger Delevan Pipeline would include a larger intake/discharge structure that would result in greater environmental impacts due to both the construction of a larger intake/discharge structure into an area with sensitive habitat and the effects on geomorphology from discharging an additional 1,000 cfs. It would also require a larger penetration of the existing levee on the bank of the Sacramento River. Constructing a larger pipeline also significantly increases the cost of the project ($4.19 billion). To further refine and optimize the remaining reservoir size and conveyance packages, preliminary operations modeling was conducted and an estimate of the potential net benefits was made.

Table 5-8 presents a preliminary estimate of the net benefit associated with each potential package, ranked in order of highest potential net benefit to lowest.

Table 5-8. Preliminary Net Benefit Determinations for Storage and Conveyance Screening Scenarios

Reservoir Storage (TAF)	Conveyance				Net Annual Benefit ($Million, 2007)
	T-C+GCID (cfs)	Delevan Pipeline Diversion (cfs)	Delevan Pipeline Release (cfs)	Total Diversion Capacity (cfs)	
1,810	3,900	0	1,500	3,900	$16.25
1,270	3,900	2,000	1,500	5,900	$16.15
1,810	3,900	2,000	1,500	5,900	$14.09
1,270	3,900	1,500	1,125	5,400	$7.59
1,810	3,900	1,500	1,125	5,400	$7.88
1,810	3,900	0	2,250	3,900	$4.10
1,270	3,900	0	1,500	3,900	-$0.72
1,270	3,900	3,000	2,250	6,900	-$4.72
800	3,900	1,500	1,125	5,400	-$14.14
800	3,900	2,000	1,500	5,900	-$17.41
1,270	3,900	0	0	3,900	-$18.06
800	3,900	0	0	3,900	-$22.97
800	3,900	3,000	2,250	6,900	-$30.92
1,810	3,900	0	0	3,900	-$33.69

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
TAF = thousand acre-feet
T-C = Tehama-Colusa

The top three performers in terms of net benefits were:

- A 1.81 MAF reservoir without a new diversion, but capable of releasing 1,500 cfs to the Sacramento River through the Delevan Pipeline.
- A 1.27 MAF reservoir with a new 2,000 cfs diversion and a 1,500 cfs release through the Delevan Pipeline.
- A 1.81 MAF reservoir with a new 2,000 cfs diversion and a 1,500 cfs release through the Delevan Pipeline.

These three scenarios were used to develop alternative plans.

There is a significant break in net annual benefits after the first three scenarios in Table 5-8. These results indicate:

- A release of 1,500 cfs to the Sacramento River significantly increases all benefits when compared to a release of 1,125 cfs or no release at all.
- A significant increase in cost with little increase in benefits resulting from a 2,250 cfs release.

CHAPTER 6 PLAN FORMULATION FOR SITES RESERVOIR

This chapter describes the formulation of the NODOS alternatives from the initial alternatives in the PFR to the development of the alternative plans. Also provided is a brief description of the results from the evaluation of initial alternatives in the PFR, which is the basis for the development of the alternative plans. A discussion of the pump storage opportunities, potential recreation sites, and potential mitigation measures under these alternatives follows. It concludes by synthesizing all of the prior analyses into the development of the alternative plans.

Previous Alternative Evaluations

For the PFR, nine initial alternative plans (No Project Alternative plan and eight alternative action plans) were developed to address the primary planning objectives, constraints, and criteria. Table 6-1 displays the conveyance and retained measures for each initial alternative plan. A comparative analysis of the nine alternatives was completed in the PFR. Table 6-2 summarizes the results of the comparative analysis. Of the nine initial alternatives evaluated in the PFR, Alternative WSFQ (water supply, fishery, and water quality benefits) provided a more balanced operational strategy in meeting the three preliminary primary objectives of improving water supply, anadromous fish and aquatic species survivability, and water quality (hydropower was not a primary objective in the initial studies). It was the only alternative that resulted in a net annual benefit. This alternative also provided similar results to the other alternatives in meeting the secondary objectives. As a result, the final alternatives developed for this report all used an operations scheme based on a balanced approach to meeting the primary objectives.

Based on the above evaluation and formulation process, a series of refined alternatives were developed for detailed analysis. These alternatives rely on operations that are prioritized consistent with the priorities in initial Alternative WSFQ (a balanced strategy in meeting objectives). Table 6-3 provides selected measures for each of the three alternatives.

The selected action alternatives will retain and evaluate the following major project features and feature alternatives:

- Two potential Sites Reservoir sizes:
    - 1.27 MAF
    - 1.81 MAF

Table 6-1. Selected Measures Included in Initial Alternative Plans

Initial Alternative Plans for Sites Reservoir	Conveyance	Measures Retained										
		Primary Objectives								Secondary Objectives		
		Water Supply				Anadromous Fish and Aquatic Species Survivability			Water Quality			
		New Off-stream Storage at Sites Reservoir	Conjunc-tive Use	Water Trans-fers	Water Use Efficiency	Restore Aban-doned Gravel Mines	Improve Instream Aquatic Habitat	Replenish Spawning Gravel	Improve Flows to Delta	Hydro-power	Recrea-tion	Flood Damage Reduc-tion
No Project Alternative	N/A		X	X	X							
WS1A – Reliance on Existing Canals	1,800 cfs GCID Canal 2,100 cfs T-C Canal	X	X	X	X				X	X	X	X
WS1B – New 1,500 cfs Delevan Pipeline Diversion	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Delevan Pipeline Diversion 1,125 cfs Pipeline Release	X	X	X	X				X	X	X	X
WS1C – New 2,000 cfs Delevan Pipeline Diversion	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Delevan Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X				X	X	X	X
AF1A – New 1,500 cfs Delevan Pipeline Diversion	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Delevan Pipeline Diversion 1,125 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X

Table 6-1. (Continued)

Initial Alternative Plans for Sites Reservoir	Conveyance	Measures Retained										
		Primary Objectives								Secondary Objectives		
		Water Supply				Anadromous Fish and Aquatic Species Survivability			Water Quality			
		New Off-stream Storage at Sites Reservoir	Conjunc-tive Use	Water Trans-fers	Water Use Efficiency	Restore Aban-doned Gravel Mines	Improve Instream Aquatic Habitat	Replenish Spawning Gravel	Improve Flows to Delta	Hydro-power	Recrea-tion	Flood Damage Reduc-tion
AF1B – New 2,000 cfs Delevan Pipeline Diversion	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Delevan Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WSFQ – New 2,000 cfs Delevan Pipeline Diversion with Fish/Aquatic Enhance-ments	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Delevan Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WQ1A – New 1,500 cfs Delevan Pipeline Release	1,800 cfs GCID Canal 2,100 cfs T-C Canal 1,500 cfs Pipeline Release	X	X	X	X				X	X	X	X
WQ1B – New 2,000 cfs Delevan Pipeline Diversion	1,800 cfs GCID Canal 2,100 cfs T-C Canal 2,000 cfs Delevan Pipeline Diversion 1,500 cfs Pipeline Release	X	X	X	X				X	X	X	X

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
N/A = not applicable
T-C = Tehama-Colusa
WSFQ = water supply, fishery, and water quality benefits

Table 6-2. Summary of Initial Action Alternative Plan Features and Preliminary Estimates Costs and Benefits

Item	Alternative Plan							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Objectives and Accomplishments								
Water Supply Increase (Driest Periods Average Increase/ Average Annual Increase)[a] (TAF/year)	273/336	316/368	361/382	166/184	144/189	262/276	241/225	301/276
Anadromous Fish Rating[b]	Low	Medium	Medium	High	High	Medium	Medium	Medium
Water Quality Improvement	Low	Low	Low	Low	Low	High	High[c]	High[c]
Hydropower Generated Long Term (in GWh)	105	147	153	152	157	150	128	151
Recreation[d]	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Flood Damage Reduction and Emergency Water[e]	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Economics ($ millions)[f]								
Construction Cost	$2,138.1	$2,936.7	$3,021.8	$2,951.2	$3,036.4	$3,036.4	$2,664.5	$3,021.8
Total Annual Cost	$134.2	$183.0	$188.1	$184.1	$189.3	$189.0	$166.1	$188.1
Annual Benefits	$113.11	$151.96	$154.94	$107.69	$110.80	$214.85	$144.42	$183.20
Net Benefits (Annual Benefits – Annual Cost)	-$21.09	-$31.04	-$33.16	-$76.41	-$78.50	+$25.85	-$21.68	-$4.9

[a] Water supply increases exceed the No Project Alternative and include supplies for agriculture, municipal and industrial, and environmental (Level 4). “Driest periods average” is the average quantity for the combination of periods of May 1928 through October 1934, October 1975 through September 1977, and June 1986 through September 1992. “Average annual” is the period of October 1922 through September 2003.
[b] Anadromous fish rating is based on the ability to meet flow and temperature objectives in the Sacramento River and the number of ecosystem enhancement features in the alternative.
[c] Reductions in conductivity and total dissolved solids, bromide, and chloride concentrations were approximately doubled for the two water quality alternatives in modeling simulations.
[d] Ranking based on ability of alternatives to support flat water recreation at Sites Reservoir.
[e] Ranking based on ability of alternatives to provide emergency flushing flows in the event of catastrophic levee failure in the Delta.
[f] All costs and benefits are preliminary, as presented in the Plan Formulation Report. News costs and benefits analysis will be developed for the alternatives presented.

GWh = gigawatt-hour
TAF = thousand acre-feet
WSFQ = water supply, fishery, and water quality benefits

Table 6-3. Measures Included in Alternatives for Detailed Evaluation

Alternative	**A**	**B**	**C**
Storage Capacity			
Sites Reservoir	1.27 MAF	1.81 MAF	1.81 MAF
Conveyance Capacities *(to Sites Reservoir)*[a]			
Tehama-Colusa Canal	2,100 cfs	2,100 cfs	2,100 cfs
Glenn-Colusa Canal	1,800 cfs	1,800 cfs	1,800 cfs
Delevan Pipeline[b] Diversion Release	 2,000 cfs 1,500 cfs	 Not Available[c] 1,500 cfs	 2,000 cfs 1,500 cfs
Operations Priorities *(Primary Planning Objectives)*			
Long Term *(all years)*	EESA[d] Power[e]	EESA[d] Power[e]	EESA[d] Power[e]
Driest Periods *(drought years)*	M&I	M&I	M&I
Average to Wet Periods *(non-drought years)*	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural
Anadromous Fish Measures *(non-operational; in addition to EESA associated operations changes)*			
Establish an Ecosystem Enhancement Fund	✔	✔	✔

[a] Primary season for filling Sites Reservoir is November through March; winter fill operations are constrained to diversion operating criteria.
[b] Delevan Pipeline can be operated June through March (April and May are reserved for maintenance).
[c] A pump station, intake, and fish screens are not included for the Delevan Pipeline for Alternative B. The Delevan Pipeline will be operated for releases only from Sites Reservoir to the Sacramento River year round.
[d] EESA-related operations are a function of specific conditions, and operating criteria that are defined uniquely for each action.
[e] Includes dedicated pumping/generating facilities with dedicated afterbay/forebay of 6.5 TAF in Holthouse Reservoir (enlarged Funks Reservoir) used for managing conveyance of water between Sites Reservoir and river diversion locations and hydropower generation.

cfs = cubic foot per second
EESA = ecosystem enhancement storage account
MAF = million acre-feet
M&I = municipal and industrial
TAF = thousand acre-feet

- Three potential conveyance measures:
  - GCID Canal at its existing capacity of 1,800 cfs.
  - T-C Canal at its existing capacity of 2,100 cfs.
  - Delevan Pipeline for use as a 2,000 cfs intake from the Sacramento River to a new afterbay/forebay (enlarging Funks Reservoir) with a release back from the forebay/afterbay to the Sacramento River of 1,500 cfs, or for use as release only from Holthouse Reservoir to the Sacramento River of 1,500 cfs.

Providing flexible power generation capability was added as a primary objective. Operation of NODOS would maximize efforts to pump water into storage during off-peak periods and would release water from storage and generate power during on-peak periods to the maximum extent possible. Due to the cost difference in off-peak and on-peak rates, pumped-storage can provide an economical, and commercially important, means of operating this type of large-scale water storage project. The adaptability and flexibility of the pumped storage project would be dependent on the operating capacities of various components of the system.

No Project Alternative (NEPA)/No Project Alternative (CEQA)

The terms “No Project Alternative” and “Without Project Future Conditions” are considered synonymous. The No Project Alternative is a legitimate plan that is compared against the action alternatives. Under the No Project Alternative, no actions would be taken to provide storage north of the Delta for improving water supply, enhancing the survivability of anadromous fish, improving drinking water quality in the Delta, or improving flexible hydropower generation.

For the surface storage investigations, the planning horizon for the future conditions is assumed to be 100 years. Future conditions include facilities, policies, regulations, programs, and operational assumptions included in the existing conditions, plus future actions, projects, and programs that are reasonably expected to be in place.

The modeling effort to evaluate the NODOS alternative plans began in 2010 and relied on assumptions that were finalized on July 5, 2010. Key projects and programs assumed to be in place and operating in the future include the Delta-Mendota Canal-California Aqueduct Intertie, the Freeport Regional Water Project, RBDD Fish Passage Improvement Project (gates out year-round), and interim implementation of the San Joaquin River Restoration Plan (see Table 3-1 for a more complete list).

Key assumptions regarding the No Project Alternative include the following:

- Operations of the CVP and SWP by Reclamation and DWR, respectively, are described in the Long-Term operations of the CVP and SWP. The August 2008 Biological Assessment for the CVP and SWP prepared by Reclamation and modified by the 2009 NMFS BiOp and USFWS BiOp define the flow and temperature requirements throughout the system.

- CVP and SWP operational assumptions also include continued operations under the COA; SWRCB D-1641; use of Joint Points of Diversion (which allows Reclamation and DWR to use both the CVP and SWP diversion capacity capabilities in accordance with D-1641); SWRCB Water Quality Control Plan adopted in 2006; and implementation of the CVPIA, including environmental water actions in accordance with Section 3406(b)(2).

- Operations at RBDD have been modified to improve fish passage. The project includes flat-plate fish screen, intake channel, pumping plant, access bridge, and discharge conduit to divert water from the Sacramento River into the T-C and Corning canals. The screen was designed and permitted for diversions up to 3,000 cfs.

- Modifications to Folsom Dam to increase releases during lower pool stages, or revising the surcharge storage space in the reservoir, are not currently included in the No Project Alternative.

- Potential enlargement of Shasta Lake is not included in the No Project Alternative. This project has not been authorized as of July 2013.

- Enlargement of Los Vaqueros Reservoir, the 160-TAF expansion, is included in the No Project Alternative.

- An existing Banks pumping capacity limit of 6,680 cfs was assumed.

- The No Project Alternative includes water-use efficiency to conserve and recycle water throughout California.

- The MOU between Reclamation, DWR, and SWRCB for implementing the CALFED Water Transfer Program is included in the No Project Alternative.

- Future conditions do not include assumptions for climate change related to sea level rise and changes in precipitation patterns, including changes in ratios between snow and rainfall.

- The future conditions do not include assumptions of future changes in facilities operations, land use, or policies to accommodate or mitigate the adverse impacts associated with climate change.

- The No Project Alternative does not assume new Delta conveyance facilities to be in place, rather Delta exports would continue to be pumped through the Banks and Jones pumping plants.

- All hydropower facilities of the CVP, SWP, and other waters tributary to the Sacramento River and the Delta would be operated in accordance with existing agreements and other regulatory operating agreements. Operations of these facilities would be dependent on the hydrology and water supply allocations. It is assumed that these facilities operate in the same manner they have historically.

Common Features of the Action Alternative Plans

The three initial action alternative plans propose common physical features which are integral to the performance of NODOS. These common features include the following:

- Sites Reservoir Features
  - Sites Reservoir
  - Sites Reservoir Inlet/Outlet Structure
  - Tunnel from Sites Inlet/Outlet Structure to Sites Pumping/Generating Plant
  - Sites Pumping/Generating Plant
- Red Bluff Pumping Plant
  - Add one new pump
- Holthouse Reservoir Complex Features
  - Holthouse Reservoir (Funks Reservoir enlargement)
  - Holthouse Dam
  - Holthouse to T-C Canal Pipeline
  - Holthouse Pumphouse
  - Holthouse Spillway and stilling basin
  - Temporary T-C Canal bypass
  - T-C Canal discharge dissipater
- Modifications to GCID Canal Facilities
  - Intake work
  - Canal lining (200 feet)
  - Railroad siphon replacement
- TRR Features
  - TRR
  - TRR Pumping-Generating Plant
  - TRR Pipeline
  - TRR to Funks Creek pipeline
  - Delevan pipeline
- Road relocations and South Bridge
- Electrical switchyards

- Recreation facilities (three in project, up to two additional potential future sites)
- Ecosystem enhancement storage account (EESA) features
- Sites Reservoir operations strategy
- Ecosystem Enhancement Fund

Sites Reservoir

Two reservoir storage capacity options are under consideration for the action alternative plans:

- 1.27 MAF for Alternative A.
- 1.81 MAF for Alternative B and Alternative C, collectively.

1.27 MAF Storage Capacity

For the 1.27 MAF storage reservoir, the maximum WSE of the reservoir would be 480 feet msl, with an inundation area of approximately 12,400 acres. The minimum operating water surface would be at elevation 340 feet. The reservoir would require construction of the Golden Gate Dam on Funks Creek, Sites Dam on Stone Corral Creek, and six saddle dams on the northern end of the reservoir, between the Funks Creek and Hunters Creek watersheds (see Figure 6-1). All of these dams would be zoned earth rockfill embankment-type dams, which previous investigations indicate is the most economical. However, a study of dam types would be conducted in the preliminary design phase to ensure the selection of the most economical and technically feasible dam types for all of the Sites Reservoir dams.

Golden Gate Dam would be constructed on Funks Creek, approximately 0.7 mile west of Holthouse Reservoir. The proposed dam embankment would have a crest elevation of 500 feet, a crest length of 1,450 feet, a maximum height of 266 feet above the streambed, and a total embankment volume of 6.0 million cubic yards.

Sites Dam would be constructed on Stone Corral Creek, approximately 0.25 mile east of the town of Sites and 8 miles west of the town of Maxwell. The dam embankment would have a crest elevation of 500 feet, a crest length of 725 feet, a maximum height of 250 feet above the streambed, and a total embankment volume of 2.9 million cubic yards.

Six saddle dams would be required at the northern end of Sites Reservoir, between the Funks Creek and Hunters Creek watersheds, roughly along the Glenn-Colusa County line. Total embankment volume of the saddle dams is 2.2 million cubic yards.

Total embankment volume required for the Golden Gate Dam, Sites Dam, and the six saddle dams amounts to 11.0 million cubic yards.

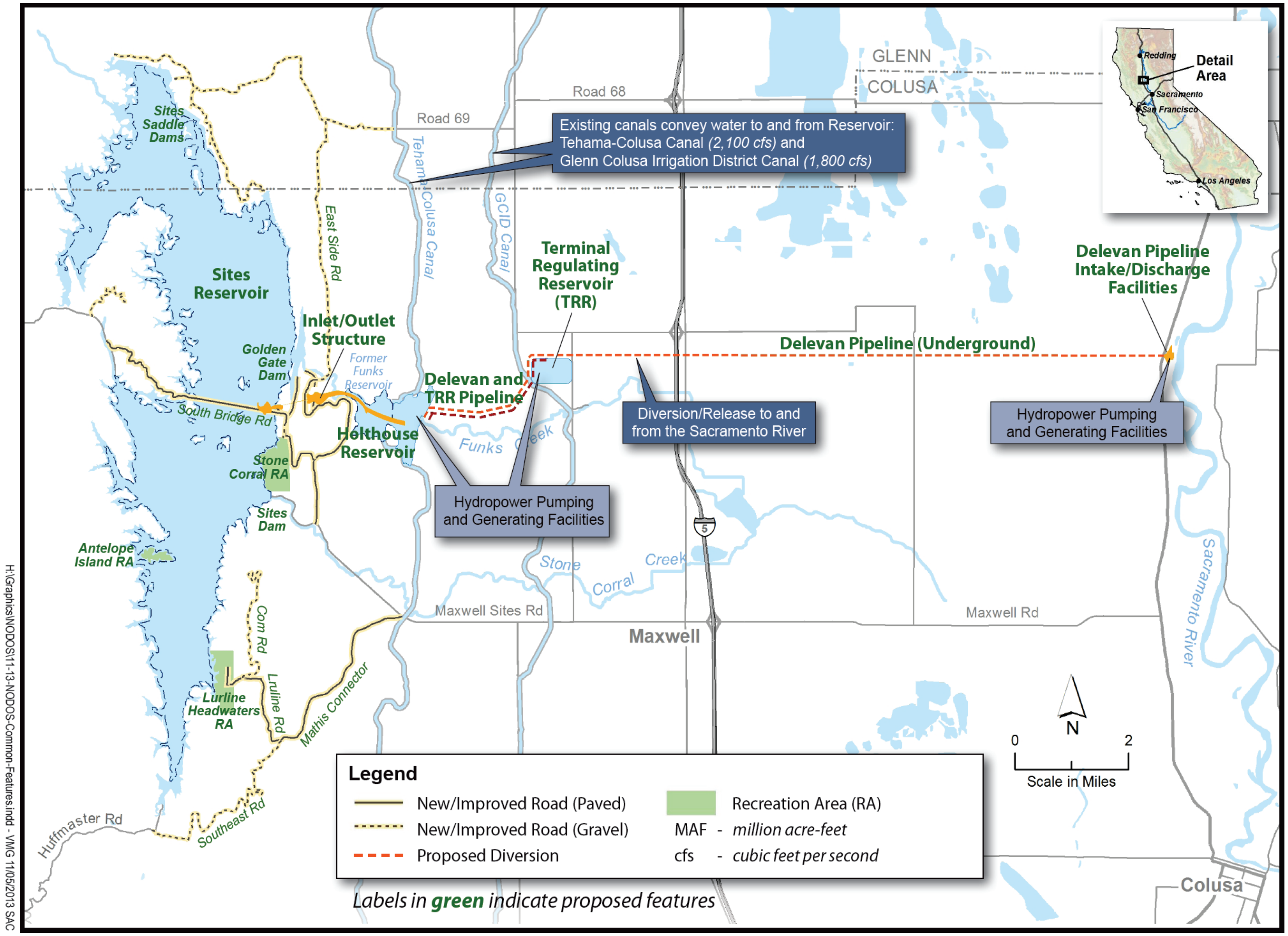


Figure 6-1. NODOS Common Features

For the pumping capacities considered, the spillway selected for the preliminary studies to signal excess filling of the reservoir would consist of one 7-foot-diameter concrete pipe constructed at the bottom of Saddle Dam No. 6 and sized primarily to accommodate inspection and maintenance. The invert of the spillway inlet would be at elevation 486.5 feet, which is the level the reservoir would reach if the full probable maximum flood was stored above the normal maximum reservoir operating level at elevation 480.0 feet.

1.81 MAF Storage Capacity

For the 1.81 MAF storage reservoir, the maximum WSE of the reservoir would be 520 feet msl, with an inundation area of approximately 14,000 acres.

Minimum operating water surface for both reservoir sizes would be at elevation 340 feet. The reservoir would require construction of Golden Gate Dam on Funks Creek, Sites Dam on Stone Corral Creek, and nine saddle dams on the northern end of the reservoir, between the Funks Creek and Hunters Creek watersheds (see Figure 6-1). These dams all would be zoned earth rockfill embankment-type dams; previous investigations indicate that this type of dam is the most economical. However, a study of dam types would be conducted in the preliminary design phase to ensure the selection of the most economical and technically feasible dam types for all of the Sites Reservoir dams.

Golden Gate Dam would be constructed on Funks Creek, approximately 1 mile west of Holthouse Reservoir. The proposed dam embankment would have a crest elevation of 540 feet, a crest length of 2,250 feet, a maximum height of 310 feet above the streambed, and a total embankment volume of 10.6 million cubic yards.

Sites Dam would be constructed on Stone Corral Creek, approximately 0.25 mile east of the town of Sites and 8 miles west of the town of Maxwell. The dam embankment would have a crest elevation of 540 feet, a crest length of 850 feet, a maximum height of 290 feet above the streambed, and a total embankment volume of 3.8 million cubic yards.

Nine saddle dams would be required at the northern end of Sites Reservoir, between the Funks Creek and Hunters Creek watersheds, roughly along the Glenn-Colusa County line. Saddle Dams 1, 2, 4, and 9 are generally characterized as small-sized dams, with heights ranging from approximately 40 to 50 feet. Saddle Dams 3, 5, 6, 7, and 8 are generally characterized as medium-sized dams, with heights ranging from approximately 70 to 130 feet. Saddle Dams 3, 5, and 8 are the tallest and largest of the nine proposed, with embankment volumes of approximately 3.5, 1.5, and 1.9 million cubic yards, respectively.

Total embankment volume required for the Golden Gate Dam, Sites Dam, and the nine saddle dams amounts to 21.0 million cubic yards.

For the pumping capacities considered, the signal spillway selected for the preliminary studies would consist of one 7-foot-diameter concrete pipe with a morning glory style inlet located on a bench part way up the left abutment of Saddle Dam 6 and sized primarily to accommodate inspection and maintenance. The invert of the morning glory spillway inlet would be at elevation 525.5 feet, which is the level the reservoir would reach if the full probable maximum flood was stored above the normal maximum reservoir operating level at elevation 520.0 feet.

Sites Reservoir Inlet/Outlet Structure

The purpose of the reservoir inlet/outlet works is to regulate reservoir releases through the tunnel to the Sites Pumping/Generating Plant. The reservoir inlet/outlet works would be located on the west end of the tunnel and southwest of the proposed Golden Gate Dam. The reservoir inlet/outlet works would consist of a low-level inlet/outlet structure for emergency drawdown releases, a multi-level inlet tower with gate-controlled outlets at various levels and two fixed wheel gates to shut down and isolate the outlet tunnel, and a tower access bridge.

The low-level inlet/outlet structure would be the same for the 1.27 MAF and 1.81 MAF reservoirs and would be approximately 120 feet from bottom of foundation to the top of trashracks. The rectangular structure dimensions would be approximately 100 feet by 120 feet. The three 30-foot by 30-foot intake openings would be covered by trashracks.

The multi-level inlet/outlet works has a tower with multiple inlet ports with the capability of drawing water at different levels in the reservoir. The multi-level outlet tower contains trashracks with port valves (butterfly valves) embedded in the inlet tower in tiers with four valves around each tier. For the 1.81 MAF reservoir, the tower would be approximately 260 feet high and have nine tiers of port valves. For the 1.27 MAF reservoir, the tower would be approximately 220 feet high and have seven tiers of port valves. The multi-level outlet tower would contain movable fish screens around two tiers for varied operational purposes (6,000 cfs for two tiers). Each port valve can be operated independently, or all valves can be operated together in each tier. The tiers are 20 feet apart from an elevation 30 feet below the maximum reservoir level down to elevation 340 feet. The high inlet tower/shaft would also contain two 9-foot by 35-foot fixed-wheel gates at the base of the tower to isolate the tower from the main tunnel and dewater the tunnel for inspection and maintenance. The main tower shaft would have an inner diameter of 32 feet and an outer diameter of 39 feet. Cranes would be used to hoist the fish screens, port valves, and gates for necessary inspection and maintenance.

An access bridge would provide access to the multi-level tower from the nearby access road. The bridge length would be approximately 440 feet for the 1.27 MAF reservoir (Alternative A) and 540 feet for the 1.81 MAF reservoir (Alternatives B and C). The bridge deck elevation would be approximately 500 feet for the 1.27 MAF reservoir and 540 feet for the 1.81 MAF reservoir. The bridge is expected to be a simple welded-plate girder system with a lightweight concrete deck. The girders would be supported by the multi-level outlet tower, cast-in-place reinforced concrete piers, and a reinforced concrete abutment.

Tunnel Connecting Sites Pumping/Generating Plant and Sites Inlet/Outlet Structures

The purpose of the tunnel is to convey water between the Sites Pumping/Generating Plant which takes water from Holthouse Reservoir and the Sites Reservoir inlet/outlet structure, which is in Sites Reservoir. The tunnel alignment is located west of the Holthouse Reservoir and south of the proposed Golden Gate Dam on Funks Creek.

The tunnel follows a straight alignment between the proposed Sites Pumping/Generating Plant location and the proposed Sites Reservoir inlet/outlet location, and is approximately 4,500 feet long.

The proposed 30-foot-diameter finished tunnel size was developed to meet DWR's Division of Safety of Dams emergency drawdown release criteria. The proposed tunnel has a design capacity of approximately 23,000 cfs. Pumping velocities through the tunnel would be 8.3 feet per second (fps) for the 5,900 cfs pumping/generating plant design. The tunnel would be concrete-lined with an additional steel liner in the first 1,000 feet adjacent to the pumping/generating plant.

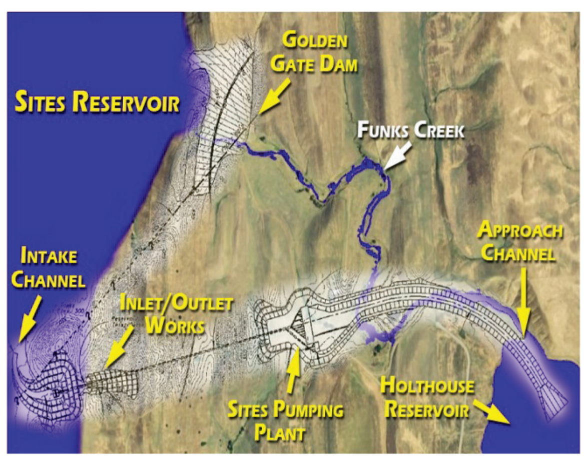
Hydroelectric Facilities

Hydroelectric generating capability has been incorporated into the pumping/ generating plant facilities, as presented in Table 6-4. In general, the addition of ancillary hydroelectric power generation to the grid would help mitigate some of the power consumption costs associated with this offstream water storage facility. Water would be pumped into Sites Reservoir primarily in the winter and spring months during off-peak periods, and water would be released primarily during the summer and fall, thereby producing hydropower when power demands and costs are typically higher. Preliminary designs and estimated costs for the hydroelectric facilities for the Sites Pumping/Generating Plant, the TRR Pumping/Generating Plant, and the Sacramento River Pumping/Generating Plant and a new pipeline were completed for this stage of planning. While every initial action alternative plan includes hydroelectric facilities, sizing of the facilities is based on the release capacity and head at the various locations. Currently, the operation of the hydroelectric facilities is based on water deliveries from Sites Reservoir during on-peak periods, which was determined by water use within the system. This operation may be refined later to optimize the use of the hydroelectric facilities based on variability in the market cost of power. A planning study is underway by Western Area Power Administration (Western) to better define system attributes in the event that it is connected to the Western system.

Sites Pumping/Generating Plant

The purpose of the Sites Pumping/ Generating Plant is to pump water from Holthouse Reservoir into Sites Reservoir and to generate electricity during the release of water from Sites Reservoir to the Holthouse Reservoir. The Sites Pumping/Generating Plant would be located approximately 3,300 feet southeast of the Golden Gate Dam.

The design capacity of Sites Pumping/ Generating Plant would be approximately 5,900 cfs. The pumping/generating plant would be located on a low, flat bench to minimize excavation.



Sites Pumping/Generating Plant

Table 6-4. Hydroelectric Pumping/Generating Plant Facilities

Pumping-Generating Equipment for Alternative A								
Unit Type	**Number of Units**	**Net Head (feet)**	**Pumping Capacity Per Unit (cfs)**	**Generating Capacity Per Unit (cfs)**	**Motor Power Total (MW)**	**Generating Power Per Unit (MW)**	**Total Plant Pumping Capacity (cfs)**	**Total Plant Generating Capacity (cfs)**
Pump – Francis Vane Dual Speed	2 (+1 Standby)	290	870	-	32.0	-	5,926	5,100
		162	870	-	17.9	-		
Pump – Francis Vane Dual Speed	2	290	435	-	16.0	-		
		162	435	-	9.0	-		
Pump/Turbine Reversible Francis, Dual Speed	4 (+1 Standby)	290/270	663	1,020	48.8	77.0		
		162/142	663	1,020	27.3	41.3		
Pump/Turbine Reversible Francis, Dual Speed	2	290/270	332	510	12.2	19.3		
		162/142	332	510	6.8	10.3		

Pumping-Generating Equipment for Alternative B								
Unit Type	**Number of Units**	**Net Head (feet)**	**Pumping Capacity Per Unit (cfs)**	**Generating Capacity Per Unit (cfs)**	**Motor Power Total (MW)**	**Generating Power Per Unit (MW)**	**Total Plant Pumping Capacity (cfs)**	**Total Plant Generating Capacity (cfs)**
Pump – Francis Vane Dual Speed	2 (+1 Standby)	323	300	-	12.3	-	3,916	5,100
		195	300	-	7.4	-		
Pump/Turbine Reversible Francis, Dual Speed	4 (+1 Standby)	323/310	663	1,020	54.3	87.7		
		195/182	663	1,020	32.8	51.5		
Pump/Turbine Reversible Francis, Dual Speed	2	323/310	332	510	13.6	22.0		
		195/182	332	510	8.2	12.9		

Table 6-4. (Continued)

Pumping-Generating Equipment for Alternative C								
Unit Type	**Number of Units**	**Net Head (feet)**	**Pumping Capacity Per Unit (cfs)**	**Generating Capacity Per Unit (cfs)**	**Motor Power Total (MW)**	**Generating Power Total (MW)**	**Total Plant Pumping Capacity (cfs)**	**Total Plant Generating Capacity (cfs)**
Pump – Francis Vane Dual Speed	2 (+1 Standby)	330	870	-	36.4	-	5,926	5,100
		202	870	-	22.3	-		
Pump – Francis Vane Dual Speed	2	330	435	-	18.2	-		
		202	435	-	11.2	-		
Pump/Turbine Reversible Francis, Dual Speed	4 (+1 Standby)	330/310	663	1,020	55.5	87.7		
		202/182	663	1,020	34.0	51.5		
Pump/Turbine Reversible Francis, Dual Speed	2	330/310	332	510	13.9	22.0		
		202/182	332	510	8.5	12.9		

cfs = cubic feet per second
MW = megawatt

The plant would be a conventional indoor-type pumping/generating plant with an in-line arrangement of pumping and pumping/generating units.

Under Alternative A, the pumping/generating plant is expected to have a 100 MW power generating capacity. Under Alternatives B and C, the pumping/generating plant is expected to have a 125 MW power generating capacity. Under Alternatives A and C, the pumping/generating plant would have a total of 12 units, two of which are for standby. These units would consist of three 870 cfs (one standby) and two 435 cfs pump units, and four 663 cfs (one standby) and two 332 cfs pump-turbine units. Under Alternative B, the pumping/generating plant has a total of 10 units, two of which are for standby. These units would consist of two 300 cfs (one standby) pump units, and four 663 cfs (one standby) and two 332 cfs pump-turbine units. Under all three alternatives, these units would be connected to an intake/discharge manifold. The Sites Pumping/Generating Plant would be similar in the general configuration to the existing SWP Chrisman Pumping Plant, except the Sites Plant would have additional pumping-generating units and two service bays on both ends of the plant.

When water is drawn out of Holthouse Reservoir and pumped up to Sites Reservoir, the pumped water flows through the intake/discharge manifold until all 12 discharge pipes coming from the pump units are full and combined into a single 26-foot-diameter pipe. This pipe would then join the 26-foot-diameter pipe coming from the emergency bypass outlet and the two pipes would connect to the 30-foot-diameter tunnel.

The Sites Pumping/Generating Plant would be connected to Holthouse Reservoir by an unlined approach channel approximately 8,300 feet long. The approach channel is expected to have relatively flat slope toward the plant and would be constructed at an elevation below the operating range of the reservoir. The channel would have a trapezoidal geometry with bench slopes and would be approximately 200 feet wide at the bottom invert and 400 to 700 feet across at the top. When Holthouse Reservoir is completely full, the channel would be almost entirely submerged. This channel would allow water from the reservoir to flow by gravity to or from the pumping/generating plant. On the other side of the pumping/generating plant, connecting it to Sites Reservoir, would be a 4,000-foot-long, 30-foot-diameter tunnel.

An electrical switchyard would be required adjacent to the Sites Pumping/Generating Plant providing power to and from the plant. The switchyard would step down the electrical voltage from high-voltage lines used to transmit electricity over long distances to a lower voltage that can be used by the pumps and other machinery in the plant in pump mode. In generating mode, the switchyard would transmit electricity generated by the water released from Sites Reservoir through the plant to the power grid. The electrical switchyard site would cover approximately 4 acres. The switchyard would be graded flat and would have multiple pieces of electric equipment on concrete pads. One transmission tower (approximately 50 feet tall) would receive the electrical line entering the site.

Additional on-site facilities related to the Sites Pumping/Generating Plant include:

- Emergency release bypass outlet
- Electrical switchyard

- Maintenance buildings
- Electrical connection
- Parking and access roads

TRR Pumping/Generating Plant

The purpose of the TRR Pumping/Generating Plant is to pump water from the TRR to the TRR pipeline that conveys water to Holthouse Reservoir. Return flows from Holthouse Reservoir to the TRR would flow through the TRR Pumping/Generating Plant to generate power.

The TRR Pumping/Generating Plant would pump 1,800 cfs of water from the TRR to Holthouse Reservoir. The TRR Pumping/Generating Plant would generate power from flows released through the TRR Pumping/Generating Plant with a maximum return flow of 1,350 cfs. The minimum water elevation in TRR for operation of the TRR Pumping/Generating Plant is 112 feet, and the maximum water elevation for operation of the TRR Pumping/Generating Plant is 121.5 feet.

The TRR Pumping/Generating Plant would be located on the north side of the TRR within a 34-acre site next to the TRR, and would be approximately 3 miles northeast of Holthouse Reservoir. On the north side of the TRR, the TRR Pumping/Generating Plant would connect to the TRR Pipeline. The TRR Pumping/Generating Plant would consist of two (plus one standby) 620 cfs and two 325 cfs pump units, providing a total pumping capability of 1,890 cfs, and two 750 cfs turbine units, each providing 4.9 MWs of power.

Structures associated with the TRR Pumping/Generating Plant would be a pumping/generating plant facilities structure, and an electrical switchyard. The TRR Pumping/Generating Plant would have a spare pump bay for backup and maintenance purposes.

Sacramento River Pumping/Generating Plant

The Sacramento River Pumping/Generating Plant would have facility features of Alternatives A and C and would have the same designs. The purpose of the Sacramento River Pumping/Generating Plant is to pump water from the Sacramento River to Holthouse Reservoir. A fish screen structure would be located in front of the plant to avoid fish entrainment and bypass fish downstream. Return flows from Holthouse Reservoir to the Sacramento River would flow through the TRR Pumping/Generating Plant to generate power.

The Sacramento River Pumping/Generating Plant would pump 2,000 cfs of water from the Sacramento River to Holthouse Reservoir. The Sacramento River Pumping/Generating Plant would generate power from flows released from Holthouse Reservoir with a maximum return flow of 1,500 cfs. The minimum water elevation in Holthouse Reservoir is 192 feet.

The Sacramento River Pumping/Generating Plant would be located on the right bank of the Sacramento River across the river from the Moulton Weir. The fish screen structure would be located along the right bank of the Sacramento River after which intake water would come into a forebay to the Sacramento River Pumping/ Generating Plant. The Sacramento River Pumping/Generating Plant would consist of four 600 cfs pump units (plus one standby) with total pumping capability of 2,400 cfs and two 750 cfs turbine units, each providing 5.4 MWs of power.

The levee along the Sacramento River at the pumping-generating facility site is a federal project levee and construction of a setback levee likely would be required before the existing levee can be breached to construct the fish screen and pumping plant facilities.

Red Bluff Pump Installation at the Pumping Plant

Modifications to the Red Bluff pumping plant were completed under another project. However, the pumps within two bays were not installed within these bays. One additional pump would be installed as part of the NODOS Project.

Holthouse Reservoir Complex

Funks Reservoir is on Funks Creek, approximately 7 miles northwest of Maxwell, in Colusa County. The existing Funks Reservoir, constructed in 1975 by Reclamation, was designed to have 2,250 AF of storage capacity covering a surface area of 232 acres at elevation 205 feet. An earthfill dam with a crest elevation of 214 feet impounds the reservoir on the east. The dam forms the eastern bank of the T-C Canal as it crosses Funks Creek. An inlet is located at the northeastern end, adjacent to the dam spillway, and at an outlet to the southeast. Both have a gated release structure. The T-C Canal requires an operational elevation of Funks Reservoir between 199.5 feet and 205.2 feet based upon information recently received from the T-C Canal Authority. The spillway overflow discharge capacity is 25,000 cfs with all gates fully open.

It would be necessary for Funks Reservoir to be enlarged to provide the storage capacity to operate the conveyance systems supplying water, regulate flows for the proposed Sites Pumping/Generating Plant, and store water for on-call power generation for up to 6 hours per day. The reservoir would be expanded by excavating the adjacent area. This enlarged Funks Reservoir has been renamed Holthouse Reservoir and preliminary studies indicate the active storage should be approximately 6,500 AF to satisfy all of the seasonal water balance needs and simultaneously permit pump-back power generation for up to 6 hours per day on a daily basis.

Holthouse Reservoir would serve as a regulating reservoir for Sites Reservoir and would be used to regulate inflows and releases to minimize power usage and maximize power generation. For the proposed conveyance option, the T-C Canal would be widened and modified upstream from Holthouse Reservoir to dissipate inflow energy before entering the reservoir. It would also serve as a regulatory reservoir for the T-C Canal.

An existing Western transmission line current crosses through the footprint of Holthouse Reservoir. Currently, the preferred relocation option is to move the segment of the line in the reservoir footprint area to the west and cross the existing Funks Reservoir at the narrowest location.

Delevan Pipeline

The Delevan Pipeline would consist of two buried 12-foot-diameter reinforced concrete pipes which would provide water conveyance capability between the Sacramento River and Holthouse Reservoir. Under Alternatives A and C, the Delevan Pipeline would be operated to provide conveyance to and from the Sacramento River through the Sacramento River Pumping/Generating Plant and then through the fish screen structure. Under Alternative B, the Delevan Pipeline would only be designed and operated to release water from Holthouse Reservoir to the Sacramento River through the Sacramento River Outlet Structure. Under Alternatives A and C, water would be pumped up from the Sacramento River to Holthouse Reservoir through the Delevan Pipeline under pressure and water would be released from Holthouse Reservoir under gravity. Under Alternative B, water would also be released under gravity conditions. In operating and maintaining this pipeline, there would be the need to provide blow-off valves, air release and vacuum valves, supervisory control and data acquisition communications, cathodic protection, and access into the pipe along the full length of the pipeline. It is expected that the blow-off and air release and vacuum valves would have associated access manholes to the inside of the pipe and that these appurtenances would be housed in a concrete access structure or vault.

Delevan Pipeline Discharge Facilities. The Delevan Pipeline Discharge Facilities is a feature of only Alternative B and provides control of the releases from Holthouse Reservoir to the Sacramento River through the Delevan Pipeline. This structure would be located on the waterside bank of the Sacramento River and would have a flowmeter and cone-valves for each of the two pipes of the Delevan Pipeline. This mechanical equipment would be housed in concrete structures. A concrete-lined discharge channel would carry the released flows from the valves down the concrete channel into a concrete spillway and into the Sacramento River. A positive barrier bar rack would cover the spillway at expected operating river levels to prevent fish from entering the structure. The levee along the Sacramento River at the outlet structure site is a federal project levee and construction of a setback levee would likely be required before the existing levee can be breached to construct the new facilities.

GCID Canal Modifications

The existing GCID intake and headworks facilities divert water from the Sacramento River into a forebay where the water is pumped by the Main Pump Station into the GCID Canal. The existing GCID intake and headworks facilities include the intake and bypass channels, fish screens, main pump station and forebay, headgates, and a gradient facility. Improvements in this area include a new headgate structure, pump rehabilitation, fish screen modifications, and a new bridge.

Glenn-Colusa Irrigation District Canal Intake

For this project, the existing headgate structure would be left in place as the bridge for County Road 203. A new headgate structure would be constructed downstream of the existing structure. The existing headgate structure would continue to operate during construction of the new headgate structure, and diversion activities would continue throughout construction.

The new headgate structure would include three automated gates (two roller gates and one radial gate), and would be located downstream of the existing structure. A new energy dissipation basin would be located downstream of the new headgates to stabilize flows under high head-drop conditions. The canal reach downstream of the new headgate structure would be lined with concrete for approximately 1,000 feet to prevent erosion due to the turbulent flow conditions. A temporary bypass channel would be built around the site of the new headgate structure to allow diversion water to flow past the construction site and maintain regular canal operation. The temporary bypass channel would be constructed using a combination of excavation, earth embankment, and sheetpile walls to isolate the construction site from the diversion canal. After completion of headgate construction, the temporary bypass would be filled in, earth embankments and sheetpile walls would be removed, and the area would be restored to pre-construction conditions.

In 2001, a 525-foot extension of the fish screen structure was completed to meet current fish screen performance criteria. New brush-cleaning systems were installed on both the new and the original portions of the fish screen. The complete structure now consists of 85 bays with 12-foot by 12-foot fish screen panels mounted in each bay. Solid steel panels, called barrier panels, close off the portion of the bay between the top of the screen panel and the structure’s top deck. The existing total screen area is 11,400 square feet, which provides approximately 3,760 cfs of diversion capacity with river levels at or above the top of the screen panels. Normal operating conditions are based on a maximum diversion rate of 3,000 cfs, with a minimum river level of 136.5 feet msl at the screens, which leaves approximately 1 foot of screen area exposed above the water surface.

Modifications to GCID Canal

The GCID Canal is an existing irrigation canal that delivers water from the Sacramento River to irrigation districts along its route from its diversion point northwest of Hamilton City to southeast of Williams. The canal is an unlined earthen channel, with capacity varying from 3,000 cfs at the upstream end to 300 cfs at the southern terminus. For this project, minor reshaping of the canal along the lower 13 miles upstream from the TRR would be required to obtain a reliable capacity of 1,800 cfs. Additionally, a railroad siphon at the California Northern Railroad crossing and check structure at Tuttle Creek would need replacement.

Earthwork is required to restore the canal invert (the deepest part of the canal), bottom width, side slopes, and bank height conditions to provide long-term reliable operating conditions during winter season operations with maximum canal flows. In addition to the earthwork modifications along the 13-mile-long reach, approximately 200 feet of the canal downstream of the new headgate structure would be concrete-lined.

Prior to modification of each canal reach, water supply to the reach would be discontinued. This interruption could be achieved by closing check gates upstream of the reach or installing temporary earth embankments. (Bypass canals may be required if water deliveries downstream of the reach cannot be interrupted.) After initial draining, the canal reach would require dewatering. The degree to which dewatering would be required in each reach would depend on soil characteristics and ground-water conditions, and may vary substantially along the length of the canal. The two principal methods of dewatering that are expected to be used are temporary shallow wells and drainage trenches. Under either dewatering method, water would be pumped out of the construction area in accordance with Central Valley Regional Water Quality Control Board (CVRWQCB) requirements and stormwater quality best management practices.

A siphon under the railroad at Main Canal Mile Post 26.6 does not meet design and operation criteria for the project and would require replacement. The existing railroad siphon structure was built in the early 1900s and includes two 6-foot-diameter barrels and five 7.25-foot by 6-foot barrels. At maximum existing flows of approximately 2,000 cfs, the head loss across the railroad siphon, due to high flow velocity and poor entrance and exit transitions, reduces upstream canal freeboard to very marginal conditions. Based on the structure's age, hydraulic capacity restrictions, and use as a major transportation link, it should be replaced. The new structure would consist of five 10-foot by 10-foot barrels. Typical future maximum velocity and head losses would be approximately 4 fps and 0.2 feet, respectively. Maximum flow through the siphon would be 2,000 cfs.

Replacement of the railroad siphon would require coordination and planning with railroad operators. Construction restrictions may exist regarding minimizing interference with regular railroad operations. To the extent possible, construction of the siphon would take place during periods of lowest train traffic and railroad shutdown time would be minimized. Replacement of the siphon under the railroad track would, however, requires the shutdown and temporary removal of the section of track directly over the siphon location.

TRR

Water conveyed down the GCID Canal would be conveyed into a future TRR. A new pumping/generating plant, the TRR Pumping/Generating Plant, would then convey the water from the TRR via a new pipeline up to Holthouse Reservoir. The TRR would be required to provide operational storage for the TRR Pumping/Generating Plant to balance out normal and emergency flow variations between the upstream GCID Canal Pump Station, the 40 miles of connecting canal, and the TRR Pumping/Generating Plant.

The TRR would be created on the valley floor next to the Main Canal by a combination of excavation and embankment. The TRR would be located approximately 3 miles northeast of Holthouse Reservoir. The reservoir would be composed of an earth embankment dam, concrete emergency overflow weir, an outfall standpipe, and an approximately 4,000-foot-long, underground, 60-inch-diameter outlet pipe to Funks Creek (TRR to Funks Creek Pipeline). A 15-foot-wide gravel road would be constructed on top of the embankment to provide access to the facility for operations and maintenance (O&M).

The embankment materials would be impervious earthen material compacted to DWR's Division of Safety of Dams standards. The reservoir would be approximately 16 feet deep with a maximum water depth of 12 feet, leaving 4 feet of freeboard. The total storage volume in the TRR would be divided into three operational components: (1) dead storage beneath the lower operating limit of the pump station; (2) normal operational storage; and (3) emergency storage. Two feet of the water depth would be for dead storage, 5 feet of water depth would be for normal operational storage, and 5 feet of water depth would be for emergency storage. The maximum WSE in the TRR cannot exceed the WSE in the GCID Canal because it is a gravity flow system. The maximum embankment height would be 21 feet above the existing grade elevation. The bottom dimensions of the reservoir would be approximately 3,780 feet by 2,070 feet, and the reservoir would have a maximum storage capacity of 2,000 AF. The TRR capacity is based on the need to provide normal transient operating storage for the TRR-to-Funks Pump Station and emergency storage to absorb flows from the Main Canal following an emergency shutdown of the TRR-to-Funks Pump Station.

GCID Canal Connection to TRR

The purpose of the connection from the GCID Canal to the TRR is to reduce the velocity of flows from the GCID Canal to approximately 1 fps to form a stable pool. The stable pool would occur just before the turnout to the connecting channel to the TRR.

The connection from the GCID Canal to the TRR would be located between the GCID Canal and the TRR and south of the TRR pipeline, and would have two features: (1) the GCID Canal energy dissipation bay with check structure, and (2) the TRR inlet channel and inlet control structure. The bay would be located along a reach of the GCID Canal approximately 500 feet long, with a 220-foot bottom width, 20-foot depth and embankment slopes with a 1.5 horizontal to 1 vertical ratio (1.5H:1V). On the east end of the bay, the reservoir inlet channel would divert flow to the reservoir. On the south end of the bay, a new radial-gate check structure would serve two purposes: (1) maintain a WSE in the canal transition section to provide available head for conveyance into the TRR, and (2) control flow to the remaining downstream reach of the GCID Canal.

The inlet channel would connect the Main Canal to the TRR. The channel is a lined trapezoidal cross-section, having a 70-foot bottom width and a length of 400 feet, with embankment slopes of 1.5H:1V. The inflow control structure is very similar to a standard GCID Canal check structure, with three large radial gates to control flow into the reservoir. The structure's top deck width would accommodate vehicle traffic to allow access along the Canal. A transition apron (a large concrete pad) into the reservoir is located immediately downstream of the control gates. The apron would be 160 feet wide and 100 feet long. The function of the concrete apron is to provide an erosion-resistant area for energy dissipation as the water enters the TRR.

The earthen embankment for the inlet channel would be approximately 20 feet high. When the radial gates at the check structure open, the gates would be approximately 15 feet above the embankment.

TRR Pipeline

The 3.5-mile-long TRR pipeline would convey water from the TRR to Holthouse Reservoir. The TRR pipeline would be bi-directional, allowing water to be pumped from the TRR to Holthouse Reservoir for storage, and allowing water to flow by gravity from Holthouse Reservoir for release to the TRR/GCID Canal. As water released from Holthouse Reservoir flows through the TRR Pumping/Generating Plant at the end of the pipeline, it would pass through turbines to generate electricity.

The TRR Pipeline would consist of two 12-foot-diameter reinforced concrete pipes with capacity to convey 1,800 cfs from the TRR to Holthouse Reservoir and 1,350 cfs from Holthouse Reservoir to the TRR. The pipeline would be buried a minimum of 10 feet (to top of pipe) below ground surface. Facilities associated with the TRR Pipeline include blow-off structures and air valve structures.

Utility Crossings

The proposed alignment of the TRR and Delevan pipelines would require three crossings of major existing infrastructure (Interstate 5, Highway 99, and Highway 45). At these crossings, the pipelines would be drilled through the ground below the existing infrastructure so that services would not be interrupted. In all, the crossings total six: Interstate 5, Highway 99, Highway 45, CBD, California Northern Railroad, and the GCID Canal. At these locations, the bore and jack construction method would likely be used. Bore and jack construction entails excavating a large pit on each side of the existing infrastructure (highway, railroad, or canal in this case) and then tunneling horizontally under the structure without disturbing it. All additional work required for bore and jack construction would be conducted within the construction easement and would not require the disturbance of additional land.

The proposed pipeline routes would also require crossing the easements of Pacific Gas and Electric Company (PG&E) 230-kilovolt (kV) and 500 kV lines and a major gas pipeline. No permanent aboveground structures would be constructed where the electric utility easements and the pipeline easements would intersect.

Other existing infrastructure that the pipeline potentially could cross includes gas lines, water lines, sewer lines, communications lines, and other infrastructure. These utilities likely would be rerouted to be aligned under the proposed pipelines, or the proposed pipelines would be installed beneath the existing utilities. Disruptions to these utilities would be minimized to the extent possible, and the ground surface would be restored to pre-construction conditions after installation of the pipelines. Construction activities for the proposed pipelines and modifications to existing utilities would occur within the identified construction easement and would require only slightly more excavation than that required for the pipeline.

Road Relocations and South Bridge

Sites Reservoir would inundate portions of Maxwell-Sites Road and Sites-Lodoga Road, and would, therefore, block travel between the towns of Maxwell and Lodoga (Figure 6-1). These roads are within Colusa County's jurisdiction. Approximately 6 miles of Huffmaster Road (a gravel road) also would be inundated. This road is also a county road, providing access to private properties primarily within the Sites

Reservoir area. Peterson Road (also a county gravel road) is entirely within the proposed reservoir footprint. This project, therefore, includes rerouting existing roads or providing alternate access for roads affected by project construction and/or operation.

The proposed public roads and South Bridge would provide vehicle access to the Sites Reservoir area project facilities, as well as allow for travel between Maxwell and areas west of the proposed reservoir including the town of Lodoga and East Park Reservoir.

The proposed primary route from Maxwell to Lodoga would be a paved two-lane road and would use portions of the existing Maxwell-Sites Road and Sites-Lodoga Road alignments. Beginning approximately 1 mile east of Sites Dam on Maxwell-Sites Road, the new route would consist of Eastside Road, Stone Corral Road, the South Bridge, and the approach road west to Sites-Lodoga Road. This route would also provide access to the proposed Stone Corral Recreation Area.

Other proposed new roads adjacent to the proposed Sites Reservoir footprint would be gravel roads providing access to private properties, proposed recreation areas, and project structures and facilities. North Road, County Road 69, and Saddle Dam Road would provide access to the Saddle Dams. Eastside Road north of Stone Corral Road would provide access to Holthouse Reservoir, Golden Gate Dam and its appurtenant structures, and to properties northeast of the proposed reservoir. Sulphur Gap Road would provide access to Huffmaster Road and Lurline Road, which would provide access to the Com Road.

All proposed new public roads were preliminarily designed with two 12-foot-wide lanes and a maximum grade of less than 6 percent per Caltrans/*American Association of State Highway and Transportation Officials* standards. The proposed ROW would be 60 feet wide. Culverts and minor bridges would be constructed to provide passage for streams and drainage of surrounding areas.

The South Bridge would be a two-lane concrete bridge. The bridge would be 35.5 feet wide and approximately 1.6 miles long. The top deck elevation would be 45 feet above the reservoir's maximum normal WSE.

Tables 6-5, 6-6, and 6-7 list characteristics of the proposed roadways, South Bridge, and the minor structures, respectively.

Table 6-5. Characteristics of Proposed New Sites Reservoir Roadways and South Bridge Approaches

Road Name	Location/Road Section Description	Miles	Road Type
North Road	Road 69 at T-C Canal to Saddle Dam 9	6.53	Gravel
	Road 69 at T-C Canal to Saddle Dam Road	4.69	Gravel
	Saddle Dam Road to Saddle Dam 9	1.84	Gravel
Saddle Dam Road	North Road to Saddle Dam 1	3.17	Gravel

Table 6-5. (Continued)

Road Name	Location/Road Section Description	Miles	Road Type
Peninsula Road	Sites Lodoga Road to Peninsula Hills Rec Road South	0.94	Gravel
Peninsula Hills Rec Road South	Peninsula Road to Peninsula Hills Recreation Area	0.53	Gravel
South Bridge Approaches	Stone Corral Road to South Bridge to Sites-Lodoga Road	5.53	Paved
East Approach	Stone Corral Road to South Bridge	0.28	Paved
West Approach	South Bridge to Sites-Lodoga Road	2.25	Paved
Stone Corral Road	Eastside Road to Stone Corral Recreation Area	1.65	Paved/ Gravel
	Eastside Road to South Bridge East Approach	1.39	Paved
	South Bridge East Approach to Stone Corral Recreation Area	0.26	Gravel
Eastside Road	Golden Gate Dam/Access Roads	5.16	Gravel
	Access Roads/Maxwell Sites Road to Stone Corral Road/Field Office and Maintenance Yard	4.08	Paved
Sulphur Gap Road	Maxwell-Sites Road to Huffmaster Road	8.30	Paved/ Gravel
	Maxwell-Sites Road to Lurline Road	3.45	Paved
	Lurline Road to Huffmaster Road	4.85	Gravel
Lurline Road/Com Road	Lurline Road between Sulphur Gap Road to Communication Tower	6.15	Gravel

T-C = Tehama-Colusa

Table 6-6. Proposed South Bridge Characteristics

Item	Dimension
Bridge Length	Approximately 8,500 feet (1.6 miles)
Bridge Width	35.5 feet
Bridge Height[a]	Approximately 45 feet
Bridge Depth[b]	20 foot maximum, 8 foot minimum
Spans	400 feet maximum, 260 feet minimum, 22 spans total
Columns	18 feet by 14 feet square, hollow, maximum height approximately 300 feet, 21 columns total
Foundations	3-foot-diameter cast-in-place drilled shafts, 8 per footing, 168 total

[a] Bridge height is the distance from the top of the bridge deck to the normal water surface elevation.
[b] Bridge depth is the distance from the top of the bridge deck to the bottom of the bridge structure that sits atop the columns.

Table 6-7. Characteristics of Proposed Minor Structures[a]

Item	Typical Dimensions
Culverts (over unnamed streams), 17 total	6-foot diameter by 100-foot length
Minor Bridge (over named streams), 1 total	40-foot width by 80-foot length

[a] Minor structures would be built using steel pipe or pre-cast pieces.

Electrical Switchyards

Proposed dedicated transmission lines would carry electricity from an existing power source (grid) to the individual pumping/generating plants. The electrical substation and transmission lines that would connect the pumping/generating plants to the grid would provide all of the electricity needed by the pumping/generating plants to run the turbines that would pump the water. The substation and transmission lines would also allow the pumping/generating plants to reverse the flow of electricity and feed electricity back into the electrical grid for use by other customers during generation activities.

The new pumping/generating plants that would run on electricity in pumping mode and would be able to feed electricity back into the electrical grid in generation mode. Each of these new plants would be connected to the existing electrical grid by a new 230kV or 115kV overhead transmission line. The new transmission lines would parallel the proposed route of the Delevan Pipeline from the Sacramento River to the TRR, and would be constructed primarily within a 150-foot-wide permanent transmission line easement that would be 150 feet north of the permanent easement described for the Delevan Pipeline and TRR Pipeline. The transmission line cannot be constructed within the same permanent easement as the pipelines because of conflicts between the transmission tower footings and the pipelines and because the transmission towers would impede access to the pipeline during future maintenance activities.

In addition to the high-voltage transmission lines described above, lower voltage overhead distribution lines to the Golden Gate Dam, Sites Dam, Sites Reservoir Bridge, and StoneCorral recreation area also would be constructed. Electricity to Golden Gate Dam likely would come from the Sites Pumping/Generating Plant site and along Funks Creek to the dam. Power to Sites Dam, Sites Reservoir Bridge, and the two recreation areas likely would come from an existing overhead distribution line that parallels Sites-Lodoga Road. The power lines would be extended to the Sites Dam site, then up the canyon walls and through the Stone Corral Recreation Area (paralleling roads to the extent possible), then along the new Stone Corral Road to the Sites Reservoir Bridge, and across the bridge along Lodoga Road to Peninsula Road to the Peninsula Hills Recreation Area.

At this site, electricity from PG&E or Western 230kV and 500kV power lines aligned north-south may be transmitted to the pumping/ generating stations, and also could be stepped down to a lower voltage (115kV). The substation would have an approximately 6-acre permanent footprint and likely would be adjacent to the Delevan Pipeline ROW where the PG&E line crosses the pipeline, but would be located within the front part of the Holthouse Reservoir Complex for the Western line. No additional construction easement would be required for the substation beyond that already described for the Delevan Pipeline.

A four breaker ring bus[1] would be required. The ring bus would be approximately 500 feet by 300 feet, and likely would be adjacent to the Delevan Pipeline ROW close to the location where the source transmission lines cross the proposed pipeline. An additional construction easement would be required for the ring bus site of approximately 4 acres.

Recreation Facilities

The purpose of the recreation facilities at Sites Reservoir is to meet public demand for recreation opportunities and related facilities created by development of the reservoir. Two primitive recreation areas are proposed to be located at different points along the reservoir:

- Stone Corral Recreation Area – The Stone Corral Recreation Area would be located on the east side of the reservoir, north of the existing Maxwell-Sites Road and the proposed Sites Dam. It would be accessed by the proposed South Bridge Road or Eastside Road. The maximum proposed size of the Stone Corral Recreation Area is 235 acres.

- Antelope Island Recreation Area – The Antelope Island Recreation Area would be located in the southwestern portion of the reservoir. Access to Antelope Island would be via water only. However, during construction, a temporary road would be constructed to provide access to the island to construct the recreation area. Although this recreational area could be accessible by road under Alternative A, a road was not proposed for this alternative. If Alternative A is selected for construction, the temporary construction road could be improved to provide access to this recreational area. The maximum proposed size of the Antelope Island Recreation Area is 49 acres.

- Lurline Headwaters Recreation Area – The proposed Lurline Headwaters Recreation Area is a 219-acre site on the southeast end of Sites Reservoir in an open meadow surrounded by oak grassland along steep mountains with excellent views. The area could support both camping and day-use, and would create an opportunity for a trail to the top of an adjacent 1,282-foot (unnamed) peak that offers additional views of the reservoir. Despite limited shoreline access, Lurline Headwaters Recreation Area would be the area best suited for recreation development on the east shore. This 219-acre area contains roughly 50 acres of level land that could support approximately 50 campsites, approximately 3 group sites, 1 restroom facility, and 10 picnic units.

Two additional locations that could be developed for future recreation areas have also been identified.

[1] A ring bus breaker would allow the electrical current flowing to each individual pump station to be isolated and interrupted, if required, for maintenance or safety without interrupting the current to the other pump stations.

Recreational activities and facilities would be offered at each of the recreation areas. An initial phase of primitive recreation development would be implemented, consistent with a Recreation Plan that would be developed. These areas have potential for future expansion, based on use, at the discretion of the facility managers.

Collectively, recreation opportunities at the three recreation areas include boating, camping, picnicking, swimming, and hiking. Depending on the recreation area, proposed facilities may include boat launch sites, trails, designated swimming and fishing access, picnic tables, shaded canopies, campfire rings/barbeques, vault toilets, dumpsters. In addition, gravel parking areas would be provided for camp sites, day-use areas, and boat launch facilities.

Table 6-8 lists the maximum number of potential facilities at each proposed recreation area.

Table 6-8. Potential Maximum Number of Primitive Facilities Proposed at the Sites Recreation Areas

Recreation Areas	Components
Stone Corral Recreation Area Size: 235 Acres	50 Campsites (Car and Recreational Vehicle) 10 Picnic Sites (With Parking) Potential For A 2-Lane Boat Launch Site Hiking Trail Electricity Water 1 Kiosk 10 Vault Toilets 35-Acre Overlook/Interpretive Area
Antelope Island Recreation Area Size: 49 Acres Access: Boat-In Access Only From Stone Corral	12 Campsites (Boat-In) Hiking Trails 1 Vault Toilet Multi-lane boat ramp
Lurline Headqaters Recreation Area Size: 219 Acres	50 Campsites (Car and Recreational Vehicle) 3 Group Camp Areas 10 Picnic Sites (With Parking) Fishing Access Hiking Trails 1 Kiosk 8 Vault Toilets

Ecosystem Enhancement Storage Account – Operational Activities

As part of CALFED, the ERP has developed an integrated systems approach based on reversing the fundamental causes of decline in fish and wildlife populations by recognizing the natural forces that created historic habitats and using these forces to help regenerate habitats. The ERP was not designed as mitigation for CALFED projects; instead, it is intended to fulfill the objectives of improving ecological processes and increasing the amount and quality of habitat, equal with other program goals related to water supply reliability, water quality, and levee system integrity.

The ERP identified more than 600 programmatic actions to improve ecological health. The ERP advocated an adaptive management implementation strategy that supports the flexible use of environmental water. This adaptive approach has been accommodated in NODOS planning by dedicating a NODOS storage allocation to ERP objectives (an ERP pool or account), then giving resource managers the ability to adjust priorities based on monitoring of implemented actions, as well as potential new priorities. The NODOS planning team identified ERP objectives that could be supported by implementing a NODOS Project and prioritized actions with input from a Sacramento River Flow Regime Technical Advisory Group. This group included environmental advocacy groups, academics, and representatives from federal and state water resource and fish and wildlife agencies. The list of potential ERP objectives includes both tributary actions and Delta actions. Ultimately, NODOS planners developed the following objectives from the ERP objectives that were incorporated into the operations strategy for the action alternative plans:

- Improve the reliability of coldwater pool storage in Shasta Lake to increase Reclamation’s operational flexibility to provide suitable water temperatures in the Sacramento River. This action would operationally translate into the increase of Shasta Lake May storage levels, and increased coldwater pool in storage, with particular emphasis on Below Normal, Dry, and Critical water year types.

- Provide releases from Shasta Dam of appropriate water temperatures, and subsequently from Keswick Dam, to maintain mean daily water temperatures year-round at levels suitable for all species and lifestages of anadromous salmonids in the Sacramento River between Keswick Dam and RBDD, with particular emphasis on the months of highest potential water temperature-related impacts (i.e., July through November) during Below Normal, Dry and Critical water year types.

- Increase the availability of coldwater pool storage in Folsom Lake, by increasing May storage and coldwater pool storage, to allow Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would utilize additional coldwater pool storage by providing releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain mean daily water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning in the lower American River from May through November during all water year types (not explicitly modeled in California Statewide Integrated System Model [CALSIM] II).

- Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds (i.e., October through March) and steelhead redds (i.e., January through May), and reduce isolation events (specifically, flow increases of 4,000 cfs or more with subsequent reduction to less than 4,000 cfs) of juvenile anadromous salmonids, particularly from October through June. Reduce the reliance upon Folsom Lake as a “real-time, first response facility” to meet Delta objectives and demands, particularly from January through August, to reduce flow fluctuation and water temperature-related impacts to fall-run Chinook salmon and steelhead in the lower American River (not explicitly modeled in CALSIM II).

- Provide supplemental Delta outflow during summer and fall months (i.e., May through December) to improve X2 (if possible, west of Collinsville, 81 km). The abundance of several estuarine species, such as delta smelt, longfin smelt, Sacramento splittail, and starry flounder has been correlated with the location of X2. There is general consensus among fisheries agencies that there is larger and higher quality habitat for delta smelt and other species when X2 is west of the confluence of the Sacramento and San Joaquin rivers.

- Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook salmon spawning in the lower Feather River from May through November during all water year types. Provide releases from Oroville Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to reduce redd dewatering, juvenile stranding and isolation of anadromous salmonids.

- Stabilize flows in the Sacramento River between Keswick Dam and the RBDD to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation lifestage periods extending from October through March), particularly during fall months.

- Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at RBDD (into the T-C Canal) and at Hamilton City (into the GCID Canal), and by providing supplemental flows (at Delevan). This action would provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (e.g., delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.

Ecosystem Enhancement Fund – Non-Operational Actions

The ecosystem enhancement fund (EEF) would be established as an endowment to provide long-term funding for aquatic habitat restoration actions on the Sacramento River and its tributaries that do not necessarily require additional water. The fund is consistent with the primary objective to increase the survival of anadromous fish and all other aquatic species. Projects implemented through the EEF would be in addition to any NODOS Project mitigation, CVPIA, or long-term operation of the CVP and SWP requirements. Similar to the EESA, the EEF has been included in each action alternative. The monetary size of the EEF would be the same in each alternative.

Seed money in the amount of $30 million would be invested into an interest bearing account. Each year, 90 percent of the accrued interest would be allocated by fund managers for fisheries habitat enhancement projects, with an emphasis on projects for the Sacramento River. The remaining 10 percent of the accrued interest would be rolled back into the account to ensure the long-term viability of the funding source. The growth of the fund is intended to allow fund managers to make ongoing contributions to facilitate non-operational actions, as the cost to implement those actions increases over time.

A Governance Board would manage the fund, prioritize potential projects, and collaboratively determine funded actions, based upon habitat needs. The fund would support planning and implementation of priority non-operational actions. Planning includes environmental documentation and permitting, as necessary. The Governance Board is anticipated to include a representative from CDFW, CVRWQCB, DWR, USFWS, Reclamation, National Oceanic and Atmospheric Administration Fisheries, and The Nature Conservancy. Projects eligible for EEF funding include those that would directly benefit anadromous fish, with an emphasis on actions in the Sacramento River (e.g., spawning gravel augmentation; sidechannel, riparian, or floodplain restoration; and constructing instream aquatic habitat downstream from Keswick Dam).

Sites Reservoir Conceptual Operations Strategy

Current operating rules for releases from Shasta Dam to the Sacramento River are governed by temperature and instream flow requirements, contractual obligations, Delta water quality and outflow requirements, and flood control. Flood control releases are prescribed by USACE, as described in *Report on Reservoir Regulation for Flood Control, Shasta Dam and Lake* (USACE, 1977). This report specifies the amount of storage for flood control purposes in Shasta Lake and determines how to make releases through the spillway. For the evaluation of NODOS action alternatives, a generally consistent operations strategy was used for each. The operations strategy is reflected in the operations simulation modeling that is the primary planning tool to determine many project benefits and impacts. The ability of each action alternative to implement this strategy effectively is subject to the conveyance options included and the coordinated operation of Sites Reservoir with other existing facilities. The strategy has three components: (1) criteria for meeting primary objectives; (2) determination of Keswick Reservoir releases; and (3) determination of Sites Reservoir releases. None of the proposed alternatives would have an adverse operational impact on the deliveries from T-C and GCID canals to users south (downstream) of the reservoir.

Each action alternative would be operated to meet primary objectives (Figure 6-2); this strategy tries to balance priorities assigned to each objective—water supply, survival of anadromous fish, Delta water quality, or flexible hydropower generation. The reservoir and the system operations are modeled through a wide range of hydrologic and operational conditions. A set of criteria is used to determine how the model operates the project for each primary beneficiary. Water supply-related operations are determined through forecast-based decisions. Anadromous fish operations are determined through a collection of flow/storage thresholds and forecast-based decisions. Delta water quality operations are determined through water quality conditions and storage thresholds. Hydropower generation was not a primary consideration in developing the operations strategy. The enlargement of Funks Reservoir was provided to allow flexibility for hydropower generation over a wide range of operating conditions.

Throughout the operations, the following two parameters are evaluated to determine strategy implementation: (1) Shasta Lake storage condition and Keswick Reservoir releases (including Shasta Lake releases and imports from the Trinity River), and (2) Sites Reservoir storage and Sites Reservoir releases to local water supply diversions and to the Sacramento River.

For most actions associated with the objective of improved survival of anadromous fish and other species, the performance of the action alternative depends on the decisions regarding Shasta Lake storage and Keswick Reservoir releases. Changes in Keswick Reservoir releases require like changes in the import of Trinity River flows, or releases of Shasta Lake storage, or a combination of both. To achieve an optimal condition for anadromous fish in the Sacramento River between Keswick and Red Bluff, releases from Shasta Lake must be managed accordingly. The releases of Shasta Lake storage are sometimes limited by the amount of storage available within that reservoir. Storage availability is a consequence of previous releases made for preceding actions and other requirements.

For actions associated with improved water supply and Delta water quality, the performance of the action alternative depends on decisions regarding Sites Reservoir storage and releases. Releases from Sites Reservoir to the Sacramento River are often constrained by the capacity to convey water to the river or to offset diversions from the river (through serving local water supply needs directly from Sites Reservoir). The releases of Sites Reservoir storage are sometimes limited by the amount of storage available within that reservoir. Storage availability is a consequence of previous releases made for preceding actions and requirements.

With power generating being a primary objective of NODOS, the two to three proposed pumping/generating plants and the associated facilities would be designed to minimize pumping costs to put water in storage and maximize power generation of the project when water deliveries are requested. These facilities also can be operated to recycle water between Sites Reservoir and Holthouse Reservoir to provide net power benefits. Each of the pumping/generation plants would have at least two turbine units to generate power using water released for Sites Reservoir, Holthouse Reservoir, and TRR. However, one of the alternatives, Alternative B, evaluates a direct release of water from Holthouse Reservoir without generation capability.

To optimize the performance of Sites Reservoir for all primary objectives, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir releases are coordinated. For each action alternative, the reduction of diversions at Red Bluff and Hamilton City are determined by the coordination of operations. Diversion reductions are a means to increase flows in the lower Sacramento River by consequently increasing releases from Sites Reservoir to local water supply users who, otherwise, would have diverted from the Sacramento River at Red Bluff or Hamilton City.

Operational Actions for Ecosystem Enhancement Fishery enhancement measures relating to river flows have been incorporated in alternative operational scenarios.

Figure 6.2. Description of Seasonal Schedules for NODOS Operations (8/10/11)

		Priority of Operation[1]	Year Type Most Suitable for Operation[2]	Months Most Suitable for Operation[3]											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
General Operation															
	Conveyance: Diversions at Red Bluff (TCC), at Hamilton City (GCC) and at the Delevan Pipeline can occur in any month; diversions of excess Delta flows are only allowed once State Water Resources Control Board D-1641, Central Valley Project Improvement Act (CVPIA) 3406(b)(2), 2008 U.S. Fish and Wildlife Service Biological Opinion (BiOp) and 2009 National Marine Fisheries Service BiOp requirements are met, State Water Project (SWP) Article 21 demands are satisfied and other excess Delta flow diversions (Freeport Regional Water Project, Los Vaqueros, Fairfield, Vacaville, Benicia, etc.) are satisfied; diversions are restricted by Sacramento River bypass criteria at Red Bluff, Hamilton City, Wilkens Slough, and Freeport and restrictions associated with protecting fish outmigration related pulse flows (7 to 10 days once a month when flow conditions provide); shading highlights period in which diversion operations occur with the November through March season shaded the heaviest.	n/a	n/a												
	Seasonal Storage Operation: NODOS storage fills during excess flow events throughout the winter and spring and drains during peak release periods throughout the summer and fall; the months in which the high and low storage points in the typical seasonal cycle are indicated.	n/a	n/a	<< *FILL CYCLE* >>		High Point >	<<<<<<<<< *DRAIN CYCLE* >>>>>>>>>						Low Point>	<< *FILL* >>	
Water Supply Operation															
SWP	SWP Contractors: SWP water supply reliability; reliability increase in years below 85%; shading highlights period in which Delta exports are increased.	DP-1	BN, D, C												
REF	Level 4 Water Supply for Wildlife Refuges: Refuge Level 4 water supply needs; replacement of purchases of North-of-the-Delta (3.35 thousand acre-feet [TAF]/year maximum) and South-of-the-Delta (101.09 TAF/year maximum) water to supplement refuges supplies up to Level 4 criteria (CVPIA); shading highlights period in which transfer operations would occur.	AVG-3	AN,BN,D												
CVP	Central Valley Project (CVP) Contractors: CVP water supply reliability; reliability increase in any year when water supply availability limits allocations; has little effect if Delta export capacity is limiting allocations; reliability increase not limited to, however mostly effects, agricultural service contractors; shading highlights typical agricultural diversion pattern.	AVG-4	AN,BN,D												
Water Quality Operation															
WQ	Delta Water Quality: Augment Delta outflow to improve water quality conditions at urban-municipal and industrial intakes; Delta outflow augmented above base D1641 operations for up to 6 months with monthly rate varying within 750 cubic feet per second (cfs), 1,000 cfs and 1,500 cfs tiers; maximum of 450 TAF/period; shading highlights period in which Delta outflow is augmented.	AVG-1	AN,BN,D												
Hydropower Operation															
HYD	Hydropower Flexible Generation: Dedicated pumping/generation facilities with an additional dedicated afterbay/forebay of 14 TAF allowing more than 30 hours/week of uninterrupted operation; generation potential increases with increase head conditions and revenue increases with increase difference in prices between diurnal pumping and generation cycles; shading highlights period in which hydropower production is augmented.	n/a	ALL												
Ecosystem Enhancement Storage Account (EESA) Actions/Operation															
EESA-1	Shasta Lake Coldwater Pool: Improve the reliability of coldwater pool storage in Shasta Lake to increase the U.S. Bureau of Reclamation's (Reclamation's) operational flexibility to provide suitable water temperatures in the Sacramento River. This action would operationally translate into the increase of Shasta Lake May storage levels, and increased coldwater pool in storage and available for use to improve temperature control (EESA-2), with particular emphasis on Below Normal, Dry, and Critical water year types.	DP-1	BN, D, C												
EESA-2	Sacramento River Flows for Temperature Control: Provide releases from Shasta Dam of appropriate water temperatures, and subsequently from Keswick Dam, to maintain mean daily water temperatures year-round at levels suitable for all species and lifestages of anadromous salmonids in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam, with particular emphasis on the months of highest potential water temperature-related impacts (i.e., July through November) during Below Normal, Dry, and Critical water year types.	DP-2	BN, D, C												
EESA-3	Folsom Lake Coldwater Pool: Increase the availability of coldwater pool storage in Folsom Lake, by increasing May storage and coldwater pool storage, to allow Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would utilize additional coldwater pool storage by providing releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain mean daily water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning in the lower American River from May through November during all water year types.	DP-2	D, C												
EESA-4	Stabilize American River Flows: Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds (i.e., October through March) and steelhead redds (i.e., January through May), and reduce isolation events (specifically, flow increases to 4,000 cfs with subsequent reduction to less than 4,000 cfs) of juvenile anadromous salmonids, particularly from October through June. Reduce the reliance upon Folsom Lake as a "real-time, first response facility" to meet Delta objectives and demands, particularly from January through August, to reduce flow fluctuation and water temperature-related impacts to fall-run Chinook salmon and steelhead in the lower American River.	DP-2	ALL												

Figure 6.2. (Continued)

		Priority of Operation[1]	Year Type Most Suitable for Operation[2]	Months Most Suitable for Operation[3]											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ecosystem Enhancement Storage Account (EESA) Actions/Operation (cont'd)															
EESA-5	Delta Outflow for Delta Smelt Habitat Improvement (Summer/Fall): Provide supplemental Delta outflow during summer and fall months (i.e., May through December) to improve X2 (if possible, west of Collinsville, 81 km). The abundance of several estuarine species, such as delta smelt, longfin smelt, Sacramento splittail, and starry flounder has been correlated with X2. There is general consensus among the fisheries agencies that there is larger and higher-quality habitat for delta smelt and other species when X2 is west of the confluence of the Sacramento and San Joaquin rivers.	AVG-2	ALL												
EESA-6	Lake Oroville Coldwater Pool: Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River from May through November during all water year types. Provide releases from Oroville Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to minimize redd dewatering, juvenile stranding, and isolation of anadromous salmonids.	DP-2	BN, D, C												
EESA-7	Stabilize Sacramento River Fall Flows: Stabilize flows in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation lifestage periods extending from October through March), particularly during fall months (avoid abrupt changes; operation limited to avoid greatly impacting coldwater pool operations in D and C years); shading highlights period of greatest effect on stabilization or flows on a daily basis.	AVG-1	AN,BN,D												
EESA-8	Sacramento River Diversion Reduction at Red Bluff and Hamilton City: Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at Red Bluff Diversion Dam (into the Tehama-Colusa Canal) and at Hamilton City (into the Glenn-Colusa Irrigation District Canal), and by providing supplemental flows (at Delevan). This action would provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (e.g., delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.	N/A	ALL												

Notes:

1. *Priority of operation "DP" indicates that the operational priority has a driest periods and "AVG" indicates an average to wet hydrologic emphasis. The number 1-4 indicates priority within the associated hydrologic emphasis. "N/A" indicates that operations are not or cannot be easily defined within the priority structure of the scenario.*
2. *Year type most suitable for operation is the D1641 40-30-30 year types that are reflected in operations studies; operations in these year types occur when supplies are available in Sites Reservoir to support the operation, when the operations criteria in the scenario allow for prioritization to the operations and when conditions are suitable for developing the benefit associated with the operation.*
3. *The heavier shaded parts of each bar highlight the months in which conditions are most suitable to the operations; the lighter shaded parts of each bar highlight the months that are less suitable to the operations; operations in these months occur when supplies are available in Sites Reservoir to support the operation, when the operations criteria in the scenario allow for prioritization to the operations and when conditions are suitable for developing the benefit associated with the operation.*

Sites Reservoir would provide a unique opportunity to establish the first firm asset EESA in California managed by the state and federal government and dedicated to restoration actions beyond existing regulatory requirements. Conceptually, the EESA uses NODOS Project assets to support modified operations that facilitate habitat enhancement actions. Use of these assets is limited to supporting ecosystem enhancement actions and cannot be used for other Project benefits or non-Project benefits. A NODOS Ecosystem Enhancement Governance Board would be created to manage the EESA. The EESA would be managed to adaptively support operational actions and respond to changing future conditions throughout the Sacramento River Basin.

Ecosystem Enhancement Fund. At this time, there is some uncertainty as to the relative success or accomplishments of proposed enhancement actions. As a result, rather than identify specific enhancement projects to accomplish the project purpose of fishery enhancement, a reserve fund or EEF would be attached to the Project's authorization to provide for environmental enhancement as more information is developed relating to the design and specific benefits of different actions. Environmental enhancement actions would include upfront monitoring of pilot studies, potentially integrated as part of CVPIA CAMP [Section 3406(b)16], to determine the success of a specific enhancement action to determine whether the action should be expanded or concluded.

Alternative A (1.27 MAF Sites Reservoir, 2,000 cfs Delevan Pipeline for Intake and Release)

Alternative A includes the common features as described in conjunction with a 1.27 MAF Sites Reservoir, as summarized in Table 6-9 and illustrated in Figure 6-3. The unique features of this alternative are the 1.27 MAF storage capacity for Sites Reservoir, the Sacramento River Pumping/Generating Plant and adjoining fish screen structure at the Sacramento River, and the 2,000 cfs capacity Delevan Pipeline which would convey water from and to the Sacramento River to the Holthouse Reservoir.

Table 6-9. Alternative A – Specific Characteristics

Major Components of Alternative A	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.27 MAF, a maximum water surface elevation of 480 feet msl, and an inundation area of 12,400 acres.
Delevan Pipeline Intake Facilities	The plant would have a pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.
Delevan Pipeline	This pipeline would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs).

cfs = cubic foot per second
msl = mean sea level
MAF = million acre-feet

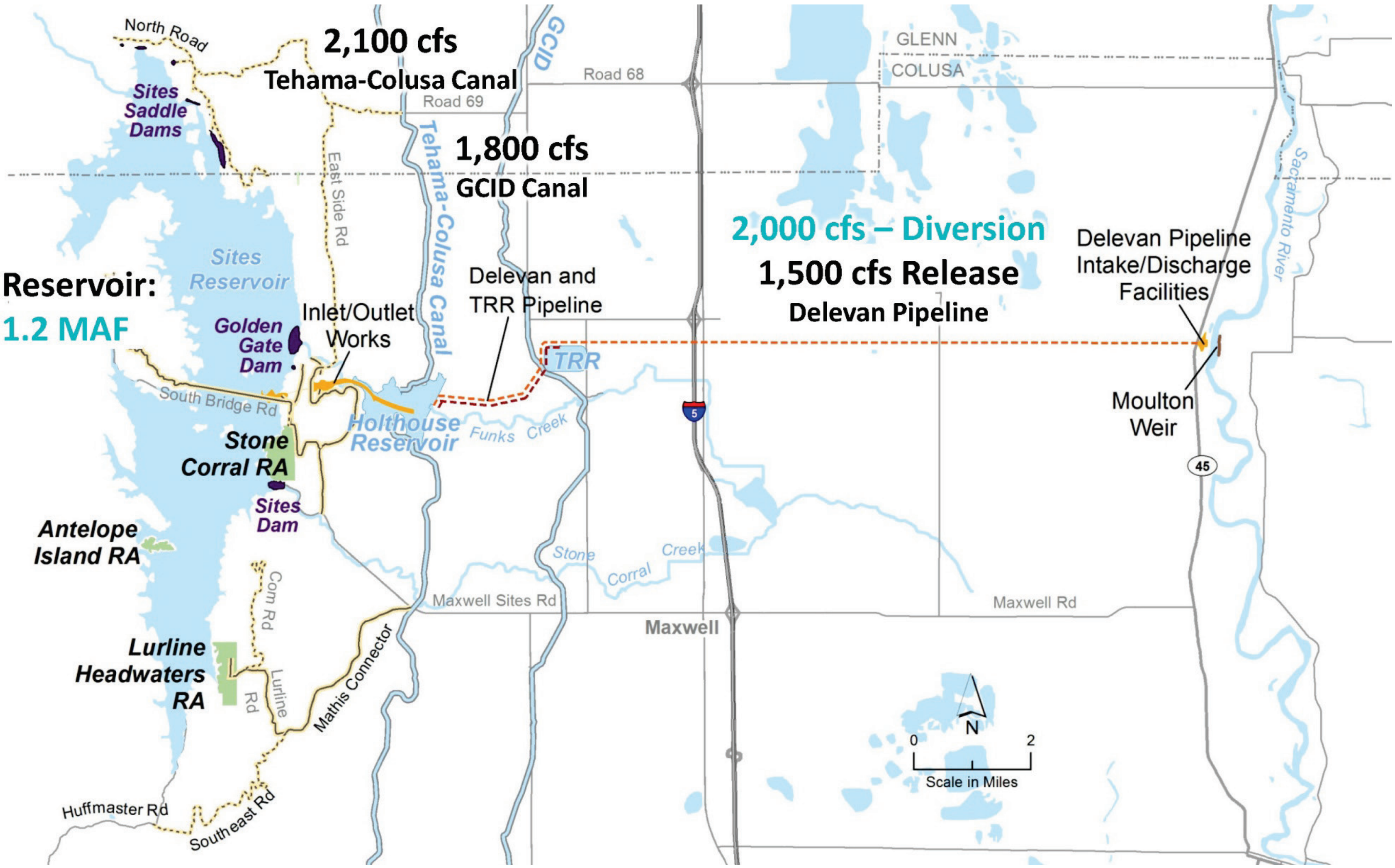


Figure 6-3. Features of NODOS Alternative A

Under Alternative A, water would be conveyed to the 1.27 MAF Sites Reservoir from the Sacramento River by pulling water in from the river through a fish screen structure by pumping at the Delevan Pipeline Intake Facilities, from the TCC, and from GCID. From this plant, water would be pumped up through the 2,000 cfs Delevan Pipeline to the Holthouse Reservoir. Water releases can be made from Holthouse Reservoir through the Delevan Pipeline at a flow of 1,500 cfs and would be able to generate power through the Delevan Pipeline Intake Facilities.

The common features provide for water storage deliveries from and storage releases to the GCID and T-C canals. Water intended for supplying CVP, SWP, GCID and T-C service areas can be stored in Sites Reservoir for future delivery. Releases made from storage would generate power from Sites, TRR, and Sacramento River Pumping/Generating Plants. This alternative also provides the unique generating capability for all scheduled releases to the Sacramento River through the Delevan Pipeline Intake Facilities. Under this alternative, water releases from storage would generate up 100 MWs at the Sites Pumping/Generating Plant as compared to 125 MW under Alternatives B and C, and would generate another 12 MWs at the Sacramento River Pumping/Generating Plants as compared to no power generation under Alternative B and 12 MWs under Alternative C.

Storage transfers between Shasta Lake and Lake Oroville, and Sites Reservoir also could be coordinated to improve water supply and flood control operations. This capability can facilitate coordinated O&M activities of CVP, SWP, GCID, and T-C facilities to provide more flexibility than that which currently exists and improved water supply reliability. Other benefits associated with the CVP, include providing an alternate source for Level 4 water supplies to wildlife refuges. Operations of Sites Reservoir would be coordinated with the operation of Shasta Lake to provide benefits to anadromous fish in the Sacramento River and water quality in the Delta. Conveyance would terminate at Holthouse Reservoir that would serve as a regulating reservoir for the Sites Pumping/Generating Plant and Delevan Pipeline Intake Facilities.

Alternative B (1.81 MAF Sites Reservoir, 1,500 cfs Delevan Pipeline for Release Only)

Alternative B includes the common features as described in conjunction with a 1.81-MAF Sites Reservoir, as summarized in Table 6-10 and illustrated in Figure 6-4. The alternative includes a 1.81 MAF storage capacity for Sites Reservoir, the 1,500 cfs capacity Delevan Pipeline, which would convey water from Holthouse Reservoir to the River Outlet Structure, and the 1,500 cfs River Outlet Structure at the Sacramento River.

Table 6-10. Alternative B – Specific Characteristics

Major Components of Alternative B	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.81 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of 14,000 acres.
Delevan Pipeline Discharge Facility	This outlet is a reinforced concrete structure that would house a flow meter and cone valve and dissipate releases up to 1,500 cfs at the Sacramento River.
Delevan Pipeline	This pipeline would provide a release up to 1,500 cfs to the Sacramento River opposite the Moulton Weir.

cfs = cubic feet per second
msl = mean sea level
MAF = million acre-feet

Under Alternative B, water would be conveyed to the 1.81 MAF Sites Reservoir from the GCID and T-C canals which are common features.

Water intended for supplying CVP, SWP, GCID, and T-C service areas can be stored in Sites Reservoir for future delivery. Releases made from storage would generate power from the Sites and TRR Pumping/Generating Plants, and would have no power generation capability when making direct releases to the Sacramento River through the 1,500 cfs Delevan Pipeline and Delevan Pipeline Discharge Facility in this alternative.

Storage transfers between Shasta Lake and Lake Oroville, and Sites Reservoir also could be coordinated to improve water supply and flood control operations. This capability can facilitate coordinated O&M activities of CVP, SWP, GCID, and T-C facilities to provide more flexibility than that which currently exists and improved water supply reliability. Other benefits associated with the CVP, include providing an alternate source for water to Level 4 water supplies to wildlife refuges. Operations of Sites Reservoir would be coordinated with the operation of Shasta Lake to provide benefits to anadromous fish in the Sacramento River and water quality in the Delta. Conveyance would terminate at Holthouse Reservoir that would serve as a regulating reservoir for the Sites Pumping/Generating Plant and Delevan Pipeline Discharge Facility.

Alternative C (1.81 MAF Sites Reservoir, 2,000 cfs Delevan Pipeline for Intake and Release)

Alternative C includes the common features as described in conjunction with a 1.81-MAF Sites Reservoir, as summarized in Table 6-11 and illustrated in Figure 6-5. This alternative includes a 1.81 MAF storage capacity for Sites Reservoir, the Delevan Pipeline Intake Facilities and adjoining fish screen structure at the Sacramento River, and the 2,000 cfs capacity Delevan Pipeline that would convey water from and to the Sacramento River to the Holthouse Reservoir.

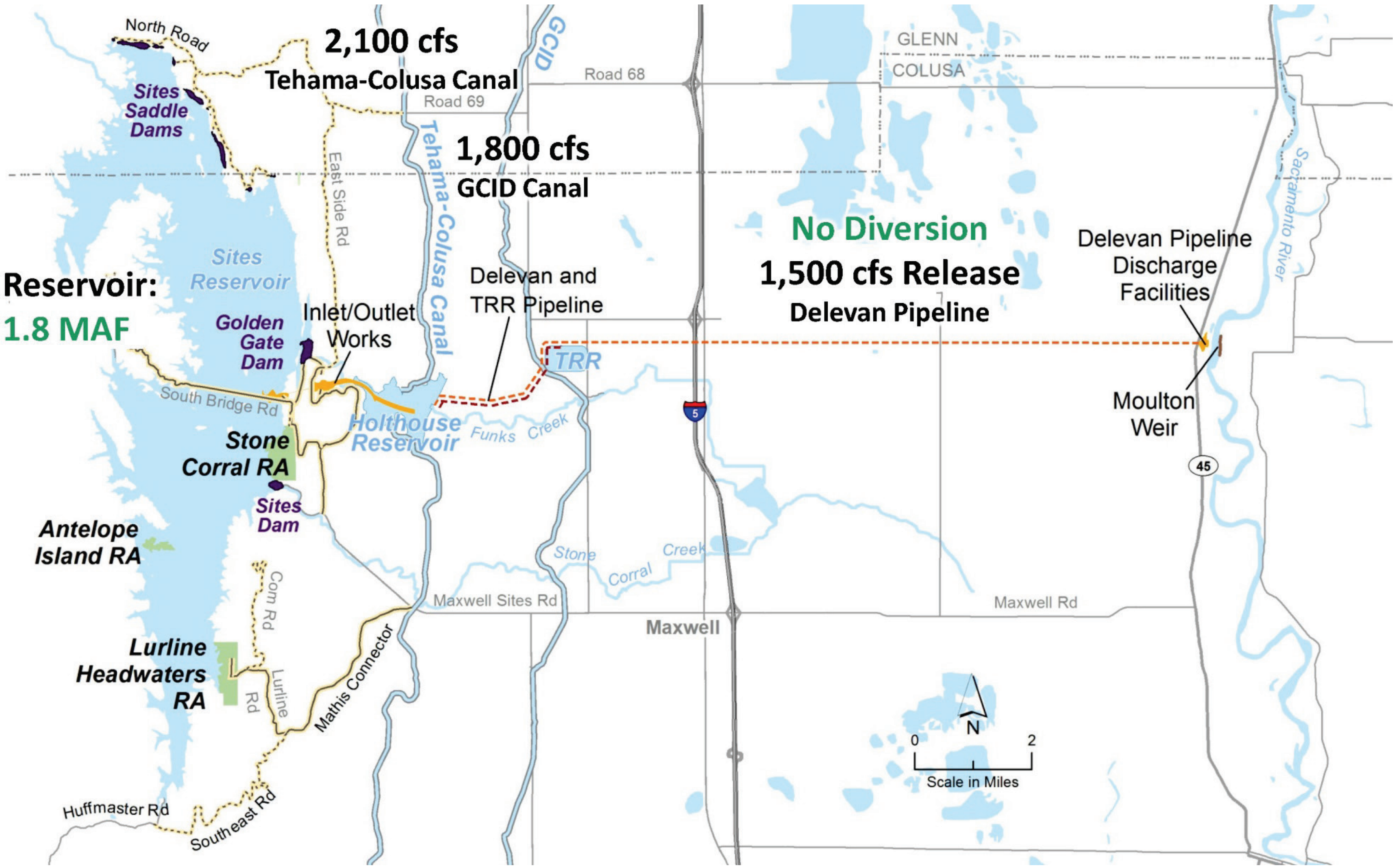


Figure 6-4. Features of NODOS Alternative B

Table 6-11. Alternative C – Specific Characteristics

Major Components of Alternative C	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.81 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of 14,000 acres.
Delevan Pipeline Intake Facilities	The plant would have a pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.
Delevan Pipeline	Would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs).

cfs = cubic feet per second
msl = mean sea level
MAF = million acre-feet

Under Alternative C, water would be conveyed to the 1.81 MAF Sites Reservoir from the existing T-C Canal, GCID Canal, and the Delevan Pipeline Intake Facilities. Water from the Sacramento River would come through the Delevan Pipeline Intake Facilities, which includes the Sacramento River Pumping/Generating Plant and associated fish screen facility, and the Delevan Pipeline to the Sacramento River from Holthouse Reservoir. Water releases can be made from Holthouse Reservoir through the Delevan Pipeline at a flow of 1,500 cfs and would be able to generate power through the Delevan Pipeline Intake Facilities.

Common features provide for water storage deliveries from, and storage releases to portions of, the GCID and T-C canals. Water intended for supplying CVP, SWP, GCID, and T-C service areas can be stored in Sites Reservoir for future delivery. In Alternative C, releases made from storage would generate power from Sites, TRR, and Sacramento River Pumping/Generating Plants. Under this alternative, water releases from storage would generate 125 MW at the Sites Pumping/Generating Plant and would generate another 12 MWs at the Delevan pipeline Intake Facilities.

Storage transfers between Shasta Lake and Lake Oroville, and Sites Reservoir also could be coordinated to improve water supply and flood control operations. This capability can facilitate coordinated O&M activities of CVP, SWP, GCID, and T-C facilities to provide more flexibility than that which currently exists and improved water supply reliability. Other benefits associated with the CVP, include providing water to an alternate source of Level 4 water supplies to wildlife refuges. Operations of Sites Reservoir would be coordinated with the operation of Shasta Lake to provide benefits to anadromous fish in the Sacramento River and water quality in the Delta. Conveyance would terminate at Holthouse Reservoir that would serve as a regulating reservoir for the Sites Pumping/Generating Plant and Delevan pipeline Intake Facilities.

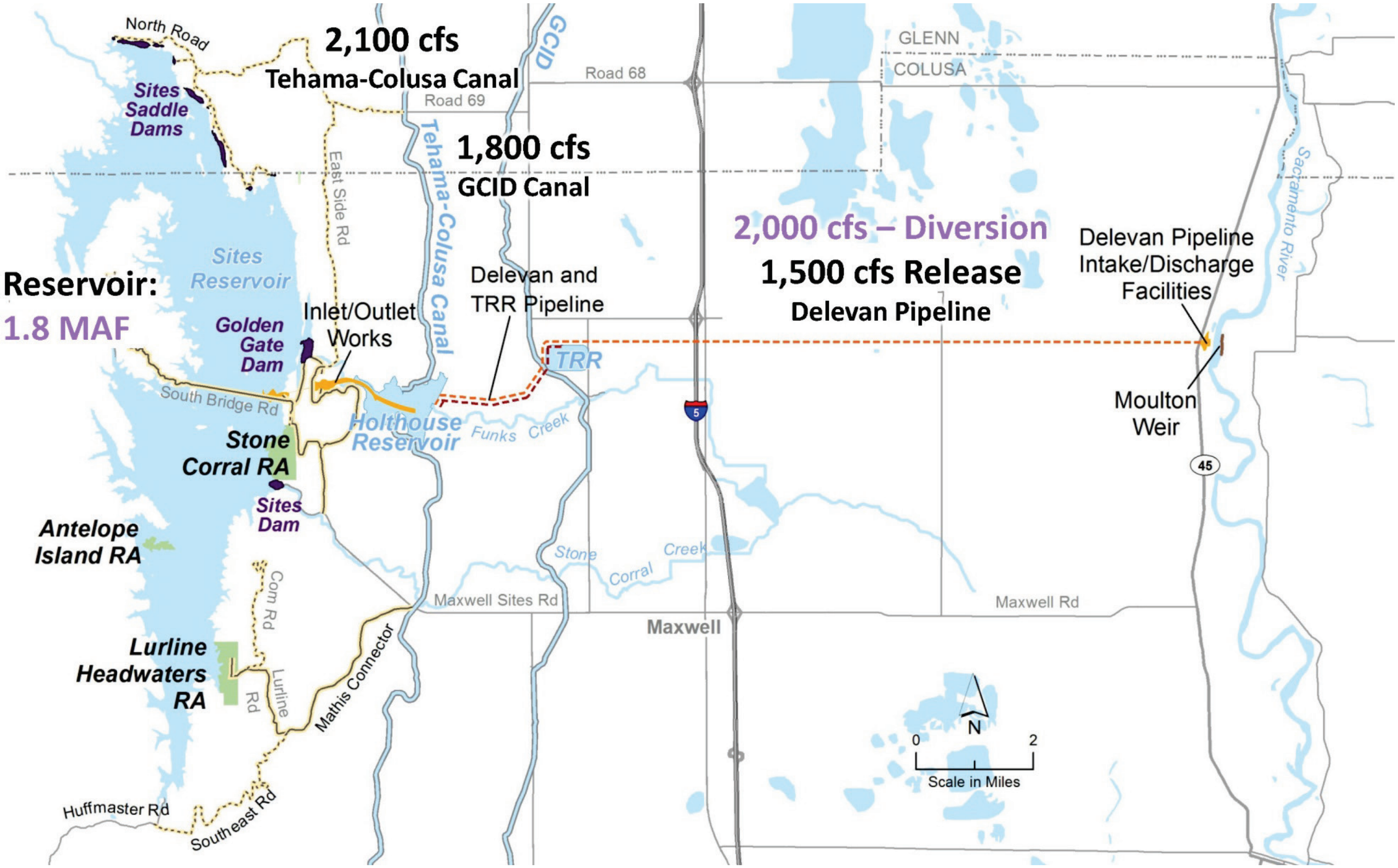


Figure 6-5. Features of NODOS Alternative C

This page intentionally left blank

CHAPTER 7 POTENTIAL ALTERNATIVE ACCOMPLISHMENTS AND BENEFITS

This section discusses the potential accomplishments of each of the alternative plans to evaluate the relative strengths and weaknesses of each plan. The methodologies used to evaluate the alternatives are detailed in the attached appendices; the results of those evaluations are presented in this section. Table 7-1 summarizes the accomplishments and estimated costs and benefits for each of the initial action alternative plans.

Improving System Flexibility

The amount of total storage defines the capacity of each alternative to meet the NODOS objectives. Figure 7-1 depicts the total storage anticipated for the three action alternatives.

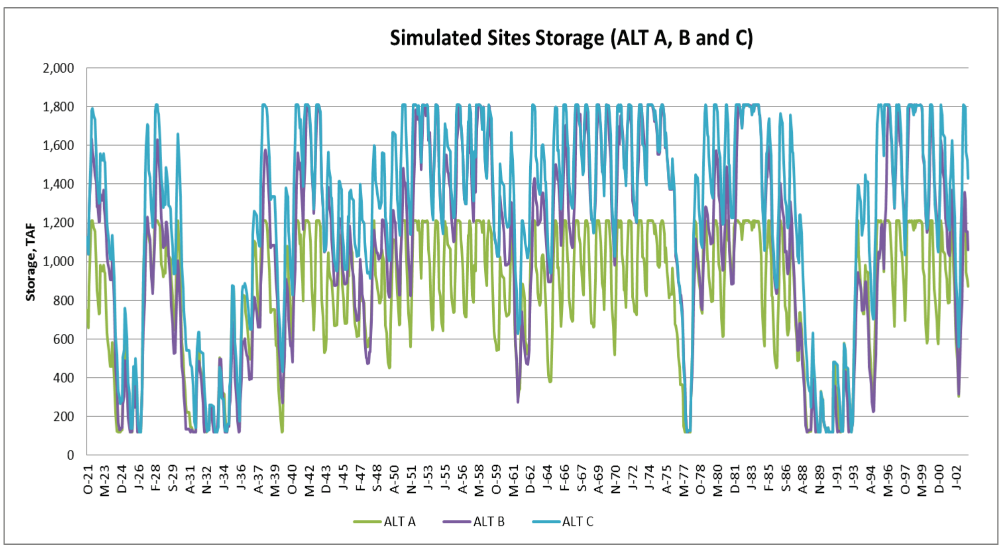


Figure 7-1. Simulated Sites Reservoir Storage, TAF

Table 7-2 summarizes the amount of storage that would be maintained in Sites Reservoir. Sites Reservoir would be filled when flows in excess of current commitments are available. Peak release periods would occur throughout the summer and fall to achieve the benefits associated with the primary objectives.

Table 7-1. Summary of Relative Accomplishments of Alternative Plans and Estimates of Preliminary Costs and Benefits

Item		ALT A	ALT B	ALT C
Objectives and Accomplishments (above No Project Alternative conditions)				
Water Supply[a] Increase (TAF/year)	(Average Annual Increase/Dry and Critical Period Average Increase)	169/333	141/271	246/383
Incremental Level 4 Alternative Water Supply for Refuges	(Average Annual Increase/Dry and Critical Period Average Increase)	44/22	72/37	74/37
Total Releases from Sites Reservoir (TAF/year)	(Average Annual Increase/Dry and Critical Period Average Increase)	425/563	429/526	488/637
Water Supply for Water Quality Improvement[a] (TAF/year)	(Average Annual Increase/Dry and Critical Period Average Increase)	128/117	136/119	165/169
Water Supply for EESA (TAF/year)[a]	(Average Annual Increase/Dry and Critical Period Average Increase)	84/91	80/98	77/86
Winter-Run Chinook Egg – Fry Survivability (IOS Model)[b]	% Increase in Critical Years	26%	21%	33%
Winter-Run Chinook Fish Production (SALMOD)[b]	% Increase in Critical Years	3%	1%	3%
Fall-Run Chinook Fish Production (SALMOD)[b]	% Increase in Critical Years	10%	9%	12%
Hydropower Generated Annually (in GWh)	Range	184 to 301	143 to 336	169 to 353
Delta Water Quality – Downstream shift in X2 (July/August)	Increase in km to west in dry years	1.4	1.4	1.7
Recreation[c]	Based on ability to support flat water recreation at reservoir	Low	Medium	Medium
Flood Damage Reduction (acres)	Acres experiencing flood damage reduction benefits	8,625	8,625	8,625
Annual Benefits ($M)		249	255	276

[a] Water supply increases above the No Project Alternative, including supplies for agriculture, M&I, and environmental purposes. Dry and critical period average is the average quantity for the combination of the SWRCB D-1641 40-30-30 Dry and Critical years for the period of October 1921 – September 2003. Average annual is for the period of October 1921 through September 2003.
[b] Increase in survivability (IOS lifecycle model) or production (SALMOD model) when compared to the No Project Alternative.
[c] Ranking based on ability of alternatives to support flat water recreation at Sites Reservoir.

ALT = Alternative
EESA = Ecosystem Enhancement Storage Account
GWh = gigawatt-hour
IOS = interactive object-oriented simulation
km = kilometer
M&I = municipal and industrial
SALMOD = a computer model that simulates the dynamics of freshwater salmonid populations
SWRCB = State Water Resources Control Board
TAF = thousand acre-feet
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand
$M = dollar amount in millions
% = percent

Table 7-2. Sites Reservoir Storage

Parameter	Alternative A	Alternative B	Alternative C
End of May Storage (TAF)			
Full Simulation	985	1,235	1,441
Dry (22%)	839	1,004	1,268
Critical (15%)	447	507	683
End of September Storage (TAF)			
Full Simulation	687	947	1,114
Dry (22%)	515	644	885
Critical (15%)	259	262	423

TAF = thousand acre-feet

Figure 7-2 depicts the enhancement of water supply for project purposes over the No Project Alternative for Alternatives A, B, and C.

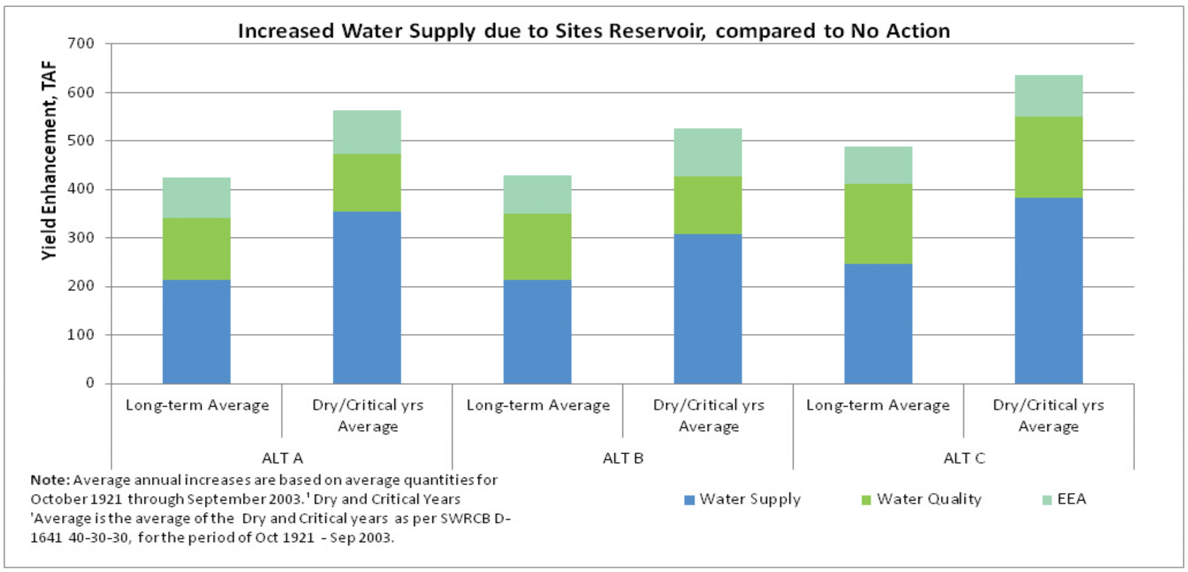
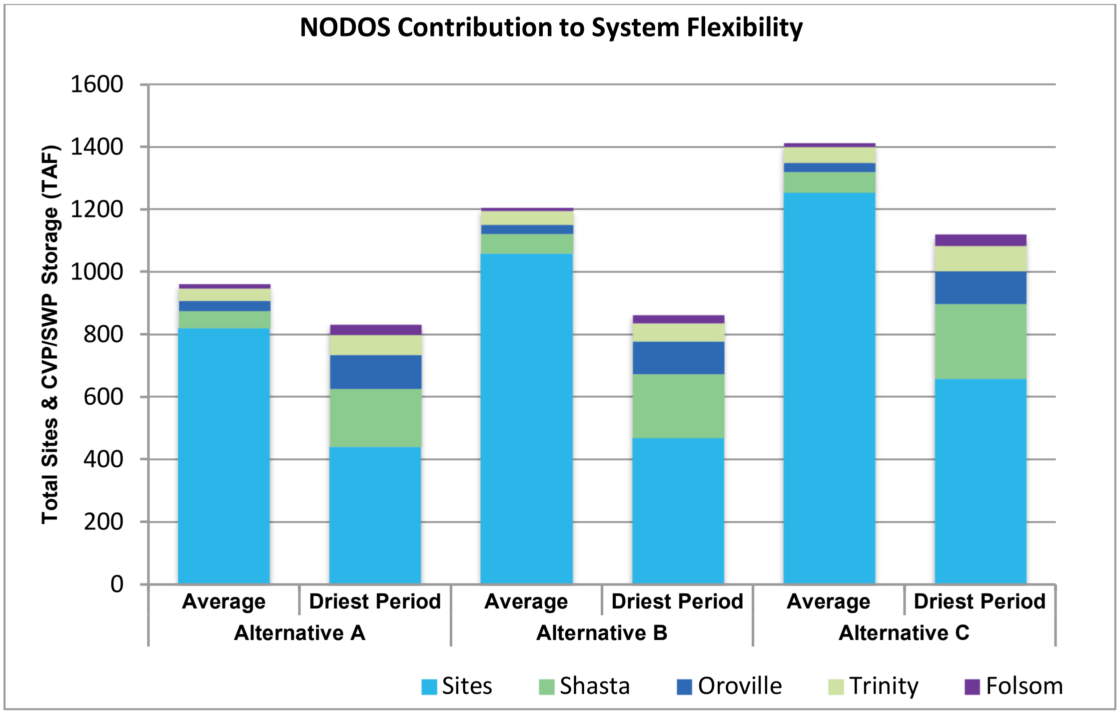


Figure 7-2. Enhancement of Water Supply for Project Purposes with Respect to No Project Alternative

Figure 7-3 compares the long-term average (October through September) and driest periods average (October through September) storage for the three alternatives. The additional storage (800 to 1,400 TAF) significantly increases the flexibility of system operations to respond to system needs. Alternative C performs best in terms of this measure of water supply reliability, followed by Alternative B.



Driest periods are essentially the drought years in the 83-year full-simulation sequence (i.e., 1928 to 1934, 1976 to 1977, and 1987 to 1992). These years are designated as multiple year dry sequences, rather than each individual year, as designated by the Indices.

Figure 7-3. Increases in Average System Storage

All three alternatives would significantly contribute to reducing the frequency of extreme occurrences (i.e., corresponding to dead pool conditions in modeling simulations) where severe droughts necessitate agency consultation to manage dwindling reservoir supplies. Over the 984-month (82-year) simulation period, there were 28 instances where the No Project Alternative would require consultation. The instances of extreme occurrences were reduced to 14 for Alternative A, 15 for Alternative B, and 9 for Alternative C.

Water Supply and Water Supply Reliability (Primary Objective)

Water supply increases over the long-term average and under dry and critical years were used to evaluate the accomplishments of each alternative to increase water supply and water supply reliability.

The ability of Sites Reservoir to improve water supply for the SWP in years below 85 percent allocation of contract amounts with an increasing emphasis on years below 65 percent allocation was modeled. Over the full simulation period, the increases are modest (3 to 3.5 percent for all alternatives); however, during critical years (approximately 15 percent of all years fall into the critical year category), increases in deliveries of 13 to 16 percent are observed (309 to 374 TAF/year). This is a significant improvement in water supply reliability. Alternative A performs slightly better than Alternative B in critical years, providing an additional 19 TAF/year. The ability to capture flows further downstream at the Delevan Pipeline with the additional intake structure under Alternative A provides greater flexibility for water supply reliability than simply having a larger reservoir as proposed in Alternative B. The model simulation results show that Alternative C, with both the additional intake and the larger reservoir, is the best performer.

The Sites Reservoir alternatives were also evaluated for their ability to provide an alternate source for incremental water for Level 4 water supply for wildlife refuges. Water is currently purchased north of the Delta (3.35 TAF/year maximum) and south of the Delta (101.09 TAF/year maximum) to supplement refuge water supplies up to Level 4 criteria. The Sites Reservoir alternatives show a significant ability to provide replacement water over the full simulation period, ranging from 48 TAF under Alternative A to 80 TAF under Alternative C. The ability to provide replacement water is significantly constrained in critical years (an additional 6 to 12 TAF could be provided).

CVP Contractors also experience modest increases in water supply. The export capacity at Jones Pumping Plant limits the increases in allocations possible to CVP Contractors. The most significant increases occur in dry years, ranging from an additional 33 TAF/year under Alternative B to 74 TAF/year under Alternative C. Alternative B is the weakest performer in dry years where the lack of an intake at the Delevan Pipeline precludes recapturing water downstream of Red Bluff and Hamilton City.

Table 7-3 provides a more detailed summary of the water supply increases achieved by each action alternative over the No Project Alternative. General observations from review of Table 7-3 include the following:

- Alternative C provides the highest average long-term annual water supply increases over the No Project Alternative in these two categories of 246 TAF/year for all water users (CVP, SWP, and wildlife refuge incremental Level 4 supplies).

- Alternative C provides the highest average long-term annual water supply reliability with dry/critical year increases over the No Project Alternative of 383 TAF/year for all water users.

- Alternatives A and B show very similar average long-term annual water supply gains. However, during the dry/critical-years, Alternative A (350 TAF) would provide more water supply than Alternative B (306 TAF).

Table 7-3. Water Supply Increases[a] (Average Annual Increase/Dry and Critical Periods Increase[b]) (TAF/Year)

Water Supply Locale and Use	Alternative A	Alternative B	Alternative C
Sacramento Valley			
CVP Settlement	9/14	5/5	8/14
CVP M&I	1/1	0/1	2/2
CVP Agriculture	9/ 10	3/5	9/9
SWP M&I	1/2	1/2	1/3
SWP FRSA	0/0	0/0	-2/-6

Table 7-3. (Continued)

Water Supply Locale and Use	Alternative A	Alternative B	Alternative C
Bay Area			
CVP Agriculture	1/1	0/0	0/1
CVP M&I	0/0	0/0	1/1
SWP M&I	9/18	10/17	10/21
San Joaquin Valley			
CVP Agriculture	6/10	-1/2	3/6
CVP M&I	0/0	0/0	0/0
CVP Exchange	0/0	0/0	0/0
SWP Agriculture	0/0	0/0	0/0
Central Coast			
SWP M&I	2/5	2/4	2/5
Tulare Lake Region			
CVP Agriculture	13/24	-1/7	7/16
SWP M&I	4/8	4/8	5/10
SWP Agriculture	31/58	33/55	35/66
South Lahontan Region			
SWP M&I	13/30	14/28	14/33
South Coast Region			
SWP M&I	62/142	66/131	68/155
SWP Agriculture	1/1	1/0	1/1
Total Agriculture and M&I			
CVP, SWP, and Other Supply	**163/325**	**134/265**	**164/337**
Environmental			
CVP Level 2 Refuge Supply	4/4	3/3	6/5
Incremental Level 4 Supply for Refuges	44/21	71/38	74/37
Total – All Users	**211/350**	**208/306**	**244/379**

[a] Increases from the No Project Alternative. See Table 5-2 for beneficiary target allocations. See Operations Priority in Tables 5-4 through 5-8 for basis of CVP/SWP allocation.
[b] Dry and critical periods average is the average quantity for the combination of the SWRCB D-1641 40-30-30 Dry and Critical years for the period of October 1921 - September 2003. Average annual is for the period of October 1921 through September 2003.

CVP = Central Valley Project
FRSA = Feather River Service Area
M&I = municipal and industrial
SWP = State Water Project
SWRCB = State Water Resources Control Board
TAF = thousand acre-feet

Figure 7-4 presents the South-of-the Delta export for the three alternatives.

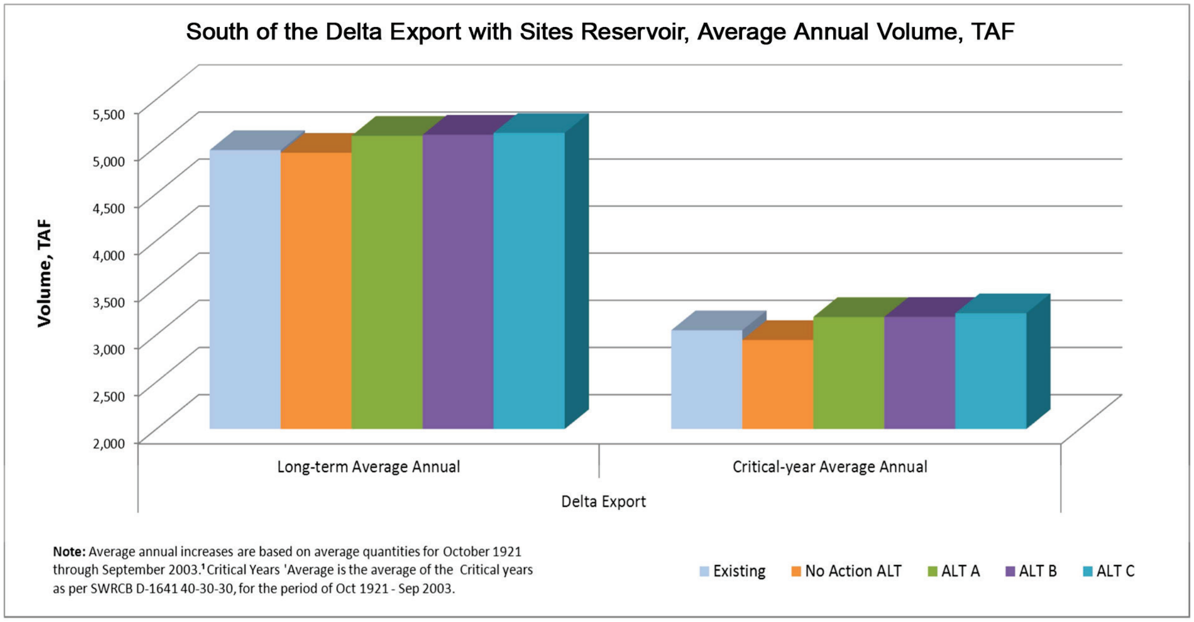


Figure 7-4. Simulated South of the Delta Export

All three alternatives also would provide additional storage that could be used to respond to seismic or other types of Delta levee failures during periods of reduced runoff. Increased inflow to the Delta potentially could be used to reduce the impact of seawater intrusion on exports and the environment. Total north-of-the-Delta storage (Sites Reservoir, Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake) would be increased by 11 to 17 percent over the full simulation period in May and 13 to 21 percent in September. Alternative C would provide the greatest increase in storage, followed by Alternative B.

Survival of Anadromous Fish and Other Aquatic Species (Primary Objective)

Several operational actions were included in each of the NODOS alternatives to improve conditions in ways that would support anadromous fish and other aquatic species (Figure 7-5). These actions include:

- Shasta Lake coldwater pool improvement
- Sacramento River flows for temperature control
- Folsom Lake coldwater pool improvement
- Stabilizing American River flows
- Increasing Delta outflow for delta smelt habitat improvement
- Lake Oroville coldwater pool improvement
- Stabilizing Sacramento River flows
- Sacramento River fall diversion reduction at Hamilton City and Red Bluff

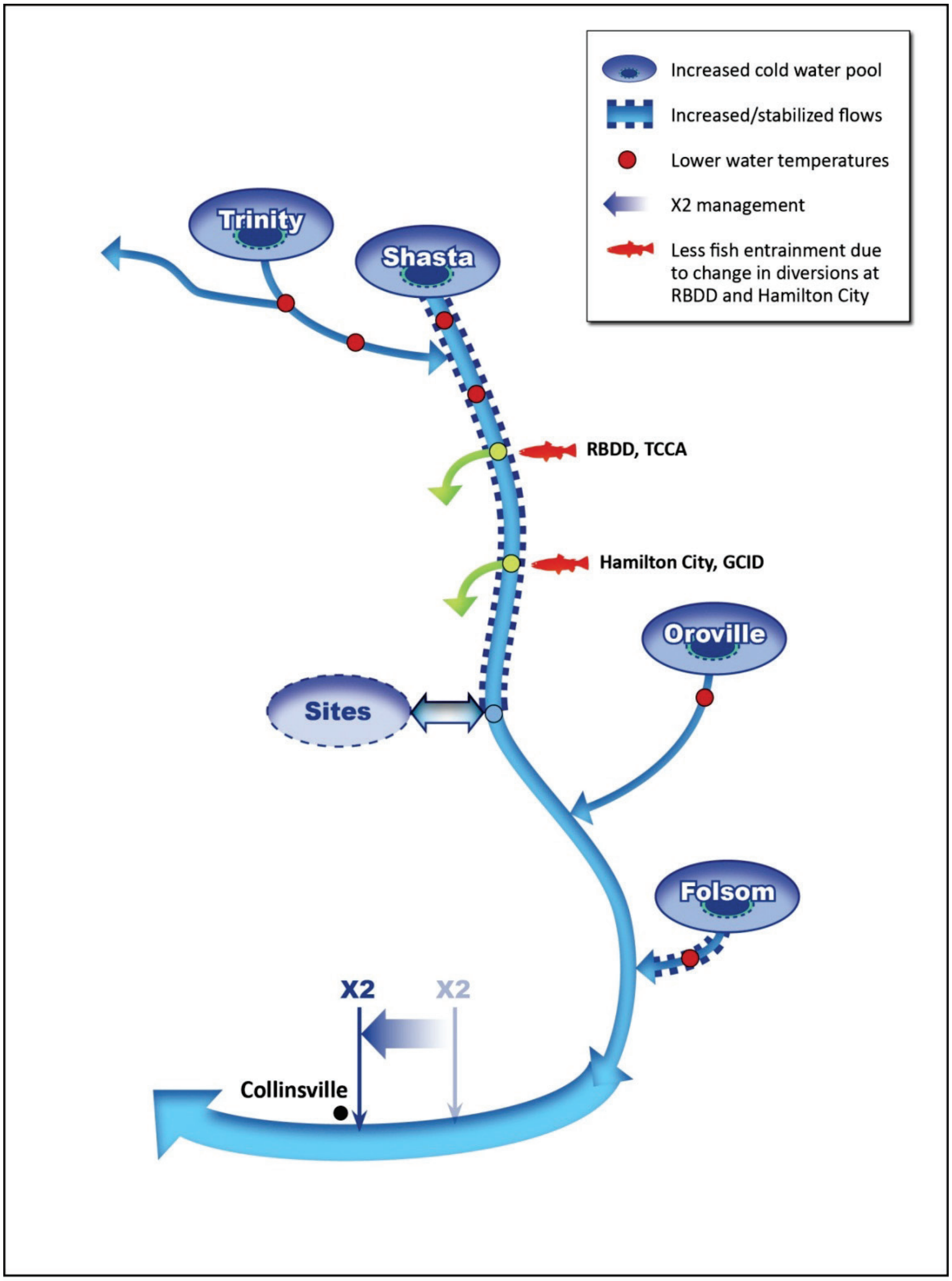
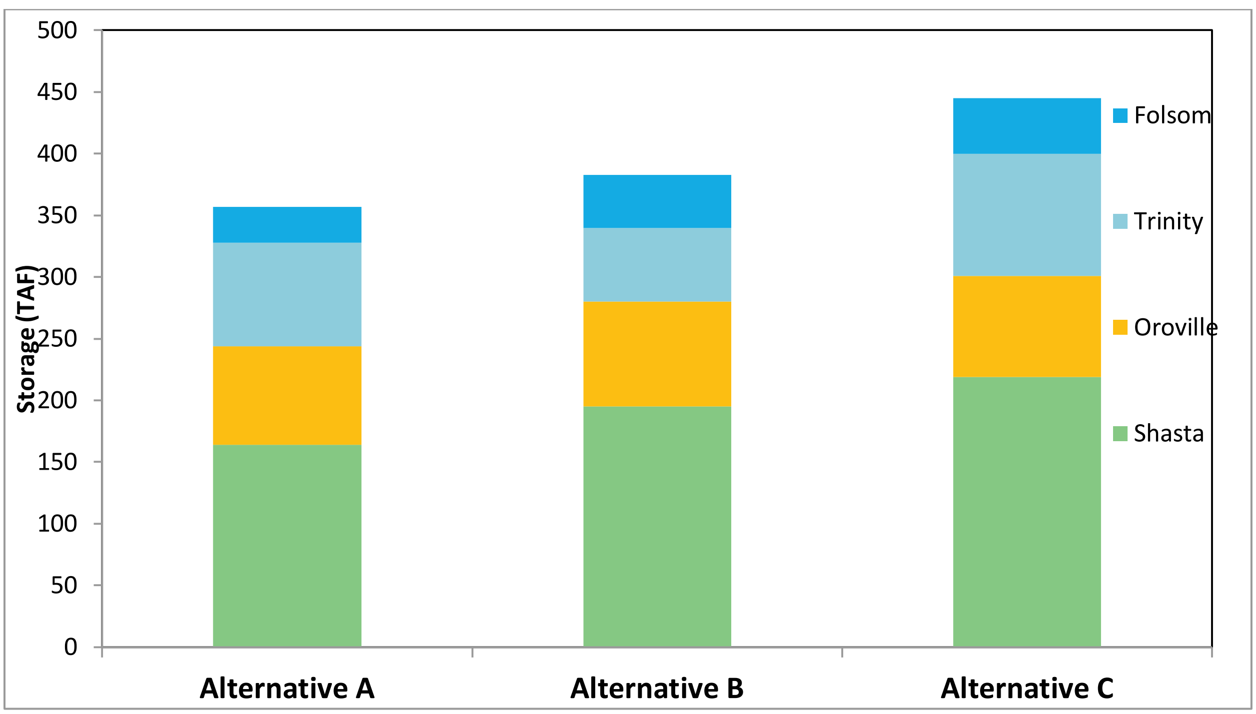


Figure 7-5. Conceptual Model of Benefits to Anadromous Fish from NODOS

The alternatives were evaluated in terms of their ability to contribute to these improved conditions. In addition to these planned actions, it was observed that each of the alternatives also results in increased storage in Trinity Lake. Alternative C is the most effective in increasing coldwater pool volumes. Alternative C is also the most effective in stabilizing flows in the Sacramento and American River. Shifting X2 downstream results in habitat increases for delta smelt and reduces water quality stress for other species including salmonids. Alternative C was most effective in achieving this objective as well. Alternative A was the least effective in achieving these beneficial physical conditions.

The interactive object-oriented simulation (IOS) and SALMOD models were used to evaluate the accomplishments of water temperature and flow improvements. Water temperature is one of the principle drivers for salmonid production. Temperature can have a significant influence on the timing of smolt runs. A threshold water temperature or a pattern of variation for a prolonged period may initiate the downstream migration. Evidence suggests a strong correlation between daytime migratory activity and water temperature. Although many juveniles migrate in higher numbers at night, a temperature cue may be their initial prompt to begin seaward migration. Temperature is also known to be a highly significant factor in determining mortality rates. There are optimum temperatures for survival and growth in which mortality is minimized. However, as temperatures reach minimum and maximum threshold values, fish stress levels elevate and mortality is increased. Beyond the threshold temperatures, mortality is high and can have a significant impact on abundance.

The feeding behavior of predators is also influenced by temperature. Metabolism increases with rising temperature; therefore, the predator is capable of consuming more prey. Temperature has other physiological effects which may influence the amount of prey consumed. Each of the NODOS action alternatives increases the coldwater pool at Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. The most significant increases in coldwater pool associated with Alternatives A, B, and C occur in the driest periods, as is shown in Figure 7-6 which depicts the corresponding September storage.



Driest periods are essentially the drought years in the 83-year full-simulation sequence (i.e., 1928 to 1934, 1976 to 1977, and 1987 to1992). These are years that are designated as multiple year dry sequences, rather than each individual year, as designated by the Indices.

Figure 7-6. Driest Periods September Carryover Storage

Stabilizing flows in the Sacramento and American Rivers reduce isolation events to support the migration of fish. Water flow and net river discharge have been shown to be highly influential in the rates at which young salmon migrate. Increased flow appears to increase the migrants rate of passage. Survival of smolts passing through the Delta is highly correlated with the discharge of the Sacramento River (Groot and Margolis, 1991), presumably due to less time for exposure to potential threats during migration.

Increasing Delta outflow increases estuarine habitat, reduces entrainment, and improves food availability for Delta species.

Table 7-4 summarizes changes in physical conditions that are considered beneficial for fish. The relative accomplishments of the various alternatives was further evaluated through computer simulations of Chinook salmon populations to assess the results of the ecosystem enhancement actions. Three computer models were used in the analysis.

- **SALMOD** was used to evaluate the linkage between habitat dynamics and smolt growth, movement, and survival between Keswick Dam and Red Bluff (Figure 7-7). SALMOD also was used to quantify the effects of flow and temperature regimes for the alternatives on annual production potential. SALMOD is habitat-based and only examines the juvenile (freshwater) life history phase, but it provides output for all four Sacramento Chinook stocks (winter-, spring-, fall-, and late fall-run).

- **IOS** was used to evaluate the influence of different Central Valley water operations and estimate the long-term response of Sacramento River winter-run Chinook populations to changing environmental conditions (e.g., river discharge, temperature, and habitat quality throughout a larger geographical reach). IOS is a lifecycle model that incorporates the whole lifecycle of a salmonid stock, but was used here only to evaluate winter-run Chinook salmon.

- **IOS/Delta Passage Model** was used to determine how salmonid smolt survival to Chipps Island might be influenced by the proposed NODOS alternatives.

No single alternative resulted in the greatest benefit during all year types and for all Chinook stocks. Different life stages of the four Chinook salmon stocks (spring, fall, late fall, and winter) are responsive to different habitat conditions. SALMOD results indicated that water temperature changes had a greater effect on mortality than river flow changes. Sites Reservoir has beneficial temperature effects for all three alternatives and all four Chinook salmon stocks. Modeling results suggest a negative impact from flow-related changes associated with pumping operations to fill the reservoir on spring- and fall-run Chinook salmon; however, the beneficial effects of lower temperatures still result in an overall predicted increase in the population for these runs (Figure 7-8).

Table 7-4. Ecosystem Enhancement Actions

			NODOS Alternative A minus No Project Alternative				NODOS Alternative B minus No Project Alternative				NODOS Alternative C minus No Project Alternative	
	No Project Alternative	**NODOS Alternative A**	**Difference**	**Relative Difference**	**No Project Alternative**	**NODOS Alternative B**	**Difference**	**Relative Difference**	**No Project Alternative**	**NODOS Alternative C**	**Difference**	**Relative Difference**
EESA-1. Shasta Lake Coldwater Pool												
Improve the reliability of coldwater pool storage in Shasta Lake to increase the U.S. Bureau of Reclamation's operational flexibility to provide suitable water temperatures in the Sacramento River. This action would operationally translate into the increase of Shasta Lake May storage levels, and increased coldwater pool in storage, with particular emphasis on Below Normal, Dry and Critical water year types.												
Trinity Lake												
End-of-Month Storage (SW-01)												
May (TAF)												
Full Simulation Period	1,810	1,843	32	1.8%	1,810	1,846	36	2.0%	1,810	1,851	40	2.2%
Dry (22%)	1,630	1,661	30	1.9%	1,630	1,671	40	2.5%	1,630	1,665	34	2.1%
Critical (15%)	1,076	1,127	51	**4.8%**	1,076	1,128	52	**4.8%**	1,076	1,140	64	**6.0%**
September (TAF)												
Full Simulation Period	1,374	1,417	43	3.1%	1,374	1,416	42	3.1%	1,374	1,424	51	3.7%
Dry (22%)	1,132	1,185	52	4.6%	1,132	1,181	48	4.3%	1,132	1,191	58	5.1%
Critical (15%)	658	737	79	**12.0%**	658	718	60	**9.1%**	658	753	95	**14.5%**
Shasta Lake												
End-of-Month Storage (SW-07)												
May (TAF)												
Full Simulation Period	3,944	3,994	50	1.3%	3,944	4,013	70	1.8%	3,944	4,007	64	1.6%
Dry (22%)	3,725	3,830	105	2.8%	3,725	3,843	118	3.2%	3,725	3,840	115	3.1%
Critical (15%)	2,416	2,612	196	**8.1%**	2,416	2,634	218	**9.0%**	2,416	2,680	264	**10.9%**
September (TAF)												
Full Simulation Period	2,630	2,731	101	3.8%	2,630	2,736	106	4.0%	2,630	2,738	108	4.1%
Dry (22%)	2,413	2,564	151	6.3%	2,413	2,591	178	7.4%	2,413	2,566	153	6.3%
Critical (15%)	1,187	1,308	121	**10.2%**	1,187	1,370	183	**15.4%**	1,187	1,396	208	**17.6%**
EESA-2. Sacramento River Flows for Temperature Control												
Provide releases from Shasta Dam of appropriate water temperatures, and subsequently from Keswick Dam, to maintain mean daily water temperatures year-round at levels suitable for all species and lifestages of anadromous salmonids in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam, with particular emphasis on the months of highest potential water temperature-related impacts (i.e., July through November) during Below Normal, Dry and Critical water year types.												
Trinity River below Lewiston[a]												
Monthly Temperature (SQ-33)												
Aug-Sep (Deg-F)												
Full Simulation Period	51.2	50.9	-0.3	-0.5%	51.2	50.9	-0.3	-0.5%	51.2	50.8	-0.3	-0.6%
Dry (22%)	50.2	50.4	0.2	0.4%	50.2	50.1	-0.1	-0.3%	50.2	50.3	0.1	0.2%
Critical (15%)	55.5	53.6	-2.0	**-3.5%**	55.5	54.0	-1.5	**-2.7%**	55.5	53.8	-1.8	**-3.2%**
Clear Creek at Igo												
Monthly Temperature (SQ-37)												
Sep-Oct (Deg-F)												
Full Simulation Period	52.9	52.7	-0.2	-0.4%	52.9	52.7	-0.2	-0.4%	52.9	52.6	-0.3	-0.5%
Dry (22%)	52.8	52.7	-0.1	-0.2%	52.8	52.7	-0.2	-0.3%	52.8	52.6	-0.2	-0.3%
Critical (15%)	56.7	55.6	-1.0	**-1.8%**	56.7	55.8	-0.9	**-1.6%**	56.7	55.7	-1.0	**-1.8%**
Sacramento River at Bend Bridge												
Monthly Temperature (SQ-05)												
Aug-Sep (Deg-F)												
Full Simulation Period	57.5	57.2	-0.3	-0.5%	57.5	57.2	-0.3	-0.5%	57.5	57.1	-0.4	-0.6%
Dry (22%)	57.9	57.5	-0.4	-0.7%	57.9	57.4	-0.5	-0.8%	57.9	57.4	-0.6	-1.0%
Critical (15%)	61.5	60.1	-1.4	**-2.2%**	61.5	60.5	-1.0	**-1.7%**	61.5	59.9	-1.5	**-2.5%**

Table 7-4. (Continued)

	No Project Alternative	NODOS Alternative A	NODOS Alternative A minus No Project Alternative: Difference	NODOS Alternative A minus No Project Alternative: Relative Difference	No Project Alternative	NODOS Alternative B	NODOS Alternative B minus No Project Alternative: Difference	NODOS Alternative B minus No Project Alternative: Relative Difference	No Project Alternative	NODOS Alternative C	NODOS Alternative C minus No Project Alternative: Difference	NODOS Alternative C minus No Project Alternative: Relative Difference
EESA-2. Sacramento River Flows for Temperature Control (cont'd)												
Sacramento River Winter-Run Chinook Salmon												
Egg to Fry Survival (AQ-01 IOS)												
Annual (fraction)												
Full Simulation Period	0.79	0.81	0.02	2.8%	0.79	0.81	0.02	3.1%	0.79	0.82	0.03	3.8%
Dry (22%)	0.76	0.80	0.04	4.8%	0.76	0.81	0.05	6.3%	0.76	0.81	0.05	6.9%
Critical (15%)	0.38	0.48	0.10	**26.1%**	0.38	0.46	0.08	**21.2%**	0.38	0.50	0.12	**33.1%**
Returning Female Spawners (AQ-01 IOS)												
Annual (#)												
Full Simulation Period	15,636	16,902	1,266	**8.1%**	15,636	16,906	1,270	**8.1%**	15,636	16,941	1,305	**8.3%**
Dry (22%)	15,604	16,718	1,113	7.1%	15,604	16,598	994	6.4%	15,604	16,501	896	5.7%
Critical (15%)	13,030	14,355	1,325	10.2%	13,030	14,487	1,458	11.2%	13,030	14,139	1,109	8.5%
EESA-3. Folsom Lake Coldwater Pool												
Increase the availability of coldwater pool storage in Folsom Lake by increasing May storage and coldwater pool storage, to allow the U.S. Bureau of Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would utilize additional coldwater pool storage by providing releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain mean daily water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning in the lower American River from May through November during all water year types.												
Folsom Lake												
End-of-Month Storage (SW-24)												
May (TAF)												
Full Simulation Period	840	844	4	0.5%	840	840	0	0.0%	840	843	3	0.3%
Dry (22%)	777	789	12	1.5%	777	789	11	1.5%	777	786	8	1.1%
Critical (15%)	437	452	14	**3.3%**	437	426	-12	-2.7%	437	449	12	**2.8%**
September (TAF)												
Full Simulation Period	496	518	22	4.5%	496	518	22	4.5%	496	520	24	4.9%
Dry (22%)	420	450	29	**7.0%**	420	460	39	9.4%	420	451	30	7.2%
Critical (15%)	239	243	5	1.9%	239	260	22	**9.1%**	239	256	17	**7.3%**
American River at Watt Ave (Sacramento)												
Monthly Temperature (SQ-19)												
Jul-Sep (Deg-F)												
Full Simulation Period	68.6	68.5	0.0	-0.1%	68.6	68.6	0.0	0.0%	68.6	68.6	0.0	0.0%
Dry (22%)	68.8	68.9	0.1	0.2%	68.8	68.9	0.1	0.1%	68.8	68.9	0.1	0.2%
Critical (15%)	71.2	70.6	-0.6	**-0.9%**	71.2	71.0	-0.2	**-0.3%**	71.2	70.8	-0.4	**-0.5%**
EESA-4. Stabilize American River Flows												
Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds (i.e., October through March) and steelhead redds (i.e., January through May), and reduce isolation events (specifically, flow increases to 4,000 cfs with subsequent reduction to less than 4,000 cfs) of juvenile anadromous salmonids, particularly from October through June. Reduce the reliance upon Folsom Lake as a "real-time, first response facility" to meet Delta objectives and demands, particularly from January through August, to reduce flow fluctuation and water temperature-related impacts to fall-run Chinook salmon and steelhead in the lower American River.												
Not applicable: Reporting Metrics require daily timestep modeling of flow operations to demonstrate how flexibility in storage operations supports stabilization of flows throughout late fall through spring.												

Table 7-4. (Continued)

	No Project Alternative	NODOS Alternative A	NODOS Alternative A minus No Project Alternative: Difference	NODOS Alternative A minus No Project Alternative: Relative Difference	No Project Alternative	NODOS Alternative B	NODOS Alternative B minus No Project Alternative: Difference	NODOS Alternative B minus No Project Alternative: Relative Difference	No Project Alternative	NODOS Alternative C	NODOS Alternative C minus No Project Alternative: Difference	NODOS Alternative C minus No Project Alternative: Relative Difference
EESA-5. Delta Outflow for Delta Smelt Habitat Improvement (Summer/Fall)												
Provide supplemental Delta outflow during summer and fall months (i.e., May through December) to improve X2 (if possible, west of Collinsville, 81 km) and increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fishes and other estuarine-dependent species (e.g., delta smelt, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp)												
X2 Position												
Monthly Averaged X2 (SQ-01)												
Jul-Aug (km)												
Full Simulation Period	82.7	81.5	-1.2	**-1.4%**	82.7	81.5	-1.2	**-1.5%**	82.7	81.4	-1.3	**-1.6%**
Dry (22%)	85.6	84.2	-1.4	-1.6%	85.6	84.2	-1.4	-1.7%	85.6	84.0	-1.7	-1.9%
Critical (15%)	88.5	88.0	-0.6	-0.6%	88.5	87.9	-0.6	-0.7%	88.5	87.9	-0.7	-0.8%
Sep-Nov (km)												
Full Simulation Period	83.4	82.8	-0.5	**-0.6%**	83.4	82.8	-0.6	**-0.7%**	83.4	82.6	-0.8	**-0.9%**
Dry (22%)	89.9	89.0	-0.9	-1.0%	89.9	88.9	-1.0	-1.1%	89.9	88.4	-1.5	-1.6%
Critical (15%)	92.2	91.9	-0.3	-0.3%	92.2	91.7	-0.6	-0.6%	92.2	91.6	-0.6	-0.7%
EESA-6. Lake Oroville Coldwater Pool												
Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River from May through November during all water year types. Provide releases from Oroville Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to minimize redd dewatering, juvenile stranding and isolation of anadromous salmonids.												
Lake Oroville												
End-of-Month Storage (SW-18)												
May (TAF)												
Full Simulation Period	3,002	3,041	40	1.3%	3,002	3,038	36	1.2%	3,002	3,038	36	1.2%
Dry (22%)	2,621	2,672	51	1.9%	2,621	2,683	62	2.4%	2,621	2,700	79	3.0%
Critical (15%)	1,760	1,868	108	**6.1%**	1,760	1,847	87	**4.9%**	1,760	1,837	77	**4.4%**
September (TAF)												
Full Simulation Period	1,831	1,844	13	0.7%	1,831	1,841	9	0.5%	1,831	1,838	7	0.4%
Dry (22%)	1,297	1,301	5	0.4%	1,297	1,319	23	1.7%	1,297	1,303	7	0.5%
Critical (15%)	941	1,014	73	**7.8%**	941	990	49	**5.2%**	941	1,010	69	**7.3%**
Feather River below Thermalito												
Monthly Temperature (SQ-16)												
Aug-Sep (Deg-F)												
Full Simulation Period	65.7	65.7	0.0	0.0%	65.7	65.7	0.0	0.0%	65.7	65.7	0.0	0.0%
Dry (22%)	65.6	65.7	0.1	0.1%	65.6	65.6	0.0	0.0%	65.6	65.6	0.0	-0.1%
Critical (15%)	67.3	66.8	-0.5	**-0.8%**	67.3	66.8	-0.5	**-0.8%**	67.3	66.7	-0.6	**-0.9%**
EESA-7. Stabilize Sacramento River Fall Flows												
Stabilize flows in the Sacramento River between Keswick Dam and the Redd Bluff Diversion Dam to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation lifestage periods extending from October through March), particularly during fall months. (Avoid abrupt changes; operation limited to not greatly impact coldwater pool operations in D and C years.)												
Sacramento River below Keswick												
Monthly Flow (SW-10)												
Dec-Feb (cfs)												
Full Simulation Period	8,394	8,980	586	7.0%	8,394	8,965	572	6.8%	8,394	8,934	540	6.4%
Below Normal (17%)	5,040	5,637	598	**11.9%**	5,040	5,669	629	**12.5%**	5,040	5,625	585	**11.6%**
Dry (22%)	3,858	4,662	804	**20.8%**	3,858	4,701	842	**21.8%**	3,858	4,650	792	**20.5%**
Critical (15%)	3,571	3,932	361	10.1%	3,571	3,942	371	10.4%	3,571	3,898	327	9.2%

Table 7-4. (Continued)

	No Project Alternative	NODOS Alternative A	NODOS Alternative A minus No Project Alternative		No Project Alternative	NODOS Alternative B	NODOS Alternative B minus No Project Alternative		No Project Alternative	NODOS Alternative C	NODOS Alternative C minus No Project Alternative	
			Difference	Relative Difference			Difference	Relative Difference			Difference	Relative Difference
EESA-8. Sacramento River Diversion Reduction at Red Bluff and Hamilton City												
Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at Red Bluff Diversion Dam (into the Tehama-Colusa Canal) and at Hamilton City (into the Glenn-Colusa Irrigation District Canal), and by providing supplemental flows (at Delevan Pipeline). This action would provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (e.g., delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.												
Glenn-Colusa Canal, Hamilton City Intake												
Diversions (OP-02a)												
Jun-Aug volume above diversion rate of 2000 cfs (TAF/season)												
Full Simulation Period	111	39	-72	**-64.5%**	111	90	-21	**-19.2%**	111	37	-74	**-66.8%**
Dry (22%)	117	23	-95	-80.5%	117	90	-28	-23.5%	117	21	-96	-81.8%
Critical (15%)	58	20	-39	-66.6%	58	48	-10	-17.4%	58	13	-45	-77.4%
Tehama-Colusa Canal, Red Bluff Intake and Glenn-Colusa Canal, Hamilton City Intake												
Diversions (OP-01a and 02a)												
Jun-Aug volume (TAF/season)												
Full Simulation Period	607	442	-165	**-27.2%**	607	556	-51	**-8.4%**	607	431	-176	**-29.0%**
Dry (22%)	563	393	-170	-30.2%	563	511	-52	-9.3%	563	370	-193	-34.3%
Critical (15%)	450	330	-120	-26.6%	450	414	-36	-8.0%	450	321	-129	-28.6%

Notes:
[a] Modeled result does not account for use of the auxiliary outlet works; nevertheless, the coldwater pool at Trinity would be increased.

cfs = cubic feet per second
Deg-F = degrees Fahrenheit
EESA = ecosystem enhancement storage account
km = kilometer
NODOS = North-of-the-Delta Offstream Storage
TAF = thousand acre-feet
X2 = the distance in kilometers from the Golden Gate Bridge to the location where salinity in the Delta is 2 parts per thousand
% = percent

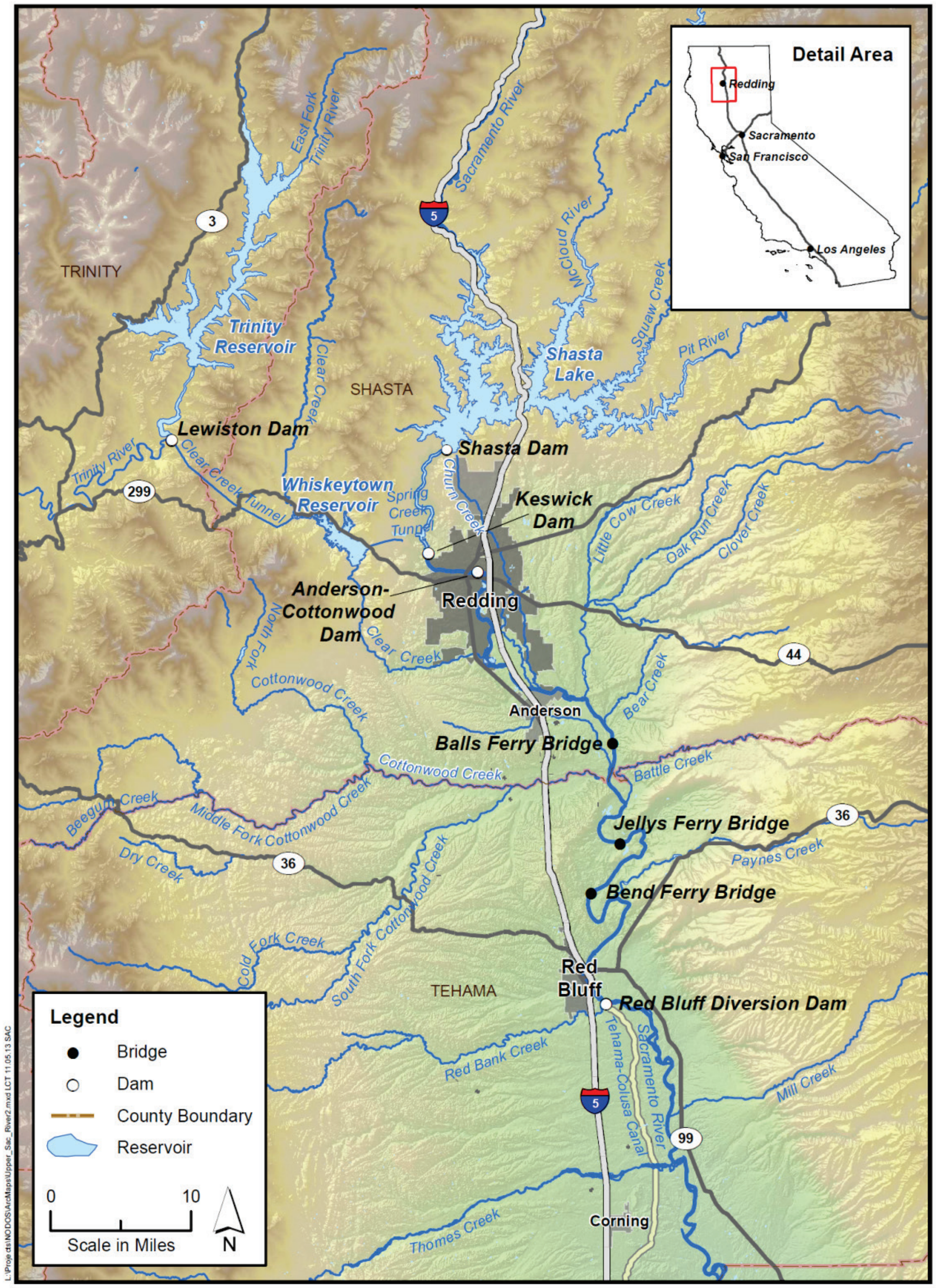


Figure 7-7. Area of Salmon Habitat Improvement Evaulated by SALMOD

The IOS model results indicated better survival of winter-run Chinook for egg to fry and fry to smolt life stages during critical year periods (Figure 7-9). The IOS model also predicted escapement (number of female spawners) of winter-run Chinook would be higher during the critical year scenario (Figure 7-10). Based on the IOS model, the survival of juvenile salmonids traveling through the Delta would not be significantly altered by any of the three NODOS alternatives (Figure 7-11) (i.e., values are slightly negative, but not considered significant).

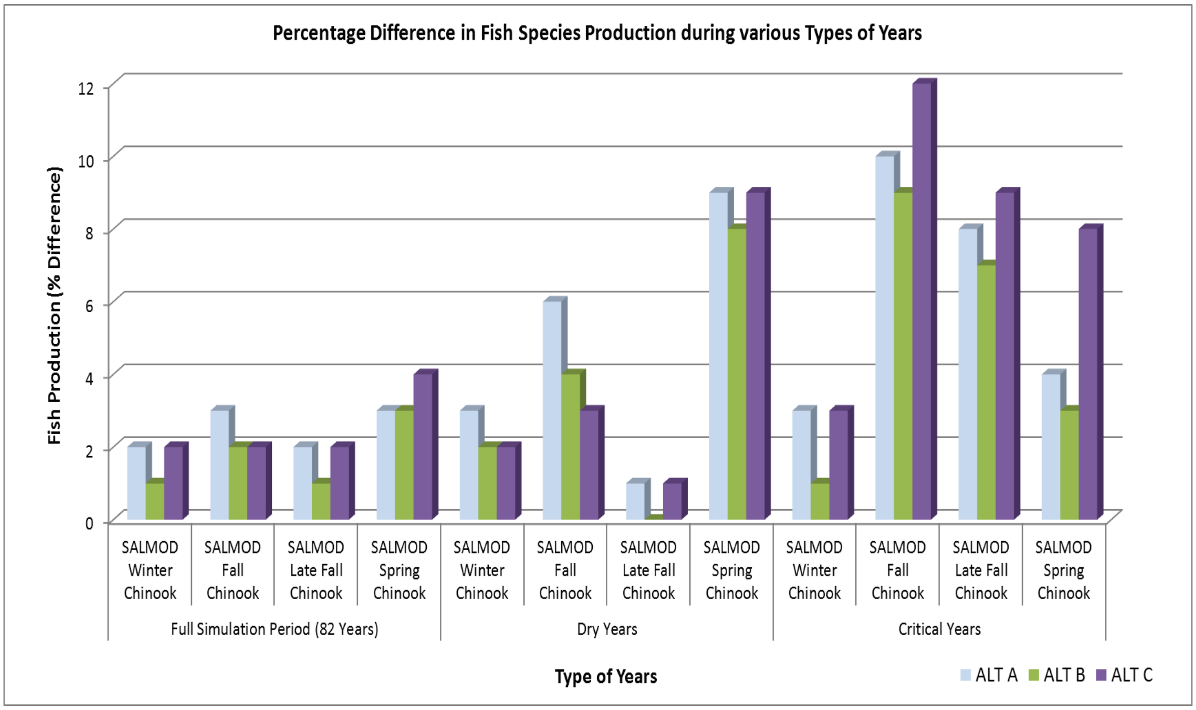


Figure 7-8. Anticipated Effects of Alternatives A, B, and C Compared to No Project Alternative on Sacramento River Chinook Salmon Juvenile Production (SALMOD Model)

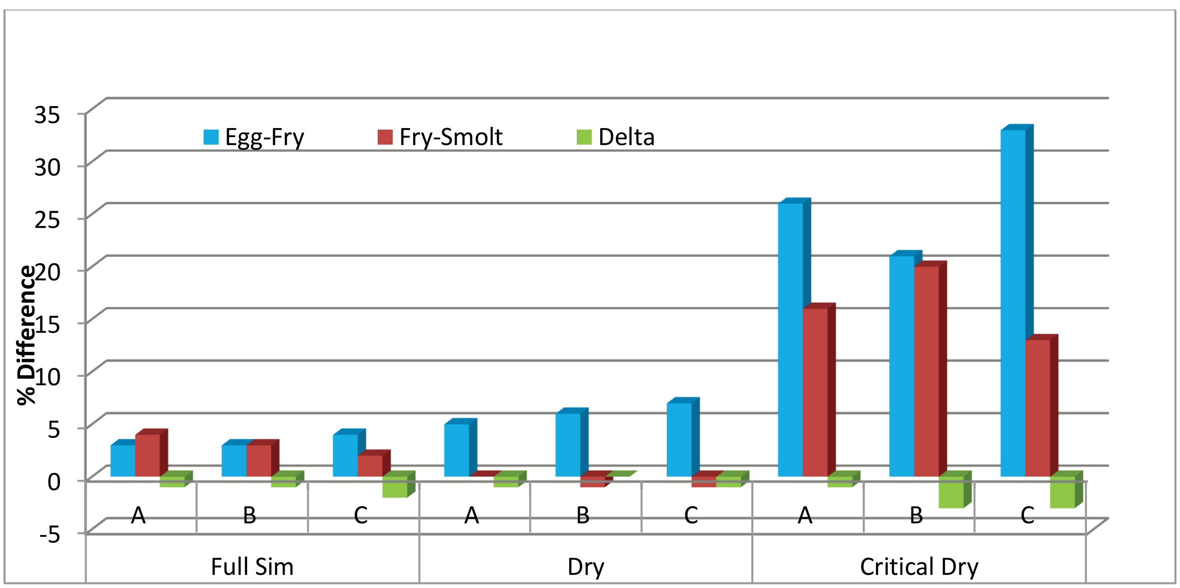


Figure 7-9. Anticipated Effects of Alternatives A, B, and C Compared to No Project Alternative on Sacramento River Winter-Run Chinook Salmon Annual Survival (IOS Model)

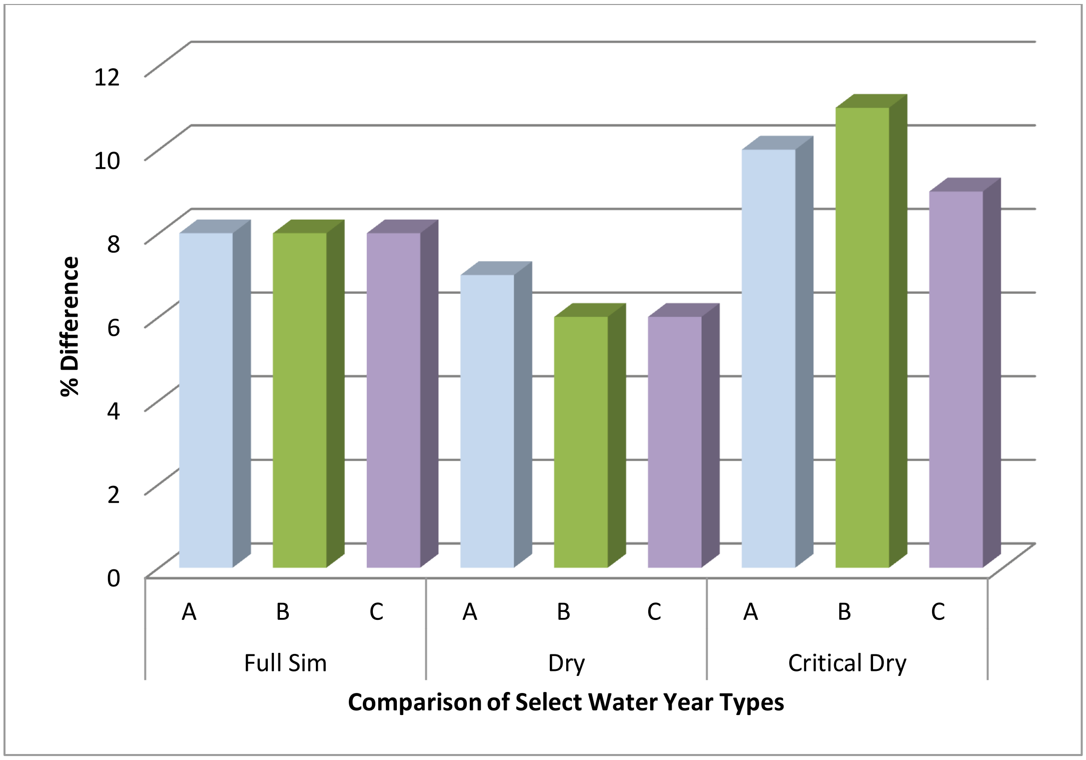


Figure 7-10. Anticipated Effects of Alternatives A, B, and C Compared to No Project Alternative on Sacramento River Winter-Run Chinook Salmon Annual (Escapement) Female Spawner Numbers (IOS Model)

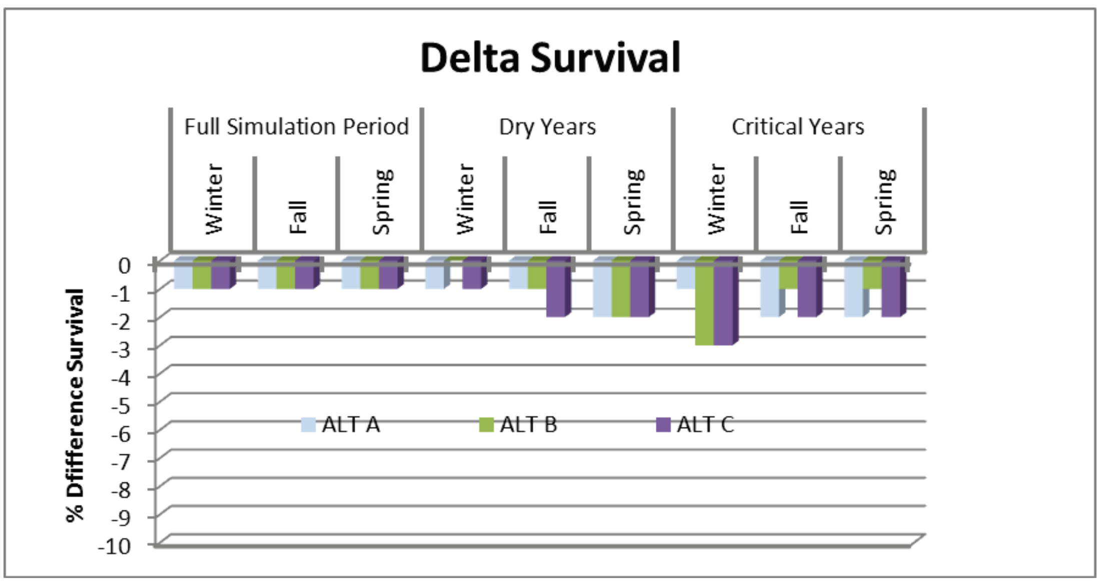


Figure 7-11. IOS Modeled Anticipated Effects of Alternatives A, B, and C Compared to No Project Alternative on Annual Delta Juvenile Survival for all Four Sacramento River Chinook Salmon Stocks

In addition to improvements to coldwater pools, flow stabilization, and X2 downstream shifting, all alternatives include establishing an EEF to support ongoing gravel augmentation and floodplain habitat restoration activities to improve habitat in the Sacramento River and tributaries between Keswick Dam and Red Bluff. This effort is identical for the three alternatives; therefore, in this regard, all three alternatives are equally effective.

Alternatives A, B, and C would improve the survival of anadromous fish populations (all Chinook stocks) in the Sacramento River. However, these alternatives would have a negligible effect on the survival of anadromous fish populations in the Delta. Temperature reductions in the Sacramento River and its tributaries resulting from these alternatives and the resulting modifications to the operation of Folsom Lake, Shasta Lake, Lake Oroville, and Trinity Lake would help increase the survival of the anadromous fish population. Therefore, all three alternatives would meet the primary objective of improving anadromous fish survivability.

Alternatives A, B, and C may improve the health and survivability of other aquatic species in the Sacramento River and tributaries, and the Delta, but the effects on these species were not modeled. It is expected that decreased temperatures and increased flows in the Upper Sacramento River also would benefit other native anadromous fish and native aquatic species in the Sacramento River and in the Delta. By providing an increase in Delta outflow, the NODOS alternatives would help maintain an X2 position at 81 km (immediately west of Collinsville) from July to November. This X2 downstream shift would increase delta smelt habitat and may reduce entrainment and improve food availability. Increased flow and decreased temperatures in the Upper Sacramento River would also benefit the ESA-listed green sturgeon in terms of better spawning and rearing habitat for juveniles. Temperature alterations in the Sacramento River and its tributaries resulting from these alternatives and its resulting modifications to the operation of Folsom, Shasta, Oroville, and Trinity dams may increase survival for the other native fish populations.

Alternative C would provide the greatest potential for increasing all four Chinook stocks in critical years. Alternative C is also the most effective in shifting the position of X2 downstream. The overall accomplishments in achieving the objective of improving populations of anadromous fish and other aquatic species is considered to be the highest for Alternative C, followed very closely by Alternative A, and then Alternative B.

Sustainable Hydropower Generation (Primary Objective)

Two approaches, complementary to each other, have been used to hydropower accomplishments associated with NODOS alternatives, namely:

- The NODOS Power Post-Processor Module developed by CH2M HILL
- The NODOS Power Optimization Scheme developed by the DWR Power and Risk Office

The NODOS Power Post-Processor Module was used to evaluate hydropower generation associated with releases from Sites Reservoir, and the NODOS Power

Optimization Scheme was used to optimize the timing and evaluate pumpback operation.

The three new pumping-generating facilities envisioned for the NODOS Project are:

- Sites Generation at Holthouse Reservoir (adjacent to the Sites Reservoir)
- TRR (connecting the GCID Canal to Funks Reservoir)
- Sacramento River diversion point (connecting the Sacramento River to the Holthouse Reservoir)

Table 7-5 presents the 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.

Table 7-5. Hydropower Generation

	Alternative A	Alternative B	Alternative C
Sites-Rated Generation Capacity (MW)	96.3	109.7	109.7
TRR-Rated Generation Capacity (MW)	9.8	9.8	9.8
Sacramento River-Rated Generation Capacity (MW)	12	N/A	12
Annual Power Generated (GWh)	184-301	143-336	169-353

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

Alternative A has a lower maximum WSE and, as a result, the Sites Generating Plant has a lower capacity. Alternatives B and C have equivalent dam heights and the units in the Sites Generation Plant are identical for these two alternatives. Alternatives A and C include generations facilities at the Sacramento River that are not present in Alternative B. The TRR Pumping/Generating Plant is identical for all three alternatives.

The annual power generated is presented as a range of values that occurs in the simulation over the 30-year analysis period for the NODOS Power Optimization Scheme. 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, significant 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. Under drought conditions, there may not be sufficient water in the reservoir for pumpback operation and releases that contribute to power generation would be diminished. As a result, there is a significant range of power generation over the 30-year analysis period, corresponding to the year type.

Water Quality (Primary Objective)

The action alternatives would provide a variety of water quality accomplishments. Coordinated operations with Shasta Lake provide additional flow and cooler water temperatures during dry conditions in the Sacramento River north of Red Bluff. These accomplishments are discussed more completely under the anadromous fish primary objective. Downstream from the Delevan Pipeline, releases from Sites Reservoir would increase flow during the driest periods; however, the greatest accomplishments to water quality from the NODOS action alternatives would be realized in the Delta and in Delta exports. This section evaluates the ability of the alternatives to provide these benefits.

Delta Water Quality

The potential for water quality improvements within the Delta was evaluated in terms of the position of X2 and the resulting Delta outflows.

X2 (Delta Salinity): X2 is a Delta management tool, and defined as the distance in km from the Golden Gate Bridge to the location where the tidally averaged near-bottom salinity in the Delta measures 2 ppt. This point is also referred to as the "Mixing Zone" and is a measure of Delta salinity. East of X2, water becomes progressively fresher, and west of X2 water becomes more saline until reaching 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 7-12 shows the change in the average X2 positions during September and October in dry and critical years for each of the action alternatives. NODOS would be operated to provide releases targeted to improve Delta water quality in a manner that results in the greatest improvement in water quality during the fall in dry and critical years. Alternative C performs best in terms of the shift in the location of X2 by 1 to 2.5 km seaward, followed by Alternative B. Alternative A provides some benefit, but the shift to the west is only 0.8 to 1.5 km.

Delta Outflows: Outflow from natural runoff is usually high enough during the months of April through July to push seawater out of the Delta. This period is also outside of the peak loading time related to agricultural drainage. As the Delta outflow decreases, the water quality is significantly degraded during the late summer and fall.

The potential improvements resulting from the NODOS alternatives to Sacramento/San Joaquin River Delta monthly outflows during dry and critical years were considered as an indicator of water quality within the Delta. A series of probability of exceedance plots in Figure 7-13 show monthly Delta outflows. The plots indicate the greatest improvement in water quality would occur during the fall (September and October) in dry and critical years. The monthly Delta outflows show the greatest increase under Alternative C, followed by Alternative A and then Alternative B.

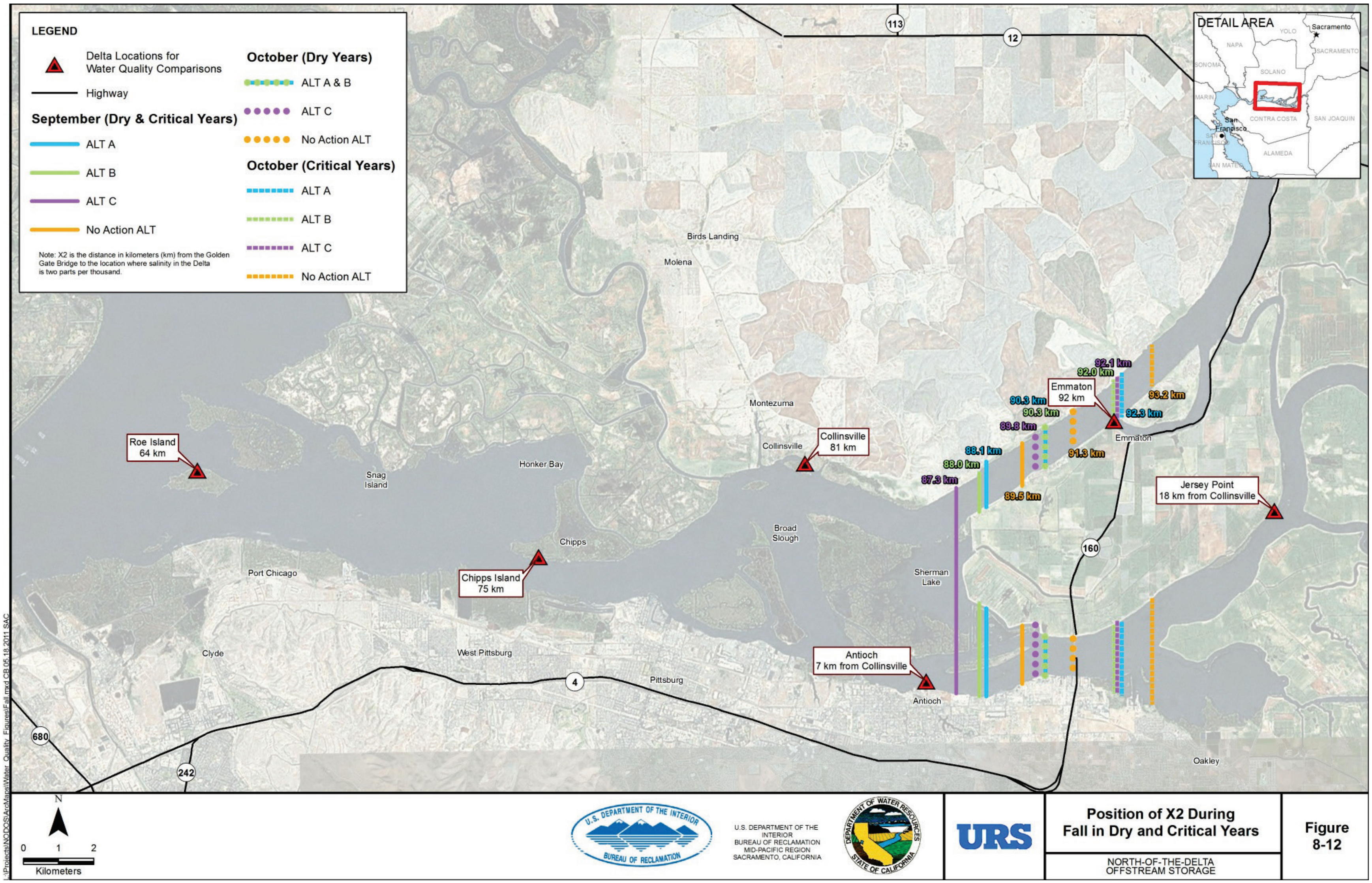


Figure 7-12. Position of X2

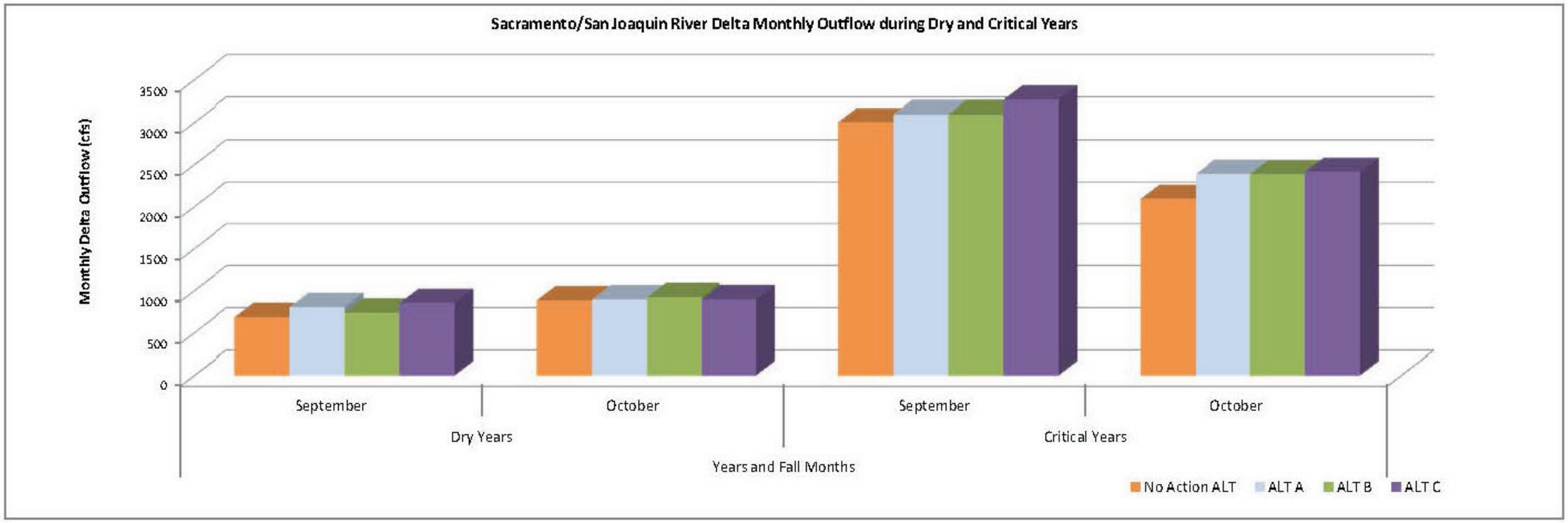


Figure 7-13. Delta Outflow

Water Quality for Agricultural, M&I Water Uses

Improved water quality in the Delta would benefit the Delta export water quality. Exporters would benefit from a decrease in treatment costs for M&I purposes and agricultural users in the San Joaquin River Basin would benefit from reduced salt loads.

Water quality improvements that would result from the NODOS alternatives for agricultural and M&I water uses are evaluated by comparing simulated EC, total dissolved solids (TDS), and chloride concentrations for the three action alternatives (Figures 7-14 through 7-17). Relative impacts related to a decrease in toxic effects of disinfectant byproducts were evaluated by comparing simulated bromide concentrations for the three action alternatives. Table 7-6 provides the EC, TDS, chloride, and bromide concentrations for the three action alternatives.

Recreation (Secondary Objective)

The action alternatives would provide new opportunities for surface-water recreation, such as boating, fishing, and swimming. In addition, new facilities would be developed to support other recreation activities such as camping, hiking, picnicking, and sightseeing. Developed access and facilities would be offered at the Stone Corral, Lurline Headwaters, and Antelope Island recreation areas. Two additional locations for future recreation areas have been identified, but are not included in the initial project costs. Future facilities would include boat launch sites, picnic areas and tables, developed campsites, restrooms, trails, designated swimming areas, and parking. Approximately 112 overnight campsites would be developed under each alternative. It is assumed that each project alternative would provide recreational development and types of recreational opportunities comparable to those available at Black Butte Reservoir.

Reservoir operations would significantly impact the accomplishments of the action alternatives to provide these recreation opportunities. For some alternatives, WSEs are considerably below maximum levels during summer months in many years, which represents the peak recreation season. In these conditions, facility use would be limited and the overall recreation experience would be impaired. Alternative C provides the highest WSEs on a regular basis, followed by Alternative A and then Alternative B.

Each of the action alternatives also would change the flows and temperature in the Sacramento River system and connected Sacramento-San Joaquin Delta. These effects could alter the suitability of these waterways for river-based recreation, such as boating (including kayaking and canoeing). However, the benefits to fisheries, including salmonids, may result in higher catch rates and size of fish. Due to the inherent difficulty translating flow and fishery effects into related recreation accomplishments, these accomplishments are acknowledged here, but not quantified.

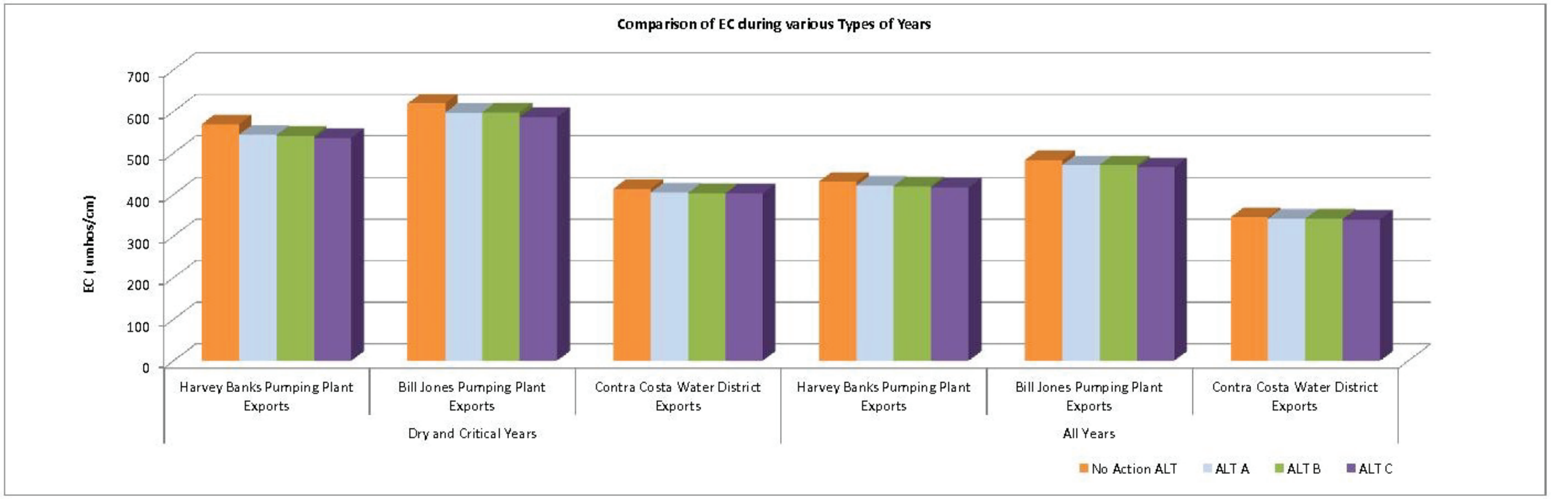


Figure 7-14. Improvements in Electrical Conductivity

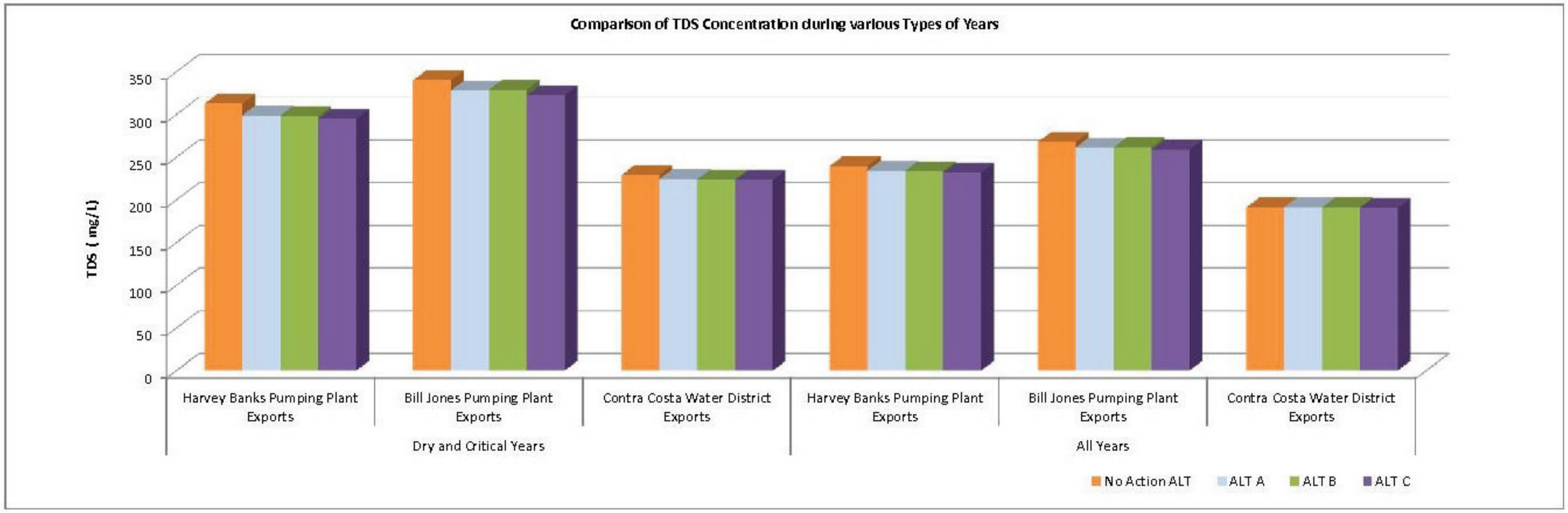


Figure 7-15. Improvements in TDS

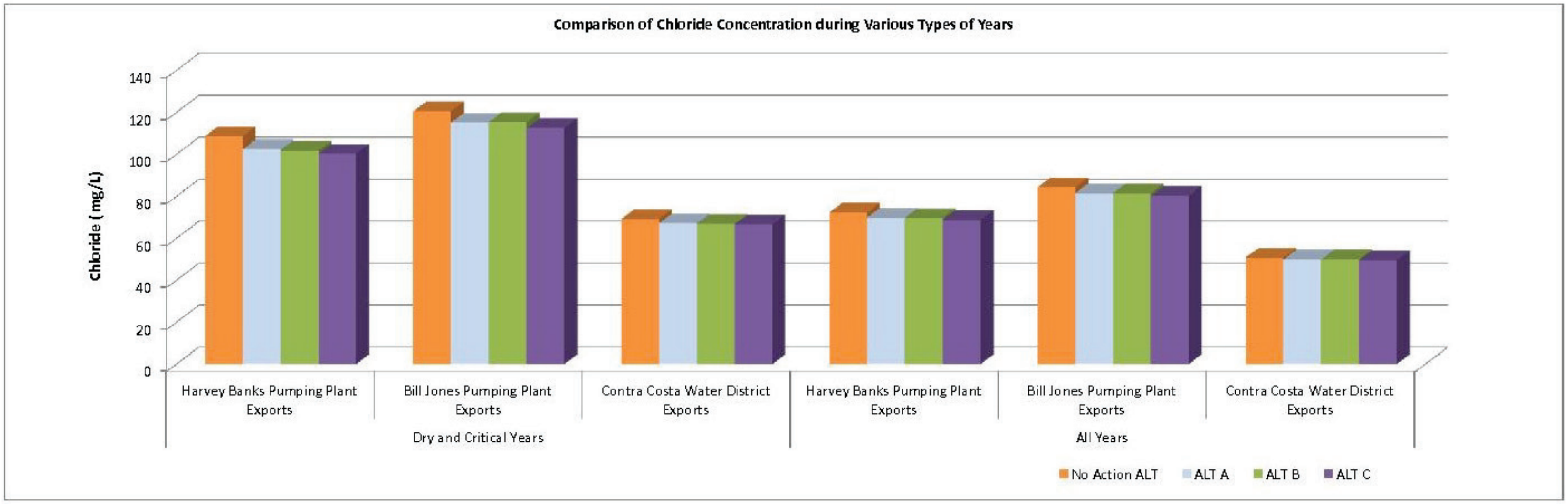


Figure 7-16. Improvements in Chloride Concentrations

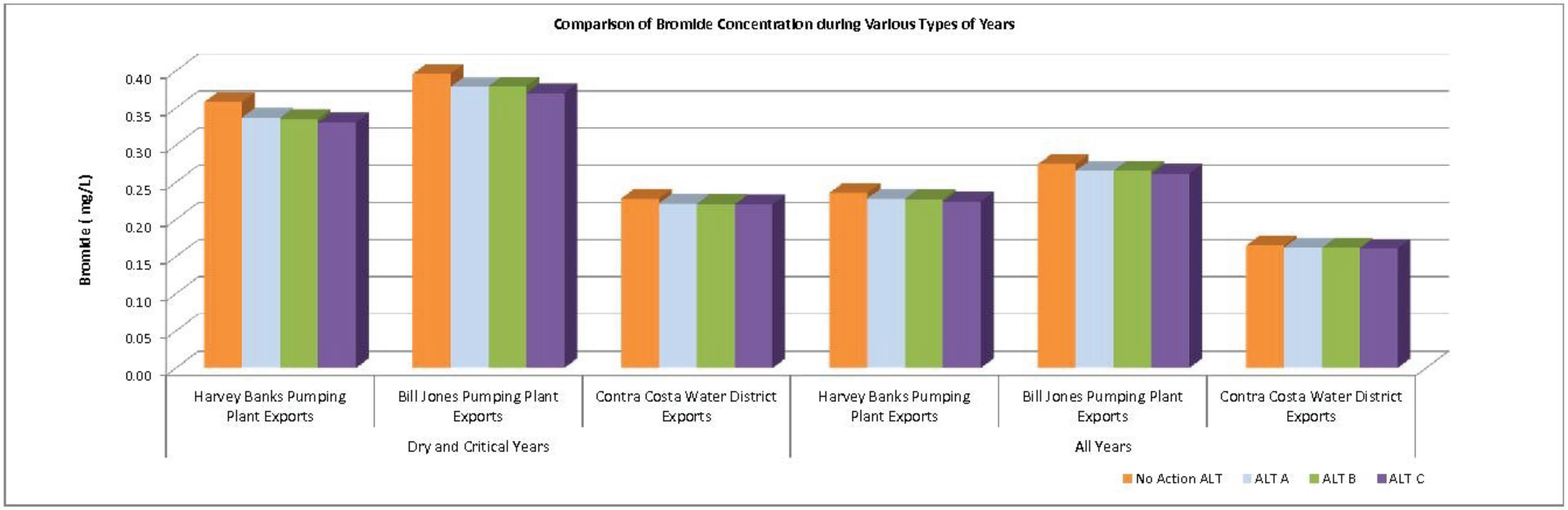


Figure 7-17. Improvements in Bromide Concentrations

Table 7-6. Quality of Exports (Average of All Years[a]/Critical and Dry Years[b])

Location	Simulated Using DSM2 Parameter	No Project Alternative	Alternative A (% Difference from No Project Alternative)	Alternative B (% Difference from No Project Alternative)	Alternative C (% Difference from No Project Alternative)
Banks Pumping Plant	EC (µmhos/cm)	431/569	421 (-2)/544 (-4)	420 (-3)/541 (-5)	417 (-3)/536 (-6)
	TDS (mg/L)	240/313	234 (-2)/299 (-4)	234 (-2)/298 (-5)	232 (-3)/295 (-6)
	Chloride (mg/L)	72/109	70 (-3)/102 (-6)	70 (-4)/102 (-6)	69 (-5)/100 (-8)
	Bromide (mg/L)	0.24/0.36	0.23 (-3)/0.34 (-6)	0.23 (-4)/0.34 (-6)	0.22 (-5)/0.33 (-8)
Jones Pumping Plant	EC (µmhos/cm)	483/619	471 (-2)/596 (-4)	471 (-2)/598 (-3)	466 (-3)/586 (-5)
	TDS (mg/L)	268/340	261 (-2)/328 (-4)	262 (-2)/329 (-3)	259 (-3)/323 (-5)
	Chloride (mg/L)	84/120	81 (-3)/115 (-5)	81 (-3)/115 (-4)	80 (-5)/112 (-7)
	Bromide (mg/L)	0.27/0.40	0.27 (-3)/0.38 (-4)	0.27 (-3)/0.38 (-4)	0.26 (-5)/0.37 (-7)
Contra Costa Water District	EC (µmhos/cm)	345/414	341 (-1)/405 (-2)	341 (-1)/403 (-3)	340 (-1)/403 (-3)
	TDS (mg/L)	193/229	191 (-1)/224 (-2)	191 (-1)/224 (-2)	191 (-1)/223 (-3)
	Chloride (mg/L)	51/69	50 (-2)/67 (-3)	50 (-2)/67 (-3)	50 (-2)/67 (-4)
	Bromide (mg/L)	0.16/0.23	0.16 (-2)/0.22 (-3)	0.16 (-2)/0.22 (-3)	0.16 (-2)/0.22 (-3)

[a] Long-Term is the average quantity for the period of October 1921 through September 2003.
[b] Dry and Critical Years Average is the average quantity for the combination of the SWRCB D-1641 40-30-30 Dry and Critical years for the period of October 1921 through September 2003. Average annual increases are based on average quantities for October 1921 through September 2003.

EC = electrical conductivity
DSM2 = one-dimensional unsteady flow and water quality model of the Sacramento-San Joaquin Delta
mg/L = milligram per liter
TDS = total dissolved solid
µmhos/cm = micromhos per centimeter

Flood-Damage Reduction (Secondary Objective)

The area along Funks Creek downstream of Funks Reservoir is in the floodplain. Under current "no project" conditions, Funks Reservoir is not a flood control reservoir. As such, it can be overwhelmed with runoff and still send peak flows downstream on Funks Creek. The NODOS action alternatives would significantly reduce the potential for flooding for the Funks Creek, Stone Coral Creek, and various other unnamed streams. Under all three NODOS alternatives, of the 22,200 acres of land prone to flooding in these watersheds, approximately 21 percent (4,660 acres) would experience a reduction in flood-related damages. This area includes the northern portion of the town of Maxwell. In addition to increasing the level of protection in the Funks Creek and Stone Corral Creek watersheds, a 100-year level of protection would also be achieved for approximately 4,025 acres in the Colusa Basin.

Water storage in Sites Reservoir could also provide flood-damage reduction benefits through coordination with other reservoirs. Diversions from the Sacramento River would not be large enough to affect the magnitude of the peak flows meaningfully, but through coordination with other reservoirs and accurate forecasting, water could be held in Sites Reservoir in lieu of water in other reservoirs to create flood-control storage space in other reservoirs. No significant differences in the accomplishments are expected between the alternatives resulting from coordination; although, with less storage, Alternative A would be more limited in its effect.

Benefits

The following evaluation of project benefits was performed in accordance with the basic guidelines for evaluating water development projects at the federal level as specified in the P&Gs.[2] Under the P&Gs, the federal objective for water contributions is to maximize the contribution to national economic development (NED) consistent with protection of the environment.

Accurate representation and comparison of the project alternatives' future benefits and costs over its full development and operating period requires that all future benefits and costs are discounted into current dollars to reflect the time value of money. Federal regulation requires use of the federal discount rate as specified by DOI for economic analysis for water resource planning. In accordance with agency regulation, the federal discount rate of 3.75 percent was used for fiscal year 2013 to calculate present value of the project's future benefits and costs for this study (Federal Register, 2013).

The project benefits and costs have been analyzed over a 100-year time planning horizon based on the expected project completion in 2023. Consequently, the end of the federal planning horizon for the project is 2122.

[2] U.S. Water Resources Council, March 10, 1983, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, Washington, D.C.

Water Supply and Water Supply Reliability Benefits

The Statewide Agricultural Production Model (SWAP) is used to allocate water for agriculture and refuges. The LCPSIM and Other Municipal Water Economics Model (OMWEM) are used to allocate water for urban purposes.

CALSIM II operational studies were used to estimate the additional water provided by the NODOS alternatives for agricultural uses. These CALSIM II water deliveries were applied to the SWAP model and the model was then run with demands based on 2030 level of development for the future no project condition and the three project alternatives. Table 7-7 presents the estimated benefits for agriculture and M&I water supplies provided by each alternative under average and dry/critical year types.

As shown in Table 7-7, the benefits realized under Alternatives A and C are similar (the differences in benefits for these two alternatives are insignificant given the accuracy of the models used). Alternative B has lower benefits as a result of the inability to recapture water further downstream because it does not include the Delevan Intake Facilities. Recaptured water could be used a second time for agricultural purposes to increase the benefits.

Table 7-7. Estimated Annual Benefit of Increased Water Supply to Agricultural Users on Average, and in Dry/Critical Years (2013 Dollars)

Alternative	Annual Benefits ($1,000s)		Annualized Benefit ($1,000s)
	2025	2060	
Average Condition			
Alternative A	$11,243	$14,175	$12,709
Alternative B	$6,490	$7,718	$7,103
Alternative C	$10,322	$12,716	$11,519
Dry/Critical Conditions			
Alternative A	$22,402	$28,078	$25,267
Alternative B	$15,662	$19,203	$17,451
Alternative C	$22,480	$28,162	$25,348

With respect to refuge water supplies, it is assumed that the water supplied would otherwise likely be acquired from existing agricultural users. Thus, the alternative source for incremental Level 4 water supplied by the NODOS alternatives would reduce the need for water acquisition. Table 7-8 presents the cost benefits associated with increased water supplies to wildlife refuges provided by each alternative under average and dry/critical year types.

Table 7-8. Estimated Annual Benefit of Increased Water Supply from Alternative Source for Incremental Level 4 Refuge Water Supplies on Average, and in Dry/Critical Years (2013 Dollars)

Alternative	Annual Benefits ($1,000s)		Annualized Benefit ($1,000s)
	2025	2060	
Average Condition			
Alternative A	$10,686	$14,361	$12,524
Alternative B	$17,457	$23,456	$20,457
Alternative C	$18,039	$24,242	$21,141

Table 7-8. (Continued)

Alternative	Annual Benefits ($1,000s)		Annualized Benefit ($1,000s)
	2025	2060	
Dry/Critical Conditions			
Alternative A	$7,311	$9,790	$8,560
Alternative B	$13,414	$17,962	$15,705
Alternative C	$13,395	$17,938	$15,684

The results show that the benefits for incremental Level 4 refuge water supplies are greatest for Alternative C, followed closely by Alternative B, and lastly by Alternative A. The value of the supplied refuge water is based on SWAP analysis to determine the value if the water had instead been used for agriculture.

The ability to supply incremental Level 4 water to refuges corresponds to the ability of the alternatives to provide water to the CVP south of the Delta. The annualized benefits for dry/critical years are lower than those during average conditions, reflecting a CALSIM II modeling constraint that specifies how limited water is allocated during dry and critical years.

Economic benefits and costs to M&I users from changes in water supplies are estimated using two models – LCPSIM and OMWEM. These models were developed by DWR for use in planning and impact studies related to water supply for SWP and CVP contractors that may be affected by surface storage projects or re-operations. LCPSIM is used to estimate the benefits of water supply changes in the urban areas of the southern San Francisco Bay–South and the South Coast regions. These two regions are expected to realize most of the M&I water supply benefits generated by the NODOS Project. Other affected CVP and SWP contractors are included in OMWEM, which covers M&I water supply benefits in the Sacramento River, San Joaquin River, San Francisco Bay-North, Central Coast, Tulare Lake, and South Lahontan regions.

There are other urban areas across the state that are not covered by either model; however, M&I water supplies delivered to these areas are negligible individually, and collectively account for less than 5 percent of total urban supplies in average years. These benefits have not been quantified.

M&I water uses include water for municipal, domestic, commercial, schools, public safety, and other applications. The NODOS Project would increase water supplies to M&I water users across the state, especially during dry/critical years. The M&I water supply benefits largely accrue to SWP contract holders located south of the Delta. M&I water deliveries increases generate economic benefit in the form of avoided water supply costs and reduction in shortage-related costs and losses.

Table 7-9 presents the urban M&I water supply cost benefits provided by each alternative under average and dry/critical year types as estimated by LCPSIM and OMWEM. Consequently, these results are subject to the limitations discussed above.

Table 7-9. M&I Water Supply Estimated Annual Benefits ($1,000s, 2013 Dollars)[a,b]

	Annual Benefits[c]		Annualized Benefit[d]
	2025	2060	
Full Simulation[e]			
Alternative A	$86,231	$228,924	$157,591
Alternative B	$88,462	$233,629	$161,059
Alternative C	$94,752	$239,921	$167,350
Dry/Critical Conditions[f]			
Alternative A	$196,709	$513,558	$355,643
Alternative B	$195,869	$412,593	$304,637
Alternative C	$235,452	$567,262	$401,918

[a] Based on LCPSIM modeling results (South Coast and San Francisco Bay-South regions) and OMWEM modeling results (Sacramento River, San-Francisco Bay-North, Central Coast, Tulare Lake, and South Lahontan regions).
[b] These figures do not account for the increased power costs attributable to additional conveyance of SWP deliveries.
[c] Annual benefits reflect the difference between shortage, conservation, and other supply costs under the project alternatives for future no project conditions based under year 2025 and 2060 level of development. The magnitude of the avoided costs are estimated using the LCPSIM and OMWEM modeling results.
[d] Annualized benefits represent avoided costs for the future no project conditions over the planning horizon (2023 to 2123).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

LCPSIM = Least Cost Planning Simulation Model
M&I = municipal and industrial
OMWEM = Other Municipal Water Economics Model
SWP = State Water Project
SWRCB = State Water Resources Control Board

M&I water supply benefits are substantially higher in dry/critical periods compared to average conditions. Annualized benefits are estimated to be up to $167 million under average conditions and nearly $402 million during dry/critical periods. In both cases, Alternative C generates the greatest benefits. As estimated by LCPSIM, most of the urban water supply benefits are concentrated in the South Coast Region and, to a lesser extent, the San Francisco Bay-South regions.

Ecosystem Enhancement Benefits

A significant benefit is attributable to the value that society places on preservation of aquatic species, especially ones that are listed. This value has not been quantitatively determined through studies for the NODOS alternatives, so a proxy method using the value of water was used to value the project's ecosystem enhancement benefit.

Two features of the NODOS alternatives are responsible for ecosystem enhancement benefits:

- Increases in the coldwater pool in existing reservoirs north of the Delta
- Increases in flow that provides flow stabilization and increased Delta outflow

Increasing the coldwater pool increases the operational flexibility to provide suitable water temperatures year-round at levels usable for all species and lifestages of Chinook salmon and steelhead. The most significant benefits are associated with the increase in the coldwater pool at Shasta Dam; however, similar benefits occur in the coldwater pool for Folsom Lake, Lake Oroville, and Trinity Lake. There is an opportunity cost associated with maintaining a greater coldwater pool.

Table 7-10 provides the increase in end-of-May storage for the four reservoirs under each alternative.

Table 7-10. Increased End-of-May Storage for Shasta Lake, Lake Trinity, Lake Oroville, and Folsom Lake (TAF)

Alternative	Average Annual Volume (TAF)[a]	Difference from No Project (TAF)	Difference from No Project (%)
Full Simulation[b]			
No Project	9,596	--	-
Alternative A	9,722	126	1.3%
Alternative B	9,737	141	1.5%
Alternative C	9,739	143	1.5%

[a] Based on CALSIM II modeling
[b] Average over entire hydrologic sequence (1921 to 2023)

TAF = thousand acre-feet
% = percent

The value of the water enhancement benefits for the increased coldwater pool are assumed to be equivalent to the agricultural use value for the quantity of coldwater pool water. Agricultural use of that water is presumed to be the most likely alternate water use and, as such, represents the foregone use value for allocating water to the coldwater pool. Table 7-11 provides enhancement benefits associated with the coldwater pool increases if the increase in end-of-May storage at all four reservoirs is valued using the unit value from SWAP.

Table 7-11. Ecosystem Enhancement Estimated Annual Benefits Associated with Increasing the Coldwater Pool ($1,000s, 2013 Dollars)

Alternative	Annualized Benefit ($1,000s, 2013 Dollars)[a,b,c,d]
Full Simulation[e]	
Alternative A	$27,420
Alternative B	$31,209
Alternative C	$31,252

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060.
[d] Based on end-of-May storage in Shasta Lake, Lake Trinity, Lake Oroville, and Folsom Lake.
[e] Average over entire hydrologic sequence (1921 to 2023).

Increased flows through the Delta and out through the San Francisco Bay would provide further beneficial effects for certain fish populations. These flows increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fish and other estuarine-dependent species (e.g., delta smelt, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp). SWRCB concluded that the best available science suggests that current Delta flows are insufficient to protect public trust resources, including fish populations (SWRCB, 2010). It should be noted that water released from Sites Reservoir for water supply or water quality purposes would often result in beneficial environmental effects; nevertheless, the benefits analysis performed in this report only looked at water released exclusively for environmental purposes to determine flow-related benefits. As a result, the estimated benefits are conservative.

Table 7-12 provides the cost benefits associated with these flows provided by each alternative under average and dry/critical year types.

Table 7-12. Ecosystem Enhancement Benefits Associated with Increased Flows ($1,000s, 2013 Dollars)

Alternative	Annual Benefit[a,b] 2025	Annual Benefit[a,b] 2060	Annualized Benefit ($)[c]
Full Simulation[d]			
Alternative A	$15,084	$21,344	$18,214
Alternative B	$14,727	$20,807	$17,768
Alternative C	$14,044	$19,857	$16,951
Dry Conditions[e]			
Alternative A	$17,706	$24,925	$21,339
Alternative B	$19,470	$27,369	$23,446
Alternative C	$16,668	$23,462	$20,088

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[d] Average over entire hydrologic sequence (1921 to 2023).
[e] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

SWAP = Statewide Agricultural Production Model
SWRCB = State Water Resources Control Board

In addition to increases in coldwater pool storage and flow-related benefits, the NODOS alternatives include the establishment of an EEF that would be used to fund various future floodplain restoration and gravel augmentation activities that would further benefit aquatic species. These actions have not yet been specified and their individual benefits are uncertain, but are assumed to be at least equal to the cost of the action.

Table 7-13 combines benefits from increasing the coldwater pool, increasing flows.

Table 7-13. Combined Estimated Annual Ecosystem Enhancement Benefits ($1,000s, 2013 Dollars)

Alternative	Annualized Coldwater Pool Benefit[a,b,c,d]	Annualized Flow Pool Benefit[a,b,c,e]	Combined Annualized Benefit
Full Simulation[e]			
Alternative A	$27,420	$18,214	$45,634
Alternative B	$31,209	$17,768	$48,977
Alternative C	$31,252	$16,951	$48,203

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060.
[d] Based on end-of-May storage increase in Shasta Lake, Lake Trinity, Lake Oroville, and Folsom Lake.
[e] Based on June through September increases in outflow.

EEF = ecosystem enhancement fund
SWAP = Statewide Agricultural Production Model

Sustainable Hydropower Generation Benefits

Hydropower benefits include:

- Market value of electricity generated by the NODOS alternatives associated with incidental water deliveries to downstream agricultural and urban water users[3]
- Net earnings associated with optimized pump storage at Sites Reservoir[4]

The cost of pumping the increase in water supply to south-of-the-Delta users is incorporated into the water supply efficiency analysis.

The DWR Power and Risk Office developed an optimization scheme for the NODOS Project operations to take advantage of opportunities and price differentials that the energy market offers to estimate the hydropower generation benefits. A pumpback operation was superimposed on the NODOS Project's diversion and release operations. Pumpback operations would enhance the project economics by capturing opportunities offered by the energy market (energy price differentials between on-peak and off-peak hours), and provide opportunities to integrate renewable energy (wind, solar, etc.).

In modeling the power needs for the diversion mode, an optimization strategy was developed to minimize energy costs of pumping operations, yet, maintain NODOS water operations objectives.

The Electric Power Research Institute Energy Portfolio Model, version 5, was used to monetize the probabilistic value of the NODOS power portfolio for each of the alternatives and operational scenarios used in the study. The Electric Power Research

[3] The initial pumping costs to fill Sites Reservoir are included as part of the operation and maintenance costs (see Chapter 10).
[4] This net benefit includes both pumping and generation.

Institute Fast Fit model, version 2.5, was used to describe the needed power and fuel price volatilities term structures, and the correlations between the different energy markets.

Overall, the power modeling shows that if NODOS pumping and generation operations are shifted to address peak demand and energy pricing considerations, the optimized costs have a significant beneficial impact on the project's economics. Table 7-14 presents the results of both the costs associated with pumping and the value of the hydropower generated.

The total net revenues are nearly equal for Alternatives A and C. Alternative B does not include a pumping/generating facility for the Delevan Pipeline. Even though pumpback operations under Alternative B are comparable to Alternatives A and C, the reduced level of hydropower generation due to releases significantly reduces the overall hydropower benefits.

Additional hydropower analysis has been performed for the proposed Alternative C configuration (Toolson and Zheng, NODOS Hydropower Benefits, November 2013). This analysis confirmed DWR's direct net energy benefits and estimates annual Ancillary Service benefits of approximately $2.5 million and System-wide Capacity benefits of $18.9 million per year. The resulting total benefit potentially attributable to the Hydropower facilities would be $23.2 million per year.

The supplemental hydropower analysis only projected benefits for the Alternative C. However, given the similarity of the proposed hydropower facilities for Alternative A, it may be expected for Alternative A would be able to generate comparable Ancillary Service and System-wide Capacity benefits. Based on the DWR initial analysis, Alternative B's future annual hydropower generation is projected to approximately 67 percent of Alternative C's annual power generation. Assuming that Alternative B potential Ancillary Service and System-wide Capacity benefits are similarly proportional, Alternative B would be expected to generate approximately $14.4 million annually. Combined with the estimated direct net hydropower benefits of $0.7 million, Alternative B would be expected to generate total hydropower benefits of $15.1 million per year.

Alternative A is projected to generate approximately 90 percent of Alternative C. Applying the same benefit approximation approach, Alternative A would be expected to generate approximately $19.3 million annually. Combined with the estimated direct net hydropower benefits of $1.3 million, Alternative A would be expected to generate total hydropower benefits of $20.6 million per year.

Water Quality Benefits

Improvements in Delta water quality are important for urban M&I and agricultural water supplies, as well as environmental purposes. Two models are available 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 Metropolitan Water District of Southern California service area, while 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.

Table 7-15 presents urban M&I water quality benefits provided by each alternative under average and dry/critical year types.

Table 7-14. Portfolio Values for NODOS Alternative Pumping and Generations ($1,000s, 2013 Dollars)

Pumping-Generation Site						
Planning Alternative	Alternative A		Alternative B		Alternative C	
Operations Strategy	Incidental	Optimized	Incidental	Optimized	Incidental	Optimized
NODOS Pumping	Annual Revenues					
T-C Canal Pumping	-366	-366	-452	-452	-349	-349
GCID Pumping	-608	-608	-694	-694	-600	-600
Delevan Pipeline Intake Facilities	-3,222	-3,222	N/A	N/A	-3,565	-3,565
TRR Pumping	-598	-598	-991	-991	-713	-713
Sites Pumping	-8,995	-8,275	-8,895	-8,016	-10,372	-9,506
Subtotal	-13,789	-13,069	-11,032	-10,153	-15,599	-14,733
	Preliminary Results					
NODOS Generation	Annual Revenues					
Sites Generation	6,569	7,311	6,700	7,558	8,083	9,009
TRR Generation	1,183	1,228	412	431	1,227	1,279
Sacramento River Generation	3,003	3,003	N/A	N/A	3,023	3,023
Subtotal	10,755	11,542	7,112	7,989	12,333	13,311
NODOS PumpBack Operations	Annual Revenues					
PumpBack During Diversion cycle	N/A	423	N/A	843	N/A	449
PumpBack During Release Cycle	N/A	1,385	N/A	1,102	N/A	1,298
Pure PumpBack Operations Cycle	N/A	1,050	N/A	899	N/A	1,048
Subtotal		2,858		2,844		2,795
NODOS Total Net Revenues	-3,034	1,331	-3,920	680	-3,266	1,373
NODOS Project Optimization Potential		4,365		4,600		4,639

GCID = Glenn-Colusa Irrigation District
NODOS = North-of-the-Delta-Offstream Storage
T-C = Tehama-Colusa
TRR = terminal regulating reservoir

Table 7-15. Estimated Annual M&I Water Quality Benefits ($1,000s, 2013 Dollars)[a]

Alternative	Annual Benefits[b]		Annualized Benefit[d]
	2025	2060[c]	
Average Conditions[e]			
Alternative A	$16,061	$20,150	$18,106
Alternative B	$17,363	$22,247	$19,806
Alternative C	$20,841	$27,116	$23,979
Dry/Critical Conditions[f]			
Alternative A	$18,999	$24,581	$21,814
Alternative B	$20,973	$26,711	$23,868
Alternative C	$24,401	$31,813	$28,137

[a] Based on the Lower Colorado River Basin Water Quality Model modeling results (South Coast region, excluding agricultural benefits), Bay Area Water Quality Economics Model modeling results (San Francisco Bay region), and extrapolated results for areas South of Delta (San Joaquin River, Central Coast, Tulare Lake, and South Lahontan regions). Excludes the Sacramento River region.
[b] Annual benefits reflect the difference between water quality damages under the project alternatives for future no project conditions based on year 2025 and 2060 level of development.
[c] Excludes benefits to south-of-the-Delta water users.
[d] Annualized benefits represent avoided costs for the future no project conditions over the planning horizon (2023 to 2123).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

M&I = municipal and industrial
SWRCB = State Water Resources Control Board

Annualized benefits range between $18.1 million and $24.0 million in average years and between $21.8 million and $28.1 million in dry/critical years. Alternative C offers the greatest water quality benefits. The M&I benefits are increased by both the larger reservoir size and the added pumping flexibility associated with the downstream intake at the Delevan Pipeline.

NODOS-related irrigation water quality changes potentially can affect crop production in both the short and long term. These effects are based largely on the overall salinity of the irrigation water and the resulting crop root zone salinity. Salinity is measured as TDS (parts per million milligrams per liter) or EC (deci-siemens per meter). Specific constituents, such as boron, can also limit crop yields and are particularly costly if present above tolerance threshold concentrations. 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

The first three benefits in this list are near-term effects of irrigation water TDS reductions. Near-term effects include lower TDS in root zone moisture, lower required leaching fractions, higher crop yield, and a wider range of crops that can be grown. Growers can take advantage of some or all of these benefits, depending on their irrigation and cropping decisions. For example, if irrigation water salinity improved, a grower could maintain the current cropping and reduce leaching. Alternatively, a grower could continue to leach at the same rate and potentially get better crop yield from the resulting lower soil salinity (assuming the initial water quality exceeds the crop salinity thresholds).

As listed in Table 7-16, 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 under average and dry/critical year types. Because the saved water would have been delivered to farms anyway, neither the project (CVP or SWP) nor the local district incurs any additional water delivery cost.

Table 7-16. Estimated Value of Irrigation Water Savings ($/AF, 2013 Dollars)

Alternative	Annual Values[a,b]		Annualized Values (2023-2122)[c]
	2025	2060	
Average Condition[d]			
Alternative A	$171	$215	$193
Alternative B	$172	$204	$188
Alternative C	$172	$272	$222
Dry/Critical Conditions[e]			
Alternative A	$212	$266	$239
Alternative B	$243	$298	$270
Alternative C	$217	$272	$245

[a] Annual values are based on SWAP modeling results.
[b] Annual values represent the marginal value of water used in agriculture. Not including transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060.
[d] Average over entire hydrologic sequence (1921 to 2023).
[d] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.
AF = acre-foot
SWAP = Statewide Agricultural Production Model
SWRCB = State Water Resources Control Board

Agricultural water quality benefits realized in the South Coast region are added to the benefit estimates for salinity analysis areas (i.e., water use savings) to estimate total benefits as presented in Table 7-17. Comparatively, the irrigation water quality benefits are substantially lower than the M&I water quality benefits. Annualized benefits are estimated to be as much as $1.7 million in average years and nearly $3.6 million during dry/critical years. Alternative C offers the highest agricultural water quality benefits, followed by Alternative B and then Alternative C.

Table 7-17. Estimated Annual Irrigation Water Quality Benefits ($1,000s, 2013 Dollars)[a]

Alternative	Annual Benefits[b]		Annualized Benefit[c]
	2025	2060	
Average Conditions[d]			
Alternative A	$1,197	$1,281	$1,239
Alternative B	$1,319	$1,398	$1,358
Alternative C	$1,551	$1,943	$1,747
Dry/Critical Conditions[e]			
Alternative A	$2,350	$3,047	$2,701
Alternative B	$3,236	$3,214	$3,228
Alternative C	$3,450	$3,681	$3,569

[a] Based on results of the agricultural salinity model (for irrigation water export areas served by CVP/SWP facilities) and LCRBWQM (for the South Coast region).
[b] Benefits attributed to salinity reductions only under 2025 and 2060 level of development.
[c] Annualized benefits represent avoided costs relative to the future no project conditions over the planning horizon (2023 to 2113).
[d] Average over entire hydrologic sequence (1921 to 2023).
[e] Average over dry and critical years periods over the hydrologic sequence as defined by SWRCB D-1641.

CVP = Central Valley Project
LCRBWQM = Lower Colorado River Basin Water Quality Model
SWP = State Water Project
SWRCB = State Water Resources Control Board

Recreation Benefits (Secondary Objectives)

Three of the potential recreation areas (Stone Corral, Antelope Island, and Lurline Headwaters) were considered in the evaluation of recreational benefits. The analysis of economic benefits attributed to the development of three recreation at Sites Reservoir considers several factors: the physical characteristics of the recreation facilities; recreation levels and use patterns at similar facilities; and the operational parameters for the reservoir that would affect the surface area available for recreation under the various project alternatives. The economic benefits are based on estimated visitation levels and representative consumer surplus values across anticipated recreation activities utilizing a benefits transfer approach. The analysis also accounts for substitution effects of recreation from other reservoirs.

No project-specific Contingent Valuation Method or Travel Cost Method analyses were available or conducted to estimate the recreation benefits of the project. Both of these Non-Market Valuation approaches are recommended by the P&Gs for valuing outdoor recreation activities.

In the absence of such project specific analyses, benefits transfer approach can be used to apply valuations for other similar locations to the project's future circumstances.

Economic values (as measured by consumer surplus) of the different recreation activities anticipated at Sites Reservoir were developed using a benefits-transfer approach. The values for outdoor recreation 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 2013, updated to 2013 dollars (Loomis, 2005).

The value of recreation at Sites Reservoir is also based, in part, on anticipated recreation patterns at the facility, which are based on typical patterns of recreation activity in the region. It is expected that future recreation at Sites Reservoir would be comparable to current recreation use at nearby Black Butte and East Park reservoirs. Consequently, Black Butte Reservoir activity patterns have been used to project the expected distribution of 200,000 visitor-use days at the Sites Reservoir (Reclamation, 2006).

Based on the previous recreation activity studies for other regions of the country, the weighted-average value per activity expected at Sites Reservoir is estimated to be $52.07 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 recreation use at a NODOS Project is estimated to be nearly $10.4 million. However, due to expected fluctuations to the reservoir's surface area resulting from dry year conditions, recreation activity at Sites might be expected to be slightly reduced and average between 179,000 and 186,850 annual visitor days.

To determine the "new" or net recreation benefits of a NODOS Project, the project's potential substitution effects on other recreation locations should be accounted for. It is estimated that current regional recreation use (demand) is at approximately 64 percent annually of its capacity. While Sites Reservoir could offer capacity benefits during peak periods (e.g., weekends and holidays), even accounting for future population growth and related increases in recreation demand, it is likely that most recreation demand could be accommodated by under used capacity at existing facilities. Therefore, the addition of Sites Reservoir may not contribute appreciably any additional recreation use within the region, other than reducing crowding at other regional reservoirs.

However, the market area for reservoir recreation in the vicinity of Sites Reservoir may not be as large as assumed in the demand analysis. If Sites Reservoir served a smaller geographic market (due, for example, to rising transportation costs), it can be argued that the region's existing facilities are not adequate to meet its recreation demand. For example, overcrowding is a concern at nearby Black Butte Reservoir, where visitation levels are approximately 127 percent of capacity. Such overcrowding can be a deterrent to recreation use in the region.

Development of new recreation opportunities at Sites Reservoir may enable local residents to participate in reservoir-based recreation who otherwise would not have done so. In addition, even for those people who have recreated elsewhere (particularly at overcrowded facilities), the quality of the recreational experience at Sites Reservoir may be relatively higher, thereby generating incremental recreation benefits. Based on these considerations, for this analysis as a conservative assumption it is assumed that most recreation use (75 percent) at Sites Reservoir represents substitution from other reservoirs and, as such, would not generate any new "net" recreation benefits. In which case, it is only the remaining 25 percent of visitation would represent new and/or enhanced recreation activity that generates NED benefits.

The resulting recreational benefit estimate for Sites Reservoir are considered to be conservative given the future visitation projections for the reservoir and a comparatively low share (25 percent) of this total visitation that would be expected to represent new and/or enhanced recreation activity that would generate NED benefits.

Table 7-18 shows recreation benefits analysis results for each alternative under average and dry/critical year types.

Table 7-18. Estimated Annual Recreation Benefits ($1,000s, 2013 Dollars)

Alternative	Annual Benefits[a]		Annualized Benefit[b]
	2025	2060	
Average Conditions[c]			
Alternative A	$2,349	$2,349	$2,349
Alternative B	$2,330	$2,330	$2,330
Alternative C	$2,432	$2,432	$2,432
Dry/Critical Conditions[d]			
Alternative A	$1,736	$1,736	$1,736
Alternative B	$1,649	$1,649	$1,649
Alternative C	$1,909	$1,909	$1,909

[a] Annual benefits reflect consumer surplus value for various recreation activities supported by Sites Reservoir and water operation scenarios under year 2025 and 2060 level of development.
[b] Annualized benefits represent avoided costs relative to the future no project conditions over the planning horizon (2023 to2123).
[c] Average over entire hydrologic sequence (1921 to 2023).
[d] Average over dry and critical years periods over the hydrologic sequence as defined by SWRCB D-1641.
SWRCB = State Water Resources Control Board

Under average conditions, annualized recreation benefits are estimated to be between $2.3 million and $2.4 million depending on the alternative's typical drawdown conditions. Recreation benefits are reduced in dry/critical years under all alternatives to between $1.6 million and $1.9 million. The greatest benefits are anticipated under Alternative C.

The extent of recreation benefits is not expected change over the planning horizon. It is assumed that recreation visitation would be determined primarily by water management scenarios (i.e., level of drawdown during the peak recreation season) rather than long-term population growth in the region.

The NODOS alternatives would also change the flows and temperature in the Sacramento River system and the Delta. These effects could alter the suitability of these waterways for river-based recreation, such as boating (including kayaking and canoeing). However, the benefits to fisheries, including salmonids, may result in higher catch rates and size of fish. Due to the inherent difficulty translating flow and fishery effects into related recreation benefits changes, these benefits are acknowledged here, but not quantified.

The NODOS alternatives would also contribute to higher WSEs at Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake during dry years. These higher WSEs potentially would increase the frequency of use for recreation at these reservoirs.

Flood Control Benefits

The area along Funks Creek downstream of Funks Reservoir is subject to flooding. Under current no project conditions, Funks Reservoir is not a flood control reservoir. As such, it can be overwhelmed with runoff and still send peak flows downstream on Funks Creek. The NODOS alternatives would reduce or eliminate the risk of flood 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 calculating the no project average annual cost of flooding and making an assumption on how that cost would change with NODOS alternatives.

For the land parcels located within the 100-year flood plain related to Funks and Stone Corral creeks, rice production is the primary crop in the area followed by dryland pasture. Irrigated production within the area is predominantly tomatoes (for processing), wheat or alfalfa.

Agricultural flood damages per acre were estimated for typical land use in the Central Valley based on initial losses estimated from the USACE Comprehensive Study (DWR, 2008). Crop budget data was 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 clean-up and rehabilitation costs were added as a fixed cost to each estimate.

Under the NODOS alternatives, up to 7,130 acres of farmland would experience a reduction in flood-related damages.[5] Apart from irrigated production within the floodplain, most of the land uses would not be substantially affected by the short-term flooding that the area periodically experiences.

Based on the area's general agricultural production and additional GIS analysis of the likely affected areas, it is projected that approximately 4,510 acres of rice and 1,525 acres of dryland pasture would benefit from reduced flooding as a result of the project. Based on the USACE total damage estimates of $506 per acre of rice and $276 for pasture[6], reduced farmland flood damages would be approximately $2.71 million. Conservatively assuming a 50:50 split between tomato and alfalfa production on the 1,040 acres of irrigated production that would potentially benefit from reduced flooding, the average avoided damage would be approximately $934 per acre. In which case, the total damages to irrigated production would be $971,800. The GIS analysis also suggested that approximately 50 acres of orchard production might be located within the reduced floodplain area. Because almonds are the Colusa's primary orchard crop (Colusa County, 2011), an avoided 5-day or less flood event would result in $99,900 in flood damage savings.

Consequently, the total estimated agricultural flood reduction benefit would be $3,777,600 for a 100-year flood event. In which case, the average annual reduction in farmland flood damages due to NODOS is estimated at $37,800.

---

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

[6] It is conservatively assumed that the avoided flood event would 5 days or less.

In addition, NODOS would also potentially reduce the likelihood of flood damage to some of the homes on the north end of Maxwell. Approximately a quarter of the town of Maxwell is located within the 100-year flood area of Funks Creek. The most recent census information reports 408 homes are located within Maxwell and the median home value is $227,200 (in 2013 dollars). No businesses are located within the 100-year flood plain area.

USACE structural and content damage estimates for Yuba County determined approximately a 15 percent lower rate of structural damage and 10 percent lower content damage compared to the national Flood Insurance Agency (FIA) estimates (USACE, 1999). Consequently, under 6-foot flood water conditions, homes in Yuba County would be expected to experience an average damage of 40 percent to structure value compared with a national FIA rate of 55 percent. Contents damage under the same flood conditions would be expect to be approximately 33 percent compared to a corresponding 43 percent national FIA rates.

Using the more conservative Yuba County damage to contents ratio and assuming a 6-foot flood event, the value of total avoided residential home damage (structure and contents) to Maxwell would be approximately $17,600, for a 100-year flood event that resulted in 6-foot depths above first floor. In which case, the average annual reduction in residential flood damages due to NODOS is estimated at $176,000.

As a result, the total potential flood control benefit of NODOS may be estimated to be up to approximately $200,000 per year. However, given the uncertainty of the flood event assumptions and the absence of a detailed and location specific evaluation of the area's flood reduction potential, this is considered a very preliminary estimate that could overstate NODOS accomplishments in local flood damage reduction.

Overall Benefits

The P&Gs (WRC, 1983) identify four "accounts" to display the potential effects for the evaluation of alternatives (NED, regional economic development [RED], environmental quality [EQ], and other social effects [OSE]). The NED account is summarized for the benefit categories:

- Water Supply Reliability
- Water Quality
- Fisheries Restoration and Ecosystem Enhancement
- Flood Damage Reduction
- Recreation
- Hydropower

Table 7-19 presents the total benefits for each alternative.

Table 7-19. Summary of Estimated Federal Annual Benefits for NODOS Projects ($M, 2013 Dollars)[a]

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	$12.7	$7.1	$11.5
Urban	$157.6	$161.1	$167.4
Incremental Level 4 for Refuges	$12.5	$20.5	$21.1
Conveyance Costs	($22.4)	($22.9)	($24.8)
Total	**$160.4**	**$165.8**	**$175.2**
Beneficiary	**Alternative A**	**Alternative B**	**Alternative C**
Water Quality			
Agricultural	$1.2	$1.4	$1.7
Urban	$18.1	$19.8	$24.0
Total	$19.3	$21.2	$25.7
Ecosystem Enhancement	$46.7	$50.1	$49.3
Hydropower (system)[b]	$20.6	$15.1	$23.2
Recreation	$2.3	$2.3	$2.4
Flood Damage Reduction	$0.0	$0.0	$0.0
Total	**$249.3**	**$254.8**	**$275.8**

[a] Discounted at the federal discount rate of 4.0% over 100 years.
[b] Ancillary and Capacity Benefits are approximated for Alternatives A and B.

NED = national economic development
NODOS = North-of-the-Delta Offstream Storage
$M = dollar amount in millions

Table 7-19 shows that the total annual benefits for the NODOS alternatives range from approximately $249 million for Alternative A to $276 million for Alternative C. These benefits do not include the potential additional Ancillary Service and System-wide Capacity from the future Hydropower Pumpback operations. As discussed previously, preliminary hydropower operations analysis estimates that there would potentially be approximately $21.4 million additional hydropower facility benefits of Alternative C resulting in an estimated total annual project benefits of $275.4 million. Similarly, Alternative A may be estimated to also generate approximately $19.3 million additional Ancillary Service and System-wide Capacity hydropower benefits. In which case, Alternative A estimated total annual project benefits would be $249.3 million. Alternative B would similarly be estimated to generate approximately $14.4 million in additional hydropower benefits resulting in estimated total annual project benefits of $254.5 million.

The total benefits for each alternative were also summarized for the state of California discount rate of 6 percent over 50 years, as shown in Table 7-20.

Table 7-20. Summary of Estimated Annual State Annual Benefits for NODOS Projects Using State of California Criteria ($M, 2013 Dollars)[a]

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	$12.2	$6.9	$11.1
Urban	$133.7	$136.7	$143.0
Level 4 for Refuges	$11.9	$19.5	$20.1
Conveyance (CVP/SWP)	($22.4)	($22.9)	($24.8)
Total	**$135.1**	**$140.2**	**$149.4**

Table 7-20. Summary of Estimated Annual State Annual Benefits for NODOS Projects Using State of California Criteria ($M, 2013 Dollars)[a]

Table 7-20. (Continued)

Beneficiary	Alternative A	Alternative B	Alternative C
Water Quality			
Agricultural	$1.2	$1.3	$1.7
Urban	$17.4	$19.0	$22.9
Total	**$18.6**	**$20.3**	**$24.6**
Ecosystem Enhancement	**$44.0**	**$47.2**	**$46.5**
Hydropower (system)[b]	**$18.6**	**$13.6**	$20.5
Recreation	$2.3	$2.3	$2.4
Flood Damage Reduction	$0.0	$0.0	$0.0
Total[c]	**$218.6**	**$223.6**	**$243.4**

[a] Discounted at the state discount rate of 6% over 50 years.
[b] Ancillary Service and System-wide Capacity benefits are approximated for Alternatives A and B.
[c] May not total exactly due to rounding.

CVP = Central Valley Project
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project
$M = dollar amount in millions

Using the state discount rate of 6 percent over 50 years, the annual benefits of the NODOS alternatives range from $218 million for Alternative A to over $243 million for Alternative C.

Risk and Uncertainty

During the NODOS feasibility studies, reasonable assumptions were made to support the evaluation of alternatives based on engineering and scientific judgment. Analyses were developed with advanced modeling and estimating tools using historical data and trends. Although this analysis supported the evaluation of project outcomes, many uncertainties could affect the findings of the NODOS feasibility studies. These uncertainties are discussed below.

Climate Change and Sea Level Rise

The potential for climate change results in uncertainty associated with the hydrologic analysis used to evaluate the performance of the NODOS alternatives. The potential for, and magnitude of, climate change is widely debated. DWR has initiated ongoing studies of how global climate changes could affect the way California receives and stores its water. According to the California Climate Adaptation Strategy (DWR, 2009a), California could experience increases in temperature and a drier climate as the result of climate change. The results to date indicate that climate change could affect the hydrology, water temperature, and future operations for both flood management and water supply deliveries.

NODOS investigators requested a sensitivity analysis of the effects and benefits of NODOS alternatives under scenarios associated with climate change. The resulting NODOS climate change and sea level rise sensitivity analysis has been prepared as a tool for planners, resources specialists, stakeholders, and the public to consider the influence of climate change and sea level rise on the NODOS Project and verify that the findings in this investigation are adequate.

For the climate change and sea level rise sensitivity analysis, the No Project Alternative and NODOS Alternatives A, B and C were simulated for four additional climate and sea level scenarios. The climate and sea level scenarios used in this sensitivity analysis were previously developed for the *Bay Delta Conservation Plan (BDCP) Effects Analysis and ADEIR/S* (DWR, 2012). The following four climate and sea level scenarios, in addition to the current climate and sea level scenario (Current), were selected for sensitivity analyses:

- The Early Long-Term (ELT) scenario assuming the median (Q5) of an ensemble of global climate model (GCM) projections at a point in time 15 years into the future (approximately 2025) and a sea level rise of 15 centimeters (cm) (6 inches)
- The Late Long-Term (LLT) scenario assuming the median (Q5) of an ensemble of GCM projections at a point in time 50 years into the future (approximately 2060) and a sea level rise of 45 cm (18 inches)
- The Late Long-Term (LLT Q2) scenario assuming the "drier, more warming" lower bound (Q2) of an ensemble of GCM projections at a point in time 50 years into the future (approximately 2060) and a sea level rise of 45 cm (18 inches)
- The Late Long-Term (LLT Q4) scenario assuming the "wetter, less warming: upper bound (Q4) of an ensemble of GCM projections at a point in time 50 years in the future (approximately 2060) and a sea level rise of 45 cm (18 inches)

Based on the comparison of the NODOS alternatives with the No Project Alternative evaluated across Current, ELT and all LLT climate and sea level scenarios, the following expectations have been confirmed based on the results of CALSIM II simulations of these scenarios:

- The ability to divert water into NODOS storage is the same or slightly increased due to changes in the timing of snowmelt runoff and the continued opportunity to use the intakes under a wide range of climate scenarios.
- The NODOS alternatives can provide a similar array of potential benefits under a wide range of climate and sea level scenarios.
- The NODOS alternatives could be operated to potentially mitigate some of the effects of climate change and sea level rise.

The potential effects of climate change on the primary objectives are summarized as follows:

- **Water Supply**: Between Current, ELT, and LLT climate and sea level scenarios, for all NODOS alternatives, long-term average annual total exports at Banks Pumping Plant and Jones Pumping Plant increase from the No Project Alternative consistently. Across all climate and sea level scenarios below median and dry year (lower quartile) averages show strong exports throughout, due to the NODOS alternatives, with the absolute and relative magnitude of improvement increasing as the effect of climate change and sea level rise increases. The sensitivity analysis results indicate that the increment of water provided by the NODOS alternatives could increase even as overall system supply decreases. The relative economic value of all three NODOS alternatives is likely to increase relative to the No Project Alternative condition, given that the performance of water supply reliability for agricultural, urban, and environmental uses under the No Project Alternative is decreasing as a result of climate change and sea level rise.

- **Improving the Survivability of Anadromous Fish**: For the primary objective of increasing survival of anadromous fish populations, the highest priority is to maintain improved storage conditions through the dry years (lower quartile) and summer months (July through September season). The most substantial relative improvement in storage is at Shasta Lake. The improvement in storage conditions during the dry years (lower quartile) and summer months (July through September season) for cooler water (coldwater pool improvement) and more water, is translated into temperature and flow-dependent habitat.

- **Water Quality**: Between Current, ELT, and LLT climate and sea level scenarios, for all NODOS alternatives, X2 position and Old River at Rock Slough salinity conditions are improved during the April through December seasons. As sea level progresses from ELT to LLT, the magnitude of improvement in water quality (due to supplemental Delta outflow) deceases. An improvement is indicated by a reduction in X2 position or a reduction in EC.

- **Hydropower Generation**: Hydropower generation was not evaluated in the CALSIM II simulation of climate change, but the model did verify the ability to fill the reservoir under the climate change scenarios. Operations to generate hydropower would, therefore, be sustained under changed climatic conditions. Ongoing analysis of the integration of hydropower with opportunities to generate renewable energy would provide greater insight into how hydropower generation might vary under the climate change scenarios.

Water Supply Reliability and Demands

Economic and Population Growth: The extent of the benefits realized from project implementation would be affected by both economic and population growth or decline. Economic and population growth may vary from the projections used to support the evaluation, and may result in changes in the economic benefits. Changes in future energy costs may result in significant differences in the economic benefits associated with water supply and hydropower generation.

California's population is expected to increase by 39 percent by 2060 (California Department of Finance, 2013). The projected population gain – nearly 15.4 million people between 2010 and 2060 – would exceed the current populations of either Illinois or Pennsylvania. This population growth could force some of the existing supplies devoted to agriculture to be redirected to urban uses. Six counties that are expected to attain a population of at least 1 million will be inland counties. Four counties expected to reach a population of 1 million are Fresno, Kern, San Joaquin, and Ventura. Much of the growth in the Central Valley would occur on land currently used for agricultural purposes.

Energy Costs Associated with Transporting Water to the South Coast: To generate the energy price forecast for the study, three sources were used:

- Forward energy "broker" quotations provided by Tullet Liberty[7]
- Natural gas futures and natural gas futures basis as reported by the New York Mercantile Exchange
- Forecasted spot electricity and natural gas prices as provided by Ventyx semiannual structural forecast (formerly Global Energy Decisions)[8]

Nevertheless, there is extraordinary volatility in wholesale energy markets, especially price risk and uncertainty in the underlying fuel markets. Changes in future energy costs may result in significant differences in the economic benefits associated with water supply and hydropower generation.

Anadromous Fish Populations

Long-term conclusions relative to anadromous fish survival supported the evaluation of the accomplishments of NODOS. Anadromous fish are highly affected by changes in their surroundings, especially elevated temperatures and low flows. Trying to predict fish survival is difficult because of the many factors that influence it. To reduce the uncertainty associated with the evaluation of anadromous fish populations, the NODOS feasibility studies considered three independent lines of analysis:

- A qualitative evaluation of the effects of the increases in coldwater pool and flow stabilization on fish populations
- Use of the SALMOD model to evaluate smolt growth, movement, and survival between Keswick Dam and Red Bluff
- Use of the IOS lifecycle model to evaluate the long-term response of Sacramento River winter-run Chinook salmon populations

In general, findings from each of the methods indicated overall beneficial trends from the implementation of NODOS, although the magnitude of the affects varied between methods.

Independent of the model, uncertainty is also related to seasonal and long-term water conditions throughout the Sacramento River, in the Delta, and in the Pacific Ocean. Potential climate change also has the potential to influence fish survival.

Pelagic (Open Water) Organism Population Decline in the Delta: This report has incorporated restoration actions and operational strategies designed to protect pelagic organisms. A major concern in the Delta is the health of pelagic (open water) organisms, including delta smelt, threadfin shad, longfin smelt, and striped bass. In fall 2004, Delta fish surveys registered sharp declines in these four pelagic species.

---

7 Tullet Liberty, among other things, is an energy brokerage company that matches buyers and sellers.
8 Ventyx is forecasting the actual day-ahead cash price that would occur in the spot markets in the future, not the price at which futures or forward contracts should be priced.

Subsequent surveys have confirmed the trend, raising concerns that delta smelt risk extinction, and longfin smelt risk extirpation.

Water System Operations Analysis

Continuing uncertainty in the regulatory environment makes the long-term planning of CVP and SWP operations challenging. In 2008, Reclamation and DWR published the *CVP and SWP Long-Term Operational Criteria and Plan* (OCAP) *and Biological Assessment* of impacts on species listed under ESA 16 U.S. Code §1531, 1973. In response to the BA, USFWS issued a BiOp on the OCAP in December 2008, addressing the impacts of the CVP/SWP operations on delta smelt. In June 2009, NMFS issued a BiOp on the OCAP addressing the impacts of the CVP/SWP operations on salmonids (NMFS, 2009). Both the USFWS and NMFS BiOps included an RPA that the agencies believed would enable the CVP/SWP operations to continue in compliance with the ESA. The USFWS and NMFS RPAs included non-operational and operational actions whose potential impact on CVP/SWP operations would vary significantly from year to year depending on biological, hydrologic, and meteorological variables that are difficult to predict. More recently, in response to lawsuits filed against the BiOp RPAs, District Judge Oliver W. Wanger has heard testimony and has issued rulings regarding the BiOps.

The Existing Condition and No Project Alternative CALSIM II models used by the NODOS modeling team to establish the modeling of the Alternatives assumes the full implementation of the operational actions of the USFWS and NMFS BiOps. However, under full implementation of the BiOps, not all conditions of the BiOps can be met, due to conflicting hydrologic, operational and regulatory requirements that are not yet reconciled. The result is the occurrence in the simulations of what is referred to in this document as “extreme operational conditions.” Extreme operational conditions are defined as simulated occurrences of storage conditions at CVP and SWP reservoirs in which storage is at “dead pool” levels. Reservoir storage at or below the elevation of the lowest outlet is considered to be at dead pool level. Under extreme operational conditions, flows may fall short of minimum flow criteria, salinities may exceed standards, diversions may fall short of allocated volumes and operating agreements may not be met. Under extreme operational conditions, the CALSIM II model utilized a series of exceptions (a set of rules under high penalty conditions) to reach a numerically feasible solution to allow for the continuation of the simulation. The outcome of these types of solutions in CALSIM II may vary greatly depending upon the antecedent conditions from the previous time-step result. The model may reach a numerical solution, but the results of the simulation may not reflect a reasonably expected outcome (i.e., an outcome which would require negotiation).

Analysis of 2008 USFWS BO and 2009 NMFS BO RPAs: The future regulatory requirements to meet environmental needs are uncertain. This uncertainty is especially true of the requirements for delta smelt and Chinook salmon. Analyses and model runs performed for evaluating the NODOS alternatives simulated regulatory conditions from the BiOps from USFWS and NMFS, released in 2008 and 2009, respectively. Legal challenges to these BiOps make it difficult to describe future operations with any degree of certainty. The constraints governing water operations are likely to change with release of revised USFWS and NMFS BiOps. USFWS is scheduled to issue a new BiOps in 2013 and the NMFS would issue a new BiOp in 2016.

The results of the models and evaluations would change if the operations are changed in response to new regulations. Future changes to regulatory criteria, including the BiOps for endangered species in the Delta and flow requirements established by the SWRCB, may necessitate additional modeling to reflect changes in regulatory conditions prior to construction of a NODOS Project.

BDCP and Potential New Conveyance: The BDCP is being collaboratively prepared by federal, state, and local agencies, environmental organizations, and other interested parties. It is intended as a conservation strategy for the Delta and designed to advance the coequal planning goals of restoring ecological functions in the Delta and improving water supply reliability.

A range of alternatives for providing species/habitat protection and water supply reliability are being evaluated. This effort includes evaluating new conveyance facilities with capacities of up to 12,000 cfs. The following discussion describes how the implementation of new conveyance might affect the performance of a NODOS Project.

- **Water Supply and Water Supply Reliability:** Construction of new conveyance would reduce the uncertainty associated with Delta diversions and being able to export water from the Delta. Delta levees are vulnerable to flood and seismic events that could disrupt future water supplies. New conveyance would improve the likelihood of uninterrupted service. Furthermore, diversions with new conveyance are expected to be more sustainable from a regulatory standpoint because the conveyance would reduce existing conditions that do not support the recovery of aquatic species in the Delta.

- **Anadromous Fish Survival:** All BDCP alternatives are expected to improve habitat conditions throughout the Delta. These alternatives should improve survival throughout the entire lifecycle of anadromous fish. Efforts to improve conditions in the Sacramento River for anadromous fish are expected to be reinforced if BDCP is implemented.

- **Water Quality:** Implementation of BDCP would improve the water quality of exports to an extent where the marginal benefits from NODOS to water quality for exporters would be significantly reduced. NODOS would continue to provide releases that would support improvements of Delta water quality and shift the position of X2 westward.

Other New Storage Projects: Water operations modeling was based on existing system facilities and operational constraints. There are other potential storage projects outside of the NODOS study area that would be integrated into the CVP and SWP if implemented. These projects were not accounted for in the model and would change the findings if implemented. Implementation of other new storage, while not expected to eliminate the benefits resulting from a NODOS Project, would alter the operational priorities used for the evaluation in this study.

Unresolved Issues

Engineering and Cost Estimates

Cost estimates are currently being prepared to support the feasibility studies. Additional engineering is being performed to develop a feasibility-level engineering design that will serve as a basis for the cost estimates that will be presented in the forthcoming Feasibility Report. These estimates will be used to evaluate the net benefits, develop a cost allocation, and evaluate the financial feasibility of the alternatives.

Coordinated Operations Agreement

The COA is a negotiated settlement agreement between Reclamation and DWR originally signed in 1986, allocating water between the CVP and SWP. It seeks to protect in-basin uses and Delta conditions in an equitable fashion, while determining each respective project's allowable deliveries and exports.

Article 14 through Article 16 of the COA allows for modifying the agreement due to changed circumstances, including the construction of additional facilities. Implementation of the NODOS Project could provide a basis for modifying the COA. Any proposed changes in the COA to incorporate a NODOS Project either would require congressional re-authorization or need to be incorporated into the authorizing legislation for NODOS.

This investigation evaluated the NODOS alternatives using current COA rules, resulting in accomplishments of additional diversions, deliveries, and storage levels north and south of the Delta. The relative benefit amounts are partially driven by the sub-allocation of supply between the CVP and SWP. Changing the rules of COA from the addition of a NODOS Project may alter the relative sharing between the two projects, but the overall system-wide effect of the new facility should be relatively the same.

Eventually, both a new COA and cost-sharing agreement for NODOS would need to be negotiated should authorization be obtained. However, it would be speculative at this time to assume a different sharing formula than currently exists.

Off-Site Mitigation for Impacts on Biological Resources

Details regarding the off-site opportunities to mitigation impacts on biological resources in the Primary Study Area are still being developed. Potential mitigation lands containing special status species habitat comparable to habitat that would be affected by the construction of Sites Reservoir are being identified. Future documents would discuss how conservation and enhancement efforts on these lands may be applied for mitigation of loss of habitat.

Water Rights

Improving water supply and the reliability of water supplies is a primary objective for NODOS. Water rights, appropriated by SWRCB, must be in place before the project can operate. Evaluation of water rights would remain a focus of the NODOS feasibility studies.

CHAPTER 8 NEXT STEPS

The NODOS feasibility studies are ongoing. Additional work is needed to complete the evaluation of technical, environmental, and economic feasibility. Specific ongoing studies include:

- Additional engineering design, including updated set of drawings to support the cost estimate.
- A feasibility-level cost estimate.
- The mitigation requirements to be incorporated into the cost estimate.
- Evaluation of the NED, RED, EQ, and OSE account.
- Determining the effectiveness, efficiency, completeness, and acceptability of the alternative plans.
- Sensitivity analysis to evaluate the response of the alternative to the potential implementation of new conveyance in the Delta.
- The financial feasibility of the project.

There will be an opportunity for public comment on a draft report of the findings of the feasibility studies prior to finalizing the recommendations. Input on the draft report could result in new alternatives for consideration or in modifications to the alternatives presented. To further refine the analysis, additional simulations of the reservoir performance may also be performed following the draft release.

This page intentionally left blank

CHAPTER 9 GLOSSARY

The definitions in this glossary include the areas under primary planning objectives for the NODOS feasibility studies and the regulatory terms used in the process.

Term	Definition
acre-foot	The volume of water that would cover 1 acre to a depth of 1 foot, or 325,851 gallons of water. A flow of 1 cubic foot per second (cfs) for 1 day is approximately 2 acre-feet.
active capacity	The reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements. It is also the total capacity less the sum of the inactive and dead capacities.
active conservation capacity (active storage)	The reservoir capacity available for seasonal or cyclic water storage, that is assigned to regulate reservoir inflow for irrigation, power, municipal and industrial use, fish and wildlife, navigation, recreation, water quality, and other purposes. It does not include exclusive flood control capacity. It extends from the top of the active conservation capacity to the top of the inactive capacity (or dead capacity where there is no inactive capacity).
anadromous fish	Fish that spend a part of their lifecycle in the sea and return to freshwater streams to spawn.
alluvial/alluvium	A general term for clay, silt, sand, gravel, or similar unconsolidated soil strata deposited by flowing water in the bed of the stream or on its floodplain or Delta.
Anadromous Fish Restoration Program	Required to be developed under Section 3406(b)(1) of the Central Valley Project Improvement Act (CVPIA) that identifies instream and Delta flows and other actions needed for the recovery of anadromous fish species.
aquifer	An underground layer of permeable rock, or soil that stores water and yields significant quantities of water to wells or springs.
average annual runoff	Average value of total annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.
average year water demand	Demand for water under average hydrologic conditions for a defined level of development.
Bay-Delta Conservation Plan (BDCP)	The BDCP is being prepared by a group of local water agencies, environmental and conservation organizations, state and federal agencies, and other interest groups. The BDCP is being developed in compliance with the federal Endangered Species Act (ESA) and the California Natural Communities Conservation Planning Act. When complete, the BDCP will provide the basis for the issuance of endangered species permits for the operation of the state and federal water projects. The plan would be implemented over the next 50 years. The heart of the BDCP is a long-term conservation strategy that sets forth actions needed for a healthy Delta. The Draft BDCP was released in November 2010.
bedload	Sediment in a stream that is moved on or immediately above the stream bed usually consisting of boulders, pebbles, and gravel.

Term	Definition
biota	All living organisms of a region.
beneficial use	Actual or reasonable potential use that may be made of waters of the State, including but not limited to domestic, municipal, agricultural, and industrial.
benefit-cost ratio	The ratio of the present value of project benefits to the present value of the project costs, used in economic analysis.
berm	A sloped wall or embankment (typically constructed of earth, hay bales, or timber framing) used to prevent inflow or outflow of material.
Biological Opinion (BiOp)	Under Section 7 of the Federal ESA, a document which states the opinion of the appropriate federal regulatory agency, National Marine Fisheries Service (NMFS) or U.S. Fish and Wildlife Service (USFWS), as to whether a federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat. Often, a biological assessment is prepared by the consulting or action agency as source material for the regulatory agency.
brackish water	Water with a salinity that exceeds normally acceptable standards for municipal, domestic, and irrigation uses, but less than that of seawater.
CALFED Bay-Delta Program (CALFED)	A collaboration among 25 state and federal agencies that came together with a mission to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the San Francisco Bay/Sacramento–San Joaquin Delta (Delta) system.
CALFED Final Programmatic Environmental Impact Report (EIR)/Environmental Impact Statement (EIS)	The National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) compliance document that provides the environmental consequences of alternative actions relating to the CALFED Program.
CALFED Programmatic Record of Decision (ROD)	The ROD issued by the federal lead agencies for adopting the CALFED project as described in the CALFED Programmatic Final EIR/EIS and associated actions.
California Aqueduct	The primary conveyance facility of the State Water Project (SWP), which conveys water from the Delta, through the San Joaquin Valley along the eastern slope of the Coastal Range to Southern California.
California Endangered Species Act (CESA)	CESA is implemented by the California Department of Fish and Wildlife (CDFW). CESA prohibits the “take” of listed threatened or endangered species.
California Species of Special Concern	Species designated by the DFG as having declining population levels, limited ranges, and/or continuing threats making them vulnerable to extinction. The purpose of this designation is to halt or reverse their decline by calling attention to their plight and addressing issues of concern early enough to secure their long term viability.

Term	Definition
California Water Plan (CWP) Update	The CWP provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. The CWP is updated every 5 years, and identifies and evaluates existing and proposed statewide demand management and water supply augmentation programs and projects to address the state's water needs.
CALSIM (California Statewide Integrated Model)	A planning model designed to simulate the system-wide monthly operations of the Central Valley Project (CVP) and SWP under current and future conditions that was jointly developed by California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation). CALSIM predicts how reservoir storage and river flows would be affected based on incorporated changes in future system operations. CALSIM output is typically used to help assess impacts on water supply, water quality, aquatic resources, and recreation.
CALSIM II	The version of CALSIM used for this study.
carryover water	Table A water that is allocated to a contractor in a given year, but is unused by it that year, which is stored for that contractor in SWP supply reservoirs (when storage space is available) for use by that contractor in a following year. The water is temporarily stored or carried over primarily in San Luis Reservoir (SWP).
Central Valley Project (CVP)	Federally operated water management and conveyance system that provides water to agricultural, urban, and industrial users in California. The CVP was originally authorized by legislation in 1937.
Central Valley Project Improvement Act (CVPIA)	Title 34 of federal legislation Public Law 102-575, signed into law on October 30, 1992, that mandates major changes in the management of the federal CVP. The CVPIA recognizes that fish and wildlife are equal in importance to agricultural, municipal, industrial, and hydropower uses.
CVP Operations Criteria and Plan (OCAP)	The OCAP describes the regulatory and physical constraints and conditions under which the CVP and SWP currently operate.
contaminants	Any undesirable physical, chemical, biological, or radiological substance present in water as a result of human activities.
cooperating agency	Under NEPA, any agency, other than the lead federal agency, that has jurisdiction by law or special expertise related to an action requiring an EIS and has agreed to provide assistance in the preparation of an EIS. The USFWS, U.S. Army Corps of Engineers (USACE), U.S. Forest Service, and NMFS are cooperating agencies for the North-of-the-Delta Offstream Storage (NODOS) project.
critical habitat	An area designated as critical habitat listed in 50 Code of Federal Regulations (CFR) Parts 17 or 226 (50 CFR 402.02). Critical habitat areas are specific geographic areas, whether occupied by special-status species or not, that are determined to be essential for the conservation and management of special-status species, and that have been formally described in the *Federal Register*.

Term	Definition
cubic feet per second (cfs)	A unit of discharge for measurement of a flowing liquid equal to a flow of 1 cubic foot per second (448.8 gallons per minute, 7.48 gallons per second, or 1.98 acre-feet per day). A rate of streamflow; the volume, in cubic feet, of water passing a reference point in 1 second.
Decision 1641 (D-1641)	State Water Resources Control Board water rights decision (March 2000) that implemented the 1995 Bay-Delta Water Quality Control Plan, establishing terms and conditions regulating points of diversion for the CVP and SWP. D-1641 superseded earlier issued D-1485.
Delta	See *San Francisco Bay/Sacramento–San Joaquin Delta.*
Delta Cross Channel (DCC)	An existing gated structure and channel connecting the Sacramento River at Walnut Grove to the North Fork of the Mokelumne River. The facility was constructed as feature of the CVP to control movement of Sacramento River water into the central Delta and to the south-Delta export pumps.
Delta export	Water pumped from the Delta used for purposes outside the Delta.
Delta Mendota Canal (DMC)	The major conveyance facility of the CVP, which carries water from the Delta to the town of Mendota in the central San Joaquin Valley.
Delta Outflow	Downstream flow from the Delta that protects the beneficial uses within the Delta from the intrusion of saline water.
Delta Risk Management Strategy (DRMS)	DRMS program was undertaken to evaluate the risk and consequences to the state (e.g., water export disruption and economic impact) and the Delta (e.g., levees, infrastructure, and ecosystem) associated with the failure of Delta levees and other assets considering their exposure to all hazards.
Delta Stewardship Council (DSC)	The DSC was created in legislation to achieve the state mandated coequal goals for the Delta. "Coequal goals" means the two goals of providing more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The primary responsibility of the DSC is to develop, adopt, and implement the Delta Plan. The DSC, through its adoption and implementation of the Delta Plan, is tasked with providing a more reliable water supply for California. (California Water Code [CWC] Section 85054).
Delta Vision	Delta Vision process concluded at the end of 2008, a little more than 2 years after it began, with a suite of strategic recommendations for long-term, sustainable management of the Delta. Delta Vision Committee submitted its final implementation plan to Governor Arnold Schwarzenegger on recommended actions to how the Sacramento-San Joaquin Delta should be managed to fulfill its co-equal goals of water supply reliability and ecosystem restoration. The implementation plan sets priorities based on the Delta Vision Strategic Plan developed by the Governor's Delta Vision Blue Ribbon Task Force.
dissolved oxygen (DO)	The amount of oxygen dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation.
diversion	The act of taking water out of a river system or changing the flow of water in a system for use in another location.

Term	Definition
drainage area	The area of land from which water drains into a river, usually bounded peripherally by a natural divide of some kind such as a hill—for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called river basin or watershed.
drought condition	Drought (a period of abnormally low rainfall) is a gradual phenomenon. Defining when drought begins is a function of water shortage impacts to water users. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users in a different part of the state or with a different water supply. Individual water suppliers may use criteria such as rainfall/runoff, amount of water in storage, decline in groundwater levels, or expected supply from a water wholesaler to define their water supply conditions.
DSM2	Delta Simulation Model II (DSM2) is a publicly available one-dimensional hydrodynamic, water quality, and particle-tracking model. DSM2 can calculate stages, flows, velocities; many mass transport processes, including salts, multiple non-conservative constituents, temperature, trihalomethane formation potential and individual particles throughout the Delta; uses output from CALSIM II.
ecosystem	An interactive system that includes the organisms of a natural community association together with their abiotic physical, chemical, and geochemical environment.
electrical conductivity (EC)	A measurement of how easily electricity flows through water. This correlates with the total dissolved solids (TDS) in water. The higher the TDS, the more easily electricity flows through the water, the higher the electrical conductivity. Also see *salinity.*
emergency spillway	A spillway which provides for additional safety should emergencies not contemplated by normal design assumptions be encountered (i.e., inoperable outlet works, spillway gates, or spillway structure problems). The crest is usually set at maximum water surface. A spillway that is designed to provide additional protection against overtopping of a dam and is intended for use under extreme conditions such as misoperation or malfunction of the service spillway or other emergency conditions.
emergent vegetation	Flooded or ponded areas that support rooted, herbaceous vegetation with parts of the shoot both below and above water.
endangered species	Those species listed as endangered under ESA and CESA; any species which is at high risk of extinction in the near future throughout all or a significant portion of its range.
Endangered Species Act (ESA)	The federal Endangered Species Act of 1973 is administered by the U.S. Department of Interior's USFWS and by the Commerce Departments' National Oceanic and Atmospheric Administration-Fisheries (NOAA Fisheries, or NMFS). ESA Section 9 and its implementing regulations prohibit "take" of listed threatened or endangered species.
endemic species	A species restricted to and known to occur naturally only within a specific geographic area.

Term	Definition
enhancement	Actions that are expected to improve conditions beyond current levels.
entrainment	The incidental trapping of fish and other aquatic organisms in water diverted from streams, rivers, and reservoirs; the process of drawing fish into diversions along with water, resulting in the loss of such fish.
environmental water	The water for wetlands, for the instream flow in a major river or in the Bay-Delta designated for environmental purposes, or for a designated wild and scenic river.
ephemeral	A stream, pool, or lake that occurs for only the “wet” portion of the year. These bodies of water are usually dry during the summer months.
erosion	The gradual wearing away of land by water, wind, general weather conditions, and reservoir fluctuations; the diminishing of property by the elements. With regard to levees specifically: loss of levee material as a result of the effects of channel flows, tidal action, boat wakes, and wind-generated waves.
estuary	Regions of interaction between rivers and nearshore ocean waters, where river flow and tidal action mix fresh and saltwater.
eutrophication	The degradation of water quality as a result of enrichment by nutrients, primarily nitrogen and phosphorus, which in turn results in excessive plant (principally algae) growth and decay.
Evolutionarily Significant Unit (ESU)	A population or group of populations that is considered distinct (and hence a “species”) for purposes of conservation under the ESA. To qualify as an ESU, a population must (1) be reproductively isolated from other conspecific populations, and (2) represent an important component in the evolutionary legacy of the biological species.
exceedance plots	A probability plot of, for example, flows where N percent exceedance flow is the flow that is equaled or exceeded N percent of the time.
extinct (species)	No longer in existence because of failure to adapt to environmental change. (Compare to *extirpated*.)
extirpated (species)	No longer surviving in regions that were once part of the species’ range. (Compare to *extinct.*)
flood frequency analysis	A procedure for identifying the magnitude of flow (i.e., the N year precipitation event) would be that event that will be equaled on an average of every N years. In the case of a 20-year event, there is a 5 percent chance that it will be equaled during any given year. Recurrence interval: Also referred to as flood frequency, or return period.
greenhouse gas (GHG) emissions	Also referred to as carbon intensity or carbon footprint. Various water use activities (and other activities) can involve the use of substantial amounts of carbon-based energy, which in turn results in GHG emissions that contribute to the accumulation of GHG in the atmosphere and is related to the climate change.

Term	Definition
gross reservoir capacity	The total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes inactive storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).
groundwater	Any water naturally stored underground in aquifers, or that flows through and saturates soil and rock, supplying springs and wells.
groundwater overdraft	The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.
habitat	The specific places where the environmental conditions (i.e., physical and biological conditions) are present that are required to support occupancy by individuals or populations of a given species.
harm	An act that kills or injures wildlife. Such an act may include significant habitat modification or degradation where it kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).
hydraulics	Study of the practical effects and control of moving water; used to refer to the relationship among channel geometry and flow, velocity, and depth of water.
hydrograph	A chart or graph showing the change in flow over time for a particular stream or river.
hydrology	Science dealing with natural runoff and its effects on streamflows.
hydrostatic pressure	The pressure of water at a given depth resulting from the weight of the water above it.
inactive capacity (inactive storage)	Reservoir capacity exclusive of and above the dead capacity from which the stored water is normally not available because of operating agreements or physical restrictions. Under abnormal conditions, such as a shortage of water or a requirement for structural repairs, water may be evacuated from this space. The inactive capacity extends from the top of inactive capacity to the top of dead capacity.
incidental take	Take that results from, but is not the purpose of, carrying out an otherwise lawful activity.
Least-Cost Planning SIMulation model (LCPSIM)	Urban economic model to determine the least cost solution for supply/demand balance.
lead agency	The government agency that has the principal responsibility for carrying out or approving a project and, therefore, the principal responsibility for preparing CEQA/NEPA documents. For the NODOS feasibility studies, Reclamation is the federal lead agency under NEPA and DWR is the state lead agency under CEQA.
levee	A natural or artificial embankment that constrains the flow of water to a channel.
Level 2 refuge water	The amount of water required to meet existing refuge management needs within the Central Valley.

Term	Definition
Level 4 refuge water	The amount of water needed for full refuge habitat development within the Central Valley.
mean sea level (msl)	The average height of the sea's surface over a long period. MSL is used as a datum plane for the measurements of elevations and depths.
mitigation	Those actions that will minimize the impacts that are projected to occur through project development.
Monterey Agreement	DWR and certain representatives of the SWP contractors agreed in 1994 to a set of principles, known as the Monterey Agreement, to settle long-term water allocation disputes, and to establish a new water management strategy for the SWP. The disputes focused on the allocation of shortages in water supply, and particularly under what circumstances the initial reductions to agricultural use should be imposed prior to reducing allocations to urban contractors, dealing with both temporary shortages that occur due to droughts and other temporary causes and the possibility of specified types of permanent shortages of supply of project water.
nonnative species	Botanical, wildlife, and aquatic species that originate elsewhere and are brought into a new area. Nonnative species may dominate the local species or in some way negatively affect the environment of native species.
non-project water	Water that is not CVP or SWP water. Other water supplies acquired by CVP and SWP contractors.
normal pool (or reservoir) elevation	The highest elevation at which reservoir water is normally stored. This is usually the spillway crest elevation.
noxious weed	An alien, introduced or exotic, undesirable plant species that is aggressive and overly competitive with more desirable native species.
Operations Criteria and Plan (OCAP)	See *CVP Operations Criteria and Plan.*
offstream storage	A reservoir that is not constructed on a major stream and receives water through conveyance from a remote location. The water supply for the reservoir is diverted from a nearby stream via one or more conveyance facilities to the reservoir.
project yield	Water supply that can be delivered on a long-term basis that is attributed to all features of a project, including integrated operation of units that could be operated individually.
pumped storage project	A hydroelectric power plant and reservoir system using an arrangement whereby water released for generating energy during peak load periods is stored and pumped back into the upper reservoir, usually during periods of reduced power demand.
pumping-generating plant	A plant which can either pump water or generate electricity, depending on the direction of water flow.
range	The geographic area a species is known or believed to occupy.
Reasonable and Prudent Alternative (RPA)	The BiOps prepared by USFWS and NMFS may include RPA(s) that provide alternative actions to a proposed project that impose certain restrictions on project operations in order to be protective of the species when a proposed project is found to have the potential to jeopardize endangered species.

Term	Definition
Reasonable and Prudent Measure (RPM)	The BiOps prepared by USFWS and NMFS may include RPM(s) that impose certain restrictions on project operations in order to be protective of the species.
Reclamation Temperature and Mortality model (RECTEMPMORT)	This model provides monthly average temperature calculations and uses output from CALSIM II.
recycled water	Urban wastewater that becomes suitable, as a result of treatment, for a specific beneficial use. Also called reclaimed water.
responsible agency	Under CEQA, an agency other than the lead agency that has legal responsibility for carrying out or approving a project or elements of a project. Those that have a legal responsibility to approve the project. These agencies are required to rely on the lead agency's environmental document in acting on whatever aspect of the project requires its approval, but must prepare and issue its own findings regarding the project (State CEQA Guidelines Section 15096). The California Department of Fish and Wildlife (CDFW), Office of Historic Preservation, Central Valley Flood Protection Board, Air Resources Board, and Regional Water Quality Control Board are responsible agencies for the NODOS feasibility studies.
riparian	Vegetation or other resources associated with a river dependent on groundwater and floodwater controlled by the river. The land adjacent to a natural watercourse such as a river or stream, and pertains to riparian water rights. Often supports vegetation that provides important wildlife habitat, and important fish habitat values when growing large enough to overhang the bank.
riprap	A protective blanket of large loose stones, placed in random fashion on the upstream and downstream faces of embankment dams, streambanks, on a reservoir shore, on the sides of a channel, or other land surfaces to protect them from erosion or scour caused by current, wind, and/or wave action.
restoration	Actions that are viewed as providing recovery to a pre-existing ecological condition.
river basin	The area of land from which water drains into a river, usually bounded peripherally by a natural divide of some kind such as a hill; for example, the Sacramento River Basin, in which all land areas drain into the Sacramento River. Also called drainage area or watershed.
runoff	The volume of surface flow from an area.
saddle dam	A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.
SALMOD	Salmonid population model, using streamflow, water temperature and habitat type.
San Francisco Bay/Sacramento–San Joaquin River Delta (Delta)	As described in CWC Section 12220, an area that generally extends from Sacramento to the north, Tracy to the south, Interstate 5 to the east, and Collinsville to the west. The Delta covers approximately 738,000 acres.

Term	Definition
salinity	The amount of dissolved salts in a given volume of water. Salinity may be expressed in terms of a concentration or as an EC. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. Also see *total dissolved solids*.
salmonid	Fish species belonging to the salmon family, including salmon and trout.
scour	Removal of soil or fill material by the flow of floodwaters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.
sediment	Rock and mineral particles transported by water. Sediment relevant to wetlands tends to be relatively fine because the low gradients involved do not transport larger particles.
sedimentation	The deposition by settling of a suspended material.
seepage	The movement of water through a porous material in response to a hydraulic gradient.
seismicity	The frequency, intensity, and distribution of earthquake activity in an area.
settlement	A downward movement of a surface as a result of underlying soil compression or consolidation caused by an increased load or the loss of underlying soil (foundation) support.
smolt	A young salmon that has assumed the silvery color of the adult and is ready to migrate to the sea.
snags	Fallen branches, any dead or dying standing tree, washed-out shrubs, and small logs. They are important for the provision of food, shelter, and breeding places for animals in the water.
special status species	Federal and state classifications for plant and animal species that are either listed as threatened or endangered, are formally recognized candidates for listing, or are declining to a point where they may be listed.
spillway	A structure that passes normal and/or flood flows in a manner that protects the structural integrity of the dam. Overflow channel of a dam or impoundment structure. A structure over or through which flow is discharged from a reservoir.
Sites Project Joint Powers Authority	The Authority consists of seven member agencies: Reclamation District 108, Tehama-Colusa Canal Authority, Yolo County Flood Control and Conservation District, Maxwell Irrigation District, Glenn-Colusa Irrigation District, the County of Colusa, and the County of Glenn. The Authority formed to pursue the development and construction of Sites Reservoir.
stakeholder	Anyone who lives in a watershed or has land management, administrative, or other responsibilities or interests in it. Stakeholders may be individuals, businesses, government agencies, or special-interest groups.
stage	Water surface elevation above an established datum; typically measured in feet above msl.

Term	Definition
State Water Project (SWP)	A California State water storage and conveyance system that pumps water from the Delta for agricultural, urban domestic, and industrial purposes. The SWP was authorized by legislation in 1951.
suspended load	Sediment that is transported by suspension in the water column of a stream or river.
Table A amounts	The maximum amount of SWP water that the state agreed to make available for delivery to a contractor during the year. The state and the SWP contractors also use Table A amounts to serve as a basis for allocation of some SWP costs among the contractors.
take	(1) Under the Federal ESA: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. (2) Under the CESA: An action to or attempt to hunt, pursue, catch, capture, or kill.
terrestrial species	Types of species of animals and plants that live on or grow from the land.
threatened species	Any species which has potential of becoming endangered in the near future.
total dissolved solids (TDS)	A quantitative measure of the residual minerals dissolved in water that remains after evaporation of a solution. Usually expressed in milligrams per liter. Also see *salinity*.
trash rack	A metal or reinforced concrete structure placed at the intake of a conduit, pipe, or tunnel that prevents entrance of debris over a certain size. A device or structure located at an intake to prevent floating or submerged debris from entering the intake.
tributary	Stream flowing into a lake or larger stream.
turbidity	Defined as a decrease in the transparency of a solution due to the presence of suspended and some dissolved substances. This causes incident light to be scattered, reflected, and attenuated rather than transmitted in straight lines; the higher the intensity of the scattered or attenuated light, the higher the value of turbidity. Generally reported as either Nephelometric Turbidity Units, or the older Fiber Transceiver Units.
unimpaired flow	The flow past a specified point on a natural stream that is, or would be, unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifi-cations in land use. Sometimes referred to as historic flow without development.
Upper Sacramento River Daily Operations model (USRDOM)	The model developed to simulate daily reservoir operations and daily river flows for the Upper Sacramento River.
Upper Sacramento River Temperature/ Water Quality Model (USRWQM)	The model developed to simulate the temperature regime of the Upper Sacramento River and provide estimates of daily average riverine temperature conditions.
vernal pools	Ephemeral wetlands forming in shallow depressions underlain by a substrate near the surface that restricts the percolation of water.

Term	Definition
water conveyance capacity	The flow capacity of a channel, used to describe the flow in channels.
water quality	Description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.
Water Quality Control Plan (WQCP)	The WQCP (or Basin Plan) defines and designates beneficial uses of waters, establishes water quality objectives to protect those uses, identifies water quality threats and outlines corrective measures to be implemented. The WQCP is used to develop discharge limits and guide Regional Water Quality Control Board decisions on specific cases.
water reliability	A measure of a system's ability to sustain the social, environmental, and economic systems that it serves during the years (e.g., dry, wet, average years).
water rights	In water law, refers to the right of a user to use water from a water source (e.g., a river, stream, pond, or source of groundwater).
water transfers	Marketing arrangements that can include: the permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; the sale or lease of a contractual right to water supply.
water year	From October 1 through September 30.
waters of the United States	As defined in Section 404 of the Clean Water Act: Navigable waters of the United States, interstate waters, all other waters where the use or degradation or destruction of the waters could affect interstate or foreign commerce, tributaries to any of these waters, and wetlands that meet any of these criteria or are adjacent to any of the above.
watershed	The area of land from which water drains into a river, usually bounded peripherally by a natural divide of some kind such as a hill—for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called drainage area or river basin.
wetland	Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Term	Definition
X2	The location (measured in kilometers from the Golden Gate Bridge) of 2 parts per thousand TDS. The length of time X2 must be positioned at set locations in the estuary each month is determined by a formula that considers the previous month's inflow to the Delta and a "Level of Development" factor, denoted by a particular year. X2 is currently used as the primary indicator in managing Delta outflows. The X2 indicator is also used to reflect a variety of biological consequences related to the magnitude of fresh water flowing downstream through the estuary and the upstream flow of saltwater in the lower portion of the estuary. The outflow that determines the location of X2 also affects both the downstream transport of some organisms and the upstream movement of others and affects the overall water operations of the CVP and SWP.

This page intentionally left blank

CHAPTER 10 REFERENCES

Bartholow, J.M., 2003. Modeling Chinook Salmon with SALMOD on the Sacramento River, California.

Bartholow, J.M. and J.A. Henriksen, 2006. *Assessment of Factors Limiting Klamath River Fall-Run Chinook Salmon Productions Potential using Historical Flows and Temperatures.*

California Department of Finance, 2013. *New Population Projections: California to Pass 50 Million in 2049*, January.

California Federal Bay-Delta Program (CALFED), 2000a. *CALFED Bay-Delta Program Final Environmental Impact Statement/Environmental Impact Report*.

CALFED, 2000b. *CALFED Bay-Delta Programmatic Record of Decision*.

CALFED, 2000c. *Initial Surface Water Storage Screening Report*.

CALFED, 2006. CALFED Bay-Delta Program Water Use Efficiency Element, Water Use Efficiency Comprehensive Evaluation.

Delta Stewardship Council, 2010. http://deltacouncil.ca.gov/water-supply

Delta Stewardship Council, 2012. *Delta Plan*.

Delta Vision Blue Ribbon Task Force, 2008. *Our Vision for the California Delta.*

Department of Interior (DOI), 1999. Central Valley Project Improvement Act.

DOI, 2000. *Record of Decision, Trinity River Main Mainstem Fishery Restoration Final Environmental Impact Statement/Environmental Impact Report*.

DOI, 2008. *Fish Passive Improvement Project at the Red Bluff Diversion Dam Tehama County, California, Final Environmental Impact Statement/Environmental Impact Report*.

Department of Water Resources (DWR), 2003. *California Groundwater.* Bulletin 118. Update 2003. October.

DWR, 2005. *California Water Plan Update 2005: A Framework for Action*.

DWR, 2006. *Technical Memorandum Report on Progress on Incorporating Climate Change into Management of California's Water Resource.*

DWR, 2008. *Flood Rapid Assessment Model (F-RAM) Development.* Developed by URS for DWR. November.

DWR, 2009a. *California Water Plan Update 2009: Integrated Water Management*.

DWR, 2009b. *Delta Risk Management Strategy, Phase 1.* February.

DWR, 2009c. *The State Water Project Delivery Reliability Report 2009 (Draft).* December.

DWR, 2010. *Climate Change Characterization and Analysis in California Water Resources Planning Studies Final Report.* (Available December 2011).

DWR, 2011. Bulletin 132-11, Appendix B, Table B-24. *Equivalent Unit Charge for Water Supply for Each Contractor.*

DWR, 2012. *Bay Delta Conservation Plan (BDCP) Effects Analysis and ADEIR/S.*

Federal Register, 2012. Volume 78, Number 52. Bureau of Reclamation (Reclamation), DOI.

Groot and Margolis, 1991. *Pacific Salmon Life Histories*. December.

Kent, J.J., 1999. *Application of SA of a salmonid population model for the Sacramento River, California.* Master's Thesis, Colorado State University, Fort Collins, Colorado, 79 p.

Loomis, J. 2005. *Updated outdoor recreation use values on national forests and other public lands. General Technical Report PNW-GTR-658.* Portland, Oregon: USDA Forest Service, Pacific Northwest Research Station. http://www.fs.fed.us/pnw/pubs/pnw_gtr658.pdf

National Marine Fisheries Service, 2009. *Biological Opinion and Conference Opinion of the Long-Term Operations of the Central Valley Project and State Water Project,* National Marines Fisheries Service, Southwest Region. June 4.

National Oceanic and Atmospheric Administration Fisheries Service, 1997. *National Marine Fisheries Service, Proposed Recovery Plan for the Sacramento River Winter-Run Chinook Salmon.* August.

Public Policy Institute of California, 2012. *Envisioning Futures for the Sacramento San Joaquin Delta*.

United States Bureau of Reclamation (Reclamation), 1989. *Report on Refuge Water Supply Investigations: Central Valley Hydrologic Basin, California.* Sacramento, California.

Reclamation, 2004. *Evaluation of Groundwater Potential for Incremental Level 4 Refuge Water Supply.*

Reclamation, 2006. Stony Gorge Dam. March. http://www.usbr.gov/dataweb/dams/ca10194.htm

Reclamation, 2007 to 2012. *Central Valley Project Ratebook*, Schedule B-2.

Reclamation, 2008. *Water Supply and Yield Study.* March.

Reclamation, 2011a. *Draft Shasta Lake Water Resources Investigation Feasibility Report*. November.

Reclamation, 2011b. *Preliminary Draft Shasta Lake Water Resources Investigation Environment Impact Statement*. November.

Reclamation, 2012. *Final Value Planning Study, North-of-the-Delta Offstream Storage Investigation*. November.

Reclamation and DWR, 2002. *North-of-the-Delta Offstream Storage Investigation Scoping Report.*

Reclamation and DWR, 2006a. *North-of-the-Delta Offstream Storage Investigation Final Initial Alternatives Information Report.*

Reclamation and DWR, 2006b. *South Delta Improvements Program.* Final. December.

Reclamation and DWR, 2008. *North-of-the-Delta Offstream Storage Investigation Plan Formulation Report.*

Reclamation and DWR, 2011. SECURE Water Act Section 9503(c) – *Reclamation Climate Change and Water 2011*. April.

State Water Resources Control Board (SWRCB), 1995. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*.

SWRCB, 2010. *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem. State of California. California Environmental Protection Agency*. Final. August 3.

Toolson and Zhang, 2013. NODOS Hydropower Benefits, November.

United States Army Corps of Engineers, 1977. *Report on Reservoir Regulation for Flood Control, Shasta Dam and Lake*.

United States Fish and Wildlife Service, 2008. *Technical Memorandum: Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley (CVP) and State Water Project (SWP).*

United States Water Resources Council, 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.*

United States Water Resources Council, 2013. *Principles and Requirements for Federal Investments in Water Resources*, March.

This page intentionally left blank

APPENDIX A

Evaluation of Initial Action Alternative Plans

Table of Contents

Page

Table of Contents (Continued)

Page

Tables

Page

Tables (Continued)

Page

Figures

Page

This page intentionally left blank

PLAN FORMULATION

The plan formulation process for the North-of-the Delta-Offstream Storage (NODOS) feasibility studies were iterative and organized into three major phases: the Initial Alternatives Information Report (IAIR) (Bureau of Reclamation [Reclamation] and Department of Water Resources [DWR], 2006a), Plan Formulation Report (PFR) (Reclamation and DWR, 2008), and the ongoing feasibility studies and Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

- **IAIR:** Documents the first stage of the planning process and identifies several features and activities (structural and non-structural) to meet the planning objectives, more commonly called management measures. The IAIR summarizes the preliminary screening for the management measures that focuses on the evaluation of potential reservoir locations.

- **PFR:** Documents the second stage of the planning process, revisits the problems and needs, planning objectives, and planning constraints; provides a more complete evaluation of management measures, including the identification of additional measures, such as conveyance operations, groundwater and conjunctive use, and others.

- **Feasibility Studies and EIR/EIS:** These forthcoming reports will provide a more complete evaluation of the management measures including additional reservoir locations, reservoir sizes, conveyance options and sizes, pump storage opportunities, recreational sites, and mitigation measures, as well as the development and evaluation of comprehensive alternative plans.

Because the planning process was iterative and spread over several years, descriptions of management measures, reservoir locations, and conveyance options are more current and complete in this progress report than they were in the IAIR or PFR. Regulations have changed, engineering concepts have been modified, computer models have been updated, and planning objectives have changed since the prior documents were prepared. As a result, the main text of the progress report provides coverage of each step in the process needed to develop complete alternative plans.

This appendix was developed to document portions of the plan formulation process that are not described in detail in the main body of the progress report. These items include:

- Updated detailed descriptions of the management measures that are summarized in a series of tables in Chapter 4 of the main text.

- Two potential reservoir locations that were suggested by the public after the close of the scoping period.

- The preliminary alternative descriptions and evaluation performed in the PFR that informed the development of alternatives for detailed analysis in the subsequent feasibility studies.

A1.0 MANAGEMENT MEASURES

Numerous management measures have been identified to address each of the primary planning objectives. The development of measures has been an iterative process. Measures initially were identified in the IAIR (Reclamation and DWR, 2006a) and subsequently refined in the PFR and subsequent feasibility studies.

Water Supply

Various potential water management measures were identified to address the primary water supply objective. This objective includes increasing water supplies, water supply reliability, and Sacramento Valley water management flexibility for agricultural, municipal and industrial (M&I), and environmental purposes.
Table A1-1 identifies the measures considered, their potential to address the primary objective, and whether the measures were retained or not recommended for further consideration.

The water supply measures identified were separated into nine categories: (1) surface water storage, (2) reservoir reoperation, (3) groundwater storage, (4) conjunctive water management, (5) coordinated operation and precipitation enhancement, (6) demand reduction, (7) recycling, (8) water transfers and purchases, and (9) conveyance and Delta export.

Table A1-1. Summary of Management Measures to Address Water Supply Reliability Needs

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Surface Water Storage		
Construct Colusa Reservoir Complex, a new offstream surface storage facility in Glenn and Colusa counties.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Cottonwood Reservoir Complex, a new offstream surface storage facility in Tehama County.	Moderate to high potential to increase water supply reliability.	Not Recommended – Difficult to fill in all water year types without negatively affecting other water supplies. Could have negative impacts on steelhead and salmon.
Construct Red Bank Project, a new offstream surface storage facility in Tehama County.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Sites Reservoir, a new offstream surface storage facility in Glenn and Colusa counties.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Newville Reservoir, a new offstream surface storage facility in Glenn County.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Veterans Lake, a new offstream surface storage facility in southwest Shasta County.	Moderate to high potential to increase water supply reliability.	Not Recommended – Difficult to fill in all water year types without negatively affecting other water supplies. Could have negative impacts on steelhead and salmon.

Table A1-1. (Continued)

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Surface Water Storage (cont'd)		
Raise Shasta Dam.	Moderate to high potential to increase water supply reliability.	Under study by Reclamation independent from the NODOS feasibility Studies as part of the Shasta Lake Water Resources Investigation and a separate feasibility study under Public Law 96-375.
Construct new storage reservoir(s) upstream from Shasta Lake.	Low potential – Several sites/projects would provide only marginal increases to water supply reliability.	Not recommended – Measure would provide only marginal increases to water supply reliability, coupled with higher unit costs, inconsistency with CALFED evaluation criteria, and lack of local support.
Construct new storage on other tributaries to the Sacramento River downstream from Shasta Dam.	Low to High potential – Several sites/projects (e.g., Auburn Dam) would increase system water supply reliability.	Not recommended – Measure would be limited in their ability to contribute to other planning objectives (e.g., water quality and aquatic resources) and have overriding environmental issues and opposition.
Construct new water storage in the Delta or within the San Joaquin River watershed.	Low to high potential for surface water storage projects (upper San Joaquin River) to increase water supply reliability for CVP, primarily in the San Joaquin Valley and Tulare Lake Basin.	The potential for storage in the upper San Joaquin River watershed is being independently evaluated by Reclamation.
Increase total or seasonal conservation storage at other CVP/SWP/local/private facilities.	Moderate potential for increasing storage in existing reservoirs (e.g., Los Vaqueros Reservoir).	Raising Los Vaqueros Dam has been evaluated by CCWD independent from the NODOS feasibility studies and construction is being planned. This action does not address all planning objectives of the NODOS feasibility studies.
Reservoir Reoperation		
Increase storage space in existing north-of-the-Delta storage facilities by changing operations, including reallocating space from flood control.	Low potential – Considerable space would have to be reallocated to improve water supply reliability.	Measure is being evaluated independently from the NODOS feasibility studies as part of the water system reoperation and optimization studies currently underway by DWR as specified under California State Water Code 83002.

Table A1-1. (Continued)

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Reservoir Reoperation (cont'd)		
Increase conservation pool in existing north-of-the-Delta storage facilities by encroaching on dam freeboard.	Low potential – Very small space increase would be possible.	Not recommended – Measure would have very limited potential to encroach on existing freeboard above gross pool and would increase flood risk.
Groundwater Storage		
Develop groundwater storage in the Sacramento River Basin.	Low potential to enhance system yield for water users. Most benefits would be realized at local level.	Not recommended – Aquifers in the Sacramento River Basin are fully recharged during years of normal precipitation. Therefore, aquifer capacity is unavailable for conventional groundwater storage. This alternative would also have high potential for public and legal challenge due to water rights issues and potential third party impacts.
Conjunctive Water Management		
Develop additional groundwater storage south of the Delta.	Moderate potential to enhance system yield for south of the Delta users.	Not recommended – The ability of this measure to improve the performance of the NODOS Project for water supply is limited and does not contribute to the other objectives. It could be implemented independently after construction if a cost-effective location can be identified.
Increase opportunities for conjunctive use of surface and groundwater storage in the Sacramento River Basin.	Low potential to enhance system yield for many potential uses.	Not recommended – Aquifers in the Sacramento River Basin are fully recharged during years of normal precipitation. Therefore, aquifer capacity is unavailable for conventional groundwater storage. New groundwater storage facilities also would face considerable legal and public acceptance challenges because of water rights issues and potential third-party impacts.
Precipitation Enhancement		
Implement additional precipitation enhancement.	Low potential to improve drought-period water supply reliability.	Not recommended – Does not contribute to increasing the flexibility of the water supply system because its effectiveness is greatly reduced under drought conditions.

Table A1-1. (Continued)

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Demand Reduction		
Implement water-use efficiency methods.	Moderate potential to benefit overall California water supply reliability.	Retained – Although water-use efficiency does not increase water supplies, conservation is being actively pursued as part of the CALFED program. The measure is retained as a complementary action in the No Project Alternative.
Retire agricultural lands.	Low to moderate potential – Would reduce water demand rather than increase ability to meet projected future demands.	Not recommended – Measure would not contribute to increasing system flexibility or meeting the planning objectives. Land retirement test programs are being performed by Reclamation. On a large scale, this measure could have substantial negative impacts on agricultural industry.
Recycling		
Implement additional recycling.	Moderate potential to address statewide water needs.	Retained – Additional recycling is retained as a complementary action.
Water Transfers and Purchases		
Transfer water between users and source shift (use groundwater in lieu of surface water).	Very low potential – Would not generate a sufficient increase in water supply reliability.	Retained – Measure would not be an alternative to new water sources or a reliable substitute for new storage north-of-the Delta. The measure is likely to be accomplished with or without additional efforts to develop new sources and is retained as a complementary action in the No Project Alternative.
Conveyance and Delta Export		
Extend Tehama-Colusa Canal to Vacaville.	Low potential – Would not improve the water supply reliability of existing contractors.	Not recommended – The focus for the NODOS feasibility studies is on improving supply reliability for existing contractors, not establishing new contracts.
Expand Banks Pumping Plant.	Moderate potential to help increase water supply reliability south of the Delta.	Not recommended – Measure is not being evaluated as part of the NODOS feasibility studies due to uncertainties regarding revisions to the BiOps
Improve Delta export and conveyance capability through coordinated CVP and SWP operations.	Moderate potential to help increase water supply reliability south of the Delta.	Not recommended – JPOD1 is being pursued in other programs pending resolution of BiOp issues. Measure is not an alternative to increasing water supply reliability north of the Delta. It does not address planning objectives or constraints/principles/criteria.

Table A1-1. (Continued)

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Conveyance and Delta Export (cont'd)		
Construct New Delta Conveyance.	High potential to increase water supply reliability south of the Delta.	Not recommended – Project is being actively pursued by BDCP independent of the NODOS feasibility studies. The effects of potential implementation on NODOS are discussed in Chapter 10.

The joint operation of the two projects (CVP and SWP) is commonly referred to as the JPOD.

BDCP = Bay Delta Conservation Plan
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
DWR = Department of Water Resources
JPOD = joint point of diversion
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project

Surface Water Storage

Colusa Reservoir Complex – The Colusa Reservoir Complex would be constructed in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the town of Maxwell. The Colusa Reservoir Complex would provide up to 3.0 million acre-feet (MAF) of new offstream storage, giving it a high potential to address the water supply reliability objective. This reservoir would encompass the entire footprint of Sites Reservoir, but be approximately twice the size of Sites Reservoir. This measure was retained for further development.

Cottonwood Reservoir Complex – The Cottonwood Reservoir Complex would be located in northwest Tehama County, approximately 12 miles southwest of Anderson. The Cottonwood Reservoir Complex could be designed as a 0.4 MAF reservoir (Cottonwood South Reservoir) or as a 1.0 MAF reservoir (Cottonwood South Reservoir and Cottonwood North Reservoir). This results in a moderate to high ability to address the water supply reliability objective. As the largest undammed tributary on the Sacramento River, Cottonwood Creek has been designated as critical habitat for salmon and steelhead. Construction of the Cottonwood Reservoir Complex would not support the project purpose of increasing the populations of anadromous fish and other aquatic species. Also, the ability to reliably fill the reservoir without pulling water out of other reservoirs is questionable. The Cottonwood North Reservoir would be filled from the Beegum Creek and Dry Creek watersheds. The Cottonwood South Reservoir would be an onstream reservoir on Salt Creek. This measure was not retained for further development.

Red Bank Project –The Red Bank Project would be constructed in northwest Tehama County, approximately 17 miles west of Red Bluff. The Red Bank Project includes four small reservoirs in close proximity: Dippingvat, Blue Door, Lanyan, and Schoenfield. The Red Bank Project would divert water from the South Fork Cottonwood Creek at Dippingvat Reservoir, the North Fork Red Bank Creek to fill Blue Door and Lanyan Reservoirs, and from Red Bank Creek to fill Schoenfield Reservoir. The combined storage would be approximately 0.35 MAF. This storage capacity results in a moderate potential to address the water supply reliability objective. This measure was retained for further development.

Sites Reservoir – Sites Reservoir would be constructed in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the town of Maxwell. Sites Reservoir would provide up to 2.1 MAF of storage (a variety of reservoir sizes were evaluated). This storage capacity provides a high potential to satisfy the water supply reliability objective. This measure was retained for further development.

Newville Reservoir – Newville Reservoir (also known as Thomes-Newville Reservoir) would be constructed in north-central Glenn County, approximately 18 miles west of Orland. Newville Reservoir would be located upstream from Black Butte Lake. Water from Thomes Creek would be diverted to fill the reservoir. The reservoir would provide 1.9 to 3.0 MAF of storage. This storage capacity results in a high potential to address the water supply reliability objective. This measure was retained for further development.

Veterans Lake – Veterans Lake would be constructed as an offstream reservoir in southwest Shasta County near Ono approximately 17 miles west of Anderson. Veterans Lake could provide up to 1.0 MAF of storage. This storage capacity results in a moderate to high ability to address the water supply reliability objective. As the largest undammed tributary on the Sacramento River, Cottonwood Creek has been designated as critical habitat for salmon and steelhead. Construction of Veterans Lake would not support the project purpose of increasing the populations of anadromous fish and other aquatic species. Veterans Lake would be filled from the North Fork and Middle Fork of Cottonwood Creek. Also, the ability to reliably fill the reservoir without pulling water out of other reservoirs is questionable. Additional information on the evaluation of Veterans Lake is provided in later in this appendix. This measure was not retained for further development.

Increase Conservation Storage Space in Shasta Lake by Raising Shasta Dam – This measure would increase the amount of available space for conservation storage in Shasta Lake by raising the height of Shasta Dam. This action could increase water supply reliability for Sacramento Valley users, the State Water Project (SWP) and Central Valley Project (CVP), improve Delta water quality, and contribute to ecosystem restoration. Compared to the other facilities, this measure would result in a moderate to high increase in water supply reliability, depending on the size of the raise.

Raising the height of Shasta Dam is independently evaluated in the Shasta Lake Water Resources Investigation feasibility study authorized by Public Law 96-375.

Construct New Conservation Storage Reservoir(s) Upstream from Shasta Lake – This measure would consist of constructing dams and reservoirs at one or more locations upstream from Shasta Lake, primarily for increased water conservation storage and operational flexibility. Numerous reservoir storage projects have been considered, and many have been constructed in the water shed upstream from Shasta Lake. These potential project sites would be capable of only marginally improving water supply reliability to the CVP. The overall potential to increase water supply reliability is considered low. An additional offstream storage site at Goose Valley, near Burney, was considered; however, the likely costs to develop the project would exceed water supply benefits by at least 2 to 1. Furthermore, larger project sizes at the Goose Valley site are physically feasible, but there is little potential for water to fill the facility.

Accordingly, this site was not considered further, and this measure was not recommended for further consideration in the NODOS feasibility studies.

Construct New Conservation Storage on Other Tributaries to the Sacramento River Downstream from Shasta Dam – Numerous onstream surface water storage projects along tributaries to the Sacramento River downstream from Shasta Dam have been investigated in past studies. Several of those projects could contribute substantially to increasing water supply reliability, including the Cottonwood Creek Project (1.6 MAF on Cottonwood Creek north of Red Bluff), the Auburn Dam Project (up to approximately 2.3 MAF on the Middle Fork American River near Sacramento), and the Marysville Lake Project (920,000 AF on the Yuba River near Marysville). Depending on the location, the potential increase in water supply reliability ranges from low to high. Although each of these potential projects could contribute considerably to increasing the water supply reliability of the CVP and SWP systems, state and local interests have rejected them as potential candidates for new water sources. Each has been eliminated from further consideration primarily because it would not contribute to the primary planning objectives or because it would have overriding environmental issues and opposition. This measure was not recommended for further consideration in the NODOS feasibility studies.

Construct New Conservation Surface Water Storage in the Delta or San Joaquin River Watershed –Numerous surface water storage sites have been identified in the past along the eastern and western sides of the San Joaquin Valley and in areas to the east of the Delta, near Stockton. Potential onstream storage site projects include enlarging Pardee Reservoir on the Mokelumne River, enlarging and modifying Farmington Dam on Littlejohns Creek, and enlarging Friant Dam on the upper San Joaquin River. Numerous potential offstream storage site projects also have been considered in the San Joaquin Valley, Ingram Canyon Reservoir, Quinto Creek Reservoir, and Panoche Reservoir. The potential to increase water supply reliability ranges from low to high depending on the location for the new storage. Most of the potential onstream or offstream storage projects were not recommended for further consideration in this study because they would not contribute to all of the planning objectives of the NODOS feasibility studies. An independent feasibility study of the upper San Joaquin River was authorized in Section 215 of Public Law 108-7. This study is independent of the NODOS feasibility studies and addresses specific planning objectives that differ from those of the NODOS feasibility studies.

Increase Total or Seasonal Conservation Storage at Other CVP/SWP/ Local/Private Facilities – This measure would consist primarily of providing additional conservation storage space in other major reservoirs in the Sacramento River watershed by enlarging existing dams and reservoirs. Candidate projects include additional storage in facilities such as Lake Berryessa on Putah Creek, Folsom Lake on the American River, Trinity Lake on the Trinity River, and Lake Oroville on the Feather River. The resulting increase in water supply reliability if the measure was implemented would be moderate at best. All known efforts to increase storage space in other northern California CVP or SWP reservoirs were rejected by CALFED and local interest groups. Most of these alternatives would have a higher unit cost than NODOS to achieve significant increases in water storage. An independent evaluation for enlarging Los Vaqueros Dam was previously performed and efforts are underway to expand the reservoir. Further expansion of Los Vaqueros will be studied independently from the NODOS feasibility studies. For these reasons, and because this measure would not address all objectives or constraints of the NODOS feasibility studies, this measure was not recommended for further consideration.

Reservoir Reoperation

Increase Conservation Storage Space in Existing North-of-the-Delta Storage Facilities by Changing Operations, Including Reallocating Space from Flood Control – This measure would consist of changing the flood control operations of Shasta Dam, Oroville Dam, Folsom Dam, or other facilities north of the Delta. This measure includes changes in the timing as well as reducing the maximum flood pool to increase water supply. The potential increase in water supply reliability from these actions is considered low. A comprehensive water system reoperation and optimization study looking at these and other options is currently underway by DWR as specified under CWC 83002 independent from the NODOS feasibility studies to determine how much additional water, if any, could be stored.

Increase the Conservation Pool in Existing North-of-the-Delta Facilities by Encroaching on Dam Freeboard – This measure would consist of increasing the conservation storage space by raising the gross pool elevation without raising dam height. It is estimated that major modifications to dams and appurtenances would be required to allow operational encroachments on the design freeboard of the dams, only to gain a small potential increase in water supply yield. This measure was not recommended for further development, primarily because of the limited potential for encroaching on the existing freeboards and the relatively high cost to resolve the uncertainty issues associated with encroachments.

Groundwater Storage

Develop Groundwater Facilities in the Sacramento River Basin – This measure would involve using groundwater banking opportunities in the Primary Study Area to increase water supply and water supply reliability. One way this could be accomplished is through the construction of a large-scale aquifer storage and recovery (ASR) project.

DWR data show that Sacramento Valley aquifers are generally fully recharged during years of normal precipitation (DWR, 2003). Therefore, groundwater banking areas are not as prevalent in northern California as they are in other areas (e.g., the San Joaquin Valley) (NHI and Glenn-Colusa Irrigation District [GCID], 2011; URS 2007). The potential to increase water supply reliability from constructing facilities is considered low in the Sacramento Valley. Reclamation, DWR, and others have pursued ongoing groundwater programs, such as the Sacramento Valley Water Management Program (SVWMP) to study and optimize the use of groundwater resources.

Conjunctive Water Management

Develop Additional Conservation Groundwater Storage South of the Delta – This measure would consist of either developing new groundwater recharge projects south of the Delta or contributing to existing recharge projects. The capacity of such systems could result in moderate increases in water supply reliability for south of Delta users if implemented in the future as a complimentary action; however, developing these facilities south of the Delta would not benefit anadromous fish in the Sacramento River watershed, improve Delta water quality, or generate additional hydropower. Therefore, it was not retained for further evaluation.

Increase Opportunities for Conjunctive Use of Surface and Groundwater Storage in the Primary Study Area – This measure would consist of using groundwater storage and/or transfers in conjunction with new or existing surface storage. There is limited opportunity to develop conjunctive use with existing groundwater storage facilities in the Primary Study Area because these aquifers fully recharge in normal years. As a result, the potential for increasing the water supply reliability is considered low. Constructing new groundwater storage would involve unproven technology on a large scale and could have adverse third-party impacts. Increased groundwater pumping might have negative impacts on stream flow and temperature in the Sacramento River. New groundwater storage facilities also would face considerable legal and public acceptance challenges because of water rights issues and potential third-party impacts. If developed by others, potential future operations of a NODOS Project would be coordinated with the SVWMP, the Yuba Accord Conjunctive Use Program, the Drought Risk Reduction Investment Program, the Dry Year Program, and transfers from willing sellers to buyers. This measure is being separately evaluated as part of the reoperations study underway by DWR to meet the requirements of California Water Code (CWC) 83002. This measure was not recommended for further consideration in the NODOS feasibility studies.

Coordinated Operation and Precipitation Enhancement

Implement Additional Precipitation Enhancement – Precipitation enhancement is a process by which clouds are stimulated to produce more rainfall or snowfall than naturally produced.

Precipitation enhancement is not a short-term remedy for droughts because supply increases can only be achieved during years when it would otherwise rain or snow naturally – in other words, in above-average precipitation years. Accordingly, precipitation enhancement is not an alternative to new system storage, which focuses on conserving water in wetter years for use in dryer years. The potential to improve water supply reliability is considered low. This measure was not recommended for further consideration in the NODOS feasibility studies primarily because it would not address the planning objectives and is not an alternative to NODOS.

Demand Reduction

Implement Water-Use Efficiency (WUE) Methods – Potential critical impacts to agricultural and urban resources resulting from water shortages could be reduced through WUE methods. The *California Water Plan Update 2005: A Framework for Action* (DWR, 2005) identified a variety of agricultural and urban WUE measures. Supporting information to the Plan is contained in the CALFED *Bay-Delta Program Water Use Efficiency Element, Water Use Efficiency Comprehensive Evaluation*

(CALFED, 2006). This CALFED document indicated that the potential for recovering what are currently deemed irrecoverable agricultural losses in the Sacramento River and San Joaquin River basins could be approximately 142,000 AF on an average annual basis, with resulting unit costs of approximately $200/AF. Larger amounts are technically feasible; however, the cost to achieve these amounts increases considerably. The report also identified various urban WUE programs with the potential to reduce average annual urban water use by approximately 1.1 million AF per year by 2030 through a series of best management practices. Statewide, the ability to improve water supply reliability is considered moderate.

WUE would help reduce demands and should be pursued to help offset future shortages in water supplies. Accordingly, the concept of WUE was retained.

Retire Agricultural Lands – Although the equivalent unit cost of water for this measure might be competitive with other potential water sources, this measure was not recommended for further consideration, primarily because it likely would have only a limited ability to help meet future water demands outside of the San Joaquin Valley. The potential to increase water supply reliability is considered low to moderate. There might be a limited ability to successfully apply this measure at costs similar to the cost for less productive lands, but this measure would not address the other planning objectives of the NODOS feasibility studies.

Recycling

Implement Additional Recycling – Opportunities to implement recycling within the Primary Study Area are limited. Additional recycling is being implemented on a statewide basis. The potential to improve water supply reliability is considered low. Recycling must be considered as an element of any plan addressing the future of water in California and is included as a complimentary action.

Water Transfers and Purchases

Transfer Water between Users and Source Shifting – Transfers and source shifting would not generate new water for the CVP or SWP, but would simply transfer surface water from a seller willing to forgo surface water use, for a time, to a willing buyer. In addition, ongoing infrastructure limitations on conveying water from north to south of the Delta are expected to encourage the most feasible and reliable water transfers to be implemented under future no project conditions. Any remaining opportunities for transfers probably would include high uncertainties, be small, difficult to implement, and more costly. Consequently, this measure was retained as a complementary action.

New or Modified Conveyance Facilities

Extension of the Tehama-Colusa (T-C) Canal to Vacaville – The T-C Canal could be extended to Vacaville to deliver water to additional service areas. However, extending the T-C Canal does not deliver water to the locations required to meet the NODOS feasibility studies’ primary objectives of increased survivability of anadromous fish and other aquatic species or Delta water quality improvement. Furthermore, the intent of the NODOS feasibility studies is to provide greater flexibility to existing contractors and not to establish new contracts. The potential to improve water supply reliability is considered low. Therefore, this measure was not recommended for further consideration under the NODOS feasibility studies.

Expand Banks Pumping Plant – The current allowable pumping capacity at the SWP Banks Pumping Plant is 6,680 cubic feet per second (cfs). The potential to improve water supply reliability is considered moderate. Until the environmental compliance documentation associated with the biological opinion (BiOp) on the coordinated operation of the CVP and SWP is complete, Reclamation and DWR are suspending efforts to increase the pumping capacity to 8,500 cfs during certain seasonal periods. Therefore, it was not recommended for further consideration in the NODOS feasibility studies.

Improve Delta Export and Conveyance Capability through Coordinated CVP and SWP Operations – This measure would consist of improving Delta export and conveyance capability by more effectively coordinating the management of surplus flows in the Delta using a joint point of diversion (JPOD). JPOD operations would allow federal and California water managers to use excess or available capacity in their respective south Delta diversion facilities at the Tracy and Banks pumping plants. The potential to improve water supply reliability is considered moderate. This measure was not recommended for further consideration in the NODOS feasibility studies because implementation has been postponed pending resolution of ongoing BiOp issues in the Delta.

Construct New Delta Conveyance – Alternative conveyance options are being considered to route water to the Banks and Jones pumping plants. The new facilities under consideration through the Bay Delta Conservation Plan (BDCP) process would not increase the capacity of the pumping plants or conveyance to the south, but could increase water supply reliability by reducing current operational constraints on pumping that protect endangered species. A variety of canal, through-Delta, and tunneling options are under evaluation. The potential for increasing water supply reliability is considered high. However, this measure does not contribute to all of the planning objectives for the NODOS Project and was not recommended for further consideration in the NODOS feasibility studies. Alternatives are being separately studied through BDCP. If adopted, new Delta conveyance would increase the water supply benefits derived from a NODOS Project.

Table A1-1 identifies the measures considered, their potential to address the primary objective, and whether the measures were retained or not recommended for further consideration.

Anadromous Fish Survivability

Various potential water management measures were identified to address the primary objective of increasing the survival of anadromous fish populations in the Sacramento River and increasing the health and survival of other aquatic species.

Improved Fish Habitat

Restore Abandoned Gravel Mines Along the Sacramento River – Instream gravel mining has contributed to the degradation of aquatic and floodplain habitat. These activities have created large artificial pits at various locations in the Sacramento

River Basin that disrupt natural geomorphic processes and riparian regeneration. High fish mortality from stranding and unnatural predation occurs in many abandoned pits that either lose their connections with the river during low-flow periods or otherwise interfere with effective fish passage between the river and mine areas. The potential for improving survivability is considered low to moderate, depending on the scale of implementation. This measure would consist of acquiring, restoring, and reclaiming several inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Implementation of this measure requires extensive in-river construction to place fill into the abandoned pits. Although there are long-term benefits, the short-term impacts associated with the in-river construction effort on water quality (e.g., turbidity) and aquatic species are significant. This measure was not recommended for further development as part of the NODOS feasibility studies.

Restore Floodplains with Opportunities to Construct Instream Aquatic Habitat Downstream from Keswick Dam – Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks downstream passage of gravels, bed sediments, and woody debris that were historically replenished by upstream tributaries. As a result, aquatic habitat is poor for the spawning and rearing of anadromous fish, and predation can be high because instream cover is lacking. Despite these unfavorable channel conditions, coldwater releases from Keswick Dam attract large numbers of spawning fish to this reach. This measure would consist of floodplain restoration efforts that include opportunities for constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam. The primary objective of this effort is to create spawning and rearing habitat for anadromous fish (CALFED, 2008). The potential for increasing survivability of anadromous fish is considered moderate to high. This measure was retained for potential further development because it has a high likelihood of success in helping to achieve the primary objective.

Replenish Spawning Gravel in the Sacramento River – Gravel suitable for spawning has been identified as an important influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED and the AFRP, are proceeding with annual gravel replenishment on the Sacramento River in selected locations. With the exception of the Central Valley Project Improvement Act (CVPIA) (b)(13) program, these programs represent single applications at discrete locations. This measure would consist of helping to replenish spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff on a long-term basis beyond the existing CVPIA program. Although there are some water quality impacts associated with introducing gravel into the river, it is much less construction intensive than gravel mine restoration. The potential for increasing the survivability of anadromous fish is considered moderate. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective.

Remove Instream Sediment along Middle Creek – This measure would consist of implementing a fine sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. It would not contribute directly to improved ecological conditions along the mainstream of the Sacramento River and the potential for increasing the survivability of anadromous fish is considered low. This measure was not recommended for further development primarily because it is unrelated to other measures recommended for further study.

Rehabilitate Inactive Instream Gravel Mines along Stillwater and Cottonwood Creeks – This measure would consist of rehabilitating ecological conditions in former instream gravel mining sites along Stillwater Creek. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. The potential increases in survivability of anadromous fish are considered to be low. This measure is independent of the construction of the other measures associated with NODOS and would not benefit from coordination of operations with Shasta Dam or other anticipated project results. This measure was not recommended for further development.

Improved Water Quality/Flow/Temperature for Fish

Improve Flows and Temperature by Integrating a New Offstream Storage Facility into System Operations – When integrated into system operations, offstream storage provides opportunities to increase coldwater pools and improve flows in the Sacramento River. This includes additional storage in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. These changes help assure the appropriate flows necessary for critical life stages for anadromous fish and riparian habitat. This measure has a high potential for improving water temperature and flows to benefit anadromous fish. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective.

Enlarge Shasta Lake Coldwater Pool and Improve Flow Conditions by Enlarging Shasta Dam – Cold water released from Shasta Dam greatly influences water temperature conditions on the Sacramento River between Keswick and Red Bluff, and can have an extended influence on river temperatures farther downstream. This measure would consist of enlarging the coldwater pool by either raising the height of Shasta Dam and enlarging the minimum operating pool or increasing the seasonal carryover storage in Shasta Lake.

In addition to water temperature, flow conditions in the Upper Sacramento River are important in addressing anadromous fish needs. Enlarging Shasta Dam and modifying seasonal storage and releases would also benefit anadromous fisheries. This measure has a moderate to high potential for improving flow and temperature conditions, depending on the size of the enlargement. This measure is being independently evaluated in a separate feasibility study under Public Law 96–375.

Modify GCID Canal and Anderson-Cottonwood Irrigation District Diversions to Reduce Flow Fluctuations – This measure would consist of modifying operations at existing diversions to irrigation districts to reduce extreme flow fluctuations and their resulting impacts on anadromous fish. This measure has a moderate potential for improving flow conditions for anadromous fish. However, negative impacts on water deliveries from the diversions would conflict with another primary objective of increasing water supply reliability. Therefore, this measure, as a stand-alone action, was not recommended for further development primarily because of potential impacts to water supply reliability. Modifications to diversions continue to be considered as part of the operations strategy for new offstream storage measures.

Increase Instream Flows on Clear, Cow, and Bear Creeks – This measure would involve the construction of turnouts from conveyance to a new offstream reservoir to increase instream flows on Clear, Cow, and Bear creeks during critical periods to support anadromous fish that spawn in the creek. The potential for improving flow conditions for anadromous fish is considered low. This measure was not recommended for further development primarily because the conveyance facilities for the water supply measures retained for further evaluation are all too far south for constructing turnouts to these tributaries.

Construct a Storage Facility on Cottonwood Creek to Augment Spring Instream Flows – This measure would consist of constructing a dry dam or offstream storage facility on upper Cottonwood Creek to support flows for spring-run Chinook salmon. A storage facility would allow late-spring and summer releases for spring-run Chinook salmon and improve overall seasonal aquatic conditions. This measure was not recommended for further development because it is highly likely that this measure would have considerable and overriding adverse environmental impacts on the Cottonwood Creek watershed. It could, potentially, sever access to existing spawning locations. Although it would improve flows, the negative effects likely outweigh benefits to anadromous fish.

Remove Shasta Dam and Reservoir – This measure would consist of removing the existing Shasta Dam and Reservoir to benefit anadromous fishery resources. The Shasta Division of the CVP provides supplemental irrigation services to almost one-half million acres of land in California's Central Valley. It also provides water for M&I purposes and power generation amounting to approximately 680,000 kilowatts. In addition, Shasta Dam helps reduce flooding over a large area along the Sacramento River. Estimates of flood damages prevented by Shasta Dam and Reservoir during the major storms of 1995 and 1997 were approximately $3.5 and $4.3 billion, respectively. Although the potential benefit to anadromous fish resources along the Upper Sacramento River might be sizeable (numerous studies would be required to define the potential benefits and disadvantages to the fisheries), these benefits would by no means begin to approach the monetary benefit associated with the existing project. No known project or projects could replace the benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities at any price. This measure was not recommended for further consideration primarily because it would violate at least one of the planning criteria concerning the potential to adversely impact existing project purposes.

Improved Fish Migration

Screen Diversions on Old Cow and Cow Creeks – This measure would consist of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. This measure might reduce salmonid mortality at diversions within the Cow Creek watershed. The overall potential for improving fish migration throughout the Sacramento River watershed is considered low. However, this measure was not recommended for further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the Sacramento River Basin.

Remove or Screen Diversions on Battle Creek – This measure would consist of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, coldwater spawning habitat. Some of these diversions have been screened over the past several years, but there are others that could be screened. The overall potential for improving fish migration is considered to be moderate. This measure was not recommended for further development primarily because there are already independent efforts underway to address unscreened diversions.

Construct a Fish Barrier at Crowley Gulch on Cottonwood Creek – This measure would consist of constructing a fish barrier at the mouth of Crowley Gulch on Cottonwood Creek to eliminate the stranding of adult fall-run Chinook salmon. The overall potential to improve fish migration throughout the Sacramento River Basin is considered low. This measure was not recommended for further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival throughout the Sacramento River Basin.

Construct a Migration Corridor from the Sacramento River to the Pit River – This measure would consist of providing passage to spawning areas upstream from Shasta Dam for anadromous fish from the Sacramento River. One concept would include connecting the upper Pit River to the Sacramento River. Although there is a moderate potential for increasing populations of fish, the associated cost and uncertainties are high. This and similar measures were not recommended for further consideration primarily because of the high cost for complex infrastructure, the major impacts to other facilities and extensive long-term O&M requirements, and the high uncertainty of the potential to achieve and maintain successful fish passage and spawning.

Re-operate the CVP to Improve Overall Fish Management – This measure would include re-operating all of the CVP facilities in the Upper Sacramento River system to improve anadromous fish resources. CVPIA implementation already includes reoperation to benefit fish. Additional reoperation is likely to provide a diminished level of benefits and have an adverse impact on other project objectives. The potential to improve survivability is considered to be low. This measure was not recommended for further development.

Construct a Fish Ladder on Shasta Dam – This measure would include constructing a fish ladder on Shasta Dam to allow the passage of anadromous fish to access Shasta Lake and approximately 40 miles of the Upper Sacramento River, approximately 24 miles of the lower McCloud River, and various small creeks and tributaries to Shasta Lake. Implementing a fish ladder of this magnitude has significant uncertainties and, therefore, the potential for improving the survivability of anadromous fish throughout the Sacramento River Basin is considered low. This measure was not recommended for further consideration because of the estimated high cost of constructing and operating the fish ladder, the low likelihood for success in getting the fish to successfully ascend the ladder, and the likely major impacts to existing warm and coldwater species in the upper river reaches.

Reintroduce Anadromous Fish to Areas Upstream from Shasta Dam – This measure would include trapping anadromous fish along the Sacramento River immediately downstream from Keswick Dam, transporting the fish by tanker truck from the Delta to areas along the Upper Sacramento River near Volmers, and releasing the fish in the Upper Sacramento River to spawn. This measure also would include trapping the potential out-migrating fish and transporting them to the Sacramento River near Keswick for release into the lower river. The potential for improving the survivability of fish in the Sacramento River Basin is considered low. This measure was not recommended for further consideration because of the high cost to implement the plan, its low likelihood for success, given the inability to recapture the out-migrants, and likely major impacts to existing warm and coldwater species in the upper river.

Integrated, Flexible Generation of Hydropower

Various potential measures were identified to address the primary objective of providing sustainable hydropower. Following is a brief discussion of the array of measures considered.

Incorporate Pumped Storage into NODOS Project – Construction of new reservoir and afterbay could generate hydropower for use in capacity firming of variable resources (e.g., wind and solar).

Iowa Hill Pumped Storage Project – The Sacramento Municipal Utility District has completed an EIR/EIS for new 400-megawatt (MW) pumped storage at Iowa Hill as part of their Upper American River Project. Although this project meets the primary objective for sustainable hydropower, it does not meet the other primary objectives for the NODOS Project.

Mokelumne Pumped Storage Project – The Pacific Gas and Electric Company (PG&E) has filed with Federal Energy Regulatory Commission (FERC) and received permits for a preliminary study of new pumped storage on the Mokelumne River. Although this project meets the primary objective for sustainable hydropower, it does not meet the other primary objectives for the NODOS Project.

Red Mountain Bar Pumped Storage Project – Turlock Irrigation District and Modesto Irrigation District are evaluating building a new reservoir adjacent to Don Pedro Reservoir to enable pumped storage hydropower generation. Although this project meets the primary objective for sustainable hydropower, it does not meet the other primary objectives for the NODOS Project.

Mulqueeney Ranch Pumped Storage Project – The Mulqueeney Ranch project is being evaluated by Brookfield Renewable Power as a new project to generate approximately 230 MWs that would be constructed in the vicinity of Patterson Pass. Although this project meets the primary objective for sustainable hydropower, it does not meet the other primary objectives for the NODOS Project.

Kings River Pumped Storage Project – PG&E has received a preliminary FERC permit and is studying two potential pumped storage alternatives (one in the Lost Canyon area and the other on Lower Short Hair Creek) on the Kings River. Although this project meets the primary objective for sustainable hydropower, it does not meet the other primary objectives for the NODOS Project.

Water Quality

The various potential water management measures identified to address the primary objective of improving water quality in the Delta for M&I users fall into two major categories: increased flow to improve Delta water quality, and source water treatment improvements.

Increased Flow to Improve Delta Water Quality

Improve Water Quality by Increasing Flows from New Conservation Offstream Surface Storage – Offstream storage could provide additional flow to the Delta to augment Delta outflow and improve water quality during periods of poor water quality. Offstream storage could allow changes in the timing, magnitude, and duration of diversions from the Sacramento River. This measure was retained for potential further development because it has a high likelihood of success in helping to achieve both primary objectives.

Extend T-C Canal to Cache Creek to provide flow from Sites Reservoir to the Delta – This measure would involve extending the T-C Canal to Cache Creek or installing a pipeline from the T-C Canal to Cache Creek. Water then could be released from NODOS into Cache Creek to flow into the Sacramento River. Cache Creek has water quality issues, including high concentrations of mercury in sediments that would be difficult to remove. The creek also has flow limitations. Most sediment releases occur under high flow conditions during the wet season. Any water quality benefits from discharging water from NODOS to Cache Creek are overshadowed by the mobilization of mercury-laden sediments during July through September. This alternative would face substantial public and agency resistance; therefore, it was not recommended for further consideration in the NODOS feasibility studies.

Source Water Treatment Improvements

Implement Treatment/Supply of Agricultural Drainage Water – This measure would consist of collecting agricultural drainage water from farms along the Sacramento and San Joaquin rivers and treating the drainage water for reuse. Major elements of this measure probably would include an agricultural drainage collection system, pre-treatment of drainage water, desalination facilities, ancillary facilities associated with desalination and brine disposal, and conveyance of treated water to end users. In addition, removal of total organic carbons and pesticides, plus supplementary disinfection, might be required before municipal agencies would consider using the treated agricultural runoff as a potable water supply. This measure would be costly to implement and operate initially; in addition, there would be problems relative to brine disposal. This measure would not reduce raw water quality concerns in the Delta. Accordingly, this measure was not recommended for further evaluation.

Construct Desalination Facility – This measure would consist of constructing seawater or brackish surface or groundwater desalination plants to supplement existing water supplies and help offset future demands. In addition, a conveyance system would be needed to transport the desalinated water to the customer or to the water agency distribution systems. Although technological advances have substantially decreased treatment costs, desalination remains costly compared with most other water sources. Even with continual improvement in membrane technology, energy costs can account for as much as one-half of the total cost of desalination. This measure would not reduce raw water quality concerns in the Delta. This measure was not recommended for further evaluation.

This page intentionally left blank

A2.0 ALTERNATIVE RESERVOIR LOCATIONS

Initial evaluation activities associated with the NODOS Project included an evaluation of 52 potential reservoir locations prior to the CALFED Record of Decision (ROD). Twelve sites throughout California were previously identified by CALFED as promising locations for further evaluation, including four north-of-the Delta potential locations:

- Colusa Reservoir Complex
- Red Bank Project
- Sites Reservoir
- Newville Reservoir

These proposed locations were evaluated in detail and the results of that evaluation are discussed in Chapter 4 in the main text of this Progress Report. Two additional proposed sites were identified during the feasibility studies as potential locations for offstream storage reservoirs: Cottonwood Reservoir Complex and Veterans Lake.

Reservoir Location Descriptions

Locations for the Cottonwood Reservoir Complex and Veterans Lake are described below and shown on Figure A2-1.

- **Cottonwood Reservoir Complex** – Cottonwood Reservoir is located in northwest Tehama County, approximately 21 miles southwest of Anderson. The Cottonwood Reservoir Complex could be designed as a 0.4 MAF reservoir (Cottonwood South Reservoir) or as a 1 MAF reservoir (Cottonwood South Reservoir and Cottonwood North Reservoir). At 0.4 MAF, the reservoir (Cottonwood South Reservoir) would cover 3,400 acres. At 1 MAF, the reservoir would cover 7,100 acres at a mean pool elevation of 1,300 feet. The Cottonwood South Reservoir would be filled by runoff from 179,500 acres in South Fork Cottonwood Creek, Salt Creek, and Hensley Creek watershed. The Cottonwood North Reservoir would be filled by runoff from 84,000 acres from the Beegum Creek and Dry Creek watershed. Cottonwood South Reservoir would be formed by a dam on Salt Creek just upstream from Dexter Gulch, 4 miles south of Route 36. Cottonwood North Reservoir would be formed by a dam on Dry Creek just downstream from the confluence with Pentacola Gulch, on Route 36.

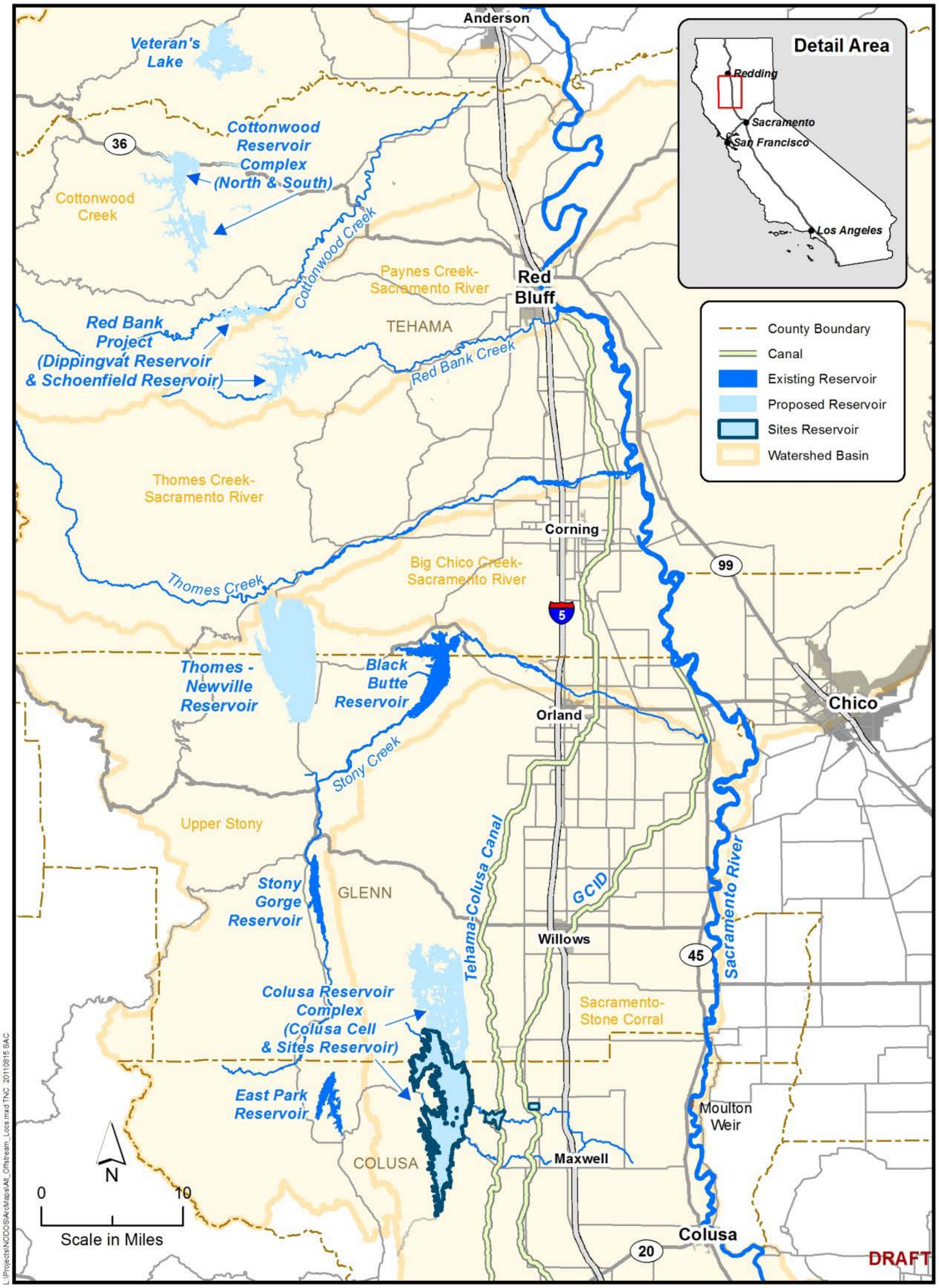


Figure A2-1. Alternative Offstream Locations for NODOS

- **Veterans Lake** – Veterans Lake would be located in southwest Shasta County near Ono, approximately 17 miles west of Anderson, and would inundate 5,100 acres and store up to 0.6 MAF at a mean pool elevation of 1,050 feet. Veterans Lake would be filled from the North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, and Jerusalem Creek watershed covering 109,500 acres. Veterans Lake would be formed by Roaring Dam on Roaring Creek and by Crow Dam on Crow Creek and six small saddle dams along the ridge between Roaring Creek and Bee Creek. Roaring Creek Dam would be approximately 3 miles downstream from Bland Road, off of A-16 Platina Road.

Initial Evaluation of Potential Locations

Because all of the projects are upstream of the Delta and adjacent to the Sacramento River, the types of benefits (such as supplemental yield for various uses and reduced diversions from the Sacramento River during the peak local delivery period) would vary primarily in scale. Table A2-1 lists the comparative project characteristics.

Table A2-1. Comparison of Storage and Watershed Areas

Attribute	Colusa Reservoir Complex	Red Bank Project	Sites Reservoir	Newville Reservoir	Cottonwood Reservoir Complex	Veterans Lake
Gross Storage (acre-feet)	3,300,000[a]	354,000[a]	1,200,000 to 1,900,000[a]	1,800,000 to 3,000,000[a]	400,000 to 1,000,000	600,000 to 1,000,000
Dead Storage (acre-feet)	100,000	N/A	40,000	50,000	8,000 to 40,000	20,000
Watershed (acres)	94,700	109,200	59,700	174,700	263,500	109,500

[a] From Initial Surface Water Storage Screening (CALFED, 2000c).

Physical Environment

Figure A2-1 shows delineation of United States Geological Survey watersheds and subbasins containing the proposed offstream reservoirs. Table A2-1 shows the drainage area of the watersheds upstream of the dams. Reservoir locations are preferred with high gross storage and reduced areas of watershed impacts (generally indicative of reduced environmental impacts).

Topography

The physical topography of the watersheds draining the east side of the Coast Range toward the Sacramento Valley is diverse. The topography ranges from steep, rugged, mountainous terrain within the upper watersheds to rolling foothills in the project areas to relatively flat alluvial terrain as the watersheds enter the Sacramento Valley. Elevations range from less than 40 feet on the valley floor to over 8,000 feet along the Coast Range divide.

- **Cottonwood Reservoir Complex** – The Cottonwood Reservoir Complex area consists of typical foothill topography made up of rolling hillocks and broad, shallow valleys. The project area is located between the north end of the Sacramento Valley, and the slopes and high peaks of the inner coastal range located to the west of the site. The elevation in the Cottonwood Reservoir area ranges from approximately 890 feet to over 1,000 feet above sea level. Beegum Creek parallels State Highway 36 and is the main drainage feature in the project area; it dissects the project area in an approximately west to east direction heading to its confluence with the Dry Creek, Cottonwood Creek, and the Sacramento River south of Redding.

- **Veterans Lake** – The Veterans Lake area consists of low elevation rolling hills interspersed with wide and shallow valleys. The area is located between the northernmost tip of the Sacramento Valley that lies to the east of the proposed project site, and the slopes and high peaks of the inner coastal range located to the west of the site. Elevation in the project area ranges from approximately 950 feet to over 1,050 feet above sea level. Roaring Creek is the main drainage feature in the project area and dissects it in an approximately west to east direction heading to its confluence with the Cottonwood Creek and eventually with the Sacramento River just south of Redding.

Water Resources

Table A2-2 shows the optional water supply sources considered for the alternative NODOS projects. Colusa Reservoir Complex, Cottonwood Reservoir Complex, Red Bank Project, Sites Reservoir, Newville Reservoir, and Veterans Lake each have a number of optional water supply sources. These sources may be packaged in various combinations to generate sufficient water supply for a specific project. Cottonwood Reservoir Complex has 10 optional water supply sources and Veterans Lake has 9 optional water supply sources. Local inflow sources are not shown, but each offstream project would receive some local inflow from the relatively smaller streams that flow directly to the offstream reservoirs.

Table A2-2. Optional Water Supply Sources for NODOS Projects

Colusa Reservoir Complex	Cottonwood Reservoir Complex	Red Bank Project	Sites Reservoir	Newville Reservoir	Veterans Lake
• Colusa Basin Drain • Grindstone Creek • Little Stony Creek • Sacramento River • Stony Creek • Thomes Creek	• Beegum Creek • Cold Fork Creek • Clear Creek • Dry Creek • Hensley Creek • Sacramento River • Salt Creek • South Fork Cottonwood Creek • Stinking Creek • Weemasoul Creek	• South Fork Cottonwood Creek	• Colusa Basin Drain • Grindstone Creek • Little Stony Creek • Sacramento River • Stony Creek • Thomes Creek	• Sacramento River • Stony Creek • Thomes Creek	• Clear Creek • Crow Creek • Duncan Creek • Jerusalem Creek • Middle Fork Cottonwood Creek • North Fork Cottonwood Creek • Roaring Creek • Sacramento River • Wilson Creek

Streamflow records were reviewed to determine the relative quantity of water that has historically flowed in various streams. Table A2-3 shows November through March streamflow volumes at representative locations for the period 1945-1994. Figure A2-2 shows the location of waterways listed in Table A2-3. The November through March period was chosen to avoid any operational conflicts with existing facilities and water rights. Local irrigation operations often begin in April and conveyance facilities are being used for deliveries. Most of the data shown are directly from gage station streamflow records. A number of the data records needed to be extended or adapted using basic hydrologic correlations. Correlations for the entire period of record were required for Grindstone Creek, inflow to East Park Reservoir, South Fork Cottonwood Creek, North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, Beegum Creek, Cold Fork Creek, Hensley Creek, Dry Creek, and Jerusalem Creek.

Table A2-3. November – March Streamflow Volumes, 1945-1994 of Optional Water Supply Source Streams

Source and Location	Minimum (MAF)	Maximum (MAF)	Average (MAF)
Sacramento River at Butte City	1.613	14.415	5.4607
Whiskeytown Reservoir at Keswick Reservoir[a]	0.541	1.297	0.937
Stony Creek below Black Butte Dam	0.001	1.052	0.2345
Colusa Basin Drain at Highway 20	0.039	0.759	0.2089
Inflow to Stony Gorge Reservoir	0.004	0.509	0.1513
Thomes Creek at Paskenta	0.007	0.359	0.1509
Beegum Creek, Dry Creek, Cold Fork Creek, Hensley Creek, and South Fork Cottonwood Creek to Cottonwood South Reservoir[b]	0.089	0.238	0.144
Beegum Creek and Dry Creek to Cottonwood North Reservoir[b]	0.084	0.222	0.134
Inflow to Proposed Grindstone Reservoir	0.009	0.301	0.0854
Middle Fork Cottonwood Creek to Veterans Lake[b]	0.053	0.141	0.085
Inflow to East Park Reservoir with Rainbow Diversion	0.001	0.222	0.0762
South Fork Cottonwood Creek at Dippingvat	0.005	0.259	0.0754
Clear Creek at Whiskeytown Reservoir[c]	0.021	0.206	0.063
North Fork Cottonwood Creek to Veterans Lake[b]	0.021	0.057	0.034

[a] Values computed based on 10 years of record, Bureau of Reclamation.
[b] Values computed based on SCS runoff methodologies.
[c] Values computed based on 46 years of record, USGS gauging station, Clear Creek at Igo.

MAF = million acre-feet
SCS = Soil Conservation Service
USGS = United States Geological Survey

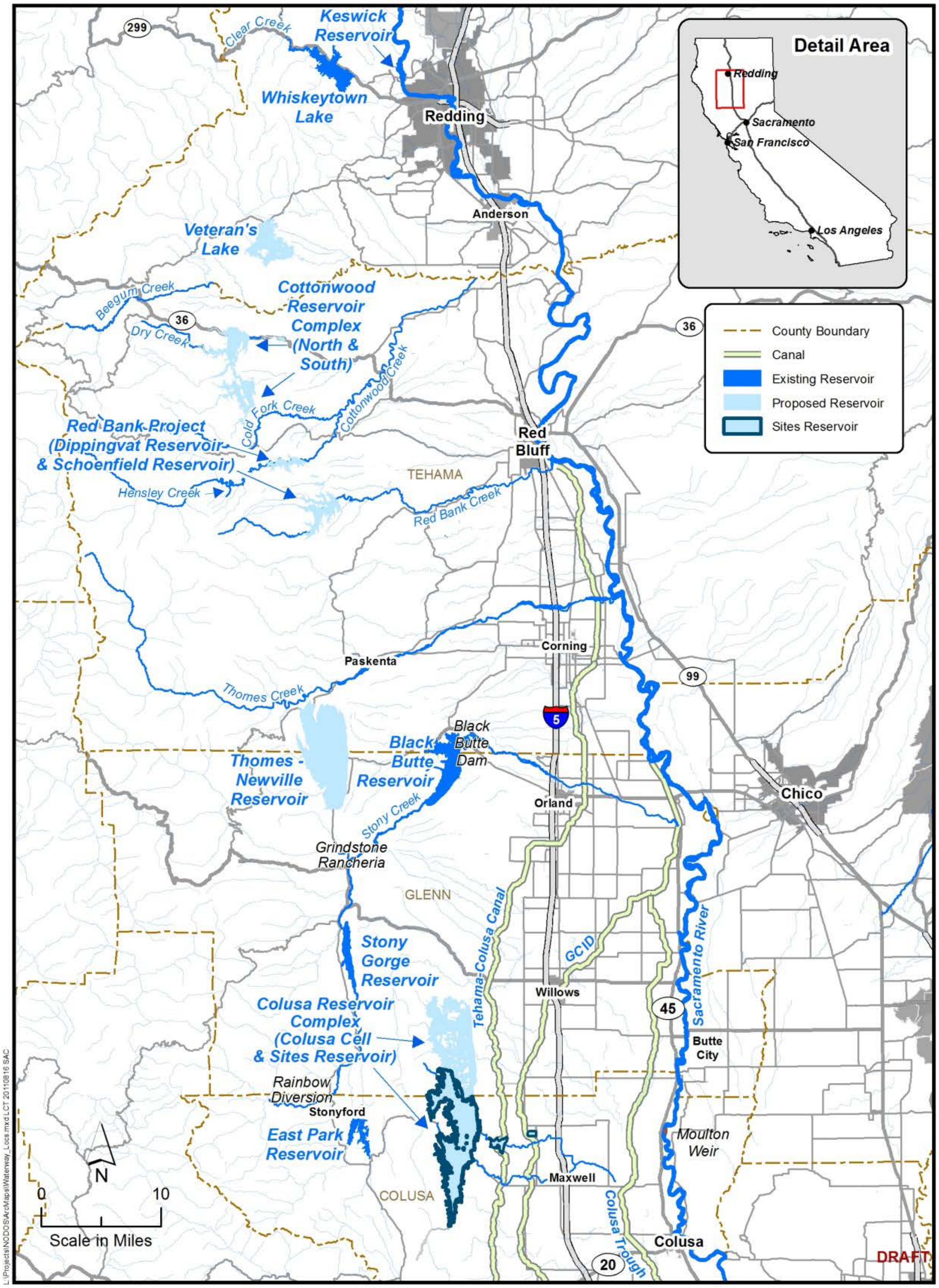


Figure A2-2. Locations of Waterways in the NODOS Vicinity

By far, the Sacramento River is the largest water supply source for the options considered. With an average historical five-month flow volume at Butte City of nearly 5.5 MAF, the river's flow is more than 5 times the size of the second largest option, Whiskeytown Reservoir. The six smallest optional water supply sources are Grindstone Creek, Middle Fork Cottonwood Creek, East Park Reservoir, South Fork Cottonwood Creek, Clear Creek, and North Fork Cottonwood Creek, each with an average November through March runoff of less than 0.1 MAF. The sources are not independent options. All of the tributary streams contribute to the flow of the Sacramento River. Outflow from East Park Reservoir becomes inflow to Stony Gorge and ultimately contributes to the flow below Black Butte.

Streamflow volumes are dependent upon diversion location. In general, volumes increase in the downstream direction. Optional diversion locations for the Sacramento River are at the existing T-C Canal diversion in Red Bluff, the existing GCID Canal diversion near Hamilton City, and a new diversion opposite Moulton Weir. Diversion locations investigated for Stony Creek include Black Butte Lake, Stony Gorge Reservoir, and East Park Reservoir with additional water from the Rainbow Diversion, and at the GCID Canal crossing. The diversion location investigated for Colusa Basin Drain is due west of Moulton Weir, approximately 10 miles north of Highway 20. Thomes Creek diversion locations include a number of options west of Paskenta and at the T-C Canal crossing. The Grindstone Creek diversion location is from a potential Grindstone Reservoir. The Grindstone Dam site is approximately 2.5 miles upstream from the confluence with Stony Creek. The diversion location for South Fork Cottonwood Creek is at the proposed Dippingvat Reservoir for the Red Bank Project. A diversion from the GCID Canal was evaluated for Newville Reservoir.

Biological Resources

The following subsections summarize biological resources, such as vegetation, fish, and wildlife, found in the potential Cottonwood Reservoir Complex and Veterans Lake project areas.

Vegetation

The watersheds of Sacramento Valley west-side streams contain a variety of vegetative communities, including white fir, Klamath mixed conifer, Douglas fir, ponderosa pine, closed-cone pine-cypress, montane hardwood conifer, montane hardwood, blue oak *woodland*, valley oak woodland, blue oak foothill pine, montane riparian, valley foothill riparian, montane chaparral, mixed chaparral, chamise-redshank chaparral, annual grassland, and cropland.

The vegetation in the Cottonwood Reservoir area is dominated by blue oak woodland (*Quercus douglasii* Woodland Alliance), valley oak woodland (*Quercus lobata* Woodland Alliance), and introduced annual grassland alliance dominated by a variety of non-native grass species such as wild oats (*Avena barbata*), rye grasses (*Lolium* spp.), non-native barley (*Hordeum* spp.), and brome grasses (*Bromus* spp.). Several smaller areas dominated by foothill pine, chaparral, riparian and wetland plant species are also present and contain a large diversity of native plant species.

Blue oak woodlands occur in higher areas of rolling hills throughout the Cottonwood Reservoir area. Valley oak woodlands are located primarily near the valley bottoms. Both of these plant communities are dominated almost solely by the two species of oak. Oak woodlands are considered sensitive plant communities and are strictly protected by California law (Senate Concurrent Resolution 17 and Public Resources Code Section 21083.4).

Based on the California Natural Diversity Database (CNDDB) (California Department of Fish and Game [CDFG]) several listed plant species have a high potential to occur in the Cottonwood Reservoir area. These plant species include the dimorphic snapdragon (*Antirrhinum subcordatum*), Jepson's milk-vetch (*Astragalus rattanii* var. *jepsonianus*), big-scale balsamroot (*Balsamorrhiza macrolepis* var. *macrolepis*), Brandegee's eriastrum (*Eriastrum brandegeeae*), Tracy's eriastrum (*Eriastrum tracyi*), Stebbin's harmonia (*Harmonia stebbinsii*), dubious pea (*Lathyrus sulphureus* var. argillaceus), woolly meadowfoam (*Limnanthes floccosa* ssp. *floccosa*), and leafy–stemmed miterwort (*Mitella caulescens*).

The vegetation in the Veterans Lake area is dominated by three major vegetation alliances: blue oak woodland (*Quercus douglasii* Woodland Alliance), valley oak woodland (*Quercus lobata* Woodland Alliance), and introduced annual grassland alliance dominated by a variety of non-native grass species such as wild oats (Avena barbata), rye grasses (*Lolium* spp.), non-native barley (*Hordeum* spp.), brome grasses (*Bromus* spp.) and others. Several smaller areas dominated by foothill pine, cypress, chaparral, riparian, and wetland plant species are also present.

Blue oak woodlands are typically located in higher areas on rolling hills throughout the Veterans Lake site. Valley oak woodlands occur near the valley bottoms where they can reach the underground water table. Both of these plant communities are dominated by the two species of oak, and both are considered sensitive and strictly protected by California law (Senate Concurrent Resolution 17 and Public Resources Code Section 21083.4). The northern interior cypress forest alliance is another sensitive plant community with a high potential to occur in the area, based on the CNDDB records. Two listed plant species with a high potential to occur in the Veterans Lake area are the Siskiyou fireweed (*Epilobium siskiyouense*) and blushing wild buckwheat (*Eriogonum ursinum* var. *erubescens*).

Fish and Wildlife Resources

A wide variety of wildlife species utilize the Cottonwood Reservoir Complex and Veterans Lake project areas in and around the proposed reservoir areas either seasonally or year-round.

The watersheds of the North Coast Range draining east toward the Sacramento Valley contain native and non-native species, warm-water and coldwater species, and anadromous and resident fish species. At least 24 species of fish are present in these watersheds. Several state- or federally listed fish species occur in the region, including steelhead and various runs of Chinook salmon. Coldwater habitats are present in the upper watersheds of the major streams including Cottonwood Creek, Red Bank Creek, and Thomes Creek.

In 1976, CDFG conducted studies in lower Cottonwood Creek (below the north fork confluence) and in South Fork Cottonwood Creek. The survey found 10 resident game species and 13 nongame species of fishes. The survey also found runs of fall-run, late fall-run, and spring-run Chinook salmon in lower Cottonwood Creek and spring-run Chinook salmon and steelhead in South Fork Cottonwood Creek.

In addition to providing habitat for salmon, Cottonwood Creek is the most important source of sediments to the Sacramento River, sediments which help maintain riparian rejuvenation. Cottonwood Creek has been designated as Essential Fish Habitat by the National Marine Fisheries Service (NMFS) and the Pacific Fisheries Management Council. Essential fish habitat is habitat necessary to support a long-term sustainable salmon fishery.

Summary of Evaluated Animal and Plant Species

Table A2-4 provides the results from a screening level CNDDB evaluation of the animal and plant species evaluated and the probability of species occurrence with the reservoir project areas.

Table A2-4. Occurrence and Listing Status of Animal and Plant Species Evaluated

Species	Status[a]		Occurrence Probability within Reservoir Sites[b]	
***Scientific Name* (Common Name)**	**Federal**	**State**	**Cottonwood**	**Veterans Lake**
Amphibian				
Ascaphus truei (Pacific tailed frog)	None	CSC	x	
Rana boylii (Foothill yellow-legged frog)	BLM S	CSC		x
Oncorhynchus tshawytscha (Chinook salmon – Central Valley Spring Run ESU)	FT	ST	x	
Oncorhynchus tshawytscha (Chinook salmon – Sacramento River Winter Run ESU)	FE	SE	x	
Oncorhynchus tshawytscha (Chinook salmon – Central Valley Fall/Late Fall-Run ESU)	NMFS SC, FS	CSC	x	
Birds				
Accipiter gentilis (Northern goshawk)	BLM S	CSC, CDF S		x
Dendroica petechia brewsteri (Yellow-warbler)	USFWS BCC	CSC	x	
Mammals				
Martes americana humboldtenis (Humboldt marten)	FS	CSC	x	
Martes pennanti DPS (Pacific fisher)	FC, FS, BLM S	CSC		x
Perognathus inornatus inornatus (San Joaquin pocket mouse)	BLM S	CSC	x	
Taxidea taxus (American badger)	None	CSC		x

Table A2-4. (Continued)

Species	**Status[a]**		**Occurrence Probability within Reservoir Sites[b]**	
***Scientific Name* (Common Name)**	**Federal**	**State**	**Cottonwood**	**Veterans Lake**
Plants				
Antirrhinum subcordatum (Dimorphic snapdragon)	None	4.3	x	
Astragalus rattanii var. *jepsonianus* (Jepson's milk-vetch)	None	1B.2	x	
Balsamorhiza macrolepis var. *macrolepis* (Big-scale balsamroot)	None	1B.2	x	
Epilobium siskiyouense (Siskiyou fireweed)	None	1B.3		x
Eriastrum brandeegeae (Brandegee's eriastrum)	None	1B.2	x	
Eriastrum tracyi (Tracy's eriastrum)	None	1B.2	x	
Eriogonum ursinum var*. Erubescens* (Blushing wild buckwheat)	None	1B.3		x
Harmonia stebbinsii (Stebbins' harmona)	None	1B.2	x	
Lathyrus sulphureus var*. argillaceus* (Dubious pea)	None	3	x	
Leptosiphon nuttallii (Mt. Tedoc leptosiphon)	None	1B.3	x	
Limnanthes floccosa (Woolly meadowfoam)	None	4.2	x	
Mitella caulescens (Leafy-stemmed mitrewort)	None	4.2	x	

[a] **Status Key:**

1B	=	Rare, threatened or endangered in California and elsewhere
2	=	Rare, threatened or endangered in California but more common elsewhere.
3	=	Plants for which we need more information – review list
4	=	Plants of limited distribution – watch list
.1	=	Seriously endangered in California (CDFG, 2012)
.2	=	Fairly endangered in California (CDFG, 2012)
.3	=	Not very endangered in California (CDFG, 2012)
BLM S	=	Bureau of Land Management sensitive
CDF	=	California Department of Forestry and Fire Protection sensitive species
CSC	=	California Species of Special Concern
DPS	=	Distinct population segment
ESA	=	Endangered Species Act
ESU	=	Evolutionary significant unit
FC	=	Federal Candidate for listing under the ESA
FE	=	Federally Endangered under the ESA
FS	=	Forest Service Sensitive Species
FT	=	Federally Threatened
NMFS SC	=	National Marine Fisheries Service species of concern
SE	=	State Endangered under CESA
ST	=	State Threatened under CESA
USFWS	=	U.S. Fish and Wildlife Service
USFWS BCC	=	USFWS birds of conservation concern

Table A2-4. (Continued)

[b] Includes species that have been observed in survey efforts and the probability of species that may be present in the area, based on preliminary habitat evaluations, but have not been observed to date.

Occurrence Probability Key:

x = Record in the California Natural Diversity Database database within 1 mile of the site.

Socio-Economic Resources

The following subsections discuss socioeconomic resources encountered in the Cottonwood Reservoir Complex and Veterans Lake study area.

Land Use

The watersheds draining the east slope of the Coast Range are subject to a variety of land use practices. Upper elevations are primarily commercial forest lands and managed for timber production, outdoor recreation, and grazing. Foothill areas are currently managed primarily for livestock grazing. Some foothill valleys support dryland grain or orchard production. Extensive mineral extraction activities have historically occurred throughout foothill and mountain areas. Sacramento Valley portions of the watersheds support a wide variety of agricultural uses including livestock grazing, irrigated grain and truck-crops, and orchards.

Land use within the Cottonwood Reservoir Complex is dominated by seasonal and year-round livestock grazing. Limited horse and sheep grazing may also occur. Only two occupied ranch complexes exist within the project area. However, several corrals and stock ponds to support livestock occur within the reservoir area. Limited commercial firewood harvesting may occur in some areas.

Land use within the Veterans Lake is dominated by seasonal and year-round livestock grazing. Limited horse and sheep grazing may also occur. One large occupied ranch complex exists within the project area. Several corrals and stock ponds to support livestock occur within the reservoir area.

Cultural Resources

Current information on the cultural resources present in the Cottonwood Reservoir area has not been ascertained. However, the Cottonwood Reservoir locale is upstream and adjacent to the Tehama Lake project surveyed by the United States Army Corps of Engineers (USACE) in 1982, and it is possible that the two projects may overlap to a degree. The Tehama Lake survey identified 122 cultural resources within 22,000 acres. The resources are represented by 80 prehistoric sites and 43 historic-era deposits. A large percentage of the prehistoric resources were midden habitation sites; the remaining sites were lithic scatters. Virtually all of the historic sites reflect some element of ranching; only one mining site was recorded.

Future studies of the Cottonwood Reservoir location would likely have results similar to that of the Tehama Lake survey due to similar topography and the availability of comparable resources.

A record search was not completed for the Veterans Lake area. However, data is available from an intensive survey that was conducted in 1981-1982 for the proposed 24,000-acre Dutch Gulch Lake, which was located directly downstream from the Veterans Lake site. It is worthy to note that the Dutch Gulch Lake study included the lower reaches of Veterans Lake along Roaring Creek. This survey resulted in the identification of 283 sites (117 prehistoric and 166 historic-era). The prehistoric deposits represent long and short-term habitation and a variety of resource procurement sites. The historic-era remains primarily reflect ranching and mining activities, including a number of Chinese mining sites. Further studies at Dutch Gulch resulted in the recommendation of three prehistoric and one historic-era district, and seven prehistoric and two historic-era individual sites that are eligible for listing in the national Register of Historic Places.

The land forms and resources present in the Veterans Lake project are similar to those found at Dutch Gulch. This similarity would suggest that an intensive survey of Veterans Lake would produce a similar site density of cultural resources.

Conclusions from Initial Evaluation of Potential Reservoir Locations

Three viable surface storage measures suitable for more detailed evaluation were identified through the initial evaluation process: Red Bank Project, Colusa Reservoir Complex, Sites Reservoir, and Newville Reservoir. Potential reservoir locations associated with Cottonwood Creek were not recommended for more detailed evaluation, including Cottonwood Reservoir Complex (Cottonwood South Reservoir [an offstream reservoir formed by a dam on Salt Creek] and Cottonwood North Reservoir [an offstream reservoir formed by a dam on Dry Creek]). More detailed evaluations were also not performed for Veterans Lake (an offstream reservoir in Roaring Creek, Crow Creek, and Wilson Creek watersheds). As noted in the CALFED *Initial Surface Water Storage Screening* (CALFED, 2000c), Cottonwood Creek is the largest undammed tributary in the Upper Sacramento River basin and the most important source of sediment in the Sacramento River. Cottonwood Creek has been designated as a critical habitat for spring run Chinook and Steelhead (Federal Register, 2000). This creek provides spawning habitat for fall-run and late-fall-run Chinook salmon and supports spring-run Chinook salmon. Given the importance of Cottonwood Creek to Sacramento River health and fishery production, onstream locations would compromise the NODOS objective to increase the populations of anadromous fish and other aquatic species.

The Cottonwood Reservoir Complex proposes a larger reservoir and the height of the dam increases the potential for hydropower generation through pumped storage. Major concerns include the ability to fill the reservoir rapidly enough to provide a cost-effective yield and the cost of conveyance. The proposed diversion schemes reduce the fish passage conflicts with steelhead and Chinook, but the alteration of flows could have significant impacts on anadromous fish. The effects of the intakes on sediment transport and the size distribution of the sediment would also need to be studied. The effect of the reservoir on sediment transport in Cottonwood Creek and the lack of coldwater pool benefits would also be a concern. In addition, the size of the natural channel downstream of Cottonwood Reservoir Complex would constrain the rate for discharging water from the reservoir to less than 1,000 cfs, and, if higher outflows are required, the additional construction and operating cost would be higher when compared to Sites Reservoir.

Veterans Lake could be filled from North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, and Duncan Creek. Reservoir sizes of 0.5 thousand acre-feet (TAF) and 1 MAF are possible. Because the reservoir would be filled from tributaries to the Sacramento River, there is less water available to fill the reservoir than is available directly from the Sacramento River. Mean annual runoff from Cottonwood Creek is 650 TAF, compared to a mean annual runoff in the Sacramento River of 8,518 TAF at Colusa (DWR, 2009a). Challenges in filling the reservoir would significantly constrain the yield for Veterans Reservoir. The cost of new conveyance at Veterans Lake from Whiskeytown Reservoir or the Sacramento River through Whiskeytown Reservoir to minimize the fill time would be high in comparison to the cost of constructing the reservoir itself. Water surface elevation in the reservoir would vary significantly in response to demand due to the relatively steep topography. As an offstream reservoir, Veterans Lake would not create a new barrier to fish passage, but the intakes on Cottonwood Creek might alter the sediment load or size distribution of the sediment in Cottonwood Creek. Altering the flows in Cottonwood Creek by operating a diversion might be detrimental to spawning salmon and is likely to be a significant concern to NMFS, U.S. Fish and Wildlife Service (USFWS), and CDFG. Veterans Lake is also unlikely to offer the magnitude of the coldwater pool benefits at Shasta Lake that can be accomplished with Sites Reservoir. Additionally, the size of the natural channel downstream of Veterans Lake would constrain the rate for discharging water from the reservoir to less than 1,000 cfs, and if higher outflows are required, the additional construction and operating cost would be higher when compared to that for Sites Reservoir.

This page intentionally left blank

A3.0 INITIAL PLAN FORMULATION

The IAIR recommended the following initial alternative scenarios be carried forward into the PFR for further development into detailed initial alternatives:

- Initial Alternative A – Environmental Focus
- Initial Alternative B – Water Quality Focus
- Initial Alternative C – Water Supply Focus
- No-Action Alternative

Instead of developing an exhaustive list of plans to account for the vast array of potential measure combinations and sizes, the PFR focused on developing an array of nine different initial action alternative plans to address the primary planning objectives, constraints, and criteria (sustainable hydropower generation was a secondary objective at the time the initial alternative evaluation was performed).

The following initial action alternative plans were developed from the retained measures:

- A No Project (National Environmental Policy Act [NEPA])/No Project (California Environmental Quality Act [CEQA]) Alternative
- Three initial action alternative plans with a water supply focus (Alternatives WS1A, WS1B, and WS1C)
- Two initial action alternative plans with an environmental enhancement focus to improve the survival of anadromous fish and other aquatic species (Alternatives AF1A and AF1B)
- One initial action alternative plan that blends water supply (with enhanced municipal and industrial [M&I] use) with environmental enhancement (Alternative WSFQ)
- Two initial action alternative plans with a water quality focus (Alternatives WQ1A and WQ1B)

Table A3-1 presents the initial action alternative plans, along with the conveyance and retained measures included in each. Table A3-2 shows the yield targets (percent) for each beneficiary category for each initial action alternative plan. The yield targets are used by CalSim-II modeling to allocate the storage in Sites Reservoir to provide the benefits. The yield targets for each of the beneficiaries vary among the action alternatives, depending on the focus and priorities of beneficiaries in each action alternative. The actual percentage of the yield for the beneficiaries in each action alternative may differ slightly from the yield targets because of operations constraints (e.g., pumping and conveyance capacity limits, storage capacity, etc.). It should be noted that at the time the initial alternatives were evaluated, long-term implementation of the environmental water account (EWA) was assumed. Inclusion of the EWA is no longer considered in the evaluation of complete alternative plans in the main body of the text.

Common Features of the Initial Action Alternative Plans

Several features are common to the remaining eight initial action alternative plans from the NODOS feasibility studies. The following preliminary features were incorporated into the initial alternatives:

- Sites Reservoir
- Sites Pumping Plant
- Funks Reservoir enlargement
- Minor modifications to Glenn-Colusa Irrigation District (GCID) Canal intake fish screens at Hamilton City
- Modifications to GCID Canal
- GCID Canal terminal regulating reservoir
- Road and utility relocations
- Transmission lines and substation requirements
- Hydroelectric facilities
- Recreation facilities
- Ecosystem restoration account features
- Sites Reservoir operations strategy

Sites Reservoir

The reservoir configuration used for the initial evaluation of alternatives would have a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet mean sea level (msl), and an inundation area of approximately 14,000 acres. The minimum operating water surface would be at elevation 320 feet. The reservoir would require construction of Golden Gate Dam on Funks Creek, Sites Dam on Stone Corral Creek, and nine saddle dams on the northern end of the reservoir, between the Funks Creek and Hunters Creek watersheds. These dams all would be zoned earth rockfill embankment type dams; previous investigations have indicated that this type of dam would be the most economical.

Table A3-1. Selected Measures Included in Initial Action Alternative Plans

		Measures Retained										
		Primary Objectives								Secondary Objectives		
		Water Supply				Anadromous Fish and Aquatic Species Survivability			Water Quality			
Initial Action Alternative Plans	**Conveyance**	**New Offstream Storage at Sites Reservoir**	**Conjunctive Use**	**Water Transfers**	**Water Use Efficiency**	**Restore Abandoned Gravel Mines**	**Improve Instream Aquatic Habitat**	**Replenish Spawning Gravel**	**Improve Flows to Delta from New Storage**	**Hydropower**	**Recreation**	**Flood Damage Reduction**
No Project Alternative	N/A		X	X	X							
WS1A – Reliance on Existing Canals	1,800-cfs GCID Canal 2,100-cfs T-C Canal	X	X	X	X				X	X	X	X
WS1B – New 1,500-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 1,500-cfs Pipeline Diversion 1,125-cfs Pipeline Release	X	X	X	X				X	X	X	X
WS1C – New 2,000-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 2,000-cfs Pipeline Diversion 1,500-cfs Pipeline Release	X	X	X	X				X	X	X	X
AF1A – New 1,500-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 1,500-cfs Pipeline Diversion 1,125-cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
AF1B – New 2,000-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 2,000-cfs Pipeline Diversion 1,500-cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WSFQ – New 2,000-cfs Pipeline with Fish Enhancements	1,800-cfs GCID Canal 2,100-cfs T-C Canal 2,000-cfs Pipeline Diversion 1,500-cfs Pipeline Release	X	X	X	X	X	X	X	X	X	X	X
WQ1A – New 1,500-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 1,500-cfs Pipeline Release	X	X	X	X				X	X	X	X
WQ1B – New 2,000-cfs Pipeline	1,800-cfs GCID Canal 2,100-cfs T-C Canal 2,000-cfs Pipeline Diversion 1,500-cfs Pipeline Release	X	X	X	X				X	X	X	X

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
N/A = not applicable
T-C = Tehama-Colusa

This page intentionally left blank

Table A3-2. Yield Target[a] for Each Beneficiary Category (percent)

Beneficiary	Plan Formulation Yield Targets (%)[b]							
	Initial Action Alternative Plans							
	WS1A	WS1B	WS1C	AF1A	AF1B	WSFQ	WQ2A	WQ1B
Water Supply (Agriculture, M&I, and Environmental)								
Urban and Agricultural	65	65	65	40	40	50	50	50
Local (non-CVP)	3	3	3	3	3	0	3	3
SWP	30	30	30	20	20	30	25	25
CVP	10	10	10	7	7	5	10	10
Environmental								
Level 4 Refuge	8	8	8	5	5	5	5	5
EWA	14	14	14	5	5	10	7	7
Water Quality (Urban and Restoration)	15	15	15	15	15	30	30	30
Ecosystem Restoration	20	20	20	45	45	20	20	20
TOTAL	100	100	100	100	100	100	100	100

[a] Targets allocated based on operational priorities of alternatives.
[b] Percentages developed using professional judgment for initial modeling evaluation.

CVP = Central Valley Project
EWA = Environmental Water Account
M&I = municipal and industrial
SWP = State Water Project

Golden Gate Dam would be constructed on Funks Creek, approximately 1 mile west of Funks Reservoir. The proposed dam embankment would have a crest elevation of 540 feet, a crest length of 2,250 feet, a maximum height of 310 feet above the streambed, and a total embankment volume of 10,590,000 cubic yards.

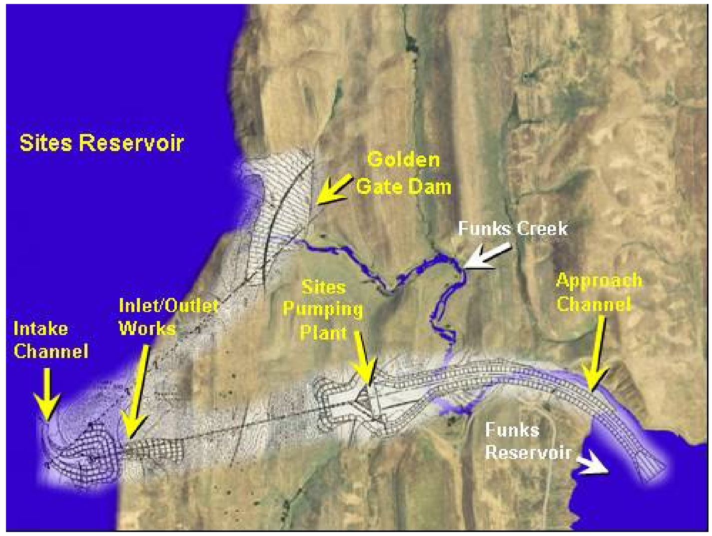
Sites Dam would be constructed on Stone Corral Creek, approximately 0.25 mile east of the town of Sites and 8 miles west of the town of Maxwell. The dam embankment would have a crest elevation of 540 feet, a crest length of 850 feet, a maximum height of 290 feet above the streambed, and a total embankment volume of 3,836,000 cubic yards.

Nine saddle dams would be required at the northern end of Sites Reservoir, between the Funks Creek and Hunters Creek watersheds, roughly along the Glenn-Colusa County line. Saddle Dams 1, 2, 4, and 9 are generally characterized as small-sized dams, with heights ranging from approximately 40 to 50 feet. Saddle Dams 3, 5, 6, 7, and 8 are generally characterized as medium-sized dams, with heights ranging from approximately 70 to 130 feet. Saddle Dams 3, 5, and 8 are the tallest and largest of the nine proposed saddle dams, with embankment volumes of approximately 3.5, 1.5, and 1.9 million cubic yards, respectively.

For the pumping capacities considered, the emergency spillway selected for the preliminary studies would consist of one 7-foot-diameter concrete pipe buried in the abutment or bottom of Saddle Dam 4 and sized primarily to accommodate inspection and maintenance. The invert of the spillway inlet would be at elevation 526 feet, 6 feet above the normal maximum pool. Saddle Dam 4 would be within a sheltered cove, which would prevent wind-driven waves from entering the spillway inlet structure when the reservoir water surface was at or near the maximum elevation of 520 feet.

Sites Pumping Plant

The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. Currently, Funks Reservoir operates in coordination with the T-C Canal, between elevation 205 feet and elevation 208 feet. Each alternative action plan would require a different pumping capacity. The pumping plant would house a combination of 680-cubic cfs and 350-cfs units to meet the needs of the alternative action plans. In each plan, an additional 680-cfs unit would be provided for standby.



Sites Pumping Plant
Source: DWR, 2007

The proposed Sites Pumping Plant would be approximately 3,300 feet southeast of (downstream from) Golden Gate Dam. The location and layout, including the plant/control building and conveyances, were determined on the basis of hydraulic and plant equipment requirements, foundation conditions, and the orientation of local faults. The final plant location should be determined by establishing a point of economic balance between the cost of the required excavation, tunnel length, and discharge lines, and the cost of long-term pumping.

The approach channel between Funks Reservoir and the Sites Pumping Plant would have a zero slope. The pumping plant would operate with tailwater elevations between 204 feet and 207 feet during pumping, and coordination with the conveyance facilities would be required to maintain the tailwater elevations in Funks Reservoir. The Sites Pumping Plant would be a conventional, indoor-type pumping plant, with an in-line arrangement of vertical pumping units. The pumping plant would have a reinforced concrete substructure and a steel superstructure, with the draft tube invert at elevation 170 feet.

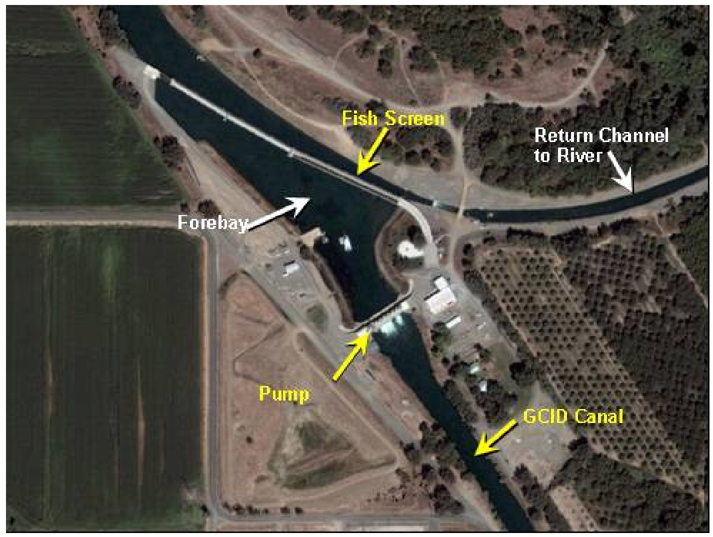
Funks Reservoir Enlargement

Funks Reservoir is on Funks Creek, approximately 7 miles northwest of Maxwell, in Colusa County. The existing Funks Reservoir, constructed in 1975 by Reclamation, has 2,250 acre-feet (AF) of total design storage capacity covering a surface area of 232 acres at elevation 205 feet. An earthfill dam with a crest elevation of 214 feet impounds the reservoir on the east. The dam forms the eastern bank of the T-C Canal as it crosses Funks Creek. An inlet is located at the northeastern end, adjacent to the dam spillway, and at an outlet to the southeast. Both have a gated release structure. The T-C Canal requires an operational elevation of Funks Reservoir between 204 feet and 206.25 feet. The spillway overflow discharge capacity is 25,000 cfs with all gates fully open.

Funks Reservoir would be modified to provide increased storage capacity to operate the conveyance system and regulate flows for the proposed Sites Pumping Plant. As designed, the active storage capacity of Funks Reservoir is 1,170 AF. To accommodate total inflow pumping capacities ranging from 3,900 cfs to 5,900 cfs, total active storage volumes from 1,300 to 5,290 AF were considered and analyzed. Selection of the enlarged reservoir capacity depends on the total inflow from the proposed conveyance options and the design capacity of the Sites Pumping Plant.

Funks Reservoir would serve as a forebay and afterbay for Sites Reservoir and would be used to regulate inflows and releases. For the proposed conveyance option, the T-C Canal would be widened and modified upstream from Funks Reservoir to dissipate inflow energy before entering the reservoir.

Modifications to GCID Canal Intake Fish Screens



Glenn-Colusa Irrigation District Canal Intake
Source: DWR, 2007

The original GCID fish screen structure, built in 1972, consisted of 40 drum-screen assemblies mounted in separate bays within the 480-foot-long reinforced concrete structure. The drum screens were retrofitted in 1993 with flat plate screens and a new cleaning system. In 2001, a 525-foot extension of the fish screen structure was completed to meet current fish screen performance criteria. New brush-cleaning systems were installed on both the new and the original portions of the fish screen. The complete structure now consists of 85 bays with 12-foot by 12-foot fish screen panels mounted in each bay. Solid steel panels, called barrier panels, close off the portion of the bay between the top of the screen panel and the structure’s top deck. The existing total screen area is 11,400 square feet, which provides approximately 3,760 cfs of diversion capacity with river levels at or above the top of the screen panels. Normal operating conditions are based on a maximum diversion rate of 3,000 cfs, with a minimum river level of 136.5 feet msl at the screens, which leaves approximately 1 foot of screen area exposed above the water surface.

The existing structure has a crest elevation of approximately 155.5 feet msl, based on the barrier panel top elevation. At river levels above the crest elevation, water can flow into the forebay without passing through the fish screens. The river flow rate for this condition is approximately 120,000 cfs. The return period (average occurrence) of flows equal to or greater than 120,000 cfs is approximately 1 in 5 to 1 in 10 years. By raising the screen crest height, the facility could operate at or above a river flow rate of 120,000 cfs and could provide additional operating days and increased diversion quantity per season. The average increase in operating time with the proposed fish screen crest raise would be approximately 10 days. The new crest elevation is based on providing a consistent crest height across the entire length of the structure, including the north and south abutments. The maximum river level for diversion would be elevation 159.0 feet, with a corresponding river flow of about 150,000 cfs. At river flows above 150,000 cfs, the entire area surrounding the GCID Canal Main Pump Station would be subject to nuisance flooding, prevent controlled diversions into the forebay, and make any higher target for operating criteria impractical.

Modifications to GCID Canal

Minor reshaping along the lower 13 miles upstream from the terminal regulating reservoir (TRR) would be required to obtain a reliable capacity of 1,800 cfs. Siphons, check structures, and bridges were evaluated to determine whether modification or complete replacement would be needed to ensure proper operation. Five siphons along the GCID Canal convey Main Canal flows under major cross drainages, such as Stony Creek. Two options were considered to increase siphon capacity: adding more siphon barrels and modifying the inlet/outlet structures; or complete replacement. The choice to modify or completely replace was made based on the age and condition of the existing siphon and the required capacity increase. Only the railroad siphon would require replacement. Seven check structures located along the GCID Canal are used to control water levels in the canal. Only the Tuttle Creek check structure would require replacement. There are 32 bridges along the project length, varying from minor farm service bridges to a bridge on Interstate 5. One bridge at Delevan Road would require replacement.

GCID Canal Terminal Regulating Reservoir

Water conveyed down the GCID Canal would be conveyed into a future TRR. A new pump station, the TRR-to-Funks Pump Station, would then convey the water from the TRR via a new pipeline up to the existing Funks Reservoir. The TRR would be required to provide operational storage for the TRR-to-Funks Pump Station to balance out normal and emergency flow variations between the upstream GCID Canal Pump Station, the 40 miles of connecting canal, and the TRR-to-Funks Pump Station.

The TRR, a shallow reservoir to provide operational storage for the GCID Canal-to-Funks Pump Station, as necessary, would be created on the valley floor next to the Main Canal by a combination of excavation and embankment. The general location of the TRR would be based on the requirement to have gravity flow from the Main Canal into the TRR. The TRR capacity would be based on the need to provide normal transient operating storage for the TRR-to-Funks Pump Station and emergency storage to absorb flows from the Main Canal following an emergency shutdown of the TRR-to-Funks Pump Station. Major appurtenance features would include a Main Canal transition bay, a connecting channel from the Main Canal to the TRR, and a flow control inlet structure. The reservoir would have a storage capacity of 2,000 AF and a square footprint covering approximately 200 acres, with bottom dimensions of approximately 2,900 feet by 2,900 feet. The depth would be approximately 17 feet, with a maximum embankment height of approximately 21 feet.

Road and Utility Relocations

Sites Reservoir would inundate portions of Maxwell Sites Road and Sites-Lodoga Road, blocking travel between Maxwell and Lodoga (Figure A3-1). These roads are owned by Colusa County. Approximately 6 miles of the gravel Huffmaster Road, south of the town of Sites, also would be inundated. Huffmaster Road is a private road that provides access to properties mostly within the Sites Reservoir area. The project would include five new recreation areas, and road access to these sites also would be needed. In addition to road relocation costs, the project would require the relocation of utilities, including gas pipelines, power lines, telephone lines, and cable service. The service lines to a microwave station adjacent to the reservoir site also would require relocation.

Four alternative road alignments, including two with bridge segments over the reservoir and two that route around the reservoir without a bridge, are being considered. The bridge routes would provide more direct access, with reduced travel times, compared to the road routes without the bridges around the northern or southern ends of the reservoir. To identify the preferred route, all variables must be evaluated, including construction costs, operation and maintenance (O&M) costs, travel times, environmental issues, and the identification of the most frequent road users. Users would include weekend recreational traffic and daily traffic (e.g., travel to and from school). At a later stage of project development, additional roads would be included in the road alignment alternatives to provide access to potential recreation areas and project facilities.

Transmission Lines and Substation Requirements

Operation of the project pumping plants would require power. The Sites Pumping/ Generating Station has a maximum generating capacity of 150 megawatts (MW) of power. A 230-kilovolt (kV) substation could be built within 0.25 mile of the transmission corridor. The first alternative configuration would require a four-breaker ring bus substation; the alternative configuration would require a six-breaker ring bus substation.

Transmission lines coming from the substations generally would follow the pipelines to each of the pump stations. There would be 3 miles of transmission lines from the substation to the Sites Reservoir (pumping/generating) Pump Station and 1.2 miles of transmission lines from the substation to the Glenn-Colusa Pump Station.

Hydroelectric Facilities

To provide the secondary benefits associated with hydropower, hydroelectric facilities would be added to many of the pumping plants as feasible. In general, the addition of ancillary hydropower to the grid would help mitigate some of the power consumption costs associated with this offstream facility. Water would be pumped into Sites Reservoir primarily during the winter, and water would be released primarily during the summer and fall, thereby producing hydropower when power demands and costs are typically higher. At this stage of planning, hydroelectric facilities have been designed and costed for the Sites Pumping Plant, the TRR Pumping Plant, and the Sacramento River Pumping Plant for the new pipeline. While

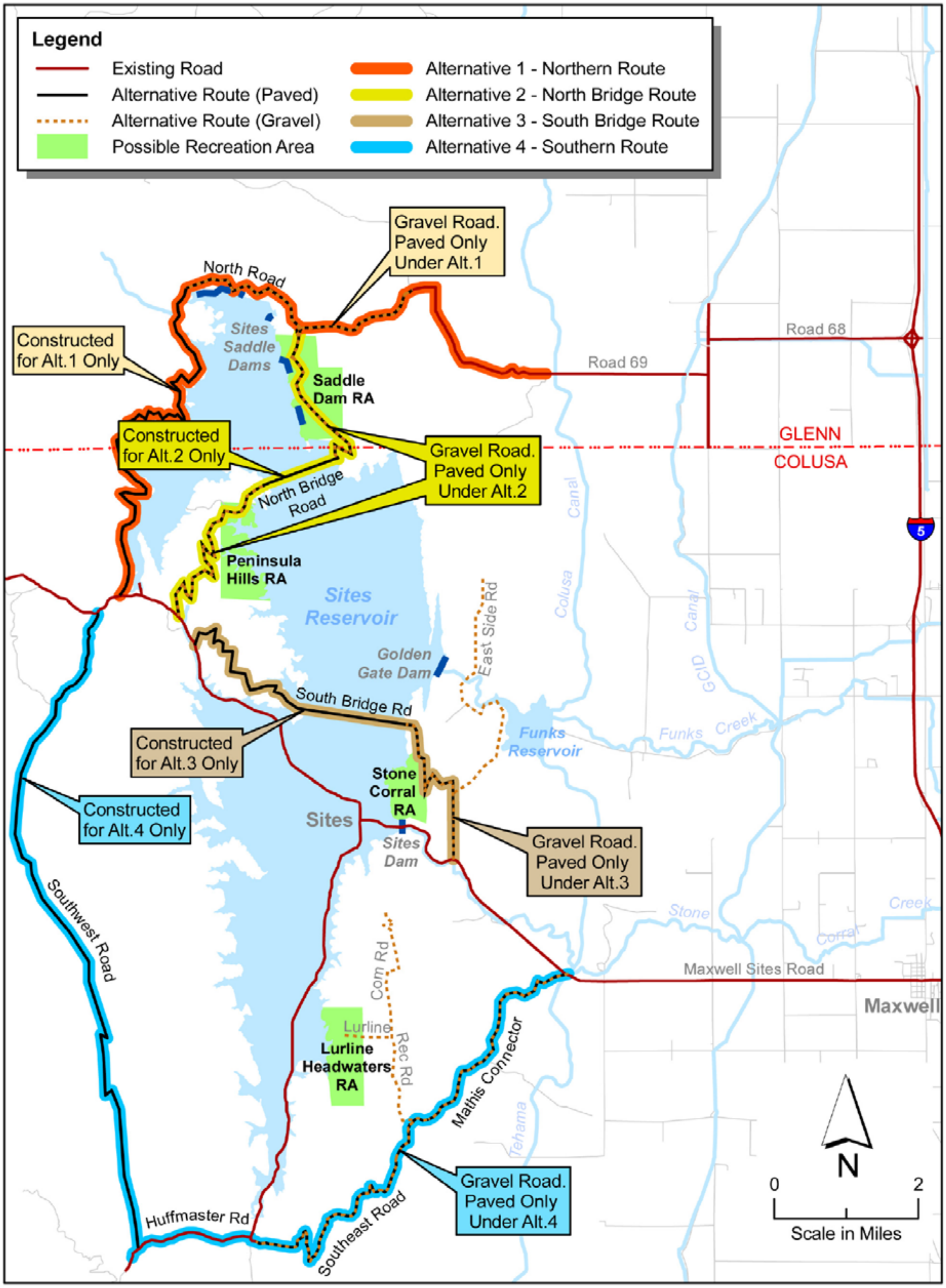


Figure A3-1. Sites Reservoir Road Relocation Route Alternatives Evaluated in Initial Alternatives

every initial action alternative plan includes hydroelectric facilities, sizing of the facilities is based on the release capacity and head at the various locations. Currently, the operation of the hydroelectric facilities is based on water deliveries from Sites Reservoir, which was determined by water use within the system. This operation may be refined later to optimize the use of the hydroelectric facilities based on variability in the market cost of power.

Recreation Facilities

Sites Reservoir, at 1.8 MAF, would be the seventh largest reservoir in California, and preliminary studies indicate that additional recreation opportunities in the area are needed. DWR developed some conceptual recreation facilities options that could be implemented as part of a Sites Reservoir plan. Recreational activities and uses for Sites Reservoir would be offered at up to five recreation areas: Stone Corral, Sites Saddle Dams, Peninsula Hills, Antelope Island, and Lurline Headwaters recreation areas. Each of the initial action alternative plans would include the five recreation areas and would provide visitors with options for hiking, boating, overnight camping, fishing, swimming, and day-use picnicking. Facilities to be included for these activities would consist of boat launch sites, picnic tables, campfire rings and barbeques for overnight camping, restrooms, trails, designated swimming and fishing areas, and parking. As proposed, Peninsula Hills Recreation Area has a maximum potential for up to 200 campsites available to users, while Stone Corral and Lurline Headwaters each have a maximum potential for up to 50 campsites, and Antelope Island has a maximum potential for up to 12 campsites. The Saddle Dam recreation area would not have campsites.

Ecosystem Restoration Account Features

NODOS provides a unique opportunity to provide the first firm asset ecosystem restoration account (ERA) in California managed by California and/or the federal government and dedicated to restoration actions beyond regulatory requirements. As part of CALFED, the Ecosystem Restoration Program (ERP) has developed an integrated systems approach based on reversing the fundamental causes of decline in fish and wildlife populations by recognizing the natural forces that created historic habitats and using these forces to help regenerate habitats. The ERP was not designed as mitigation for CALFED projects; instead, it is intended to fulfill the objectives of improving ecological processes and increasing the amount and quality of habitat, equal with other program goals related to water supply reliability, water quality, and levee system integrity.

The ERP has identified more than 600 programmatic actions to improve ecological health. The ERP advocates an adaptive management implementation strategy that supports the flexible use of environmental water. This adaptive approach has been accommodated in NODOS planning by dedicating a NODOS storage allocation to ERP objectives (an ERP pool or account), and then giving resource managers the ability to adjust priorities based on the monitoring of implemented actions, as well as potential new priorities. The NODOS planning team identified ERP objectives that could be supported by implementing a NODOS Project and prioritized actions with input from a Sacramento River Flow Regime Technical Advisory Group. The list of potential ERP objectives includes both tributary actions and Sacramento-San Joaquin Delta (Delta) actions. This group included environmental advocacy groups, academics, and representatives from federal and California water resource and wildlife agencies. Ultimately, NODOS planners adopted a short list and longer list (as in AF1A and AF1B) of ERP objectives that were incorporated into the operations strategy for the initial action alternative plans (see Table A3-3).

Table A3-3. NODOS ERA Objectives

	Initial Action Alternative Plans			
Description	**WS1A**	**AF1A, AF1B**	**WSFQ**	**WS1B, WS1C, WQ1A, WQ1B**
ERP Objectives (ERA Short List)				
Improve the reliability of coldwater carry-over storage at Shasta Lake (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream Temperatures, Target 1/Action 1) (CALFED, 2000c; 2000d).	✓	✓	✓	✓
Increase supplemental flows for coldwater releases for salmon and steelhead between Keswick and RBDD (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream Temperatures, Target 1—use November 1997 AFRP targets) (CALFED, 2000c; 2000d).	✓	✓	✓	✓
Reduce diversions at Red Bluff to provide water into the T-C Canal and at Hamilton City to provide water into the GCID Canal during July, August, and September. Priority is to reduce diversions at GCID. This concept is designed to minimize diversion effects to fish during identified critical periods (from the 2000 CALFED ERP Plan, Sacramento River Zone, Water Diversion, Target 1/Action 1C) (CALFED, 2000c; 2000d).	✓	✓	✓	✓
Improve the reliability of coldwater carry-over storage at Folsom Lake and stabilize flows in the American River (from the 2000 CALFED ERP Plan, American River Basin Zone, Central Valley Stream-flow, Targets 1, 2, and 3) (CALFED, 2000c; 2000d).	✓	✓	✓	✓
Modify spring flows into a “snowmelt pattern” in years with peak storm events in late-winter and early-spring, from Red Bluff to Colusa. The snowmelt pattern would be designed to increase the success of cottonwood cohorts, specifically (from the 2000 CALFED ERP Plan, Sacramento River Zone, Riparian and Riverine Aquatic Habitats, Target 1/Action 1C) (CALFED, 2000c; 2000d).	✓	✓	✓	✓
Stabilize fall flows to avoid abrupt reductions from Keswick to Red Bluff (assumes November 1997 AFRP flow targets). This action is intended to reduce adverse conditions for spawning fall-run Chinook salmon (U.S. Fish and Wildlife Service, 1997).			✓	

Table A3-3. (Continued)

Description	Initial Action Alternative Plans			
	WS1A	AF1A, AF1B	WSFQ	WS1B, WS1C, WQ1A, WQ1B
Stabilize fall flows to avoid abrupt reductions from Keswick to Red Bluff (assumes 6,000-cfs target from October through January and 4,500-cfs target for September). This concept is designed to avoid adverse conditions for spawning fall-run Chinook salmon (i.e., egg desiccation) (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream-flow, Target 2/Action 2) (CALFED, 2000c; 2000d).		✓		✓
ERP Objectives (ERA Long List – ERA Short List Plus Actions Below)				
Provide a flow event by supplementing normal operating flows from Shasta and Keswick Dams in March during years when no flow event has occurred during winter or is expected to occur. Flow events would be provided only when sufficient inflow to Shasta Lake was available to sustain the prescribed releases. This action could be refined by evaluating its indirect costs and the overall effectiveness of achieving objectives, which are 8,000 to 10,000 cfs in dry years and 15,000 to 20,000 cfs in below-normal years (from the 2000 CALFED ERP Plan, Sacramento River Zone, Central Valley Stream-flow, Action 1/Target 1) (CALFED, 2000c; 2000d).		✓		
Provide a March Delta outflow from the natural late-winter and early-spring peak inflow from the Sacramento River. This outflow should be at least 20,000 cfs for 10 days in dry years, at least 30,000 cfs for 10 days in below-normal water years, and 40,000 cfs for 10 days in above-normal water years. Wet-year outflow is generally adequate under the present level of development (from the 2000 CALFED ERP Plan, Sac-SJ Delta Zone, Central Valley Stream-flow, Target 1) (CALFED, 2000c; 2000d).		✓		
Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years (from the 2000 CALFED ERP Plan, Sacramento-San Joaquin Delta Zone, Central Valley Stream-flow, Target 4) (CALFED, 2000c; 2000d).		✓		

AFRP = Anadromous Fish Restoration Program
CALFED = CALFED Bay-Delta Program
cfs = cubic feet per second
ERA = NODOS Ecosystem Restoration Account
ERP = CALFED Ecosystem Restoration Program
GCID = Glenn-Colusa Irrigation District
NODOS = North-of-the-Delta Offstream Storage
RBDD = Red Bluff Diversion Dam
T-C = Tehama-Colusa

In addition to the restoration account described, the Delta water quality action also will improve pelagic habitat conditions. The water quality action improves water quality for agricultural, urban, and environmental diversions from the Delta and for several pelagic species, including delta smelt.

Sites Reservoir Operations Strategy

Current operating rules for releases from Shasta Dam to the Sacramento River are governed by temperature and instream flow requirements, contractual obligations, Delta water quality and outflow requirements, and flood control. Flood control releases are prescribed by the United States Army Corps of Engineers (USACE), as described in *Report on Reservoir Regulation for Flood Control, Shasta Dam and Lake* (USACE, 1977). This report specifies the amount of storage for flood control purposes in Shasta Lake and determines how to make releases through the spillway. For the evaluation of NODOS action alternatives, a generally consistent operations strategy was used for each. The operations strategy is reflected in the operations simulation modeling that is the primary planning tool to determine many of the project benefits and impacts. The ability of each action alternative to implement this strategy effectively is subject to each action alternative's specific primary objective focus, the conveyance options included, and the coordinated operation of Sites Reservoir with other existing facilities. The strategy has three components: (1) criteria for meeting primary objectives; (2) determination of Keswick releases; and (3) determination of Sites Reservoir releases.

Each action alternative would be operated to meet three primary objectives, but priorities assigned to each objective would vary, depending on the focus of the action alternative—water supply, survival of anadromous fish, or Delta water quality. The modeled reservoir and the system operations use the alternative operating rules through a wide range of hydrologic and operational conditions. A set of criteria is used to determine how the model operates the project for each primary beneficiary. Water supply-related operations are determined through forecast-based decisions. Anadromous fish operations are determined through a collection of flow/storage thresholds and forecast-based decisions. Delta water quality operations are determined through water quality conditions and storage thresholds.

Throughout the operations, the following two parameters are evaluated to determine strategy implementation: Shasta Lake storage condition and Keswick releases (including Shasta Lake releases and imports from the Trinity River); and Sites Reservoir storage and Sites Reservoir releases to local water supply diversions and to the Sacramento River.

For most actions associated with the objective of improved survival of anadromous fish and other species, the performance of the action alternative depends on the decisions regarding Shasta Lake storage and Keswick releases. Changes in Keswick releases require like changes in the import of Trinity River flows, or releases of Shasta Lake storage, or some combination of both. To achieve an optimal condition for anadromous fish in the Sacramento River between Keswick and Red Bluff, releases from Shasta Lake must be managed accordingly. The releases of Shasta Lake storage are sometimes limited by the amount of storage available in Shasta Lake. Storage availability is a consequence of what releases were made for preceding actions and other requirements.

For actions associated with improved water supply and Delta water quality, the performance of the action alternative depends on the decisions regarding Sites Reservoir storage and releases. The releases from Sites Reservoir to the Sacramento River are often constrained by the capacity to convey water to the river or to offset diversions from the river (through serving local water supply needs directly from Sites Reservoir). The releases of Sites Reservoir storage are sometimes limited by the amount of storage available in Sites Reservoir. Storage availability is constrained by the releases made for preceding actions and requirements.

To optimize the performance of Sites Reservoir for all primary objectives, Shasta Lake, Lake Oroville, and Sites Reservoir releases are coordinated. For each action alternative, the reduction of diversions at Red Bluff and Hamilton City are determined by the coordination of operations. Diversion reductions are a means to increase flows in the lower Sacramento River by consequently increasing releases from Sites Reservoir to local water supply users who would otherwise have diverted from the Sacramento River at Red Bluff or Hamilton City.

For each action alternative, the extent to which operations at Sites Reservoir, Shasta Lake, and Lake Oroville are coordinated depends on the primary objective focus and the conveyance options used. The action alternatives that focus on the survival of anadromous fish dictate greater changes to Keswick Dam releases and therefore to Shasta Lake releases. The action alternatives that have a lesser capacity to convey water from Sites Reservoir to the Sacramento River must rely more on Shasta Lake and/or Lake Oroville releases to meet the increased summer and fall Delta exports (for water supply) and Delta outflows (for water quality).

Summary of Common Features

Table A3-4 provides a summary of the common features of the initial action alternative plans under analysis as part of the PFR process.

Table A3-4. Summary of Common Features of NODOS Initial Action Alternative Plans

Sites Reservoir	Gross Storage Capacity – 1.8 MAF Water Surface Elevation – 520 feet msl Minimum Operating Pool – 320 feet msl Inundation Area – 14,000 acres
Golden Gate Dam (Sites Reservoir)	Location – Funks Creek Earth Rockfill Embankment Dam Crest Length – 2,250 feet Maximum Height – 310 feet Embankment Volume – 10,590,000 cubic yards
Sites Dam (Sites Reservoir)	Location – Stone Corral Creek Earth Rockfill Embankment Dam Crest Length – 850 feet Maximum Height – 290 feet Embankment Volume – 3,836,000 cubic yards

Table A3-4. (Continued)

Saddle Dams (Sites Reservoir)	Location - North End from Funks Creek to Hunters Creek Earth Rockfill Embankment Dams Dams 1, 2, 4, 9 – 40 to 50 feet high Dams 3, 5, 6, 7, 8 – 70 to 130 feet high
Emergency Spillway (Sites Reservoir)	Location – Saddle Dam 4 Diameter – 7 feet Inlet Elevation – 526 feet
Sites Pumping Plant	Location – Downstream from Golden Gate Dam Capacity – Varies
Funks Reservoir	Active Storage Volume – 1,300 to 5,290 AF Pumping Capacity – 3,900 to 5,900 cfs
GCID Canal Fish Screens	Modified Crest Elevation – 159.0 feet msl Maximum Operating Flow – 150,000 cfs
GCID Canal	Existing Capacity at Funks Reservoir (With Minor Reshaping) – 1,800 cfs
T-C Canal	Existing Capacity at Funks Reservoir – 2,100 cfs
GCID Canal Terminal Regulating Reservoir	Capacity – 2,000 AF Footprint – 200 acres Depth – 17 feet Maximum Embankment Height – 21 feet
Ecosystem Restoration Account	See Table A3-3
Road Relocations and Access Roads	Road Alignments Additional Roads
Utility Relocations	Four- or Six-Breaker Ring Configuration Transmission Lines
Hydroelectric Facilities	Generation at TRR and Delevan Pipeline Intake Facilities
Recreation Facilities	Five Recreation Areas
Sites Reservoir Operations Strategy	Reservoir Operations Developed and Formulated with Facilities to Provide Optimum Benefits for Each Project Objective

AF = acre-foot
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
NODOS = North-of-the-Delta Offstream Storage
T-C = Tehama-Colusa

Alternative WS1A (Reliance on Existing Canals)

Initial Action Alternative Plan WS1A (Alternative WS1A) (see Table A3-5 and Figure A3-2) would focus on meeting the primary objective for water supply by constructing Sites Reservoir and relying on the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to and from the reservoir.

Table A3-5. Alternative WS1A Major Components and Operations Prioritization

Major Components of Alternative WS1A	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 3. Local water supply 4. Alternative source of Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A3-3) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir is being further refined in the feasibility studies underway).
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

Alternative WS1A would use the common features already described. WS1A could deliver water from Sites Reservoir to the local GCID and T-C service areas. By coordinating Sites Reservoir operations with Shasta Lake and Lake Oroville, benefits would be achieved throughout the Central Valley Project (CVP) and State Water Project (SWP) systems and the associated watersheds. The highest priorities of Alternative WS1A would be to improve the water supply reliability of CVP and SWP contractors and local T-C Canal water users, to provide long-term water supplies for the EWA, and to provide an alternative source for wildlife refuge Level 4 water supply.

Sites Reservoir, through direct release to the T-C and GCID Canals, could deliver water to serve up to half of the Tehama-Colusa Canal Authority (TCCA) and GCID contractors' service areas that, without Sites Reservoir, would be delivered entirely by direct diversion from the Sacramento River. These deliveries would facilitate coordinated operations with other CVP and SWP reservoirs, additional deliveries to

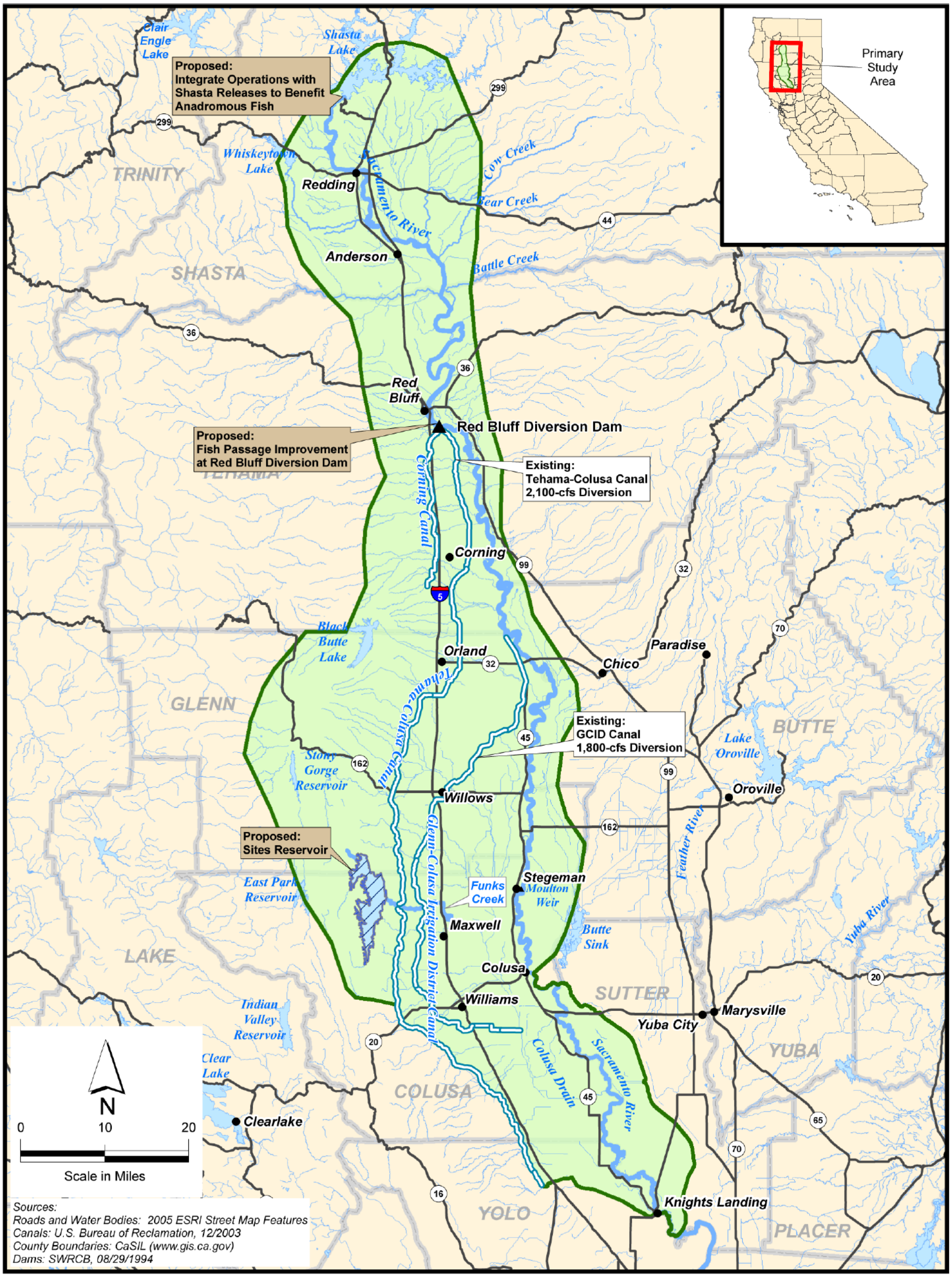


Figure A3-2. WS1A-Water Supply with Reliance on Existing Canals

contractors, and other NODOS benefits. Improved local water supply reliability for the T-C Canal users could be delivered directly from Sites Reservoir. Other benefits associated with the CVP, including supply reliability to south-of-Delta contractors, the EWA, and an alternative source for Level 4 water supplies to wildlife refuges, would require coordinated operation with Shasta Lake. Benefits associated with the SWP, including improvements to contractor reliability and the EWA, would be accomplished by coordinating operations with Lake Oroville Reservoir, as well.

Operations of Sites Reservoir would be coordinated with the operation of Shasta Lake to provide benefits to anadromous fish in the Sacramento River and water quality in the Delta, as well. Conveyance would terminate at an enlarged Funks Reservoir that would serve as a forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. For modeling purposes, operations under Alternative WS1A were prioritized as presented in Table A3-5.

For the initial alternative action plan analysis, a 1.8 MAF reservoir was used in CalSim II modeling runs to assess potential benefits to water users. The size of the reservoir is being refined in the feasibility studies.

Alternative WS1B (New 1,500-cfs Diversion and 1,125-cfs Release Pipeline)

Initial Action Alternative Plan WS1B (Alternative WS1B) (see Table A3-6 and Figure A3-3) would focus on meeting the primary objective of water supply by constructing Sites Reservoir, and would include a new conveyance (pumping plant and pipeline) from the Sacramento River to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to and from the reservoir.

Table A3-6. Alternative WS1B Major Components and Operations Prioritization

Major Components of Alternative WS1B	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 3. Local water supply 4. An alternative source of Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A3-3) of Sacramento River restoration actions	

Table A3-6. (Continued)

Major Components of Alternative WS1B	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 1,500-cfs diversion and capacity to release up to 1,125 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

In Alternative WS1B, the Delevan Pipeline would provide capacity for a 1,500-cfs diversion with a 1,125-cfs release. Alternative WS1B would use the common features already described, and would provide diversion from the Sacramento River at three locations and release back to the river at the Delevan Pipeline diversion location. This release capability would facilitate direct benefits “downstream,” primarily in the Delta. The coordinated operation would provide additional benefits associated with the integration of Sites Reservoir storage into existing system operations. The highest priorities of Alternative WS1B would be to improve the reliability of water supply to CVP and SWP contractors and local T-C Canal water users, to provide long-term water supply for the EWA, and to provide an alternative source for Level 4 water supply for wildlife refuges.

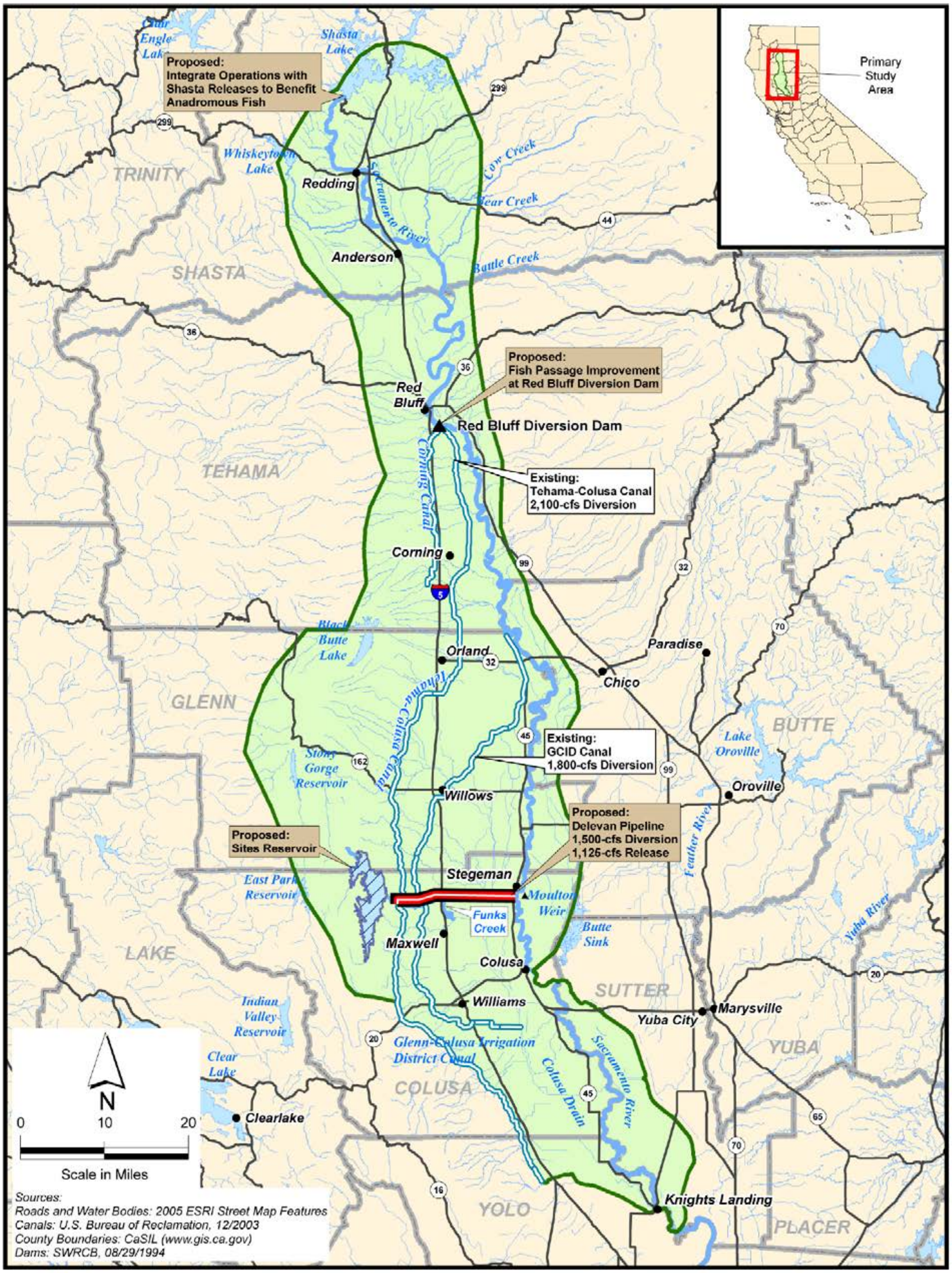


Figure A3-3. WS1B-Water Supply with Conjunctive Use of Groundwater and 1,500-cfs Pipeline

Benefits to T-C Canal users could be delivered directly from Sites Reservoir through the T-C Canal. Other benefits would derive from a combination of direct delivery through the Delevan Pipeline and coordinated operations with existing reservoirs.

Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and the Red Bluff Diversion Dam (RBDD).

Alternative WS1C (New 2,000-cfs Diversion and 1,500-cfs Release Pipeline)

Initial Action Alternative Plan WS1C (Alternative WS1C) (see Table A3-7 and Figure A3-4) would focus on meeting the primary objective of water supply. It would include the Delevan Pipeline to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to and from the reservoir. Alternative WS1C would use the common features already described.

Table A3-7. Alternative WS1C Major Components and Operations Prioritization

Major Components of Alternative WS1C	Details of Major Components
Operations Priority 1. SWP contractors 2. CVP contractors 2. Local water supply 4. Alternative source of Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. Delta water quality 7. ERA short list (see Table A3-3) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 2,000-cfs diversion capacity to release up to 1,500 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connection to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.

Table A3-7. (Continued)

Major Components of Alternative WS1C	Details of Major Components
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

In Alternative WS1C, the Delevan Pipeline would be formulated with the capacity for a 2,000-cfs diversion and a 1,500-cfs release. The highest priorities of this alternative would be to improve the reliability of water supply to CVP and SWP contractors and local T-C Canal users, to provide long-term water supplies for the EWA, and to provide an alternative source for Level 4 water supply for wildlife refuges. Conveyance would terminate at an enlarged Funks Reservoir that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. For modeling purposes, operations under Alternative WS1C were prioritized as presented in Table A3-7.

The operation of Sites Reservoir would be integrated with the operation of Shasta Dam as described in the Sites Reservoir Operations Strategy to reduce summer irrigation diversions, provide flows to improve fish passage and water temperatures between Keswick Dam and Red Bluff, improve the reliability of the coldwater pool at Shasta Lake, and improve conditions for riparian establishment (shaded riverine aquatic habitat [SRAH] and large woody debris).

Alternative AF1A (New 1,500-cfs Pipeline with Enhanced Ecological Benefits)

Initial Action Alternative Plan AF1A (Alternative AF1A) (see Table A3-8 and Figure A3-5) would focus on meeting the primary objective of anadromous fish survival by using Sites Reservoir to provide additional flexibility in water management that would benefit anadromous fish. Alternative AF1A would include the common features previously described and the Delevan Pipeline (1,500-cfs diversion) to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to and from the reservoir (Table A3-8). The Delevan Pipeline capacity in Alternative AF1A would provide up to 1,125-cfs release capacity to the Sacramento River.

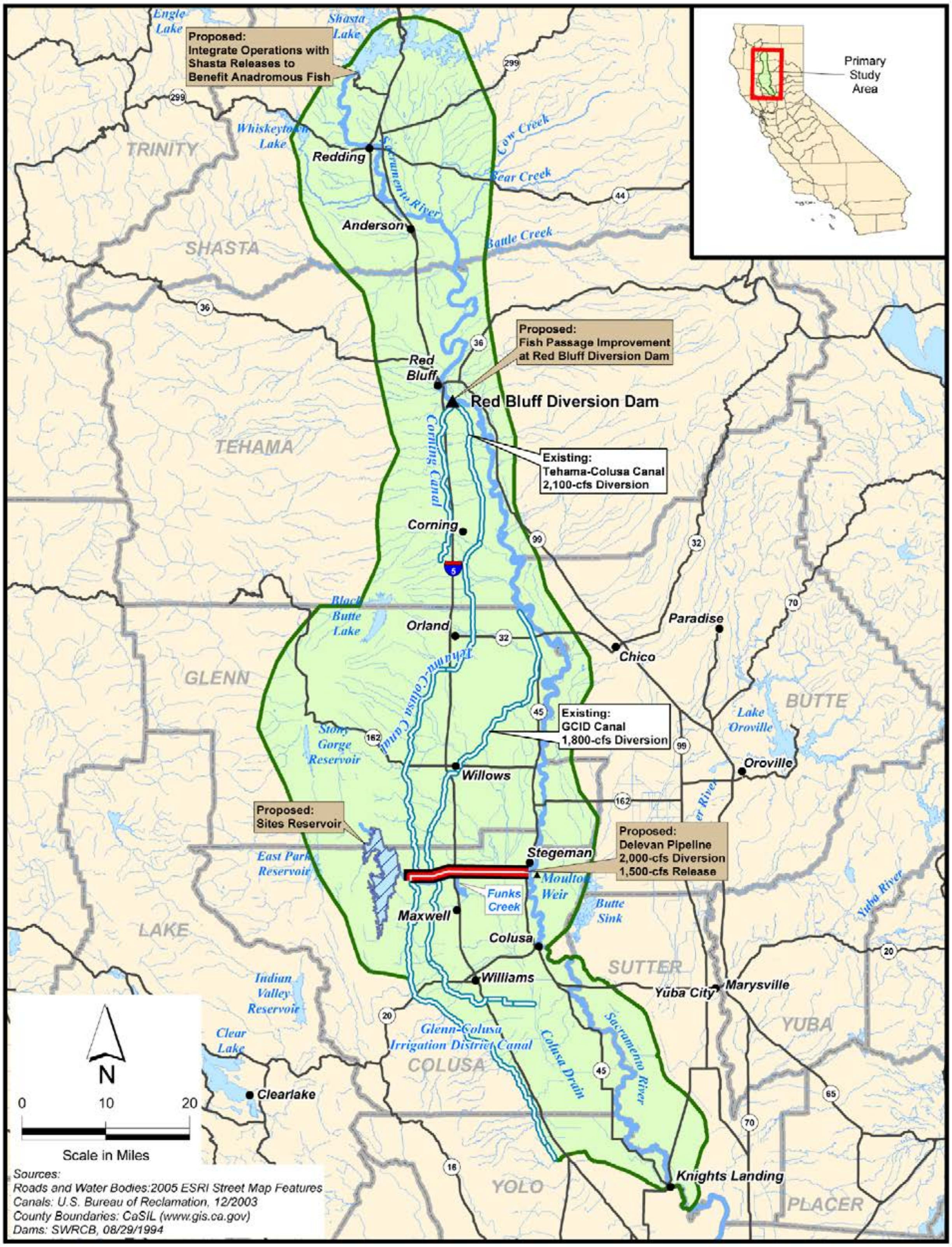


Figure A3-4. WS1C-Water Supply with 2,000-cfs Pipeline

Table A3-8. Alternative AF1A Major Components and Operations Prioritization

Major Components of Alternative AF1A	Details of Major Components
Operations Priority 1. ERA long list (see Table A3-3) of river and Delta restoration actions 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for Level 4 water supply for wildlife refuges 6. Delta water quality 7. EWA or similar future program demands	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 1,500-cfs diversion capacity to release up to 1,125 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

Conveyance would terminate at an enlarged Funks Reservoir that would serve as forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir.

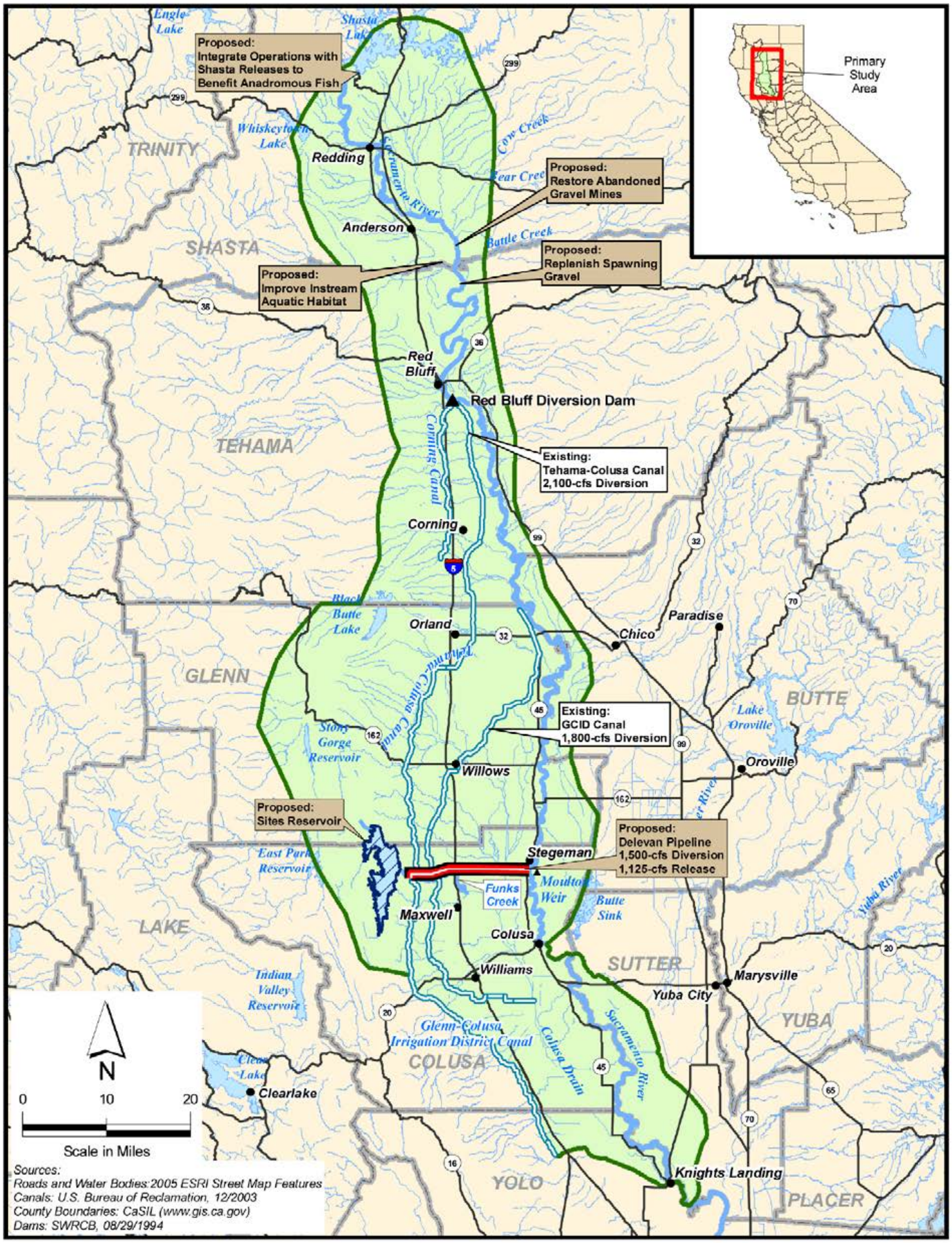


Figure A3-5. AF1A-Water Supply with 1,500-cfs Pipeline

Alternative AF1A also incorporates the following three measures to benefit anadromous fish.

- **Abandoned Gravel Mine Restoration:** Alternative AF1A would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing and prevent stranding.

- **Spawning Gravel Replenishment:** Alternative AF1A would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.

- **Instream Aquatic Habitat Improvements:** Alternative AF1A would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative AF1A also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

Alternative AF1B (New 2,000-cfs Diversion and 1,500-cfs Release Pipeline)

Initial Action Alternative Plan AF1B (Alternative AF1B) (see Table A3-9 and Figure A3-6) would focus on meeting the primary objective of anadromous fish survival by using Sites Reservoir to provide additional flexibility in water management that would benefit anadromous fish. Alternative AF1B includes the common features previously described and the Delevan Pipeline (2,000-cfs diversion) to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to and from the reservoir. The Delevan Pipeline in Alternative AF1B would provide up to 1,500-cfs release capacity to the Sacramento River.

Table A3-9. Alternative AF1B Major Components and Operations Prioritization

Major Components of Alternative AF1B	Details of Major Components
Operations Priority 1. ERA long list (see Table A3-3) of river and Delta restoration actions 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for Level 4 water supply for wildlife refuges 6. Delta water quality 7. EWA or similar future program demands	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide an additional 2,000-cfs diversion and capacity to release up to 1,500 cfs to the Sacramento River opposite the Moulton Weir. The new pipeline would be constructed parallel to Delevan Road to convey water from the Sacramento River west to the T-C Canal, just before connecting to Funks Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

Alternative AF1B also would incorporate the following three measures to benefit anadromous fish.

- **Abandoned Gravel Mine Restoration:** Alternative AF1B would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing and prevent stranding.

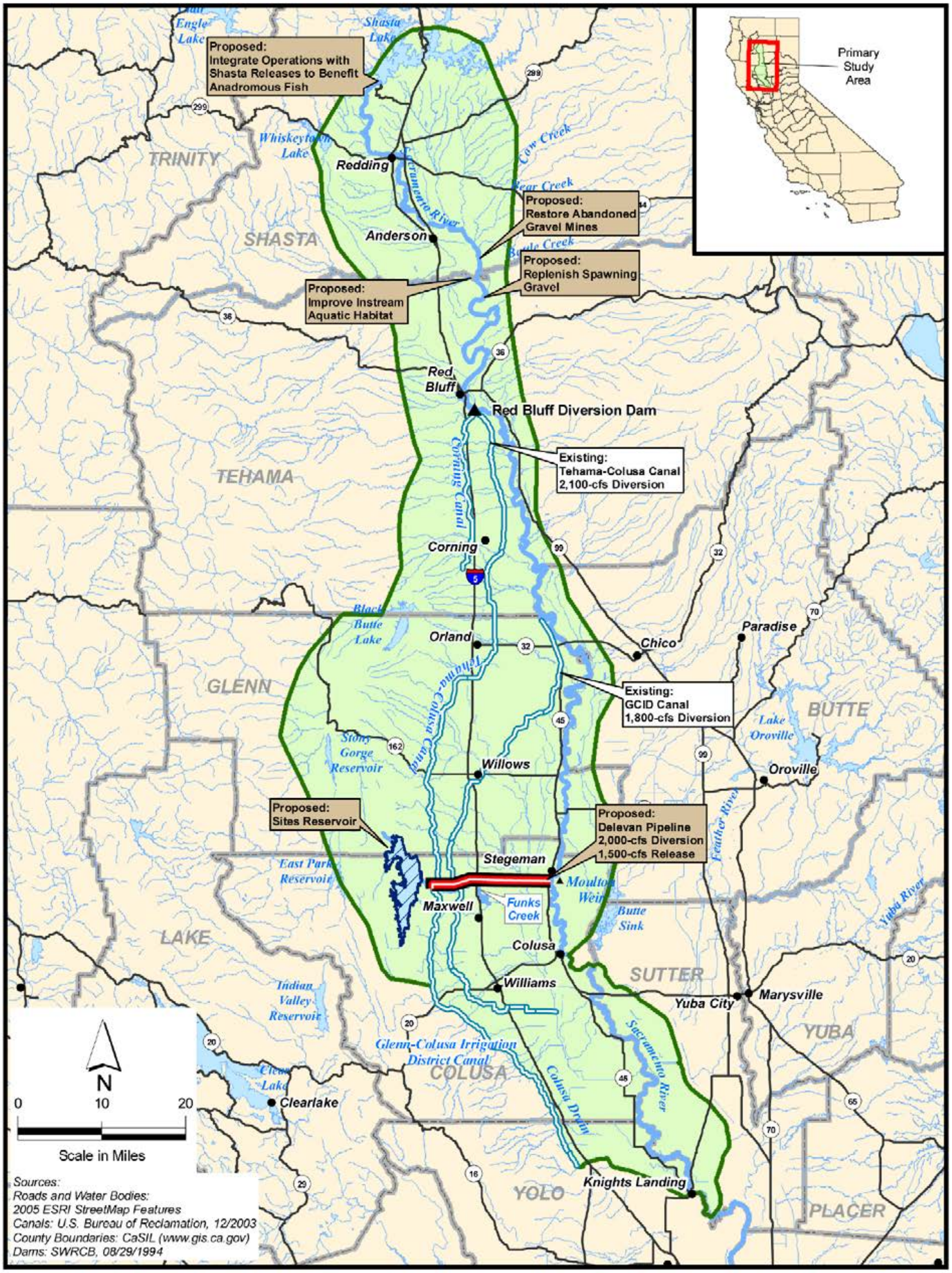


Figure A3-6. AF1B-Anadromous Fish Enhancement with 2,000-cfs Pipeline

- **Spawning Gravel Replenishment:** Alternative AF1B would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.

- **Instream Aquatic Habitat Improvements:** Alternative AF1B would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative AF1B also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments might include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

Alternative WSFQ (New 2,000-cfs Diversion and 1,500-cfs Release Pipeline with Fish Enhancements)

Initial Action Alternative Plan WSFQ (Alternative WSFQ) (see Table A3-10 and Figure A3-7) would focus on meeting the primary objectives of water supply and water quality by releasing water to the Sacramento River to increase Delta outflows during the summer and fall. The priorities of Alternative WSFQ would be to improve both water quality and the reliability of water supply to CVP and SWP contractors, to provide long-term water supply for the EWA, and to provide an alternative source for Level 4 water supply for wildlife refuges and Delta water quality improvements. Alternative WSFQ would include the common features previously described and the Delevan Pipeline (2,000-cfs diversion with 1,500-cfs release) to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion), to convey water to and from the reservoir (Table A3-10). Conveyance would terminate at an enlarged Funks Reservoir that would serve as forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and RBDD.

Table A3-10. Alternative WSFQ Major Components and Operations Prioritization

Major Components of Alternative WSFQ	Details of Major Components
Operations Priority 1. SWP contractors 2. Delta water quality 3. CVP contractors 4. Alternative source for Level 4 water supply for wildlife refuges 5. EWA or similar future program demands 6. ERA short list (see Table A3-3) of Sacramento River restoration actions, but not including stabilization of fall flows	

Table A3-10. (Continued)

Major Components of Alternative WSFQ	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs)
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

Alternative WSFQ also would incorporate the following three measures to benefit anadromous fish.

- **Abandoned Gravel Mine Restoration:** Alternative WSFQ would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features might be created to encourage spawning and rearing and prevent stranding.

- **Spawning Gravel Replenishment:** Alternative WSFQ would include replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River.

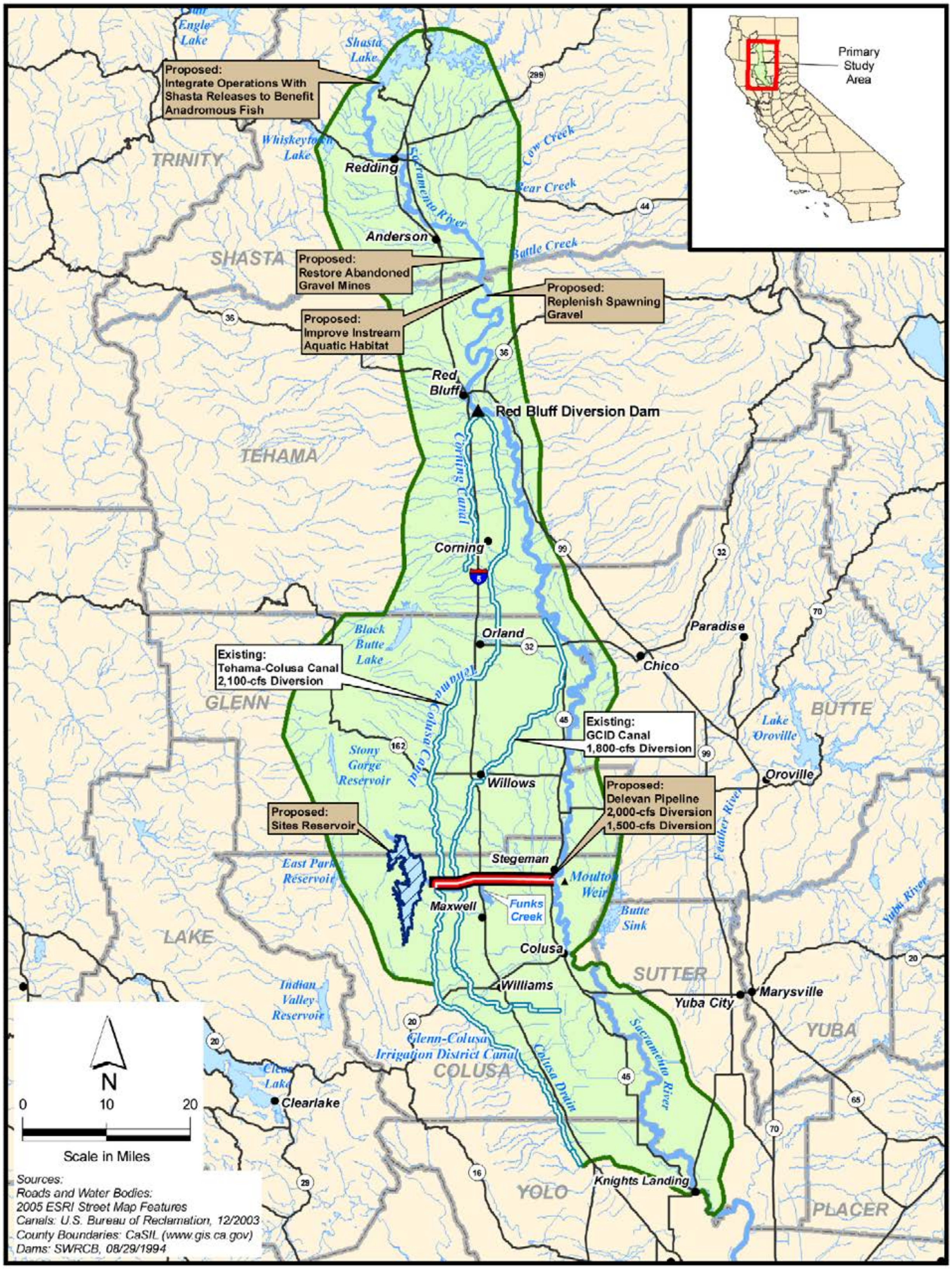


Figure A3-7. WSFQ-Water Supply with Fish Enhancement and 2,000-cfs Pipeline

- **Instream Aquatic Habitat Improvements:** Alternative WSFQ would include restoring instream habitat along the lower arms of the Sacramento River. This component would include improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. Alternative WSFQ also would include improving and restoring instream aquatic habitat using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments might include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that would cause scouring and help clean gravel.

Alternative WQ1A (New 1,500-cfs Release Pipeline)

Initial Action Alternative Plan (Alternative WQ1A) (see Table A3-11 and Figure A3-8) would focus on meeting the primary objective of water quality by releasing water to the Sacramento River to increase Delta outflow during the summer and fall months. Alternative WQ1A would use the common features already described and a new release-only Delevan Pipeline (Table A3-11). The pipeline would be designed to release up to 1,500 cfs to the Sacramento River. The reservoir would be filled using the existing T-C Canal and GCID Canal. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and Red Bluff. Conveyance would terminate at an enlarged Funks Reservoir that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir.

Table A3-11. Alternative WQ1A Major Components and Operations Prioritization

Major Components of Alternative WQ1A	Details of Major Components
Operations Priority 1. Delta water quality 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for Level 4 water supply for wildlife refuges 6. EWA or similar future program demands 7. ERA short list (see Table A3-3) of Sacramento River restoration actions	

Table A3-11. (Continued)

Major Components of Alternative WQ1A	Details of Major Components
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would allow releases to the Sacramento River (up to 1,500 cfs) but would not serve as a diversion for additional water to fill Sites Reservoir.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

Alternative WQ1B (New 2,000-cfs Diversion and 1,500-cfs Release Pipeline)

Alternative WQ1B (see Table A3-12 and Figure A3-9) would use the common features already described and would include the Delevan Pipeline capable of a 2,000-cfs diversion with a 1,500-cfs release that would supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) in conveying water to and from the reservoir. Alternative WQ1B would focus on meeting the primary objective of water quality by releasing water to the Sacramento River to increase Delta outflows during the summer and fall months. Conveyance would terminate at an enlarged Funks Reservoir that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Funks Reservoir into Sites Reservoir. Operations of the reservoir would be integrated with the operation of Shasta Dam to provide benefits to anadromous fish between Keswick Dam and Red Bluff.

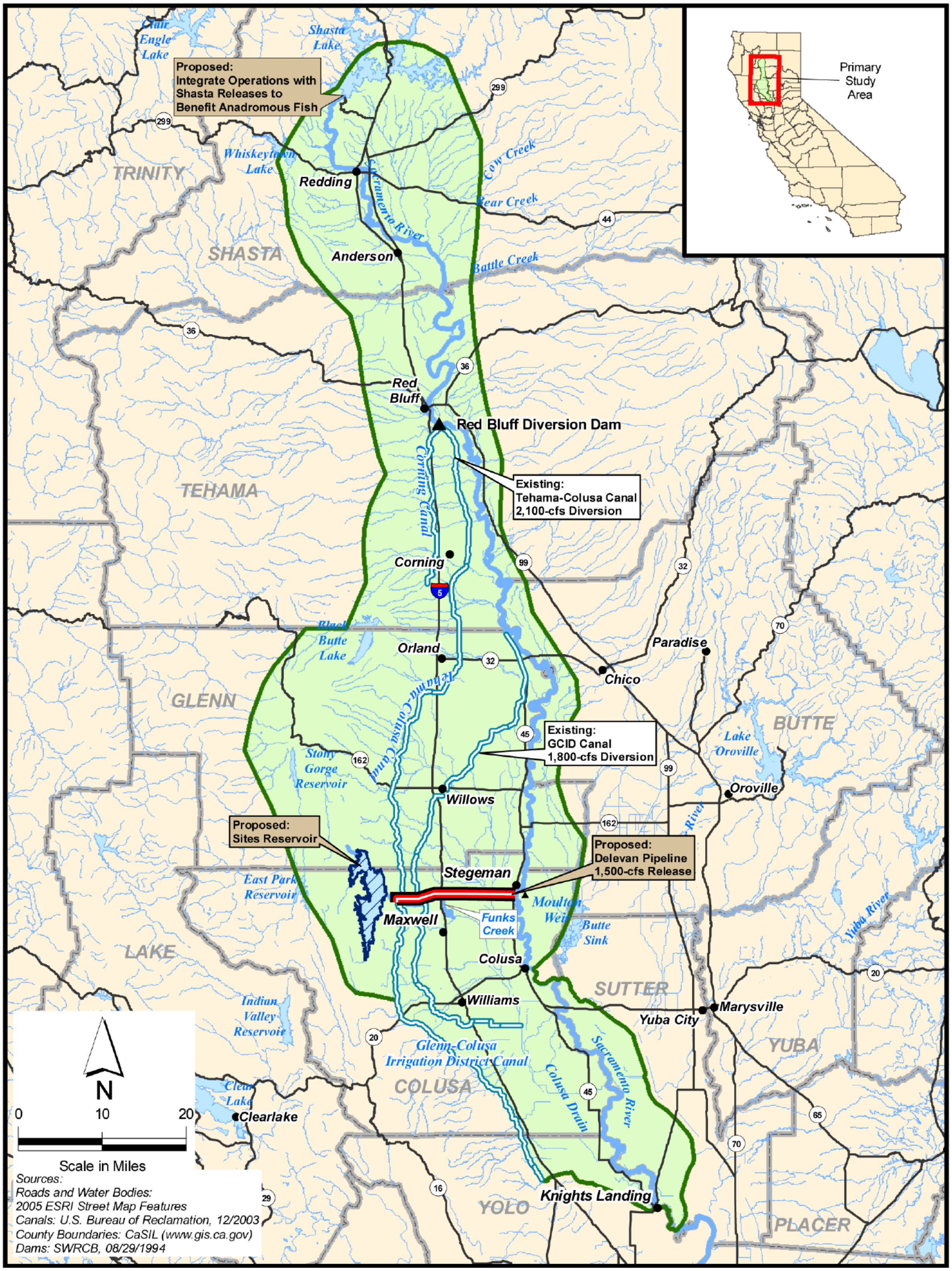


Figure A3-8. WQ1A-Water Quality with 1,500-cfs Pipeline

Table A3-12. Alternative WQ1B Major Components and Operations Prioritization

Major Components of Alternative WQ1B	Details of Major Components
Operations Priority 1. Delta water quality 2. SWP contractors 3. CVP contractors 4. Local water supply 5. Alternative source for Level 4 water supply for wildlife refuges 6. EWA or similar future program demands 7. ERA short list (see Table A3-3) of Sacramento River restoration actions	
Sites Reservoir	Reservoir configuration used for the initial evaluation of alternatives has a storage capacity of 1.8 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres (the size of the reservoir will be refined in the feasibility studies).
Delevan Pipeline	Would provide a new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs).
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.
Modifications to GCID Canal	Minor modifications to the fish screens for GCID.
	Minor reshaping of 13 miles of the canal.
	Replacement of 1 siphon, 1 check, 1 bridge.
	Installation of a TRR.
	Installation of a pipeline from the TRR to Funks Reservoir.

cfs = cubic feet per second
CVP = Central Valley Project
ERA = Ecosystem Restoration Account
EWA = Environmental Water Account
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
msl = mean sea level
SWP = State Water Project
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

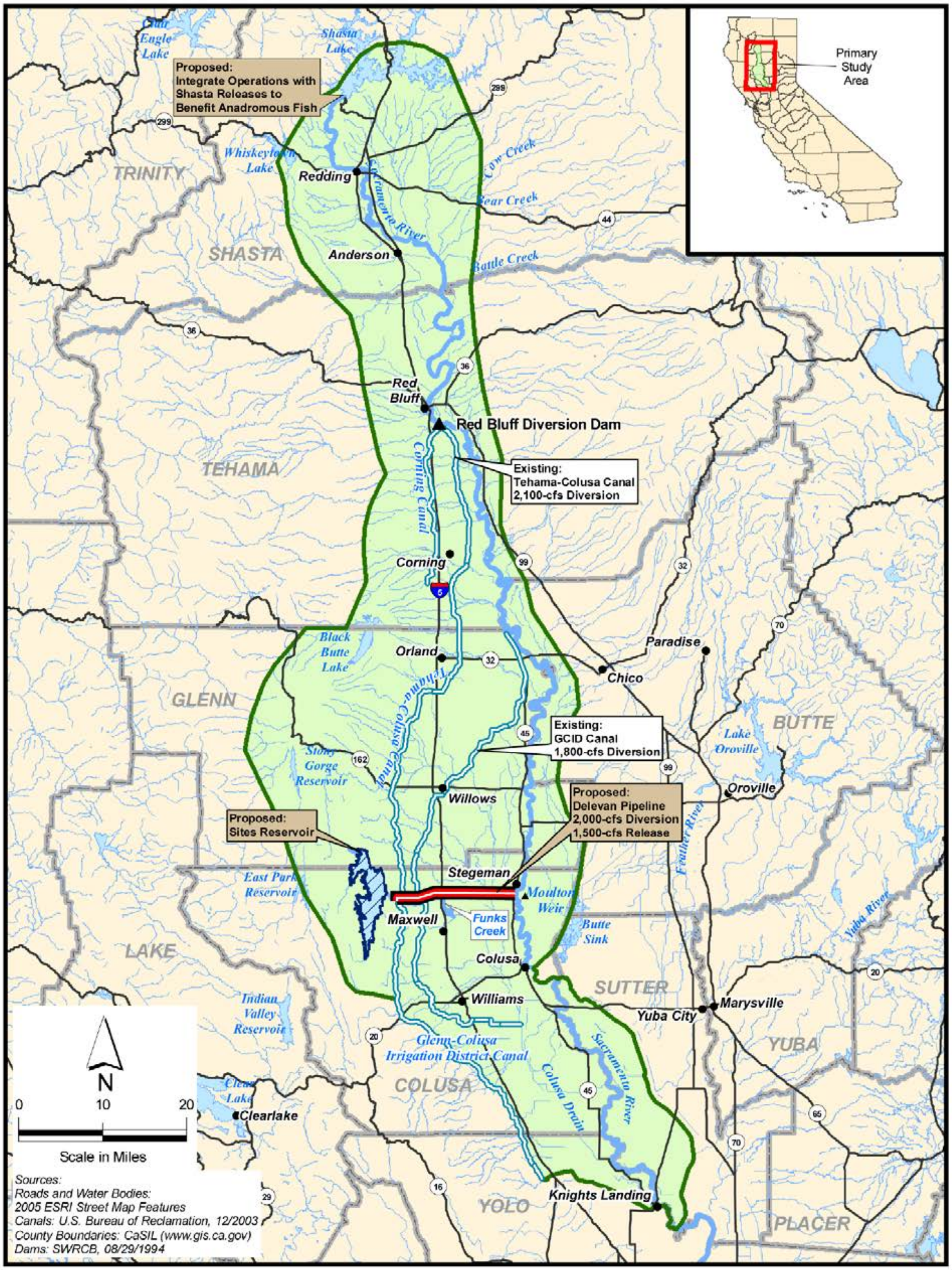


Figure A3-9. WQ1B-Water Quality with 2,000-cfs Pipeline

This page intentionally left blank

A4.0 INITIAL ACTION ALTERNATIVE PLAN ACCOMPLISHMENTS

This section discusses the potential accomplishments of each of the initial action alternative plans relative to the primary and secondary objectives. The accomplishments are used subsequently to evaluate the relative strengths and weaknesses of each plan. The appraisal level costs presented for each initial action alternative plan in the PFR were preliminary and subject to change in subsequent phases of the feasibility studies. Table A4-1 summarizes the accomplishments and appraisal-level cost estimates and benefits for each of the initial action alternative plans.

Accomplishments and Costs for Alternative WS1A (Reliance on Existing Canals)

Water Supply and Reliability – Alternative WS1A would provide an alternative source for Level 4 water supply for refuges and the EWA and improve water supply reliability for local water users (e.g., TCCA and potentially GCID service areas) and the CVP and SWP contractors. The long-term and driest periods average increases in water supply (agricultural and municipal and industrial (M&I) and environmental Level 4 supply for refuges and EWA) would be 336 TAF/year and 273 TAF/ year, respectively. Water supply benefits of this alternative would be achieved by releases from Shasta Lake and Lake Oroville through exchange and coordinated/ integrated operations. As part of the exchange and coordinated/integrated operations with Shasta Lake, water from Sites Reservoir, through direct release to the GCID Canal and T-C Canal, would be delivered to serve up to half of the GCID and TCCA contractor's service areas downstream from Funks Reservoir that, without Sites Reservoir, would be delivered entirely by direct diversion from the Sacramento River.

Anadromous Fish Survival – The primary anadromous fish benefit from this alternative would derive from the reduction of summer diversions at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff. The combined average annual reduction of diversions is 280 TAF. Diversions at the two intakes would increase from November through March during the Sites Reservoir filling period. The priority is to reduce diversions at the GCID Canal during the irrigation season to reduce predation downstream from the GCID Canal intake. There could be increases in critical years in coldwater carryover storage at Shasta Lake; however, the likelihood of end-of-September storage is unchanged from the future No Project Alternative.

Water Quality – This alternative would coordinate operations with Shasta Lake to provide increased flows in July through September to improve water quality in the Delta. The average annual release for Delta water quality from Shasta Lake would be 74 TAF/year, which would result in average reductions of 2 percent for electrical conductivity (EC), 2 percent for total dissolved solids (TDS) concentrations, 3 percent for chloride concentrations, and 3 percent for bromide concentrations, in Banks Pumping Plant exports.

Table A4-1. Summary of Relative Accomplishments of Initial Action Alternative Plans and Estimates of Preliminary Costs and Benefits

Item	Initial Action Alternative Plans							
	WS1A	WS1B	WS1C	AF1A	AF1B	WSFQ	WQ1A	WQ1B
Objectives and Accomplishments								
Water Supply[a] Increase (Driest Periods Average Increase/Average Annual Increase) (TAF/year)	273/336	316/368	361/382	166/184	144/189	262/276	241/225	301/276
Anadromous Fish Rating[b]	Low	Medium	Medium	High	High	Medium	Medium	Medium
Water Quality Improvement[c]	Low	Low	Low	Low	Low	High	High	High
Hydropower Generated Long Term (in GWh)	105	147	153	152	157	150	128	151
Recreation[d]	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Flood Damage Reduction and Emergency Water[e]	**Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**
Economics ($ millions)[f]								
Construction Cost	$2,138.1	$2,936.7	$3,021.8	$2,951.2	$3,036.4	$3,036.4	$2,664.5	$3,021.8
Total Annual Cost	$134.2	$183.0	$188.1	$184.1	$189.3	$189.0	$166.1	$188.1
Annual Benefits	$113.11	$151.96	$154.94	$107.69	$110.80	$214.85	$144.42	$183.20
Net Benefits (Annual Benefits – Annual Cost)	-$21.09	-$31.04	-$33.16	-$76.41	-$78.50	+$25.85	-$21.68	-$4.9

[a] Water supply increases exceed the No Project Alternative and include supplies for agriculture, M&I, and environmental (Level 4 and EWA). Driest periods average is the average quantity for the combination of periods of May 1928 through October 1934, October 1975 through September 1977, and June 1986 through September 1992. Average annual is for the period of October 1922 through September 2003.
[b] Anadromous fish rating is based on the ability to meet flow and temperature objectives in the Sacramento River and the number of ecosystem restoration features in the alternative.
[c] Reductions in conductivity and TDS, bromide, and chloride concentrations were approximately doubled for the two WQ alternatives in modeling simulations.
[d] Ranking based on ability of alternatives to support flat water recreation at Sites Reservoir.
[e] Ranking based on ability of alternatives to provide emergency flushing flows in the event of catastrophic levee failure in the Delta.
[f] All costs and benefits for initial alternatives evaluated in the PFR are at an appraisal level. Refined alternatives with feasibility level costs and benefits are currently under development.

EWA = Environmental Water Account
GWh = gigawatt-hour
M&I = municipal and industrial
TAF = thousand acre-feet
TDS = total dissolved solids
WQ = water quality

Hydropower Benefits, Recreation, and Flood Damage Reduction – This alternative would include a new hydropower generation facility between Sites Reservoir and Funks Reservoir. The new facility would generate a long-term annual average of 105 gigawatt-hour (GWh) and an annual average of 86 GWh during the driest periods. Alternative WS1A would be a net consumer of energy (-351 GWh/year). Additional analysis is needed to determine the effect of Sites Reservoir on levels in Shasta Lake; however, the effect should be positive, in general, since Sites Reservoir would provide increased storage in Shasta Lake during extended dry periods. Recreational benefits might include wildlife viewing, camping, and flat water activities. Storage in Sites Reservoir might provide small ancillary benefits in flood damage reduction through coordinated flood-control operations with other reservoirs. With no conveyance to directly release water back to the Sacramento River, this alternative would not be able to directly provide flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $2,138.1 million; the estimated annual cost is approximately $134.2 million (Table A4-2).

Table A4-2. Alternative WS1A Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,021.9
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	–
New Electrical Transmission	14.5
Environmental Enhancement[d]	–
Land Acquisition and Right-of-Way	81.0
Subtotal Contract Costs	**1,295.8**
Mitigation (10%)	129.6
Total Contract Costs (includes 10% unlisted items**)**	**1,425.4**
Scope/Market Conditions Contingency (20%)	285.1
Total Field Costs	**1,710.5**
Non-Contract Costs (25%)	427.6
Total Project Construction Costs (2007 dollars)	**2,138.1**
Interest During Construction - Foregone Investment Value (4.875% federal rate)	413.7
Total Capital Cost (2007 dollars)	2,551.8
Interest and Amortization	125.5
Annual Operations and Maintenance (Excludes Replacement Costs)	8.7
Total Annual Cost	**134.2**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 4,000 cfs, Funks Reservoir modification 4,000 cfs, Southern Bridge Route and Roads, five Recreation Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] N/A this alternative.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative WS1B (Existing Canals and New 1,500-cfs Diversion/1,125-cfs Release Pipeline)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 368 TAF/year and 316 TAF/year, respectively. Inclusion of the 1,500-cfs intake capacity/1,125-cfs release capacity Delevan Pipeline would enable releases from Sites Reservoir directly to the Sacramento River.

Anadromous Fish Survival – The combined average annual reduction of summer diversions at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff is 236 TAF. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is reduced by 3.7 percent over the future No Project Alternative.

Water Quality – Inclusion of the Delevan Pipeline would enable Sites Reservoir to make direct releases to the Sacramento River for export and Delta water quality improvements. The addition of the pipeline would increase the water quality benefits in the Delta. Given the limited release capacity of the Delevan Pipeline, water exchanges and coordinated operations with Shasta Lake would be needed to provide releases for Delta water quality improvements during July through September. This alternative would reduce the average EC by 2 percent and the reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 2 percent, 4 percent, and 4 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 84 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir, between Funks Reservoir and the TRR, and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 147 GWh and an annual average of 137 GWh during the driest periods. The net consumption of energy throughout the entire system is 460 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. Storage in Sites Reservoir might provide small ancillary benefits in flood-damage reduction through coordinated flood-control operations with other reservoirs. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,125-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta. Although this is not a large release, the proximity of Sites Reservoir to the Delta would make this an important feature because of the improved response time (flows would reach the Delta faster than they would from other upstream reservoirs).

Preliminary Estimated Costs – The estimated construction cost is $2,936.7 million; the estimated annual cost is approximately $183.0 million (Table A4-3).

Table A4-3. Alternative WS1B Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	369.8
New Electrical Transmission	22.9
Environmental Enhancement[d]	–
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,779.8**
Mitigation (10%)	178.0
Total Contract Costs (includes 10% unlisted items)	**1,957.8**
Scope/Market Conditions Contingency (20%)	391.6
Total Field Costs	**2,349.4**
Non-Contract includes Permitting (25%)	587.3
Total Construction Costs (2007 dollars)	**2,936.7**
Interest During Construction - Foregone Investment Value (4.875% federal fate)	568.9
Total Capital Cost (2007 dollars)	**3,505.6**
Interest and Amortization	**172.4**
Annual Operations and Maintenance (excludes replacement costs)	10.6
Total Annual Cost	**183.0**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 6,000 cfs, Funks Reservoir modification 6,000 cfs, Southern Bridge Route and Roads, five recreation Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Not applicable

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
N/A = not applicable
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative WS1C (Existing Canals and New 2,000-cfs Diversion/1,500-cfs Release Pipeline)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 382 TAF/year and 363 TAF/year, respectively. Inclusion of the 2,000-cfs Delevan Pipeline would enable releases throughout the year from Sites Reservoir directly to the Sacramento River.

Anadromous Fish Survival – The combined average annual reduction of diversions at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff is 233 TAF. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is reduced by 1.2 percent over the future No Project Alternative.

Water Quality – This alternative would reduce the average EC by 2 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 2 percent, 4 percent, and 4 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 91 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 153 GWh and an annual average of 134 GWh during the driest periods. The net consumption of energy by all facilities is 471 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,500-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $3,021.8 million; the estimated annual cost is approximately $188.1 million (Table A4-4).

Table A4-4. Alternative WS1C Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	421.4
New Electrical Transmission	22.9
Environmental Enhancement[e]	–
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,831.4**
Mitigation (10%)	**183.1**
Total Contract Costs(includes 10% unlisted items)	**2,014.6**
Scope/Market Conditions Contingency (20%)	402.9
Total Field Costs	**2,417.5**
Non-Contract Costs includes Permitting (25%)	604.4
Total Construction Costs (2007 dollars)	**3,021.8**

Table A4-4. (Continued)

Item	Cost
Interest During Construction - Foregone Investment Value (4.875% federal rate)	584.9
Total Capital Cost (2007 dollars)	**3,606.8**
Interest and Amortization	177.3
Annual Operations and Maintenance (excludes replacement costs)	10.8
Total Annual Cost	**188.1**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 6,000 cfs, Funks Reservoir modification 6,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Delevan Pipeline and Sacramento River Pumping/Generating Plant (2,000-cfs diversion), connection to electrical grid.
[e] Not applicable.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
N/A = not applicable
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative AF1A (Existing Canals and New 1,500-cfs Diversion/1,125-cfs Release Pipeline with Enhanced Ecological Benefits)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 184 TAF/year and 166 TAF/year, respectively. Inclusion of the Delevan Pipeline (1,500-cfs diversion, 1,125-cfs release) would enable direct release of water throughout the year from Sites Reservoir to the Sacramento River.

Anadromous Fish Survival – The operational scheme for this alternative would give the highest priority to meeting the full list of ERA objectives (see Table A3-3) to benefit anadromous fish. This alternative would achieve an average annual combined 344 TAF Sacramento River diversion reduction at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is increased by 1.2 percent over the future No Project Alternative. Average long-term releases from Keswick Dam would increase by 305 TAF/year. Reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area would create valuable aquatic and floodplain habitat. Replenishing gravel suitable for spawning has been identified as an important influencing factor in the recovery of anadromous fish populations in the Sacramento River. Instream aquatic habitat improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also may benefit terrestrial species that inhabit the shoreline of the Sacramento River.

Water Quality – This alternative would reduce the average EC by 2 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 2 percent, 3 percent, and 3 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 73 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 152 GWh and an annual average of 137 GWh during the driest periods. The average net consumption of energy for all facilities is 225 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,125-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $2,951.2 million; the estimated annual cost is approximately $184.1 million (Table A4-5).

Table A4-5. Alternative AF1A Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	369.8
New Electrical Transmission	22.9
Environmental Enhancement	8.8
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,788.6**
Mitigation (10%)	178.9
Total Contract Costs(includes 10% unlisted items)	**1,967.5**
Scope/Market Conditions Contingency (20%)	393.5
Total Field Costs	**2,361.0**
Non-Contract Costs includes Permitting (25%)	590.2
Total Construction Costs (2007 dollars)	**2,951.2**

Table A4-5. (Continued)

Item	Cost
Interest During Construction - Foregone Investment Value (4.875% federal rate)	571.7
Total Capital Cost (2007 dollars)	**3,522.9**
Interest and Amortization	173.2
Annual Operations and Maintenance (excludes replacement costs)	10.9
Total Annual Cost	**184.1**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 6,000 cfs, Funks Reservoir modification 6,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Delevan Pipeline and Sacramento River Pumping/Generating Plant (1,500-cfs diversion), connection to electrical grid.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative AF1B (Existing Canals and New 2,000-cfs Diversion/1,500-cfs Release Pipeline)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 189 TAF/year and 144 TAF/year, respectively. Inclusion of the Delevan Pipeline (2,000-cfs diversion and 1,500-cfs release) would enable the direct release of water throughout the year from Sites Reservoir to the Sacramento River.

Anadromous Fish Survival – The operational scheme for this alternative would give the highest priority to meeting the full list of ERA objectives (see Table A3-3) to benefit anadromous fish. This alternative would achieve an average annual combined Sacramento River diversion reduction of 344 TAF at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is increased by 2.4 percent over the future No Project Alternative. Average long-term releases from Keswick Dam would increase by 315 TAF/year. Average storage at Shasta Lake and Folsom Lake also would increase for this alternative, and flows would be stabilized on the Sacramento River, from Keswick to Red Bluff, in the fall and winter during dry years. Reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area would create valuable aquatic and floodplain habitat. Replenishing gravel suitable for spawning has been identified as an important influencing factor in the recovery of anadromous fish populations in the Sacramento River. Instream aquatic habitat improvements would help provide favorable spawning conditions; and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also might benefit terrestrial species inhabiting the shoreline of the Sacramento River.

Water Quality – This alternative would reduce the average EC by 2 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 2 percent, 3 percent, and 3 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 76 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 157 GWh and an annual average of 137 GWh during the driest periods. The net consumption of energy by all facilities is 257 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,500-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $3,036.4 million; the estimated annual cost is approximately $189.3 million (Table A4-6).

Table A4-6. Alternative AF1B Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Facilities, Inlet/Outlet, Pumping/Generating Plant, and Funks Reservoir Enlargement[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	421.4
New Electrical Transmission	22.9
Environmental Enhancement	8.8
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,840.2**
Mitigation (10%)	184.0
Total Contract Costs (includes 10% unlisted items)	**2,024.2**
Scope/Market Conditions Contingency (20%)	404.8
Total Field Costs	**2,429.1**
Non-Contract Costs includes Permitting (25%)	607.3
Total Construction Costs (2007 dollars)	**3,036.4**
Interest During Construction - Foregone Investment Value (4.875% federal rate)	588.0
Total Capital Cost (2007 dollars)	**3,624.4**

Table A4-6. (Continued)

Item	Cost
Interest and Amortization	178.2
Annual Operations and Maintenance (excludes replacement costs)	11.1
Total Annual Cost	**189.3**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 6,000 cfs, Funks Reservoir modification 6,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Delevan Pipeline and Sacramento River Pumping/Generating Plant (2,000-cfs diversion), connection to electrical grid.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative WSFQ (Existing Canals and 2,000-cfs Pipeline and Fish Enhancements)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 276 TAF/year and 262 TAF/year, respectively.

Anadromous Fish Survival – The combined average annual reduction of diversions at the Hamilton City GCID Canal and at the T-C Canal at Red Bluff is 208 TAF. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is reduced by 2.4 percent over the future No Project Alternative. Average long-term releases from Keswick Dam would increase by 307 TAF/year. Reclaiming inactive gravel mining sites along the Sacramento River near the Primary Study Area would create valuable aquatic and floodplain habitat. Replenishing gravel suitable for spawning has been identified as an important influencing factor in the recovery of anadromous fish populations in the Sacramento River. Instream aquatic habitat improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also might benefit terrestrial species inhabiting the shoreline of the Sacramento River.

Water Quality – This alternative would reduce the average EC by 5 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 5 percent, 8 percent, and 8 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 170 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 150 GWh and an annual average of 153 GWh during the driest periods. The average net consumption of energy for all facilities is 471 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative includes a 1,500-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $ 3,036.4 million; the estimated annual cost is approximately $189.0 million (Table A4-7).

Table A4-7. Alternative WSFQ Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pump/ Generating Station[d]	421.4
New Electrical Transmission	22.9
Environmental Enhancement	8.8
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,840.2**
Mitigation (10%)	184.0
Total Contract Costs (includes 10% unlisted items)	**2,024.2**
Scope/Market Conditions Contingency (20%)	404.8
Total Field Costs	**2,429.1**
Non-Contract Costs includes Permitting (25%)	607.3
Total Construction Costs (2007 dollars)	**3,036.4**
Interest During Construction - Foregone Investment Value (4.875% federal rate)	588.0
Total Capital Cost (2007 dollars)	**3,624.4**
Interest and Amortization	178.2
Annual Operations and Maintenance (excludes replacement costs)	10.8
Total Annual Cost	**189.0**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 5,000 cfs, Funks Reservoir modification 5,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/ Generating Plant and Pipeline (1,800 cfs).
[e] Delevan Pipeline and Sacramento River Pumping/Generating Plant (2,000-cfs diversion), connection to electrical grid.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative WQ1A (Existing Canals and New 1,500-cfs Release Pipeline)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 225 TAF/year and 241 TAF/year, respectively. Inclusion of the Delevan Pipeline would enable releases throughout the year from Sites Reservoir directly to the Sacramento River.

Anadromous Fish Survival – The combined average annual reduction of diversions at the Hamilton City GCID Canal intake and the T-C Canal intake at Red Bluff is 197 TAF. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is reduced by 1.2 percent over the future No Project Alternative. Average long-term releases from Keswick Dam would increase by 262 TAF/year.

Water Quality – The operational scheme for this alternative would assign the highest priority to improving Delta water quality for the 6-month period from July through December. This alternative would reduce the average EC by 4 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 4 percent, 7 percent, and 8 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvement would be 169 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 128 GWh and an annual average of 105 GWh during the driest periods. The average net consumption of energy by all facilities is 243 GWh/yr. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,500-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $2,664.5 million; the estimated annual cost is approximately $166.1 million (Table A4-8).

Table A4-8. Alternative WQ1A Estimated Construction and Annual Costs ($ Millions)[a]

Item	Cost
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,021.9
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	316.0
New Electrical Transmission	14.5
Environmental Enhancement[e]	–
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,614.8**
Mitigation (10%)	161.5
Total Contract Costs (includes 10% unlisted items)	**1,776.3**
Scope/Market Conditions Contingency (20%)	355.3
Total Field Costs	**2,131.6**
Non-Contract Costs includes Permitting (25%)	532.9
Total Construction Costs (2007 dollars)	**2,664.5**
Interest During Construction - Foregone Investment Value (4.875% federal rate)	516.4
Total Capital Cost (2007 dollars)	**3,180.8**
Interest and Amortization	**156.4**
Annual Operations and Maintenance (excludes replacement costs)	9.7
Total Annual Cost	**166.1**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 4,000 cfs, Funks Reservoir modification 4,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Delevan Pipeline (1,500-cfs release) is release only; therefore, it does not include electrical connections or pumping plant costs.
[e] N/A this alternative.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TRR = terminal regulating reservoir

Accomplishments and Costs for Alternative WQ1B (Existing Canals and New 2,000-cfs Diversion/1,500-cfs Release Pipeline)

Water Supply and Reliability – The long-term and driest periods average increases in water supply (agricultural and M&I, and environmental Level 4 supply for refuges and EWA) would be 276 TAF/year and 301 TAF/year, respectively.

Anadromous Fish Survival – The combined average annual reduction of summer diversions at the GCID Canal and T-C Canal intakes is 233 TAF. The likelihood of end-of-September storage exceeding 1.9 MAF in Shasta Lake is reduced by 1.2 percent over the future No Project Alternative. Average long-term releases from Keswick Dam would increase by 268 TAF/yr.

Water Quality – The operational scheme for this alternative would assign the highest priority to improving Delta water quality for the 6-month period from July through December. This alternative would reduce the average EC by 5 percent and reduce the concentrations of TDS, chlorides, and bromides in Banks Pumping Plant exports by 5 percent, 9 percent, and 9 percent, respectively. The average release from Sites Reservoir and Shasta Lake for Delta water quality improvements would be 169 TAF/year.

Recreation, Hydropower, and Flood Damage Reduction – This alternative would include new hydropower generation facilities between Sites Reservoir and Funks Reservoir and between Funks Reservoir and the TRR and a turbine in the Delevan Pipeline to further increase power generation. These new facilities would generate a long-term annual average of 151 GWh and an annual average of 147 GWh during the driest periods. The average net consumption of energy for all facilities is 403 GWh/year. The reservoir would provide opportunities for hiking and camping and limited opportunities for fishing and boating. The diversions off of the Sacramento River would not be large enough to reduce peak flows; however, Sites Reservoir could improve flood protection for the Sacramento River Basin by increasing flood control reservation space in existing reservoirs through the exchange of storage capacity at Sites Reservoir. This alternative would include a 1,500-cfs release capacity through the Delevan Pipeline that could provide some flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures within the Delta.

Preliminary Estimated Costs – The estimated construction cost is $3,021.8 million; the estimated annual cost is approximately $188.1 million (Table A4-9).

Table A4-9. Alternative WQ1B Estimated Construction and Annual Costs ($ Millions)[a]

Item	Costs
Sites Reservoir Dams and Pumping Facilities, Inlet/Outlet, Pumping/Generating Plant, Funks Reservoir and Facilities (1.8 MAF)[b]	1,124.7
GCID Canal Modifications[c]	37.1
TRR Pumping Station and Pipeline (1,800 cfs)	141.4
Delevan Pipeline and Sacramento River Pumping/Generating Station[d]	421.4
New Electrical Transmission	22.9
Environmental Enhancement[e]	-
Land Acquisition and Right-of-Way	84.0
Subtotal Contract Costs	**1,831.4**
Mitigation (10%)	183.1
Total Contract Costs (includes 10% unlisted items)	**2,014.6**
Scope/Market Conditions Contingency (20%)	402.9
Total Field Costs	**2,417.5**

Table A4-9. (Continued)

Non-Contract Costs including Permitting (25%)	604.4
Total Construction Costs (2007 dollars)	**3,021.8**
Interest During Construction - Foregone Investment Value (4.875% federal rate)	584.9
Total Capital Cost (2007 dollars)	**3,606.8**
Interest and Amortization	177.3
Annual Operations and Maintenance (Excludes Replacement Costs)	10.8
Total Annual Cost	**188.1**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.
[b] Includes Sites Dam, Reservoir Clearing, Golden Gate Dam, nine Saddle Dams, Long Tunnel and Multi-Level Inlet/Outlet, Sites Pumping/Generating Plant 6,000 cfs, Funks Reservoir modification 6,000 cfs, Southern Bridge Route and Roads, five Recreational Facilities.
[c] GCID upgrade 1,800-cfs option (headgate, tuttle check, TRR siphon), TRR, TRR Pumping/Generating Plant and Pipeline (1,800 cfs).
[d] Delevan Pipeline and Sacramento River Pumping/Generating Plant (2,000-cfs diversion), connection to electrical grid.
[e] N/A this alternative.

cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
TRR = terminal regulating reservoir

Comparison of Initial Action Alternative Plans

A critically important element of the plan formulation process is the comparison of the initial action alternative plans. This preliminary evaluation is based on consideration of four evaluation criteria identified in the principals and guidelines (P&Gs) (WRC, 1983) for water resources planning. These criteria are (1) completeness, (2) effectiveness, (3) efficiency, and (4) acceptability.

Completeness

Completeness, with respect to the initial action alternative plans formulated by the NODOS feasibility studies, is the extent to which each initial action alternative plan provides and accounts for all necessary investments or other actions by Reclamation or DWR and by local entities to ensure the realization of the planned effects. Other public or private actions crucial to realizing the objectives of the initial action alternative plans are identified as well. Key considerations include the ability of the initial action alternative plan to meet all objectives of the NODOS feasibility studies and the reliability of the project in all types of water years. Key observations include the following:

- The No Project Alternative rates very low. Each initial action alternative plan contributes to meeting all of the primary and secondary objectives.

  The initial action alternative plans do not rely heavily on any other actions. The performance of all of these plans would be enhanced through the implementation of conjunctive-use programs; however, the additional benefits associated with conjunctive use were not included in the modeling effort or benefits determinations used in evaluating alternatives.

- The initial action alternative plans are considered equally reliable from an engineering standpoint. O&M requirements would be reduced for Alternative WS1A, given the absence of the Delevan Pipeline. However, some differences in reliability would be evident under dry conditions. The reliability of Alternative WS1A in meeting all of the primary objectives would be reduced under dry conditions. Alternative WQ1B would be the best performer under dry conditions.

Effectiveness

Effectiveness is the extent to which the initial action alternative plans eliminate the specified problems and achieve the objectives of the NODOS feasibility studies.

Water Supply and Water Supply Reliability (Primary Objective)

Figure A4-1 shows the exceedance probability of total TCCA deliveries, CVP south-of-the Delta deliveries, and SWP south-of-the-Delta deliveries of each of the initial action alternatives and the No Project Alternative. The exceedance plots provided show the likelihood of increased reliability for TCCA, CVP, and SWP users. Table A4-10 provides a comparative summary of the water supply increases achieved by each initial action alternative plan over the No Project Alternative.

The analysis of this objective includes CVP, SWP, local water supply, Level 4 supply for refuges, and EWA. It does not include additional water released to improve Delta water quality. General observations from review of Table A4-10 include the following:

- Alternatives WS1C, WS1B, and WS1A provide the highest average long-term annual water supply, with total water supply increases over the No Project Alternative (382, 368, and 336 TAF/year, respectively).

- Alternative AF1A provides the lowest average long-term annual water supply, with a total water supply increase over the No Project Alternative of only 184 TAF/year.

Water supply reliability is also improved by reductions in groundwater pumping to reduce overdraft. The greatest reductions are for Alternatives WS1A, WS1B, and WS1C which reduce groundwater pumping by 70, 64, and 70 TAF per year, respectively. Alternatives WQ1A and WQ1B provide reductions of 54 and 64 TAF per year, respectively. Lesser reductions in pumping of 39, 38, and 37 TAF per year, respectively, are achieved by alternatives AF1A, AF1B, and WSFQ.

Water Quality (Primary Objective)

Improved water quality in the Delta was evaluated in terms of the ability of each alternative to reduce the adverse effects of salinity on drinking water quality and other beneficial uses. By improving water quality in the Delta, it is also expected that a subsequent decrease in treatment cost of exported water would be realized.

Table A4-10. Water Supply Increases[a] (Dry Periods Average Increase[b]/Average Annual Increase) (TAF/Year)

Water Supply Locale and Use	Initial Action Alternative Plans							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Sacramento Valley								
TCCA Delivery[c]								
TCCA CVP Delivery	19 / 11	14 / 8	19 / 9	8 / 5	4 / 4	6 / 5	16 / 7	14 / 9
TCCA Non-CVP Delivery	35 / 20	30 / 21	32 / 23	19 / 15	18 / 14	1 / 1	35 / 23	36 / 23
CVP Agriculture (includes TCCA CVP Delivery)	21 / 12	15 / 10	22 / 11	9 / 5	5 / 5	7 / 6	18 / 8	16 / 10
CVP M&I	2 / 0	1 / 1	2 / 1	0 / 0	0 / -0	0 / 0	1 / 0	1 / 0
Bay Area								
CVP Agriculture	4 / 2	3 / 2	4 / 2	2 / 1	1 / 1	1 / 1	3 / 1	3 / 1
CVP M&I	3 / 1	2 / 1	4 / 2	0 / 0	0 / 0	1 / 0	3 / 1	2 / 1
SWP M&I	4 / 12	9 / 14	8 / 14	5 / 7	6 / 7	13 / 15	5 / 8	11 / 12
San Joaquin Valley								
CVP Agriculture	105 / 41	81 / 32	110 / 41	50 / 23	28 / 21	30 / 13	86 / 34	79 / 32
CVP M&I	0 / 0	0 / 0	1 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
SWP Agriculture	16 / 20	36 / 29	32 / 27	19 / 15	20 / 17	50 / 32	19 / 17	38 / 26
South and Central Coast								
SWP M&I	0 /84	55 / 111	60 / 111	27 / 46	30 / 51	105 / 116	34 / 62	72 / 92
Total Ag and M&I								
CVP, SWP, and Local Supply	**190 / 192**	**232 / 221**	**275 / 232**	**131 / 112**	**108 / 116**	**208 / 184**	**204 / 154**	**258 / 197**
Environmental								
Level 4 Supply for Refuges	32 / 56	24 / 55	26 / 55	11 / 23	11 / 24	15 / 35	15 / 31	17 / 35
EWA	51 / 88	60 / 92	62 / 95	24 / 49	25 / 49	39 / 57	22 / 40	26 / 44
Total – All Users	273 / 336	316 / 368	363 / 382	166 / 184	144 / 189	262 / 276	241 / 225	301 / 276

[a] Increases from the No Project Alternative. A.1-2 for beneficiary target allocations. See Operations Priority in Tables A.1-5 through A.1-12 for basis of CVP/SWP allocation.
[b] Driest periods increases are the average quantity for the combination of the periods May 1928 through October 1934, October 1975 through September 1977, and June 1986 through September 1992. Average annual increases are based on average quantities for October 1922 through September 2003.
[c] For purposes of preliminary evaluations in this PFR phase, TCCA deliveries were used to model local deliveries. This is subject to change as additional modeling studies are made for the feasibility studies and report.

CVP = Central Valley Project
EWA = Environmental Water Account
M&I = municipal and industrial
PFR = Plan Formulation Report
SWP = State Water Project
TAF = thousand acre-feet
TCCA = Tehama-Colusa Canal Authority

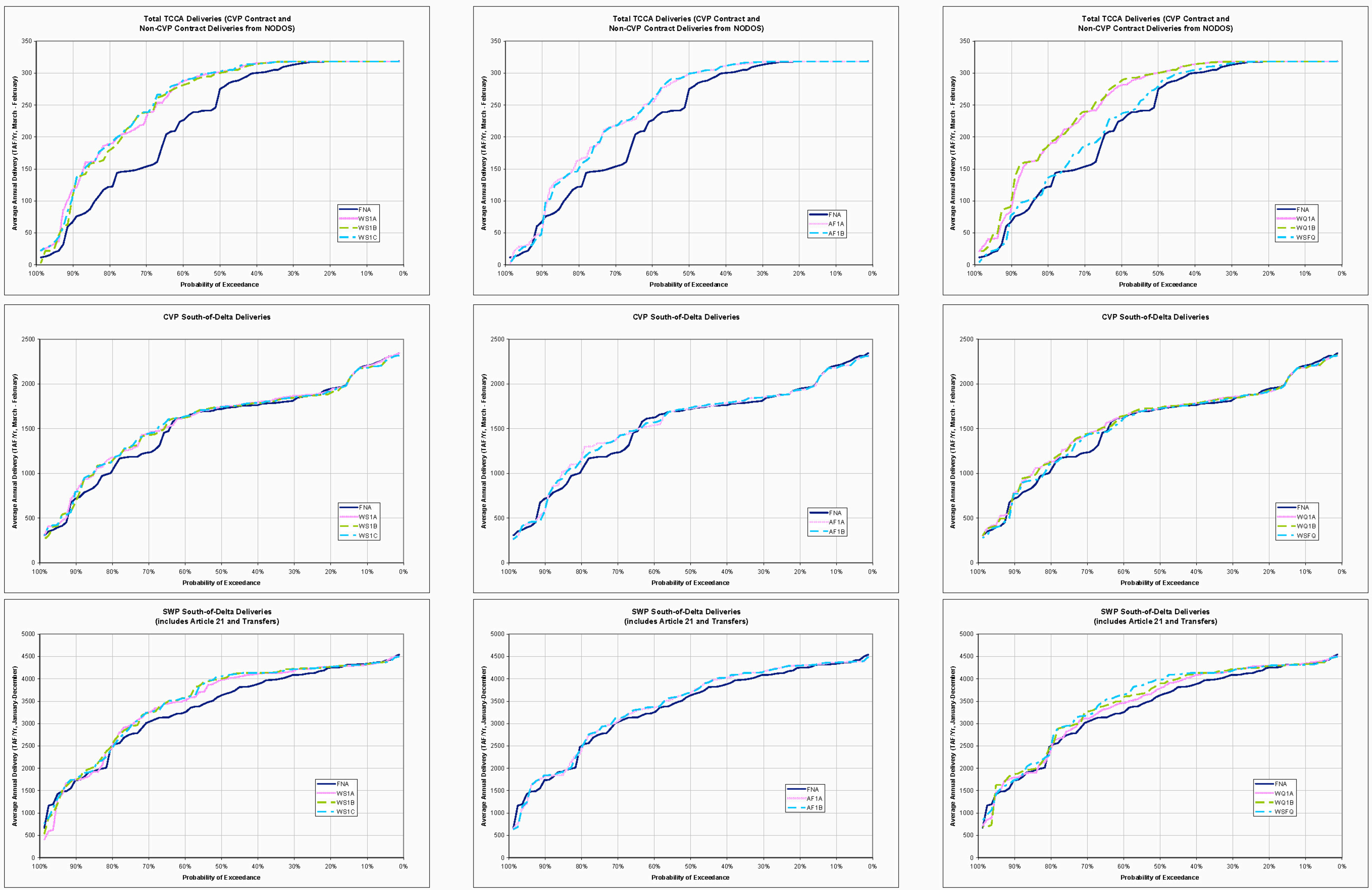


Figure A4-1. Exceedance Plots for Water Supply Reliability

This page intentionally left blank

The X2 location is the distance in kilometers (km) from the Golden Gate Bridge to the location where salinity in the Delta is two parts per thousand. Regulatory standards are defined for maintaining the X2 location downstream from specific locations in the western Delta for a predefined number of days. Table A4-11 shows the change in X2 location for dry and critical years. Figures A4-2, A4-3, A4-4, and A4-5 show the average X2 position by month for the long-term average, wet and above normal years, below normal years, and dry and critical years. The greatest improvement is during the fall in dry and critical years, where the X2 location is shifted by 1 to 3 km inland.

Table A4-11. Change in X2 Location During Dry and Critical Years[a] (km)

	Initial Action Alternative Plans							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Oct	-1	-2	-2	-1	-1	-2	-2	-3
Nov	0	0	-1	0	0	-1	-1	-1
Dec	0	0	0	0	0	-1	0	-1
Jan	1	0	0	0	0	0	0	0
Feb	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1
Apr	1	1	1	0	0	1	1	1
May	0	0	0	0	0	0	0	0
Jun	0	0	0	-1	-1	0	0	0
Jul	0	0	0	0	0	0	0	0
Aug	-1	-1	-1	-1	-1	-1	-1	-1
Sep	-1	-1	-1	-1	-1	-2	-2	-2

[a] Negative numbers (decrease in distance) indicate X2 is closer to the Golden Gate Bridge than the future No Project Alternative, whereas positive numbers (increase in distance) indicate X2 is further from the Golden Gate Bridge than the future No Project Alternative.

km = kilometer

Relative impacts to salinity were evaluated by comparing simulated EC, TDS, and chloride concentrations (see Table A4-12). Impacts on water quality for all alternatives are illustrated on Figure A4-6. Relative impacts related to a decrease in toxic effects of disinfectant byproducts were evaluated by comparing simulated bromide concentrations. Key observations from Table A4-12 include the following:

- Simulations predict that the implementation of all project alternatives would result in some reduction to average EC, TDS, and chloride concentrations at the Banks Pumping Plant and would, therefore, achieve some degree of improvement to salinity in water available for export.

- Water quality Alternatives WSFQ, WQ1A and WQ1B would provide substantially greater reduction in salinity, bromides, and chlorides than the other project alternatives.

In summary, Alternatives WSFQ, WQ1A, and WQ1B best meet the objective of improving Delta water quality.

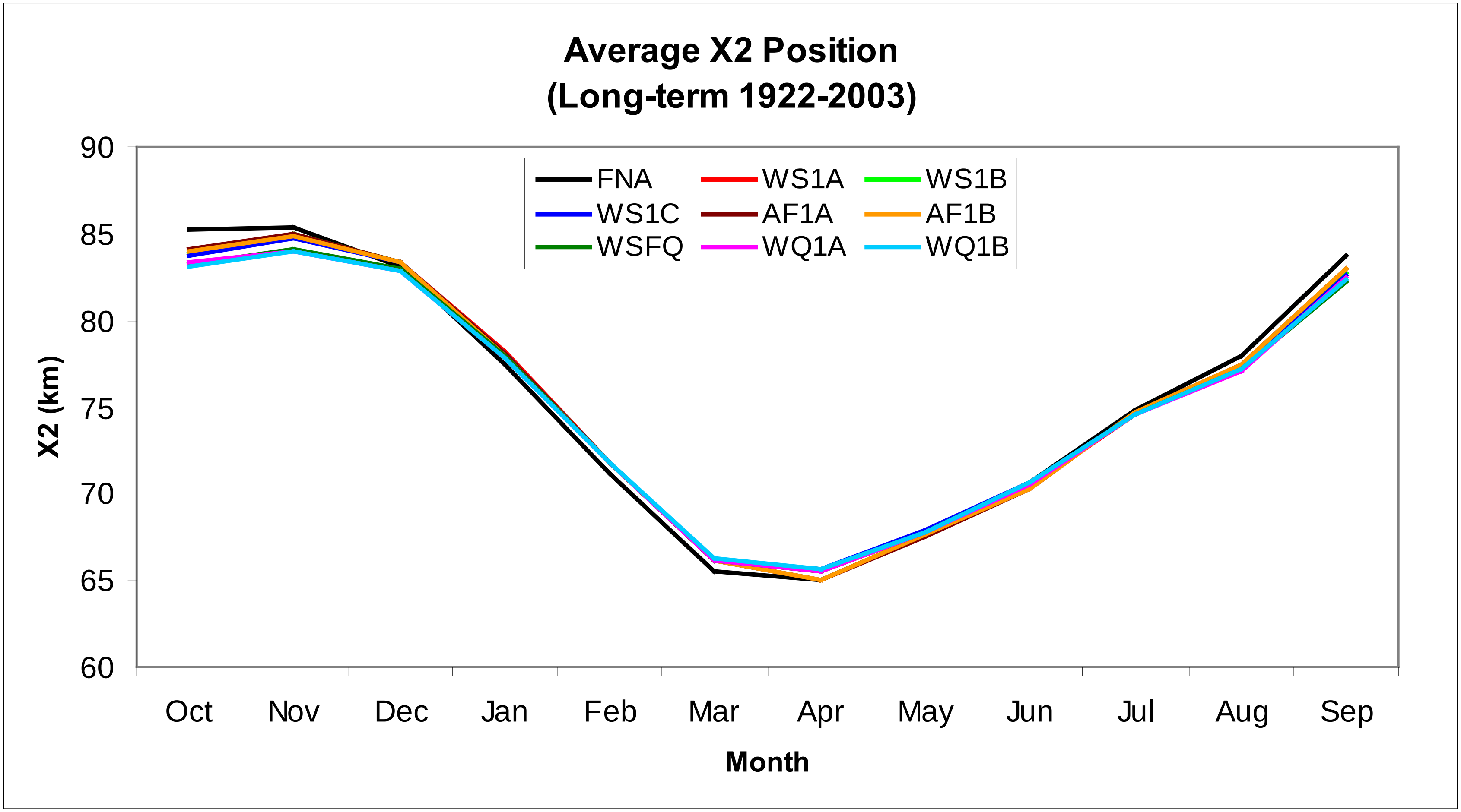


Figure A4-2. Change in Long-Term Average X2 Position for All Initial Alternatives Compared to the Future No Project (FNP) X2 Position

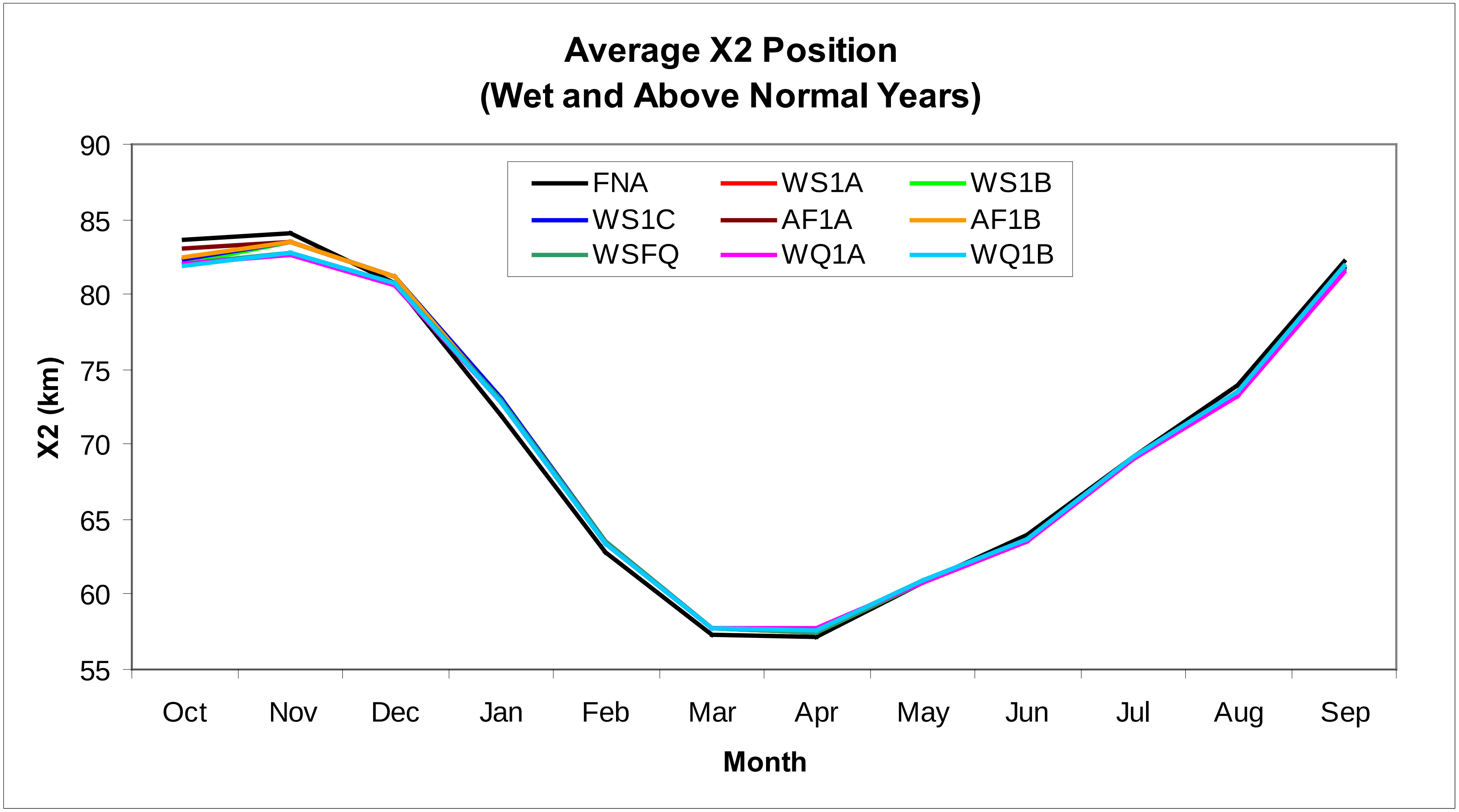


Figure A4-3. Change in X2 Position During Wet and Above Normal Years for All Initial Alternatives Compared to the Future No Project (FNP) X2 Position

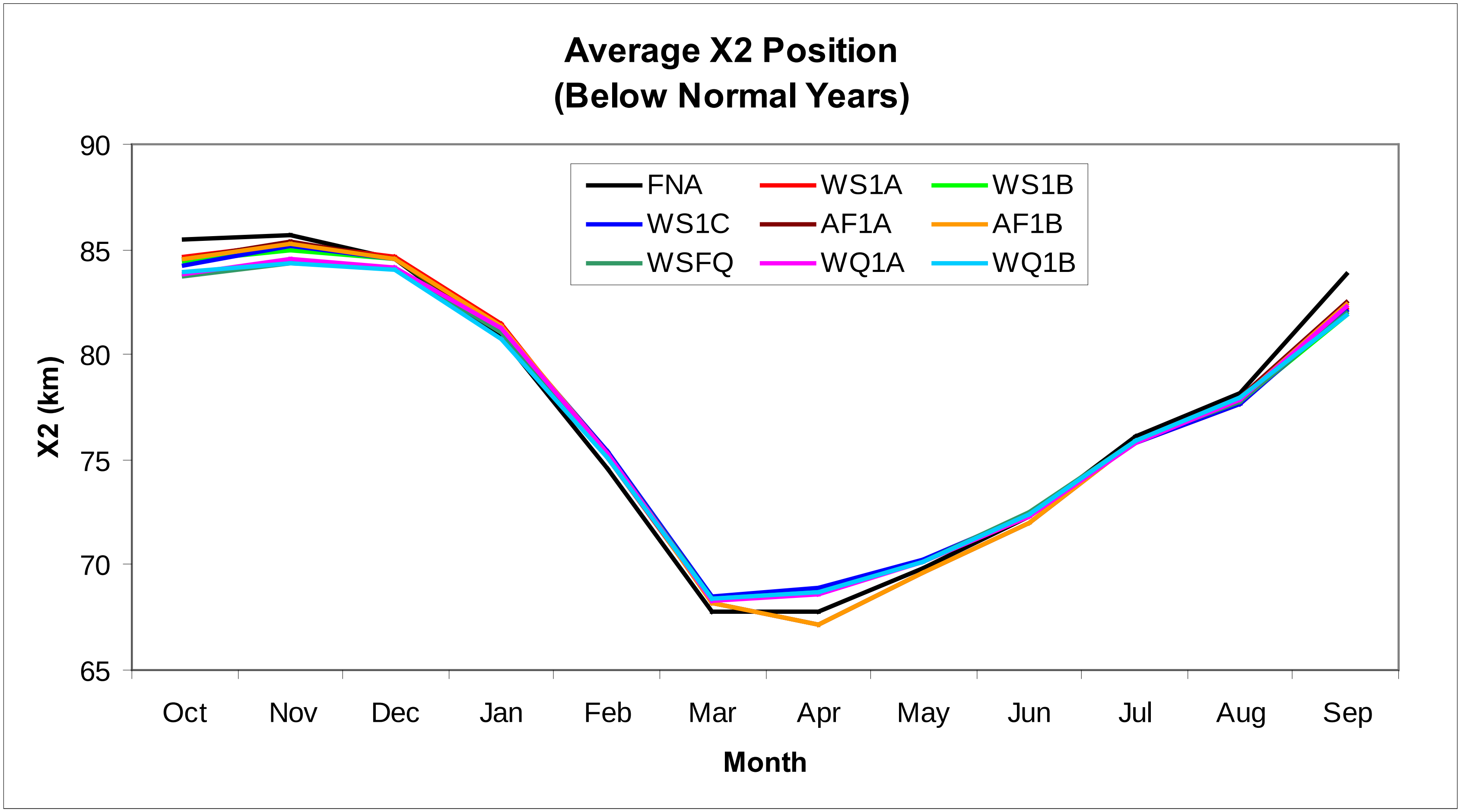


Figure A4-4. Change in X2 Position During Below Normal Years for All Initial Alternatives Compared to the Future No Project (FNP) X2 Position

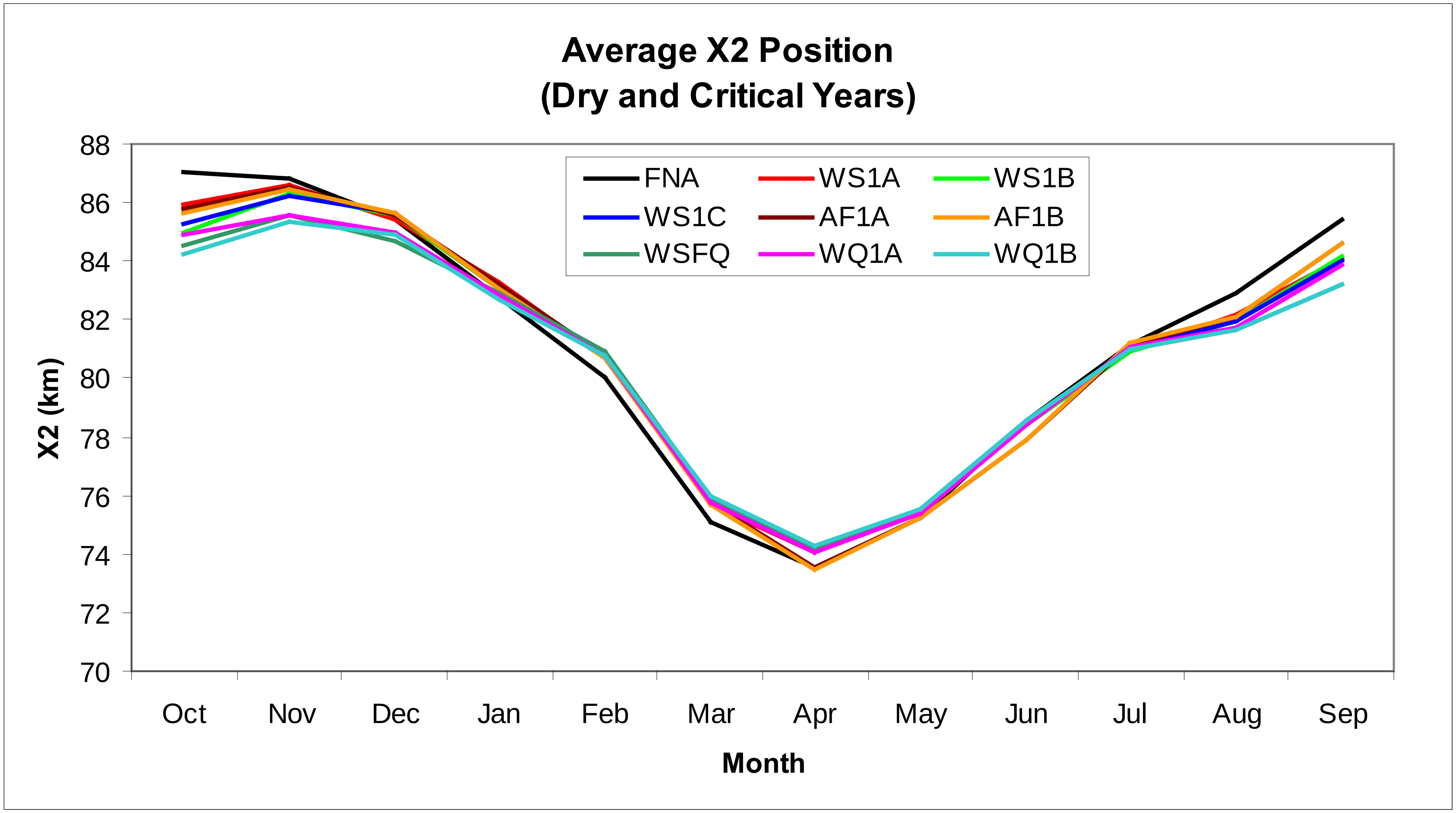


Figure A4-5. Change in X2 Position During Dry and Critical Years for All Initial Alternatives Compared to the Future No Project (FNP) X2 Position

Table A4-12. Quality of Banks Pumping Plant Exports (Weighted Average of all Values of Monthly Simulation)

Simulated Using DSM2 Parameter	Initial Action Alternative Plans								
	FNA	WS1A (% Difference from FNA)	WS1B (% Difference from FNA)	WS1C (% Difference from FNA)	AF1A (% Difference from FNA)	AF1B (% Difference from FNA)	WSFQ (% Difference from FNA)	WQ1A (% Difference from FNA)	WQ1B (% Difference from FNA)
EC (μmhos/cm)	442.7	435.5 (-2)	434.6 (-2)	431.3 (-3)	434.9 (-2)	434.1 (-2)	434.1 (-5)	423.2 (-4)	418.9 (-5)
TDS (mg/L)	283.3	276.6 (-2)	278.1 (-2)	276.0 (-3)	278.3 (-2)	277.8 (-2)	269.3 (-5)	270.9 (-4)	268.1 (-5)
Chloride (mg/L)	76.15	73.16 (-4)	73.83 (-3)	72.90 (-4)	73.92 (-3)	73.71 (-3)	69.93 (-8)	70.60 (-7)	69.36 (-9)
Bromide (mg/L)	0.248	0.238 (-4)	0.240 (-3)	0.237 (-4)	0.241 (-3)	0.240 (-3)	0.227 (-9)	0.229 (-8)	0.225 (-9)

cm = centimeter
EC = electrical conductivity
FNP = future no project
mg/L = milligrams per liter
TDS = total dissolved solids
μmhos = micromhos

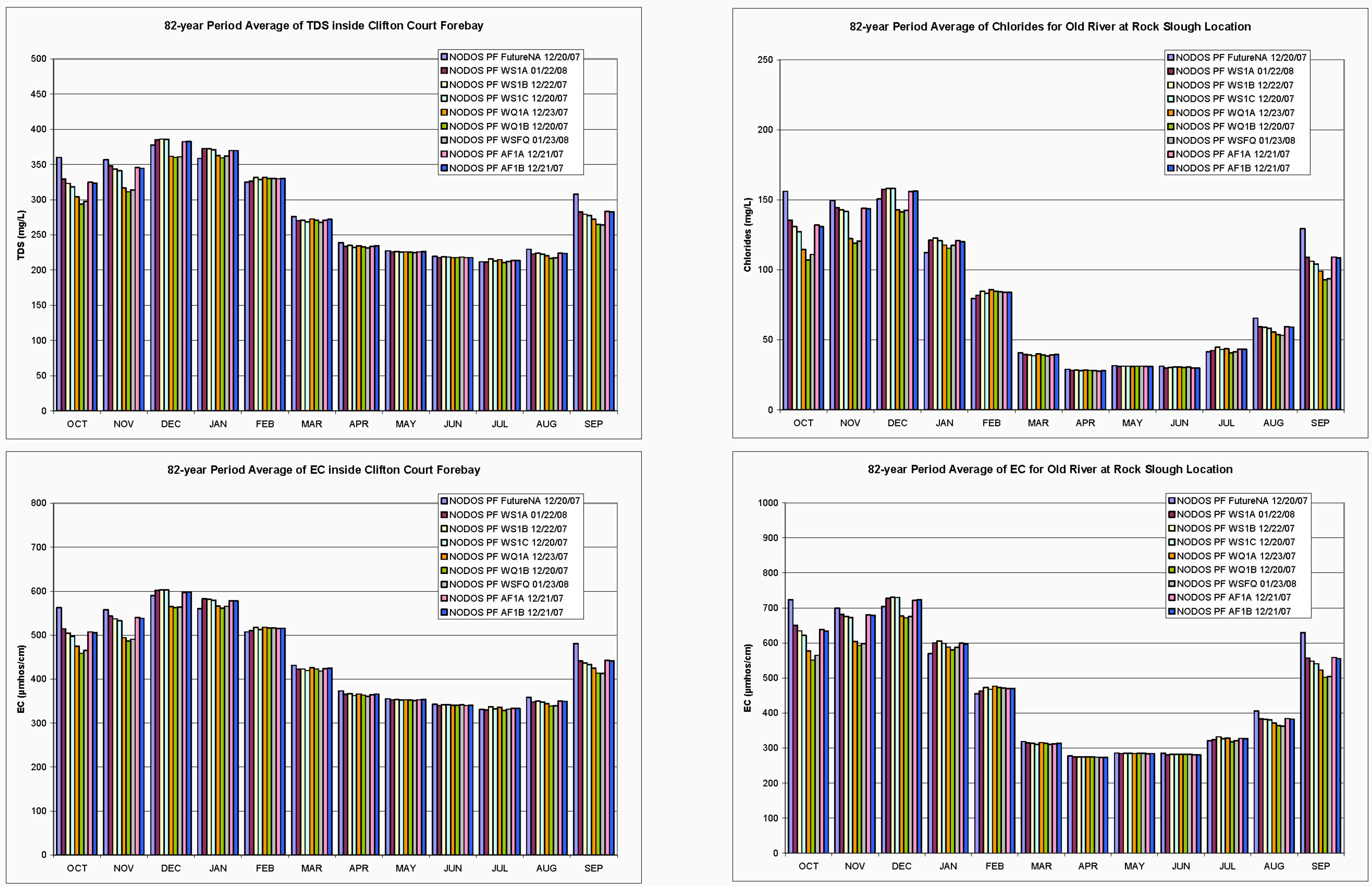


Figure A4-6. Water Quality Plots for all Initial Alternatives

This page intentionally left blank

Survival of Anadromous Fish and Other Aquatic Species (Primary Objective)

The NODOS Project alternatives include an ERA that would be used to provide water for restoration actions within the Bay-Delta watershed. The account is conceived to provide first-of-its-kind-in-California firm water assets, owned and managed by the state and/or federal government, for restoration actions beyond regulatory requirements. The initial NODOS formulations include a set of restoration actions associated with the Sacramento River, including, for example, an improved temperature regime below Shasta Lake, reduced diversions, and stabilization of flows for anadromous fish. Alternatives AF1A, AF1B, and WSFQ include several habitat restoration programs, including restoration of gravel mines, improvement of instream habitat, and replenishment of spawning gravels.

Conceptual development of the restoration account includes an adaptive management approach to restoration actions. This adaptive approach could mean support for experimental actions or the ability to refine actions as scientific understanding of ecosystem processes improve. In addition, restoration managers may determine that a different set of actions have priority over the existing actions and that the restoration account's assets should be allocated to meeting higher priority objectives.

Each alternative plan would result in some modifications to the operation of Shasta, Oroville, and Folsom reservoirs. These modifications would result in changes in flows that would affect the temperature and habitat downstream from these reservoirs; water temperatures are one of the principle drivers for salmonid production.

The relative effectiveness of the various alternative plans was evaluated based on the performance of the ecosystem restoration actions, including improvements in temperature in the Upper Sacramento River, and improvements in Delta outflow in March (Table A4-13). This ranking system assumes that increasing diversion rates at all of the diversions would not result in substantial mortality associated with these diversions. This assumption is based on ongoing studies at GCID, and it further assumes that recent changes to reduce predation rates will be successful.

Table A4-13. Effect of Initial Action Alternatives on Anadromous Fish and Aquatic Resources

	Initial Action Alternative Plans							
	WS1A	**WS1B**	**WS1C**	**WQ1A**	**WQ1B**	**AF1A**	**AF1B**	**WSFQ**
Habitat Enhancements	N	N	N	N	N	SB	SB	SB
Increased Diversions	SA	SA	SA	SA	SA	SA	SA	SA
ERA Level 1 Benefits[a]	SB	SB	SB	SB	SB	SB	SB	SB
ERA Level 2 Benefits[b]	NA	NA	NA	NA	NA	SB	SB	NA
Sacramento River Temperatures	SA	SA	SA	N	SA	SB	SB	SB
Delta Habitat Water Quality	SB	SB	SB	SB	SB	SB	SB	SB
Overall	N	N	N	N	N	SB	SB	SB

Table A4-13. (Continued)

[a] Objectives identified in Table A3-3 that all initial action alternatives would address.
[b] Additional objectives identified in Table A3-3 that only some initial action alternatives would address.

ERA = Ecosystem Restoration Account
N = neutral
NA = not applicable
SA = slight adverse effect
SB = slight beneficial effect

The SALMOD model projects that these alternatives would have provided for better production of spring- and winter-run Chinook in drought periods, especially in the periods from 1930 to 1935 and 1988 to 1993; however, these benefits did not necessarily manifest themselves in shorter drought periods, such as 1977 to 1978. Key observations include the following:

- The two anadromous fish alternative plans (Alternatives AF1A and AF1B) would provide greater benefits for fisheries than the remaining alternatives. Alternative WSFQ also includes fish habitat enhancements, but the operations are not quite as beneficial to fish as those for Alternatives AF1A and AF1B.

- The remaining alternatives would provide substantially lower potential benefits to aquatic resources.

In addition to benefiting anadromous fish and aquatic species in the Sacramento River Basin, NODOS also would benefit aquatic species in the Delta. By providing an increase in Delta outflow, NODOS would help maintain an X2 position at 80 km (immediately west of Collinsville) from May to December. This outflow increase would increase delta smelt habitat and may reduce entrainment and improve food availability.

Ancillary Benefits of Hydropower Generation (Secondary Objective)

Although each of the project alternatives would be a net consumer of power, each also would have the ability to generate electricity when water is released from the reservoir. Table A4-14 summarizes the total power that would be generated at the Sites Reservoir generating facilities under each alternative. The results show that alternatives with conveyance to the Sacramento River would produce more power than Alternative WS1A, which does not have conveyance to the Sacramento River.

Table A4-14. Long-Term Total Power Generated (GWh)

	Initial Action Alternative Plans							
	WS1A	WS1B	WS1C	AF1A	AF1B	WSFQ	WQ1A	WQ1B
Power Generated (GWh)	105	147	153	152	157	150	128	151

GWh = gigawatt-hour

It should be noted that while none of the initial action alternative plans is intended to contribute a large supply of additional power to the statewide grid, the Sites Reservoir complex is capable of adding power to the statewide grid during the summer, and power generation facilities would help offset the power usage and provide some ancillary power benefits to the local or state power grid.

Recreation (Secondary Objective)

Several recreational opportunities, such as hiking, boating, camping, fishing, and swimming in the immediate vicinity of Sites Reservoir would be provided at comparable levels by all initial action alternative plans.

The NODOS Project would affect flatwater, or reservoir-based, recreation in the following ways:

- Recreational opportunities at Sites Reservoir
- Water level impacts at Shasta Lake, Lake Oroville, and Folsom Lake

Operating strategies will be employed to mitigate any impacts to recreation at Shasta Lake, Lake Oroville, and Folsom Lake (these impacts are not expected to be adverse and should be generally beneficial).

For initial evaluation in this PFR, differentiation of flatwater recreational opportunities focused on the average annual water surface elevation at Sites Reservoir. At full pool, Sites Reservoir would store 1.8 MAF at an elevation of 520 feet. The maximum surface area of the reservoir would be 14,130 acres. The reservoir would be fully useable for recreation. At a water surface elevation of 480 feet, the reservoir surface area would be nearly 90 percent of the maximum surface area and would be fully useable. This determination is based on an assumption that boat launch ramps would be functional to an elevation of 400 feet (Rischbieter and Elkins, 2000). Alternative WS1A would maintain a reservoir level at or above 440 feet on the most frequent basis (78 percent) and would experience less drawdown than the other initial action alternative plans. All of the other initial action alternative plans would be generally similar in performance, relative to each other.

Flood-Damage Reduction and Emergency Water (Secondary Objective)

Water storage in Sites Reservoir could provide flood-damage reduction benefits through coordination with other reservoirs. The diversions off of the Sacramento River would not be large enough to affect the magnitude of the peak flows meaningfully, but through coordination with other reservoirs and accurate forecasting, water could be held in Sites Reservoir in lieu of water in other reservoirs to create flood-control storage space in other reservoirs. All of the alternatives would provide almost equivalent performance in meeting this objective.

With no direct release back to the Sacramento River, Alternative WS1A would have no direct ability to provide flushing flows (to prevent saltwater intrusion) through the Delta in the event of catastrophic levee failures of multiple islands within the Delta. The remaining seven alternatives, all of which have the Delevan Pipeline, could provide some flushing flows in the event of catastrophic levee failures. Although these flows would not be a large release, the proximity of Sites Reservoir to the Delta would make this an important feature because of the improved response time (flows would reach the Delta faster than they would from existing upstream reservoirs).

Acceptability

Acceptability assesses the degree of acceptance by federal, California, and local entities and the public. It considers compatibility with existing laws, regulations, and public policies. A strategy for future public and stakeholder outreach has been developed (see Chapter 9) to evaluate the acceptability of the alternative plans. At this stage in the planning process, it appears that all initial action alternative plans would be ranked similarly. Key issues affecting all alternatives are likely to include the following:

- Affected property that would be inundated by Sites Reservoir
- Impacts to cultural resources from the construction of Sites Reservoir
- Opportunities for new recreational facilities associated with Sites Reservoir
- Benefits to water supply and water supply reliability
- Benefits to wildlife, habitat, and fisheries
- Benefits to water quality

Efficiency

Efficiency is the extent to which the initial action alternative plans are the most cost-effective means of alleviating the specified problems and realizing the project objectives, consistent with protecting the environment. This section addresses the environmental consequences of constructing and operating the NODOS Project; the following section, Summary of Potential Effects, provides a comparative evaluation of the monetary costs and benefits associated with each plan.

Environmental Impacts and Mitigation

Most of the adverse impacts identified for the NODOS Project would be associated with the construction of the reservoir and conveyance facilities.

Many of the adverse impacts would be associated with features common to all of the alternatives. The level of short-term, construction-related, potential impacts to air quality, traffic, cultural resources, land use, biology, and water quality would be slightly greater for alternatives in which the amount of construction disturbance was greater. However, these impacts generally are considered short-term, could be addressed through mitigation, and therefore are not likely to determine the selected alternative.

Table A4-15 summarizes the potential impacts and environmental consequences that are key differentiators between alternative plans.

Table A4-15. Differentiating Potential Impacts and Mitigations for Initial Action Alternative Plans

Resource Area	Potential Impact Description	Applicable Plans	Potential Mitigation
Physical Environment			
Geomorphology, Sedimentation, and Erosion	Additional Delevan Pipeline diversion of 0.7% to 4.4% of the river flow on average. Releases might create potential for river channel scour.	All, except WS1A	Requires further analysis.
Water Quality	Scour and sedimentation from the Delevan Pipeline could increase downstream turbidity and sedimentation.	All, except WS1A	Outlet structure should be engineered to reduce or eliminate scour.
Water Quality	Increase in turbidity and pollutant discharge during gravel mine restoration and replenishment of spawning gravel.	AF1A, AF1B, WSFQ	Comply with conditions of 404, 401, and 1602 Permits.
Biological Environment			
Aquatic and Fishery Resources	Potential for losses from impingement or entrainment from Delevan Diversion.	All, except WS1A	State-of-the-art fish screen proposed for Delevan Pipeline to mitigate entrainment.

Summary of Potential Effects

National Economic Development Account

The P&Gs (WRC, 1983) identify four “accounts” to display the potential effects for the evaluation of alternatives (national economic development [NED], regional economic development [RED], environmental quality [EQ], and other social effects [OSE]). Tables A4-16 and A4-17 provide a preliminary analysis of NED benefits. Other information that is required by law or that will have a material bearing on the decision-making process is considered in the other accounts (EQ, RED, and OSE).

Table A4-16. Annual NED Benefits by Initial Action Alternative Plans[a]

Annual Benefit	Initial Action Alternative Plans (Preliminary, 2007 $ Million)							
	WS1A	WS1B	WS1C	AF1A	AF1B	WSFQ	WQ1A	WQ1B
Water Supply								
Agricultural	$10.22	$9.57	$10.64	$6.10	$5.94	$5.85	$8.18	$9.39
Urban[b]	$50.07	$74.38	$73.52	$38.12	$42.55	$94.41	$46.75	$76.65
Other Urban[c]	$8.26	$17.25	$17.68	$6.46	$6.46	$20.72	$11.04	$15.48
EWA	$13.19	$13.94	$14.36	$7.19	$7.27	$8.72	$5.95	$6.71
Refuges	$12.64	$12.21	$12.28	$5.27	$5.15	$7.68	$6.78	$7.88
Total	**$94.38**	**$127.35**	**$128.48**	**$63.14**	**$67.37**	**$137.38**	**$78.70**	**$116.11**
Water Quality								
Urban	$8.44	$10.61	$12.34	$8.01	$7.71	$22.05	$16.36	$20.53
Other Urban	$1.00	$1.80	$2.17	$1.01	$0.87	$3.60	$2.85	$3.08

Table A4-16. (Continued)

Annual Benefit	Initial Action Alternative Plans (Preliminary, 2007 $ Million)							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Fisheries Restoration and Enhancement								
Upstream	$2.55	$6.95	$6.67	$18.04	$18.47	$11.58	$9.44	$8.16
Delta	$12.20	$17.75	$18.62	$14.92	$15.93	$52.36	$38.03	$43.52
Recreation	$17.01	$16.79	$16.49	$17.34	$17.13	$17.81	$14.54	$17.34
Hydropower	-$22.47	-$29.29	-$29.83	-$14.77	-$16.68	-$29.93	-$15.50	-$25.54
Total	**$113.11**	**$151.96**	**$154.94**	**$107.69**	**$110.80**	**$214.85**	**$144.42**	**$183.20**

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development..
[b] Urban – Urban water users in the South Coast and South Bay hydrologic regions.
[c] Other Urban – Urban water users in the Central Coast and interior southern California outside of South Coast and South Bay.

EWA = Environmental Water Account
NED = National Economic Development

Table A4-17. Annual NED Benefits and Annual Costs by Initial Action Alternative Plans[a]

Measure	Initial Action Alternative Plans (Preliminary $ Millions)							
	WS1A	**WS1B**	**WS1C**	**AF1A**	**AF1B**	**WSFQ**	**WQ1A**	**WQ1B**
Annual Benefits	$113.11	$151.96	$154.94	$107.69	$110.80	$214.85	$144.42	$183.20
Annual Costs	$134.20	$183.00	$188.10	$184.10	$189.30	$189.00	$166.10	$188.10
Net Benefits (Benefits – Costs)	-$21.09	-$31.04	-$33.16	-$76.41	-$78.50	+$25.85	-$21.68	-$4.90

[a] All costs for initial alternatives from the PFR are at an appraisal level. Refined alternatives with feasibility level costs are currently under development.

NED = national economic development

- The NED account shows changes in the economic value of the national output of goods and services.
- The RED account shows the regional incidence of NED effects, income transfers, and employment effects.
- The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms.
- The OSE account shows urban and community impacts and effects on life, health and safety.

Table A4-16 summarizes all NED benefits for each initial action alternative plan in millions of dollars annually; values are annualized assuming the project has been completed and is operating at full capacity.

Total annual benefits are greatest for Alternative WSFQ, and least for Alternative AF1A. Water supply benefits are higher than those for any other project purpose for all initial action alternative plans, with Alternative WSFQ the highest at $137 million and Alternative AF1A the lowest at $63 million.

For the PFR, it has been assumed that the value of water supply dedicated for ecosystem restoration purposes in the Sacramento River is consistent with the value of EWA's north-of–the-Delta water purchases. For ecosystem restoration benefits in the Delta, the value of the water used to augment Delta outflow is assumed to be equal to the weighted average value of water supply for south-of-the-Delta urban, agricultural, Level 4 supply for refuges, and EWA.

Hydropower benefits are negative because they capture the net energy consumption throughout the entire water delivery system that would be employed by the NODOS Project. These costs exceed the value of power generation associated with the reservoir.

Table A4-17 shows a preliminary comparison of annual NED values for the initial action alternative plans. Alternative WSFQ provides the largest net benefits. Net benefits are negative for the remaining alternatives. Additional investigation is required to provide more rigorous quantification of the physical benefits and economic values. Some of the ecosystem restoration and water quality benefits have not been quantified. Additional development of analytical tools and methodologies is presently underway to more fully quantify both the ecosystem restoration and water quality economic benefits.

Regional Economic Development Account

RED impacts can be determined at both the California and regional levels. With additional water supply, the value of agricultural output increases because the NODOS Project would increase supplies of project water and reduce crop idling for water transfers to environmental and urban water users. RED impacts will be developed further in the next stage of the feasibility studies.

Environmental Quality Account

Assessment of ecosystem restoration benefits is a complex analysis that puts a financial value on the benefits derived from protecting and enhancing aquatic and terrestrial species and their habitat. While it may be comparatively easy to quantify the direct costs associated with many ecosystem actions, evaluating the benefits derived by society is not a simple matter. Reclamation and DWR are engaged in ongoing efforts to develop new modeling tools and additional analytical methods to quantify the number of fish protected as a direct result of NODOS actions listed in each of the NODOS alternatives.

The operations strategies for the NODOS alternatives were developed to meet specific ecosystem restoration objectives (Table A3-3).

Table A4-18 provides a summary of potential EQ benefits. The aquatic resources analysis found that all of the water supply and water quality alternatives would have a slight beneficial effect on anadromous fish runs.

The anadromous fish alternatives would have more of a beneficial effect on anadromous fish runs in the upstream (Sacramento River) area, but these alternatives provide less water supply for Delta outflow than some other alternatives. For every alternative, it was assumed that 100 TAF/year of the upstream fisheries water supply would be required to offset the effects of upstream project operations. For the anadromous fish alternatives, approximately 125 TAF/year more are provided for upstream flow, but only 73 to 76 TAF/year are provided for Delta outflow. For alternatives other than the anadromous fish alternatives, only 17 to 76 TAF/year above the offset are provided for upstream flow, but anywhere from 74 to 170 TAF/year are provided for Delta outflow.

It is generally assumed that ESA recovery must occur with or without NODOS. This means that water supplies for recovery would be provided with or without NODOS. Therefore, benefits of water use that are lost because of water acquisitions for fish in the No Project Alternative are thereby avoided by providing water for fish using the project. For both upstream and Delta fishery water, the value of water was based on its opportunity cost.

If the threatened and endangered species populations were to increase because of the project, then application of non-use values instead of water cost savings would be appropriate. Many studies have suggested that people have non-use values for endangered fish that are much larger than the potential water acquisition cost savings counted here.[1]

There is a degree of uncertainty about the fisheries restoration benefits. Only some of the physical effects of the project have been measured. It is likely that some of the physical effects would be negative for some anadromous fish runs. Furthermore, some assumptions for the No Project Alternative are not clear at this time, and the selection of these assumptions could have large effects on the benefits estimates.

NODOS also can be used to provide a flexible ERA for restoration actions within the Bay-Delta watershed. The account is conceived to provide first-of-its-kind-in-California firm water assets, owned and managed by California and/or the federal government for restoration actions beyond regulatory requirements. This restoration account would employ an adaptive management approach to restoration actions. The account could support experimental actions in a flexible way that refines actions as scientific understanding of ecosystem processes improve. This approach would enable restoration managers to reallocate restoration account assets if they determine that a different set of actions have priority over the existing actions.

[1] See, for example, Fisher et al., 1991; Layton, 2001; Loomis, 1996; Olsen et al., 1991.

Table A4-18. Summary of Potential Environmental Quality Benefits

Resource Area	Potential Impact Description	Applicable Plans
Physical Environment		
Geomorphology, Sedimentation, and Erosion	Reduce erosion in lower Sacramento River associated with reducing peak flood flows.	All
Water Quality	Improve water quality in lower Sacramento and Delta.	All
Water Quality	Improve water quality in Extended Study Area.	All
Biological Environment		
Aquatic and Fishery Resources	Improve coldwater carry-over storage at Shasta Dam.	All
Aquatic and Fishery Resources	Provide supplemental flows for coldwater releases between Keswick and RBDD.	All
Aquatic and Fishery Resources	Reduce diversions at RBDD into T-C Canal and at GCID Canal from July through September.	All
Aquatic and Fishery Resources	Stabilize fall flows from Keswick to RBDD to avoid abrupt reductions assuming November 1997 AFRP flow targets.	WSFQ
Aquatic and Fishery Resources	Stabilize fall flows from Keswick to RBDD with 6,000-cfs target from October through January and 4,500 cfs for September.	WS1B, WS1C, WQ1A, WQ1B, AF1A, AF1B
Aquatic and Fishery Resources	Improve coldwater carryover storage at Folsom Lake and stabilize flows in American River.	All
Aquatic and Fishery Resources	Modify spring flows into snowmelt pattern with peak storm in late winter and early spring from RBDD to Colusa to benefit cottonwoods.	All
Aquatic and Fishery Resources	Provide flow event supplementing normal flows from Shasta and Keswick in March, when no winter flow event has occurred.	AF1A, AF1B
Aquatic and Fishery Resources	Provide a March Delta outflow from late winter through early spring peak inflow from the Sacramento River.	AF1A, AF1B
Aquatic and Fishery Resources	Provide a minimum flow of 13,000 cfs on the Sacramento River below Sacramento in May of all but critical years.	AF1A, AF1B
Aquatic and Fishery Resources	Improve water temperature in the Sacramento River in compliance with NOAA Fisheries Service temperature criterion of 56°F.	AF1A, AF1B, WSFQ
Aquatic and Fishery Resources	Create new warm water fish habitat in Sites Reservoir.	All
Aquatic and Fishery Resources	Fish enhancements (abandoned gravel mine restoration, instream aquatic habitat improvement, replenishing spawning gravel, and improving fish habitat in mainstem Sacramento).	AF1A, AF1B, WSFQ
Wildlife	Contribute to Level 4 water supply, benefiting wildlife refuges.	All

AFRP = Anadromous Fish Restoration Program
cfs = cubic feet per second
GCID = Glenn-Colusa Irrigation District
NOAA = National Oceanic and Atmospheric Association
RBDD = Red Bluff Diversion Dam
T-C = Tehama-Colusa
°F = degrees Fahrenheit

Following is a set of restoration actions focused on Delta species and ecosystem processes that may be supported with water from Sites Reservoir. These actions are derived from multiple sources, including the CALFED ERP and Delta Regional Ecosystem Restoration Implementation Plan, the Delta Vision Delta Ecosystem Restoration Plan, and DWR's Pelagic Fish Action Plan. Many of these actions are also considered in the Resources Agency's Bay Delta Conservation Plan. The Action 1 objective, described hereafter, is supported in all of the initial action alternative plans using the water quality objective described previously. In current formulations, water from the restoration account is not used to achieve this objective, even though there is an apparent ecosystem restoration benefit. As the feasibility studies progress, additional exploration of these Delta restoration actions may be warranted, and these actions may be included explicitly in NODOS restoration account actions as part of an alternative plan.

1. **Maintain X2 West of Collinsville during May – December (summer/fall).** An increase in Delta outflow, by maintaining an X2 position at 80 km from May to December, would increase delta smelt habitat and may reduce entrainment and improve food availability. Water from NODOS could support this action directly.

2. **Provide Flows through Yolo Bypass into Cache Slough (summer).** Flows in Yolo Bypass currently flow upstream in summer to meet several user needs in the Bypass. Maintaining positive flow would provide downstream transport of high food web productivity associated with the Yolo Bypass into the Delta. Water from NODOS could be provided to the Yolo Bypass from the ERA using a number of optional infrastructure and water delivery changes. Infrastructure and/or operational modifications would be required to provide summertime deliveries using Knights Landing Ridge Cut, Fremont Weir, or Sacramento Weir. In addition, it is likely that fish passage from the Yolo Bypass to the Sacramento River would require improvement with additional infrastructure. Another option is to exchange water with Yolo or Solano County users and allow additional flow from Cache and Putah Creeks to flow through the Yolo Bypass. Under these options, deliveries would be made from NODOS by extending the T-C Canal.

3. **Manage Flooding in North Delta for Seasonal Floodplain Habitat.** These actions would increase the area and time of inundation within the Yolo Bypass and the Consumnes River floodplain to increase plankton production to support juvenile, adult, and egg production of delta smelt. NODOS could contribute to an action associated with the Yolo Bypass. This action probably would require infrastructure and/or operational modifications to allow additional water into the Yolo Bypass; the concept also may require land-use modifications.

4. **Relocate North Bay Aqueduct (NBA) Intake on Barker Slough and Relocate Large Local Agricultural Intakes.** These two intake relocation actions would shift net flow downstream and mitigate drinking water dissolved organic carbon issues. These actions would be part of a larger effort to restore the tidal marsh in the Cache Slough complex. NODOS could provide alternative intake locations with a reliable Delta-independent diversion for the NBA contractors and agricultural users. One option is to extend the T-C Canal to the NBA pipeline. Another option is to provide exchange water to Solano agricultural Putah Creek users and then use Solano Project water as a replacement for NBA users.

5. **Yolo Bypass Enhancements.** Actions include: (1) add operable structure to Fremont Weir to allow lower Sacramento River flows into the Bypass; (2) enhance fish passage through Fremont Weir for multiple species (salmon, steelhead, sturgeon); (3) enhance Lower Putah Creek local floodplain; (4) enhance connectivity, fish passage, and agricultural access along toe drain/Lisbon Weir; (5) update fish ladder at Fremont Weir; and (6) provide localized floodplain enhancement, such as along toe drain.

   Actions will provide: (1) increased inundation frequency to yearly or biannual; (2) improved quality and availability of juvenile salmonid rearing habitat; (3) improved quality and availability of splittail spawning and rearing habitat; (4) improved primary production exports to lower Sacramento River/west Delta; (5) improved salmon and splittail access to Putah Creek; (6) improved fish passage at Fremont weir; and (7) improved migratory and resident bird habitats.

   Ongoing discussions regarding restoration in the Yolo Bypass indicate a strong connection between infrastructure and water supply. A new and reliable supply dedicated to users within the Yolo Bypass may help facilitate an implementation plan. If additional reliable water were available in the Yolo Bypass, water could be delivered to Bypass water users and thereby make the tidal Lisbon Weir (which is a fish barrier) unnecessary. A check dam near the Putah Creek confluence with the toe drain also could be operated in a more fish-friendly way if sufficient water supply were made available to users currently dependent on the dam.

6. **Increase Spring Delta Outflows.** An increase in total Delta outflow during the February to June period in "below normal," "dry," and "critically dry" water years would create low-salinity habitat (i.e., 1 to 3 parts per thousand salinity) in Suisun Bay. The action would increase the amount of low-salinity open-water habitat; facilitate downstream transport of sediment, nutrients, prey, and anadromous and estuarine juvenile fish; and promote improved abundance and survival of multiple fish and aquatic invertebrate species. NODOS could support these supplemental outflows directly.

7. **Experiment with Targeted Salinity Intrusions to Control Invasive Species and Promote Fish Populations.** This action is designed to test the effectiveness of promoting conditions that support desirable aquatic species, such as delta smelt, and control Brazilian waterweed, water hyacinth, and Asian clam. NODOS could support experimental flow strategies as described here. The restoration account could support experimental flow strategies in many locations (especially below the CVP and SWP reservoirs) within the Bay-Delta watershed.

EQ benefits will be developed further in the next stage of the feasibility studies.

Other Social Effects Account

Table A4-19 summarizes potential positive OSE. Potential OSE also include the following:

- Temporary construction-related benefits might derive to local communities, with limited opportunities for long-term, operation-related employment.

- There could be potential short-term adverse effects for those directly affected by construction.
- Storage in Sites Reservoir would provide ancillary benefits in flood-damage reduction.
- More than 14,000 acres of land would have to be acquired for Sites Reservoir and proposed facilities; relocation of affected people and property would be required.
- Potential impacts to instream aquatic habitats must be identified and assessed collaboratively with the federally recognized tribes and Bureau of Indian Affairs.

OSE will be developed further in the next stage of the feasibility studies.

Table A4-19. Summary of Potential Other Social Effects Benefits

Resource Area	Potential Impact Description	Applicable Plans
Socioeconomic Environment		
Environmental Justice	No disproportionate impacts to disadvantaged groups were identified for any alternative.	
Land Use		
Land Use	Conversion of natural and irrigated grassland and pasture into Sites Reservoir.	All
Recreation and Public Access	Increased recreation opportunities from new reservoir, including 1,350 acres of shoreline lands.	All
Water Supply	Long-term increases in CVP and SWP water supply reliability.	All
Power and Energy	Increased contribution to the power grid during on-peak demand from new hydropower generation facilities.	All

CVP = Central Valley Project
SWP = State Water Project

Summary of Comparisons of Initial Action Alternative Plans and Conclusions

Table A4-20 summarizes the evaluation of the plans with respect to the four criteria. Each plan is complete and effective in addressing the NODOS feasibility studies planning objectives and constraints. Additional investigation is required to provide more rigorous quantification of the physical benefits and economic values.

Table A4-20 presents a qualitative comparison and ranking of alternative plans that uses the criteria of completeness, effectiveness, efficiency, and acceptability. This preliminary comparison ranks alternative plans WSFQ and WQ1B higher than the other plans. Alternative WSFQ has benefits greater than costs and also offers the greatest total benefits of any of the initial action alternatives considered.

Alternative WQ1B has costs that are only slightly greater than benefits. This alternative merits additional investigation to better define the design, costs, and benefits. This analysis would include additional characterization of ecosystem benefits to the Delta and water quality benefits to agriculture south of the Delta.

Alternative WS1A is ranked third among the alternative plans when comparing benefits to costs. It has the third highest benefit-to-cost ratio. This plan's benefit-to-cost ratio could change substantially if the reservoir size were optimized. This alternative is also the least expensive of the alternatives considered.

This page intentionally left blank

Table A4-20. Summary Comparison of Comprehensive Plans

Alternative	Comparison Criteria				Relative Ranking
	Completeness	Effectiveness	Efficiency	Acceptability	
No Project Alternative	Addresses none of the planning objectives. Reliability is very low under dry conditions.	Does not address any of the primary objectives.	By taking no action, problems and needs will continue to increase, resulting in either more costly actions or water supply shortages.	Does not address any of the CALFED goals.	
Relative Rank	*Very Low*	*None*	*None*	*Very Low*	*Very Low*
WS1A	Addresses all objectives, but reliability is low for all objectives under dry conditions. O&M requirements are simplified by the absence of the Delevan Pipeline.	Modeling results demonstrate the absence of the Delevan Pipeline diversion would substantially reduce water supply under dry conditions. Provides moderate improvement in Delta water quality and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower benefit. Reservoir benefits recreation because it is typically full. Absence of Delevan Pipeline eliminates direct ability to provide emergency flushing flows.	Impacts are short-term and can be mitigated. Annual benefits are moderate ($113 million). Has lowest construction cost of any alternative, but a negative net benefit (-$21 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Low*	*Low*	*Moderate*	*Moderate*	*Moderate*
WS1B	Addresses all objectives. Has high reliability for water supply, moderate reliability for supporting anadromous fish, and low reliability for Delta water quality improvements.	Highly effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has highest annual benefits ($152M). Has moderate construction cost and negative net benefit (-$31 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*[a]
WS1C	Addresses all objectives. Has high reliability for water supply, moderate reliability for supporting anadromous fish, and low reliability for Delta water quality improvements.	Highly effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality and an overall low benefit to anadromous fish and aquatic resources. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has moderate annual benefits ($155M). Has moderate construction cost and negative net benefit (-$33 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*
AF1A	Addresses all objectives. Has high reliability for supporting anadromous fish and moderate reliability for water supply and Delta water quality improvements.	Moderately effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality and an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lowest annual benefits ($108M). Has moderate construction cost and negative net benefit (-$76 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Low*	*Moderate*	*Moderate*[1]
AF1B	Addresses all objectives. Has high reliability for supporting anadromous fish and moderate reliability for water supply and Delta water quality improvements.	Moderately effective in improving water supply and water supply reliability. Provides moderate improvement in Delta water quality and an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lower annual benefits ($111M). Has moderate construction cost and negative net benefit (-$78 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Low*	*Moderate*	*Moderate*

Table A4-20. (Continued)

Alternative	Comparison Criteria				Relative Ranking
WSFQ	Addresses all objectives. Has high reliability for water supply and water quality improvements. Reliability is moderate for supporting anadromous fish.	Highly effective in improving water supply and water supply reliability. Provides high improvement in Delta water quality. Has an overall high benefit to anadromous fish and aquatic resources. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has high annual benefits ($214 million). Has moderate construction cost and positive net benefit ($26 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*High*	*High*	*High*	*Moderate*	*High*
WQ1A	Addresses all objectives. Has high reliability for Delta water quality improvement and moderate reliability for water supply and supporting anadromous fish.	Moderately effective in improving water supply and water supply reliability. Provides great improvement in Delta water quality. Has an overall low benefit to anadromous fish and aquatic resources in the Sacramento River, but more significant benefit to Delta habitat. Provides moderate hydropower and low recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has lower annual benefits ($144M). Has moderate construction cost and negative net benefit (-$22 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*Moderate*	*Moderate*	*Moderate*	*Moderate*	*Moderate*
WQ1B	Addresses all objectives. Has high reliability for Delta water quality improvement and water supply and moderate reliability for supporting anadromous fish.	Highly effective in improving water supply and water supply reliability. Provides high improvement in Delta water quality. Has an overall low benefit to anadromous fish and aquatic resources in the Sacramento River, but higher benefit to Delta habitat. Provides low hydropower and recreation benefits. Provides moderate flood damage reduction and emergency flushing water supply.	Impacts are short-term and can be mitigated. Has second highest annual benefits ($183 million). Has moderate construction cost and a slightly negative net benefit (-$5 million).	Consistent with the goals of CALFED for various programs, including water supply reliability, water quality, and ecosystem restoration.	
Relative Rank	*High*	*High*	*Moderate*	*Moderate*	*Moderate to High*

[a] The ongoing feasibility studies consider combining features from the initial alternatives to enhance completeness and improve net benefits. Particular emphasis will be placed on combining alternatives (e.g., WS1B and AF1A) to maximize benefits to both water supply and the survivability of anadromous fish and other aquatic species.

CALFED = CALFED Bay-Delta Program
O&M = operation and maintenance

APPENDIX B

Engineering

(Under Development)

APPENDIX C

Economics

Table of Contents

Page

Table of Contents (Continued)

Page

Tables

Page

Tables (Continued)

Page

Attachment 1 Tables:

Figures

Page

This page intentionally left blank

CHAPTER 1 INTRODUCTION

This appendix was prepared for the North-of-the-Delta Offstream Storage (NODOS) feasibility studies being performed by the United States (U.S.) Department of the Interior (Interior), Bureau of Reclamation (Reclamation), and the California Department of Water Resources (DWR). These feasibility studies evaluate the effectiveness of offstream storage in the northern Sacramento Valley for improved water supply and water supply reliability, hydropower generation, improved water quality, and enhanced survival of anadromous fish and other aquatic species. This appendix documents the methodologies used to evaluate the economic benefits for the alternatives.

Project Overview

Traditionally, reservoirs are created by constructing dams on major streams (onstream storage). Offstream storage involves diverting water from a stream and transporting the water through a conveyance system to a reservoir that may be miles away from the point of diversion.

Development of the proposed offstream storage facilities would add flexibility to the state's water management system. The project would enable Reclamation and DWR to divert water from the Sacramento River during high flow periods and deliver water to the Sacramento River as needed during lower flow periods. With additional storage capacity and integrated operations coordinated with other water facilities, the project's diversions and deliveries can be managed to allow better system-wide responses to water demand, water quality and reliability requirements. In addition, the project would improve the state's water management system to respond to future water supply needs from climate change impacts and system interruptions from earthquake or flood events.

Purpose and Scope

Estimating the benefits of potential project accomplishments is critical to establishing economic feasibility and identifying a corresponding recommended plan. It is also instrumental in allocating project costs among the various purposes and in identifying cost-sharing responsibilities among federal and non-federal entities.

Primary Planning Objectives

The primary planning objectives of NODOS are to:

- Increase water supplies to meet existing contract requirements, including improved water supply reliability, and greater flexibility in water management for emergency response and agricultural, municipal and industrial (M&I), and environmental users;

- Increase the survival of anadromous fish populations in the Sacramento River, as well as the survivability of other aquatic species

- Provide flexible hydropower generation

- Improve the quality of water used for M&I and agricultural purposes throughout California and environmental water quality in the Delta

Secondary Planning Objectives

The secondary planning objectives of NODOS are to:

- Develop additional recreational opportunities in the Primary Study Area

- Create incremental flood-damage reduction opportunities in support of major northern California flood-control reservoirs

Approach

The basic guidelines for evaluating water development projects at the federal level are specified in the Principles and Guidelines (P&Gs).[1] Under the P&Gs, the federal objective for water contributions is to maximize the contribution to national economic development (NED) consistent with protection of the environment

Alternatives

In accordance with the P&Gs, the NODOS feasibility studies analyze three project alternatives and a No Project Alternative. The key components of the proposed alternatives relevant to the economic analysis are as follows:

- **Alternative A:** Sites Reservoir has a 1.27 MAF storage capacity and would use the existing Tehama-Colusa (T-C) Canal (2,100 cubic feet per second [cfs]) and Glenn-Colusa Irrigation District Canal (GCID) (1,800 cfs) and a Delevan pipeline with a diversion capacity of 2,000 cfs and release capacity of 1,500 cfs for conveyance. The Delevan pipeline would have a fish screen intake and pumping plant.

- **Alternative B:** Sites Reservoir has a 1.81 MAF storage capacity and would use the existing T-C Canal (2,100 cfs) and GCID Canal (1,800 cfs) and a new release only Delevan pipeline (release capacity of 1,500 cfs for conveyance). There are no fish screen intake and pumping plant facilities for the proposed Delevan pipeline.

- **Alternative C** is similar to Alternative B, except the Delevan pipeline has a fish screen intake and pumping plant with a diversion capacity of 2,000 cfs and a release capacity of 1,500 cfs.

All three alternatives include pump storage hydropower facilities to enable optimized hydropower generation throughout the year.

---

[1] U.S. Water Resources Council, March 10, 1983, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, Washington, D.C.

Discount Rate

The proposed project's future construction and operations will generate benefits and incur costs throughout its period of development and operation. The size and timing of these future benefits and costs will vary. Generally, costs incurred (or revenues generated) in the near-term will have a greater value than if the same nominal cost is incurred at a later date. This value difference reflects the effects of the time value of money.[2]

As a result, all project benefits and costs must be adjusted into a common point in time for accurate representation and comparison of the benefits and costs occurring at different times during its future development and operating period. The discount rate is a conversion factor used to translate the future nominal value of a benefit or expenditure into its comparable value for another time period. This creates a common basis that makes it easier to compare the value of benefits. The future benefits (or costs) are said to be expressed in "nominal terms" when their values are stated in the actual dollar amount that will occur at that future date. Once a nominal value is adjusted in to the common-time basis (e.g., 2013 dollars) using the appropriate discount rate, the adjusted benefit (or cost) will be expressed in "real" terms. The higher the discount rate, the lower the present value of future cash flows.[3]

Federal regulation requires use of the federal discount rate as specified by the Interior for economic analysis for water resource planning. In accordance with agency regulation, the federal discount rate of 3.75 percent was used for fiscal year 2013 to calculate present value of the project's future benefits and costs for this study (Federal Register, 2013).

Planning Horizon

The final documentation for the feasibility studies and the EIR/EIS are anticipated to be completed in 2014. Project approvals and funding are assumed to be obtained in 2015, after which project implementation would begin. Project operation would then be expected to occur in 2023.

The project benefits and costs have been analyzed over a 100-year time planning horizon based on the expected project completion in 2023. Consequently, the end of the federal planning horizon for the project is 2122.

---

[2] Generally, invested capital will appreciate in nominal value over its investment period. The extent of this growth is determined by the investment's interest rate. For example, $100 invested in 2011 at a 5 percent annual interest rate will be worth $105 a year later in 2012 – substantially greater than the value of a $100 invested in 2012.

[3] For example, if the discount rate was 5 percent, a $100 payment made in 2012 would be equivalent in present value terms (i.e., 2011 dollars) to $95.23 (i.e., $95.23 x 1.05 = $100). In other words, the discounted value of a $100 payment in 2012 would have a present value of $95.23 in 2011 dollar terms.

This page intentionally left blank

CHAPTER 2 ECONOMIC BACKGROUND

Principles and Guidelines

As discussed in Chapter 1, the primary guidance document for studies of federal water projects is the P&Gs (U.S. Water Resources, 1983). The P&Gs are used by federal water resource development agencies, including the United States Army Corps of Engineers (USACE), Reclamation, Tennessee Valley Authority, and Natural Resources Conservation Service. Under the P&Gs, the federal objective for water contributions is to maximize the contribution to NED consistent with protection of the environment.

In addition to NED, the P&Gs include three other accounts (RED, EQ, and OSE) for evaluation of alternative plans. Each is discussed below.

National Economic Development

The NED account is required for any water project study in which federal participation is considered. It shows changes in the net economic value of national output of goods and services. The contributions reflect the direct net benefits which would accrue to Glenn and Colusa County and to the rest of the nation if a project is implemented. Benefit categories considered may include agricultural water supply (and resulting net farm income); M&I water supply (and avoided costs of the most likely alternative source); flood control (and avoided property damages); hydropower (and avoided costs of alternative power sources); recreation (and visitors' willingness to pay [WTP]); and environmental enhancement.

The benefits may include both marketed and non-marketed goods and services. Marketed goods and services are those which are priced in markets or that can be observed to have a monetary value (e.g., water for agricultural or M&I use). Non-marketed goods and services are not traded in market structures, for example, recreation.

The NED account relates to the part of the National Environmental Policy Act (NEPA) human environment which identifies beneficial and adverse effects on the economy that occur because of water resource planning and development. It includes both benefits and costs of project development. There are three broad categories of benefits:

- Increases in the net economic national output of goods and services
- Value of increased output arising from external economies
- Value generated by use of otherwise unemployed or under-employed labor resources

Relevant NED account costs reflect the opportunities foregone because a plan is implemented, for example, reduced outputs in other sectors or employment losses. Costs include:

- Implementation: construction, operation and maintenance (O&M), planning and design and land costs

- Other direct costs: uncompensated adverse effects on third parties (e.g., increased water treatment costs for additional supplied water)

For each plan alternative under consideration, “with” and “without” analysis must be applied to determine the net increase in the production of goods and services over those that would be obtained in the absence of the plan.

The general measurement standard for increases in the national output of goods and services will be the total value of the increase, where total value is defined by the concept of willingness to pay for each increment of output of the plan. In cases when it is not possible or cost efficient to measure actual demand for goods and services, four alternative techniques can be used to estimate the alternatives total value (in order of preference): willingness to pay, change in net income, cost of the most likely alternative and administratively established values.

Regional Economic Development

The RED account tracks changes in the distribution of regional economic activity that result from each alternative plan (i.e., the potential economic effects of a project at the local or regional level). RED effects are often identified and quantified as transfers of economic activity within a region or between regions, as opposed to NED effects which measure the increase in net value of national output of goods and services.

The most common metrics analyzed under the RED account are regional employment and income within the region of interest; however, other measures of RED effects can also be used. Other RED metrics include, but are not limited to, value added, the value of economic output (or business revenues), indirect business taxes, and population distribution.

A project’s “value-added” impacts would include the contribution to the regional economy from increased or decreased activity by affected business sectors. Indirect business taxes effects consist of the changes in tax revenues (e.g., sales, income, property, and business taxes) and other fees (e.g., business and vehicle licenses) for the region. The distribution of residents and businesses will affect the location of any project-related expenditures and economic linkage between consumers and businesses which, in turn, will determine the type, magnitude, and location of the resulting economic effects on the region’s economy.

It is important to note the distinction between the RED and NED effects of a project. The focus of the NED account is at the national level, while the RED account evaluates local and regional economic effects. From an accounting perspective, because the NED account registers all effects on the national economy, any differences between the two accounts reflect transfers of economic activity to the RED region of interest from outside the area (i.e., “rest of Nation”). Because there may be overlap between RED and NED effects, it is important to note that the two accounts are usually not additive.

Generally, the region(s) selected for analysis under the RED account are those areas where most of the regional economic activity generated by a project is expected to occur. Because of the potential overlap between NED and RED effects, most or all NED benefits will accrue to the regions of interest in the RED analysis, which are supplemented by transfers of income and employment from other areas.

RED analysis considers not only direct effects of a project, but also the indirect effects associated with inter-industry linkages and related trade flows and induced effects from spending of labor income. When defining the region for analyzing impacts, its location and its economic linkages need to be considered. An impact region may be quite large if there are numerous linkages to other municipalities and/or counties. These effects are commonly measured using input-output analysis. These concepts are described in more detail in Chapter 3 of this appendix.

Finally, analysis of RED effects is not a required component of federal project evaluation because measured changes in economic activity in the region of interest may be offset by changes in other areas. However, RED analysis is commonly included in water project studies nonetheless in order to understand the economic impacts on those regions primarily affected by the project, which is of particular interest to local project sponsors and stakeholders.

Environmental Quality

The EQ account includes the alternatives' beneficial and adverse effects on ecological, aesthetic, and cultural attributes of natural and cultural resources. Ecological factors directly or indirectly sustain dynamic, diverse, viable ecosystems. Cultural factors are evidence of past and present habitation which can be used to reconstruct or preserve human lifestyles and living conditions. Aesthetic attributes are perceptual stimuli which provide pleasant surrounding for human enjoyment.[4]

Environmental effects which can be monetized are placed in the NED account. Other environmental effects that are typically expressed in physical or qualitative rather than monetary terms are placed in the EQ account. Effects may be described relative to frequency, duration, location, and other characteristics.

Other Social Effects

The OSE account identifies and integrates into water resource planning information the effects on urban and community settings; life, health, and safety; displacement; long-term productivity; and energy requirements and conservation.[5] The primary types of urban and community impacts include:

- Income distribution
- Employment distribution (especially the share to minorities)
- Population distribution and composition

[4] P&Gs, p. 11.
[5] P&Gs, p. 12.

- Fiscal condition of state and local governments
- Quality of human life

Principal life, health, and safety effects include:

- Risk of flood, drought, or other disaster which would affect security of life, health, or safety
- Potential loss of life, property, and essential public services because of structural failure
- Other effects (e.g., changes in air or water quality) not included in the NED or EQ accounts

Displacement refers to the effects of alternatives on the displacement of people, businesses, and farms. Long-term productivity effects refer to the continued use and enhancement of such productive resources as agricultural land for future generations.

Economic Concepts

Most of the goods and services purchased by individuals, businesses, or governments are traded in markets. Supplies, raw materials, food, automobiles, clothing, and utilities and other services typically are purchased at prices that are set in established markets. The benefits from the purchases of these goods and services accrue directly to the purchaser.

Natural resources can provide a variety of services or benefits that are generally not bought or sold in markets and hence do not have market prices, such as biological diversity. In some cases, the societal (or economic) value of a natural resource may differ widely from its market value. For example, an acre of wetland may be traded in the market based on its appraised value for residential or commercial development. However, the value may be much higher based on the availability of the land for mitigation purposes and for the services the land provides, such as, groundwater recharge or flood control (Freeman, 2003).

Market Value

The economic evaluation of water projects is difficult because it involves elements of welfare economics which are not directly observable. Each person's welfare is conceptually measurable by the utility one gains from consuming various goods and services. Utility is not measurable, however, nor is the comparison of utility levels among consumers. However, assuming that people are trying to maximize their utility, their utility maximizing behavior is observable and is the basis for estimating benefits.

For purposes of project evaluation, the most commonly used approach for measuring consumers' utility maximizing behavior is willingness to pay (WTP) or user value. WTP is an expression of a consumer's utility relationships. It is assumed that consumers are rational and, consequently, WTP is a realistic expression of the value which a consumer places on a good, service, or resource. The minimum WTP can be approximated by estimating the dollar value of a product in a particular application. However, depending on their utility relationship, a consumer may have an actual WTP higher than the market price of the good or service (in which case an individual would gain an added “consumer surplus” benefit by the transaction).

For the NODOS Project, farmers receiving CVP and SWP water may be able to increase production and profits because of the resulting supplemental or more reliable water supplies. The increment in profit is a benefit from the project and is a market-based value. Similarly for a consumer, the user-value of an incremental or more reliable water supply is the value that the consumer places (or is willing to pay) on irrigating his or her yard and lawn or filling his or her swimming pool. In the latter case, lower bound of the consumer’s WTP is based on the water cost to irrigate the yard or fill the pool.

Non-Market Value

As the name implies, non-market goods and services are those for which a price is not easily observed or determined because willing seller-willing buyer markets do not exist for the goods and services. For that reason, most activities involving most environmental resources are characterized as non-market goods. Examples include the personal utility received from views from a scenic viewpoint or preservation of threatened and endangered species. The costs of environmental protection or enhancement actions may be estimated using typical market-based metrics. The benefits of such actions are more difficult to quantify.

Use and Non-Use Values

There are two main elements of value which need to be distinguished: use and non-use value. Use value accrues to those individuals who actually use an economic resource. However, there are also individuals who do not use an economic resource but still value that resource’s existence. Thus, total economic value (TEV) can be defined as follows:

TEV = Use Values (market and non-market) + Non-Use Values (non-market)

Use values are associated with resource-related activities that have human interaction, such as fishing, hunting, and camping. In general, non-market values for *use* value are more easily determined than those for *non-use* values.

Non-use values reflect the belief that people place values on resource and environmental services which are irrespective to any use they might make of the resources (Freeman, 2003). Three typical non-use values are defined: existence, bequest, and option. Existence value relates to a measure that a person places on his knowledge that a resource (for example, an anadromous fishery) exists. Bequest value relates to the measure that a person places on his or her ability to bequeath the availability of a resource to future generations. Option value exists because people are willing to pay for resource preservation or enhancement even if they never visit or use the resource.

Non-Market Valuation Techniques

Non-market valuation (NMV) techniques are appropriate for valuation of several objectives of the NODOS Project. NMV techniques can be classified into two types: revealed preference (RP) techniques and stated preference (SP) techniques. RP techniques will primarily capture the use values of a resource; however, SP techniques can capture both use and non-use values.

Revealed Preference Techniques

- RP techniques rely on either observations of peoples' actions in buying and selling goods (or services) or by observing behavior and the associated costs (e.g., travel cost method for recreation) that are in some way specifically related to the non-marketed impact under consideration. For instance, peoples' preferences for housing – as reflected by the prices paid for property – can be used to infer the values they hold for environmental and social factors that affect house prices but which themselves are not marketed directly. Examples would include pollution, scenic views, neighborhood social facilities, etc.

Stated Preference Techniques

- SP techniques involve people being asked survey questions regarding the strength of their preferences for specified environmental or social changes. The questions are designed to focus on the trade-offs people are willing to make between the environmental and social improvements and their personal wealth and well-being.

Other Valuation Techniques

Other alternative methods for valuing environmental attributes include benefits transfer; the cost saving or relocation method; replacement cost; interpretation of similar decisions; preventative expenditure; and threshold analysis. These techniques can be used to provide an indication of value under certain conditions and situations at a substantially reduced cost to the survey methods discussed above. The benefits transfer method was applied to NODOS.

Benefits transfer is the process of taking information about economic benefits (i.e., WTP estimates) from one context (the "study site") and transferring it to another context (the "option site"). Benefit transfer estimates can be based on RP or SP based value estimates for comparable economic situations. In selecting the appropriate transfer value from the literature, a good understanding of the quality of the original study is required and the following criteria should be met to ensure that the original study and the new context are similar enough to ensure a valid result:

- Physical characteristics of the two sites should be similar.
- Changes being valued in study should be similar.
- Policy context should be similar.

- The affected population's cultural and socio-economic characteristics should be similar.

A more rigorous benefit transfer approach involves transferring a benefit function from one context to another. The benefit function statistically relates the public's willingness to pay for characteristics of the study site and the people whose values were elicited. When a benefit function is transferred, adjustments can be made for differences in these characteristics, thus allowing for greater precision in transferring benefit estimates between contexts. If a previous benefit estimation study includes a variety of socioeconomic variables, physical characteristics variables, or other factors that can be input to represent a variety of sites, then the benefit transfer requirements become much less restrictive. In such case, the assumption for the benefit transfer is that the relationship between the willingness to pay and the explanatory variables is consistent between the different sites (contexts). However, if the benefits transfer is based on an average value point estimate, it will be more limited in its applicability.

Reliability of Estimated Non-Market Values

Braden and Kolstad (1991) in assessing a wide range of NMV techniques have concluded that the methods presently being used provide reasonable estimates and that they do so with regularity and consistency. Other studies have shown that the valuations for non-market 'goods' are as reliable, or unreliable, as those for market traded goods.

Litigation over natural resources damages, has led to an upsurge of interest in NMV methods. Even though NMV techniques have been recommended for use by the *Comprehensive Environmental Response, Compensation and Liability Act 1980* (Lockwood and Carberry, 1998), they remain controversial. Following the Exxon-Valdez oil spill, Exxon commissioned a number of studies that were critical of contingent valuation method (CVMs). In response, the US government established a "blue ribbon" National Oceanic and Atmospheric Administration (NOAA) panel under the joint chairmanship of Nobel Laureates Kenneth Arrow and Robert Solow (Arrow et al., 1993). The NOAA Panel concluded that, subject to a number of guidelines, CVMs could lead to estimates that would be sufficiently reliable to assist in determining natural resources damages, whether by the judiciary or by administrators.

Presentation of Results

The economic modeling for NODOS was undertaken using a variety of models and methods as described in the following chapters. The results are presented for the full simulation period (representing all seasonal conditions) and alternatively for dry and critical years. The results for the full simulation are used in the NED account. The results for dry and critical years are presented for informational purposes. For most primary objectives, NODOS enhances water supply reliability for all purposes, resulting in greater benefits during dry and critical years. Several benefit categories do not have adequate data available to quantify the entire benefit. These are identified within the respective subsections. The overall total benefit value, therefore, represents a conservative estimation.

A key assumption in the quantification of benefits was assumed population growth and its impact on future water demand. NODOS is assumed to become operational in 2023 with a time horizon of 100 years. In estimating benefits, two future conditions were assumed, 2025 and 2060. The 2025 and 2060 urban water demand estimates are based on the historical and projected population, persons per household, and applied water use estimates developed for the 2005 California Water Plan Update's "current trends" future scenario. Annual population (and consequently urban water demand) growth was assumed to occur at a constant rate between 2025 and 2060.

The annualized benefits calculated within NODOS interpolate modeled annual benefits (reflecting urban population growth) between 2025 and 2060, and then assumed constant annual benefits from 2060 to the end of the projects time horizon in 2123.[6] This is shown diagrammatically in Figure 1.

In presenting benefits, the present value of benefits over 100 years is calculated and then annualized over 100 years using the federal discount rate of 3.75 percent.

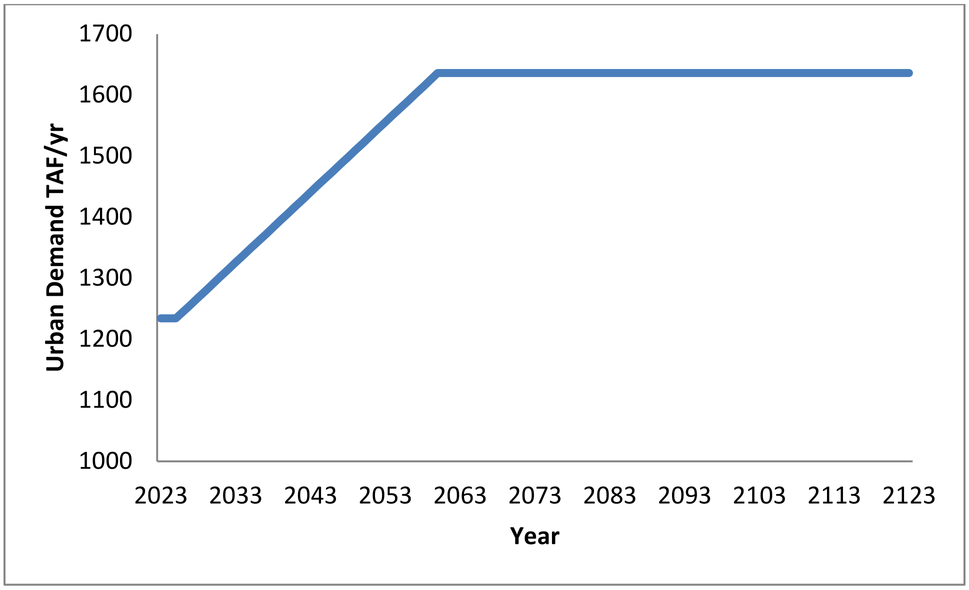


Figure 1. Assumed Population Growth (and Associated Urban Water Demand) – Interpolated Between 2025 and 2060 and Then Remaining Constant Beyond 2060 (Example)

[6] The constant post 2060 conditions were selected as a conservative assumption.

CHAPTER 3 WATER SUPPLY RELIABILITY BENEFITS

Increased water supply and water supply reliability are a primary goal of the NODOS Project. The Statewide Agricultural Production Model (SWAP) is used to estimate the benefits of water allocated for agriculture and refuges. The Least Cost Planning Simulation Model (LCPSIM) and Other Municipal Water Economics Model (OMWEM) are used to estimate the benefits of water allocated for urban purposes.

Agricultural and Refuge Water Supplies

Operation of the NODOS Project would affect agricultural water supplies in two ways. First, the project would supply water for irrigation to local Sacramento Valley users and to Central Valley Project (CVP) and State Water Project (SWP) users in the San Joaquin Valley. Second, the NODOS Project would provide an alternate source of water for Level 4 refuge supply – water that would otherwise most likely be acquired from existing agricultural users. Thus, the incremental water from NODOS would avoid part of that water acquisition and its associated costs.

Available Methods

SWAP was used as the agricultural economics production model used to assess agricultural and refuge benefits for NODOS. The SWAP model is the evolution of a series of production models and shares some basic model structure, and data and regional configuration used by the Central Valley Production Model (CVPM). SWAP provides for flexibility in production technology and input substitution, and it has been extended to allow for a greater range of analyses, including interregional water transfers and climate change effects.

SWAP Description and Assumptions

The SWAP model is an agricultural production model developed specifically for large-scale analysis of agricultural water supply and cost changes. SWAP is a regional model of irrigated agricultural production and economics that simulates the decisions of agricultural producers (farmers) in California. Its data coverage is most detailed in the Central Valley, but it also includes production regions for the Central Coast, South Coast, and desert areas.

Agricultural water sources in SWAP include: CVP contract supply, CVP water rights and exchange supply, SWP contract supply, local surface water, and local groundwater. As conditions change within a SWAP region (e.g., the quantity of available project water supply increases or the cost of groundwater pumping increases), the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs. It also fallows land when that appears to be the most cost-effective response to resource conditions.

The SWAP model covers 27 agricultural sub-regions in the Central Valley. The sub-regions are based on water budget areas, called Detailed Analysis Units, which DWR uses for water planning.

SWAP is used to compare the long-run agricultural economic responses to potential changes in CVP and SWP irrigation water delivery, other surface or groundwater conditions, or other economic values or restrictions. Results from the CALSIM II model are used as inputs into SWAP through a standardized data linkage tool. Groundwater analysis is used to develop assumptions, estimates, and, if appropriate, restrictions on pumping rates and pumping lifts for use in SWAP.

Typical output of the SWAP model includes revenues by regions and crop, land use, water use, crop stress percent, and marginal value of water. Additional post processing analysis of the SWAP model results is performed to convert its results to estimate the economic value of the various projected water supply changes to agricultural producers. In addition to aggregating the results for the numerous sub regions, the post processing analysis also converts the results into a national perspective consistent with federal P&G requirements for economic analysis.

SWAP Limitations

The SWAP model is an optimization model that makes the profit maximizing adjustments to changes in water supply, prices, costs or other inputs. Constraints can be imposed to simulate restrictions on how much adjustment is possible or how fast the adjustment can realistically occur. Nevertheless, an optimization model can tend to over-adjust and minimize costs associated with detrimental changes or, similarly, maximize benefits associated with positive changes.

SWAP does not explicitly account for the dynamic nature of agricultural production. To the extent that agriculture is in a “steady-state” at any point in time, crop rotation and other inter-temporal effects are accounted for in the calibration routine (Howitt, 1995). In general, SWAP provides a point-in-time comparison between two conditions. This is consistent with the way most economic and environmental impact analysis is conducted, but it can overlook sometimes important adjustment costs.

SWAP also does not explicitly incorporate risk or risk preferences (e.g., risk aversion) into its objective function. Risk and variability are handled in two ways. First, the calibration procedure for SWAP is designed to reproduce observed crop mix. The starting calibrated SWAP base condition will also reproduce the observed crop mix to the extent that crop mix incorporates risk spreading and risk aversion. Second, variability in water delivery, prices, yields, or other parameters can be evaluated by running the model over a sequence of conditions or over a set of conditions that characterize a distribution, such as a set of water year types.

CVP and SWP water costs remain at without-project prices. No additional costs are added in the model to account for costs of the NODOS Project.[7] Similarly local, non-project surface water supply is assumed to be the same for both the with-project and

[7] The water costs for NODOS-supplied water were unknown at the time of analysis. Furthermore, the extent that NODOS-supplied water would be incorporated with the CVP project (hence, the water supply costs could be shared amongst all CVP participants) has not be determined. Substantially increased surface water prices relative to groundwater costs could result in increased pumping and less future surface water use than estimated, However, the strong current and future demand for additional agricultural and urban water south of the Delta suggests that major supply reliability benefits nonetheless would be associated with “new” water supplied by NODOS.

without-project conditions. Groundwater is an alternative source to augment CVP and SWP delivery in many sub-regions. Groundwater costs and availability, therefore, have an important effect on how SWAP responds to changes to surface water deliveries. Groundwater pumping costs are explicitly broken out into fixed, variable, and O&M components in SWAP. Unit pumping costs change depending on the water-year type as the depth to groundwater changes by region. Additionally, pumping costs increase over the respective time horizon of the study consistent with PG&E power costs. Maximum pumping capacities, by region, in SWAP must rely on an accompanying groundwater analysis and careful specification of groundwater assumptions. Groundwater pumping capacities by region were estimated by DWR for use in SWAP (Howitt, et al., 2009).

Alternate Benefit Estimation Approaches

Despite its limitations, the SWAP model is considered the most appropriate approach for estimating the economic value of the project's future agricultural and refuge water supply benefits. Other alternative benefit estimation approaches include user-value (willingness to pay) or determining the least-cost alternative means to achieve the same water supplies.

As discussed in Chapter 2, a resource's user value will represent value that consumers place for a obtaining that resource. For agricultural producers, the user-value might represent an additional water supply's contribution to their production and, ultimately, their profits. The market price (if it exists) can be used to determine a clear demonstrated monetary value that consumers are willing to pay.

Consequently, a user-value approach requires understanding the output value of the agricultural users' crop production and/or their water purchase prices and transactions. A key difficulty is accurately collecting and representing such typically proprietary information – especially in the case of very large and varied private transactions. While survey data approaches can be used, they are generally difficult and costly to administer. Also, extrapolating respondents' answers to a large user population may misrepresent the benefits.

Economic evaluation analysis performed for other major California water storage project feasibility studies have collected historical data on public water sales transaction within California. In 2006, the Los Vaqueros Expansion Investigation characterized the California's Water Market for its *Initial Economic Evaluation for Plan Formulation Study* (Reclamation, 2006c). The analysis presented data for permanent water right sales, long-term transfers, and spot market (short-term) for both North- and South-of-Delta transactions. The analysis also performed regression analysis on the water transfers to estimate the level of water trading activity and unit price for water trades. The analysis then used the findings to project future environmental water prices.

More recently, the Shasta Lake Water Resources Investigation has performed a similar investigation on past water market transactions within California (Reclamation, 2011). The Shasta Lake analysis expanded on the previous Los Vaqueros study by including subsequent water purchase transactions and also forecasting future agricultural and M&I water prices. The Shasta Lake analysis also developed estimates of the expected conveyance charges and conveyance losses that would be associated with future delivery of purchased water.

These water transfer market analyses provide a partial but limited representation of the water supply reliability benefits. Based as they are on transactions, the analyses will not estimate the full consumer and producer surplus associated with buyers that would have willingly paid a higher price than their seller needed to complete the deal. In addition, the great majority of the transactions are for short-term or “spot” market sales of existing water supplies. In contrast, the project represents a long-term water source adding substantial quantities of “new” water. As such, the project water supply potentially offers a far more dependable source of water with more predictable future long-term costs as they will be less susceptible to future market fluctuations.

In addition, the scale and long-term nature of the project’s water supply are substantially greater than most of the successful water sale agreements to date. From 1990 to 2007, the total estimated volume of annual market transaction for the State of California varied from 56,775 AF to a high of 883,989 AF (Reclamation, 2008a). During the same period, the number of market transactions varied from a low of 4 to a high of 46 – with an average size of 18,410 AF per year. NODOS would provide an average annual volume of between 212,000 and 236, 000 AF of water for agriculture, M&I, and ecosystem enhancement uses.[8] As such, on its own, NODOS would represent a major proportion of statewide total water sales transaction.

Water sales with farmers and water districts also may be affected by the specifics of the local land conditions, location, and/or deal participants. It is unclear that there would be sufficient viable permanent water sellers – particularly given that the transaction costs (including legal, administrative, wheeling, and, if necessary, new infrastructure development costs) for implementation would likely be substantial and possibly prohibitive.

As a result, while water transfer data can provide useful indication of the economic value of water, it is very difficult to rely on such a user value approach to estimate the full water supply benefits associated with a potential major and new water supply such as NODOS. Consequently, the NODOS analysis considers water price data for verifying the reasonableness of the SWAP model economic benefit estimates.

Use of the least-cost alternative approach requires identifying a feasible comparable alternative supply source so that the project’s net benefit can be determined by subtracting its development cost from the cost for development of the alternative supply. Given the scale and complexity of NODOS as a multiple benefit water supply project, it is difficult to identify a suitable comparable alternate project. Furthermore, considerable analysis would be necessary to develop the cost analysis to adequately characterize a least-cost alternative so that NODOS’s net benefit value could be estimated.

Given the inherent difficulties of both alternate benefit evaluation approaches, the SWAP model is used to estimate NODOS’s agricultural and refuge supply benefits.

[8] The project would also result in 129,000 to 154,000 AF of increased June-to-September Delta outflows, which would improve the Delta and upstream fish habitat conditions.

Modeled Results

CALSIM II operational studies were used to estimate the additional water provided by NODOS for agricultural uses (Table 3-1) and the alternate source water provided for refuge supplies (Table 3-2).

Table 3-1. Annual Volume of Increased Water Supply to Agricultural Users for Full Simulation and Dry/Critical Years

Alternative	Annual Volume (TAF)[a]	Difference from No Project (TAF)	Difference from No Project (%)
Full Simulation[b]			
No Project	1,808	--	--
Alternative A	1,878	70	3.9%
Alternative B	1,845	37	2.0%
Alternative C	1,869	61	3.4%
Dry/Critical Conditions[c]			
No Project	999	--	--
Alternative A	1,117	118	11.8%
Alternative B	1,073	74	7.4%
Alternative C	1,106	107	10.7%

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

SWRCB = State Water Resources Control Board
TAF = thousand acre-feet

Table 3-2. Annual Volume of Alternate Water Supply Available to Refuge Water Supplies for Full Simulation and Dry/Critical Years

Alternative	Annual Volume (TAF)[a]	Difference from No Project (TAF)
Full Simulation[b]		
No Project	0	--
Alternative A	48	48
Alternative B	74	74
Alternative C	80	80
Dry/Critical Conditions[c]		
No Project	0	--
Alternative A	25	25
Alternative B	41	41
Alternative C	42	42

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

SWRCB = State Water Resources Control Board
TAF = thousand acre-feet

The modeling studies specify deliveries in the 82 years of historical hydrology under the future no project and with project alternatives. In addition to evaluating performance over the full 82-year simulation period, the performance in “dry and critical” water year types was also evaluated. Dry years account for 22 percent of the years in the 82 year period and critical years account for 15 percent of the years. Full simulation conditions represent the average values for the 82 year period (this is not the same as the results in an average water year).

No water is supplied to the refuges by NODOS under the no project scenario. Differences from the No Acton Alternative are, therefore, equal to the Annual Volume under each alternative.

As shown in Table 3-1, the NODOS Project alternatives would provide an estimated 37 to 70 TAF increase in average annual water supplies to agricultural users throughout the state.

With respect to refuge water supplies, it is assumed that this water would otherwise most likely be acquired from existing agricultural users. Thus, the incremental water supplied by NODOS would avoid part of that water acquisition and the associated costs.

As shown in Table 3-2, the NODOS Project alternatives would provide an estimated 48 to 80 TAF alternate supply in average annual water supplies to the refuges.

These CALSIM II water deliveries were applied to the SWAP model and the model was then run with demands based on 2025 and 2060 levels of development for the future no project alternative and the three project alternatives. Table 3-3 and 3-4 show the benefits for agriculture and for refuge water, respectively.

Table 3-3. Estimated Annual Benefit of Increased Water Supply to Agricultural Users for Full Simulation and Dry/Critical Years ($1,000s, 2013 Dollars)[a,b]

Alternative	Annual Benefits[c]		Annualized Benefit ($)[d]
	2025	2060	
Full Simulation[e]			
Alternative A	$11,243	$14,175	$12,709
Alternative B	$6,490	$7,718	$7,103
Alternative C	$10,322	$12,716	$11,519
Dry/Critical Conditions[f]			
Alternative A	$22,402	$28,078	$25,267
Alternative B	$15,622	$19,203	$17,451
Alternative C	$22,480	$28,162	$25,348

[a] Based on SWAP modeling results.
[b] These figures do not account for the increased power costs attributable to additional conveyance of CVP/SWP deliveries.
[c] Annual benefits reflect the difference between changes in agricultural production and or groundwater supply costs under the project alternatives for future No Project conditions based under year 2025 and 2060 level of development.
[d] Annualized benefits assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

CVP = Central Valley Project
SWAP = Statewide Agricultural Production Model
SWP = State Water Project
SWRCB = State Water Resources Control Board

Table 3-4. Estimated Annual Benefit of Alternate Water Supply to Refuge Water Supplies for Full Simulation and Dry/Critical Years ($1,000s, 2013 Dollars)[a,b]

Alternative	Annual Benefit[c]		Annualized Benefit ($)[d]
	2025	2060	
Full Simulation[e]			
Alternative A	$10,686	$14,361	$12,524
Alternative B	$17,457	$23,456	$20,457
Alternative C	$18,039	$24,242	$21,141
Dry/Critical Conditions[f]			
Alternative A	$7,311	$9,790	$8,560
Alternative B	$13,414	$17,962	$15,705
Alternative C	$13,395	$17,938	$15,684

[a] Based on SWAP modeling results.
[b] These figures do not account for the increased power costs attributable to additional conveyance of CVP/SWP deliveries.
[c] Annual benefits reflect the difference between changes in agricultural production and or groundwater supply costs under the project alternatives for future No Project conditions based under year 2025 and 2060 level of development.
[d] Annualized benefits assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure1).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

CVP = Central Valley Project
SWAP = Statewide Agricultural Production Model
SWP = State Water Project
SWRCB = State Water Resources Control Board

Within these tables, annual benefits are shown for assumed population growth in the year 2025 and the year 2060. As described in Chapter 2 of this appendix, the annualized benefit estimate was then calculated by interpolating these annual benefits between the years 2025 and 2060, and then keeping population growth constant from the year 2060 to the end of the planning horizon in year 2123. The annualized benefit calculation in effect assumes that the project's benefits will increase from their estimated 2025 level to their 2060 level at a constant rate of annual increase. Then after 2060, the annual benefit of the project would remain unchanged for the rest of the analysis period (i.e., 2023). The average annual benefit value for each alternative over the 100-year analysis period is also converted into a net present value using the federal discount rate so that the weighted average appropriately balances the project's long-term and near-term benefit stream. The resulting annualized benefit value represents the constant annual value, which would result in an equivalent discounted total benefit over the analysis period as that estimated from the variable benefit stream associated with the projects estimated 2005 and 2060 benefit values.

Table 3-3 shows NODOS's water supply benefits to agricultural users as estimated by the SWAP model for each of the project alternatives.[9] For the full simulation, the results show that the benefits to agricultural users are greatest for Alternative A, followed closely by Alternative C, and lastly by Alternative B. During dry and critical years, the annualized benefits are more than double those on average. There is also little difference between the benefits obtained by Alternatives A and C during dry and critical years.

Table 3-4 shows NODOS's water supply benefits to refuge water supplies. The results show that the benefits are greatest for Alternative C, followed closely by Alternative B, and lastly by Alternative A. The annualized benefits for dry/critical years are lower than those over the full simulation, which reflect a CALSIM II modeling constraint that specifies how limited water is allocated during dry and critical years.

NODOS's water provision for Refuge use may also be expected to have an additional and secondary ecosystem benefit as that water can be expected to result in increased groundwater recharge downstream within the Central Valley. Currently, the Central Valley Region of the Regional Water Quality Control Board is in process of approving its proposed long-term Irrigated Lands Regulatory Program to reduce regulating waste discharges from irrigated agricultural lands to improve soil and groundwater conditions within the watersheds of the Sacramento River, San Joaquin River and Tulare Lake Basins. Increased groundwater recharge from the Refuge flows may be expected to improve groundwater conditions. However, estimating both the magnitude and location of the Refuge flow's contribution to groundwater quality improvements within the three basins is difficult. Furthermore, estimating the value of its groundwater improvements (by avoided costs methods or otherwise) will also be difficult. Consequently, no ecosystem enhancement benefits have been attributed to the secondary groundwater improvement benefits of the NODOS's Refuge flows.

Urban M&I Water Supplies

M&I water uses include water for municipal, domestic, commercial, schools, public safety, and other applications. Development of the NODOS Project would increase M&I water supplies over the long term, with a greater change in yields during dry/critical periods.

Available Methods

M&I benefits can be estimated based on consumers' "willingness to pay," measured by estimating demand functions and use of existing price elasticity estimates as a type of benefits. Such an approach generally would be expected to provide a higher total benefit value because it will represent the higher consumer surplus value that many consumers obtain from their M&I water use.

[9] The SWAP model determined the combined total producer and consumer benefits of the increased agricultural production. Post processing of the results was also performed to represent the model estimates of the total benefits into a NED perspective in accordance with P&G guidelines.

Alternatively, a cost-based approach has been used to determine the minimum benefit value for the M&I water supplies as a more conservative valuation approach. The cost-based approach does not include the additional consumer surplus values associated with many M&I users likely higher marginal values of water. Cost-based methods are based on actual and lower water supply costs and prices, as most utilities are regulated and use average cost pricing to set water prices. As a result, cost-based results will provide lower estimates of the M&I water supply benefit values.

Economic benefits and costs to M&I users from changes in water supplies are estimated using two models – LCPSIM and OMWEM. These models use consumer surplus values based on the results of “willingness-to-pay” studies and were developed by DWR for use in planning and impact studies related to water supply for CVP and SWP contractors that may be affected by surface storage projects or re-operations. LCPSIM is used to estimate the benefits of water supply changes in the urban areas of the San Francisco Bay–South and the South Coast regions. These two regions are expected to realize most of the M&I water supply benefits generated by the NODOS Project. Other affected CVP and SWP contractors are included in OMWEM, which covers M&I water supply benefits in the Sacramento River, San Joaquin River, San Francisco Bay-North, Central Coast, Tulare Lake, and South Lahontan regions. The LCPSIM and OMWEM models are described in greater detail below.

There are other urban areas across the state that are not covered by either model; however, M&I water supplies delivered to these areas are negligible individually, and collectively account for less than 5 percent of the average total urban supplies. These benefits have not been quantified.

Least Cost Planning Simulation Model (LCPSIM)

LCPSIM is an annual time-step urban water service system simulation/optimization model. Its objective is to find the least-cost water management strategy for a region, given the mix of demands and available supplies. It uses shortage management measures, including the use of regional carryover storage, water market transfers, contingency conservation, and shortage allocation rules to reduce regional costs and losses associated with shortage events. It also considers the adoption of long-term regional demand reduction and supply augmentation measures that reduce the frequency, magnitude, and duration of shortage events.

A shortage event, or forgone use, is the most direct consequence of water service system unreliability. Forgone use occurs when, for example, residential users or businesses have an established lifestyle or level of economic production based on expected availability of water that is not met in a particular year or sequence of years. The model uses a shortage loss function derived from contingent valuation studies and water agency shortage allocation strategies to value the forgone use.

Assuming that long-term demand reduction and supply augmentation measures are adopted in order of their cost, with lowest cost measures adopted first, LCPSIM finds the water management strategy that minimizes the sum of the total annual cost of the adopted long-term reliability enhancement measures and the annual shortage costs and losses remaining after their adoption (Figure 2). Beyond the least-cost point shown, the cost of additional reliability enhancement exceeds the avoided costs and losses resulting from foregone use. At any lower level of reliability enhancement, the expected costs and losses from foregone use exceed the costs to enhance reliability. The value of the availability of supply from a proposed project such as NODOS can be determined from the change it produces in this least-cost mix of demand and supply measures and shortages.

For more information on LCPSIM assumptions refer to DWR (2010).

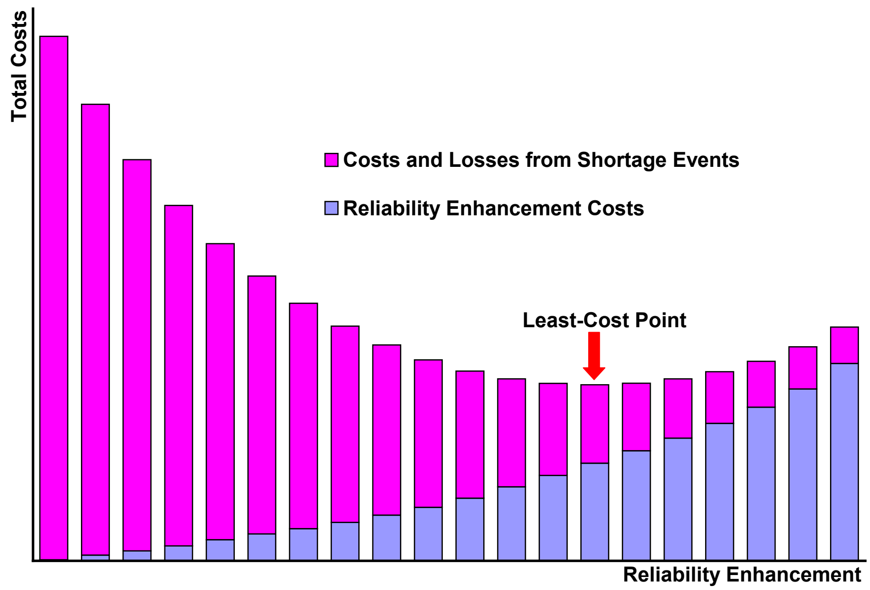


Figure 2. The Effect of Increasing Reliability on Total Costs

Other Municipal Water Economics Model (OMWEM)

A number of relatively small M&I water providers receive SWP or CVP water but are not covered by LCPSIM. A set of individual spreadsheet calculations, collectively called OMWEM, can be used to estimate economic benefits of changes in SWP or CVP supplies for these potentially affected M&I water providers. The OMWEM model includes CVP M&I supplies north of Delta, CVP and SWP supplies to the Central Valley and the Central Coast. In addition the model includes SWP supplies or supply exchanges to the desert regions east of LCPSIM’s South Coast region. The model estimates the economic value of M&I supply changes in these areas as the change in cost of shortages and alternative supplies (such as groundwater pumping or transfers).

For more information on OMWEM assumptions, refer to the *Draft Economic Model Summary* (CH2M HILL, 2011).

Model Limitations

Both LCPSIM and OMWEM assume that regions being evaluated have the facilities and institutional agreements in place to move water within the region as needed to minimize the economic effect of shortage events.

The models do not include the full level of detail that may exist in local water providers' plans. The results produced by the models are useful for comparing alternatives and to provide an approximate estimate of avoided cost. However, the results should not be viewed as precise representations of individual water providers' costs or options.

The following potential limitations regarding LCPSIM have been identified:

- LCPSIM is not appropriate for individual water agency management decisions because of the simplifying assumptions it makes about regional system operations.
- Because LCPSIM is used to optimize regional economic efficiency from a statewide perspective, LCPSIM results may not reflect decisions made by local water agencies that are based on their cost perspective. Also, local planning decisions are likely to be influenced by local cost effectiveness and political concerns as well as additional factors of importance to regional water agency managers and water users that are not necessarily aligned with the LCPSIM objective.
- LCPSIM relies on base urban quantity demanded as estimated by the Institute for Water Resources-Municipal and Industrial Needs or similar models. These base urban quantity demanded amounts are not reduced further in LCPSIM in response to the higher urban user water prices which can be anticipated as regions use water pricing as a means of recovering the cost of increasing water reliability.
- LCPSIM uses regional operations studies for local imported supplies to obtain annual delivery information. Regional water supply sources that are not modeled on a year-to-year basis are assumed to be available at their average year values.
- LCPSIM determines its reliability benefits estimates on the basis of a risk-neutral view of risk management. Risk-averse management (risk minimization) by regional agencies–which has been the predominant mode–might result in the justification of more costly water management measures than under the risk-neutral assumption.
- LCPSIM is operated on an annual basis. Therefore, it does not simulate seasonal water decisions.
- Base urban use amounts are not reduced in LCPSIM in response to the higher urban user water prices that can be anticipated as regions use water pricing to offset water reliability cost increases.
- Because one of two extended drought periods occurs soon after the start of the hydrologic period, model results are known to be sensitive to starting storage conditions.

Generally, OMWEM has the same limitations as LCPSIM. In addition, decision rules about water supply costs and shortages are relatively simplistic.

Modeled Results

CALSIM II operational studies were used to estimate the additional water provided by NODOS for M&I use. Other water demands and supplies were estimated using data from the DWR as well as local agencies' planning studies and Urban Water Management Plans. CALSIM II water deliveries were then applied to the LCPSIM and OMWEM models with future water demands based on 2025 and 2060 development conditions. The models were then run and results were obtained for the future no project condition and the three project alternatives.

The NODOS Project would increase water supplies to M&I water users across the state, especially during dry/critical years. The M&I water supply benefits largely accrue to SWP contract holders located south of the Delta. Table 3-5 shows estimates for the full simulation and dry/critical year deliveries to M&I water users under the project alternatives. On average, the NODOS Project would provide an estimated 93 to 103 TAF of incremental water supplies to urban users annually. The change in M&I water deliveries are greater in dry/critical years, ranging from 191 to 230 TAF per year. M&I water deliveries increases generate economic benefit in the form of avoided water supply costs.

Table 3-5. Annual Volume of Increased Water Supply to M&I Water Users Under NODOS (TAF)

Alternative	Average Annual Volume (TAF)[a]	Difference from No Project	Difference from No Project (%)
Full Simulation[b]			
No Project	2,487	--	--
Alternative A	2,580	93	3.7%
Alternative B	2,584	97	3.9%
Alternative C	2,590	103	4.1%
Dry/Critical Conditions[c]			
No Project	1,941	--	--
Alternative A	2,148	207	10.7%
Alternative B	2,132	191	9.8%
Alternative C	2,171	230	11.8%

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

M&I = municipal and industrial
SWRCB = Sacramento Water Resources Control Board
TAF=thousand acre-feet

Table 3-6 presents the urban M&I water supply benefits for the NODOS Project alternatives as estimated by LCPSIM and OMWEM. Consequently, these results are subject to the limitations discussed above.

Table 3-6. M&I Water Supply Benefits ($1,000s, 2013 Dollars)[a,b]

Alternative	Annual Benefits[c] 2025	Annual Benefits[c] 2060	Annualized Benefit[d]
Full Simulation[e]			
Alternative A	$86,231	$228,924	$157,591
Alternative B	$88,462	$233,629	$161,059
Alternative C	$94,752	$239,921	$167,350
Dry/Critical Conditions[f]			
Alternative A	$196,709	$513,558	$355,643
Alternative B	$195,869	$412,593	$304,637
Alternative C	$235,452	$567,262	$401,918

[a] Based on LCPSIM modeling results (South Coast and San Francisco Bay-South regions) and OMWEM modeling results (Sacramento River, San-Francisco Bay-North, Central Coast, Tulare Lake, and South Lahontan regions).
[b] These figures do not account for the increased power costs attributable to additional conveyance of SWP deliveries.
[c] Annual benefits reflect the difference between shortage, conservation, and other supply costs under the project alternatives for future No Project conditions based under year 2025 and 2060 level of development.
[d] Annualized benefits represent lost agricultural benefits for the future No Project conditions over the planning horizon (2023-2123).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

LCPSIM = Least Cost Planning Simulation Model
M&I = municipal and industrial
OMWEM = Other Municipal Water Economics Model
SWRCB = Sacramento Water Resources Control Board
SWP = State Water Project
TAF = thousand acre-feet

M&I water supply benefits are substantially higher in dry/critical periods compared to the benefits on average. Annualized benefits are estimated to be up to $167 million for the full simulation and nearly $402 million during dry/critical periods.[10] In both cases, the greatest benefits are generated under Alternative C. As estimated by LCPSIM, most of the urban water supply benefits are concentrated in the South Coast and, to a lesser extent, the San Francisco Bay-South regions.

Emergency Water Supplies

Water from the Sacramento River is withdrawn from the Delta and delivered to California residents and agriculture. The Delta is the hub of the water for two-thirds of California's population and supplies water for up to three million acres of farmland. The Delta is protected by an intricate network of levees that are under varying stages of disrepair. Recent studies of the structural integrity of Sacramento-San Joaquin Delta infrastructure systems show that many do not meet guidelines for acceptable public performance for extreme storm and earthquake conditions (DWR, Delta Risk Management Strategy, 2009b [DRMS]).

[10] The annual benefit calculation method is the same as that used for the refuge supply's annual benefit calculation.

An earthquake could trigger a disaster as great, if not greater, than Hurricane Katrina, which caused devastating impacts for New Orleans. More recently, the DRMS assessed the economic risk posed by Delta levee failures initiated by seismic and hydrologic events. The study found that “a major earthquake of magnitude 6.7 or greater in the vicinity of the Delta Region has a 62 percent probability of occurring within the next 30 years. This could cause multiple levee failures, fatalities, extensive property destruction, and adverse economic impacts of $15 billion or more” (DWR, 2009b).

One of the more significant impacts of levee failures would likely be damage to the state’s water supply system. For example, if 20 Delta islands were flooded as a result of a major earthquake, the export of fresh water from the Delta could be interrupted for approximately a year and a half. Water supply losses of up to 8 million AF would be incurred by state and federal water contractors and local water districts.

In the event of a levee failure in the Delta, NODOS will provide an additional source of water for emergency response including direct emergency water supplies and dilution flows that prevent saline water from contaminating otherwise fresh water. The public benefits associated with this unforeseen use of NODOS water supplies have not been quantified, but are discussed later in the EQ and OSE accounts as public safety benefits.

CHAPTER 4 WATER QUALITY BENEFITS

Urban M&I Water Quality

NODOS would affect the quality of urban water supplies for many users who divert water from the Delta. The major diversion points for urban use that would be affected are the SWP Banks Pumping Plant, Contra Costa Water District intakes, CVP Tracy Pumping Plant, North Bay Aqueduct, and urban and industrial diversions in Contra Costa County.

Water quality in urban service areas would be affected by changes in both the amount and quality of Delta-supplied water. Many water quality constituents would be affected. Salinity and disinfection byproduct precursors (DBPPs) are among the most economically-important constituents, but nutrients, pathogens and a range of other pollutants are also important. Only changes in salinity are evaluated in this analysis. Consequently, the estimates of water quality benefits presented in Chapter 4 should be considered conservative.

Available Methods

Two models are available 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 (LCRBWQM) covers water users in the Metropolitan Water District of Southern California (MWD) service area while the Bay Area Water Quality Economics Model (BAWQM) 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.

Lower Colorado River Basin Water Quality Model

The LCRBWQM covers nearly the entire urban coastal region of southern California. LCRBWQM was developed by Reclamation and MWD. LCRBWQM divides MWD's service area into 15 sub-areas to reflect each sub-region's unique water supply conditions and benefit factors. These regions include the North West, San Fernando Valley-West, San Fernando Valley-East, San Gabriel, Central Los Angeles, Central and West Basins, Coastal Plain, North West Orange County, South East Orange County, Western MWD, Eastern MWD, Upper Chino, Lower Chino, North San Diego, and South San Diego. The salinity model is designed to assess the average annual salinity benefits or costs based on demographic data, water deliveries, total dissolved solid (TDS) concentration, and cost relationships for typical household, agricultural,[11] industrial, and commercial water uses. It uses mathematical functions that define the relationship between TDS and key items in each affected category, such as the useful life of appliances, specific crop yields, and costs to industrial and commercial customers.

The LCRBWQM calculates the economic benefits or costs of SWP and Colorado River Aqueduct salinity changes compared to a selected baseline condition. The model inputs from CALSIM II and DSM2 are SWP East and West Branch deliveries

[11] As described below, for reporting purposes the LCRBWQM estimated agricultural water quality benefits are presented with the other south-of-the-Delta agricultural water quality benefits.

and TDS of these deliveries in milligrams per liter (mg/L), respectively. A separate model routine is available to estimate salinity of urban water supplies delivered to the South Coast based on timing of urban deliveries, mixing in San Luis Reservoir, and salinity estimates at Edmonston Pumping Plant. LCRBWQM outputs are used to compare changes in average salinity and annual salinity costs.

Updates to and limitation of LCRBWQM are discussed jointly with the BAWQM below.

Bay Area Water Quality Economics Model

The BAWQM includes the portion of the Bay Area region from Contra Costa County south to Santa Clara County. The model was developed and used for the economic evaluation of a proposed expansion of Los Vaqueros Reservoir (Reclamation, 2006). It uses estimated relationships between salinity and damages to residential appliances and fixtures to estimate the benefits from salinity reductions. Specific model outputs compare change in average salinity and change in annual salinity costs.

To properly reflect the changes between without- to with-project conditions under NODOS, several updates were made to the water quality economics models since the PFR was prepared. The updates include indexing all prices to 2007 dollars and developing LCRBWQM to include 2009, 2025, and 2060 levels of development. BAWQM was also updated to include 2009, 2025, and 2060 levels of development.

Model Limitations

While the LCRBWQM and BAWQM are the best available models for determining the project’s future water quality benefits, a key limitation is that they only consider economic benefits for salinity improvements. The economic benefits of other water quality constituents are not estimated. Research has shown that consumers are willing to pay to avoid many other water quality constituents, and hence only valuing salinity will underestimate the water quality benefit. These “other” constituents include many manmade chemicals, pathogens, and byproducts that may have health implications.

The models use dated information about the current ownership patterns and costs of modern water using appliances. The BAWQM does not include commercial, industrial or public users, and costs to utility infrastructure are not included.

An input to the models is the average expected water quality of water supplies over the full hydrologic period. This simplification could result in error in economic benefit estimates. More detail on the quality of supplies used over the hydrologic period might result in a different expected value and could also provide better insights about water management during dry/critical periods.

Lastly, the models do not cover all of the south-of-Delta (SOD) regions where water quality benefits are realized due to NODOS. Therefore, the model results from LCRBWQM and BAWQM were extrapolated to represent benefits for these “other” regions.[12]

[12] Water quality benefits for other south-of-the-Delta users are available for 2025 level of development only. Accordingly, estimated benefits in 2060 and annualized benefits over the planning horizon (2023-2123) are understated.

Modeled Results

Table 4-1 presents urban M&I water quality benefits.

Table 4-1. Estimated Annual M&I Water Quality Benefits Based on Estimated Salinity ($1,000s, 2013 Dollars)[a]

Alternative	*Annual Benefits[b]*		*Annualized Benefit[d]*
	2025	*2060[c]*	
Full Simulation[e]			
Alternative A	$16,061	$20,150	$18,106
Alternative B	$17,363	$22,247	$19,806
Alternative C	$20,841	$27,116	$23,979
Dry/Critical Conditions[f]			
Alternative A	$18,999	$24,581	$21,814
Alternative B	$20,973	$26,711	$23,868
Alternative C	$24,401	$31,813	$28,137

[a] Based on LCRBWQM modeling results (South Coast region, excluding agricultural benefits), BAWQM modeling results (San Francisco Bay region), and extrapolated results for areas South of Delta (San Joaquin River, Central Coast, Tulare Lake, and South Lahontan regions). Excludes the Sacramento River region.
[b] Annual benefits reflect the difference between water quality damages under the project alternatives for future No Project conditions based on year 2025 and 2060 level of development.
[c] Excludes benefits to south-of-the-Delta water users.
[d] Annualized benefits represent avoided costs for the future No Project conditions over the planning horizon (2023-2123).
[e] Average over entire hydrologic sequence (1921 to 2023).
[f] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

BAWQM = Bay Area Water Quality Economics Model
LCRBWQM = Lower Colorado River Basin Water Quality Model
M&I = municipal and industrial
SWRCB = State Water Resources Control Board

Annualized benefits range between $18.1 million and $24.0 million on average and $21.8 million and $28.1 million in dry/critical years.[13] Alternative C offers the greatest water quality benefits.

Irrigation Water Quality

NODOS-related irrigation water quality changes can potentially affect crop production in both the short and long term. These effects are based largely on the overall salinity of the irrigation water and the resulting crop root zone salinity. Salinity is measured as TDS (parts per million, mg/L) or electrical conductivity (deci-siemens per meter [dS/m]). Specific constituents, such as boron, can also limit crop yields and are particularly costly if present above tolerance threshold concentrations.

[13] The annual benefit calculation method is the same approach as that used for the refuge supply's annual benefit calculation.

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

The first three benefits in this list are near-term effects of irrigation water TDS reductions. Near-term effects include lower TDS in root zone moisture, lower required leaching fractions, higher crop yield, and a wider range of crops that can be grown. Growers can take advantage of some or all of these benefits, depending on their irrigation and cropping decisions. For example, if irrigation water salinity improved, a grower could maintain the current cropping and reduce leaching. Alternatively, a grower could continue to leach at the same rate and potentially get better crop yield from the resulting lower soil salinity (assuming the initial water quality exceeds the crop salinity thresholds).

Near-term water quality effects can be estimated using standard crop yield-salinity relationships. For example, the well-known Maas-Hoffman relationships can be used to evaluate the crop yield effects of Delta water salinity changes.[14] This relationship shows little or no effects on crop yield if a sufficient leaching fraction is provided during irrigation to prevent salts from accumulating in the root zone. Therefore, as the electrical conductivity (EC) or TDS increases in irrigation water, the leaching fraction required also increases.

Rhoades (1974) developed an empirical relationship between the EC of irrigation water (EC_w) and the EC of a saturation-soil extract (EC_e) that a grower needs to maintain to avoid or minimize salt damage to crop yields. These relationships form the standard approach for evaluating the near-term effect of changes in irrigation water salinity (Ayers and Westcot, 1985; Hoffman, 2009).

Available Methods

The appropriate way to assess near-term benefits of lower irrigation water salinity depends on the range of water quality changes under evaluation. If soil and/or irrigation water salinity is currently high and yield limiting, the benefit of salinity reduction in irrigation water can include improved crop yields, wider crop selection, and reduced irrigation management. On the other hand, if salinity levels are below crop thresholds, irrigation management is focused on preventing salt accumulation in the crop root zone, and reduced salinity may allow growers to reduce the leaching fractions that are currently applied.

---

[14] An example of the application of crop yield-salinity relationships can be found in *California Department of Water Resources, Delta Risk Management Strategy, Phase 1 Report and Technical Memoranda* (DWR, 2009a).

Because estimates of current salinity of delivered CVP and SWP water are below the tolerance threshold for even the most salt sensitive crops, and the change in salinity from implementing the NODOS Project are relatively small, this analysis is based on the latter scenario where benefits are attributed to reduced leaching fractions, which is discussed in greater detail below.

Ayers and Westcot (1994) cite Rhoades' work to provide a calculation of the leaching fraction required for given applied water salinity and target root zone salinity based on crop tolerance (see Attachment 1 for the equations and assumptions used). The reduction in rates of applied water, times the area receiving the water, results in a volume of water available for use elsewhere in the region. The value of this water can be estimated using the same approach used to value any direct changes in SWP or CVP irrigation water deliveries.

The SWAP model was used to estimate the unit value (or marginal value) of an additional unit of water available for irrigation (Table 4-2). Because the saved water would have been delivered to farms anyway, neither the project (SWP or CVP) nor the local district incurs any additional water delivery cost.

Table 4-2. Estimated Value of Irrigation Water Savings ($/AF, 2013 Dollars)

Alternative	Annual Values[a,b]		Annualized Values (2023-2122)[c]
	2025	2060	
Full Simulation[d]			
Alternative A	$171	$215	$193
Alternative B	$172	$204	$188
Alternative C	$172	$272	$222
Dry Conditions[e]			
Alternative A	$212	$266	$239
Alternative B	$243	$298	$270
Alternative C	$217	$272	$245

[a] Annual values are based on SWAP modeling results.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[d] Average over entire hydrologic sequence (1921 to 2023).
[d] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

AF = acre-foot
SWAP = Statewide Agricultural Production Model
SWRCB = State Water Resources Control Board

Model Limitations

A more comprehensive analysis of water quality benefits would consider the complex set of relationships among irrigation, crop use, soil salinity, and groundwater conditions. The following major qualifications apply to this analysis. This analysis:

- Assumes that growers are actively managing their leaching requirement to avoid salt accumulation in the soil and its effects on crops, and that growers have enough control over irrigation application rates to make small adjustments in leaching.

- Assumes that growers are currently applying water using an optimum leaching fraction for each type of crop that is grown.
- Assumes CVP and SWP water salinity reductions will not directly affect lands that are irrigated with other sources (e.g., groundwater).
- Uses a steady-state calculation based on irrigation water as the only significant source of salts introduced into the root zone.
- In certain situations where soils have high proportions of sodium relative to other base conditions, irrigation with extremely low TDS water can lead to soil dispersion, loss of structure, and impaired drainage. The approach used here assumes that reducing TDS in irrigation water will not have a detrimental effect on soil structure.

These qualifications suggest that the benefit estimation analysis may overestimate, or at least provide an upper bound, on the near-term benefit of small reductions in irrigation water salinity. The assumptions may not be valid in all locations in the study area; however, they are expected to provide a reasonable basis for the calculations that follow.

This approach will not capture the long-term benefit of reducing the salt load added to the soil and groundwater. As described above, estimating long-term benefits requires more complex evaluation of groundwater conditions and trends. Thus, while the approach will likely overstate the near-term benefits, it excludes any estimate of the long-term benefit. The net effect is unclear, but is more likely to provide a conservatively low estimate of the total benefits.

Modeled Results

The CALSIM II model and DWR Simulation Model (DSM2) were used to estimate TDS and EC of water pumped by the CVP and SWP facilities under 2025 level of development.[15] Jones Pumping Plant supplies water to the Delta-Mendota Canal, the primary source of CVP water delivered into the Grasslands salinity analysis area (Table 4-3). Banks Pumping Plant supplies water to the California Aqueduct, which either delivers it directly to contractors or conveys it to San Luis Reservoir, from which it is delivered to contractors (Table 4-4). Results shown are pumping-weighted averages simulated monthly over the hydrologic period October 1921 to September 2003. Although the DSM2 values should not be considered as absolute, the model does provide an indication of a trend towards slight decreases in salinity for all of the alternatives. This decrease can then be used in determining the water quality benefit.

[15] No separate water quality modeling for NODOS was conducted at 2060 level of development.

Table 4-3. Salinity at Jones Pumping Plant, by Alternative[a]

Alternative	Average TDS (mg/L)	Difference from No Project (mg/L)	Difference from No Project (%)
Full Simulation[b]			
No Project	268.0	--	--
Alternative A	261.4	-6.6	-2%
Alternative B	261.7	-6.3	-2%
Alternative C	258.8	-9.2	-3%
Dry/Critical Conditions[c]			
No Project	340.1	--	--
Alternative A	328.0	-12.1	-4%
Alternative B	328.9	-11.2	-3%
Alternative C	322.6	-17.6	-5%

[a] Based on DSM2 modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

mg/L = milligrams per liter
SWRCB = State Water Resources Control Board
TDS = total dissolved solids

Table 4-4. Salinity at Banks Pumping Plant, by Alternative[a]

Alternative	Average TDS (mg/L)	Difference from No Project (mg/L)	Difference from No Project (%)
Full Simulation[b]			
No Project	239.8	--	--
Alternative A	234.3	-5.6	-2%
Alternative B	233.9	-5.9	-2%
Alternative C	232.0	-7.8	-3%
Dry/Critical Conditions[3]			
No Project	313.0	--	--
Alternative A	299.3	-13.7	-4%
Alternative B	298.2	-14.9	-5%
Alternative C	295.1	-18.0	-6%

[a] Based on DSM2 modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

mg/L = milligrams per liter
NODOS = North-of-the-Delta Offstream Storage
SWRCB = State Water Resources Control Board
TDS = total dissolved solids

Table 4-5 shows the estimated irrigation water "saved" by reduced leaching requirements resulting from lower irrigation water salinity. These physical benefits are translated into economic benefits by applying irrigation water values (Table 4-2) to the quantity of saved water.[16]

Table 4-5. Estimated Savings in Irrigation Water for Leaching, by Salinity Analysis Area

Alternative/Benefit	Grasslands	Westlands	Tulare	Kern	San Felipe
Full Simulation					
Alternative A					
Percent Savings	0.13%	0.10%	0.10%	0.12%	0.23%
Volume Saved (AF per year)	1,328	548	128	654	83
Alternative B					
Percent Savings	0.13%	0.10%	0.11%	0.13%	0.24%
Volume Saved (AF per year)	1,276	569	136	700	86
Alternative C					
Percent Savings	0.19%	0.14%	0.14%	0.17%	0.32%
Volume Saved (AF per year)	1,849	769	181	934	117
Dry/Critical Conditions					
Alternative A					
Percent Savings	0.13%	0.10%	0.10%	0.12%	0.23%
Volume Saved (AF per year)	1,148	303	96	505	41
Alternative B					
Percent Savings	0.13%	0.10%	0.11%	0.13%	0.24%
Volume Saved (AF per year)	1,101	307	102	535	41
Alternative C					
Percent Savings	0.19%	0.14%	0.14%	0.17%	0.32%
Volume Saved (AF per year)	1,598	423	136	727	57

Irrigation water savings do not vary under 2025 and 2060 level of development.

AF = acre-feet

In addition, agricultural water quality benefits are realized in the South Coast region as estimated by LCRBWQM. These benefits are added to the benefit estimates for salinity analysis areas (i.e., water use savings) to estimate total benefits as presented in Table 4-6. Comparatively, the irrigation water quality benefits are substantially lower than the M&I water quality benefits shown in Table 4-1. Annualized benefits are estimated to be as much as $1.7 million on average and $3.6 million during dry/critical years.

[16] The benefits described for agricultural water users are in addition to the agricultural water quality benefits in the South Coast region estimated using the LCRBWQM as described above.

Table 4-6. Irrigation Water Quality Benefits ($1,000s, 2013 Dollars)[a]

Alternative	Annual Benefits[b]		Annualized Benefit[c]
	2025	2060	
***Full Simulation*[d]**			
Alternative A	$1,197	$1,281	$1,239
Alternative B	$1,319	$1,398	$1,358
Alternative C	$1,551	$1,943	$1,747
***Dry/Critical Conditions*[e]**			
Alternative A	$2,350	$3,047	$2,701
Alternative B	$3,236	$3,214	$3,228
Alternative C	$3,450	$3,681	$3,569

[a] Based on results of the agricultural salinity model (for irrigation water export areas served by CVP/SWP facilities) and LCRBWQM (for the South Coast region).
[b] Benefits attributed to salinity reductions only under 2025 and 2060 level of development.
[c] Annualized benefits represent avoided costs relative to the future No Project conditions over the planning horizon (2023-2123).
[d] Average over entire hydrologic sequence (1921 to 2023).
[e] Average over dry and critical years periods over the hydrologic sequence as defined by SWRCB D-1641.

CVP = Central Valley Project
LCRBWQM = Lower Colorado River Basin Water Quality Model
SWP = State Water Project
SWRCB = State Water Resources Control Board

This page intentionally left blank

CHAPTER 5 ECOSYSTEM ENHANCEMENT

The NODOS Project will enable changes to the volume and timing of environmental flows at critical times throughout the year. These flow changes will provide many benefits to users of water from the Sacramento River, improve habitat, and benefit aquatic species including anadromous fish and delta smelt. Within this chapter, the approaches that are available to evaluate the environmental benefits associated with fish populations and habitat are discussed.

The types of economic benefits that could be quantified are:

- Increases in consumptive use values for commercial and recreational fisheries or non-consumptive use values for recreation
- Non-use values that people place on the fishery or ecosystem enhancement even though they may never fish or see the improvement
- Reduced costs for the recovery and management of the ecosystem and/or fishery species

The benefits of NODOS extend beyond the projected increased use values for recreational and commercial catches of salmonids. A significant benefit could also be attributable to the listed status of the species and the value which society places on their preservation. This distinction has important implications for the methods used to value the benefits and allocated costs of the project.

As discussed in Chapter 2 of this appendix, numerous techniques are available for quantifying NMVs including revealed preference (RP) and stated preference (SP) and other low-cost techniques.[17] No recent SP or RP studies are available specifically for the fisheries restoration and environmental enhancement benefits NODOS will provide.

Alternatively, a "benefits transfer" approach can be applied to valuation studies performed for other locations to provide an indication of value for these benefits at NODOS. For benefit transfer to be useful for assessing the fisheries and ecosystem enhancement benefits associated with NODOS, the two sites' physical characteristics should be similar, and the changes being valued should also be similar.

Anadromous Fish Populations

Fisheries' modeling was undertaken using two models, the Winter-Run Chinook Life Cycle Model (WRCLCM) Interactive Object-oriented Salmon Simulation/Delta Passage Model developed by Cramer Fish Sciences, and the Salmonid Population Model (SALMOD) developed by CH2M HILL for Reclamation. For more information on these models including their assumptions, limitations and outputs, see the Modeling Appendix to the EIR/EIS.

[17] Note that mixing and matching willingness to pay and avoided cost estimates would double count the restoration benefits.

Over the full hydrological simulation period, the total increase in salmon production (all species) is estimated to be approximately 936 habitat units under Alternative A.[18] Under Alternative B, 683 habitat units are projected to be created and 756 habitat units would be created under Alternative C.

NODOS is estimated to increase the annual number of Chinook winter-run female spawners by 8 percent from the No Project scenario. While this future spawning improvement is beneficial, the extent to which this population growth would contribute to the achievement of species restoration goals is currently unknown. Furthermore, NODOS is expected to result in fishery improvements in terms of survival rates and mortality rates; however, how these rates relate to fish numbers caught in the ocean is not known.

Data for Benefits Transfer

Commercial/Recreational Fishing

Under the P&Gs, commercial fishing profitability effects resulting from project-related ocean harvest changes can be used as a method for evaluating its fish population benefits. This approach can monetize the fisheries benefit for inclusion in the NED account to the extent that fishery biologists can quantify the effect that NODOS will have on fish numbers and specifically on future fish caught. However, since NODOS expected effects on ocean fishing's commercial catches cannot be reliably projected, its effects on commercial fishing profitability cannot be estimated.

Unlike commercial fishing, recreational or sport fishing activities typically do not take place within a market setting (with the exception of for-hire charterboat, partyboat, and guideboat activities). As a result, market price information is generally unavailable and nonmarket valuation techniques are typically employed. The travel cost method (TCM) and CVM are the most common nonmarket valuation techniques used in valuing sport fishing and other outdoor recreation activities.

Both approaches are recommended by the P&Gs for use in valuing outdoor recreation activities. However, NODOS expected effects on recreational fishing activity or catches cannot be reliably projected, and consequently its related fish population benefits cannot be determined. Therefore, without additional studies, the use of benefit transfer as a technique for quantifying fishery restoration benefits is not recommended.

Species Recovery

As discussed previously, the P&G's indicate that while benefits are best measured based on user's willingness to pay, in the absence of the ability to measure the willingness to pay other approaches can be used instead. NED principles allow that the alternative cost of an action can be used to determine its NED benefit value. With respect to anadromous fish, it is reasonable to assume that recovery of these species must occur regardless of NODOS and, consequently, that some population goals will be achieved in any case. Therefore, the effect of NODOS may be to change the cost of recovery, but not the ultimate fish population levels. If the fish population change

[18] Each habitat unit is equivalent to 1,000 additional salmon produced.

caused by NODOS can be adequately determined, then the NODOS contribution to the recovery goal's achievement can be identified. If the cost of recovery can be estimated, then the NODOS share of recovery cost avoided likewise can be estimated.

Recovery planning is currently underway for Endangered Species Act listed Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead to return them to viable status in the Central Valley. Initial cost estimates for recovery plans range from $1.1 billion to $14 billion over the next five years and up to $11.2billion over 50 years in 2013 dollars (National Marine Fisheries Service, 2009). The annualized value of $10.4 billion over 50 years is $478 million at a federal discount rate of 3.75 percent.

Further relevant studies include those undertaken to assess individual's annual WTP for the avoided loss of endangered species. Loomis and White (1996) assessed the economic values of the threatened and endangered species in the U.S. They found that the WTP for single species preservation is $9.28 per household per year (2013 dollars). In addition, they found that the lump sum for all species preservation is $23.99 per household (2013 dollars).

Ecosystem Enhancement

Data for Benefits Transfer

Several contingent valuation surveys have been undertaken within the Central Valley (e.g., Loomis et al. [1991]) to elicit WTP values. Values were obtained from five environmental agendas: a wetlands maintenance program, a wetlands improvement program, contaminant maintenance program, a contaminant reduction program and a salmon improvement program. The programs focused on reversing the negative water quality effects of agricultural runoff and re-establishing the Chinook salmon fishery which had been severely diminished as a result of the construction of the Friant Dam on the San Joaquin River. The survey which included households in California, Oregon, Washington, and Nevada contacted 1,960 households by phone, from which 1,004 (51 percent) completed the mailed questionnaire.

Using this survey data, Hanemann et al. (1991), found that California households are willing to pay $337 per household per year (2013 dollars) to restore flows in the upper San Joaquin River. The survey described how these flows would affect salmon and other fish in the river as well as wildlife and vegetation along the river banks. Given the 51 percent response rate, the value of restoring flow (thereby improving wildlife and habitat) was estimated at $172 per household (2010 dollars).

Loomis and Creel (1992) used the TCM and a stated preference contingent valuation to determine WTP for increased flows in the San Joaquin Valley for the San Joaquin and Stanislaus rivers, respectively.

While NODOS will increase the volume of flows in the Sacramento River, these volumes are not similar to the restoration flows modeled within the San Joaquin River. Furthermore, these past contingent valuation studies are relatively old and therefore the accuracy and current relevance of their findings are difficult to determine. Therefore, the economic values for the environmental enhancement benefits have not been based on the contingent valuation data.

Benefit Derivation

Ideally, an SP or RP study specifically for the project or another similar project to estimate WTP values would be performed to assess NODOS's fisheries restoration and environmental enhancement benefits. However, given the absence of suitable SP or RP studies, the proxy method described below was used to value the project's fisheries restoration and enhancement benefit.

Any water released from Sites Reservoir will likely benefit the environment. Using a conservative approach, only the average annual release of water specifically not assigned to other purposes (i.e., water supply or improved water quality outcomes) might reasonably be attributed to fisheries and ecosystem enhancement outcomes. As shown in Table 5-1, annual water releases of between 77.5 and 83.6 TAF would be attributable to ecosystem enhancement.

Table 5-1. Increased Water Supply for Ecosystem Enhancement Under NODOS (TAF)

Alternative	Average Annual Volume (TAF)[a]	Difference from No Project (TAF)	Difference from No Project (%)
Full Simulation[b]			
No Project	0.0	--	--
Alternative A	83.6	83.6	--
Alternative B	80.2	80.2	--
Alternative C	77.5	77.5	--
Dry/Critical Conditions[c]			
No Project	0.0	--	--
Alternative A	91.2	91.2	--
Alternative B	98.4	98.4	--
Alternative C	85.6	85.6	--

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).
[c] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

NODOS = North-of-the-Delta Offstream Storage
SWRCB = State Water Resources Control Board
TAF = thousand acre-feet

The SWAP model results are used to estimate the unit value (or marginal value) of this water. Table 5-2 shows the estimated economic value benefits of NODOS's increased water supply for ecosystem enhancement.

Table 5-2. Estimated Ecosystem Enhancement Benefits from Increased Flows ($1,000s, 2013 Dollars)

Alternative	Annual Benefit[a,b]		Annualized Benefit ($)[c]
	2025	2060	
Full Simulation[d]			
Alternative A	$15,084	$21,344	$18,214
Alternative B	$14,727	$20,807	$17,768
Alternative C	$14,044	$19,857	$16,951
Dry Conditions[e]			
Alternative A	$17,706	$24,925	$21,339
Alternative B	$19,470	$27,369	$23,446
Alternative C	$16,668	$23,462	$20,088

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[d] Average over entire hydrologic sequence (1921 to 2023).
[e] Average over dry and critical years over the hydrologic sequence as defined by SWRCB D-1641.

SAWP = Statewide Agricultural Production Model
SWRCB = State Water Resources Control Board

On average, the annual benefits for fisheries restoration and ecosystem enhancement vary from $18.2 million for Alternative A and $16.9 million for Alternative C (2013 dollars). For the estimated 12 million households in California, this corresponds to between $1.52 and $1.41 per household per year.[19]

Under dry year conditions, the annual benefits for fisheries restoration and ecosystem enhancement increases to between $20.1 million for Alternative C and $23.4 million for Alternative B (2013dollars). For the estimated 12 million households in California, this amount corresponds to between $1.67 and $1.95 per household per year.

The greatest accomplishments in ecosystem enhancement come not from flows, but from better temperature management. Increasing the coldwater pool increases the operational flexibility to provide suitable water temperatures year-round at levels suitable for all species and life stages of Chinook salmon and steelhead. The most significant benefits are associated with the increase in the coldwater pool at Shasta Lake; however, similar benefits occur in the coldwater pool for Folsom Lake, Lake Oroville, and Trinity Lake. There is an opportunity cost associated with maintaining a greater coldwater pool at these facilities.

[19] These per household values are provided for illustrative purposes. It is important to note that these benefit values represent only the project's more limited ecosystem benefits, which are far smaller than the more comprehensive and permanent ecosystem restoration benefits presumably evaluated by the WTP studies discussed above.

Table 5-3 provides the increase in end-of-May storage for the four reservoirs.

Table 5-3. Increased End-of-May Storage for Shasta Reservoir, Lake Trinity, Lake Oroville, and Folsom Lake (TAF)

Alternative	Average Annual Volume (TAF)[a]	Difference from No Project (TAF)	Difference from No Project (%)
Full Simulation[b]			
No Project	9,596	--	-
Alternative A	9,722	126	1.3%
Alternative B	9,737	141	1.5%
Alternative C	9,739	143	1.5%

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).

TAF = thousand acre-feet

If the increase in end-of-May storage at all four reservoirs is valued using the unit value from SWAP to represent the opportunity cost for the coldwater supply, significant additional ecosystem enhancement benefits may be attributable to NODOS (Table 5-4).[20]

Table 5-4. Ecosystem Enhancement Benefits Associated with Increasing the Coldwater Pool ($1,000s, 2013 Dollars)

Alternative	Annualized Benefit ($1,000s, 2013 Dollars)[a,b,c]
Full Simulation[d]	
Alternative A	$27,420
Alternative B	$31,209
Alternative C	$31,252

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Based on end-of-May storage in Shasta Lake, Lake Trinity, Lake Oroville, and Folsom Lake.
[d] Average over entire hydrologic sequence (1921 to 2023).

[20] The coldwater pool values in Table 5-4 are based on the unit values estimated by SWAP for NODOS's ecosystem enhancement in Table 5-2. Arguably, such use of those unit values for might slightly overstate the value that would be estimated if additional SWAP analysis had been performed for the coldwater pool supplies. However, given that no additional economic benefit has been attributed to the day/critical conditions, these coldwater values still may be considered relatively conservative. Furthermore, the Table 5-4 values are less/comparable to those alternatively determined under the least cost approach in Table 5-6.

Ecosystem Enhancement Fund

As part of the NODOS Project, additional ecosystem enhancement activities are proposed to be performed annually, funded by a $30-million capital allocation. Funded activities would likely consist of streambed restoration activities such as gravel importation as well as realignment and vegetation management to further improve the fishery habitat. The level of ecosystem restoration would be based on the annual interest generated by the capital allocation with the principal amount slowly drawn down over the project's 100 year lifetime.

A 3.75 percent federal discount rate is used for near-term project construction and then subsequent payback of its construction cost (Federal Register, 2013). For the proposed environmental enhancement fund (EEF), future returns would likely vary in accordance with typical long term and cyclical economic conditions (i.e., future inflationary periods) affecting the fund. Consequently, it is considered more appropriate to project the fund's expected future investment returns on average past returns and inflation rates that rather than recent financial conditions.

According to the Office of Management and Budget (OMB), the nominal 30-Year treasury interest rate averaged 7.1 percent between 1979 and 2010 (OMB, 2011). Over the same period, OMB reports that real 30-Year treasury interest rate averaged approximately 4.3 percent – higher than the current nominal federal discount rate of 3.75 percent. Over the last 20 years, the real rate average 3.67 percent annually. Conservatively applying this lower real federal interest rate to determine the likely annual future returns from the EEF, the $30 million fund would provide a constant annual payout of approximately $1,109,200 (in current year dollar terms) at a 3.67 percent real interest rate over a 100 year period. Consequently, provided the annual earnings are used appropriately, that would be equivalent to approximately $1.1 million in Environmental Enhancement annually.

Least Cost Alternative Approach

The economic value of the ecosystem enhancement accomplishments of NODOS can be estimated based on a "least-cost approach" basis. Under such an approach, the next best alternate project for achieving the same outcomes (i.e., salmon habitat increases) is identified and its development cost can be used to represent the project's restoration benefits. Ideally, demonstrated expenditures for similar salmon restoration projects would be used to estimate the project's restoration benefits.

Under the P&G's, a least-cost valuation approach can be used when: the two projects' outputs are similar; the NED benefits cannot be estimated from market prices or net income changes; and the alternative project would be implemented. For the NODOS Project's coldwater benefits, the most comparable approach for reducing water temperatures during critical periods along the Sacramento River likely would be to raise the dam at Shasta Lake. Additional surface storage at Shasta Lake could be developed to ensure a greater coldwater supply that could be used during critical periods to decrease down-stream water temperatures.

While analysis of the net income changes for the ecosystem benefits have been performed above, the least-cost alternative approach has been used as a supplemental approach for verifying the net income approach's results. Finally, a future increase in the height of the Shasta Dam is considered a reasonable and implementable alternative, given the ongoing planning and design for the reservoir expansion.

As part of the Shasta Lake Water Resource Investigation, preliminary design and cost analysis for three Shasta Dam raise scenarios have been developed – 6.5 feet, 12.5 feet and 18.5 feet. Corresponding salmon population increases for the three dam raise scenarios were also projected using the CalSim and SALMOD models. Table 5-5 shows the estimated annual costs and salmon production for the three Shasta Dam raise scenarios.

Table 5-5. Salmon Production and Annual Cost for Shasta Dam Raise Scenarios (2013 Dollars)

Dam Raise (feet)	Habitat Units[a]	Annual Cost ($1,000s)[b]	Cost per Habitat Unit[c] ($)
6.5	816	$44,100	$54,000
12.5	1,058	$49,960	$47,200
18.5	1,112	$55,790	$50,200

[a] Each habitat unit equals 1,000 additional salmon produced.
[b] Dollar values expressed in 2013 dollars and based on a 3.75 percent annual discount rate.
[c] Unit cost values have been rounded to the nearest $100.

As can be seen from Table 5-5, the estimated minimum average annual equivalent cost per habitat unit is $47,200. Table 5.6 shows the annual benefits for each of the NODOS Project alternatives' salmon habitat improvement accomplishments based on applying this "per habitat benefit estimate" to each alternative's expected salmon habitat restoration increases.[21]

Table 5-6. Least-Cost Approach Ecosystem Enhancement Benefits Estimates (2013 Dollars)

Alternative	Projected Habitat Units	Annualized Benefit ($ 1000s, 2013 Dollars)[a,]
Alternative A	936	$44,200
Alternative B	683	$32,200
Alternative C	756	$35,700

[a] Annual benefits are based on average annual equivalent cost per habitat unit of $47,200.

Annual anadromous fish habitat benefits of up to $44.2 million are estimated under Alternative A based on a least-cost approach basis for raising Shasta Dam. The annual anadromous fish habitat benefits are projected to be up to $32.2 million under Alternative B and $35.7 million under Alternative C. These benefits estimates from the least-cost approach are substantially higher than the enhancement benefit values based solely on the assigned water flows (shown in Table 5-2).

[21] The annualized benefit estimate based on the $47,200 minimum alternative cost per habitat unit are likely conservative since the actual cost for creating 756 new habitat units (i.e., equal to Alternative C) is most similar to the 6.5 foot dam raise scenario and a $54,000 cost per habitat unit (Table 5-6). In which case, Alternative C's benefits would be closer to $40.8 million.

Alternative A's estimated ecosystem enhancement benefit value of $44.2 million under the least-cost value approach is approximately $1.4 million less than the combined values of its estimated assigned water flow benefits ($18.2 million as shown in Table 5-2) and coldwater supply values ($27.4 million as shown in Table 5-4). For Alternatives B and C, their least cost approach estimates are comparable to their estimated coldwater benefits (shown in Table 5-4). Consequently, the value of their combined estimated ecosystem enhancement benefits (i.e., both assigned the flow and coldwater storage components) exceeds their estimated ecosystem enhancement benefits using the least cost approach.

Comparison of the various benefit estimates indicate that sole reliance on the least-cost approach would under-represent the project's total economic enhancement benefits. Because the project's coldwater and assigned water flow attributes are separable, it therefore is considered reasonable to include the full value of both in the project's total economic enhancement benefit estimate.[22]

Benefits Not Included or Quantified

While the above benefit derivations for water supply flows and coldwater storage values ecosystem benefits for the Sacramento, Feather, and American rivers, it does not address the additional benefits associated with supplemental Delta outflow during the summer and fall months to improve X2. Increased flows through the Delta and out through the San Francisco Bay are beneficial for numerous fish populations. These flows increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fish and other estuarine-dependent species (e.g., delta smelt, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp.

The California State Water Resources Control Board (State Water Board) concluded that the best available science suggests that current flows in the Delta are insufficient to protect public trust resources, including fish populations (State Water Resources Control Board, 2010). In determining the extent of protection to be afforded public trust resources through the development of the flow criteria, the State Water Board considered the broad goals of the planning efforts the criteria are intended to inform, including restoring and promoting viable, self-sustaining populations of aquatic species. They stated that flow modification is one of the immediate actions available, although the linkage between flows and fish response are often indirect and are not fully determined.

The initial approach of valuing water released from Sites Reservoir dedicated to environmental enhancement (Table 5-2) partially captures the value of increasing Delta outflow. However, the volume of water released for water quality purposes provides a secondary benefit of increasing Delta outflow and shifting X2. It is also possible to value the increase in Delta outflow directly (Table 5-7).

[22] Under other operating conditions, the project's water flow benefits could be separately achieved with little or no water temperature improvements (i.e., coldwater storage benefits).

Table 5-7. Increased June – September Delta Outflow (TAF)

Alternative	Average Annual Volume (TAF)[a]	Difference from No Project (TAF)	Difference from No Project (%)
Average Conditions[b]			
No Project	2,110	--	--
Alternative A	2,240	129	6%
Alternative B	2,246	135	6%
Alternative C	2,265	154	7%

[a] Based on CALSIM II modeling.
[b] Average over entire hydrologic sequence (1921 to 2023).

TAF = thousand acre-feet

Table 5-8 shows the corresponding ecosystem enhancement benefits for increasing Delta outflow using the unit value from SWAP.

Table 5-8. Estimated Ecosystem Enhancement Benefits Associated with Increasing the June – September Delta Outflow ($1,000s, 2013 Dollars)

Alternative	Annualized Benefit ($1,000s, 2013 Dollars)[a,b,c,d]
Average Condition[e]	
Alternative A	$28,080
Alternative B	$29,880
Alternative C	$33,660

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[d] Based on June through September increases in outflow.
[e] Average over entire hydrologic sequence (1921 to 2023).

Total Fisheries Restoration and Ecosystem Enhancement Benefits

The total fisheries restoration and ecosystem enhancement benefits for the NODOS Project are estimated based on the combined increased ecosystem water supply (Table 5.2), coldwater storage-related ecosystem enhancement benefits (Table 5.4) and expected ongoing ecosystem enhancement account activities averaging $1.1 million per year. The combined total values for the alternatives are shown in Table 5-9. These combined benefits are considered the most reasonable estimate of the total NODOS Project ecosystem benefits given the likely conservative nature of the least cost approach (as noted above) and limited attribution of any project-related X2 benefits.

Table 5-9. Estimated Ecosystem Enhancement Benefits Combining the Fisheries Restoration Water Supply, Coldwater Pool Increase and Habitat Restoration ($1,000s, 2013 Dollars)

Alternative	Annualized Benefit ($1,000s, 2013 Dollars)[a,b,c,d]
Average Condition[e]	
Alternative A	$46,734
Alternative B	$50,077
Alternative C	$49,303

[a] Annual benefits are based on SWAP marginal values for water and CALSIM II water volumes.
[b] Annual values represent the marginal value of water used in agriculture. Not including any transaction costs, the values represent the value with which water would trade to other (urban) uses.
[c] Annualized values assume interpolated annual benefits between 2025 and 2060 and then constant annual benefits beyond 2060 (Figure 1).
[d] Based on end-of-May storage increase in Shasta Lake, Lake Trinity, Lake Oroville, and Folsom Lake.
[e] Based on June through September increases in outflow.

Based on the combined increased ecosystem water supply and coldwater storage-related ecosystem enhancement benefits, the NODOS Project's total fisheries restoration and ecosystem enhancement benefits are estimated to be approximately $46.7 million under Alternative A and $49.3 million under Alternative C. Alternative B is projected to have the greatest fisheries restoration and ecosystem enhancement benefits of $50.1 million.

This page intentionally left blank

CHAPTER 6 HYDROPOWER

Hydropower generation by the NODOS facilities is a primary benefit of the project. The seasonal water diversions for NODOS will require power while its seasonal water releases will generate power. Water diversions into NODOS will take place in the winter and spring, and water releases will occur during the summer and fall. A pumpback component of NODOS operations has been modeled separately and will occur throughout the year as conditions allow.

The three new pumping-generating facilities envisioned for the NODOS Project include the plants at Holthouse Reservoir (adjacent to the Sites Reservoir), at the Terminal Regulating Reservoir (connecting the GCID Canal to Funks Reservoir), and at the Sacramento River diversion point (connecting the Sacramento River to the Holthouse Reservoir). Additional facilities required for filling Sites Reservoir include the existing pumping plants at the Tehama-Colusa Canal Authority intake at Red Bluff and at the GCID Canal intake near Hamilton City.

Hydropower benefits from the different NODOS facilities include:

- Revenues from generated energy incidental to water deliveries to downstream agricultural and urban water users[23]
- Net revenues resulting from an optimized pumpback operation at Sites Reservoir[24]
- Net revenue/cost associated with delivering additional water deliveries to CVP and SWP water customers
- Revenues from selling ancillary services (AS), capacity products, and potentially selling renewable energy firming services

Available Methods

Two approaches, complementary to each other, have been used to assess the net hydropower benefits associated with NODOS Alternatives, namely:

- The NODOS Power Post-Processor Module developed by CH2M HILL
- The NODOS Power optimization scheme developed by DWR’s Power and Risk Office (PARO)

These two approaches are discussed below.

[23] The initial pumping costs to fill Sites Reservoir are included as part of the operation and maintenance costs (see Chapter 10).
[24] This net benefit includes both pumping and generation.

NODOS Power Post-Processing Module

Hydropower benefits and pumping costs are estimated with a spreadsheet post-processor module which evaluates the power impacts of flow scenarios from CALSIM II operations studies using monthly intervals. The module estimates average annual energy generation and use at proposed NODOS facilities and system-wide, including all existing CVP and SWP facilities that would be operated differently if NODOS is built. The module estimates average annual power requirements for pumping facilities and determines whether off-peak energy use targets are met. The module is also used to estimate average annual peaking power capacity and annual energy generation. Transmission losses are estimated for both pumping and generation facilities.

For each alternative, modeling simulations were completed using the following Power models:

- LTGen model, for analysis of CVP facilities;
- SWP_Power module, for analysis of SWP facilities; and
- NODOS_Power module, for analysis of NODOS related facilities.

The hydropower module calculates the future No Project condition of both CVP and SWP power facilities without a NODOS Project. The module then calculates the power generation provided by the existing CVP and SWP system as well as the pumping demand required by both systems to move water throughout California.

For more information on the assumptions used in this model, refer to the Modeling Appendix to the EIR/EIS.

NODOS Power Optimization Scheme

DWR's PARO developed an optimization scheme for the NODOS Project operations to take advantage of opportunities and price differentials that the energy market offers. NODOS Project operations, constraints, and assumptions, as envisioned by the water operations modeling team, are maintained. However, operations were optimized to maximize the Power Portfolio value of the NODOS assets. A pumpback operation was superimposed on the NODOS Project's operation modes (Diversion and Release modes) to the extent that the pumping, generation, and storage assets are simultaneously available to complete the pumpback operations. The premise is that through optimization of project's operations, the inherent excess design capacities of the project's components (resulting from hydrology swings) can be translated to operational flexibility, and operations and maintenance net costs of the project can be minimized.

For the purpose of modeling the NODOS power operations, three project operation modes are identified: diversion mode (pumping) from the Sacramento River to fill up Sites Reservoir; release mode (generation) from Sites Reservoir to meet the NODOS Project water release objectives; and a pumpback mode to better utilize residual capacities of the different NODOS Project components. The NODOS Project pumpback operations are meant to enhance the project economic performance by capturing opportunities offered by the energy market (energy price differentials between on-peak and off-peak hours), and to provide the support/products needed to integrate renewable energy (e.g. wind and solar).

An optimization strategy was developed to minimize energy costs of pumping operations that also maintains NODOS water operations objectives for the diversion mode. Consequently, flat monthly pumping operations are maintained (24 hours a day and 7 days a week where applicable), for all three diversion points along the Sacramento River. Once water is diverted from the Sacramento River into Holthouse Reservoir, the rest of the diversion operations (i.e., pumping into Sites Reservoir) could be optimized to better utilize Sites Pumping Plant capacity, and the available storage in Holthouse Reservoir. It would be more economical to retain the on-peak diversions from the Sacramento River in Holthouse Reservoir (as scheduled) and to pump that water into Sites Reservoir during off-peak hours (on daily basis). The intent of redesigning the diversion mode is to avoid on-peak high electricity costs. Hence, all pumping operations into Sites Reservoir are optimized to occur (if possible) during the off-peak periods (including shoulder hours where operations are transitioning between peak and off-peak modes). Moreover, this shift in operations will provide an opportunity to superimpose a pumpback operation cycle on the NODOS Project diversion mode. In its optimized mode and during on-peak hours, the Sites Pumping-Generating plant will be available for generation. During the off-peak periods, the residual pumping capacity will be available to pump the water back into Sites Reservoir.

For the NODOS Project’s water release mode (i.e., generation mode), an optimization strategy was developed to maximize generation revenues from the project’s generation assets. For this strategy and to the extent physically possible, all planned daily releases from Sites Reservoir into Holthouse Reservoir will occur during the on-peak period (or “super-peak” hours), to capture the most value the energy market offers for the NODOS Project generation. As a result of on-peak releases from Sites Reservoir into Holthouse Reservoir, water will be released into the Terminal Regulating Reservoir, T-C Canal, and the Sacramento River up to their facility capacities (and within the planned limits for the water release). The residual water in Holthouse Reservoir (from the On-Peak Sites Reservoir releases) would be released during the off-peak period to satisfy the NODOS Project’s water delivery obligations. A key requirement for this strategy to be effective is that Holthouse Reservoir’s active storage would be made available before the beginning of the next on-peak cycle (i.e., next day’s cycle). Optimizing the release (generation) mode will better utilize the Sites Power Plant capacity (i.e., improve revenues), and provide an opportunity to superimpose a pumpback operation cycle on the water release mode.

A third component of the NODOS Project power operations is a daily pumpback operation. For periods when the NODOS Project is neither in its diversion nor release modes, Sites Reservoir pumping and generation facilities can operate in a pure pumpback mode to take advantage of the energy price differentials between the on-peak and off-peak hours, and serve ancillary market needs. Under solely a pumpback operation mode, water would be released from Sites Reservoir into Holthouse Reservoir during the on-peak (or super peak) hours to generate energy and would be pumped back into Sites Reservoir in the off-peak hours to complete the pumpback cycle. The pumpback operation could be superimposed on the diversion and release modes when the energy market prices relative to the Sites Pumping Plant’s efficiency (cycle efficiency) are suitable. At Sites Reservoir, the extent of the pure pumpback operations, and pumpback incidental to the NODOS Project diversion and release modes, are driven by electricity market prices, pumping-generating cycle efficiency, residual pumping capacity, residual generation capacity, and the Holthouse Reservoir's residual storage capacity.

Power Portfolio Models available to DWR's PARO have been used for the analysis for the NODOS Project. Specifically, the Electric Power Research Institute (EPRI) Energy Portfolio Model (EPM), Version 5, is used for the analysis. The operations of the NODOS Project's different assets are translated to a representative set of financial instruments and are incorporated into the EPM model. The model monetizes the probabilistic value of the NODOS power portfolio for each of the alternatives and operational scenarios used in the study. EPRI Fast Fit model, Version 2.5, is used to describe the needed power and fuel price volatilities term structures, and the correlations between the different energy markets that the NODOS Project will be participating in, or competing with.

The EPM is a computer software/model that is designed to help businesses manage value and risk in the power and energy markets. The EPM is used in the current study to value the different NODOS Project assets and energy needs. The EPM requires the user to describe the intended operations of project assets and underlying commodity prices. For the NODOS Project the intended operations are the results of the optimization scheme that PARO developed and executed for the project. The objective of using the EPM model is to value the NODOS Project energy assets and contract needs, and to assess its energy portfolio's exposure to major sources of risk. The EPM provides a set of templates that facilitates the description and evaluation of common types of power and fuel contracts (including supply contracts, standard and customized forward, and option contracts). The model characterizes each commodity market by a forward price curve and a term volatility structure. A correlation matrix characterizes the behavior of pairs of commodity markets is also used by the model.

For more information on the assumptions used in this model, refer to the Modeling Appendix to the EIR/EIS.

Modeling Results

Expected power generation and use was estimated using these two approaches/ models and the resulting net revenue projections were calculated based on 2025 and 2060 forecasted energy costs. Results are presented below for all three project alternatives under two different NODOS operations scenarios.

The first is an incidental scenario that assumes the NODOS Project would be operated for purposes other than optimal power generation and, therefore, there is no consideration of peak and off-peak timing of the resulting power use and generation. Instead, it is assumed that the resulting pumping and generation are scheduled according to the expected demand for water deliveries. It is further assumed that there will be no pumpback operation at the NODOS Project (flat operations will limit availability of project components).

The second is an *optimized scenario* assuming the NODOS Project would be operated to achieve optimal power generation and usage (with no impact to water objectives) – pumping during off-peak periods and generating during peak (or super peak) periods, to the extent possible. In addition, this scenario assumes that the residual pumping, generating, and storage capacities at Sites and at Holthouse reservoirs will be used to superimpose a pumpback operation cycle and to provide a reliability reserve for renewable energy integration needs.

The system-wide power generation, use and net revenue results for the incidental and optimized scenarios were obtained from the NODOS Power Post-Processing Module. Power costs and revenues for the incidental and optimal scenarios relevant to the NODOS Project operations are the modeling results supplied by DWR's PARO. The results from the two aforementioned approaches were merged (integrated) to produce the study results, as presented in Table 6-1 It should be noted that NODOS power optimization analysis (performed by DWR) shows that the NODOS Project, as a standalone project, will have a positive cash flow. The economics of the project are greatly enhanced through optimizing operations and by superimposing pumpback operations on the water diversion and release modes.

Table 6-1 provides the average annual power generation and use results for the three project alternatives under both the incidental and optimized scenarios. Table 6-1 shows that, under the incidental production scenario, system-wide NODOS is a net power user under all the alternatives.

Under the optimized scenario, NODOS operations are timed to schedule generation and pumping according to peak demand and energy pricing and each of the project alternatives are projected to generate positive net revenues from their hydropower operations. The model results show both reduced pumping costs and increased power generation revenues for the Sites facility compared with the incidental scenario results. The Table 6-1 shows that there is a significant revenue advantage from optimized operation of NODOS's hydropower facilities. This advantage is illustrated by the NODOS Project Optimization Potential, presented in Table 6-1 as estimated annual increases in net revenues of $4.37 million, $4.60 million, and $4.64 million for Alternatives A, B, and C respectively.

Overall, the power modeling shows that if NODOS pumping and generation operations are shifted to address peak demand and energy pricing considerations, the optimized costs and revenues have a significant beneficial impact on the project's economics.

Table 6-1. Estimated Net Revenue from NODOS Power Use and Generation for the Three Project Alternatives ($1,000s, 2013 Dollars)

Pumping-Generation Site						
Planning Alternative	Alternative A		Alternative B		Alternative C	
Operations Strategy	Incidental	Optimized	Incidental	Optimized	Incidental	Optimized
NODOS Pumping	**Annual Revenues**					
T-C Canal Pumping	-366	-366	-452	-452	-349	-349
GCID Pumping	-608	-608	-694	-694	-600	-600
Delevan Pipeline Intake Facilities	-3,222	-3,222	N/A	N/A	-3,565	-3,565
TRR Pumping	-598	-598	-991	-991	-713	-713
Sites Pumping	-8,995	-8,275	-8,895	-8,016	-10,372	-9,506
Subtotal	-13,789	-13,069	-11,032	-10,153	-15,599	-14,733
	Preliminary Results					
NODOS Generation	**Annual Revenues**					
Sites Generation	6,569	7,311	6,700	7,558	8,083	9,009
TRR Generation	1,183	1,228	412	431	1,227	1,279
Sacramento River Generation	3,003	3,003	N/A	N/A	3,023	3,023
Subtotal	10,755	11,542	7,112	7,989	12,333	13,311
NODOS PumpBack Operations	**Annual Revenues**					
PumpBack During Diversion cycle	N/A	423	N/A	843	N/A	449
PumpBack During Release Cycle	N/A	1,385	N/A	1,102	N/A	1,298
Pure PumpBack Operations Cycle	N/A	1,050	N/A	899	N/A	1,048
Subtotal		2,858		2,844		2,795
NODOS Total Net Revenues	-3,034	1,331	-3,920	680	-3,266	1,373
NODOS Project Optimization Potential		4,365		4,600		4,639

Hydropower Benefits

In presenting the benefits of hydropower, the operating costs associated with filling Sites Reservoir were included with the cost estimate as an annual operating cost. Table 6-2 presents these costs under the incidental operations for average water conditions. The annual hydropower pumping costs vary from $11.0 million for Alternative B to nearly $15.6 million for Alternative C.

Table 6-2. Hydropower Pumping Costs – Incidental Operations ($1,000s, 2013 Dollars)

Alternative	Alternative A	Alternative B	Alternative C
Annual Cost	**$13,789**	**$11,032**	**$15,599**

Table 6-3 lists the annual benefits from hydropower generation from water release for all alternatives. These summarized results have been summed from the comprehensive modeling data shown in Table 6-1. The annual costs and generation benefits are the results for the incidental operating conditions. As shown in Table 6-3, under Alternative B the estimated annual power cost for the incidental operations is $3.92 million.

Table 6-3. Preliminary Estimated Hydropower Generation Benefits – Incidental Operations ($1,000s, 2013 Dollars)[a,b,c]

Alternative	Alternative A	Alternative B	Alternative C
NODOS Generation	$10,755	$7,112	$12,333
Power Cost	**$3,034**	**$3,920**	**$3,266**

[a] Hydropower benefits were modeled using PARO's EPM, and an energy post processing module that incorporates the LTGen model, the SWP Power module and a NODOS power module. Benefits do not include capacity or ancillary benefits.
[b] Costs to fill Sites Reservoir are included as annual pumping costs.
[c] Annual benefits were modeled for average conditions only.

EPM = energy portfolio model
NODOS = North-of-Delta Offstream Storage
PARO = Power and Risk Office
SWP = State Water Project

However, the proposed pumpback facilities consisting of expansion of the Sites pumping/generating plant and Holthouse facilities would enable the reservoir's future pumping and generation operations to be optimized so that the reservoir intake and outflow can occur during more favorable electricity pricing periods. The proposed pumpback facilities would also allow additional pumpback hydropower operations. Table 6-4 shows the cost and revenue effects of the pumpback operations on the project.

Under Alternative B, future optimized pumping and generation of Sites Reservoir would reduce the project's power cost from $3.92 million to $2.164 million – a saving of $1.756 million. In addition, future pumpback hydropower operations are estimated to generate $2.844 million in revenue. Consequently, the total revenue impact of the pumpback operations under Alternative B is estimated at $4.6 million per year.

Table 6-4. Preliminary Estimated Pumpback Generation Benefits – Optimized Operations ($1,000s, 2013 Dollars)[a,b,c]

Alternative	Alternative A	Alternative B	Alternative C
NODOS Pumping Cost – Optimized	$13,069	$10,153	$14,733
NODOS Generation – Optimized	$11,542	$7,989	$13,311
Power Cost - Optimized	**$1,527**	**$2,164**	**$1,422**
Power Cost Savings - Optimized[d]	$1,507	$1,756	$1,844
Pumpback Operations Revenues	$2,858	$2,844	$2,795
Total Pumpback Benefits	**$4,365**	**$4,600**	**$4,639**

[a] Hydropower benefits were modeled using PARO's EPM, and an energy post-processing module that incorporates the LTGen model, the SWP power module and a NODOS power module. Benefits do not include capacity or ancillary benefits.
[b] Costs to fill Sites Reservoir are included as annual pumping costs.
[c] Annual benefits were modeled for average conditions only.
[d] Savings represent the reduction in the total power cost between the incidental and optimized operations.

EPM = Energy Portfolio Model
NODOS = North-of-Delta Offstream Storage
PARO = Power and Risk Office
SWP = State Water Project

As shown in Table 6-5, under all alternatives NODOS's combined hydropower and pumpback operations are projected to result in net revenues. Consequently, the project would have no power cost charge but instead would generate hydropower benefits ranging from approximately $0.63 million for Alternative B up to nearly $1.3 million in net revenues for Alternative C.

Table 6-5. Estimated Hydropower Net Revenues – Optimized Operations ($1,000s, 2013 Dollars)

Alternative	Alternative A	Alternative B	Alternative C
Annual Net Revenues	**$1,331**	**$680**	**$1,373**

Additional Benefits of NODOS Hydropower Facilities

In addition to supporting the NODOS Project water operations, project's power facilities (pumping and generating) may participate in three additional power markets: AS; Capacity Markets; and Renewable Integration.

Ancillary Services Benefits

The California Independent System Operator (CAISO) procures AS to ensure that it has adequate reserve generation capacity to maintain the electric system reliability and system frequency, by matching generation and load at all times under both normal and abnormal operating conditions. In their restructured electricity market (Post MRTU), CAISO obtains AS services through a competitive bidding process. On a daily basis, CAISO procures four primary AS services (regulation, spinning reserves, non-spinning reserves, and replacement reserves), in day-ahead market. The two additional AS that CAISO procures are black-start and voltage support services, which are procured on a long term basis.

For the NODOS Project pumping/generating facilities, if interconnected to CAISO grid, AS would be a significant operations and costs/revenues concern. For the NODOS Project to participate in the CAISO AS market, the CAISO Tariff requires a participating generator to undergo a certification process -- the process details are beyond the scope of this study. CAISO Tariff states that a participating generator is a generator or other seller of Energy or AS through a Scheduling Coordinator over the CAISO grid from a generating unit with a rated capacity of 1 MW or greater, or from a generating unit providing AS and/or Imbalance Energy through an aggregation arrangement approved by the CAISO – a criteria that the NODOS Project will clearly meet. The CAISO accepts market bids for Energy and AS only from Scheduling Coordinators on behalf of the participating generator.

In general, AS market participation is an opportunity to translate inherent operational flexibilities and excess capacities into revenue opportunities. For the NODOS Project, the highest priority is to supply the intended seasonal water cycle (diversions/deliveries) that the project was designed to provide. Therefore, revenue opportunities from AS market participation will have to be obtained as an incidental activity after the project's primary water supply operational responsibilities have been achieved.

During its pumping cycle, the NODOS Project will have the opportunity to sell Non Spin AS into the CAISO market as a participating load (meeting CAISO Tariff definition). However, AS participation will be limited to the Sites Reservoir pumping plant, so that Sacramento River water diversions could be maintained at all times. The assumption is that if the pump load at Sites Reservoir Pumping Plant are dropped by CAISO, water diversions from the Sacramento River could be stored in Holthouse Reservoir for the period of time CAISO needs the service. Currently, the maximum period for a Non Spin AS is two hours.

During its generation cycle, the NODOS Project will have the opportunity to sell Regulation Down AS into the CAISO market. In this analysis, the NODOS Project water release cycle is optimized to capture the most value of the associated energy (generation-cycle). Hence, water releases from Sites Reservoir are designed to occur during the on-peak periods. Accordingly, the project's generation facilities are assumed to sell Regulation Down AS mostly during on-peak periods, and to a lesser extent in the off-peak periods. The assumption is that if called upon, NODOS's Regulation Down AS may necessitate a temporary delay in water releases that could be rectified within few hours. Also, it is assumed that the NODOS Project facilities will be equipped with AGC (automatic generation control) system that could be ramped down to satisfy CAISO requirements for provision of AS power supplies. Participating in the Regulation Down AS market may result in temporarily foregoing some of the on-peak generation revenues.

Capacity Market

CAISO is charged, under both California law and by the Federal Energy Regulatory Commission (FERC), with the responsibility of maintaining and operating a reliable grid system (transmission system) – a system that is under their operational control.

System reliability is a very complex subject, as it is inextricably intertwined with market economics - a subject that is beyond the scope of this analysis. Nevertheless, resource adequacy (RA) is a crucial element of reliable grid operations and relevant to the NODOS Project operations. CAISO through their FERC approved Tariff, along with RA requirements adopted by the California Public Utilities Commission (CPUC) mandates, are intended to establish a process that ensures that capacity procured for RA purposes is available when and where it is needed. For the NODOS Project, RA obligations are a pseudo financial obligation in the diversion (pumping) mode (self-provided), and a revenue opportunity in release (generation) mode.

There are several ways through which capacity value of a power asset can be harnessed. One way is the consideration of RA capacity value utilization. The state of California has embraced an RA mandate/regime (AB380) in order to make power resources available when and where they are needed, and to promote investment in new resources and maintenance of existing facilities. CPUC governs the RA program for entities under its jurisdiction and the CAISO monitors the RA program implementation by utilities, including publicly owned utilities and government agencies. Currently, RA capacity is being traded bilaterally through a solicitation and bidding process and the price of capacity negotiation is opaque. However, the CAISO Tariff requires the CAISO to procure capacity as a backstop, should a load serving entity fail to meet its RA obligation showings. The RA obligation showings take place in an annual showing, as well as monthly showings. The FERC has authorized the CAISO to charge or pay the default RA capacity procurement price of $67/KW-year.

It is assumed that the NODOS Project will offer capacity in the CAISO market to participants that need to secure capacity to meet their RA obligations. For a generation asset, there are two different levels of participation (local RA, and system RA) in CAISO’s Capacity market, based on the relative location of that specific asset to pre-established zones within the CAISO grid. The NODOS Project facilities and their potential interconnection location to the CAISO grid do not fall in one of the congested CAISO zones, where the generation assets can sell local RA products. Moreover, current CAISO market has sufficient system RA, with very little monetary value for assets to capture from capacity offerings. However, system RA needs, system configuration, and assets geographical distribution are changing all the time. Consequently, as the CAISO market evolves in the future there may be some future opportunities for the NODOS Project to participate in the RA market.

Renewable Integration

The California Renewable Energy Resources Act (CRERA), signed by California Governor Brown on April 12, 2011, significantly increased the state’s renewable portfolio standard targets from 20 percent to 33 percent by 2020. CRERA also expanded the compliance obligations to include virtually all retail sales of electricity in California. In September 2010, CAISO undertook a multi-phase stakeholder process (Renewable Integration Market and Product Review Initiative [RIMPR]), aimed at identifying changes to the energy market structure and at introducing new market products to reliably mitigate the impact of renewable generation (Intermittent generation) as it penetrates the market. Recently the CAISO has refocused its RIMPR from an expansive market to a more incremental phased approach. CAISO is focused on developing a high level roadmap addressing short, medium, and long term market enhancement to meet renewable integration needs.

Improved energy storage technologies for pump-storage hydroelectric facilities is a promising area for technological improvement that could greatly improve their role in power generation and delivery. The conventional role for energy storage facilities is storing off-peak energy for use during the on-peak periods or to provide ancillary services. New roles for energy storage include making intermittent renewable energy facilities into dispatchable resources and enhancing both grid reliability and power quality.

For the NODOS Project, there is great potential for the project's generation and pumping assets to participate in providing renewable integration services as the market needs evolve. Hydropower assets have a unique feature that is not available from other energy storage technologies - fast ramping that can simultaneously provide both high capacity and energy. Although, the NODOS Project's potential renewable energy integration benefits are certain, it is difficult to monetize that potential at this time because of the absence of a clear tradable market for these services.

Renewable Energy – Green Power

Hydropower is the primary source of renewable energy within the United States.[25] In 2010, hydropower accounted for 60 percent of all renewable energy generation and 6 percent of overall electricity consumption (EIA, 2011). It is a clean, reliable, and extremely efficient source of energy that can be ramped up and down quickly at any time of the day. As demonstrated by the California Public Utilities Commission, setting a market price reference for qualifying Green Power that exceeds the market price for non-renewable energy sources, hydropower is a valuable renewable energy resource.

However, NODOS is atypical from most hydropower plants in that it is an off-stream storage facility. Unlike on-stream storage reservoirs, NODOS requires power to be used to pump water into the storage before any hydroelectric power can be generated. With seasonal releases, the energy generated would be 143 to 353 gigawatt hours. Consequently, NODOS would be a net user of energy.

Peaking Plant

A key benefit of hydropower is its ability to rapidly ramp up and down to meet short-term energy needs. The time that a peaking plant operates may be many hours, a day, or as little as a few hours per year depending on the region. In California, peaking plants are generally gas turbines that burn natural gas.

The need for peaking plants is essential given the growth of alternative renewable energies such as solar and wind where production fluctuates throughout the day and throughout the year.

[25] However, under circumstances (such as the NODOS project) where applied energy is necessary for its water storage, specific hydropower facilities may not operate as a renewable energy source.

Although gas turbine plants dominate the peaking plant category, hydroelectric with the ability for pumped storage can be used as a source for peak load power. The value of NODOS as a peaking plant can be estimated as the avoided cost of investing in development of an alternative peaking plant.

To quantify this avoided cost, it is necessary to understand the current and predicted use of peaking plants, as well as the planned future capital investments in new peaking plants. The benefit of NODOS from its use as a “peaking plant” will be the change in the present value of the currently planned new investment that would otherwise be necessary. However, this data was not available and, consequently, no benefits are quantified for the NODOS Project at this time.

NODOS Hydropower Generation Benefits Including Capacity and Ancillary Services

Additional hydropower analysis has been performed for the proposed Alternative C configuration (Toolson and Zheng, 2013). This analysis confirmed DWR’s direct net energy benefits and estimates annual Ancillary Service benefits of approximately $2.5 million and System-wide Capacity benefits of $18.9 million per year. The resulting total benefit potentially attributable to the hydropower facilities would be $23.2 million per year.

The supplemental hydropower analysis projected benefits only for Alternative C. However, given the similarity of the proposed hydropower facilities for Alternative A, it may be expected for Alternative A would be able to generate comparable Ancillary Service and System-wide Capacity benefits. Based on the DWR initial analysis, Alternative B’s future annual hydropower generation is projected to approximately 67 percent of Alternative C’s annual power generation. Assuming that Alternative B potential Ancillary Service and System-wide Capacity benefits are similarly proportional, Alternative B would be expected to generate approximately $14.4 million annually. Combined with the estimated direct net hydropower benefits of $0.7 million, Alternative B would be expected to generate total hydropower benefits of $15.1 million per year.

Alternative A is projected to generate approximately 90 percent of Alternative C. Applying the same benefit approximation approach, Alternative A would be expected to generate approximately $19.3 million annually. Combined with the estimated direct net hydropower benefits of $1.3 million, Alternative A would be expected to generate total hydropower benefits of $20.6 million per year.

CHAPTER 7 OTHER BENEFITS

Flood Damage Reduction

The area along Funks Creek downstream of Funks Reservoir is currently subject to flooding. Under current "No Project" conditions, Funks Reservoir is not a flood control reservoir. As such, it can be overwhelmed with runoff and still send peak flows downstream on Funks Creek. The NODOS alternatives will reduce or eliminate the risk of Funks Creek, Stone Corral Creek, and various other unnamed streams from flooding. Additional reductions in flooding would be realized in some portions of the downstream Colusa Basin. The reduction in flood damages can be estimated by calculating the "no project" average annual cost of flooding and making an assumption on how this would change with NODOS alternatives.

Figure 3 shows the land use of parcels located within the 100 year flood plain related to Funks and Stone Corral creeks. Rice production is the primary crop in the area followed by dryland pasture. Irrigated production in the area is predominantly tomatoes (for processing), wheat or alfalfa. Wheat and alfalfa crops are generally followed by a second planting of seed crops such cucumbers and watermelons (Azezedo, 2012).

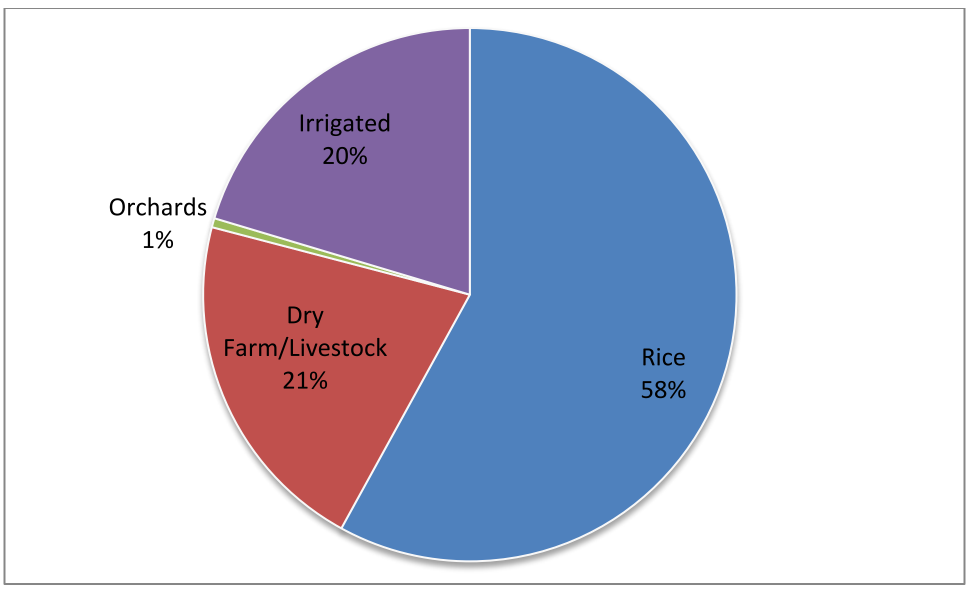


Figure 3. Agricultural Land Use within the Affected Floodplain
Source: County parcels intersecting the 100-year floodplain (URS)

Where flood risks are reduced, an opportunity exists to develop the land for higher value uses and, therefore, increased economic value. Opportunities for land use change due to changes in flood risk have not been modeled in the Feasibility Report.

In 2008, agricultural flood damages per acre were estimated for typical land use in the Central Valley based on initial losses estimated for the USACE Comprehensive Study (DWR, 2008). Crop budget data was 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 a flood were to occur. Land cleanup and rehabilitation costs are added as a fixed cost to each estimate. As shown in Table 7-1, the study estimated that flood damages per acre ranged from less than zero for pasture to approximately $3,480 for wine grapes.[26]

Table 7-1. Crop Product Categories and Cost Estimates (2013 Dollars)

Product	Weighted Average Annual Damages	Establishment Costs	Land Cleanup and Rehabilitation	Total (less than 5 days)	Total (more than 5 days)
Corn	$52	$0	$264	$315	$315
Rice	$244	$0	$261	$506	$506
Walnuts	$628	$5,674	$261	$889	$6,563
Almonds	$1,737	$3,773	$261	$1,999	$5,773
Cotton	$323	$0	$264	$587	$587
Tomatoes	$1,090	$0	$252	$1,342	$1,342
Wine Grapes	$3,480	$3,479	$252	$3,733	$7,212
Alfalfa	$268	$264	$261	$529	$794
Pasture	-$16	$88	$292	$276	$364
Safflower	$176	$0	$259	$435	$435
Sugar Beets	$336	$0	$281	$617	$617
Beans	$119	$0	$264	$382	$382
Other	$0	$0	$264	$264	$264

Under the NODOS alternatives, up to 7,130 acres of farmland would experience a reduction in flood-related damages.[27] Apart from irrigated production within the floodplain, most of the shown land uses would not be substantially affected by the short-term flooding that the area periodically experiences. In addition, approximately the northern quarter of the town of Maxwell is also located within the 100-year flood plain and, consequently, might benefit from project-related flood area reductions.

Based on the area's general agricultural production and additional geographic information system (GIS) analysis of the likely affected areas, it is projected that approximately 4,510 acres of rice and 1,525 acres of dryland pasture flooding would benefit from reduced flooding as a result of the project. Based on the USACE total damage estimates of $506 per acre of rice and $276 for pasture,[28] the reduced farmland flood damages would be approximately $2.71 million. Conservatively assuming a 50:50 split between tomato and alfalfa production on the 1,040 acres of irrigated production that would potentially benefit from reduced flooding, then the average avoided damage would be approximately $934 per acre. In which case, the total damages to irrigated production would be $972,000. The GIS analysis also

[26] The negative damages (i.e., benefit) from flooding to pasture reflects the expected yield gains from the additional water content in the soils.
[27] The specific locations and related agricultural production within the floodplain that would be less affected by flood events are not known.
[28] It is conservatively assumed that the avoided flood event would five days or less.

indicated that approximately 50 acres of orchard production might be located within the reduced floodplain area. Because almonds are Colusa County's primary orchard crop (Colusa County, 2011), an avoided five-day or less flood event would result in approximately $100,000 in flood damage savings.

Consequently, the total estimated agricultural flood reduction benefit would be $3,782,000 for a 100-year flood event. In which case, the average annual reduction in farmland flood damages due to NODOS is estimated at $37,800 ($3,782,000 divided by 100).

In addition, NODOS potentially would reduce the likelihood of flood damage to some of the homes in the northern portion of Maxwell. Approximately 25 percent of the town of Maxwell is located within the 100-year floodplain of Funks Creek. The most recent census information reports 408 homes are located within Maxwell with a median home value of $227,200 (in 2013 dollars). No businesses are located within the 100-year flood plain area.

USACE structural and content damage estimates for Yuba County were approximately 15 percent lower for structural damage and 10 percent lower for content damage than the national Flood Insurance Agency (FIA) estimates (USACE, 1999). Consequently, under six foot flood water conditions, homes in Yuba County would be expected to experience on average damage of 40 percent to structure value compared with a national FIA rate of 55 percent. Contents damage under the same flood conditions would be expect to be approximately 33 percent of structure value in Yuba County compared to a corresponding 43 percent national FIA rates.

Using USACE's more conservative Yuba County damage to contents ratio and assuming a 6-foot-high flood event, the value of total avoided residential home damage (structure and contents) to Maxwell would be approximately $16,917,000 (102 homes x $227,200 x 73 percent damage) for a 100-year flood event that resulted in 6 foot depths above the first floor. In which case, the average annual reduction in residential flood damages due to NODOS is estimated at $169,200 ($19,917,000 divided by 100).

Interstate 5 passes through a short section of the 100-year floodplain near Maxwell. However, it is not expected that NODOS would substantially reduce the flood potential for highway closure because other sections of the highway would remain more vulnerable to closure under potential flood events (e.g., near the City of Winters).

As a result, the total potential flood control benefit of NODOS may be estimated to be up to approximately $207,000 per year. However, given the uncertainty of the flood event assumptions and the absence of detailed and location specific evaluation of the area's flood reduction potential, this estimate is considered very preliminary and could overstate NODOS likely effectiveness in local flood damage reduction.

Recreation

The NODOS Project would directly provide recreational benefits at Sites Reservoir by establishing a new venue for recreational activity in the project area. Project operations could also indirectly affect other existing recreation opportunities in the

Sacramento River and facilities connected throughout the CVP/SWP systems by downstream flow changes.

Sites Reservoir Recreation

At maximum capacity, Sites Reservoir would be the seventh largest reservoir in California with a storage volume of approximately 1.81 MAF and surface area of approximately 14,000 acres. The reservoir would provide new opportunities for surface-water recreation, such as boating, fishing, and swimming. In addition, new facilities would be developed to support other recreation activities like camping, hiking, picnicking, and sightseeing. Potential recreation development for the facility has been previously evaluated[29] and an updated analysis of recreational opportunities and constraints has been prepared as part of this Feasibility Report (see Appendix E).

Based on these studies and current management judgment, it is foreseen that developed access and facilities would initially be offered at three recreation areas: Stone Corral and Antelope Island. Future facilities would include boat launch sites, picnic areas and tables, developed campsites, restrooms, trails, designated swimming areas, and parking. Approximately 62 overnight campsites would be developed. It is assumed that under all project alternatives, comparable levels of recreational development and types of recreational opportunities available at Sites Reservoir would be provided.

Available Methods

The TCM and CVM are the most common NMV techniques used in valuing outdoor recreation activities. Both approaches are recommended by the P&Gs for use in valuing outdoor recreation activities. While no original NMV studies have been conducted for the project, the benefits-transfer approach can be used to estimate the value of new recreation at Sites Reservoir.

The analysis of economic benefits attributed to full development of surface water recreation at Sites Reservoir considers several factors: the physical characteristics of the recreation facilities: recreation levels and use patterns at similar facilities; and the operational parameters for the reservoir which will affect the surface area available for recreation under the various project alternatives. The economic benefits are based on estimated visitation levels and representative consumer surplus values across anticipated recreation activities utilizing a benefits transfer approach. The analysis accounts for substitution effects of recreation from other reservoirs.

Modeled Assumptions

It has been estimated that potential visitation to Sites Reservoir would be “several hundred thousand recreation-days per year” (CALFED, 2000). More recent planning estimates indicate that the reservoir has the potential to support an average of 410,000 recreation user days annually (Reclamation, 2006). For this analysis, based on the development of the three recreation areas, it is assumed that Sites Reservoir would have a maximum capacity of 200,000 visitor days per year. Visitor use days

[29] See CALFED (2000).

would likely decline when reservoir operations reduce surface area during peak recreation months. This adjustment is discussed below.

The value of recreation at Sites Reservoir is based, in part, on anticipated recreation patterns at the facility, which are based on typical patterns of recreation activity in the region. It is expected that future recreation at Sites Reservoir would be comparable to current recreation use at nearby Black Butte and East Park reservoirs. Consequently, Black Butte Reservoir activity patterns have been used to project the expected distribution of 200,000 visitor-use days at the Sites Reservoir, as presented in Table 7-2) (Reclamation, 2006).

Table 7-2 also presents the economic values (as measured by consumer surplus) of the different recreation activities anticipated at Sites Reservoir using a benefits-transfer approach. These values are derived from published estimates for specific outdoor activities across distinct regions of the U.S. and represent average values derived from individual studies conducted between 1967 and 2003, updated to 2013 dollars (Loomis, 2005). The weighted-average value per activity expected at Sites Reservoir is $52.07 per day. Based on a maximum of 200,000 visitor days per year across a range of activities, the maximum annual value of recreation is nearly $10.4 million.

Table 7-2. Estimated Maximum Annual Visitation and Value by Activity Based on Local Reservoir Activity Patterns

Activity	Maximum Number of Visitor Days[a]	Value per Visitor Day ($2004)	Value per Visitor Day (2013 Dollars)	Maximum Economic Value
Shore fishing	17,400	$47.16	$57.91	$1,007,635
Boat fishing	9,000	$47.16	$57.91	$521,190
Picnicking	46,000	$41.46	$50.91	$2,341,807
Sightseeing	39,600	$36.84	$45.24	$1,791,472
Swimming/beach use	45,200	$42.68	$52.41	$2,369,030
Walking	5,800	$30.84	$37.87	$219,663
Bicycling/motorcycling	2,600	$73.78	$90.61	$235,579
Off-road vehicle	200	$22.92	$28.14	$5,629
Horseback riding	800	$18.12	$22.25	$17,799
Boating/waterskiing	31,200	$46.27	$56.83	$1,772,955
Other	1,600	$48.70	$59.80	$95,680
Total	200,000	$42.40	$52.07	$10,413,712

Source: Loomis (2005).

[a] Based on activity patterns at Black Butte Reservoir.

It is expected that project operations under the various project alternatives would affect recreation use and values at Sites Reservoir as a result of changes in surface area available for recreation. CALSIM II projects ending storage volumes and surface area by month for each alternative. For some alternatives, water storage and surface area are considerably below maximum levels during summer months in many years, which represents the peak recreation season. In these conditions, the use of facilities would be limited, crowding would occur, and the overall recreation experience would be impaired. Such effects can result in reduced visitation levels and/or diminish the economic value attributed to recreation activities.

Table 7-3 shows assumptions of the share of maximum economic value that could be obtained under other future conditions. It is assumed that full economic value would be obtained in any month when the reservoir's end-of-month surface area is more than 10,000 acres. End-of-month surface area estimates in May, June, and July are weighted equally in the quantification of recreation values.

Table 7-3. Share of Maximum Economic Value Obtained for Ranges of Surface Areas

End-of-Month Surface Acreage	Percent of Maximum Recreation Value
More than 10,000 acres	100%
8,000 to 10,000	80%
6,000 to 8,000	60%
4,000 to 6,000	40%
2,000 to 4,000	20%
Less than 2,000	0%

The potential substitution effects of merely relocating existing recreation activity from other nearby reservoirs to Sites Reservoir must also be considered to quantify NED recreation benefits accurately. To the extent that substitution occurs, it represents a reduction in NED benefits. Based on data compiled by Reclamation, it appears that recreation use at reservoirs in the general market area that would be served by Sites Reservoir is less than capacity at those reservoirs.[30] Specifically, it is estimated that current regional recreation use (demand) is approximately 64 percent annually of capacity. While, Sites Reservoir could offer capacity benefits during peak periods (e.g., weekends and holidays), even accounting for future population growth and related increases in recreation demand, it is likely that most recreation demand could be accommodated by under used capacity at existing facilities. Therefore, the addition of Sites Reservoir may not contribute appreciably any additional recreation use within the region, and any use of Sites Reservoir could mostly result in reduced visitation at other regional reservoirs.

However, the market area for reservoir recreation in the vicinity of Sites Reservoir may not be as large as assumed in the analysis outlined above. If Sites Reservoir served a smaller geographic market (due, for example, to rising transportation costs), it can be argued that the region's existing facilities are not adequate to meet its recreation demand. For example, overcrowding is a concern at nearby Black Butte Reservoir, where visitation levels are approximately 127 percent of capacity. Such overcrowding can be a deterrent to recreation use in the region.

[30] Reservoirs considered include: Englebright Reservoir, Lake Pillsbury, Lake Mendocino, Camp Far West Reservoir, Rollins Reservoir, Collins Lake, Berryessa Reservoir, Folsom Lake, Lake Oroville, Indian Valley Reservoir, Stony Gorge Reservoir, Black Butte Reservoir, and East Park Reservoir.

Development of new recreation opportunities at Sites Reservoir may enable local residents to participate in reservoir-based recreation who otherwise would not have done so. In addition, even for those people that have recreated elsewhere (particularly at overcrowded facilities), the quality of the recreational experience at Sites Reservoir may be relatively higher, thereby generating incremental recreation benefits. Based on these considerations, for this analysis as a conservative assumption, it is assumed that most recreation use (75 percent) at Sites Reservoir represents substitution from other reservoirs, and, as such, would not generate any new "net" recreation benefits. In which case, it is only the remaining 25 percent of visitation would represent new and/or enhanced recreation activity that generates NED benefits. The resulting recreational benefit estimate for Sites Reservoir are considered to be conservative given the future visitation projections for the reservoir and a comparatively low share (25 percent) of this total visitation that would be expected to represent new and/or enhanced recreation activity that would generate NED benefits.

Modeled Results

Table 7-4 presents the recreation benefits analysis results.

Table 7-4. Estimated Annual Recreation Benefits ($1,000s, 2013 Dollars)

Alternative	Annual Benefits[a]		Annualized Benefit[b]
	2025	2060	
Average Conditions[c]			
Alternative A	$2,349	$2,349	$2,349
Alternative B	$2,330	$2,330	$2,330
Alternative C	$2,432	$2,432	$2,432
Dry Conditions[d]			
Alternative A	$1,736	$1,736	$1,736
Alternative B	$1,649	$1,649	$1,649
Alternative C	$1,909	$1,909	$1,909

[a] Annual benefits reflect consumer surplus value for various recreation activities supported by Sites Reservoir and water operation scenarios under year 2025 and 2060 level of development. Benefits only attributed to the 25% of future visitation expected to be from new recreational use.
[b] Annualized benefits represent avoided costs relative to the future No Project conditions over the planning horizon (2023-2123).
[c] Average over entire hydrologic sequence (1921 to 2023).
[d] Average over dry and critical years periods over the hydrologic sequence as defined by SWRCB D 1641.

SWRCB = State Water Resources Control Board

As shown in Table 7-4, under average conditions annualized recreation benefits are estimated to be between approximately $2.3 million and $2.4 million, depending on the alternative's typical drawdown conditions. In dry/critical years under all alternatives, recreation benefits are reduced to between $1.6 million and $1.9 million. The greatest benefits are anticipated under Alternative C.

The extent of recreation benefits is not expected change over the planning horizon. It is assumed that recreation visitation will be primarily determined by water management scenarios (i.e., level of drawdown during the peak recreation season) rather than long-term population growth in the region.

Other Reservoir Recreation

Recreation at other reservoirs in the SWP/CVP water systems was evaluated based on the effect of NODOS on operational changes in these systems. Operational effects were evaluated at the following reservoirs: San Luis Reservoir, Folsom Lake, Lake Oroville, Shasta Reservoir, and Trinity Lake.

With NODOS, the long-term average water storage, elevation, and surface area of these other reservoirs would be affected, thereby resulting in potential effects on recreation. Overall, NODOS would be expected to result in minor increases in storage, reservoir levels and surface areas at the Shasta, Trinity, Oroville, and Folsom facilities. A minor decrease in these parameters at San Luis Reservoir would also be expected. Assuming that recreation is positively correlated to surface area, NODOS would have a net positive impact on recreation at other lakes and reservoirs that are part of the CVP/SWP supply systems. These minor beneficial impacts were not quantified for the Feasibility Report.

River Recreation

NODOS would also change the flows and temperature in the Sacramento River system and connected Sacramento-San Joaquin Delta. These effects could alter the suitability of these waterways for river-based recreation, such as boating, including kayaking and canoeing. In addition, there would be benefits to fisheries, including salmonids, which may result in higher catch rates and size of fish. Due to the inherent difficulty translating flow and fishery effects into related recreation benefits changes, these benefits are acknowledged here, but not quantified for the Feasibility Report. Appendix E presents more detail on the potential physical benefits to recreation resources.

CHAPTER 8 SUMMARY OF BENEFITS

This chapter summarizes the following categories of benefits:

- Water Supply Reliability
- Water Quality
- Fisheries Restoration and Ecosystem Enhancement
- Flood Damage Reduction
- Recreation
- Hydropower

Table 8-1 presents the total NED benefits for NODOS.

Table 8-1. Summary of Estimated Federal Annual NED Benefits for NODOS Projects ($M, 2013 Dollars)[a]

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	$12.7	$7.1	$11.5
Urban	$157.6	$161.1	$167.4
Incremental Level 4 for Refuges	$12.5	$20.5	$21.1
Conveyance Costs	($22.4)	($22.9)	($24.8)
Total	**$160.4**	**$165.8**	**$175.2**
Water Quality			
Agricultural	$1.2	$1.4	$1.7
Urban	$18.1	$19.8	$24.0
Total	$19.3	$21.2	$25.7
Ecosystem Enhancement Account	$46.7	$50.1	$49.3
Hydropower (system)[b]	$20.6	$15.1	$22.8
Recreation	$2.3	$2.3	$2.4
Flood Damage Reduction	$0.0	$0.0	$0.0
Total	**$249.3**	**$254.8**	**$275.4**

[a] Discounted at the federal discount rate of 3.75% over 100 years.
[b] Ancillary and Capacity Benefits are approximated for Alternatives A and B.

NED = national economic development
NODOS = North-of-the-Delta Offstream Storage
$M = dollar amount in millions

Using the federal discount rate of 3.75 percent over 100 years, the total annual benefits for NODOS range from $249 million for Alternative A to $275 million for Alternative C.

Table 8-2 summarizes the total benefits for the State of California discount rate of 6.0 percent over 50 years.

Table 8-2. Summary of Estimated Annual State Annual Benefits for NODOS Projects Using State of California Criteria ($M, 2013 Dollars)[a]

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	$12.2	$6.9	$11.1
Urban	$133.7	$136.7	$143.0
Level 4 for Refuges	$11.9	$19.5	$20.1
Conveyance (CVP/SWP)	($22.4)	($22.9)	($24.8)
Total	**$135.1**	**$140.2**	**$149.4**
Water Quality			
Agricultural	$1.2	$1.3	$1.7
Urban	$17.4	$19.0	$22.9
Total	**$18.6**	**$20.3**	**$24.6**
Ecosystem Enhancement Account	**$44.0**	**$47.2**	**$46.5**
Hydropower (system)[b]	**$18.6**	**$13.6**	**$20.5**
Recreation	**$2.3**	**$2.3**	**$2.4**
Flood Damage Reduction	$0.0	$0.0	$0.0
Total[c]	**$218.63**	**$223.6**	**$243.4**

[a] Discounted at the state discount rate of 6% over 50 years.
[b] Ancillary Service and System-wide Capacity benefits are approximated for Alternatives A and B.
[c] May not total exactly due to rounding.

CVP = Central Valley Project
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project
$M = dollar amount in millions

Using the State of California discount rate of 6.0 percent over 50 years, the annual benefits of NODOS range from $218 million for Alternative A to $244 million for Alternative C.

CHAPTER 9 REFERENCES

Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner, H. Schuman, (1993). Report of the NOAA panel on contingent valuation. Federal Register 58(10), 4602 14.

Ayers, R. S., and D.W. Westcot, 1985 (Reprinted 1989, 1994). *Water Quality for Agriculture, United Nations Food and Agriculture Organization Irrigation and Drainage Paper 29*. Assessed May 2011 at http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm#TOC

Braden, J. B., and C.D. Kolstad, 1991. *Measuring the demand for environmental quality, North-Holland, Amsterdam*.

CALFED Bay-Delta Program, 2000. *North of the Delta Offstream Storage Investigation Progress Report, Appendix J: Recreation Requirements and Opportunities: Sites Reservoir Alternative*. Report prepared by: Douglas Rischbieter and David Elkins, California Department of Water Resources. April 2000.

Department of Water Resources (DWR), 2008. Flood Rapid Assessment Model (F-RAM) Development. Developed by URS for DWR. November 2008.

DWR. 2009a. *Delta Risk Management Strategy, Phase 1 Report and Technical Memoranda*. Sacramento, CA.

DWR, 2009b. *Delta Risk Management Strategy – Phase 1 Draft Executive Summary*. Prepared from documents developed by URS Corporation/Jack R. Benjamin & Associates, Inc. January 2009.

DWR, 2010. *Least-Cost Planning Simulation Mode*l. Prepared by the Division of Statewide Integrated Water Management. September 2010. Accessed May 2011 at http://www.water.ca.gov/economics/downloads/Models/LCPSIM_Draft_Doc.pdf

DWR, 2005. *Land and Water Use Analysis*. Not released.

CH2M HILL, 2011. *Draft Economic Model Summary*. Draft Technical Memorandum prepared for the Department of Water Resources. December 30 2010.

Federal Register, 2013. *Change in Discount Rate for Water Resource Planning*. FR Doc. 2013-06177 Filed 3-15-13; 8:45 am Accessed at https://federalregister.gov/a/2013-06177. October 2013.

Freeman III, A.M., 2003. *The Measurement of Environmental and Resource Values: Theories and Methods. Washington D.C.: Resources for the Future*.

Hanemann, Michael, J. Loomis, and B. Kanninen, 1991. *Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. American Journal of Agricultural Economics, Vol. 73, No. 4*. (Nov., 1991), pp. 1255-1263.

Hoffman, Glenn, 2009. *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*. Draft report prepared for State Water Resources Control Board, Division of Water Rights. Sacramento, CA. July, 2009.

Howitt, R.E., 1995. *Positive Mathematical-Programming, American Journal of Agricultural Economics*, 77(2), pp. 329-342.

Howitt, R.E., D. MacEwan, J. Medellín-Azuara, and J.R. Lund. 2009. *Economic Modeling of Agriculture and Water in California Using the Statewide Agricultural Production Model*. Technical Report to the *2009 California Water Plan Update*, California Department of Water Resources, Sacramento, California.

Institute for Water Resources, United States Army Corps of Engineers (USACE), 2011. *Regional Economic Development (RED) Procedures Handbook*, 2011-RPT- 01. March.

Jones and Stokes Associates, Inc., 1987. *Juneau area sport fishing economic study*. Prepared for Alaska Department of Fish and Game, Juneau, Alaska. November 1987.

Lockwood, M. and D. Carberry, 1998. Stated preference surveys of remnant native vegetation conservation. Johnstone Centre Report No. 104. Johnstone Centre, Albury.

Loomis, J., and M. Creel, 1992. *Recreation Benefits of Increased Flows in California's San Joaquin and Stanislaus Rivers*. Rivers Vol 3, no. 1, 1-13

Loomis, J., M. Hanemann, B. Kanninen, and T. Wegge, 1991. *Willingness to Pay to Protect Wetlands and Reduce Wildlife Contamination from Agricultural Drainage*. In A. Dinar and D. Zilberman (eds.), The Economics and management of Water and Drainage in Agriculture. Boston, Massachusetts: Kluwer Academic Publishers, pp. 411-445.

Loomis, J., 2005. Updated outdoor recreation use values on national forests and other public lands. Gen. Tech. Rep. PNW-GTR-658. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 26 p.

Loomis, J.B. and D.S White, 1996. *Economic Benefits of Rare and Endangered Species: Summary and Meta-analysis*. Ecological Economics, 18: pp. 197-206.

National Marine Fisheries Service, 2009. *Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead*. Sacramento Protected Resources Division. October 2009.

Olsen, D. and J. Richards, 1992. *Summary Report: Rogue River Summer Steelhead and Fall Chinook sport fisheries—Economic valuation study*. The Pacific Northwest Project. Lake Oswego, Washington.

Pacific Fishery Management Council, 2011. *Review of 2010 Ocean Salmon Fisheries.* (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Reclamation (U. S. Bureau of Reclamation), 2006a. *San Luis Unit Drainage Feature Re-evaluation. Final EIS. Mid-Pacific Region, Sacramento, California*.

Reclamation, 2006b. *Sites Reservoir Visitation Analysis and Excess Capacity/Demand Substitution Analysis*. Prepared by Jon Platt, Technical Service Center, Denver, Colorado.

Reclamation, 2006c. *Initial Economic Evaluation for Plan Formulation. Los Vaqueros Expansion Investigation. Mid-Pacific Region. Sacramento, California.*

Reclamation, 2008a. *North of Delta Offstream Storage Investigation Plan Formulation Report*. Report prepared by URS for Reclamation, September 2008.

Reclamation, 2008b. *Estimating Fishery Economic Use Values*. Report number EC-2008-02. Prepared by Jon Platt, Technical Service Center, Denver, Colorado. January 2008.

Reclamation, 2008c. *Water Supply and Yield Study. Mid-Pacific Region, Sacramento, California*. March 2008.

Reclamation, 2011. *Los Vaqueros Reservoir Expansion Investigation. Appendix D – Economic Analysis. Mid-Pacific Region, Sacramento, California*. November 2011.

Rhoades, J.D., 1974. *Drainage for salinity control. In: Drainage for Agriculture*. Van Schilfgaarde J. (ed). Amer. Soc. Agron. Monograph No. 17, pp 433–462.

State Water Resources Control Board, 2010. *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem. State of California, California Environmental Protection Agency*. Final Report. August.

Toolson and Zheng, 2013. *NODOS Hydropower Benefits*, November.

USACE, 1999. *Post-Flood Assessment for 1983, 1986, 1995, and 1997 Central Valley, California. Prepared by Sacramento District, Sacramento, California*. March.

U.S. Energy Information Administration (EIA), 2011. http://www.eia.gov/kids/energy.cfm?page=hydropower_home-basics

U.S. Water Resources Council, 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, D.C.

Walsh, R.G. and J.B. Loomis, 1997. *The Contribution of Recreation to National Economic Development.* President's Commission on American Outdoors, U.S. government, 1997.

White, E.M. and D.J. Stynes, 2010. *Updated Spending Profiles for National Forest Recreation Visitors by Activity*. November, 2010.

State Water Resources Control Board. 2010. Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem. State of California. California Environmental Protection Agency. Final Report. August 3, 2010)

Introduction

This attachment presents the assumptions used to quantify the benefits from improved irrigation water quality to agriculture.

Geographic Extent of Benefits

Water from the South Delta is delivered to a large geographic area that supports numerous crops and irrigation methods. Some of these areas are salt-affected and drainage-affected and have limitations for virtually all crops. Crop production in these areas requires careful irrigation management and leaching of salts. Other irrigated areas are not drainage-affected (as yet), but sensitive crops, such as orchards and vegetables, still require that growers maintain adequate leaching to prevent salt from accumulating in the root zone.

The following areas receive irrigation water exported from the Delta through SWP or CVP facilities:[31]

- The grasslands area of western Merced and Stanislaus counties, is served primarily by the Delta-Mendota Canal of the CVP.
- Westlands Water District, a CVP contractor, receives CVP water primarily from the San Luis Canal/California Aqueduct.
- The Tulare Lake area, primarily in Kings County, receives SWP water from the California Aqueduct.
- The Kern area in the San Joaquin Valley portion of Kern County, receives large irrigation deliveries from the SWP, plus some CVP deliveries through the Cross Valley Canal.
- San Felipe Division of the CVP, in San Benito and southern Santa Clara counties, receives its water via a pipeline from San Luis Reservoir.

Table 1.1-1 displays the five salinity analysis areas and the corresponding detailed analysis units (DAUs) that receive Delta export water from SWP or CVP facilities. Also shown are the corresponding SWAP regions used for estimating the benefit of saved water. For each of these areas, the savings in irrigation water used for leaching is calculated, based on the crops grown and their salt sensitivities.

Table 1.1-1. Salinity Analysis Areas and Corresponding Regions Used as Data Sources

Salinity Analysis Area	Detailed Analysis Unit(s)	SWAP Region(s)
Grasslands	216	10
Westlands	244	14A, 14B
Tulare	235, 237, 238, 241, 246	15A, 15B
Kern	254, 255, 256, 259, 260, 261	19A, 19B, 21A, 21B, 21C
San Felipe	044, 062	NA

[31] The NODOS project would also affect salinity of water exported by Contra Costa Water District (CCWD); however, due to the limited amount of agricultural production in the CCWD service area, it is excluded from the analysis of agricultural water quality benefits.

Calculation of Reduction in Irrigation Requirement

The leaching requirement is expressed as a fraction and represents the amount of irrigation water that needs to be applied to a crop (above and beyond what the crop requires) so that salts are flushed through the root zone in the soil and do not adversely affect crop yield. In the areas of interest, leaching requirements for representative crops are estimated for conditions without the NODOS Project (Scenario 1) and for conditions with the project (Scenario 2).

The leaching requirement is determined from the following equation developed by Rhoades (1974):

$$LR = EC_w \div (5 \times EC_e - EC_w) \quad \text{Eqn. 1}$$

where:

EC_w is the EC of the irrigation water in dS/m;
EC_e is the crop threshold (dS/m measured on a saturated paste soil extract).

It is assumed that current volumes of applied water include the optimum leaching fraction for the existing condition (i.e., Scenario 1). Therefore, the amount of applied water minus the leaching fraction would be:

$$AW_{NL} = AW_1 \times (1 - LR_1) \quad \text{Eqn. 2}$$

where:

AW_{NL} = applied irrigation water without the leaching fraction (AF)
AW_1 = current volume of applied irrigation water, with leaching fraction (Scenario 1; AF)
LR_1 = leaching requirement for the existing condition (Scenario 1)

The volume of applied water with the leaching fraction that would be required with the NODOS Project (Scenario 2) is:

$$AW_2 = AW_{NL} \div (1 - LR_2) \quad \text{Eqn. 3}$$

where:

LR_2 = leaching requirement with the NODOS Project (Scenario 2; AF)

And the net water savings (V) achieved by reducing the leaching requirement (via supplying lower TDS water) would be:

$$V = AW_1 - AW_2 \quad \text{Eqn. 4}$$

Total water delivery reduction for each geographic area is determined by summing each crop's potential reduction in irrigation volume:

$$V_T = \sum(V_{crop1}, V_{crop2}, etc.) \quad \text{Eqn. 5}$$

The analysis is based on crop acreages and water use rates developed by DWR in its most recent land and water use surveys. Threshold EC by crop is reported in FAO Irrigation and Drainage Paper 29 (Ayers and Westcot, 1985).

Crop Acreages and Water Use

Assumed crop categories, acreages, and water use are based on DWR's 2005 land and water use analysis (DWR, publication not yet released). For each of 20 crop categories and for each DAU, DWR estimates the acreage, irrigation water applied, and evapo-transpiration of applied water. Acreages are based on periodic detailed crop surveys and remote sensing, supplemented by additional information gathered from County Agricultural Commissioner's reports. Water use estimates are based on water balances constructed from measured diversions and return flows, estimated crop ET, and expert judgment.

Table 1.1-2 summarizes the crop acreages for each of the five analysis areas. Note that these are the total irrigated acres within the areas, and include lands that are irrigated by groundwater or other local water sources. For purposes of this analysis, we assume that the crop mix for the entire analysis area is representative of the crop mix potentially affected by changes in CVP and SWP irrigation water salinity. The same assumption is used for water use rates: we assume that the applied water per acre for each analysis area is representative of that for lands irrigated by SWP or CVP water. Table 1.1-3 displays the applied water rates, in AF per acre, for the crops in each analysis area.

Table 1.1-2. 2005 Irrigated Acreages by Salinity Analysis Area (1,000 Acres)

Crop	Grasslands	Westlands	Tulare	Kern	San Felipe
Grain	8.5	27.4	40.1	48.3	0.8
Rice	6.3	0.0	0.0	0.0	0.0
Cotton	83.5	155.0	201.3	106.3	0.0
Sugar Beets	5.4	4.6	2.9	3.4	0.0
Corn	28.5	7.9	68.4	69.7	1.3
Dry Beans	14.0	4.7	3.5	1.9	0.0
Safflower	1.8	1.3	1.8	0.8	0.0
Other Field	45.0	4.3	67.7	17.7	0.9
Alfalfa	69.7	11.3	84.7	123.7	0.8
Irrigated Pasture	11.8	2.1	4.4	3.7	0.7
Tomatoes, Proc.	40.5	87.4	22.6	7.6	1.0
Tomatoes, Fresh	9.8	4.7	1.3	2.5	1.1
Cucurbits	20.9	26.5	0.6	4.6	0.9
Onion, Garlic	4.1	28.1	1.7	6.1	2.0
Potatoes	0.1	0.0	0.0	20.6	0.0
Other Truck	22.5	37.2	2.2	33.5	35.5
Almonds, Pistachios	31.8	66.5	47.0	88.9	0.0
Other Deciduous	20.1	5.4	34.6	14.3	5.4
Subtropical	0.9	1.0	0.6	24.2	0.0
Vineyards	1.9	10.3	57.9	39.0	1.7
Total	**427.0**	**485.7**	**643.3**	**616.8**	**52.0**

Table 1.1-3. Average Applied Water by Crop and Salinity Analysis Area (AF per Acre)

Crop	Grasslands	Westlands	Tulare	Kern	San Felipe
Grain	0.79	1.01	1.04	1.18	0.86
Rice	8.00	N/A	N/A	N/A	N/A
Cotton	3.43	2.52	2.78	2.75	N/A
Sugar Beets	1.50	3.09	1.31	1.76	N/A
Corn	2.74	2.30	2.67	3.09	1.92
Dry Beans	2.60	1.83	2.55	2.81	N/A
Safflower	1.89	1.65	2.10	2.20	N/A
Other Field	2.86	2.27	2.48	2.56	2.31
Alfalfa	4.84	3.56	4.16	4.38	3.32
Irrigated Pasture	4.84	3.88	4.31	4.40	3.70
Tomatoes, Proc.	2.60	1.84	2.47	2.47	2.21
Tomatoes, Fresh	2.03	1.23	1.66	1.54	2.06
Cucurbits	2.01	1.36	1.78	1.69	1.35
Onion, Garlic	3.58	2.19	3.04	2.82	2.35
Potatoes	1.41	N/A	N/A	1.26	N/A
Other Truck	0.93	0.81	0.79	0.99	2.23
Almonds, Pistachios	4.07	3.22	3.46	3.84	N/A
Other Deciduous	3.47	3.60	3.57	3.11	3.20
Subtropical	2.98	2.84	2.69	2.97	N/A
Vineyards	2.89	2.12	2.30	2.41	1.47

AF = acre feet
N/A = not applicable

Crop Threshold Values

Equation 1, above, is used to estimate the leaching requirement needed to maintain soil salinity below a threshold level, given the salinity of irrigation water. The threshold is determined by the salt sensitivity of each crop. Ayers and Westcot (1985) provide threshold soil salinities by crop, based on experimental findings from a number of studies. Table 1.1-4 summarizes the thresholds used in this analysis.

Table 1.1-4. Threshold Soil Salinity Used to Estimate Leaching Requirement (dS/m of a Saturated Paste Soil Extract)

Crop	ECe (dS/m)	Crop	ECe (ds/m)
Grain	6.0	Tomatoes, Proc.	2.5
Rice	3.0	Tomatoes, Fresh	2.5
Cotton	7.7	Cucurbits	3.2
Sugar Beets	7.0	Onion, Garlic	1.2
Corn	1.7	Potatoes	1.7
Dry Beans	1.0	Other Truck	1.0
Safflower	7.2	Almonds, Pistachios	1.5
Other Field	1.7	Other Deciduous	1.5
Alfalfa	2.0	Subtropical	1.7
Irrigated Pasture	1.7	Vineyards	1.5

dS/m = deci-siemens per meter
EC = electrical conductivity

Estimated Savings in Leaching Water, by Salinity Analysis Area

The estimated water savings for each crop is calculated as the reduction in leaching water applied to maintain soil salinity at or below the threshold EC. Note that not all crop acres within each salinity analysis area are irrigated with Delta water, so the analysis is performed for each analysis area in two steps. First, the volume saved per acre is calculated for each crop using the procedure described in Equations 1 through 5 in the methodology section above, and then converted to a total saved water volume for the analysis area as a percent of total delivered irrigation water. Second, this percent reduction is multiplied by the analysis area's total delivery of irrigation water from the Delta. An assumption of this approach is that lands irrigated with Delta water have a similar crop mix to those in the analysis area as a whole.

This page intentionally left blank

APPENDIX D

Real Estate Plan

Table of Contents

Page

Tables

Page

Figures
(at end)

1.0 PURPOSE

The purpose of this appendix is to identify the potential impact on private properties from construction and operation of the proposed Sites Reservoir and associated facilities, and to estimate the potential cost of acquiring real estate in support of the project. The estimate presented herein for real estate costs is not an appraisal, and is not to be used as a budget placeholder. Impacts on real estate and associated costs of real estate provided herein are gross estimates based on potentially inundated lands and number of impacted parcels, current real estate values, and the cost of acquisition for feasibility-level evaluation only.

This analysis includes lands that would be acquired in fee for inundated lands; in fee and by permanent easement for reservoir area facilities such as roads, inlet and outlet structures, conveyance pipelines, recreation facilities, dams, utilities, and bridges; and temporary use agreement for staging and construction activities. The analysis was based on information available in June 2011. Figure 1 shows the location of Sites Reservoir and associated facilities.

Costs associated with borrow sites, mitigation lands, cemetery relocations, and potential eminent domain proceedings are not evaluated in this report.

2.0 BACKGROUND

The North-of-the-Delta Offstream Storage (NODOS) concept has been studied by the Department of Water Resources (DWR) since 1957, and by the U.S. Bureau of Reclamation (Reclamation) since 1964. Traditionally, reservoirs are created by constructing dams on major streams (onstream storage). An offstream storage reservoir is typically constructed on a small, generally seasonal stream that contributes a minor share of the water supply to the reservoir. Offstream storage involves diverting water from a major stream and transporting the water through a conveyance system to the reservoir.

3.0 PROJECT OWNERSHIP AND OPERATIONS

The ownership and operation of the proposed Sites Reservoir has not been determined, but potential participants include the California Department of Water Resources (DWR), the Sites Project Joint Powers Authority (JPA), a commercial power provider, Reclamation, Glenn-Colusa Irrigation District (GCID), Tehama-Colusa Canal (T-C Canal), and other local agencies.

4.0 EXISTING FEDERAL PROJECTS AND PROGRAMS

As owner and operator of Shasta Dam and Reservoir, Keswick Dam and Reservoir, and various components of the Central Valley Project (CVP), Reclamation has a major effect on existing and future environmental resources in the region. Ongoing projects or programs relevant to the NODOS feasibility studies include the CVP and the Central Valley Project Improvement Act (CVPIA).

Central Valley Project – The CVP is the largest reservoir and delivery system in California. It spans 35 California counties and supplies water to more than 250 long-term water contractors in the Central Valley, Santa Clara Valley, and San Francisco Bay Area. Approximately 90 percent of the water delivered through the CVP is for agriculture. CVP operation is regulated by several requirements and agreements.

Central Valley Project Improvement Act – The CVPIA redefined the purposes of the CVP to include the protection of fish and wildlife, restoration and enhancement of associated habitats. The CVPIA identified many specific measures and programs to meet the new project purposes, and directed the Secretary of the Interior (the Secretary) to operate the CVP consistent with these purposes.

5.0 PROJECT DESCRIPTION

The proposed NODOS Project would include water supply, conveyance, and storage from the Sacramento River through existing, expanded, or new facilities. Water would be diverted to the proposed offstream storage Sites Reservoir from the river, primarily in winter months. The stored water would be returned to the Sacramento River via a new conveyance system or be distributed to local water users through existing facilities such as the GCID and T-C Canal. Water would be provided in exchange for water that otherwise would have been released from Shasta Lake. In total, implementation of the project is expected to require the acquisition of approximately 26,470 acres of land and an additional 273 acres used temporarily for staging and construction activities. Table 1 provides preliminary estimates of the size of each project feature.

Table 1. Sites Reservoir Project Features

Project Feature	Size (acres)
Sites Reservoir (1.81 MAF)	14,307
Holthouse Reservoir Complex	511
Funks Reservoir	327
Terminal Regulating Reservoir	191
TRR Pumping/Generating Plant	1
Dams	158
Sites Intake/Outlet Structure	102
Delevan Pipeline Intake Facilities	19
Recreation Areas (3)	504
Delevan Pipeline Permanent Easement	141
New and Improved Roads	257
GCID Connection to TRR	7
Field Office Maintenance Yard	18
Sites Electric Switchyard	4
Additional Acreage for Operation and Maintenance (Alternative B)	9,930
Total	**26,470**

GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet
NODOS = North-of-the-Delta Offstream Storage

Sites Reservoir would be located approximately 10 miles west of Maxwell, California (see Attachment 1: Mapping). The 1.81 MAF reservoir would be formed by constructing a dam (Sites Dam) approximately 290 feet high on Stone Corral Creek and a dam (Golden Gate Dam) approximately 310 feet high on Funks Creek. Nine saddle dams ranging up to 130 feet high would also be built along the Reservoir's northern boundary. The proposed Sites Reservoir water control features (appurtenances) include water intake and outlet structures, a SPGP located downstream of the Golden Gate Dam site on Funks Creek, and an emergency spillway located adjacent to Sites Saddle Dam No. 6. Sites Dam would have a low-level outlet capable of releasing stream maintenance flows into Stone Corral Creek.

The existing 40-foot-high Funks Dam forms a 2,000-acre-foot (AF) reservoir 1 mile downstream of the Golden Gate Dam site. This reservoir was constructed by Reclamation in 1976 and is part of the T-C Canal system. Funks Reservoir serves as a re-regulating reservoir to stabilize flows in the canal below Funks as diverters come online and offline. For all of the water source options, imported water entering Sites Reservoir would pass through the Holthouse Reservoir complex, which would serve as a forebay/afterbay to the SPGP.

Development of Sites Reservoir with a diversion capability from the Sacramento River would require at least minimal modification of the T-C Canal and GCID Canal intakes, construction of a Terminal Regulating Reservoir (TRR) and a pumping-generating plant on the GCID Canal, inter-connection from the GCID Canal to the T-C Canal, and construction of the proposed Sacramento River Pumping-Generating Plant, which would divert up to 2,000 cubic feet per second (cfs) from the Sacramento River, through the proposed Delevan Pipeline. Winter river flows diverted into these canals and pipeline would be conveyed into Holthouse Reservoir and then pumped into Sites Reservoir. These modified or new facilities would allow winter diversions of water from the river when downstream criteria are met. Total diversion capacity from the Sacramento River for the currently proposed source and conveyance alternatives would not exceed 5,900 cfs.

When water is released from Sites Reservoir, it would be routed through reversible pump-turbine generators to generate clean hydroelectric power. Power from these releases could help offset the energy costs associated with pumping. As currently envisioned, water would be pumped on a seasonal basis into Sites Reservoir during periods of relatively lower energy cost and released through the hydroelectric generation facilities during times of higher energy value. Pumping and release would each take place approximately 5 months of the year. During the approximately 2 months per year that water is not being stored or released to accomplish major project goals, daily pump-back operations would be performed to enhance the peak power-generating capability and online reliability of California's electric grid. This pump-back operation would also increase the economic return on the project without losing control of the water impounded by Sites Reservoir.

Sites Reservoir would inundate portions of Maxwell Sites Road and Sites Lodoga Road, blocking travel between Maxwell and Lodoga. These roads are owned by Colusa County. Approximately 6 miles of Huffmaster Road, south of the town of Sites, also would be inundated. Huffmaster Road is a private gravel road providing access to properties mostly within the Sites Reservoir area.

The proposed project would include three initial and up to two additional new recreation areas, and road access to these sites also would be needed. In addition to road relocation costs, the project would require relocation of utilities, including gas pipelines, power lines, telephone lines, and cable service. The service lines to a microwave station adjacent to the reservoir site also would require relocation.

The project would also include new roads to provide access to and around the reservoir including a new bridge.

Operation of the project pumping plants would require power. The proposed Sites pumping-generating plant would have a maximum generating capacity of 150 megawatts of power. A 230-kilovolt substation could be built within 0.25 mile of the transmission corridor. The pumping configuration of one alternative would require a four-breaker ring bus substation; the other alternative configuration would require a six-breaker ring bus substation.

Transmission lines from the substations generally would follow the water conveyance pipelines to each of the pump stations. There would be up to 3 miles of transmission lines from the substation to the Sacramento River Pumping-Generating Plant (SPGP) and up to 1.2 miles of transmission lines from the substation to the TRR Pump Station.

To provide the secondary benefits associated with hydropower, hydroelectric facilities would be added to as many of the pumping plants as feasible. In general, supplying ancillary hydropower to the grid would help mitigate some of the power consumption costs associated with this offstream facility. Water would be pumped into Sites Reservoir primarily during the winter, and water would be released primarily during the summer and fall, thereby producing hydropower when power demands and costs are typically higher. At this stage of planning, hydroelectric facilities have been designed and costed for the SPGP, the TRR Pumping Plant, and the SPGP for the proposed pipeline.

Sites Reservoir, at a maximum capacity of 1.81 MAF, would be the seventh largest reservoir in California, and preliminary studies indicate that additional recreation opportunities in the area may be needed in the future. DWR has developed several conceptual recreation facilities options that could be implemented as part of a Sites Reservoir plan. Recreational activities and uses for Sites Reservoir would be offered at up to five proposed recreation areas: Stone Corral, Saddle Dam, Peninsula Hills, Antelope Island, and Lurline Headwaters recreation areas. Two locations would be developed initially.

Each of the initial action alternative plans would include the five recreation areas and would provide visitors with options for hiking, biking, boating, overnight camping, fishing, swimming, and day-use picnicking. Facilities to be included for these activities would consist of boat launch sites, picnic tables, campfire rings and barbeques for overnight camping, restrooms, trails, designated swimming and fishing areas, and parking. As proposed, Peninsula Hills Recreation Area has a maximum potential for up to 200 campsites available to users, while Stone Corral and Lurline Headwaters each have a maximum potential for up to 50 campsites, and Antelope Island has a maximum potential for up to 12 campsites.

Additional land would be acquired to serve as mitigation sites. The types and acreages of mitigation land would be determined based on forthcoming environmental resource assessments being conducted by the sponsoring agency and the requirements of local, state, and federal resource agencies.

6.0 PROJECT IMPLEMENTATION SCHEDULE

The proposed project is expected to take 8 years to complete, from the Investigation Phase and Feasibility Report process (currently ongoing) through project construction. Land acquisitions and infrastructure, business, and residential relocations are expected to take approximately 30 months and possibly longer to complete and would be conducted in 2015 through 2018. The majority of acquisitions and relocations would be completed prior to project construction. Project construction is estimated to be completed in 2025.

7.0 LAND ACQUISITION COST ESTIMATE

URS collected and analyzed data from recent land sales, 2010 market listings, and local land use patterns for Colusa and Glenn counties from a variety of sources. These data form the basis for the market valuation estimate provided in this Real Estate appendix.

Summary of Real Estate Impacts and Costs

Table 1 summarizes the total estimated land acquisition costs for Sites Reservoir and associated facilities. Table 2 is arranged by ownership and administration costs for parcels requiring acquisition due to inundation, relocation, and both permanent and temporary easements.

Table 2. Summary of Estimated Real Estate Costs

Lands Acquired	Land Cost Estimate	Administrative Cost Estimate
Private Lands Acquired in Fee	$116,543,000	
Administrative Costs Due to Acquisition in Fee of Private Lands		$6,542,000
Private Land Required for New Road and Utility Right-of-Way	$771,000	
Private Land Required for Delevan Pipeline Permanent Easement	$1,195,000	
Private Lands Required for Delevan Pipeline Temporary Easement	$577,000	
Administrative Costs Due to Road/Utility Right-of-Way and Temporary Use Agreements		$2,600,000
Private Lands Acquired in Fee for Residence and Business Relocation	$5,322,000	
Administrative Cost Due to Residence and Business Relocation		$4,875,000
Subtotal	**$124, 408,000**	**$14,017,000**
Total of Real Estate Costs	**$138,425,000**	

While this estimate is intended to evaluate costs across the Sites Reservoir alternatives, some of the scope and cost of additional efforts associated with real estate acquisition are still unknown, including, but not limited to, the following:

- Cost of conducting hazardous materials surveys for lands to be purchased before acquisition and costs for removing underground storage tanks or other hazardous materials that may be found on property proposed for acquisition.
- Cost related to any eminent domain condemnation that could be required to acquire properties necessary for project implementation.
- Cost for mitigation lands.
- Cost for cemetery relocation.

Value Estimate Analysis Methodology

The following methodology was used to analyze the value of parcels impacted by the various reservoir alternatives, and to apply a value estimate to those parcels.

Due to the recent downturn in California real estate values, especially in the Central Valley, fee titles and permanent easements were assumed to be 85 percent of the high market value estimated in 2008. Temporary use agreements were assumed to be 25 percent of the 2008 high market value. This value was developed based on the assumption that the average duration of a construction project would be approximately 5 years with a 5 percent of fee value per year.

This report provides a market value estimate based on the recent sales of similar parcels within the same land use categories sold between 2007 and 2011. Values are based on data extracted from First American Core Logic Realist real estate information service (Core Logic, 2011).

An analysis of the sales data shows that land values have fallen since 2007, but have recently stabilized and regained some strength. Because the predominant land uses in this area of Colusa and Glenn counties are agriculture and agriculture-related, agricultural land values were used to establish an overall market trend based on median sales price per acre for land in the area from 2007 to 2011. The median sales price per acre reached its peak of $9,400 in 2008; fell significantly in 2009 to $6,500; and recovered to greater than 85 percent of the previous peak in 2010 to $8,200 per acre. Sales in each land use category were analyzed, and a range of sale prices for each was identified. Based on the trend analysis and sale price ranges, current values of each land category are estimated to be 85 percent of the 2008 high market value. The sold parcels were also sorted by size because, in general, land cost per acre decreases when the size of the parcel increases. Price break-points were identified based on the size of the sold parcels and were then applied to the estimated values of the parcels proposed for acquisition.

For the purposes of this preliminary feasibility analysis, land values are assumed to remain stable and not increase significantly during the land acquisition process prior to start of construction in 2016.

Additional assumptions used in the valuation analysis are provided below.

Assumptions

The following list of assumptions is common to all Sites Reservoir alternatives:

1. It is assumed that the following land-use categories appropriately represent current uses at the proposed NODOS Project site. It is also assumed that these are the only categories of land types that would be directly impacted by the project:
   - General Agriculture/Farm/Truck Crops
   - Livestock/Pasture
   - Orchard
   - Residential Acreage
   - Residential Lot
   - Mobile Home Lot
   - Single Family Residence
   - Retail Trade
2. Non-economic remnants will be analyzed as greater project detail is available.
3. It is assumed that PL 91-646 relocations of homeowners or businesses would involve administrative costs, benefits, and expenses of $75,000 per residence/business property (see Section 8.0).
4. It is assumed that covenants or easements on lands to be acquired would (for the purpose of this estimate) be valued at full fee value, not as a percentage of the fee.
5. It is assumed that electrical transmission lines and relocated utilities would be within the permanent easements and rights of way acquired for project pipelines and roads.

Value Estimate Applied to Impacted Parcels

Maps annotated with assessor's parcels and land use data were prepared for the evaluation of all parcels, improved and unimproved, to visually determine acquisitions required for the proposed project. Mapping and parcel data were verified through comparison with available Assessor's Parcel Maps published by Parcel Quest Online Services (Parcel Quest, 2011). Full value of the parcel was accounted for in the value estimate for the property. Table 3 lists the land use types and associated market value unit price.

Table 3. General Assigned Market Values by Land Use Type

Land Use	Market Value Assigned
Agricultural/Farm/Truck Crops (less than 10 acres)	$32,217 per acre
Agricultural/Farm/Truck Crops (10 to 80 acres)	$10,483 per acre
Agricultural/Farm/Truck Crops (more than 80 acres)	$8,006 per acre
Pasture/Livestock (less than 80 acres)	$4,230 per acre
Pasture/Livestock (more than 80 acres)	$3,006 per acre
Orchard (less than 80 acres)	$10,561 per acre

Table 3. (Continued)

Land Use	Market Value Assigned
Orchard (more than 80 acres)	$9,031 per acre
Residential Acreage	$50,227 per acre
Residential Lots	$7 per square foot
Mobile Home Lot	$7 per square foot
Retail Trade	$142 per building square foot
Single Family Residence	$107 per building square foot

8.0 ACQUISITION ADMINISTRATION COST ESTIMATE

Reclamation would incur administrative costs in acquiring lands and easements for project construction.

Cost Estimate Methodology

As stated previously, maps annotated with structures were prepared for the evaluation of all parcels, improved and unimproved, to visually determine partial or total takes. Residential and commercial parcels improved with structures were identified, and partial or total takes were determined. This analysis enabled URS staff to make a rough estimate of potential relocations pursuant to PL 91-646, the Uniform Relocation Assistance and Real Properties Acquisition Policies Act of 1970, as amended.

The administrative cost of one parcel acquisition with no relocation is estimated at $50,000 for the purpose of this analysis. This administrative cost includes the work of surveyors, geographical informational system (GIS) staff, legal counsel, title company support, appraisers, and a team of realty specialists/land agents.

The administrative cost of one parcel acquisition with a residential or business relocation is estimated at $75,000. This amount includes all of the work discussed above for unimproved parcel acquisition, plus Relocation Advisory Services and Relocation Benefits.

Administrative costs associated with potential eminent domain actions necessary for acquisition are not included in this estimate.

9.0 LANDS, EASEMENTS, RIGHTS-OF-WAY DESCRIPTIONS

Project implementation would require the acquisition of lands by Reclamation in estates in fee and by easement for project components.

Estates to be Acquired

Estates to be acquired include the following:

- Fee simple land purchased

- Permanent easements
- Temporary construction and access easements

Total Acreage Required

Total acreage that could be impacted due to the proposed reservoir inundation area, dams, conveyance system, recreation areas, new roads, and utilities is estimated at approximately 27,024 acres. This estimate does not include acreage that may be required for mitigation offsets.

Impacted Parcels

URS GIS personnel developed a detailed database containing all Assessor's Parcel Numbers potentially impacted by the reservoir alternatives. The database identifies parcels by land use type and determines the acreage of each impacted parcel. The environmental impact report/environmental impact statement (EIR/EIS) has identified 208 parcels that would be impacted by the proposed project.

Residential/Business Relocations (PL 91-646)

PL 91-646, The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (the Uniform Act), as amended, is the primary law for acquisition and relocation activities on federal or federally assisted projects and programs. The Uniform Act sets the minimum standards for compensation and relocation assistance for the appraisal and acquisition of real property. Also, the Uniform Act sets the minimum standards for relocation advisory services and financial assistance for residential individuals, families, businesses, farms, and nonprofit organizations that must be relocated as a result of the public acquisition of the real property.

As a result of the construction of the project and the area of inundation, several homes, farms, and businesses would require relocation in accordance with PL 91-646. Through a review of county data and aerial photographs, URS has estimated that eight residences and one retail business, primarily in or near the town of Sites, would require relocation.

Current Land Use and Zoning

The current dominant land use identified for project lands is Agriculture for all project features. Additional land uses include Grazing, Livestock, Farm, Truck Crops, and Residential Acreage. The dominant land uses for parcels associated with the town of Sites within the reservoir inundation area are Single Family Residence and Residential Lot. The current zoning for all parcels aligns with the land use designations. As of 2011, parcel zoning has not been fully analyzed.

Williamson Act/Farmland Security Zone Lands

The California Land Conservation Act of 1965 (Williamson Act) allows for certain agricultural lands to receive reduced tax assessments as an incentive to landowners for preserving agricultural lands. The State of California provides subvention funding (subsidies) to the participating counties to offset the loss of tax revenue due to the reduced taxes assessed for land parcels enrolled in the program. Farmland Security Zones are established by counties, in accordance with Williamson Act provisions, to further reduce tax assessments and protect productive agricultural land from development.

There are 111 parcels associated with the proposed project that are currently enrolled in the Williamson Act in Colusa and Glenn counties. No parcels have been identified that fall within a Farmland Security Zone. Once acquired by the project sponsor, enrolled parcels would be removed from the Williamson Act and would be not eligible for subvention funding.

Road and Utility Relocations

There are several public roads within the inundation area that would be abandoned and rerouted due to construction of the project. New public road right-of-ways would be acquired to accommodate the new road alignments. Sites Lodoga Road, the main route from Sites to Lodoga and communities further to the west, passes through Antelope Valley. Huffmaster Road is a private gravel road servicing farms and ranches in the southern portion of Antelope Valley. Another private gravel road, Peterson Road, provides access to the northern portion of Antelope Valley.

A 3-mile portion of Sites-Ladoga Road between the future location of Sites Dam, west through Antelope Valley, would be abandoned. A new bridge would be constructed spanning Sites Reservoir near Sites Dam and reconnecting with the existing Sites Lodoga Road alignment farther to the west. Six miles of Huffmaster Road would be abandoned and rerouted to the east of Antelope Valley, providing improved access to lands south of Sites Reservoir. Eight miles of Peterson Road would be abandoned within the inundation area, and a new road constructed to provide access to lands north of Sites Reservoir.

Mineral Activity/Subsurface Rights

Historic uses of some of the lands required for acquisition include quarry and mineral mining activities. As such, the project may impact lands that are encumbered by subsurface rights for resource extraction, including mineral, rock, and gravel mining, and oil and natural gas extraction. Subsurface right ownership has not been investigated for this analysis, and costs associated with acquiring subsurface rights are not considered in this cost estimate. During the acquisition process, a full title investigation would be completed, and subsurface rights, if any, would be identified.

10.0 IMPACTED COMMUNITIES

The NODOS Project is located in the eastern Coast Range foothills and lowlands along the western edge of the northern Sacramento Valley. The key feature of the NODOS Project – the proposed Sites Reservoir – is located in northwestern Colusa County and southwestern Glenn County, approximately 10 miles due west of the community of Maxwell. The proposed reservoir inundation area includes most of Antelope Valley and the small community of Sites.

Residents of the rural communities of Lodoga and Stonyford west of Antelope Valley and emergency responders would experience increased travel time and distance during construction of the project to and from Maxwell and Interstate 5. The main public road to these communities, Sites Ladoga Road, is located within the inundation area and would be abandoned and rerouted via a new bridge spanning Sites Reservoir.

11.0 SPONSOR-OWNED LANDS

Other than Funks Reservoir, Reclamation currently does not own any project lands, and would acquire project lands prior to the start of construction.

12.0 LANDOWNER SUPPORT

Extensive outreach to landowners within and near the proposed Sites Reservoir was conducted between 2001 and 2008, during the development of the Initial Alternatives Information Report and PFR. Outreach efforts included public scoping meetings, project area tours, and periodic focused meetings with area landowners. Continued outreach to landowners in the Sites area is planned as part of the development of the Draft and Final EIR/EIS and Feasibility Report, providing an opportunity to re-evaluate landowner support for the project.

13.0 HAZARDOUS, TOXIC, OR RADIOLOGICAL MATERIALS

Hazardous or toxic waste materials may be present within the project footprint. These materials could be associated with historic residential or agricultural uses, and quarry or mining operations. Sources of potential hazardous or toxic waste materials would be residential septic systems, natural gas storage tanks used for heating, above-ground or underground fuel or fertilizer storage tanks for agricultural use and quarry operations. Electrical transformers containing polychlorinated biphenyls associated with electrical transmission or distribution may also be present. Environmental site assessments would be conducted prior to land acquisitions to identify any potential hazardous or toxic materials, sources, or conditions. There are no known sources of radiological wastes within project lands. Costs associated with identifying and cleanup of hazardous or toxic materials, sources, and conditions is not included in this cost estimate.

REFERENCES

California Department of Water Resources, 1957. DWR Bulletin 3, the California Water Plan.

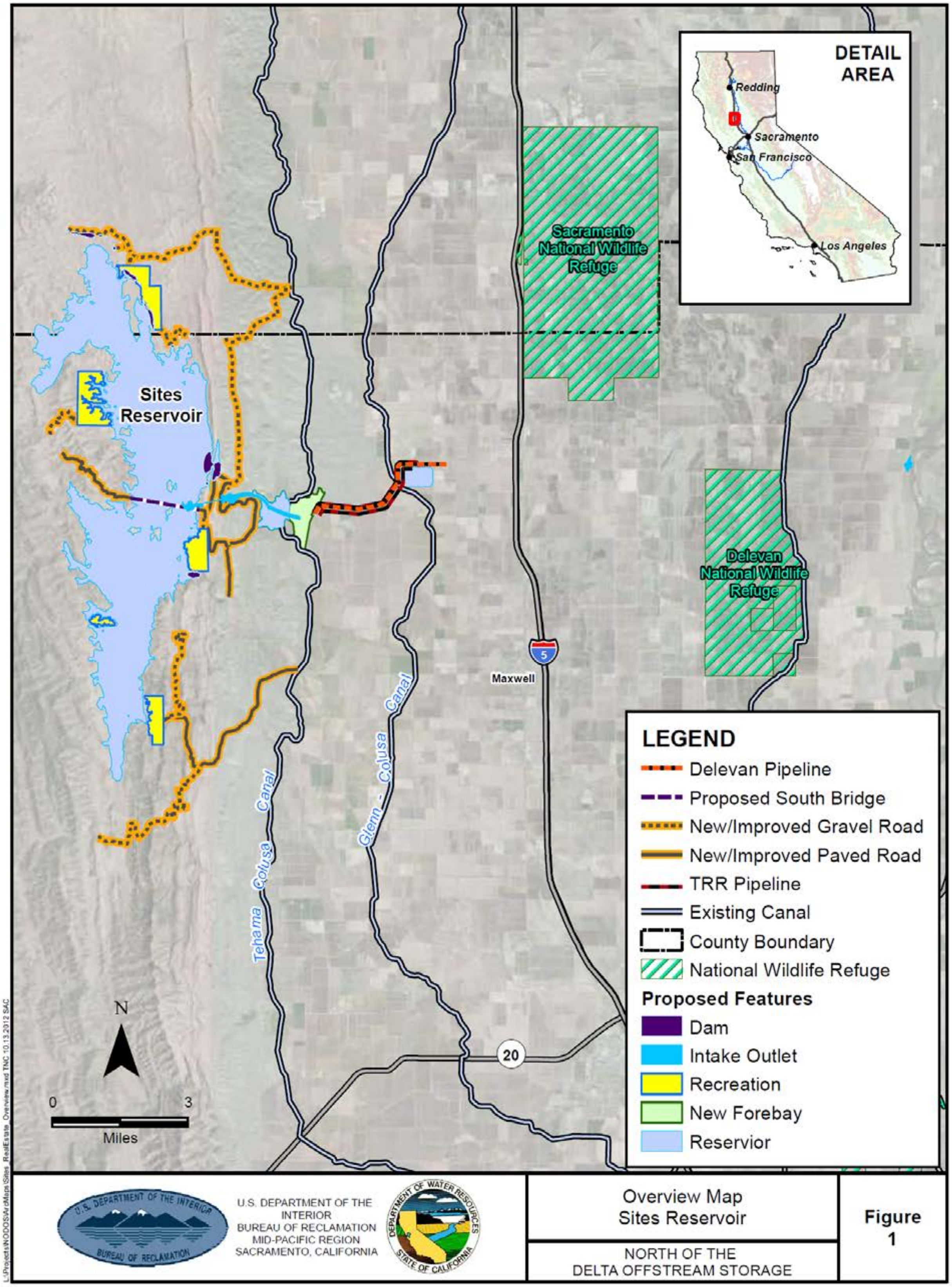
Core Logic, Inc., 2011. Realist Metrolist Property Sales Data. Accessed in March 2011 at: http://realist2.firstamres.com.

Parcel Quest Online Services, 2011. Colusa County Parcel Data. Accessed in May 2011 at: http://assr.parcelquest.com/PQGov/StdSearch.aspx?username=abccol&password=def&coassr=WAYNE%20ZOLLER.

Bureau of Reclamation (Reclamation), 1964. West Sacramento Canal Unit Report.

Reclamation, 2008. NODOS Plan Formulation Report.

Figures


DETAIL AREA
Redding
Sacramento
San Francisco
Los Angeles
Sacramento National Wildlife Refuge
Sites Reservoir
Delevan National Wildlife Refuge
Maxwell
5
20
Tehama Colusa Canal
Glenn - Colusa Canal
N
0
3
Miles
LEGEND
Delevan Pipeline
Proposed South Bridge
New/Improved Gravel Road
New/Improved Paved Road
TRR Pipeline
Existing Canal
County Boundary
National Wildlife Refuge
Proposed Features
Dam
Intake Outlet
Recreation
New Forebay
Reservior
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MID-PACIFIC REGION
SACRAMENTO, CALIFORNIA
Overview Map
Sites Reservoir
NORTH OF THE
DELTA OFFSTREAM STORAGE
Figure
1

APPENDIX E

Recreation

Table of Contents

Page

Tables

Page

Figures

Acronym List

ACHP	Advisory Council on Historic Preservation
BLM	Bureau of Land Management
CALFED	CALFED Bay-Delta Program
DDA	California Davis-Dolwig Act
DWR	California Department of Water Resources
MAF	million acre-feet
MBTA	Migratory Bird Treaty Act
msl	mean sea level
NODOS	North-of-the-Delta Offstream Storage
NPS	National Park Service
NWR	National Wildlife Refuges
OHV	off-highway vehicles
SRA	State Recreation Area
USGS	United States Geological Survey
WPRA	Water Project Recreation Act
WROS	Water Recreation Opportunity Spectrum

This page intentionally left blank

1.0 INTRODUCTION AND PURPOSE

The purpose of this appendix is to build on information developed in previous studies, prioritize proposed recreation areas at Sites Reservoir, summarize baseline recreation opportunities, and recommend a preferred recreation area on the basis of the anticipated completeness, effectiveness, efficiency, and acceptability of the recreational alternatives. A detailed analysis of the environmental impacts associated with these recreational facilities is provided in the EIS/R (Reclamation and DWR, 2011).

The construction of any reservoir north of the Delta provides an opportunity to develop new recreational facilities. Recreation in the immediate vicinity of a new reservoir could include hiking, fishing, camping, boating, mountain biking, and off-road vehicle use. Generally, large metropolitan areas, such as nearby Sacramento, have high demands for water-oriented recreational opportunities. Some of these demands are served by reservoirs on the western slope of the Sierra Nevada. However, as population increases in the Sacramento Valley, demands for flat water, river, and land-based recreation are expected to increase.

1.1 Existing Conditions

Antelope Valley

Limited recreational opportunities currently exist in proximity to Antelope Valley, which is located in Colusa and Glenn counties. The majority of lands in the area are privately owned and not accessible for public use. Consequently, current recreational use is limited to landowners, their families, friends, and employees, and totals an estimated 300 recreation visitor hours per year or 25 recreation visitors per year (DWR, 2000).

Hunting is the most common recreational activity in Antelope Valley. Upland game birds, deer, and wild boar are the most sought-after species. Occasional horseback riding and off-highway vehicle (OHV) use have been observed. Fishing is an infrequent activity because of the intermittent nature of the streams in Antelope Valley. However, DWR personnel have observed children fishing in Stone Corral Creek downstream of the proposed Sites Dam site. There are several stock ponds located throughout the Sites Reservoir project area, and some are large enough to support populations of bass, sunfish, and catfish; it is not known, however, if these ponds are used for recreational fishing (DWR, 2000).

Regional Recreation

Recreational opportunities and levels of recreational facility development vary within the region. The recreation areas available in the region include: Black Butte Lake, East Park Reservoir, Stony Gorge Reservoir, Indian Valley Reservoir, Lake Berryessa, Folsom Lake, Lake Oroville, Lake Almanor, and Clear Lake. Recreation at Black Butte Lake, and East Park, Stony Gorge, and Indian Valley reservoirs is comparable to that proposed for Sites Reservoir because of similarities in location, vegetation communities, elevation, remoteness, and topography. Although these recreation areas are considerably smaller than the proposed Sites Reservoir, all have seasonally fluctuating water levels, and peak use occurs between March and August (Rischbieter, 1999). A range of recreational facility development exists at these reservoirs. Lake Berryessa, Folsom Lake, and Lake Oroville are comparable in size to the proposed Sites Reservoir. Lake Almanor and Clear Lake have a mix of private and public facilities. These water recreation sites are those areas that could be affected by the addition of other recreation opportunities in the greater area, including the proposed development of Sites Reservoir. This section provides a review of the major reservoir-based recreation development in the greater region surrounding Sites Reservoir. A description of each area is provided with visitor information, capacity, and water-related activities available.

Shasta Lake. Shasta Lake is California’s largest reservoir. In addition to recreation, it provides water, power, flood control, and fishery benefits. Owned and operated by the U.S. Bureau of Reclamation, Shasta Lake fills in most years of normal precipitation and then recedes more than 100 feet in elevation as water and power needs are met through the year. Redding, California, population about 80,000, is the largest city in the vicinity of Shasta Lake with a greater population of more than 150,000. Trinity Lake and Whiskeytown Reservoir are major competing reservoirs within 50 miles of Shasta Lake. Shasta Lake provides vast opportunities for remote access and boat-in camping. The lake has more than 370 miles of shoreline and a maximum depth of 571 feet at full pool. Its fishery includes bass, trout, salmon, catfish, crappie, bluegill, sturgeon, and other species. In addition to fishing and boating, Shasta Lake offers extensive camping opportunities including 18 developed and 12 non-developed campground areas managed by the U.S. Forest Service. There are also 11 marinas located at various sites around the lake, some which offer private campgrounds, and miles of forest roads providing access to upland and upstream recreation opportunities.

Shasta Lake is a major recreation area with an annual visitation of more than 2,500,000 people. Shasta Lake is considered more of a destination area where visitors spending longer periods of time and travel from farther distances to enjoy the recreation/scenic diversity. This area offers a diverse range of recreational opportunities, but they are relatively different from those proposed at Sites Reservoir. Effects on the visitation and/or economic income to Shasta Lake by the potential development of Sites Reservoir are not expected to be significant due to distance and recreational/scenic diversity.

Folsom Lake. This lake is located entirely within Folsom Lake State Recreation Area (SRA), administered by the California Department of Parks and Recreation. Folsom Lake SRA is one of the most popular recreation areas in the state, with annual visitations averaging nearly 2.6 million. The predominant recreational uses are water related, such as boating and water skiing. Downstream of Folsom Dam, Lake Natoma (the Folsom Dam afterbay) is also a unit of Folsom Lake SRA. Developed recreation facilities include picnic areas, bicycle and pedestrian trails, boat launch ramps, and campgrounds. On average, the lake supports approximately 500,000 visitor use days per year; the predominant recreational activity is trail use.

Folsom Lake is also a major recreation area and is considered more of a destination area where visitors spending longer periods of time travel from farther distances to enjoy the diversity of the recreation. This area has a diversity of recreational opportunities, but the opportunities are relatively different than those proposed at

Sites Reservoir. Effects on the visitation and/or economic income to Folsom Lake by the potential development of Sites Reservoir are not expected due to distance and recreational/scenic diversity.

Lake Oroville. Lake Oroville is California's second largest reservoir and provides water, power, flood control, fishery, and recreation benefits. Owned and operated by DWR, Lake Oroville fills in most years of normal precipitation, then recedes more than 100 feet in elevation as water and power needs are met through the year. Population centers nearest Lake Oroville include the City of Oroville (population 12,000) and Chico (population 40,000). Recreation facilities at Lake Oroville SRA provide for camping, picnicking, boating, fishing, hunting, horseback riding, hiking, bicycling, and a variety of other activities. In addition, there are several less-developed car-top boat launching areas, 84 boat-in campsites, and 10 unique floating campsites.

Lake Oroville is a major recreation area and was recently assessed for the ability to add additional facilities through the Federal Energy Regulatory Commission process for relicensing. This area has a diversity of recreational opportunities with some similarities to those proposed at Sites Reservoir. This lake is one of the larger lakes within the same part of the state. Effects on the visitation and/or economic income to Lake Oroville by the proposed development of Sites Reservoir are not expected. These recreational areas would not compete with each other due to distance and differing recreational/scenic attributes. The recreational diversity that has come to identify Lake Oroville as a premier recreation area would not be overshadowed by the addition of Sites Reservoir.

Black Butte Lake. Black Butte Lake is owned and operated by the United States Army Corps of Engineers. Located on Stony Creek approximately 8 miles west of the town of Orland in Glenn County, Black Butte Lake has six recreation areas, a dam overlook, and several nature trails. Each recreation area includes restrooms and fishing access with a range of other facilities. This reservoir has the most developed recreational facilities of the four smaller recreation areas evaluated. Recreation lands surrounding the reservoir total approximately 4,000 acres and include camping, hunting, fishing, hiking, OHV, ATV, and several other recreational areas in more than seven developed recreation areas.

Black Butte Lake is a local area recreation destination and is used regularly. Competition with the development of the proposed Sites Reservoir Recreation Areas may affect visitation and economics for Black Butte Lake in the short-term as local area visitors may be inclined to visit the facilities. However, with expected growth in the area and the need for additional facilities, these areas are not expected to compete with each other over the long-term and would add to the recreational diversity in the northern region of the Central Valley and reduce overcrowding and natural resource impacts.

Stony Gorge Reservoir. Upstream of Black Butte Lake on Stony Creek is Stony Gorge Reservoir, owned and operated by the U.S. Bureau of Reclamation. This reservoir's primary purpose is to provide irrigation water for use by the Orland Unit Water Users' Association, but recreation is also a project benefit. The water level at this reservoir fluctuates widely through the seasons and could affect recreation use. According to the U.S. Bureau of Reclamation, recreation use is high in the spring and early summer, but drops off in the latter half of summer and into autumn as the water level decreases. All of the recreation areas at Stony Gorge are accessible from State Route 162 and include group camping areas, picnic and day use areas, boat ramps, and camping areas.

Stony Gorge Reservoir is a local area recreation destination and it is used regularly. Competition with the proposed development of the Sites Reservoir Recreation Areas may only minimally affect the visitation and economics of Stony Gorge Reservoir, and only in the short-term, as local area visitors may be initially inclined to visit the newer facilities. Each area would have a different spectrum of recreational opportunities. Eventually, with expected growth in the area and the need for additional facilities, these areas are not expected to compete with each other over the long-term and would reduce overcrowding and natural resource impacts.

East Park Reservoir. East Park Reservoir is located in the upstream area of the Stony Creek watershed, south of Stony Gorge Reservoir. East Park is similar to Stony Gorge in size, level of development, ownership, operation, and purpose. The reservoir is located approximately 20 miles west of Maxwell near the town of Stonyford. There are two zones of developed recreation at the lake, one on the west shore and another along the east shore. Both are relatively primitive, although some permanent restrooms have been installed. There are six named recreation areas along the shore; however, several of them merge. The recreation opportunities include camping, group camping, and water access. This recreation area has been improved as demand has increased.

East Park Reservoir is a local area recreation destination and is used regularly. Competition with the proposed development of the Sites Reservoir Recreation Areas may affect visitation and economics for East Park Reservoir minimally in the short-term as local area visitors may be inclined to visit the newer facilities which would be closer to the Central Valley. Each area would have a different spectrum of recreational opportunities. Additionally, with expected growth in the area and the need for additional facilities, these areas are not expected to compete with each other over the long-term and would reduce overcrowding and natural resource impacts.

Indian Valley Reservoir. Indian Valley Reservoir is located on the North Fork of Cache Creek in a secluded area of the Coast Range. The reservoir is surrounded by wildlands managed by Bureau of Land Management (BLM), and is owned and operated by the Yolo County Water Agency. Main access to the reservoir is from the south via State Route 20 and Walker Ridge Road. This unpaved road provides scenic views of the surrounding country and of Indian Valley Reservoir as it descends to the lake. The reservoir could also be accessed via Bartlett Springs Road from Bear Valley to the east. The recreation area has various recreation opportunities including a marina, undeveloped campgrounds, hiking, and primitive camping areas. According to BLM, this is a popular camping area year-round. The north end of the reservoir has no developed facilities, but several miles of shoreline access are provided by Bartlett Springs Road.

Indian Valley Reservoir is a local area recreation destination in the Coastal Mountains. Competition with the development of the Sites Reservoir Recreation Areas may minimally affect visitation and economics for Indian Valley Reservoir in the short-term as local area visitors may be inclined to visit the newer facilities which would be closer to the Central Valley. Each area would have a different spectrum of recreational opportunities. Additionally, with expected growth in the area and the need for additional facilities, these areas are not expected to compete with each other over the long-term and would reduce overcrowding and natural resource impacts.

Lake Berryessa. Lake Berryessa is the largest lake in Napa County, California. This reservoir is formed by the Monticello Dam, which provides water and hydro-electricity to the North Bay region of the San Francisco Bay Area.

Prior to its inundation, the valley was an agricultural region, whose soils were considered among the finest in the country. The main town in the valley, Monticello, was abandoned in order to construct the reservoir. Construction of Monticello Dam was begun in 1953 and the reservoir filled by 1963, creating what at the time was the second-largest reservoir in California after Shasta Lake.

The lake is heavily used for recreational purposes and encompasses over 20,000 acres when full. The reservoir is approximately 15.5 miles long, and 3 miles wide. It has approximately 165 miles of shoreline. It has a seaplane landing area that is open to the public. One of the larger islands supported a small plane landing area, but was closed in the early 1970s after the FAA issued a safety report. Effects on the visitation and economic income of Lake Berryessa by the potential development of Sites Reservoir are not expected due to distance and recreational/scenic diversity.

Lake Almanor. Lake Almanor is a reservoir in northwestern Plumas County, in northeastern California. The reservoir has a capacity of 1,308,000 acre-feet and a maximum depth of about 90 feet. It is formed by Canyon Dam on the North Fork of the Feather River, as well as Benner and Last Chance Creeks, Hamilton Branch, and various natural springs. The present dam was constructed by Great Western Power, from 1926 to 1927, damming the North Fork of the Feather River and flooding the meadow-filled valley generally known as Big Springs/Big Meadows. In the process, parts of the town of Prattville had to be moved to higher ground, while some structures were flooded over.

The dam is now owned by Pacific Gas and Electric Company. PG&E uses it for hydroelectricity production, but the lake is also a popular recreation area, with fishing, boating, water skiing, swimming and camping available. Effects on the visitation and economic income of Lake Almanor by the potential development of Sites Reservoir are not expected due to distance and recreational/scenic diversity

Clear Lake. Clear Lake is the largest natural freshwater lake entirely in California, and has the largest surface area of any freshwater lake entirely in California, the tenth largest by capacity. It is located in Lake County and is fed by runoff flowing into many streams as well as springs in Soda Bay. Its sole outlet is Cache Creek. There is a dam on Cache Creek to increase the lake's capacity and to regulate outflow.

With over 100 miles (160 km) of shoreline, Clear Lake is a popular spot for watersports enthusiasts. Fishing, swimming, sailing, wind surfing, waterskiing, boating, and riding personal water craft are all popular activities, primarily in the summer. There are 11 free boat launch ramps around the lake that are open to the public. Individuals may rent boats and personal water craft from many businesses around the lake.

Clear Lake is sometimes called the “Bass Capital of the West.” Largemouth bass, which are farmed and planted in the lake by California Department of Fish and Game, and other fish species can be found in the county's lakes. Fishing boats can be rented, and many stores and facilities around the lake specialize in fishing equipment. Numerous fishing tournaments and derbies are held through the year. Effects on the visitation and economic income of Clear Lake by the potential development of Sites Reservoir are not expected due to distance and recreational/scenic diversity

Wildlife Refuges. The Sacramento Valley offers a complex network of federal and California wildlife refuges along the Sacramento River that provide opportunities for fishing, hunting, and wildlife viewing via auto tours and trails. These refuges include the Sacramento, Colusa, and Delevan National Wildlife Refuges (NWRs), which are located near Sites Reservoir. Fishing and hunting account for approximately 50 percent of the total visitor use. The remaining 50 percent is devoted to hiking and photography (CALFED, 2003).

Conclusions on Competition with Other Recreation Areas. Development of one or more of the Sites Reservoir Recreation Areas described in this document would add to the diversity of the water recreation opportunities on the west side of Sacramento Valley. Due to the size and constraints of the development, these recreation areas would not compete with the surrounding area facilities in the long-term.

2.0 SITES RESERVOIR RECREATION OPPORTUNITIES

2.1 Development of Alternatives

The suitability of lands to support reservoir-based recreation is determined by several factors including topography, access, physical/aesthetic setting, projected reservoir operations, anticipated use, and competing uses. Based on these factors, five potential recreation areas have been identified (DWR, 2001 and Reclamation and DWR, 2008) along the shoreline of the proposed Sites Reservoir. Most of the design concepts presented in this appendix were previously developed by DWR. This appendix also describes additional recreational opportunities, such as a multi-use reservoir loop trail, vista points access, fishing access, and the development of wayside areas where roadway alignment is adjacent to the shoreline.

A combination of the United States Geologic Survey (USGS) topographical maps, published reports and a field visit were used to evaluate the potential recreation opportunities for Sites Reservoir shoreline areas. The recreation potential of each proposed area was assessed based on projections of a 1.27 and 1.81 million acre-feet (MAF) reservoir. It is also assumed that features such as trees, shrubs, grasslands, and rock outcrops that contribute to the aesthetic qualities of the area would be preserved where possible.

Recreation opportunities at each recreation area would likely include boating, camping, picnicking, swimming, fishing, and hiking. Proposed facilities would include boat launch areas, campsites, picnic tables, shaded picnic areas, campfire rings/barbeques, designated swimming and fishing access, trails, vault toilets, and dumpsters. Electricity and water may be available at a subset of recreation areas. All recreation areas would be fenced. Gravel parking space would be provided at each campsite. A larger, gravel parking lot would be provided at each recreation area for day-use and boat launch facilities.

2.2 Recreation Area Descriptions

Descriptions of each of the five potential recreation areas are provided below and summarized on Table 2-1.

Table 2-1. Recreation Area Type and Maximum Number of Facilities Proposed

Recreation Areas	Components
Stone Corral Recreation Area Size: 235 acres Access: Stone Corral Road (new road)	50 campsites (car and recreational vehicle) 10 picnic sites (with parking at each site) Potential for a 2-lane boat launch site (see below) Hiking trail Electricity Water 1 kiosk 10 vault toilets 35-acre overlook/interpretive

Table 2-1. Recreation Area Type and Maximum Number of Facilities Proposed

Recreation Areas	Components
Saddle Dam Recreation Area Size: 329 acres Access: Saddle Dam Road (new road)	10 picnic sites (with parking at each site) 12-lane boat launch site Swim area (50 parking stalls) Fishing access parking (20 stalls) Hiking trails 1 kiosk 5 vault toilets
Peninsula Hills Recreation Area Size: 373 acres Access: Sites Lodoga Road/Peninsula Road	200 campsites (car and recreational vehicle) 1 group camp area[a] 10 picnic sites (with parking at each site) 4-lane boat launch site Hiking trail Electricity Water 1 kiosk 19 vault toilets Potential for additional boat launches
Antelope Island Recreation Area Size: 49 acres Access: Boat-in access only from Stone Corral or Lurline Headwaters boat ramps.	12 campsites (boat-in) Hiking trails 1 vault toilet
Lurline Headwaters Recreation Area Size: 219 acres Access: From Sulphur Gap Road to Lurline Road	50 campsites (car and recreational vehicle) 3 group camp areas[a] 10 picnic sites (with parking at each site) Fishing access parking (10 stalls) Hiking trails 1 kiosk 8 vault toilets

[a] Each group camp area will accommodate up to 24 people.

Stone Corral Recreation Area. The proposed Stone Corral Recreation Area is a 235-acre site located north of the Sites Dam location on a scenic ridgeline dominated by oak woodland. The site offers excellent views of the surrounding area and dam. The recreation area would be developed with camping and picnic sites connected by roads and hiking trails. Potable water for public use, electricity for access lighting, restroom facilities, kiosk and interpretive elements, parking, and a boat ramp would be provided (Figure 2). Interpretive information about the area's cultural and natural history could be presented at a reservoir/dam overlook that could be built at one of several expansive ridge-top vistas available throughout the recreation area. The overlook site would be surrounded by existing aesthetic rock formations and could accommodate several interpretive displays, including pre-inundation photographs and information about Antelope Valley's history. The overlook could also be large enough to accommodate several benches and picnic tables. The overlook location and layout would be identified during the design development process. Access into the proposed Stone Corral Recreation Area would be from the existing Maxwell-Sites Road to the proposed Eastside Road, then west on the proposed Stone Corral Road. Stone Corral Road currently is a jeep trail, and would require upgrading. This access route would also facilitate maintenance of the proposed Sites Dam and associated waterworks.

Saddle Dam Recreation Area. The Saddle Dam Recreation Area is a 329-acre site located north of the Stone Corral Recreation Area. It is the first recreation area visitors from the north would encounter. Included in previous planning descriptions are restroom facilities, swimming and fishing access, parking, electricity for road lighting, and a kiosk with interpretive elements. The proposed Saddle Dams Recreation Area would be located on the northeast side of the reservoir (Figure 3). Access would be provided from the proposed North Road via the proposed Saddle Dam Road, which would be relocated and widened.

Peninsula Hills Recreation Area. The proposed Peninsula Hills Recreation Area is an approximately 373-acre recreation area on the northwest side of Sites Reservoir, on a peninsula that would form after inundation of Antelope Valley. Previous planning documentation included a large campground with more than 200 sites, several discrete loops, and some group facilities, as well as a four-lane boat ramp. The proposed recreation area would be located to the north of the existing Sites-Lodoga Road, and directly across the reservoir from Saddle Dam Recreation Area (Figure 4). Access would be provided from Sites Lodoga Road via the proposed Peninsula Road. The proposed recreation area would be characterized by small coves and peninsulas that are sheltered from north winds and would provide excellent opportunities for fishing and hiking. Two small islands located near the shoreline would also be created and would add to the unique qualities of this area.

Antelope Island Recreation Area. The Antelope Island Recreation Area is a 50-acre site accessible only by water in the southwestern portion of the reservoir (Figure 5). Antelope Island would be the largest island formed by inundation of the Sites Reservoir area. Once completed, access to Antelope Island would be by water only; however, a temporary road would be built to provide construction access prior to inundation. Located off the southwest shore, it would remain separated from the mainland until the reservoir was drawn down to approximately 470 feet. The anticipated frequency of drawdown of the reservoir is yet to be determined. The area would remain accessible by water to elevations of 380 feet; however, boat ramps would not be usable at reservoir water levels below 420 feet. This area would provide boaters with a secluded bay for camping located off the mainland. The island has four distinct hilltops characterized by a mosaic of vegetation types including manzanita, grey pine, blue oak, and seasonal grasses. Development of this area would be limited to only a few acres and semi-primitive with one restroom facility, approximately a dozen campsites, and no provided potable water supplies.

Lurline Headwaters Recreation Area. The proposed Lurline Headwaters Recreation Area is a 219-acre site located on the southeast end of Sites Reservoir (Figure 6), in an open meadow surrounded by oak grassland along steep mountains with excellent views. The area could support both camping and day-use, and would create an opportunity for a trail to the top of an adjacent 1,282-foot (unnamed) peak that offers additional views of the reservoir. Access to this area would be provided through the proposed Lurline Road and approximately 2 miles of upgrades to existing roads in order to connect to the Sulphur Gap realignment of Huffmaster Road. Lurline Headwaters Recreation Area does not have any shoreline area suitable for boat ramp development. Facilities likely would be located approximately 0.25 mile from the shoreline as shoreline areas are generally too steep to allow construction of reasonable parking or turnaround areas. Despite limited shoreline access, Lurline Headwaters Recreation Area would be the area best suited for recreation development on the east shore. This 219-acre area contains roughly 50 acres of level land that could support approximately 50 campsites, approximately three group sites, one restroom facility, and several (10) picnic units. Water supply and sanitary facilities may be required, depending on recreation needs. In addition, an existing Ranch Road could be used as a foot trail to the top of the existing unnamed 1,282-foot peak near the proposed recreation area.

2.3 Basis of Analysis

The assumptions made in this document to characterize the potential recreational opportunities and benefits at Sites Reservoir include:

- The maximum design water-surface elevation of Sites Reservoir, 520 feet above mean sea level (msl), is associated with a 1.81 MAF storage capacity and is considered to be the baseline scenario (URS, 2011).

- An alternative water elevation of 480 feet msl for Sites Reservoir represents the 1.27 MAF alternative (URS, 2011).

- Estimates of construction, operation, and maintenance costs by alternative shall be prepared as resources become available. Until these resources become available, the relative cost of developing, operating, and maintaining the recreation areas for Sites Reservoir shall be assumed low to medium as compared to a rural developed recreation facility.

- Specific management and maintenance requirements for the recreation areas have not been determined at this time.

- Potential environmental effects of the recreation areas were evaluated without consideration of potential mitigation measures except for avoidance.

- The reservoir’s water level would fluctuate significantly during normal operations. The maintained portion of the proposed recreation area would be limited to a designated footprint above the maximum designed reservoir water elevation and access would be provided to the reservoir.

- RVD for water use and recreation area will likely fluctuate with reservoir level.

- General recreation activities include those common to the region and that are usually of normal quality. Normal quality refers to experiences and activities that could be found in a more common setting, such as a regular city park, but are not an extraordinary recreational experience. These activities include picnicking, camping, day-use visits, hiking, horseback riding, cycling, fishing, boating, and passive recreation.

- High-quality activities include those that are not common to the region and/or nation and that are usually of high quality. High-quality activities refer to recreational activities that cannot be practiced at more common locations because of site or facility limitations, creating an extraordinary and memorable experience because of uniqueness of activity and the setting or beauty of the surrounding, cleanliness of water, presence of wildlife, etc.

- Likelihood of success at fishing and wildlife viewing enhance the value of a recreation site.

- Overuse may adversely affect the quality of recreation values. Major aesthetic qualities to be considered in assessing recreation opportunities include wildlife, geology and topography, water, and vegetation.

- Factors to be considered that would lower the quality of a recreational experience include air and water pollution, pests, poor climate, and unsightly adjacent areas.

- In Figures 1 through 6, the scenario shown is for the 1.81 MAF reservoir capacity design.

2.4 Methodology and Selection Criteria

This section describes the selection criteria used to assess the recreation area development potential of five potential Sites Reservoir recreation areas and to recommend a preferred recreation area alternative. Selection criteria were applied in detail to each site for the 1.81 MAF Sites Reservoir design baseline condition and summarized for the alternative 1.27 MAF reservoir design. Identification of the recreation areas described in this section is based on DWR’s Memorandum Report (2000 Status Report).

Selection criteria included environmental effects, site-specific security requirements, recreation, and availability of opportunity. Selection criteria are described below. A preferred recreation area would generally be one with the highest score.

Avoidance of Environmental Effects

This environmental effect analysis assesses the potential for the conceptual recreation site designs, and potential associated recreational activities, to affect specific sensitive wildlife habitat or plant communities and cultural resources known to occur in the Sites Reservoir project area. This analysis does not include a detailed project-level analysis of the potential environmental effects of construction, maintenance, or operation activities associated with the alternative recreation sites. This analysis focuses on the potential construction-related environmental effects of the development of the recreation areas’ conceptual designs. Existing sensitive wildlife habitat or plant communities surrounding or near the proposed Sites Reservoir include, but are not limited to, golden and/or bald eagle nests and wetland habitat. Impact category classifications are based on the proximity of the proposed recreation sites to the existing resources and the nature of the potential recreational activities at each site. The environmental effects rating considers significant, moderate, or minimal potential effects on existing sensitive wildlife habitat or plant communities or cultural resources.

Active or inactive golden eagle nests are protected under the Bald and Golden Eagle Protection Act (Eagle Act) (16 U.S.C. 668-668c) and the Migratory Bird Treaty Act (MBTA), and are listed as a California and a Federal Species of Special Concern. To comply with these acts, and for recreation area planning purposes, design and planning of recreation areas must refer and conform to the National Bald Eagle Management Guidelines (U.S. Fish and Wildlife Service, 2007). Pursuant to the Eagle Act, the take[1] limit for golden eagles per year is zero[2]. Thus, any recreational site development or recreational activities that have the potential to result in a taking of golden eagles would be classified as a High or significant adverse environmental effect.

Section 404 of the Clean Water Act regulates the discharge of dredged or fill materials into navigable waters of the United States, including wetlands: No discharge of dredged or fill material can be permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. The U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers have promulgated a number of regulations to implement the Section 404 permitting program. As described in Section 2.3, Basis of Analysis, potential environmental effects of the recreation areas were evaluated without consideration of potential mitigation measures except for avoidance. Thus, the potential to affect wetlands would be considered a High or a significant adverse environmental effect.

Section 106 of the Natural Historic Preservation Act of 1966 requires federal agencies to take into account the effects of their actions on historic properties, which are defined as properties that are included in the National Register of Historic Places or that meet the criteria for listing in the National Register based on local, regional, or national significance (ACHP, 2002). Historic properties include prehistoric and historic cultural resources, including structures, buildings, sites, districts, and objects, and traditional cultural properties, which are locations important to maintaining the cultural continuity of a contemporary American Indian community. Similar state regulations for cultural resources that are listed on or eligible for listing in the California Register of Historical Resources are found under Section 5024.5 of the California Public Resources Code. Any recreational site development or recreational activity that has the potential to negatively affect historic properties would be classified as having a High or adverse effect.

Security Requirements

The low score for security requirements corresponds to an elevated level of security requirements associated with critical infrastructure such as dams, as required by the Department of Homeland Security, and, as such, a high level of effort to comply with the security requirements. The moderate score refers to a moderate level of security or setback requirements associated with water supply infrastructure, such as inlet or

[1] Take means pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, or disturb.

[2] The take limit for bald eagles is five percent of their estimated annual regional productivity within each U.S. Fish and Wildlife Service region and, therefore, is less restrictive than the golden eagle take limits. As a result, this analysis focused on the more restrictive golden eagle requirements.

outlet works. The high score refers to a low-level security requirement in areas that would adequately set back from any structures.

Recreation

The recreational challenges criterion evaluated various factors such as the degree of visitor presence, visitor concentration, recreational diversity, visitor comforts, solitude and remoteness, and non-recreational use. Non-recreational use or passive recreational uses include experiencing open space in its natural setting. A low score refers to a greater number of challenges to be overcome to develop proposed sites with minimal or no potential recreation opportunities. The Medium category refers to a moderate level of recreation opportunities and moderate challenges to develop recreational opportunities. The Low category refers to a greater level of desired visitor concentration, recreation diversity, and visitor comforts, facility design and amenities as well as the naturally occurring elements, such as shade by trees, exposure and microclimates, and views.

Economic Opportunities

The economic opportunities for a site were scored by comparing the economic benefits, based on recreational use, relative to the potential associated costs of developing, operating, and maintaining a recreational facility. The low score refers to a low number of RVDs compared to the scope of developing, operating, and maintaining the recreation area. An RVD is defined as one person recreating for 12 hours, 12 people recreating for 1 hour, or any equivalent combination. The moderate score refers to a moderate number of RVDs compared to the cost of developing and maintaining the recreation area, but provides opportunities for facility expansion to meet future needs. A high score refers to a high number of RVDs compared to the cost of developing and maintaining the recreation area. The assumed number of visitors per year is based on the Sites Reservoir potential to support an average of approximately 410,000 RVDs per year (DWR, 2000), which is assumed to be a medium-high number, as compared to the range of reservoir sizes and visitation level of existing regional facilities such as the Black Butte Lake and Folsom Lake. The availability of opportunity limitations are tabulated to consider access to the recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental quality.

The recreation potential of each proposed recreation area is assessed based on a 1.81 MAF reservoir with a maximum water surface elevation of 520 feet msl (i.e., the baseline reservoir alternative). Each recreation area alternative is assessed in Section 3.0.

This page intentionally left blank

3.0 RECREATION AREA EVALUATION

This section includes the evaluation of the five recreation areas based on the methodology and selection criteria included in Section 2.4.

3.1 Stone Corral Recreation Area

The proposed Stone Corral Recreation Area is located along the east-central perimeter of the proposed Sites Reservoir (Figure 2). Various considerations and evaluations to support this determination are provided below and summarized on Table 3-1.

Table 3-1. Stone Corral Recreation Area Economic Benefits Assessment

Proposed Criteria (Assigned Ranking)	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Recreation Experience (3)	Numerous quality value activities; some general activities.	1 point – Some general private recreation activities, and no public recreation experience.	Overnight camping Day-use visitors Boating Fishing Hiking Picnicking Swimming Viewing Educational	3 points – Visitor hours, cultural and natural history, wildlife, water and land recreation.
Availability of Opportunity (3)	50 campsites 10 picnic sites 2-lane boat launch site Hiking trail Swimming area Electricity Water Interpretive kiosk Interpretive signage 10 vault toilets Overlook Parking Native tree planting	2 points – Several within 1 hour travel time; East Park Reservoir and Delevan National Wildlife Refuge are the only available recreation opportunities within 30 minutes travel time.	Overnight camping Day use visitors Boating Fishing Hiking Picnicking Swimming Viewing Educational	3 points – No anticipated competition with other comparable regional recreation facilities.
Carrying Capacity (3)	The high recreation area acreage can accommodate the proposed recreation elements.	1 point – No facility development for public recreation.	Dispersed over several spaces within total recreation area.	3 points – Expansive recreation areas and water facility.
Accessibility (2)	Good access; good roads to site; good roads within site; upgraded jeep trail (Stone Corral Road); approximately 6 miles from Interstate 5	2 points – Fair access; poor-quality roads to site; limited access within site; accessible via Maxwell Road; approximately 6 miles from Interstate 5.	Camping and day-use visitors	3 points – Access road improvements needed.

Table 3-1. (Continued)

Proposed Criteria (Assigned Ranking)	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Environ-mental Quality (3)	Proposed roads, preservation of existing natural resources within project scope	3 points – Above average aesthetic quality; ridgeline with existing oak woodland and magnificent views of surrounding area and dam site.	Associated with camping, day-use, boating and hiking.	3 points – Excellent existing natural resources within project scope.

Potential Environmental Effects

The proposed Stone Corral Recreation Area boundaries are within 0.5 mile of active and/or inactive golden eagle nests. The presence of active golden eagle nests may impose stringent requirements on the types and degree of development and use in this area, and any proposed developments on this site could result in a high level of potential adverse environmental effect on sensitive raptors. Proposed activities that are part of the development of this recreation site may fall under the National Bald Eagle Management Guidelines Category F, "Non-motorized recreation and human entry" (USFWS, 2007), and accessibility to these areas may be restricted. If proposed recreational activities would be visible or highly audible from an active nest site, per Bald and Golden Eagle Protection Act (Eagle Act) (16 U.S.C. 668-668c) and the Migratory Bird Treaty Act (MBTA), a 330-foot radius restrictive buffer zone during the breeding season may be required, particularly where eagles are unaccustomed to such activities. No known alkali wetlands or sensitive cultural resources are located within the proposed Stone Corral Recreation Area boundaries. However, given the potential to affect nesting golden eagles, the potential for adverse environmental effects would be Medium.

Potential Security Requirements

This proposed recreation area would pose a medium level of security requirements because of its relative proximity to the proposed Sites and Golden Gate dams. Security measures that could be implemented to discourage public access to the dam sites include:

- No pathways between the edge of the proposed recreation area and the dams.
- Appropriate setbacks, and visible fencing and signage to deter people from wandering too close to the dams.

Potential Recreational Challenges

This proposed recreation area would have a rural, developed recreational setting, would be patrolled by ranger or other security, and provide emergency phone service. Proposed recreation opportunities might include an overlook site offering excellent views of the surrounding area and the dam sites, campsites, shoreline fishing, picnicking, non-supervised swimming, hiking, boat ramps for mechanized and non-mechanized boating, and parking facilities. These diverse recreation opportunities at this site would expand the overall number and diversity of recreational opportunities within the region. The regional system comprises water recreation opportunities within 200 miles of the proposed Sites Reservoir, including three large lakes (Shasta Lake, Folsom Lake, and Lake Oroville) and four smaller reservoirs in the eastern foothills of the Coast Range (Black Butte Lake, Stony Gorge Reservoir, East Park Reservoir, and Indian Valley Reservoir).

Stone Corral Recreation Area would have medium recreational challenges, compared to the other proposed Sites Reservoir recreation areas, based on its higher degree of visitor presence, visitor concentration, recreation diversity, visitor comforts, and passive recreational use. The proposed Stone Corral Recreation Area site would have good access to Interstate 5, which serves as the primary north/south transportation corridor through the Sacramento Valley for major population centers in the region.

Potential Economic Opportunities

The proposed Stone Corral Recreation Area would offer a variety of recreation and likely would attract the largest number of visitors compared to the other proposed recreation areas. The Stone Corral Recreation Area features have the potential to foster return visits because of its good access to Interstate 5, which ultimately may generate revenue to sustain a portion of the operation and maintenance costs for the recreation site.

The potential economic opportunities of this recreation area alternative are high based on various criteria such as recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental quality.

3.2 Saddle Dam Recreation Area

The proposed Saddle Dam Recreation Area was not preferred for initial development because of distance from the main access road and bridge and cost of providing accessibility, presence of sensitive wetland habitat and cultural resources, and reduced water accessibility and boat ramp facilities development feasibility with the Saddle Dam alignment. The economic opportunities of this area were assessed to be High. Various considerations and evaluations to support this determination are provided below and summarized on Table 3-2.

Table 3-2. Saddle Dam Recreation Area Economic Benefits Assessment

Proposed Criteria	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Recreation Experience (2)	Numerous valuable activities; some general activities.	2 points – Some general recreation activities, and no public recreation experience.	Day-use visitors Boating Fishing Hiking	2 points – Visitor hours, water and land recreation, lack of shade throughout area.
Availability of Opportunity (3)	10 picnic sites 12-lane boat launch site Hiking trails Fishing access Electricity Kiosk 5 vault toilets Parking Designated swim area	2 points – Several within 1 hour travel time; East Park Reservoir and Delevan NWR within 30 minutes travel time.	Day use visitors Boating Fishing Hiking Swimming	3 points – No anticipated competition with other comparable regional recreation facilities.
Carrying Capacity (3)	Optimum facilities to conduct activity at site potential.	1 point – No facility development for public recreation and health and safety.	Dispersed over several spaces within recreation area.	3 points – Expansive recreation areas and water facility.
Accessibility (2)	Good access; good roads to site; good roads within site; proposed Saddle Dam Road.	1 point – Limited access by any means to site or within site.	Camping and day use visitors.	2 points – Access road improvements needed.
Environ-mental Quality (2)	Proposed roads, preservation of existing natural resources within project scope.	2 points – Above-average aesthetic quality if implementing additional trees and planting.	Associated with camping, day-use, boating and hiking.	2 points – Landscape has not as much variation, and needs shade.

Potential Environmental Effects

The Saddle Dam Recreation Area has alkali wetlands that may be affected by proposed development. Wetlands are regulated by federal and state law (Clean Water Act, Section 404). The ecological processes maintaining an alkali wetland are the dynamics between water inflow and evaporation.[3] There is a risk that the ecosystem may be affected if discharges are allowed into alkali wetlands. However, the recreational area may be developed around the alkali wetlands to minimize the environmental effects. In addition, there are sensitive cultural resources in the vicinity that are protected by federal and state law (Natural Historic Preservation Act of 1966, Section 106). The environmental effects for this recreation area are deemed High.

[3] State of Washington Department of Ecology. 2005. *Best Available Science for Wetlands.* Volume 2, Appendix 8-A. *Protecting and Managing Wetlands;* Volume 2, Appendix 9, *Protecting Wetland Functions – An Overview.*

Potential Security Requirements

This area would pose an elevated level of security requirements because of its close proximity to the proposed saddle dams. The high security requirements may cause recreation opportunities to be infeasible at this site.

Potential Recreational Challenges

This area is proposed to have a rural developed recreational setting. The recreation opportunities proposed for this area may include contact recreation such as swimming and waterskiing, parking areas, boat ramps, and opportunities for facility expansion to meet potential future needs. The potential recreational challenges are deemed high because of difficult water accessibility during at low water level conditions.

Potential Economic Opportunities

This is the only proposed recreation site which may facilitate contact water recreation such as swimming and waterskiing. This area would be the first recreation area encountered for visitors arriving from the north. The topography in this area would support the construction of the largest boat ramp and support facilities, and is expansive enough to accommodate a 12-lane ramp.

3.3 Peninsula Hills Recreation Area

The proposed Peninsula Hills Recreation Area was not preferred for initial development because of distance from the main access road and bridge and cost of providing accessibility, presence of a golden eagle nest within the footprint of the recreation area, and reduced water accessibility and boat ramp facilities development feasibility due to steep slopes. The economic opportunities of this area were assessed to be Medium. Various considerations and evaluations to support this determination are provided below and summarized on Table 3-3.

Table 3-3. Peninsula Hills Recreation Area Economic Benefits Assessment

Proposed Criteria	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Recreation Experience (3)	Numerous high quality value activities; some general activities.	2 points – Some general recreation activities, and no public recreation experience.	Overnight camping Day use visitors Boating Fishing Hiking Viewing	3 points – Visitor hours, water and land recreation.

Table 3-3. (Continued)

Proposed Criteria	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Availability of Opportunity (3)	200 campsites Group area 10 picnic sites 4-lane boat launch site Hiking trails and loops Water Electricity Kiosk 19 vault toilets Parking	2 points – Several within 1 hour travel time; none within 30 minutes travel time.	Day-use visitors Boating Fishing Hiking	2 points – Lack of shade throughout the area, no anticipated competition with other comparable regional recreation facilities.
Carrying Capacity (3)	Optimum facilities to conduct activity at site potential.	1 point – No facility development for public recreation and health and safety.	Largest campground and multi-use facility.	3 points – Expansive recreation areas and water facility.
Accessibility (2)	Good access; good roads to site; good roads within site; Sites-Lodoga/ Peninsula Road.	1 point – Limited access by any means to site or within site.	Camping and day-use visitors.	2 points – Bridge needed
Environ-mental Quality (3)	Proposed roads, preservation of existing natural resources within project scope.	3 points – Above-average aesthetic quality; magnificent views of reservoir.	Associated with camping, day-use, boating and hiking.	3 points

Potential Environmental Effects

The proposed Peninsula Hills Recreation Area has active or inactive golden eagle nests, which are protected by both the Eagle Act and the MBTA. To comply with these acts, and for recreation area planning purposes, design and planning of the recreation areas must refer and conform to the National Bald Eagle Management Guidelines (2007) as developed by the U.S. Fish and Wildlife Service.

The presence of active golden eagle nests may pose stringent requirements on the degree of development in this area. Pursuant to the Eagle Act, the take limit for golden eagles per year is zero. As a result, any proposed developments on this site may cause a high level of potential environmental effect. Proposed activities that are part of the development of this recreation site may fall under the National Bald Eagle Management Guidelines' Category F, "Non-motorized recreation and human entry." If proposed activities would be visible or highly audible from a nest, a 330-foot buffer during the breeding season may be required, particularly where eagles are unaccustomed to such activities.

Potential Security Requirements

The proposed bridge structure across the Sites Reservoir would be in close proximity to the inlet/outlet facilities associated with the reservoir.

Potential Recreational Challenges

This area is proposed to have a rural-developed to rural-natural recreational setting. The recreation facilities offered by this area may include large boat ramps, a large campground with as many as 200 sites, and parking spaces. The proposed bridge may offer opportunities for excellent views of the surrounding area and the dam, and improves accessibility to the recreation area.

Potential Economic Opportunities

The economic opportunities of this area were assessed to be Medium. Key features include a large camping area and boat ramps to support activity on the lake.

3.4 Antelope Island Recreation Area

The proposed Antelope Island Recreation Area was preferred for initial development. The protection of existing vegetation would limit the number of available campsites. Although the distance from the main access road and bridge is lengthy, it would have scenic qualities. The cost of providing accessibility to the island is high and potable water would be unavailable. The development of boat ramp facilities would be challenging to construct. Various considerations and evaluations to support this determination are provided below and summarized on Table 3-4.

Table 3-4. Antelope Island Recreation Area Economic Benefits Assessment

Proposed Criteria	Proposed Elements	Existing Facilities/ Baseline	Future Use/ Outcome	Potential Future Value
Recreation Experience (2)	Medium – A few quality value activities; some general activities.	2 points – Some general recreation activities, and no public recreation experience.	Overnight camping Boating Fishing Hiking Viewing	2 points – Secluded location, natural and exclusive character; likely low use, low number of visitors served, and minimal facilities and activity opportunities offered.
Availability of Opportunity (1)	12 campsites Hiking trails 1 vault toilet	1 point – No similar opportunity within 2 hours travel time.	Boating Fishing	1 point – Small area does not allow for many larger scale opportunities.
Carrying Capacity (2)	Optimum facilities to conduct activity at site potential.	1 point – No facility development for public recreation and health and safety.	Small natural campground, only accessible via water	2 points – Smaller useable area, more difficult to reach.
Accessibility (1)	Limited access by any means to site or within site.	1 point – Limited access by any means to site or within site.	Camping and boating	1 point – Accessible only via water.
Environ-mental Quality (1)	Preservation of existing natural resources within project scope.	Medium aesthetic quality; some natural environment.	Associated with camping, day use, boating and hiking	1 point

Potential Environmental Effects

The proposed Antelope Island Recreation Area would be on an island that would form as a result of the inundation of the reservoir. It has no significant cultural or environmental concerns.

Potential Security Requirements

This area would be a large natural area accessible only through water and would be far from any dams or other structures.

Potential Recreational Challenges

This area is proposed to have a semi-primitive recreational setting. This area would offer boaters a secluded bay for camping off the mainland. The island has four distinct hilltops characterized by a mosaic of vegetation types including Manzanita, grey pine, blue oak and seasonal grasses. The area may have a few campsites; however, the island's primitive setting offers few visitor comforts and the island's degree of solitude and remoteness may deter or attract visitors.

Potential Economic Opportunities

Because the island is within the Sites Reservoir, the development of this area would not require any additional acquisition of land. The island is proposed to be maintained in a primitive condition with development limited to a few acres. The island offers a lot of natural resources and a natural ambiance would dominate. Development of this area is deemed High because of likely low use, low number of visitors served, and minimal facilities and activity opportunities offered.

3.5 Lurline Headwaters Recreation Area

The proposed Lurline Headwaters Recreation Area was not preferred for initial development because of distance from the main access road and bridge and cost of providing accessibility, presence of a golden eagle nest, and reduced potable water accessibility and boat ramp facilities development feasibility (there is no suitable boat ramp at this recreation area). The economic benefits of this area are medium. Various considerations and evaluations to support this determination are provided below and summarized on Table 3-5.

Table 3-5. Lurline Headwaters Recreation Area Economic Benefits Assessment

Proposed Criteria	Proposed Elements	Existing Facilities/Baseline	Future Use/Outcome	Potential Future Value
Recreation Experience (2)	Numerous high quality value activities; some general activities.	1 point – Some general recreation activities, and no public recreation experience.	Overnight camping Day-use visitors Fishing Hiking Viewing Educational	2 points – Visitor hours, cultural and natural history, wildlife, water and land recreation.

Table 3-5. (Continued)

Availability of Opportunity (2)	50 campsites 3 group camp areas 10 picnic sites Fishing access Hiking trail Interpretive kiosk 8 vault toilets Parking	2 points – Several within one hour travel time; none within 30 minutes travel time.	Overnight camping Day-use visitors Fishing Hiking Viewing	2 points – No anticipated competition with other comparable regional recreation facilities.
Carrying Capacity (3)	Medium facilities to conduct activity at site potential – low boat ramp potential.	1 point – No facility development for public recreation or health and safety.	Dispersed over several spaces within recreation area.	3 points – Expansive recreation areas and water facility.
Accessibility (2)	Good access; good roads to site; good roads within site; Sulphur Gap Road to Lurline Road.	2 points – Fair access; poor-quality roads to site; limited access within site; accessible via Maxwell Road; approximately 6 miles from Interstate 5.	Camping and day-use visitors.	1 point – Access road improvements needed, steep slopes do not support boat ramp.

Potential Environmental Effects

The proposed Lurline Headwaters Recreation Area has active or inactive golden eagle nests, which are protected by both the Eagle Act and the MBTA. To comply with these acts, and for recreation area planning purposes, design and planning of the recreation areas must refer and conform to the National Bald Eagle Management Guidelines (2007) as developed by the U.S. Fish and Wildlife Service.

The presence of active golden eagle nests may pose stringent requirements on the degree of development in this area. Pursuant to the Eagle Act, the take limit for golden eagles per year is zero. As a result, any proposed developments on this site may cause a high level of potential environmental effect. Proposed activities that are part of the development of this recreation site may fall under the National Bald Eagle Management Guidelines' Category F, "Non-motorized recreation and human entry." If proposed activities would be visible or highly audible from a nest, a 330-foot buffer during the breeding season may be required, particularly where eagles are unaccustomed to such activities. In addition, there are potential sensitive cultural resources in the vicinity are that are protected by federal and state law (Section 106 of the Natural Historic Preservation Act of 1966). The environmental effects for this recreation area are deemed High.

Potential Security Requirements

This area would have a rural-natural to semi-primitive setting. This area would be far from any dams or other structures and would have minimal security requirements.

Potential Recreational Challenges

This area is proposed to have a rural-natural recreational setting. Though far away from any developments, the area allows various views of the reservoir. The area could support both camping and day use, and would create an opportunity for a trail to the top of an adjacent peak offering additional views of the reservoir. This area might accommodate 50 campsites and 10 picnic units despite limited or no shoreline access. This area is not suitable for boat ramp development as indicated DWR's 1999 Memorandum Report (2000 Status Report), the Lurline Headwaters Recreation Area does not have any shoreline area suitable for boat ramp development; however, an existing ranch road might serve as a foot trail.

Potential Economic Opportunities

Access to this area would involve upgrading 2 miles of existing roads to connect to the Sulphur Gap realignment of Huffmaster Road. The economic benefits of this area are medium.

3.6 Summary of Recreation Site Analysis for the 1.81 MAF

The proposed 1.81 MAF reservoir, with a maximum surface elevation of 520 feet, will offer opportunities for five recreation development areas at different locations, as described above, along the perimeter of the reservoir. However, Stone Corral is the recreation area recommended for potential development because it is relatively easy to access and would have moderate security requirements, recreational challenges, and economic opportunities.

Table 3-6 summarizes the application of the selection criteria and the reasoning for the selection of Stone Corral as the recommended recreation area. This analysis assumes that potential planning measures could be incorporated into Stone Corral project designs to avoid any environmental effects associated with potential Bald or Golden eagles in the vicinity.

In terms of the four evaluation criteria from the Federal P&G for water resources planning, this evaluation may be summarized as follows:

- **Completeness.** The Stone Corral Recreation Area is considered the most complete, largely due to its proximity to the primary access roadway and existing utilities. The Peninsula Hills and Antelope Island areas would be the least complete due to their location on the more remote western end of the reservoir.

- **Effectiveness.** Peninsula Hills and Stone Corral are considered the most effective of the recreational areas because they have the least significant recreational challenges.

- **Efficiency.** Stone Corral is rated highest in terms of economic opportunities. Antelope Island is considered to have the least significant environmental consequences. Overall, Stone Corral and Antelope Island are considered to be the most efficient areas for implementation.

Table 3-6. Recreation Area Assessment for the 1.81 MAF Reservoir

NODOS Recreation Site Options		Selection Criteria for 1.81 Million-Acre-Feet Option				
		Environmental Effects	**Security Requirements**	**Recreation**	**Economic Opportunities**	**Total**
Stone Corral (235 acres)	Level	2	2	3	3	10
	Status	Selected with potential planning measures to comply with the Bald and Golden Eagle Act.				
Saddle Dam (329 acres)	Level	1	2	2	1	6
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of sensitive wetland habitat and cultural resources, and reduced water accessibility and boat ramp facilities development feasibility with the Saddle Dams alignment.				
Peninsula Hills (373 acres)	Level	1	2	3	1	7
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of golden eagle within the footprint of the recreation area, and reduced water accessibility facilities development feasibility due to steep slopes.				
Antelope Island (50 acres)	Level	3	3	1	1	8
	Status	Selected as alternate because of low economic benefits of this area. The area has restricted numbers of available campsites, a lengthy distance from the main access road and bridge which may provide scenic qualities, associated cost of providing accessibility to the island, and reduced water accessibility.				
Lurline Headwaters (219 acres)	Level	1	3	2	1	7
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of golden eagle and reduced water accessibility and boat ramp facilities development feasibility.				

- **Acceptability.** The evaluation of acceptability will be further modified after the receipt of comments on the public draft. It is anticipated that accessibility will be a major factor in the acceptability of the alternatives; therefore, Stone Corral is considered to be the most acceptable of the alternatives at this time. For the same reason, Peninsula Hills and Antelope Island are considered the least acceptable alternatives.

3.7 Summary of Recreation Site Analysis for the 1.27 MAF Alternative

Each of the five recreation areas were also evaluated, using the selection criteria, for the 1.27 MAF Sites Reservoir alternative, which would have a maximum surface elevation of 473 feet. The results of the recreation area analysis are summarized in Table 3-7. The potential environmental effects, security requirements, recreational challenges, and economic opportunities of the recreation areas for the 1.27 MAF reservoir design would be similar to those described above for the 1.81 MAF baseline condition. According to the existing topography, the proposed Stone Corral Recreation Area will support proposed planning and site features and can be situated at the lower elevation adjacent to the water. The proposed Stone Corral Recreation Area is the recommended recreation area for this alternative because it is relatively easy to access and has moderate scores in the security requirements, recreational challenges, and economic opportunities categories. This analysis assumes that potential planning measures could be incorporated into Stone Corral project designs to avoid any environmental effects associated with potential golden eagles in the vicinity.

The assessment of the 1.27 MAF reservoirs matches that of the 1.81 MAF reservoir in terms of the criteria for completeness, effectiveness, efficiency, and acceptability.

Table 3-7. Recreation Area Assessment for the 1.27 MAF Reservoir

NODOS Recreation Site Options		Selection Criteria for 1.27 MAF (Million-Acre-Feet) Option				
		Environmental Effects	Security Requirements	Recreation	Economic Opportunities	Total
Stone Corral (235 acres)	Level	2	2	3	3	10
	Status	Selected with potential planning measures to comply with the Bald and Golden Eagle Act.				
Saddle Dam (329 acres)	Level	1	2	2	1	6
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of sensitive wetland habitat and cultural resources, and reduced water accessibility and boat ramp facilities development feasibility with the Saddle Dams alignment.				
Peninsula Hills (373 acres)	Level	1	2	2	1	6
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of golden eagle within the footprint of the recreation area, and reduced water accessibility and boat ramp facilities development feasibility due to steep slopes.				
Antelope Island (50 acres)	Level	3	3	1	1	8
	Status	Selected as alternate because of low economic benefits of this area. The area has restricted numbers of available campsites, a lengthy distance from the main access road and bridge which may provide scenic qualities, associated cost of providing accessibility to the island, and reduced water accessibility.				
Lurline Headwaters (219 acres)	Level	1	3	1	1	6
	Status	Not selected because of distance from the main access road and bridge and cost of providing accessibility, presence of golden eagle and reduced water accessibility and boat ramp facilities development feasibility.				

This page intentionally blank

4.0 CONCLUSION

The proposed amenities and location of the preferred Stone Corral Recreation Area would ensure that it could be a suitable and flexible facility for both alternative reservoir level scenarios. The proposed recreation area offers overnight camping, picnic sites, boat launching facilities and hiking. In addition, the recreation area will have water, electricity, kiosk, and restroom facilities. The recreation area offers opportunity for an overlook site with interpretive and educational opportunities, and excellent views of the surrounding area and the dam site, in addition to accessibility to the water.

The proposed Sites Reservoir has been identified by the DWR and the CALFED Bay-Delta Program (CALFED) as an important proposed facility under consideration in California, and its recreation component has opportunities to serve the growing Sacramento and Red Bluff regions for generations to come. Continued planning for the recreation potential on the reservoir is expected to progress and can include a program level resource and recreation management plan, which presents guidelines and goals and defines future conditions of land and water recreation, resource use and management.

This page intentionally left blank

5.0 REFERENCES

Bureau of Reclamation (United States Department of the Interior), Haas, G., R. Aukerman, V. Lovejoy, and D. Welch, 2004. *Water Recreation Opportunity Spectrum (WROS) Users' Guidebook.* Office of Program and Policy Services, Denver Federal Center, Lakewood, Colorado. July.

California Department of Water Resources (DWR), 1965. *The recreation potentials of the tentative water projects of the Upper Sacramento River Basin Investigation*. Bulletin 150, Appendix A.

DWR, 2000. *North of Delta Offstream Storage Investigation Draft Progress Report,* Appendix J: Recreation Requirements and Opportunities: Sites Reservoir Alternative. April.

DWR, 2001. *Comparative Inventory of Recreation Facilities at California's Largest Reservoirs, 2000*.

Davis-Dolwig Act, Enacted in 1961. Chapter 867, Statutes of 1961 (AB 261, Davis).

National Park Service (U.S. Department of Interior), 1965. *Project report on the recreation potential of the proposed West Sacramento Canal Unit Central Valley Project California.*

Reclamation and DWR, 2008. *North-of-the-Delta Offstream Storage Investigation Plan Formulation Report*. United States Department of the Interior, Bureau of Reclamation, Mid-Pacific Region Sacramento, California. July.

Reclamation and DWR, 2009. *NODOS Investigation Feasibility Recreation Report*.

Reclamation and DWR, 2011. *NODOS Baseline Recreation Opportunities Technical Memorandum*.

Water Project Recreation Act, 1965. United States Code Citation: 16 U.S.C. 460l-12 -460l-22, 662, [16 U.S.C 460(L)(12)- 460(L)(21); P.L.89-72; July 9, 1965; 79 Stat. 213] as amended by: P.L. 93-251; March 7, 1974; 88 Stat. 33 and P.L. 94-576; October 21, 1976; 90 Stat. 2728.

Wikipedia Commons, *Dams Owned and Operated by Federal Agencies*. http://damsafety.water.ca.gov/docs/Federal_5-07.pdf. Retrieved 2008-01-29.U.S. Geological Survey Geographic Names Information System: Lake Berryessa , URL: http://en.wikipedia.org/wiki/Lake_Berryessa, accessed April 16, 2011.

This page intentionally left blank

Figures

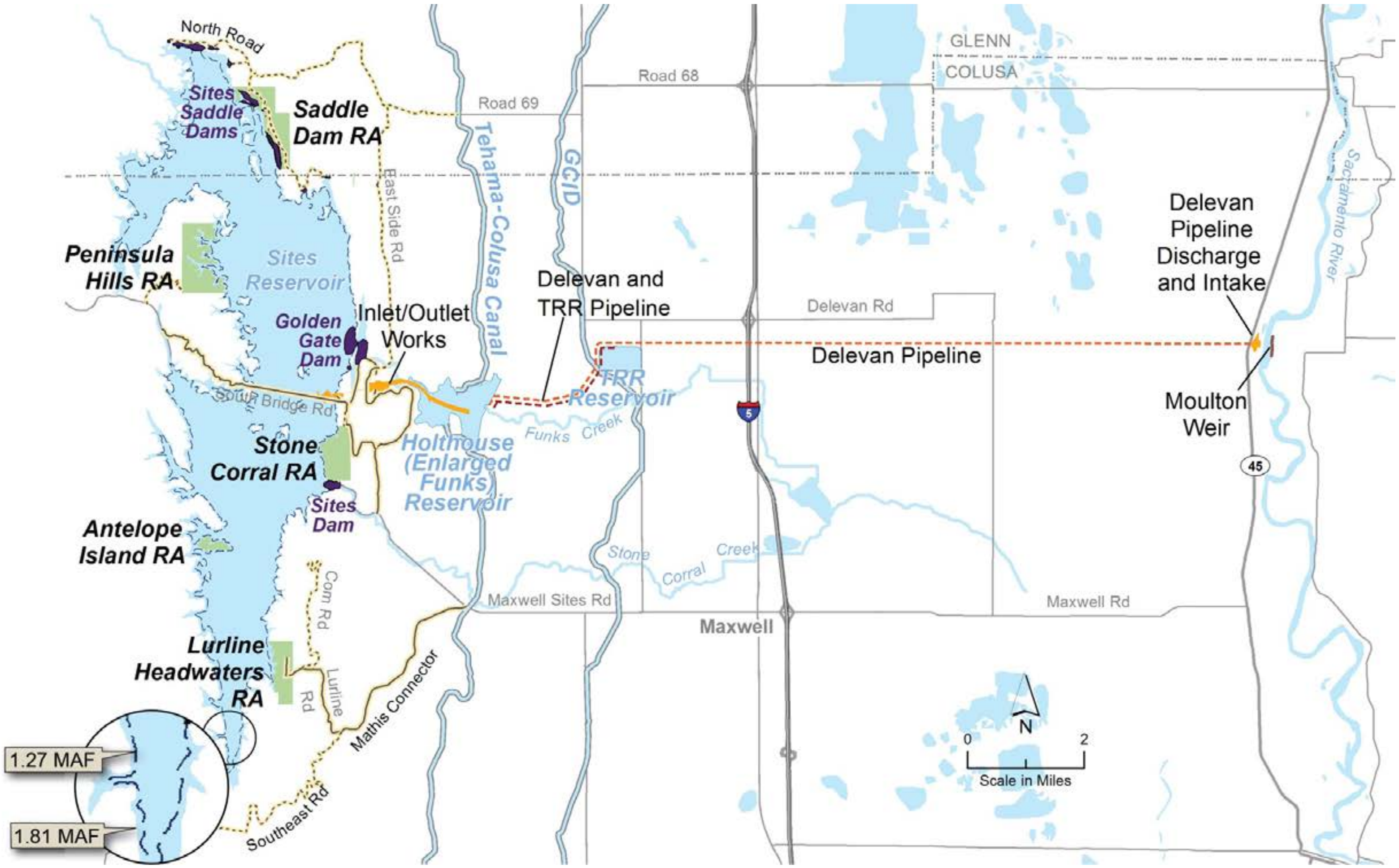


Figure 1

Sites Reservoir

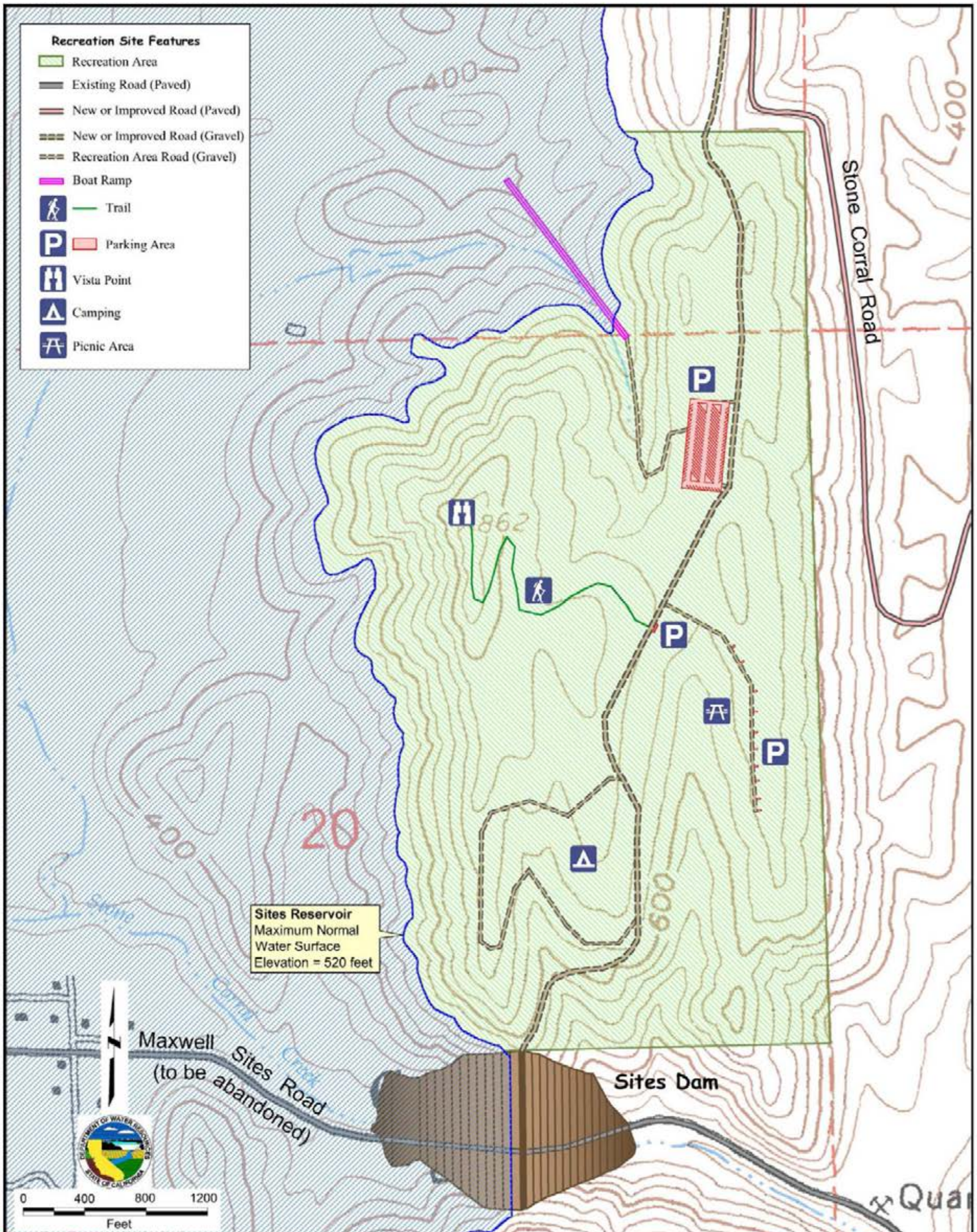


Figure 2

Stone Corral Recreation Area

Source: DWR and URS 2000

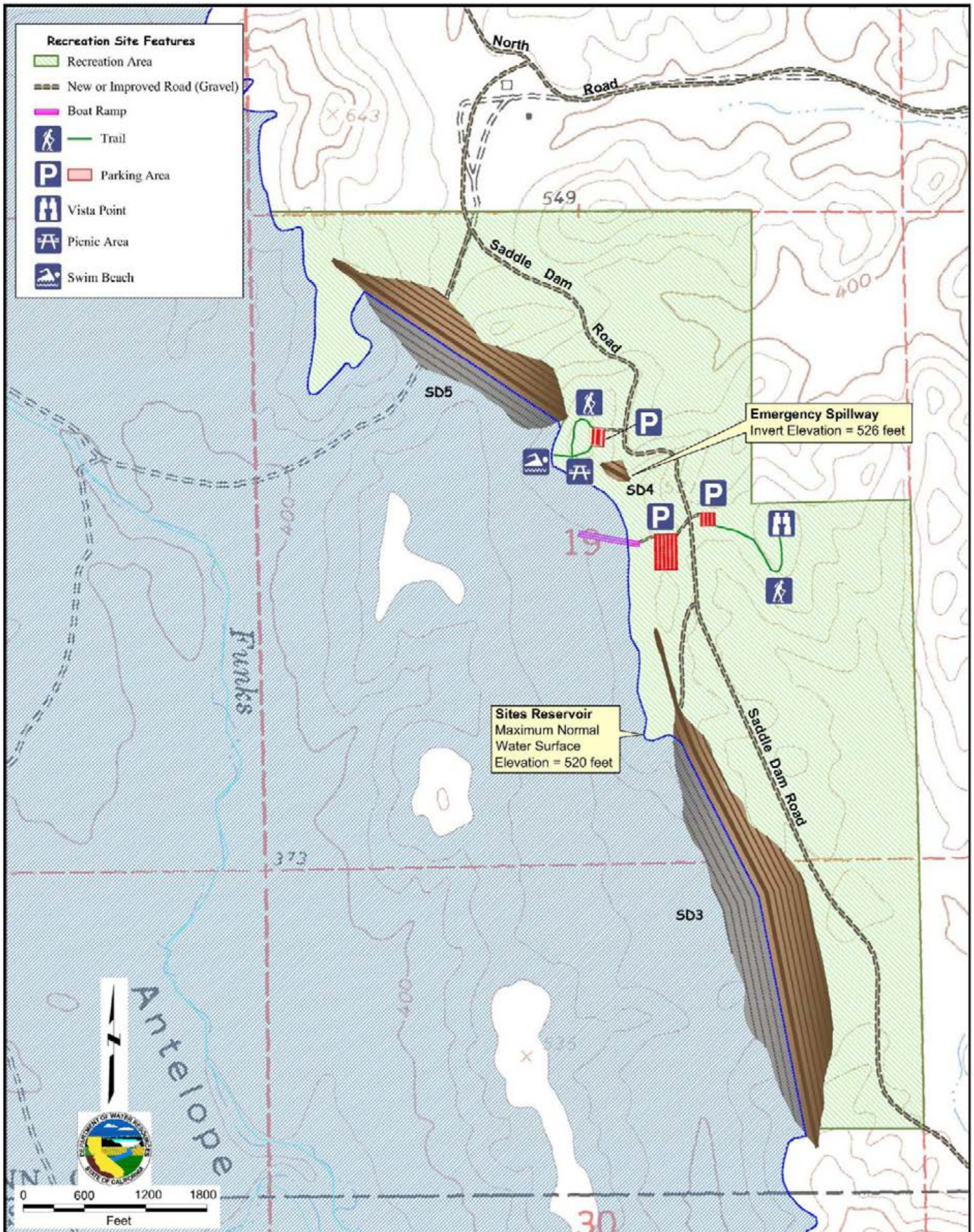


Figure 3

Source: DWR and URS 2000

Saddle Dam Recreation Area

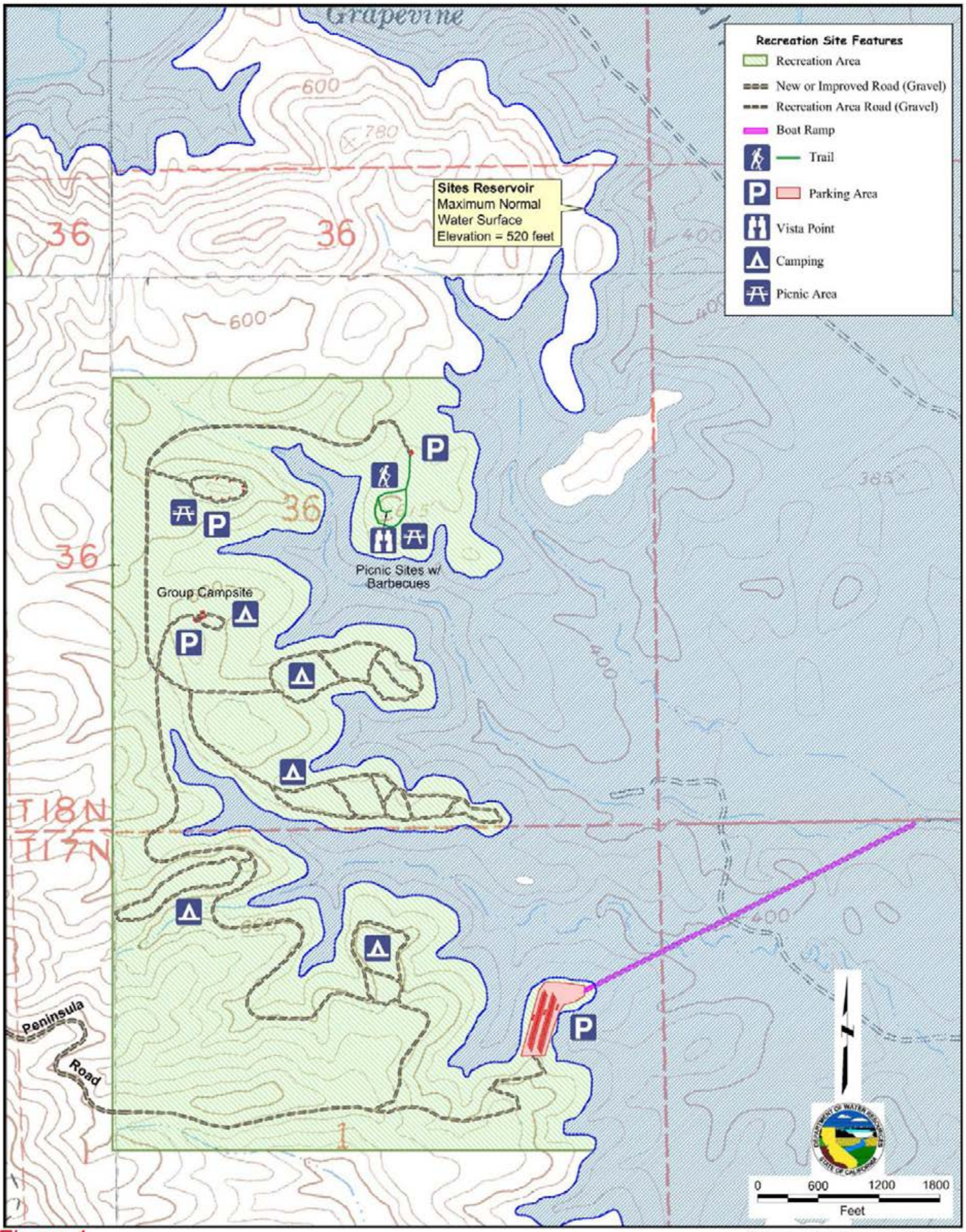


Figure 4

Peninsula Hills Recreation Area

Source: DWR and URS 2000

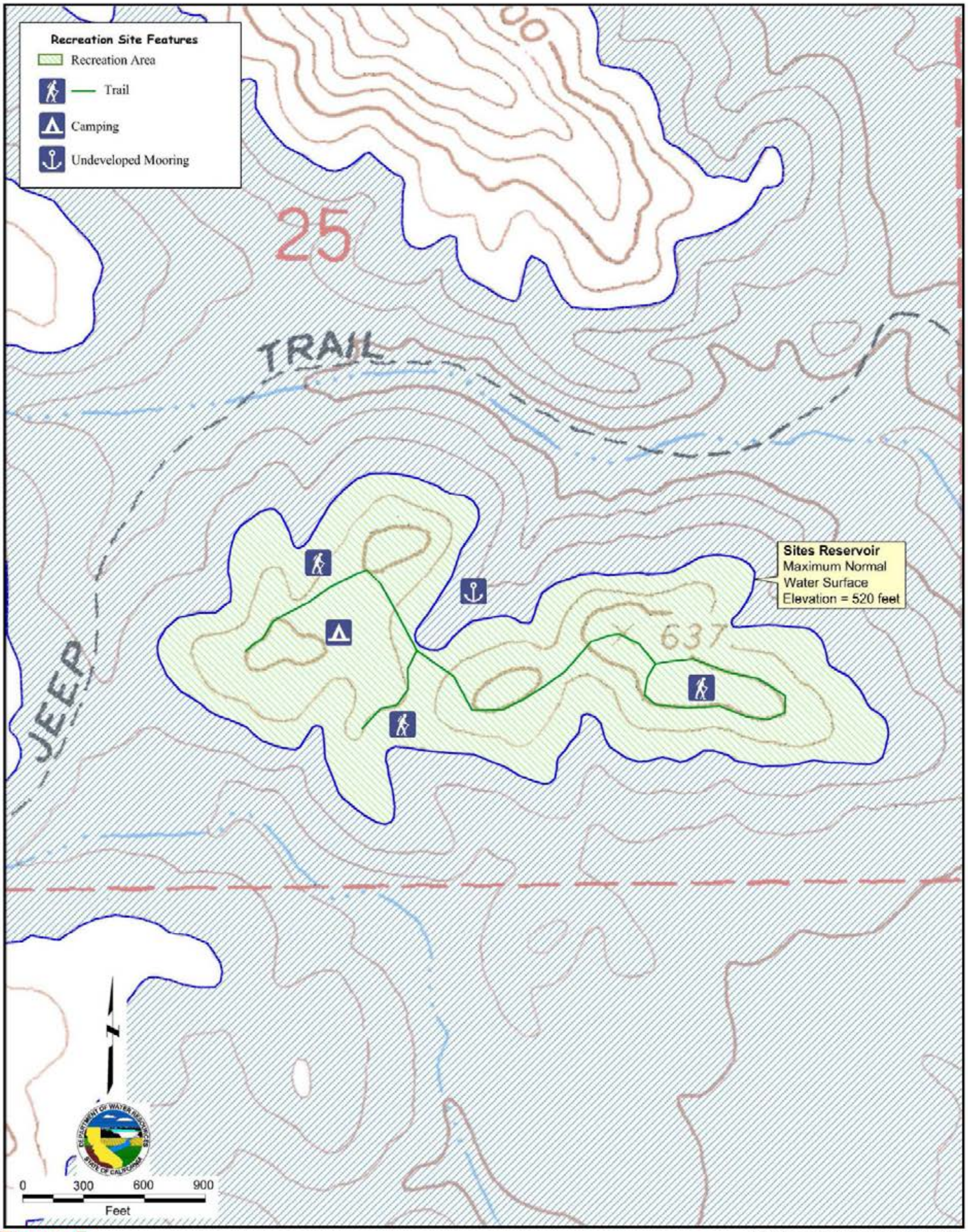


Figure 5

Antelope Island Recreation Area

Source: DWR and URS 2000

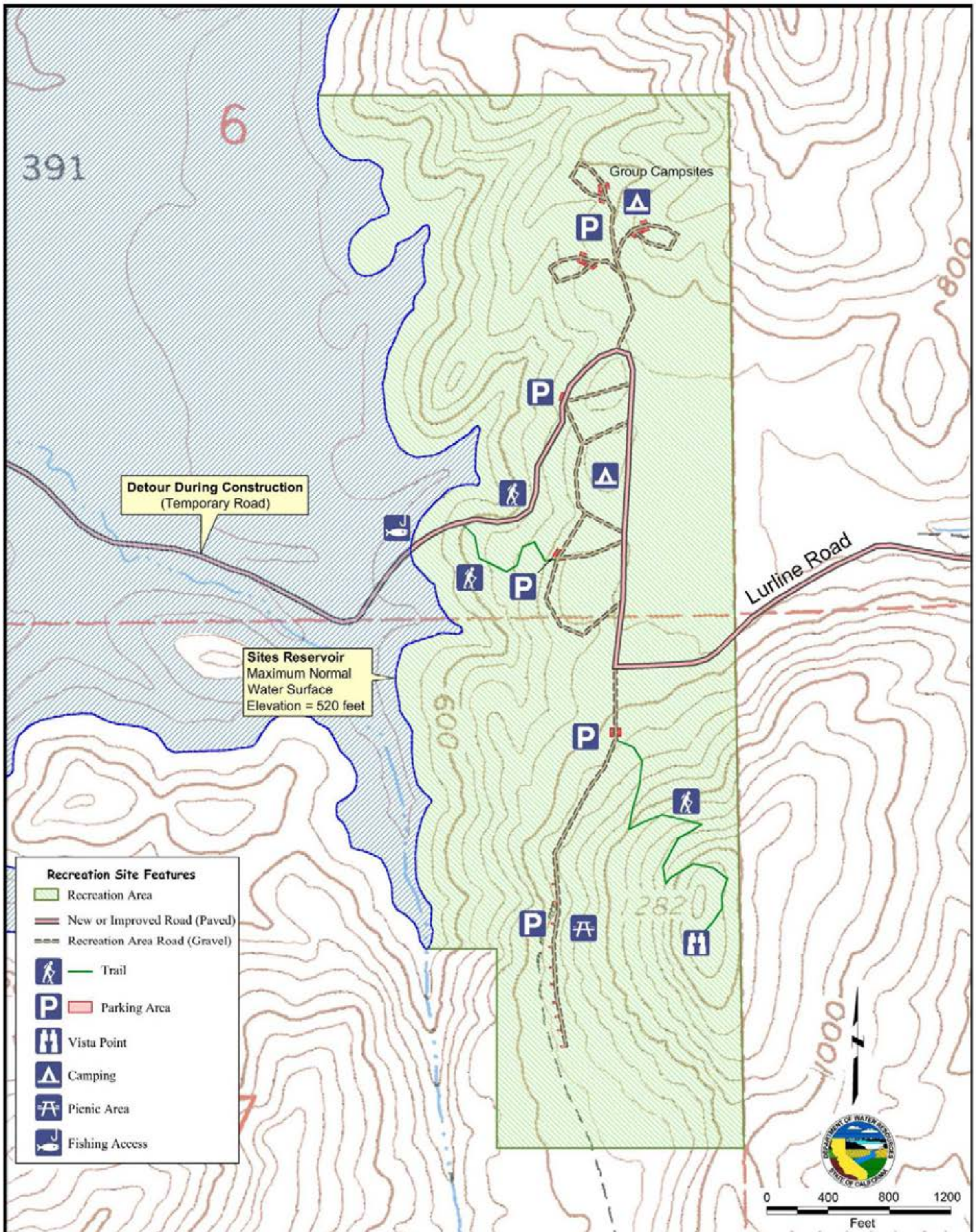


Figure 6

Lurline Recreation Area

Source: DWR and URS 2000

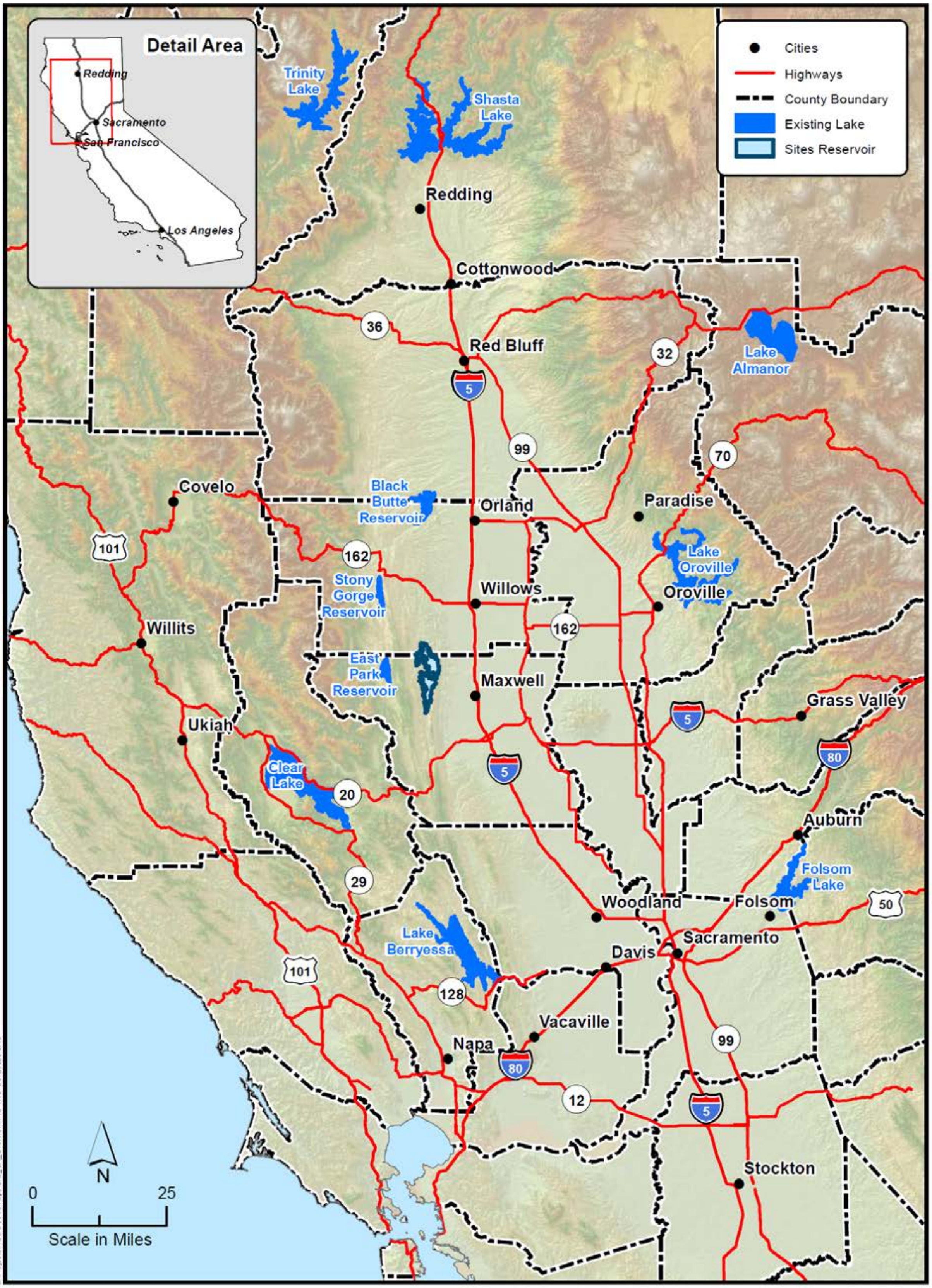
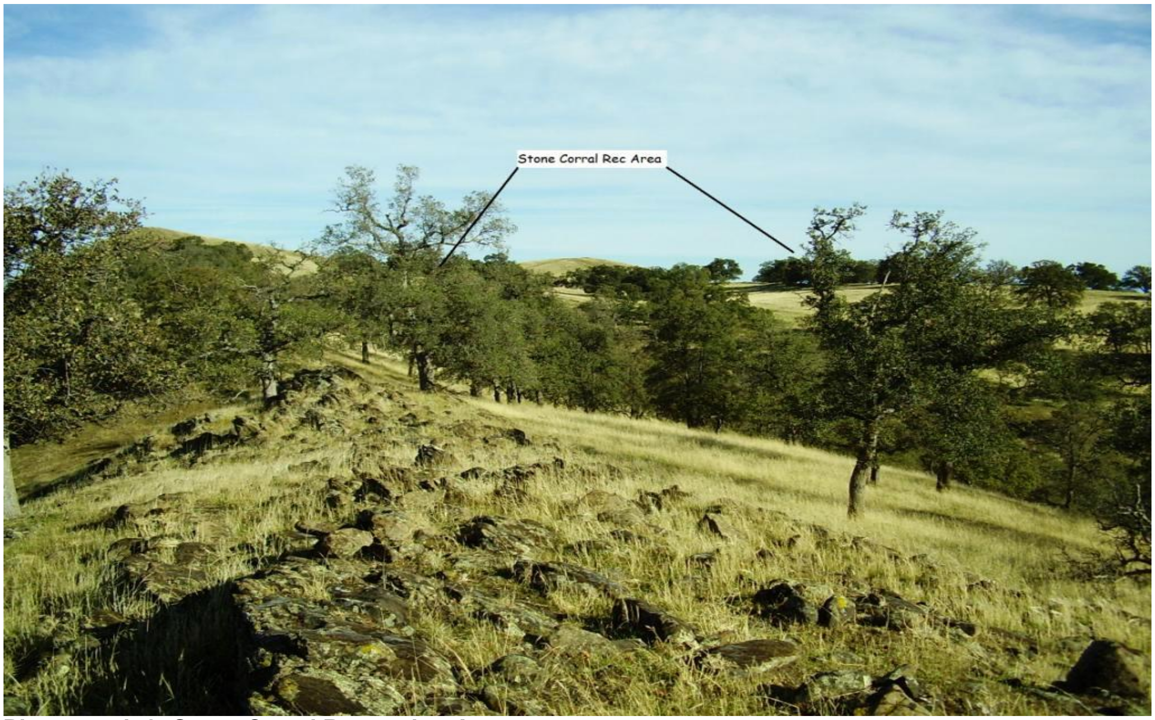


Figure 7. Regional Reservoirs in the Vicinity of Sites Reservoir

Draft

Attachment Site Photos

Photograph 1: Stone Corral Recreation Area showing centerline of Sites Dam along center abutment.



Photograph 2: Stone Corral Recreation Area.

Photograph 3: Saddle Dam Recreation Area showing approximate alignment of Saddle Dam #3.

Photograph 4: Saddle Dam Recreation Area.

Photograph 5: Peninsula Hills Recreation Area.

Photograph 6: Peninsula Hills Recreation Area showing access road.

Photograph 7: Antelope Island Recreation Area.


Photograph 8: Antelope Island Recreation Area close-up view.

Photograph 9: Lurline Headwaters Recreation Area.

Photograph 10: Lurline Headwaters Recreation Area close-up view.

This page intentionally left blank

APPENDIX F

Fish Effects

Table of Contents

Page

Table of Contents

Page

Tables

Page

Figures

Page

FISH EFFECTS

A primary planning objective of the NODOS Project is to increase anadromous fish survival in the Sacramento River and the health and survivability of other aquatic species. This appendix evaluates the relative effectiveness of NODOS Alternatives A, B, and C to meet aquatic habitat enhancement goals in the Sacramento River system and Delta. These goals include increased reliability and discharge from reservoir cold water pools to provide instream flows and water temperatures to benefit Chinook salmon (*Oncorhynchus tshawytscha*) and other species. The capacity for increased flows, especially during drier years and summer months, also helps to maintain Delta X2 west of Collinsville (81 km), and improved estuarine habitat values for smelt and out-migrating salmonids.

For this assessment, Chinook salmon are used as an indicator species to model and qualitatively analyze potential project-related impacts and in evaluating performance of aquatic habitat goals. Chinook salmon are anadromous fish which spawn in freshwater streams and grow to adulthood in the ocean. Four runs of Chinook salmon pass through the Delta and spawn in the Sacramento River and its tributaries. The four runs are recognized and named for the timing of their entry into the Sacramento River system: 1) fall-run, (2) late fall-run, (3) winter-run, and (4) spring-run (Hallock and Fry, 1967; Healey, 1991). Table F-1 summarizes the legal status of the four runs, categorized as evolutionarily significant units (ESUs) under the federal Endangered Species Act (ESA) and California Endangered Species Act (CESA).

The life history and habitat requirements of Chinook salmon have been well documented (e.g., Myers et al., 1998; Healey, 1991; Moyle 2002; Reiser and Bjorn, 1979). The freshwater period of a salmon's life is divided into four general life stages:

1) Adult upstream migration (immigration)
2) Spawning and incubation
3) Egg development and emergence of fry
4) Juvenile/smolt out-migration (emigration) to the Delta

Table F-2 summarizes the timing and duration of how these life stages differ among the four runs in the Sacramento River.

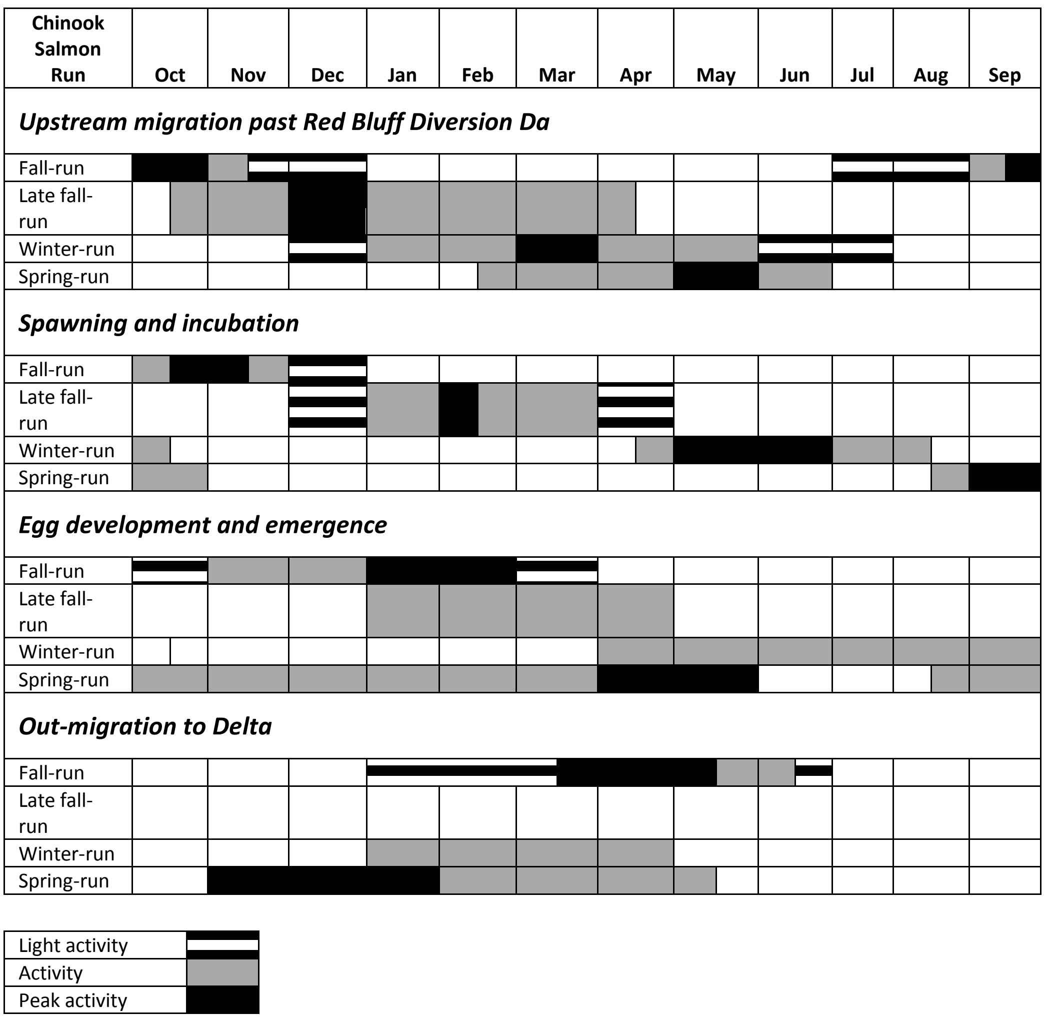
At least one life stage of Chinook salmon is present in the Sacramento River system throughout the year. High water temperatures can limit salmon growth and survival during the summer months, especially during drier years or periods of low flows. The relative number and distribution of the various life stages change throughout the year depending on the temporal and spatial distribution of the runs. The four runs of Chinook salmon rear in the Delta for variable periods of time, but some fish may migrate through the Delta and may be present for only a short time.

Table F-1. Legal Status of Chinook Salmon (*Oncorhynchus tshawytscha*) Runs in the Sacramento Valley

Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*) run	**Legal Status***	
	Federal	**State**
Central Valley fall-run ESU	SC	SSC
Central Valley late fall-run ESU	SC	SSC
Sacramento River winter-run ESU	E	E
Central Valley spring-run ESU	T	T

*Legal Status
CESA = California Endangered Species Act
E = Endangered under ESA and CESA
ESA = Federal Endangered Species Act
ESU = evolutionary significant unit
SC = Considered a Species of Concern by National Oceanic and Atmospheric Administration Fisheries
SSC = Considered a California Species of Special Concern by the California Department of Fish and Game
T = Threatened under the ESA and CESA

Table F-2. Timing of Migration and Life Stage Development by Sacramento Valley Chinook Salmon Run



Methodology. As a component of the primary planning objectives, the NODOS Project Team has identified the following eight environmental enhancement actions (EEAs):

1) Improve the reliability of coldwater pool storage in Shasta Lake to increase Reclamation's operational flexibility to provide suitable water temperatures in the Sacramento River. This EEA operationally translates into the increase of Shasta Lake May storage levels, and increased coldwater pool in storage, with particular emphasis on Below Normal, Dry, and Critical water year types.

2) Provide releases from Shasta Dam of appropriate water temperatures, and subsequently from Keswick Dam, to maintain mean daily water temperatures year-round at levels suitable for anadromous salmonid species and life stages in the Sacramento River between Keswick Dam and RBDD, with particular emphasis on the months of highest potential water temperature-related impacts (July - November) during Below Normal, Dry, and Critical water year types.

3) Increase the availability of coldwater pool storage in Folsom Lake by increasing May storage and coldwater pool storage to allow Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River (LAR). This EEA utilizes additional coldwater pool storage by providing releases from Folsom Dam (and subsequently from Nimbus Dam) to maintain mean daily water temperatures at levels suitable for juvenile steelhead over-summer rearing and fall-run Chinook salmon spawning in the LAR May – November during all water year types.

4) Stabilize LAR flows to minimize dewatering of fall-run Chinook salmon redds (October through March) and steelhead redds (January through May), and reduce isolation events (flow increases to greater than or equal to 4,000 cfs with subsequent reduction to less than 4,000 cfs) of juvenile anadromous salmonids, particularly October through June. Reduce the reliance upon Folsom Lake as a "real-time, first response facility" to meet Delta objectives and demands, particularly January through August, to reduce flow fluctuation and water temperature-related impacts to LAR fall-run Chinook salmon and steelhead.

5) Provide summer through fall (May through December) supplemental Delta outflow to maintain X2 position west of Collinsville, and increase estuarine habitat, reduce entrainment, and improve food availability for anadromous fishes and other estuarine-dependent species (Ddelta smelt, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp).

6) Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability for juvenile steelhead and spring-run Chinook salmon over-summer rearing and fall-run Chinook salmon spawning in the lower Feather River May through November during all water year types. Provide releases from Oroville Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead and spring-run Chinook salmon over-summer rearing, and fall-run Chinook salmon spawning in the lower Feather River. Stabilize flows in the lower Feather River to minimize redd dewatering, juvenile stranding, and isolation of anadromous salmonids.

7) Stabilize flows in the Sacramento River between Keswick Dam and RBDD to minimize dewatering of fall-run Chinook salmon redds (for the spawning and embryo incubation life stage periods October through March), particularly during fall.

8) Provide increased spring through fall flows in the lower Sacramento River by reducing diversions at RBDD (into the T-C Canal) and at Hamilton City (into the GCID Canal), and by providing supplemental flows (at Delevan). This EEA will provide multiple benefits to riverine and estuarine habitats, and to anadromous fishes and estuarine-dependent species (delta smelt, splittail, longfin smelt, Sacramento splittail, starry flounder, and California bay shrimp) by reducing entrainment, providing or augmenting transport flows, increasing habitat availability, increasing productivity, and improving nutrient transport and food availability.

Assumptions for Modeling of NODOS Alternatives:

The predicted effect of NODOS Alternatives A, B, and C are based on comparisons to the No Project Alternative. Effects of the Alternatives were evaluated from two different models that analyze the relationships of flow and water temperature on Chinook salmon in the Sacramento River: The Interactive Object-oriented Simulation (IOS) and Delta Passage Model (DPM) models, and the Salmonid Population Model (SALMOD). The assumptions, parameters, and outputs of these models are summarized below.

Winter-Run Chinook Life Cycle Model (WRCLCM) IOS/DPM Model (Cramer Fish Sciences)

The IOS model is a life-cycle model providing a quantitative framework to evaluate the accumulated effects of flow, temperature, diversions, and habitat conditions on multiple life stages (eggs, alevins, fry, parr, smolts, subadults and adults) of winter-run Chinook salmon that spawn in the upper reaches the Sacramento River, migrates through the Delta to the Pacific Ocean, and returns to the Upper Sacramento River to spawn. This model simulates individual daily cohorts of winter-run Chinook salmon through their life cycle. The IOS models individual life stages using functional relationships, whose form and parameters values are informed by the best available information. Functional relationships for each life stage are linked together to form a complete life cycle model that estimates the daily number of eggs for each brood year and progresses them through life stage transitions until spawning at age 3 or 4 (years) where the process begins again for the next generation. The smolt Delta migration portion of the life cycle is identical to that described for winter-run Chinook in the DPM.

IOS uses a descriptive and quantitative framework to evaluate the influence of different Central Valley water operations and estimate the long-term response of Sacramento River winter-run Chinook populations to river discharge, temperature, and habitat quality at a reach scale. IOS survival and abundance estimates do not predict future outcomes or actual survival. Rather, IOS provides an estimate of relative survival and abundance to compare alternatives. Generally, IOS results are reported as averages or as probability distributions by years, by months, and/or by water year type, but not as comparisons between specific days, months, or years.

The IOS/DPM model was used to determine how salmonid smolt survival to Chipps Island might be influenced by NODOS. Although the DPM is based on studies of winter-run Chinook surrogates (late fall-run Chinook), it was applied to spring-run and fall-run Chinook salmon by adjusting emigration timing and by assuming that migrating Chinook salmon will respond similarly to Delta conditions.

The IOS/DPM model predicts relative reach-specific survival estimates for winter, spring, and fall-run juvenile Chinook salmon passing through the Delta based on a detailed accounting of migratory pathways and reach-specific mortality as smolts travel through a network of Delta channels. It simulates migration and mortality of juvenile Chinook salmon entering the Delta from the Sacramento, Mokelumne, and San Joaquin Rivers through a simplified Delta channel network, and provides quantitative estimates of relative juvenile Chinook salmon survival through the Delta to Chipps Island.

IOS/DPM Model Assumptions:

The following assumptions were applied in the IOS/DPM model evaluations:

- IOS: The IOS life cycle model for winter-run Chinook salmon incorporates a daily time step.
- DPM: Salmon smolts arriving at Delta distributaries enter downstream reaches in approximate proportion to the flow diverted. Smolt movement in the DPM occurs daily and is a function of reach-specific length and migration speed informed by acoustic tagging studies.

IOS/DPM Model Output:

- Egg to fry survival rates
- Fry to smolt survival rates
- Adult winter-run Chinook salmon escapement (female spawners) rates
- Juvenile migration survival through the Sacramento River upstream of the Delta (e.g., annual passage, annual percent difference); and
- Juvenile migration survival through the Delta (annual percent difference).

Salmonid Population Model (SALMOD) Model (CH2M HILL)

SALMOD is a component of the Instream Flow Incremental Methodology (IFIM). SALMOD simulates population dynamics for salmonids in freshwater but not ocean habitats. SALMOD emulates dynamics of freshwater life history of anadromous and resident salmonid populations using streamflow, water temperature, and habitat type. SALMOD is a spatially explicit model that characterizes habitat quality and carrying capacity using the hydraulic and thermal properties of individual mesohabitats, which are the spatial computational units in the model.

SALMOD was developed as a tool to understand relationships between habitat dynamics and smolt growth, movement, and survival. SALMOD can:

- Quantify the impacts of flow and temperature regimes of alternatives on annual production potential
- Illustrate the differences among water year types
- Identify optimal conditions in terms of habitat, flow, and temperature for attaining maximum growth and production.

SALMOD is organized around events occurring during a biological year, beginning with spawning and typically concluding with fish that are physiologically "ready" (e.g., pre-smolts) swimming downstream toward the ocean. SALMOD operates on a weekly time step for one or more biological years and each year's cohort is independent of each other. Input variables – streamflow, water temperature, number and distribution of adult spawners – are represented by weekly average values.

SALMOD tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of local water temperature. The biological characteristics of fish within a cohort are assumed to be the same. Streamflow and habitat type determine available habitat area for a particular life stage for each time step and computational unit. Habitat area, quantified as weighted usable area (WUA), is computed from flow versus microhabitat area functions developed empirically or by using a physical habitat simulation model. The maximum number of individuals that can reside in each computational unit is calculated for each time step based on streamflow, habitat type, and available microhabitat. This model provides potential fish production values reflecting the suitability of riverine habitat for fall-, late fall-, winter-, and spring-run Chinook salmon.

SALMOD Assumptions

SALMOD represents population dynamics during freshwater life stages of anadromous fish that return to the stream as an adult to spawn. Egg and fish mortality are directly proportional to spatially and temporally variable microhabitat and macrohabitat limitations, which themselves are functions of the timing and quantity of flow and meteorological variables such as air temperature. Model processes include spawning (egg deposition), egg and alevin development and growth, mortality, and movement (due to habitat limitation, freshets, and seasonal stimuli). Pre-smolts do not graduate to the smolt stage in the model. Instead, they exit the study area and the population is reinitialized with survey estimates of spawning adults each biological year.

SALMOD Output

SALMOD estimates annual production potential, or the number of out-migrants, and annual mortality. The model evaluates changes in the Chinook salmon population between Keswick Dam and Red Bluff Diversion Dam. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Annual production potential at RBDD and mortality for each run of Chinook salmon in the Sacramento River were the outputs generated for NODOS. SALMOD results are useful in a comparative analysis and indicate condition (e.g., compliance with a standard) and trend (e.g., generalized impacts).

The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Absolute differences computed at a point in time between model results for an alternative and a baseline to evaluate impacts is an inappropriate use of model results (e.g., computing differences between the results from a baseline and an alternative for a particular day or month and year within the period of record of simulation).

SALMOD results may not allow for interpretation of processes that are not explicitly modeled or that need changes to the assumed parameters and data. Examples are alternatives that include reduced diversions or improvements to rearing habitats. Metrics such as annual production potential and annual mortality of juvenile salmonids help address management-oriented questions.

Comparison of IOS/DPM and SALMOD Models

There are strengths and weakness to IOS/DPM and SALMOD, but a combination of both models can help to evaluate the influence of different Sacramento River water operations and estimate the long-term response of Sacramento River Chinook populations to changing temperature and flow conditions. The SALMOD and IOS/DPM estimate production and mortality and can help quantify the impacts of flow and temperature. As a life-cycle model, IOS incorporates the whole life cycle of a salmonid stock, but only winter-run Chinook salmon was modeled. The IOS/DPM estimates Delta smolt survival for winter-, spring-, and fall-run Chinook salmon using a daily time step. SALMOD uses a weekly time step and is habitat based and looks only at the juvenile (freshwater) life history phase, but it provides output for all four Sacramento Chinook runs. Fish mortality is the loss of fish from a population, and is defined as the number of fish lost or the rate of loss. Determining mortality rates is critical for determining abundance of fish populations. IOS/DPM and SALMOD estimate mortality rates or quantities. IOS uses survival as the final output, but it uses mortality rates to calculate egg to fry and fry to smolt survival.

Results

Climate change and ocean productivity were not considered in IOS/DPM or SALMOD model. Climate change could require the additional projects in the future to capture surface water runoff or alter the flows or temperatures of released reservoir flows. Climate change could affect the ability of a NODOS Alternative to meet the completeness criteria by:

- Increasing ambient temperatures and thereby affecting the coldwater storage of reservoirs by affecting the stored water temperatures and/or thermocline patterns
- Altering the timing or rate of Sierra Nevada snowmelt
- Altering weather patterns and the quantity of precipitation received

The SALMOD model considers the freshwater life history phases of Chinook salmon and does not consider the variety of factors (commercial and/or recreational fishing, variability in food supplies) that affect salmon in the ocean. Consequently, SALMOD may overestimate the number of returning spawners and the potential beneficial effects of the proposed alternative or its ability to meet the primary planning objective related to increased anadromous fish survival. Additional future projects may be required to meet anadromous fish survival objectives.

Similarly, the IOS/DPM and SALMOD models do not address longer-term dynamics in riparian habitats important for long-term survival of Chinook salmon populations. Longer-term dynamics include stream bed mobilization events, riparian vegetation recruitment, and geomorphic events like scour, channel migration, and sediment deposition. Under general geomorphic models of the Sacramento River system, it is expected that five-year flow events are typically required to initiate bed mobilization to prepare bed gravels for redds or flush silt from gravels. Generally, 10-year flow events are required to initiate bed and bank scour to redistribute gravels, and remove vegetation and deposit fresh sediment to create suitable substrate for cottonwood recruitment. Cottonwood recruitment is important for the maintenance of shaded riverine aquatic (SRA) habitat to help maintain suitable water temperatures, contribute organic matter to the water column to support food web production, and to provide large woody debris for instream habitat structures.

Effectiveness

Under NODOS Alternatives A, B, and C, the most substantial expected change shown in the IOS/DPM model is for increased egg-fry and fry-smolt survival during critical years. Egg-fry survival is predicted to increase more than 25 percent under Alternatives A and C, and more than 20 percent under Alternative B. Increased fry-smolt survival is predicted to be the greatest under Alternative B at 20 percent during critical years. Delta survival is predicted to have a slight (less than 5 percent) negative effect by the IOS/DPM model during any water year or Alternative. Female spawner survival is predicted to have a modest increase in survival, generally 5 to 10 percent, under any Alternative or water year. Figure F-1 shows IOS/DPM model estimates of percent changes in Chinook salmon survival by life stage, water year type, and NODOS Alternative. Table F-3, F-4, and F-5 summarize IOS/DPM results and SALMOD model runs by Alternative.

The IOS/DPM and SALMOD models show a slight negative (-1 to -3 percent) impact on Delta survival for winter-, fall- and spring-run Chinook (Figures F-1 and F-2).

SALMOD model results indicate a slight positive (2 to 4 percent) change for annual production for all four stocks under any Alternative in the full simulation period. Dry and critical years, however, are expected to have a more substantial increase in production under any Alternative. In particular, fall-run and late fall-run production is expected to increase 7 to 11 percent. Alternative C shows the largest increase in production during dry and critical years for fall-run, late fall-run, and spring-run Chinook salmon (8 to 12 percent). Winter-run stocks show consistently minor increase, generally 2 to 4 percent, under any Alternative or water year (Figure F-3).

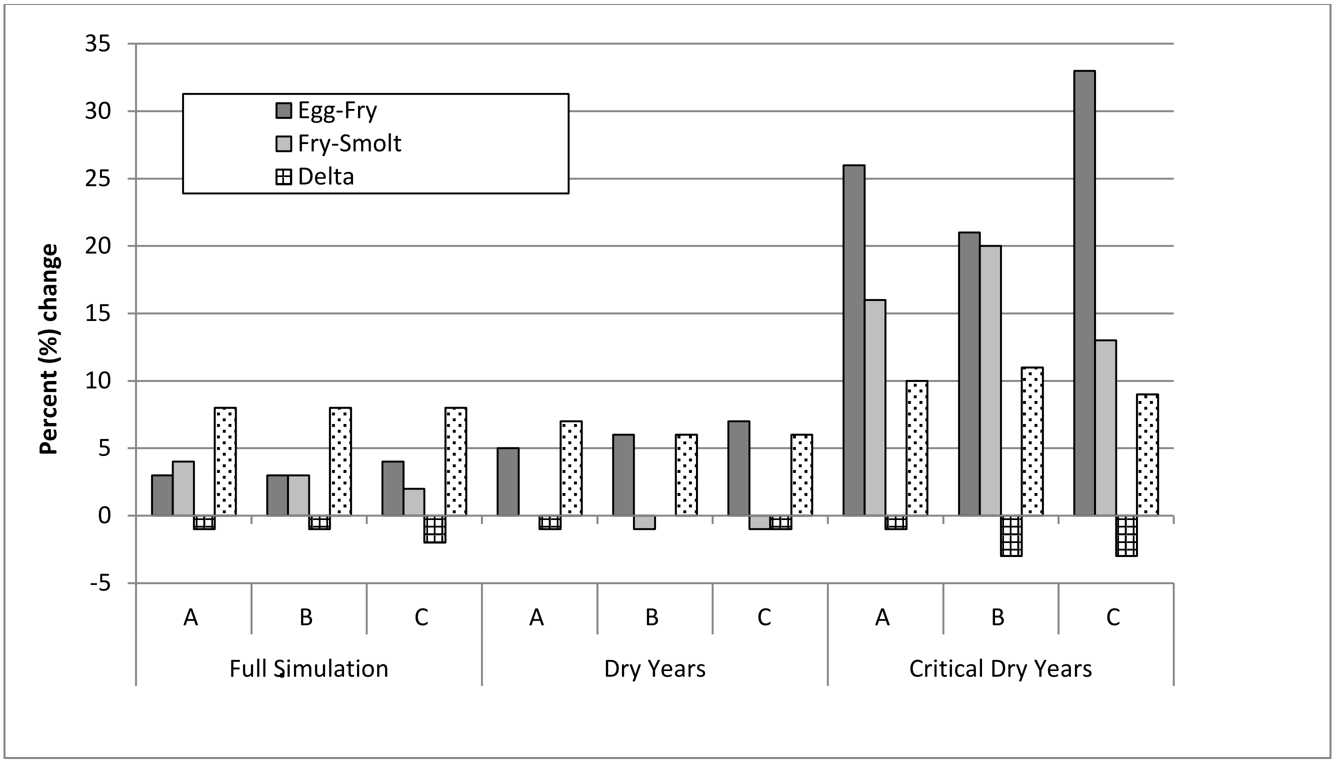


Figure F-1. IOS/DPM Estimates of Percent Change in Winter-Run Chinook Salmon Survival by Life Stage and Water Year Type under NODOS Alternatives A, B, and C

Table F-3. Anticipated Effects of Alternative A Compared to No Project Alternative on Sacramento River Chinook Salmon Populations

Annual Impact, Alternative A	Water Year Type	Fall-Run	Late Fall-Run	Spring-Run	Winter-Run
Returning spawners[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**+**
	Critical year	N/A	N/A	N/A	**+**
Juvenile egg-fry survival rate[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**+**
	Critical year	N/A	N/A	N/A	**++**
Juvenile fry-smolt survival rate[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**0**
	Critical year	N/A	N/A	N/A	**++**
Delta survival rate[a]	Full simulation period	**-**	N/A	**-**	**-**
	Dry year	**-**	N/A	**-**	**-**
	Critical year	**-**	N/A	**-**	**-**
Juvenile production[b]	Full simulation period	**+**	**+**	**+**	**+**
	Dry year	**++**	**0**	**++**	**+**
	Critical year	**++**	**++**	**+**	**+**
Juvenile temperature mortality[b]	Full simulation period	**++**	**++**	**++**	**++**
	Dry year	**++**	**++**	**++**	**++**
	Critical year	**++**	**++**	**++**	**++**
Juvenile flow mortality[b]	Full simulation period	**-**	**0**	**--**	**+**
	Dry year	**-**	**0**	**--**	**+**
	Critical year	**-**	**+**	**0**	**+**
Juvenile combined mortality[b]	Full simulation period	**+**	**+**	**++**	**++**
	Dry year	**++**	**0**	**++**	**++**
	Critical year	**++**	**++**	**++**	**++**

[a] IOS Model
[b] SALMOD Model

++ = Positive change
\+ = Slight positive change
0 = No change
– = Slight negative change
-- = Negative change

Table F-4. Anticipated Effects of Alternative B Compared to No Project Alternative on Sacramento River Chinook Salmon Populations

Annual Impact, Alternative B	Water Year Type	Fall-Run	Late Fall-Run	Spring-Run	Winter-Run
Returning spawners[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**+**
	Critical year	N/A	N/A	N/A	**+**
Juvenile egg-fry survival rate[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**+**
	Critical year	N/A	N/A	N/A	**++**
Juvenile fry-smolt survival rate[a]	Full simulation period	N/A	N/A	N/A	**+**
	Dry year	N/A	N/A	N/A	**-**
	Critical year	N/A	N/A	N/A	**++**
Delta survival rate[a]	Full simulation period	**-**	N/A	**-**	**-**
	Dry year	**-**	N/A	**-**	**0**
	Critical year	**-**	N/A	**-**	**-**
Juvenile production[b]	Full simulation period	**+**	**0**	**+**	**0**
	Dry year	**+**	**0**	**++**	**+**
	Critical year	**++**	**++**	**+**	**0**
Juvenile temperature mortality[b]	Full simulation period	**++**	**++**	**++**	**++**
	Dry year	**++**	**++**	**++**	**++**
	Critical year	**++**	**++**	**+**	**++**
Juvenile flow mortality[b]	Full simulation period	**-**	**0**	**--**	**+**
	Dry year	**-**	**0**	**--**	**+**
	Critical year	**-**	**0**	**-**	**+**
Juvenile combined mortality[b]	Full simulation period	**+**	**0**	**++**	**++**
	Dry year	**++**	**0**	**++**	**++**
	Critical year	**++**	**+**	**+**	**++**

[a] IOS Model
[b] SALMOD Model

++ = Positive change
\+ = Slight positive change
0 = No change
– = Slight negative change
-- = Negative change

Table F-5. Anticipated Effects of Alternative C Compared to No Project Alternative on Sacramento River Chinook Salmon Populations

Annual Impact, Alternative C	Water Year Type	Fall-Run	Late Fall-Run	Spring-Run	Winter-Run
Returning spawners[a]	Full simulation period	N/A	N/A	N/A	+
	Dry year	N/A	N/A	N/A	+
	Critical year	N/A	N/A	N/A	+
Juvenile egg-fry survival rate[a]	Full simulation period	N/A	N/A	N/A	+
	Dry year	N/A	N/A	N/A	+
	Critical year	N/A	N/A	N/A	++
Juvenile fry-smolt survival rate[a]	Full simulation period	N/A	N/A	N/A	+
	Dry year	N/A	N/A	N/A	-
	Critical year	N/A	N/A	N/A	++
Delta survival rate[a]	Full simulation period	-	N/A	-	-
	Dry year	-	N/A	-	-
	Critical year	-	N/A	-	-
Juvenile production[b]	Full simulation period	+	+	+	+
	Dry year	+	0	++	+
	Critical year	++	++	++	+
Juvenile temperature mortality[b]	Full simulation period	++	++	++	++
	Dry year	++	++	++	++
	Critical year	++	++	++	++
Juvenile flow mortality[b]	Full simulation period	-	0	--	+
	Dry year	-	0	--	+
	Critical year	-	+	--	+
Juvenile combined mortality[b]	Full simulation period	+	+	++	++
	Dry year	++	+	++	++
	Critical year	++	++	++	++

[a] IOS Model
[b] SALMOD Model

+ = Positive change
+ = Slight positive change
0 = No change
– = Slight negative change
-- = Negative change

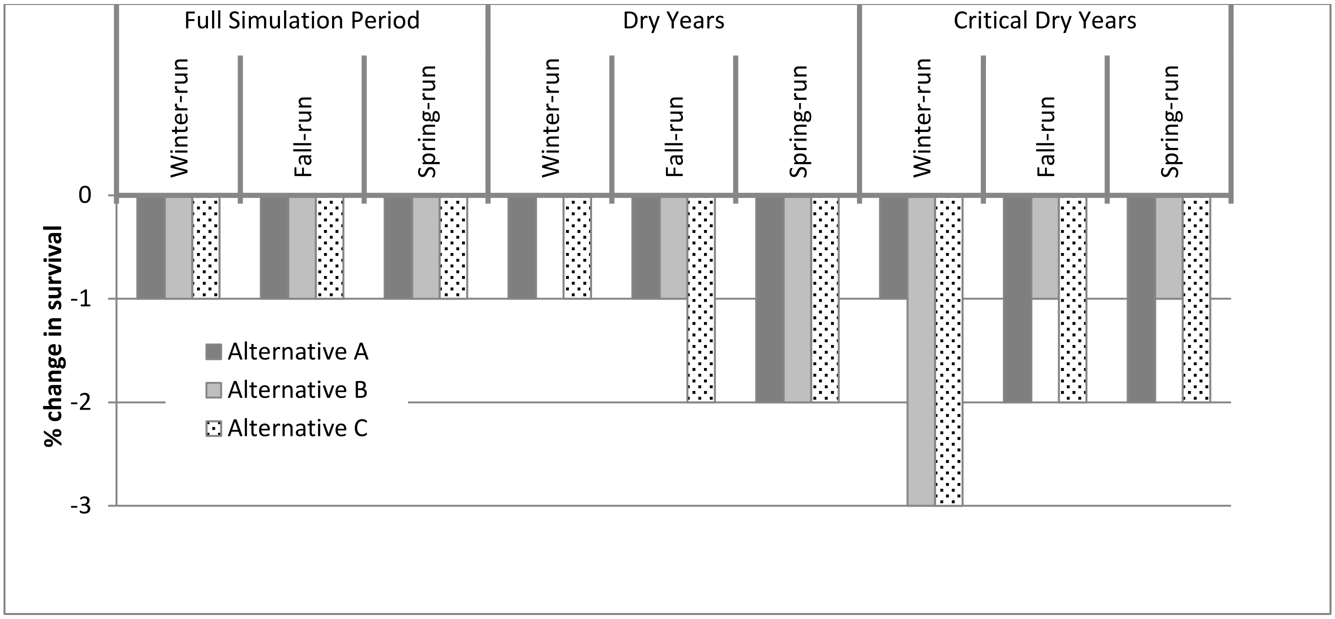


Figure F-2. SALMOD Estimates of Percent Change in Chinook Salmon Delta Survival by Population and Water Year Type under Alternatives A, B, and C

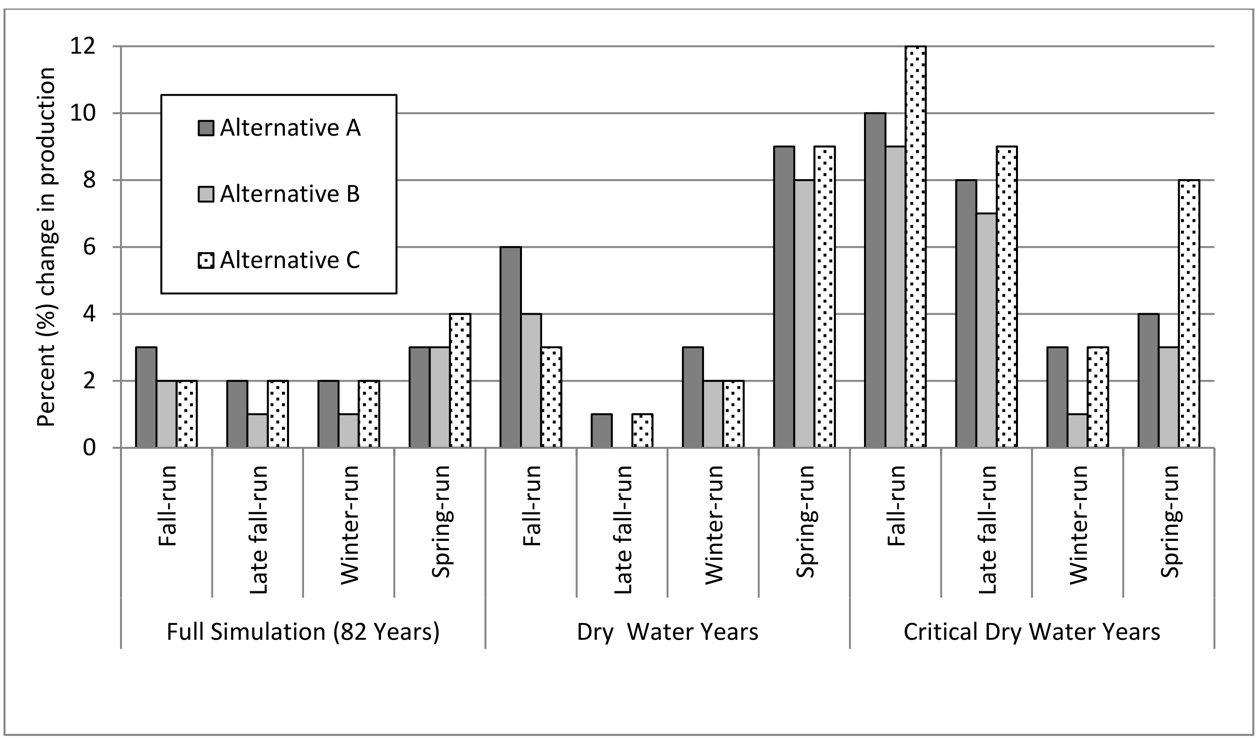


Figure F-3. SALMOD Estimates of Percent Change in Annual Chinook Salmon Production by Stock, Water Year, and NODOS Alternative

The models generally show a decrease in predicted temperature- and flow-related mortality under any water year or Alternative. There is a slight decrease in annual mortality due to flow for winter-run Chinook, no change for late fall-run Chinook under the full simulation and dry water years, and a slight positive change in critical years. Fall-run and spring-run Chinook are expected to have no or minor negative changes during any water year.

The effects of flow and temperature were pooled together for a total combined effect. The effect of temperature was more pronounced in the actual total number of juvenile mortality numbers and, thus, weighted the combined total to a greater extent to which the temperature trends/changes were mirrored in the combined total results. Exceptions were for fall-run and late fall-run Chinook. The full simulation period for fall-run and late fall-run Chinook shows no change to slight positive change. The same pattern was evident for late fall-run Chinook for the dry and critical years but was not seen for fall-run Chinook.

Acceptability

The acceptability of Alternatives A, B, and C will be determined following the receipt of public and regulatory agency input during the public review period of the Draft EIR/EIS.

I. Discussion

IOS/DPM and SALMOD Results

Alternatives A, B, and C are each expected to meet the primary NODOS Project planning objective to increase survival of, and improve instream habitat for, Chinook salmon and other aquatic species in the Sacramento River and tributaries. The expected benefits to Chinook survival appear to be greatest during critical water years and for winter-run and spring-run populations. These stocks are more likely to suffer stress and mortality related to low flows and higher temperatures from late spring through early fall, especially during drier water years.

Alternatives A, B, and C would create potential for modifications to the operation of Shasta, Oroville, and Folsom reservoirs. These modifications would result in changes in flows that would affect water temperatures and instream habitats. Water temperature is a key factor for managing Chinook populations because temperature has a strong influence on the timing of migration, mortality rates, and predator behavior. Alternatives A, B, and C also entail restoration actions on the Sacramento River, including:

- An improved temperature regime below Shasta Lake
- Reduced diversions from the Sacramento River
- Stabilization of flows for anadromous fish

Temperature can be an important influence on the timing of smolt runs. A threshold water temperature or a pattern of variation for a prolonged period may initiate the downstream migration. Evidence suggests there is a strong positive correlation between daytime migratory activity and water temperature. Although many juveniles migrate at higher numbers at night, a temperature cue may be an initial prompt to begin seaward migration.

There are optimum temperatures for Chinook survival and growth in which mortality is minimized. As temperatures reach minimum and maximum threshold values, stress levels elevate and mortality rates increase and affect abundance. Temperature also influences predator feeding behavior. Metabolism increases with temperature; therefore, predators are capable of consuming more prey. Temperature has other physiological effects which may influence the amount of prey consumed as well as the density of the predator itself.

Instream flow is highly influential in the rates at which young salmon migrate. Downstream migration rates and smolt survival in the Delta increase with flow (Groot and Margolis, 1991), presumably due to less time to interact with obstacles and potential threats along the course of the migration when the juvenile Chinook are being carried downstream by high flows.

NODOS alternatives are also expected to have a minor, generally positive impact on aquatic habitats and native fish species in the Delta. By providing an increase in Delta outflow during drier water years and during the summer, NODOS would help maintain an X2 position at 81 km (immediately west of Collinsville) from May through December. This increased downstream flow would increase delta smelt habitat, reduce entrainment risks, and improve food availability.

During NODOS Project operation, water would be diverted from the Sacramento River during higher flows – generally winter months – stored in Sites Reservoir, and released during periods of higher consumptive demand. Water diversions into Sites Reservoir would then occur primarily during times of low ambient temperatures and higher flows when water temperatures and flows are generally not a limiting factor on salmonid survival.

Increased instream flows would decrease temperature when flow and water temperature are more likely to adversely affect salmonid survival. Water temperatures are expected to be lower because the reduced demand for discharges from Shasta Lake, Folsom Lake, and Lake Oroville allow for increased storage of the cold water pools in those reservoirs later into the summer and fall.

Flow benefits for salmonids from operating Sites Reservoir include increased discharges during existing lower flow periods in the spring, summer, and fall. Alternatives A and C, which include a new water diversion at Delevan, would provide an additional benefit to instream flow and aquatic habitat by allowing more water to remain in the mainstem Sacramento River below diversions near Red Bluff and Hamilton City. Maintaining diversions below 2,000 cfs also generally improves the effectiveness of fish screens and result in reduced mortality due to entrainment or impingement.

No single Alternative evaluated provides consistently greater benefit under any water year or for any Chinook stock. SALMOD indicates that temperature changes have a greater effect on mortality than did flow changes. The IOS/DPM model results indicate better survival for winter-run Chinook for egg-to-fry and fry-to-smolt life stages during critical years. The IOS model also predicts escapement (number of female spawners) of winter-run Chinook would be higher during the critical years.

IOS/DPM indicates that juvenile salmonid survival traveling through the Delta would have a minor effect from any NODOS Alternative. Model results indicated a minor decline in juvenile Chinook salmon survival (0 to 2 percent difference, with winter Chinook at 3 percent in critical years) (Figure F-4).

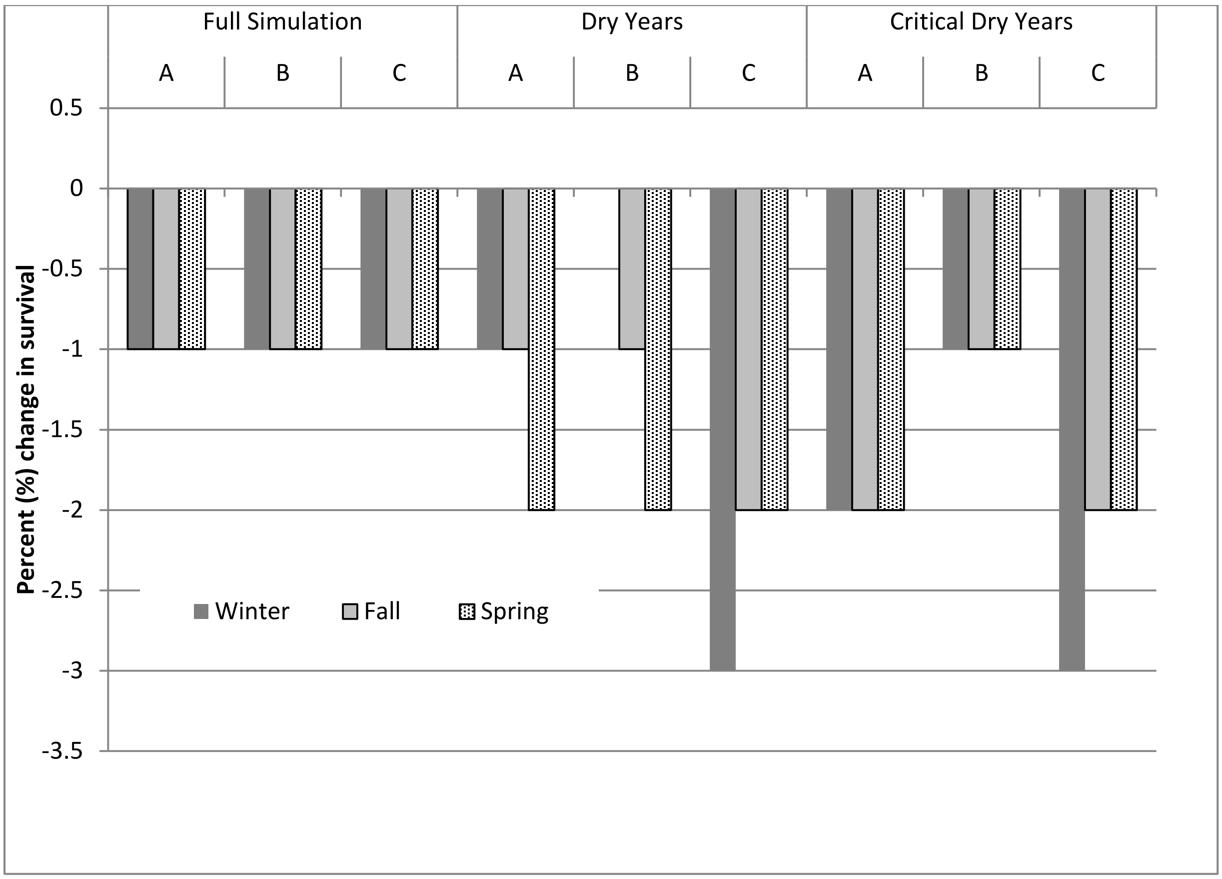


Figure F-4. IOS/DPM Estimates of Percent Change in Survival of Juvenile Chinook in the Delta

ATTACHMENT I

Sacramento River Chinook Salmon Background

Winter-Run Chinook Salmon – Endangered

Winter-run Chinook salmon were listed as endangered on January 4, 1994 (NMFS, 1994, 59 FR 440). This status was reaffirmed on June 28, 2005 (NMFS, 2005a, 70 FR 37160). The ESU includes naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in California. Critical habitat for winter-run Chinook salmon was established effective July 16, 1993 (NMFS, 1993, 58 FR 33212). The critical habitat designation includes the Sacramento River from Keswick Dam to Chipps Island, and waters between Chipps Island and the Golden Gate Bridge and to the north of the San Francisco/Oakland Bay Bridge.

Winter-run Chinook salmon are unique to the Sacramento River system. Winter-run Chinook salmon do not use the San Joaquin River or its tributaries. These fish occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries. Adult winter-run Chinook salmon immigration occurs from November through June (Taylor and Wise, 2008) with a peak during the period extending from January through April (USFWS, 1995). Figure F-5 summarizes the seasonality of the various life stages of winter-run Chinook salmon in the Sacramento River and Delta.

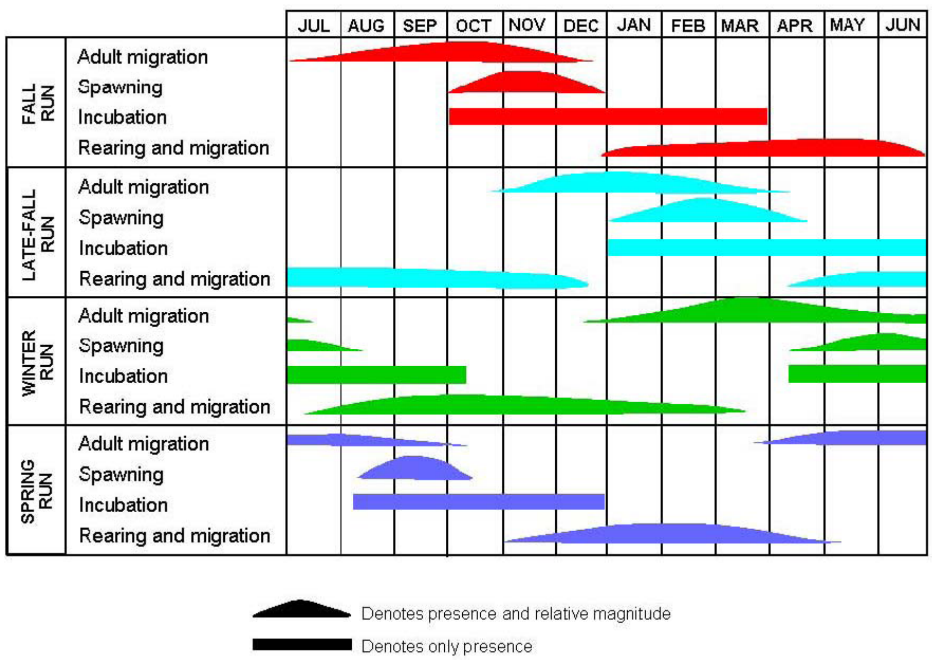


Figure F-5. Life History and Timing of Sacramento River Chinook Salmon Stocks

Winter-run Chinook salmon primarily spawn in the mainstem Sacramento River above RBDD from late-April to September, with the peak generally occurring from late June to early July. Most winter-run Chinook salmon fry only rear for a short period in the Upper Sacramento River above RBDD. They use the Sacramento River from about Red Bluff to the Delta for rearing and emigration and may be present in this area from September through June (Taylor and Wise, 2008). Winter-run Chinook salmon fry may rear for some time in the Delta as well.

The primary threat to winter-run Chinook salmon is the loss and degradation of spawning habitat. Winter-run Chinook salmon are further threatened by having only one small, extant population dependent on artificially created environmental conditions. These fish are further subject to inadequately screened water diversions, predation at artificial structures, nonnative species, pollution, adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures, and vulnerability to drought (Good et al., 2005).

Spring-Run Chinook Salmon – Threatened

On June 28, 2005, NMFS issued its final decision to retain the status of Central Valley spring-run Chinook salmon as threatened (NMFS, 2005a, 70 FR 37160). Designated critical habitat for the Central Valley spring-run Chinook salmon ESU includes 1,158 miles of stream habitat in the Sacramento River basin and 254 square miles of estuary habitat in the San Francisco-San Pablo-Suisun Bay complex (NMFS, 2005b, 70 FR 52488).

Spring-run Chinook salmon are not believed to use the San Joaquin River or its tributaries. They occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries. Spring-run Chinook enter the Delta as sexually immature adults from February through July; peak migration is during April and May (Taylor and Wise, 2008). The adults typically mature in cool, deep pools in rivers upstream of the valley floor during the summer and spawn in suitable habitat adjacent to these areas from August through December, peaking in mid-September (Taylor and Wise, 2008; Moyle, 2002).

Juvenile spring-run Chinook can rear for several months to over a year before emigrating. Most spring-run juveniles emigrate as smolts, although some portion of an annual year-class may emigrate as fry. Emigration timing varies among the tributaries of origin, and can occur during the period extending from November through June (NMFS, 2004b; Taylor and Wise, 2008). Figure F-5 summarizes the seasonality of the various life stages of spring-run Chinook salmon in the Sacramento River and Delta.

The major threats to spring-run Chinook salmon include loss of historical spawning habitat, and the degradation and modification of rearing and migration habitats: reduced instream flow during spring-run migration periods; unscreened or inadequately screened water diversions; predation by nonnative species; and high water temperatures (Good et al., 2005).

Fall-Run Chinook Salmon – Species of Concern

The Central Valley fall-run Chinook salmon ESU was classified as a Species of Concern on April 15, 2004 (NMFS, 2004a, 69 FR 19975). The ESU includes naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento River and SJR basins and their tributaries east of Carquinez Strait, California (NMFS, 1999, 64 FR 50394).

The fall run is the largest run of Chinook salmon. The fall run supports commercial and recreational fisheries along the Pacific Coast and in the Sacramento River and Delta. Fall-run Chinook salmon are already sexually maturing as they enter the freshwater environment and are typically ready to spawn within days once they reach their spawning areas. Adult Chinook salmon annually migrate upstream through the Delta from August through December. The spawning peak occurs upstream of the Delta from October through March, depending on the spawning location (Taylor and Wise, 2008).

More than 90 percent of the entire run has entered rivers by the end of November and migration and spawning can continue into December. Fall-run Chinook salmon migrate downstream through the Delta between February and June (Taylor and Wise, 2008). The Delta is considered to be the major rearing area for fall-run juveniles from the fry to smolt life stages. Figure F-5 summarizes the seasonality of the various life stages of fall-run Chinook salmon in the Sacramento River and Delta.

Late Fall-Run Chinook Salmon – Species of Concern

The Central Valley late fall-run Chinook salmon ESU was classified as a Species of Concern on April 15, 2004 (NMFS, 2004a, 69 FR 19975). The ESU includes naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento River and SJR basins and their tributaries east of Carquinez Strait, California (NMFS, 1999, 64 FR 50394).

Late fall-run Chinook salmon occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries. Adult immigration of late fall-run Chinook salmon through the Delta generally begins in October, peaks in December, and ends in April (Moyle, 2002) during a period of typically high, fluctuating flows. Spawning occurs upstream of the Delta from January to March, although it may extend into April in dry years. Late fall-run juveniles emigrate from their spawning and rearing areas to the Delta from October through March (Taylor and Wise 2008). Figure F-5 summarizes the seasonality of the various life stages of late fall-run Chinook salmon in the Sacramento River and Delta.

The majority of emigrating juveniles are smolt-sized by the time they reach the lower Sacramento River and Delta, typically from November through January. Occurrence of late fall-run juveniles in the lower river appears to coincide with the first storms. However, the later the first storm occurs, the fewer late fall-run juveniles that successfully migrate to the Delta (Snider and Titus, 2000a; 2000b). Some rearing may occur in the Delta during emigration.

Other Fish Species

Green Sturgeon – Threatened

On June 6, 2006, the Southern DPS (consisting of coastal and Central Valley populations south of Eel River) of green sturgeon were listed as threatened (NMFS, 2006, 71 FR 17757). Critical habitat has not yet been designated for this DPS.

The green sturgeon is an anadromous, native fish that occurs in low numbers in the Bay/Delta system (Moyle, 2002). Adults tend to be more marine-oriented than the more common white sturgeon. In freshwater, green sturgeon use the Sacramento River and its major tributaries, but migrate through and may forage and rear in the Delta. green sturgeon are not believed to use the San Joaquin River or its tributaries (NMFS, 2006, 71 FR 17757).

Adults begin their upstream migration in March, and enter the Sacramento River until the end of September (Taylor and Wise, 2008). Spawning occurs upstream of the Delta from February through July, with peak activity believed to occur from April through June (Taylor and Wise, 2008; Moyle et al., 1995). Green sturgeon spawning occurs predominately in the Upper Sacramento River (NMFS, 2002). Juvenile green sturgeon spend 1 to 3 years in freshwater prior to emigrating to the ocean (NMFS, 2005c).

Green sturgeon population threats include vulnerability due to concentration of spawning habitat, smaller population size, lack of population data, potentially growth-limiting and lethal temperature tolerances, harvest concerns, loss of spawning habitat, entrainment by water projects, and influence of toxic material and exotic species (NMFS, 2002).

ATTACHMENT II

SALMOD Model Results

The following figures summarize SALMOD model results for fall-run, late fall-run, winter-run, and spring-run Chinook salmon from the operation of NODOS Alternatives A, B, and C during the full simulation period (82 years), dry water years, and critical water years.

Table F-6. Estimated SALMOD percent change in fall-run Chinook salmon mortality due to temperature, flow, and combined effects by water year type and NODOS Alternative.

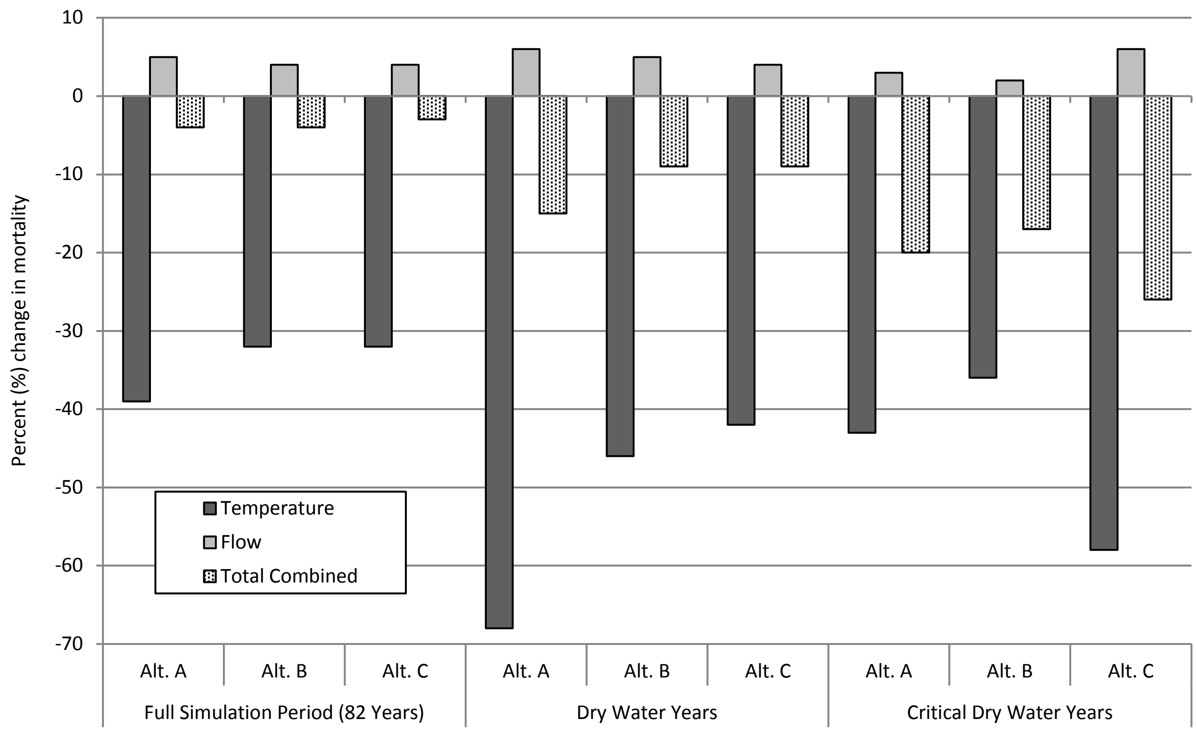


Table F-7. Estimated SALMOD percent change in late fall-run Chinook salmon mortality due to temperature, flow, and combined effects by water year type and NODOS Alternative.

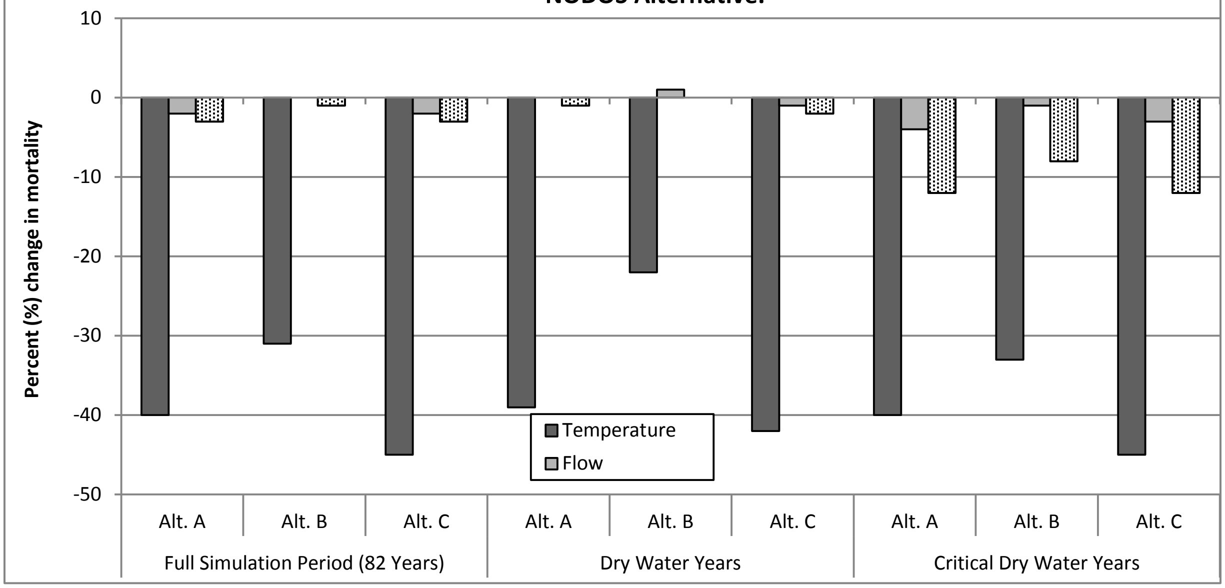
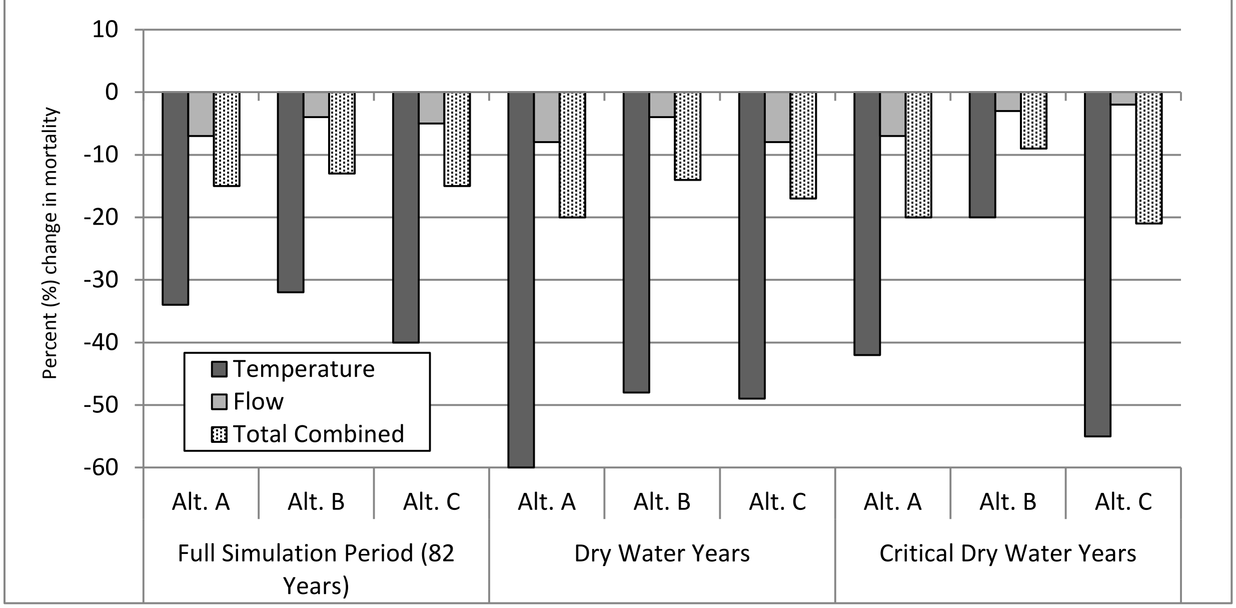


Table F-8. Estimated SALMOD percent change in winter-run Chinook salmon mortality due to temperature, flow, and combined effects by water year type and NODOS Alternative.



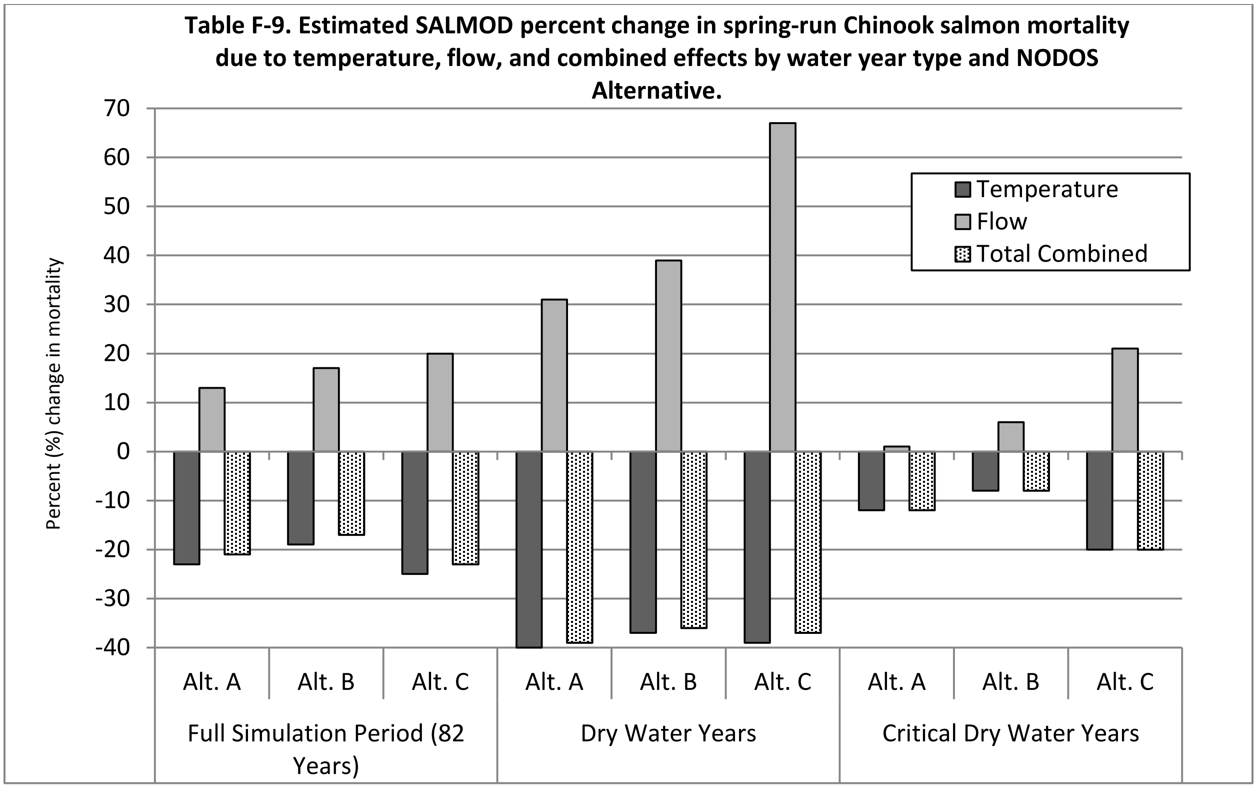


Table F-9. Estimated SALMOD percent change in spring-run Chinook salmon mortality due to temperature, flow, and combined effects by water year type and NODOS Alternative.
70
60
50
40
30
20
10
0
-10
-20
-30
-40
Percent (%) change in mortality
Temperature
Flow
Total Combined
Alt. A
Alt. B
Alt. C
Alt. A
Alt. B
Alt. C
Alt. A
Alt. B
Alt. C
Full Simulation Period (82 Years)
Dry Water Years
Critical Dry Water Years

Figure F-10. SALMOD estimated change in percent mortality by NODOS Alternative to Chinook salmon stocks during the full simulation period (82 years).

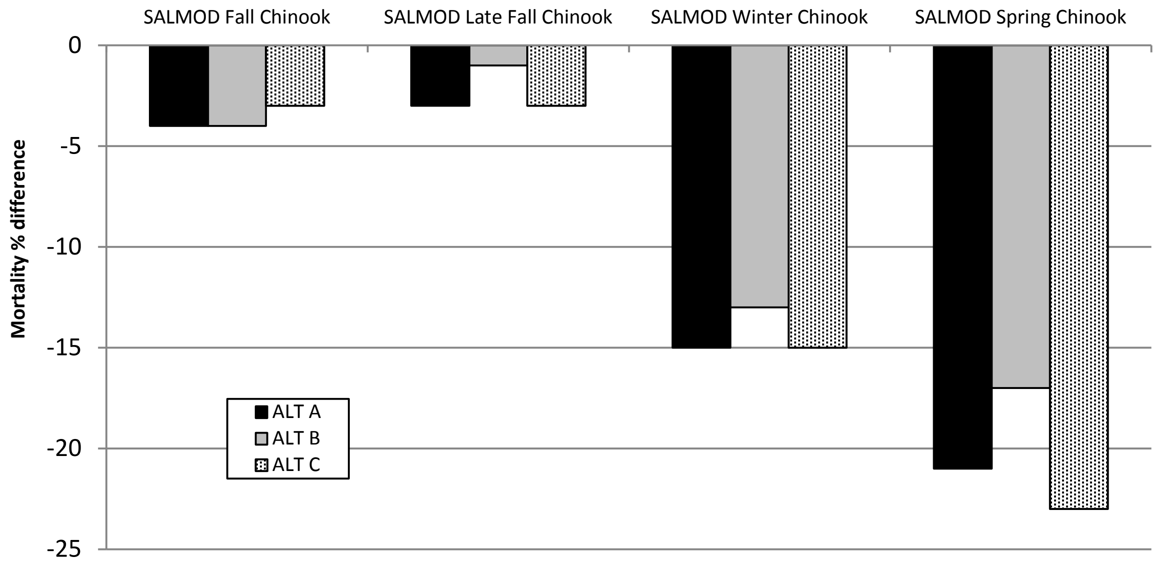


Figure F-11. SALMOD estimated change in percent mortality by NODOS Alternative to Chinook salmon stocks during dry water years.

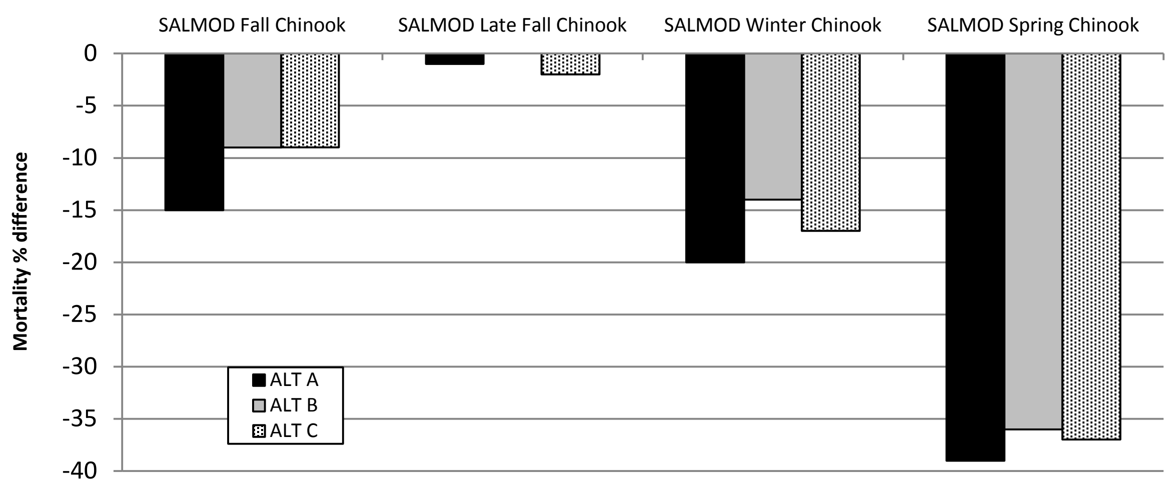
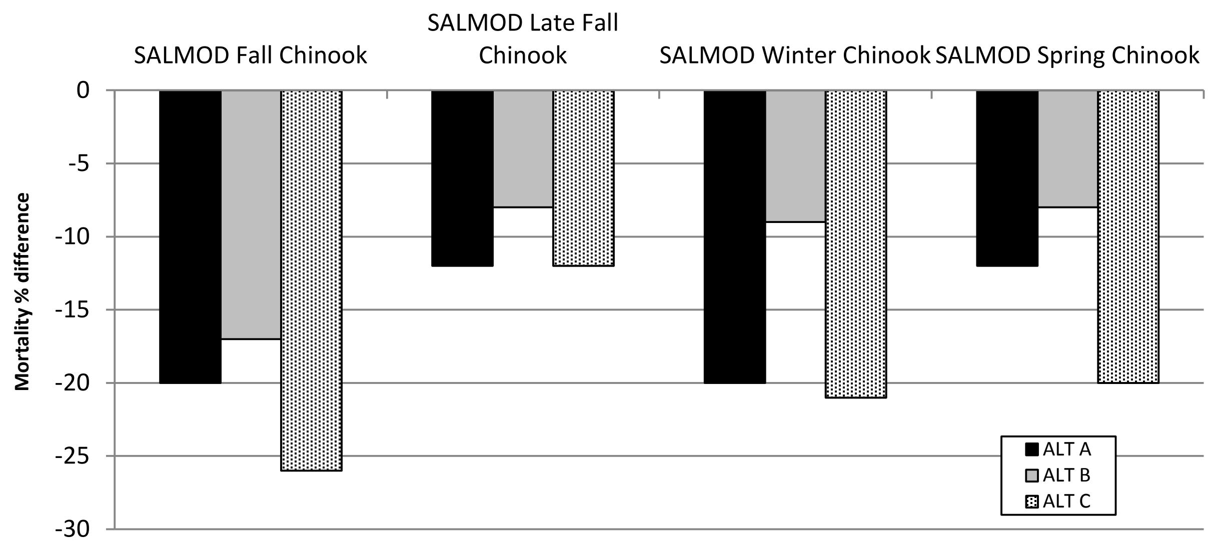


Figure F-12. SALMOD estimated change in percent mortality by NODOS Alternative to Chinook salmon stocks during dry water years.



This page intentionally left blank

APPENDIX F-1

Fish Enhancement
Non-Operational Actions

F1 NODOS FISH EVALUATION

I. Methodology

Completeness

An evaluation of completeness was performed to determine if any projects, in addition to the considered alternatives, would be required to fulfill the project objectives. The completeness analysis of the alternatives was based on an evaluation of the assumptions included in the models described above. This assumption evaluation determined if the models did not consider factors that could affect the ability of the proposed alternatives to meet the project objectives and, thereby, require the implementation of additional projects.

Effectiveness

Assumptions for modeling of NODOS Alternatives:

Ecosystem enhancement actions (EEA) included in proposed Alternatives:

- Improve the reliability of coldwater pool storage in Shasta Lake
- Provide releases from Shasta Dam of appropriate water temperatures, to maintain mean daily water temperatures in the Sacramento River year-round during Below Normal, Dry, and Critical water year types.
- Increase the availability of coldwater pool storage in Folsom Lake, to maintain mean daily water temperatures at levels in the lower American River from May through November during all water year types
- Provide supplemental Sacramento-San Joaquin Delta (Delta) outflow during summer and fall months to improve X2 (if possible, west of Collinsville, 81 kilometers)
- Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability from May through November during all water year types
- Stabilize flows in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) particularly during fall months
- Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at RBDD and at Hamilton City

Fish Model Comparison

SALMOD was developed as a tool to understand the linkage between habitat dynamics and smolt growth, movement, and survival. It can quantify the impacts of flow and temperature regimes of alternatives on annual production potential. SALMOD can illustrate the differences among water year types and can identify the optimal conditions in terms of habitat, flow, and temperature for attaining maximum growth and production. However, sufficient care should be taken while assessing alternatives that include processes not explicitly modeled in SALMOD or that need changes to the assumed parameters and data. Alternatives that include reduced diversions or improvements to rearing habitats are a few examples. Metrics such as annual production potential and annual mortality of juvenile salmonids help address management-oriented questions.

Interactive object-oriented simulation (IOS) uses a descriptive and quantitative framework to evaluate the influence of different Central Valley water operations and estimate the long-term response of Sacramento River winter-run Chinook populations to changing environmental conditions (e.g., river discharge, temperature, habitat quality at a reach scale). Survival, and abundance estimates generated by IOS are not intended to predict future outcomes or to predict actual survival. Rather, this model provides an estimate of relative of survival and abundance which is useful for making comparisons between proposed operation alternatives. Generally, the model results are appropriately reported as averages or as probability distributions by years, by months, and/or by water year type, but not as comparisons between specific days, months, or years. The IOS/Delta Passage Model (DPM) model was used to determine how salmonid smolt survival to Chipps Island might be influenced by the proposed actions of NODOS. Although the DPM is primarily based on studies of winter-run Chinook surrogates (late fall-run Chinook), it was applied to spring-run and fall-run Chinook salmon by adjusting emigration timing and by assuming that all migrating Chinook salmon will respond similarly to Delta conditions.

Both of these models are similar in that they both provide estimates of production and mortality that can help quantify the impacts of flow and temperature, but in a slightly different approach. IOS is a life cycle model that incorporates the whole life cycle of a salmonid stock, but was only modeled for winter-run Chinook salmon. The IOS/DPM model provides Delta smolt survival for winter-, spring-, and fall-run Chinook salmon. It uses a daily time step while SALMOD uses a weekly time step. SALMOD is habitat-based and only looks at the juvenile (freshwater) life history phase, but it provides output for all four Sacramento Chinook stocks (winter-, spring-, fall-, and late fall-run). There are strengths and weakness to both models, but a combination of both models may help to evaluate the influence of different Sacramento River water operations and estimate the long-term response of Sacramento River Chinook populations to changing temperature and flow conditions.

“Fish mortality” is a term widely used in fisheries science that denotes the loss of fish from a stock. Determining mortality rates is critical to determine the abundance of fish populations. “Mortality Rate” is an output for the SALMOD model and is defined as the number of fish lost or the rate of loss. The IOS model uses survival as the final output, but it uses mortality rates to calculate egg to fry and fry to smolt survival. “Survival Rate” is defined as the number of fish alive after a specified time interval, divided by the initial number, usually on a yearly basis. Mortality rate is the inverse of the survival rate.

II. Attachment A

A. Winter Run Chinook Life Cycle Model (WRCLCM) IOS/DPM Model (Cramer Fish Sciences)

The IOS model is a life cycle model that provides a quantitative framework to evaluate the accumulated effects of river flow, water temperature, flow diversions, and habitat conditions on multiple life stages (eggs, alevins, fry, parr, smolts, subadults and adults) of the Sacramento River winter-run Chinook salmon population. Winter-run Chinook spawn in the upper reaches of California's Sacramento River, migrate downriver and through the Delta to the Pacific Ocean, and return to the Upper Sacramento River to spawn. This model simulates all life stages of winter-run Chinook salmon and models individual daily cohorts of fish throughout their entire life cycle. Individual life stages are modeled using functional relationships, whose form and parameter values are informed by the best available information from literature. These functional relationships for each life stage are then linked together to form a complete life cycle model that estimates the daily number of eggs for each brood year and progresses them through life stage transitions until spawning at age 3 or 4 where the process begins again for the next generation.

The Cramer Fish Sciences-developed DPM predicts relative reach-specific survival estimates for winter-, spring-, and fall-run juvenile Chinook salmon passing through the Delta, based on a detailed accounting of migratory pathways and reach-specific mortality as smolts travel through a network of Delta channels. It simulates migration and mortality of juvenile Chinook salmon entering the Delta from the Sacramento River, the Mokelumne River, and the San Joaquin River through a simplified Delta channel network, and provides quantitative estimates of relative juvenile Chinook salmon survival through the Delta to Chipps Island.

Assumptions:

IOS: The IOS life cycle model for winter-run Chinook salmon incorporates a daily time step.

DPM: Salmon smolts arriving at distributaries enter downstream reaches in approximate proportion to the flow diverted. Smolt movement in the DPM occurs daily and is a function of reach-specific length and migration speed informed by acoustic tagging studies.

Model Output:

- Egg to Fry Survival
- Fry to Smolt Survival
- Adult winter-run Chinook salmon escapement (female spawners)
- IOS predicts juvenile migration survival through the Sacramento River upstream of the Delta (e.g., annual passage annual percent difference)

- DPM predicts juvenile migration survival through the Delta (annual percent difference)

B. Salmonid Population Model (SALMOD) Model (CH2M HILL)

SALMOD is a component of the Instream Flow Incremental Methodology(IFIM). SALMOD simulates population dynamics for salmonids in freshwater and does not include population dynamics for ocean habitat. It emulates the dynamics of the freshwater life history of anadromous and resident salmonid populations using streamflow, water temperature, and habitat type. SALMOD is a spatially explicit model that characterizes habitat quality and carrying capacity using the hydraulic and thermal properties of individual mesohabitats, which are the spatial computational units in the model. The model tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of local water temperature. SALMOD is organized around events occurring during a biological year beginning with spawning and typically concluding with fish that are physiologically “ready” (e.g., pre-smolts) to swim downstream toward the ocean. It operates on a weekly time step for one or more biological years and each year’s cohort is independent of each other. Input variables (e.g., streamflow, water temperature, number and distribution of adult spawners) are represented by their weekly average values. Streamflow and habitat type determine available habitat area for a particular life stage for each time step and computational unit. Habitat area (quantified as weighted usable area or WUA) is computed from flow versus microhabitat area functions developed empirically or by using the habitat model PHABSIM. The maximum number of individuals that can reside in each computational unit is calculated for each time step based on streamflow, habitat type, and available microhabitat. This model provides potential fish production values reflecting the suitability of riverine habitat for winter-, spring-, fall-, and late fall-run Chinook salmon.

SALMOD Assumptions:

Egg and fish mortality are directly proportional to spatially and temporally variable microhabitat and macrohabitat limitations, which themselves are functions of the timing and quantity of flow and other meteorological variables, such as air temperature. SALMOD represents the population dynamics during the freshwater life stages of an anadromous fish species that returns to the stream as an adult to spawn. Model processes include spawning (egg deposition), egg and alevin development and growth, mortality, and movement (due to habitat limitation, freshets, and seasonal stimuli). Pre-smolts do not graduate to the smolt stage within the model. Instead, they exit the study area and the population is reinitialized with survey estimates of spawning adults each biological year.

SALMOD Output:

Annual production potential or the number of outmigrants, and annual mortality of are some of the reporting metrics available from SALMOD. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Juvenile Chinook salmon annual production potential for each run of Chinook salmon in the Sacramento River at

RBDD and juvenile Chinook salmon annual mortality for each run of Chinook salmon in the Sacramento River were the outputs generated for NODOS. The model results from SALMOD are only useful in a comparative analysis and can only serve as an indicator of condition (e.g., compliance with a standard) and of trend (e.g., generalized impacts). Absolute differences computed at a point in time between model results from an alternative and a baseline to evaluate impacts is an inappropriate use of model results (e.g., computing differences between the results from a baseline and an alternative for a particular day or month and year within the period of record of simulation). The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values.

This page intentionally left blank

III. Attachment B

A. Sacramento River Chinook Salmon Background

1. Winter-Run Chinook Salmon – Endangered

Winter-run Chinook salmon were listed as endangered on January 4, 1994 (NMFS, 1994, 59 FR 440). This status was reaffirmed on June 28, 2005 (NMFS, 2005a, 70 FR 37160). The evolutionary significant unit (ESU) includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in California. Critical habitat for winter-run Chinook salmon was established effective July 16, 1993 (NMFS, 1993, 58 FR 33212). The critical habitat designation includes the Sacramento River from Keswick Dam to Chipps Island, and all waters between Chipps Island and the Golden Gate Bridge and to the north of the San Francisco/Oakland Bay Bridge.

Winter-run Chinook salmon are unique to the Sacramento River system. Winter-run Chinook salmon do not use the San Joaquin River or its tributaries. These fish occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries.

Adult winter-run Chinook salmon immigration occurs from November through June (Taylor and Wise, 2008) with a peak during the period extending from January through April (USFWS, 1995). Winter-run Chinook salmon primarily spawn in the mainstem Sacramento River above RBDD from late-April to September, with the peak generally occurring from late June to early July.

Most winter-run Chinook salmon fry only rear for a short period in the Upper Sacramento River above RBDD. They use the Sacramento River from near Red Bluff to the Delta for rearing and emigration, and may be present in this area from September through June (Taylor and Wise, 2008).

Winter-run Chinook salmon fry may rear for some time in the Delta as well. The primary threat to winter-run Chinook salmon is the loss and degradation of spawning habitat. Winter-run Chinook salmon are further threatened by having only one small, extant population dependent on artificially created environmental conditions. These fish are further subject to inadequately screened water diversions, predation at artificial structures, nonnative species, pollution, adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures, and vulnerability to drought (Good et al., 2005).

2. Spring-Run Chinook Salmon – Threatened

On June 28, 2005, NMFS issued its final decision to retain the status of Central Valley spring-run Chinook salmon as threatened (NMFS, 2005a, 70 FR 37160).

Designated critical habitat for the Central Valley spring-run Chinook salmon ESU includes 1,158 miles of stream habitat in the Sacramento River basin and 254 square miles of estuary habitat in the San Francisco-San Pablo-Suisun Bay complex (NMFS, 2005b, 70 FR 52488).

Spring-run Chinook salmon are not believed to use the San Joaquin River or its tributaries, and occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries.

Spring-run Chinook enter the Delta as sexually immature adults from February through July; peak migration is during April-May (Taylor and Wise, 2008). The adults typically mature in cool, deep pools in rivers upstream of the valley floor during the summer and spawn in suitable habitat adjacent to these areas from August through December, peaking in mid-September (Taylor and Wise 2008; Moyle, 2002). Juvenile spring-run Chinook can rear for several months to over a year before emigrating. Most spring-run juveniles emigrate as smolts, although some portion of an annual year-class may emigrate as fry. Emigration timing varies among the tributaries of origin, and can occur during the period extending from November through June (NMFS, 2004b; Taylor and Wise, 2008).

The major threats to spring-run Chinook salmon include loss of historical spawning habitat, and the degradation and modification of rearing and migration habitats: reduced instream flow during spring-run migration periods, unscreened or inadequately screened water diversions, predation by nonnative species, and high water temperatures (Good et al., 2005).

3. Fall-Run Chinook Salmon – Species of Concern

The Central Valley fall-run Chinook salmon ESU was classified as a Species of Concern on April 15, 2004 (NMFS 2004a, 69 FR 19975). The ESU includes all naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento River and San Joaquin River basins and their tributaries east of Carquinez Strait, California (NMFS 1999, 64 FR 50394).

The fall-run is the largest run of Chinook salmon. The fall-run supports significant commercial and recreational fisheries along the Pacific Coast and in the area of analysis.

Fall-run Chinook salmon are already sexually maturing as they enter the freshwater environment and typically are ready to spawn within days once they reach their spawning areas. Adult Chinook salmon annually migrate upstream through the Delta from August through December. The spawning peak occurs upstream of the Delta from October through March, depending on the spawning location (Taylor and Wise, 2008). More than 90 percent of the entire run has entered all the rivers by the end of November and migration and spawning can continue into December. Fall-run Chinook salmon migrate downstream through the Delta between February and June (Taylor and Wise, 2008). The Delta is considered to be the major rearing area for fall-run juveniles from the fry to smolt life stages.

4. Late Fall-Run Chinook Salmon – Species of Concern

The Central Valley late fall-run Chinook salmon ESU was classified as a Species of Concern on April 15, 2004 (NMFS 2004a, 69 FR 19975). The ESU includes all naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento River and San Joaquin River basins and their tributaries east of Carquinez Strait, California (NMFS 1999, 64 FR 50394).

Late fall-run Chinook salmon would occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries.

Adult immigration of late fall-run Chinook salmon through the Delta generally begins in October, peaks in December, and ends in April (Moyle, 2002) during a period of typically high, fluctuating flows. Spawning occurs upstream of the Delta from January to March, although it may extend into April in dry years. Late fall-run juveniles emigrate from their spawning and rearing areas to the Delta from October through March (Taylor and Wise, 2008). The majority of emigrating juveniles are smolt-sized by the time they reach the lower Sacramento River and Delta, typically from November through January.

Occurrence of late fall-run juveniles in the lower river appears to coincide with the first storms. However, the later the first storm occurs, the fewer late fall-run juveniles successfully migrate to the Delta (Snider and Titus 2000a, b). Some rearing may occur in the Delta during emigration.

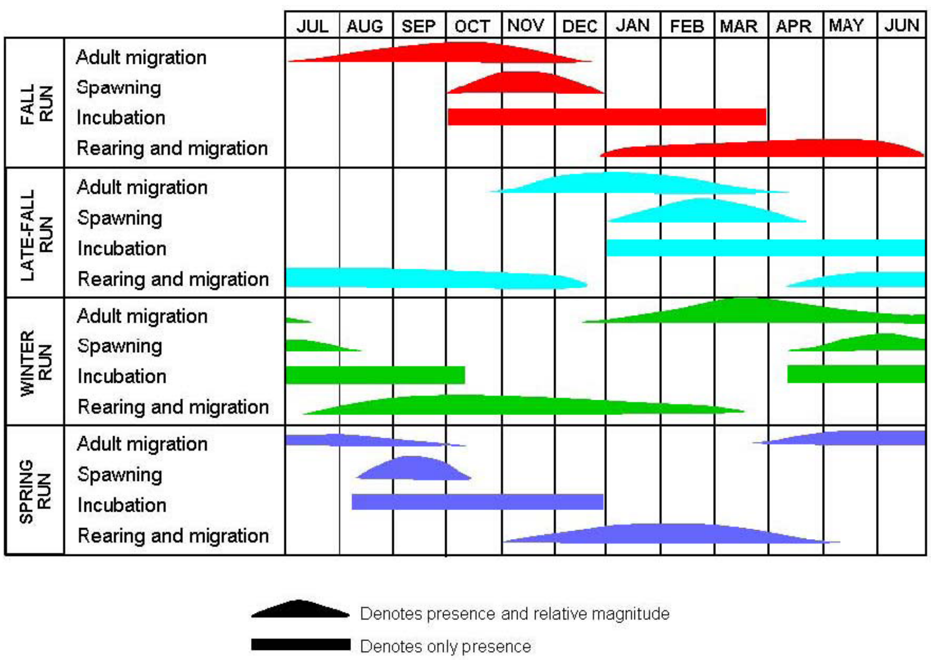


Figure F.1-1. Life History and Timing of Sacramento River Chinook Salmon Stocks

B. Other Fish Species of Concern

Green Sturgeon – Threatened

On June 6, 2006, the Southern distinct population segment (DPS) (consisting of coastal and Central Valley populations south of Eel River) of green sturgeon were listed as threatened (NMFS, 2006, 71 FR 17757). Critical habitat has not yet been designated for this DPS.

The green sturgeon is an anadromous, native fish that occurs in low numbers in the Bay/Delta system (Moyle, 2002). Adults tend to be more marine-oriented than the more common white sturgeon. In freshwater, green sturgeon use the Sacramento River and its major tributaries, but migrate through and may forage and rear in the Delta. They are not believed to use the San Joaquin River or its tributaries (NMFS, 2006, 71 FR 17757).

Adults begin their upstream migration in March (Taylor and Wise, 2008), and enter the Sacramento River until the end of September (Taylor and Wise, 2008). Spawning occurs upstream of the Delta from February through July, with peak activity believed to occur from April to June (Taylor and Wise, 2008; Moyle et al., 1995). Green sturgeon spawning occurs predominately in the Upper Sacramento River (National Marine Fisheries Service [NMFS], 2002). Juvenile green sturgeon spend one to three years in freshwater prior to emigrating to the ocean (NMFS, 2005c).

Green sturgeon population threats include vulnerability due to concentration of spawning habitat, smaller population size, lack of population data, potentially growth-limiting and lethal temperature tolerances, harvest concerns, loss of spawning habitat, entrainment by water projects, and influence of toxic material and exotic species (NMFS, 2002).

Delta Smelt – Threatened

Delta smelt (Hypomesus transpacificus) was listed as threatened under the ESA in 1993. Factors thought to have contributed to the decline of the species include reductions in freshwater outflow, entrainment losses to water diversions, entrainment at power plant intakes, changes abundance and composition of food organisms, environmental contaminants, and competition and predation from exotic invasive aquatic species.

Delta smelt are a euryhaline species (tolerant of a wide salinity range). They have been collected from estuarine waters up to 14 parts per thousand (ppt) salinity. For a large part of their one-year life span, delta smelt live along the freshwater edge of the mixing zone (saltwater-freshwater interface), where the salinity is approximately 2 ppt. Shortly before spawning, adults migrate upstream from the brackish-water habitat associated with the mixing zone and disperse widely into river channels and tidally influenced backwater sloughs. They spawn in shallow, fresh, or slightly brackish water upstream of the mixing zone. Most spawning happens in tidally influenced backwater sloughs and channel edgewaters. Although spawning has not been observed in the wild, the eggs are thought to attach to substrates such as cattails, tules, tree roots, and submerged branches.

IV. Attachment C

Table 1. Anticipated Effects of Alternative A Compared to No ProjectAlternative on Sacramento River Chinook Salmon Stocks

Alternative A	Water Year Type	Winter-Run	Fall-Run	Late Fall-Run	Spring-Run
Annual Returning Chinook Spawners[a]	Full Simulation Period	**+**	N/A	N/A	N/A
	Dry Period	**+**	N/A	N/A	N/A
	Critical Years	**+**	N/A	N/A	N/A
Annual Juvenile Chinook Egg-Fry Survival Rates[a]	Full Simulation Period	**+**	N/A	N/A	N/A
	Dry Period	**+**	N/A	N/A	N/A
	Critical Years	**++**	N/A	N/A	N/A
Annual Juvenile Chinook Fry-Smolt Survival Rates[a]	Full Simulation Period	**+**	N/A	N/A	N/A
	Dry Period	**0**	N/A	N/A	N/A
	Critical Years	**++**	N/A	N/A	N/A
Annual Chinook Delta Survival Rates[a]	Full Simulation Period	**-**	**-**	N/A	**-**
	Dry Period	**-**	**-**	N/A	**-**
	Critical Years	**-**	**-**	N/A	**-**
Annual Juvenile Chinook Production[b]	Full Simulation Period	**+**	**+**	**+**	**+**
	Dry Period	**+**	**++**	**0**	**++**
	Critical Years	**+**	**++**	**++**	**+**
Annual Juvenile Chinook Temperature Mortality[2]	Full Simulation Period	**++**	**++**	**++**	**++**
	Dry Period	**++**	**++**	**++**	**++**
	Critical Years	**++**	**++**	**++**	**++**
Annual Juvenile Chinook Flow Mortality[b]	Full Simulation Period	**+**	**-**	**0**	**--**
	Dry Period	**+**	**-**	**0**	**--**
	Critical Years	**+**	**-**	**+**	**0**
Annual Juvenile Chinook Combined Mortality[b]	Full Simulation Period	**++**	**+**	**+**	**++**
	Dry Period	**++**	**++**	**0**	**++**
	Critical Years	**++**	**++**	**++**	**++**

++ Positive Change
+ Slight Positive Change
0 No Change
– Negative Change
- Slight Negative Change

[a] IOS Model
[b] SALMOD Model

N/A = not applicable

Table 2. Anticipated Effects of Alternative B Compared to No Project Alternative on Sacramento River Chinook Salmon Stocks

Alternative B	Water Year Type	Winter-Run	Fall-Run	Late Fall-Run	Spring-Run
Annual Returning Chinook Spawners[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	+	N/A	N/A	N/A
	Critical Years	+	N/A	N/A	N/A
Annual Juvenile Chinook Egg-Fry Survival Rates[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	+	N/A	N/A	N/A
	Critical Years	++	N/A	N/A	N/A
Annual Juvenile Chinook Fry-Smolt Survival Rates[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	-	N/A	N/A	N/A
	Critical Years	++	N/A	N/A	N/A
Annual Chinook Delta Survival Rates[a]	Full Simulation Period	-	-	N/A	-
	Dry Period	0	-	N/A	-
	Critical Years	-	-	N/A	-
Annual Juvenile Chinook Production[b]	Full Simulation Period	0	+	0	+
	Dry Period	+	+	0	++
	Critical Years	0	++	++	+
Annual Juvenile Chinook Temperature Mortality[b]	Full Simulation Period	++	++	++	++
	Dry Period	++	++	++	++
	Critical Years	++	++	++	+
Annual Juvenile Chinook Flow Mortality[b]	Full Simulation Period	+	-	0	--
	Dry Period	+	-	0	--
	Critical Years	+	-	0	-
Annual Juvenile Chinook Combined Mortality[b]	Full Simulation Period	++	+	0	++
	Dry Period	++	++	0	++
	Critical Years	++	++	+	+

++ Positive Change
+ Slight Positive Change
0 No Change
– Negative Change
- Slight Negative Change

[a] IOS Model
[b] SALMOD Model

N/A = not applicable

Table 3. Anticipated Effects of Alternative C Compared to No Project Alternative on Sacramento River Chinook Salmon Stocks

Alternative C	Water Year Type	Winter-Run	Fall-Run	Late Fall-Run	Spring-Run
Annual Returning Chinook Spawners[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	+	N/A	N/A	N/A
	Critical Years	+	N/A	N/A	N/A
Annual Juvenile Chinook Egg-Fry Survival Rates[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	+	N/A	N/A	N/A
	Critical Years	++	N/A	N/A	N/A
Annual Juvenile Chinook Fry-Smolt Survival Rates[a]	Full Simulation Period	+	N/A	N/A	N/A
	Dry Period	-	N/A	N/A	N/A
	Critical Years	++	N/A	N/A	N/A
Annual Chinook Delta Survival Rates[a]	Full Simulation Period	-	-	N/A	-
	Dry Period	-	-	N/A	-
	Critical Years	-	-	N/A	-
Annual Juvenile Chinook Production[b]	Full Simulation Period	+	+	+	+
	Dry Period	+	+	0	++
	Critical Years	+	++	++	++
Annual Juvenile Chinook Temperature Mortality[b]	Full Simulation Period	++	++	++	++
	Dry Period	++	++	++	++
	Critical Years	++	++	++	++
Annual Juvenile Chinook Flow Mortality[b]	Full Simulation Period	+	-	0	--
	Dry Period	+	-	0	--
	Critical Years	+	-	+	--
Annual Juvenile Chinook Combined Mortality[b]	Full Simulation Period	++	+	+	++
	Dry Period	++	++	+	++
	Critical Years	++	++	++	++

++ Positive Change
+ Slight Positive Change
0 No Change
– Negative Change
- Slight Negative Change

[a] IOS Model
[b] SALMOD Model

N/A = not applicable

Fish Graphics IOS Model Results

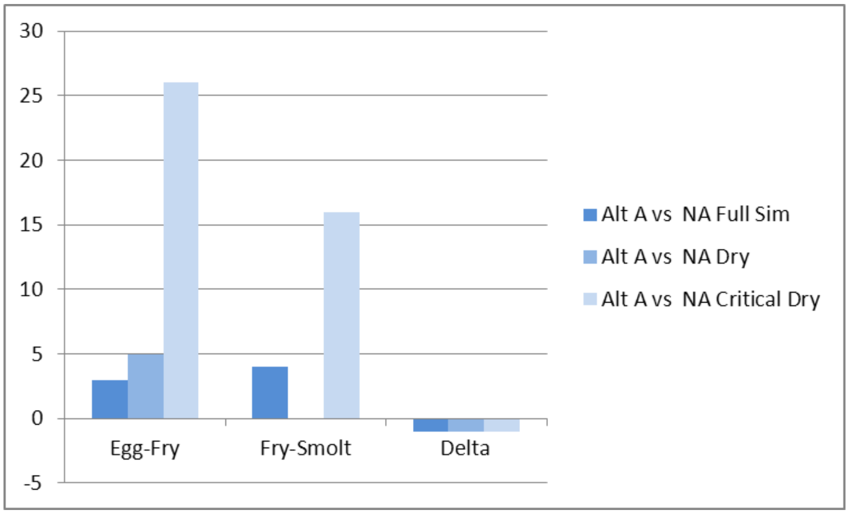


Figure F.1-2. Anticipated Effects of Alternative A Compared to No Project Alternative on Sacramento River Winter-Run Chinook Salmon Survival (IOS Model)

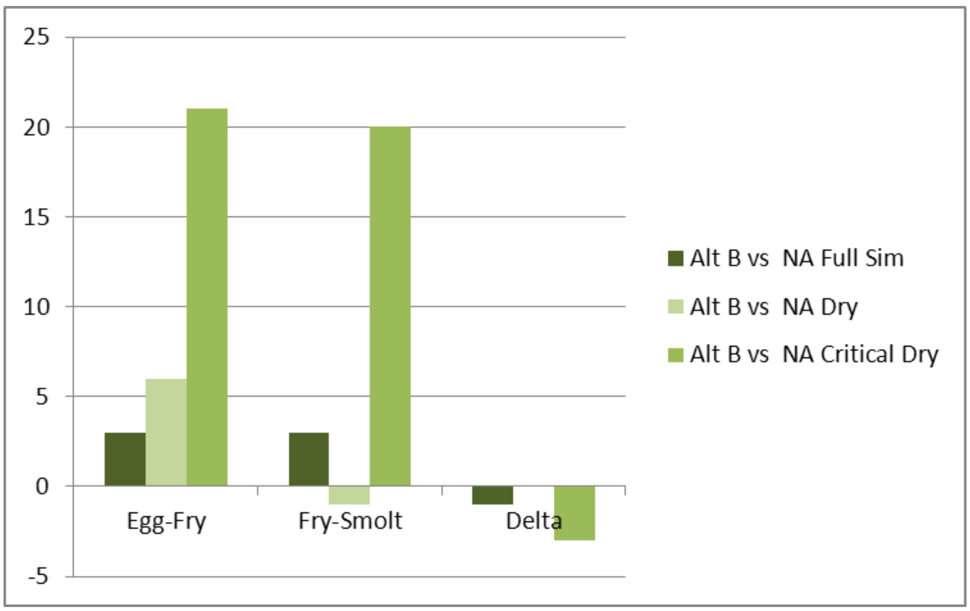


Figure F.1-3. Anticipated Effects of Alternative B Compared to No Project Alternative on Sacramento River Winter-Run Chinook Salmon Survival (IOS Model)

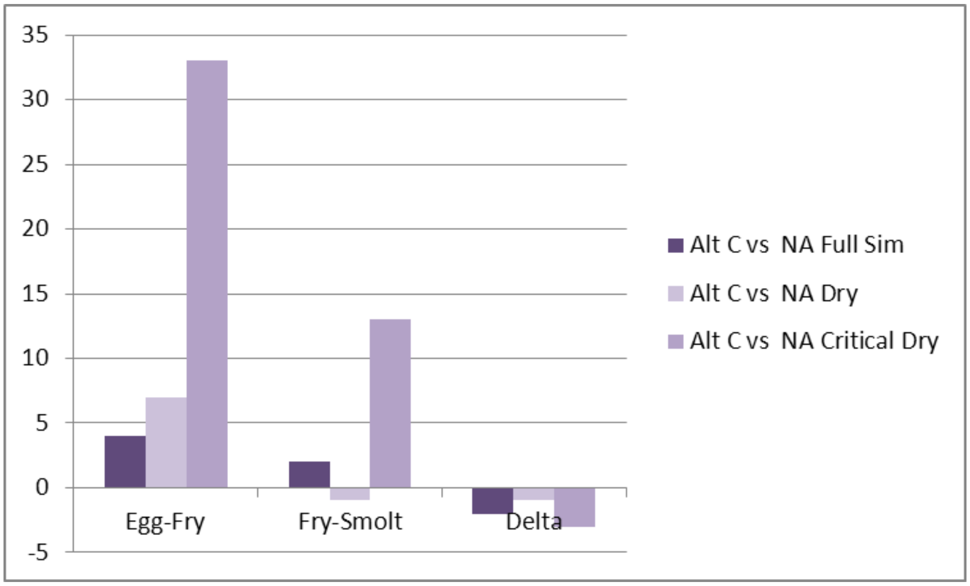
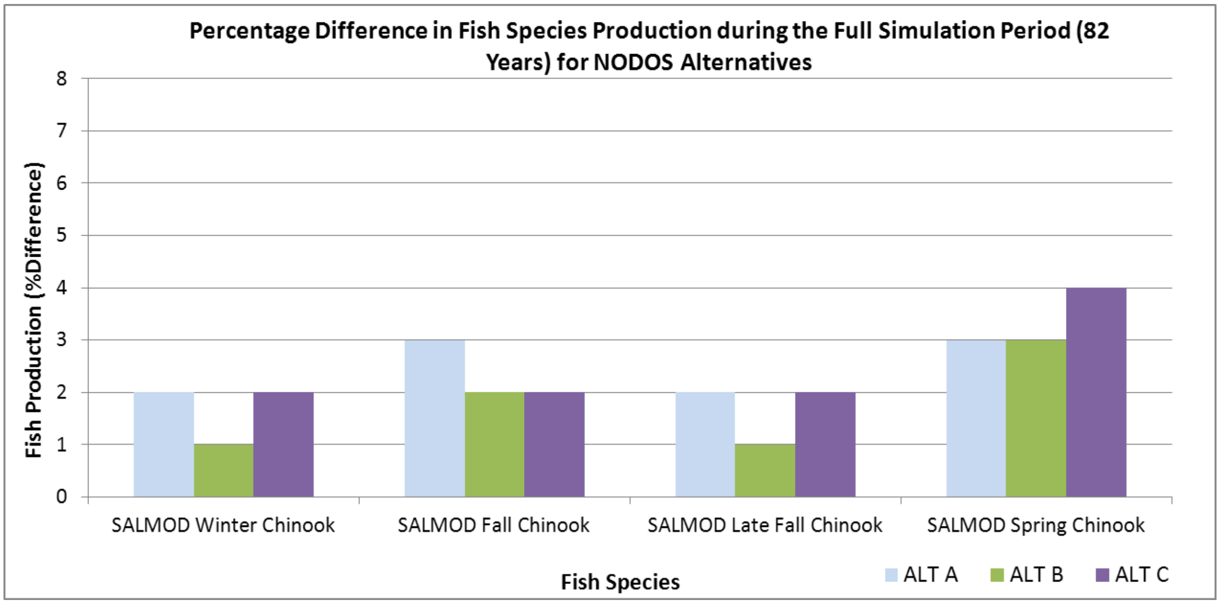
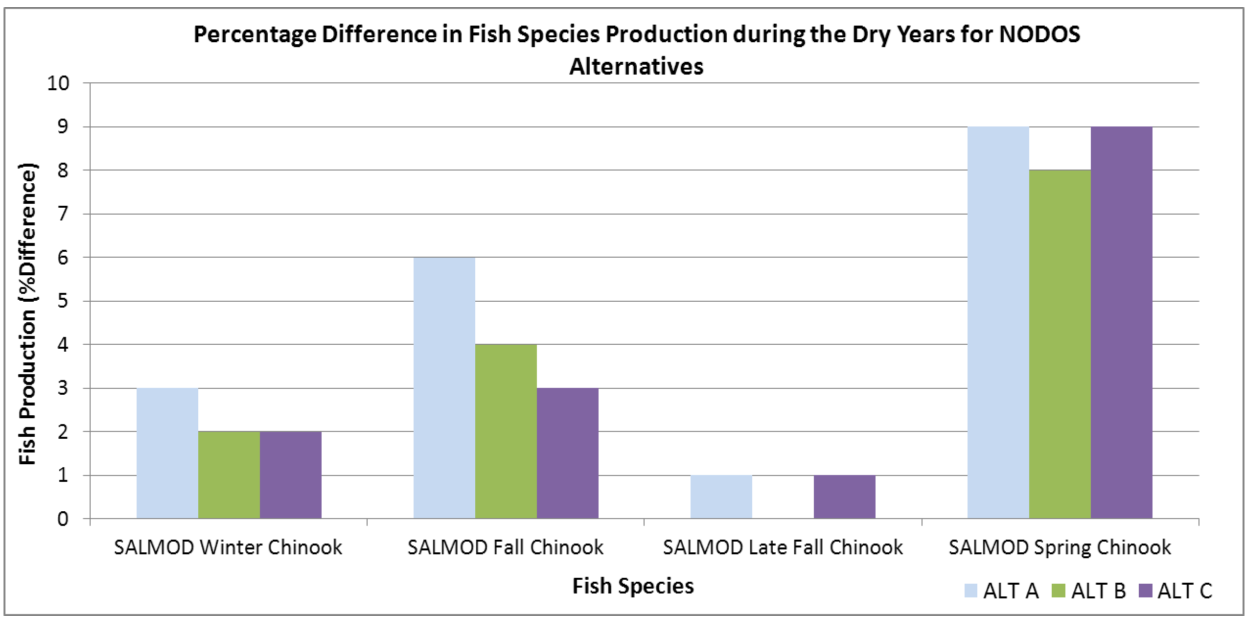
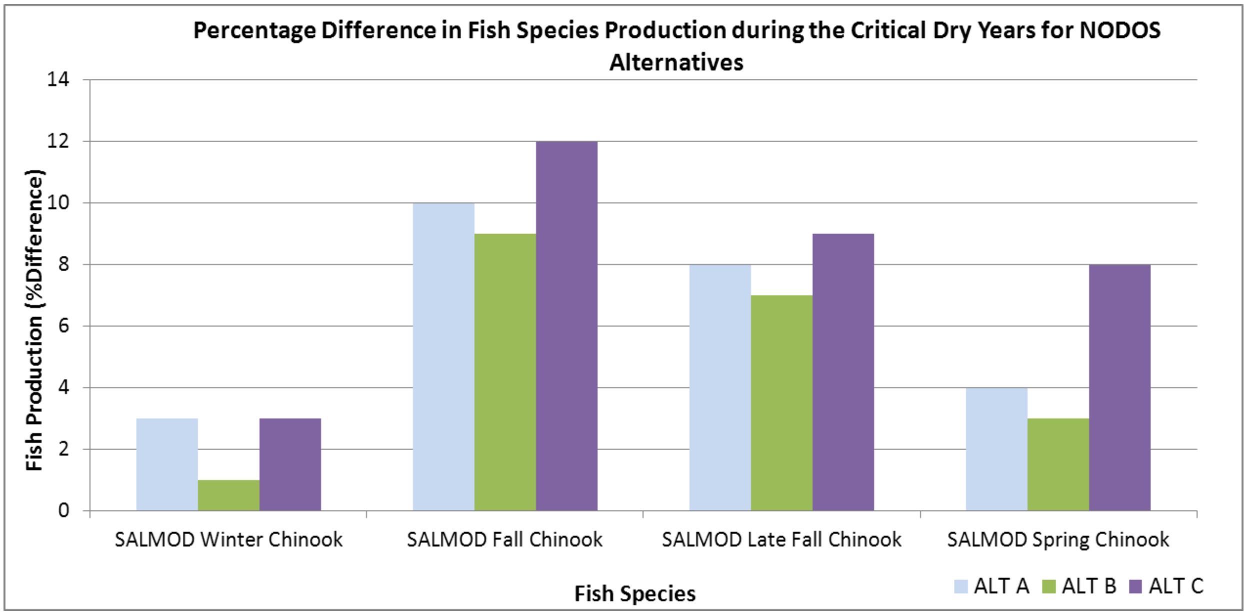


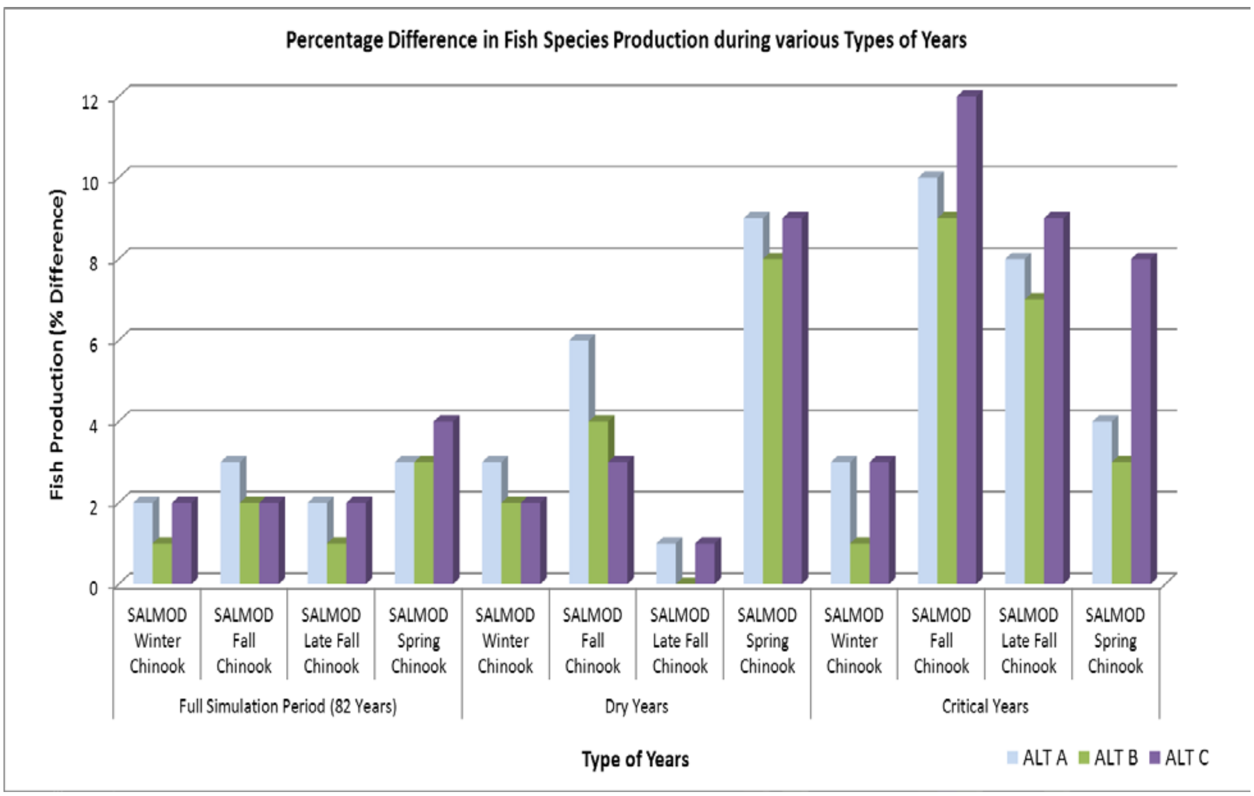
Figure F.1-4. Anticipated Effects of Alternative C Compared to No Project Alternative on Sacramento River Winter-Run Chinook Salmon Survival (IOS Model)

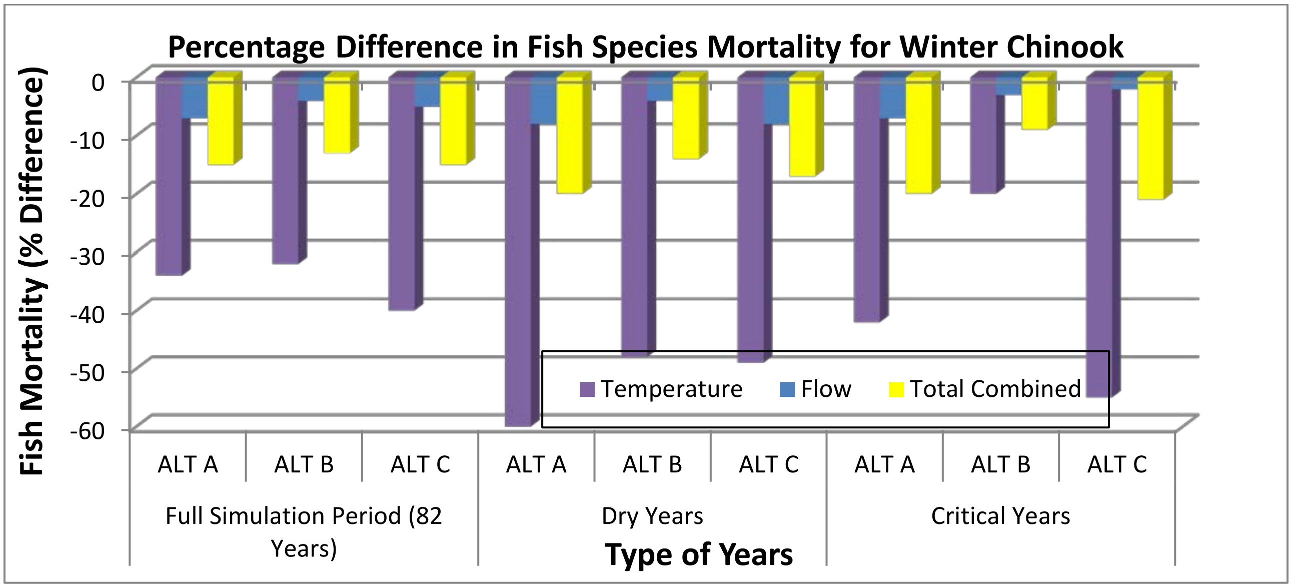
Fish Graphics SALMOD Model Results

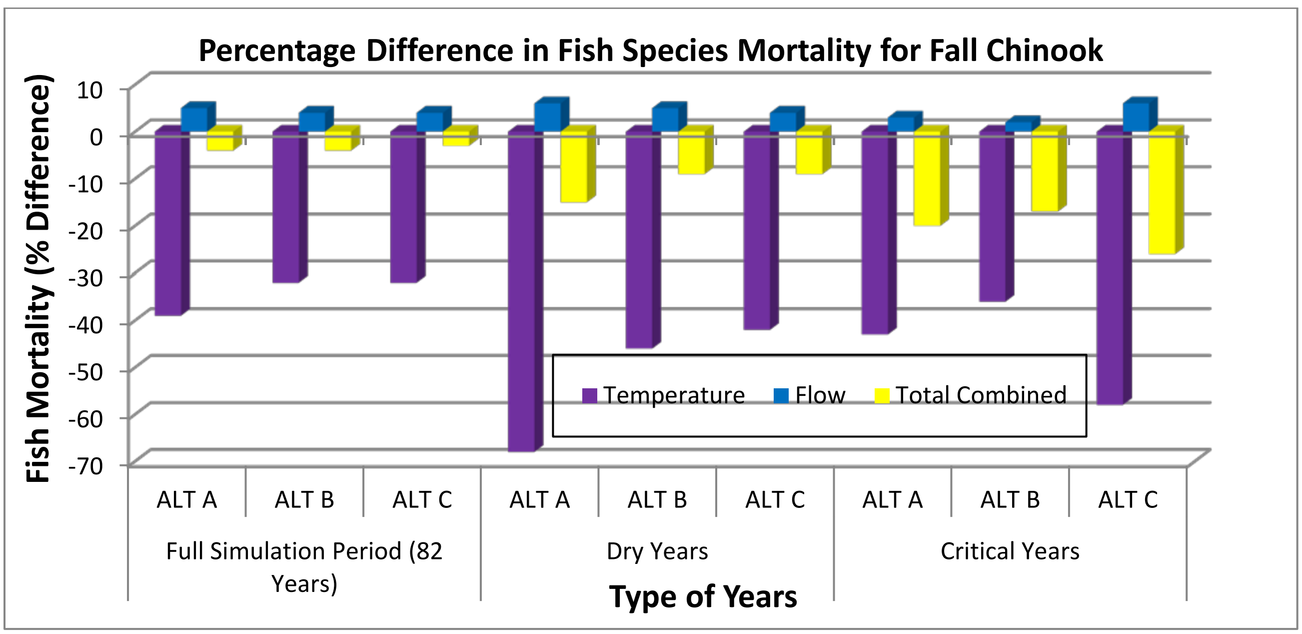


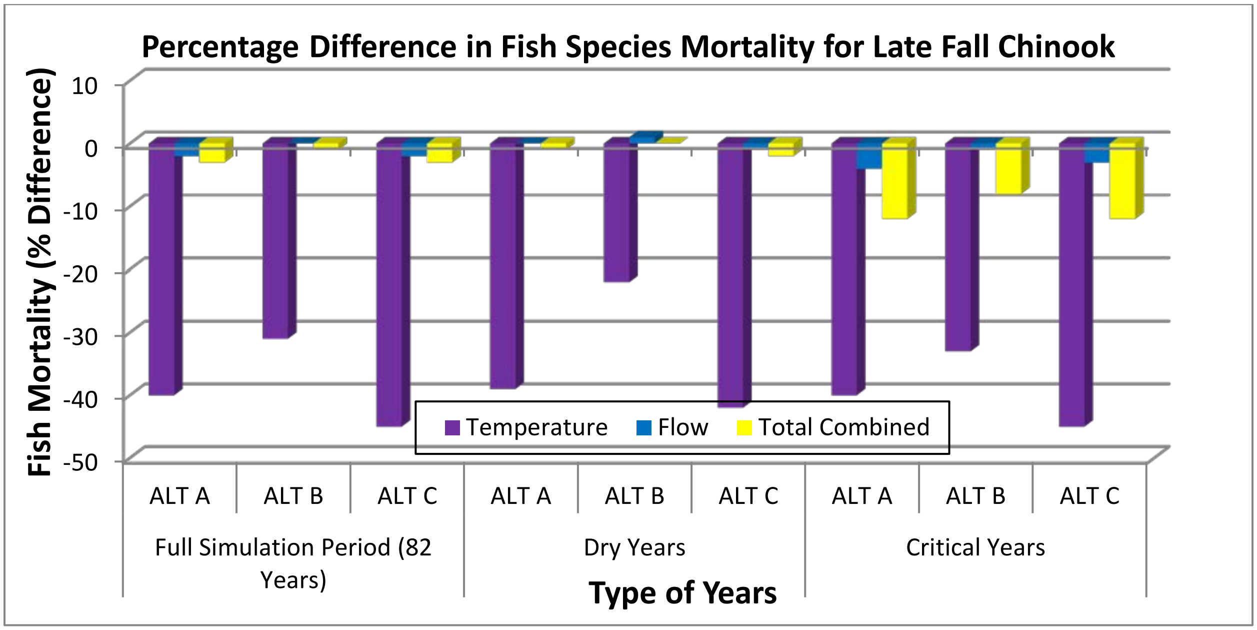


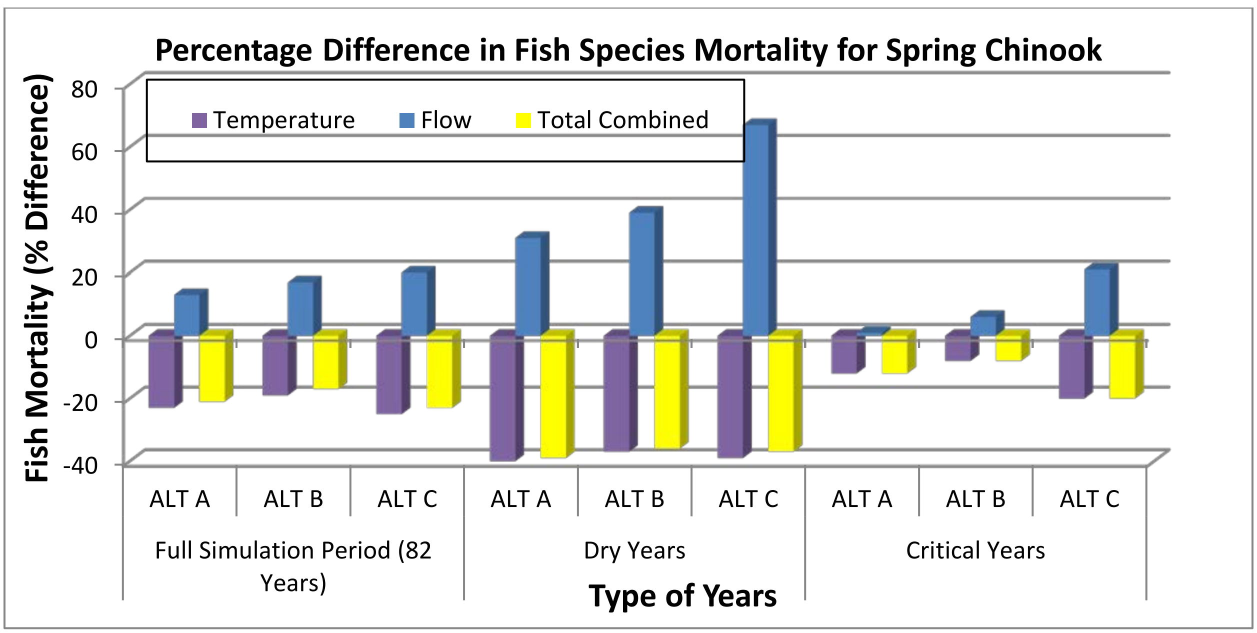

Percentage Difference in Fish Species Production during the Critical Dry Years for NODOS Alternatives
Fish Production (%Difference)
14
12
10
8
6
4
2
0
SALMOD Winter Chinook
SALMOD Fall Chinook
SALMOD Late Fall Chinook
SALMOD Spring Chinook
Fish Species
ALT A
ALT B
ALT C

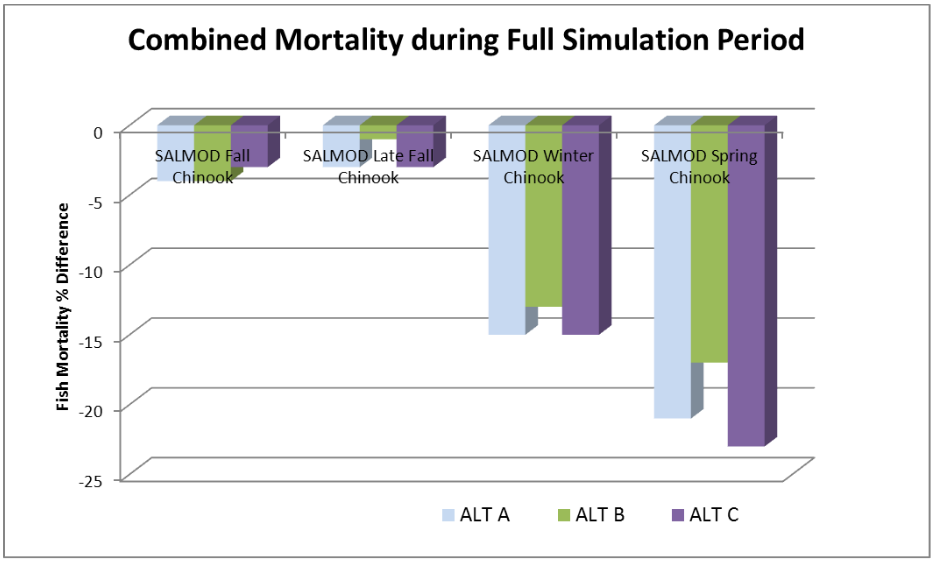

Percentage Difference in Fish Species Production during various Types of Years
Fish Production (% Difference)
12
10
8
6
4
2
0
SALMOD Winter Chinook
SALMOD Fall Chinook
SALMOD Late Fall Chinook
SALMOD Spring Chinook
Full Simulation Period (82 Years)
Dry Years
Critical Years
Type of Years
ALT A
ALT B
ALT C

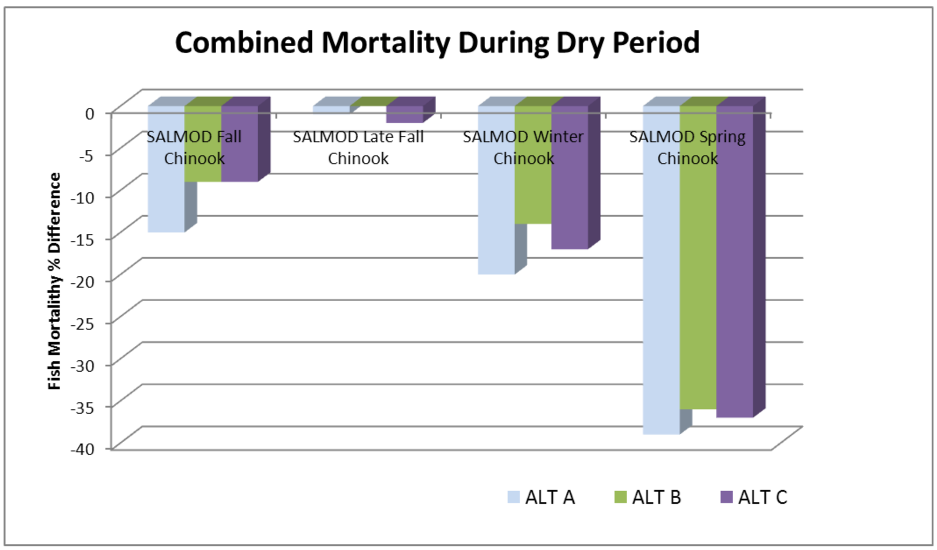

Percentage Difference in Fish Species Mortality for Winter Chinook
Fish Mortality (% Difference)
0
-10
-20
-30
-40
-50
-60
Temperature
Flow
Total Combined
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
Full Simulation Period (82 Years)
Dry Years
Critical Years
Type of Years

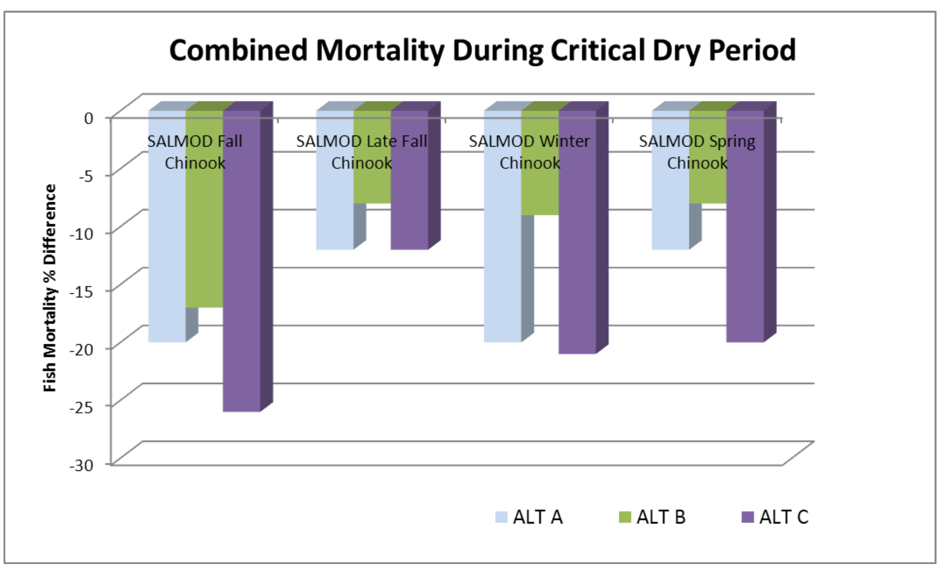

Percentage Difference in Fish Species Mortality for Fall Chinook
Fish Mortality (% Difference)
10
0
-10
-20
-30
-40
-50
-60
-70
Temperature
Flow
Total Combined
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
Full Simulation Period (82 Years)
Dry Years
Critical Years
Type of Years


Percentage Difference in Fish Species Mortality for Late Fall Chinook
Fish Mortality (% Difference)
10
0
-10
-20
-30
-40
-50
Temperature
Flow
Total Combined
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
Full Simulation Period (82 Years)
Dry Years
Critical Years
Type of Years


Percentage Difference in Fish Species Mortality for Spring Chinook
Fish Mortality (% Difference)
80
60
40
20
0
-20
-40
Temperature
Flow
Total Combined
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
ALT A
ALT B
ALT C
Full Simulation Period (82 Years)
Dry Years
Critical Years
Type of Years

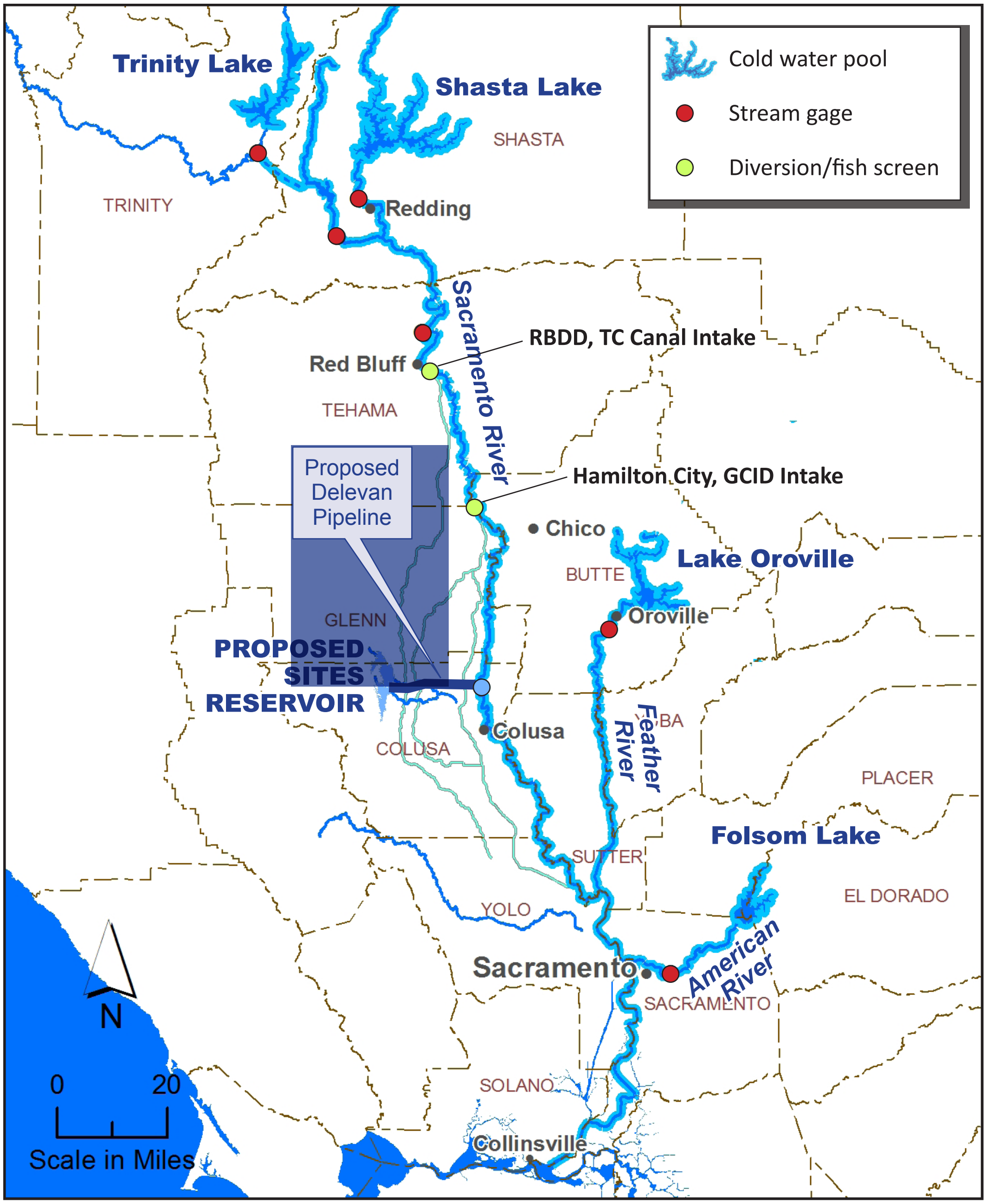

Combined Mortality during Full Simulation Period
Fish Mortality % Difference
0
-5
-10
-15
-20
-25
SALMOD Fall Chinook
SALMOD Late Fall Chinook
SALMOD Winter Chinook
SALMOD Spring Chinook
ALT A
ALT B
ALT C


Combined Mortality During Dry Period
Fish Mortalithy % Difference
0
-5
-10
-15
-20
-25
-30
-35
-40
SALMOD Fall Chinook
SALMOD Late Fall Chinook
SALMOD Winter Chinook
SALMOD Spring Chinook
ALT A
ALT B
ALT C

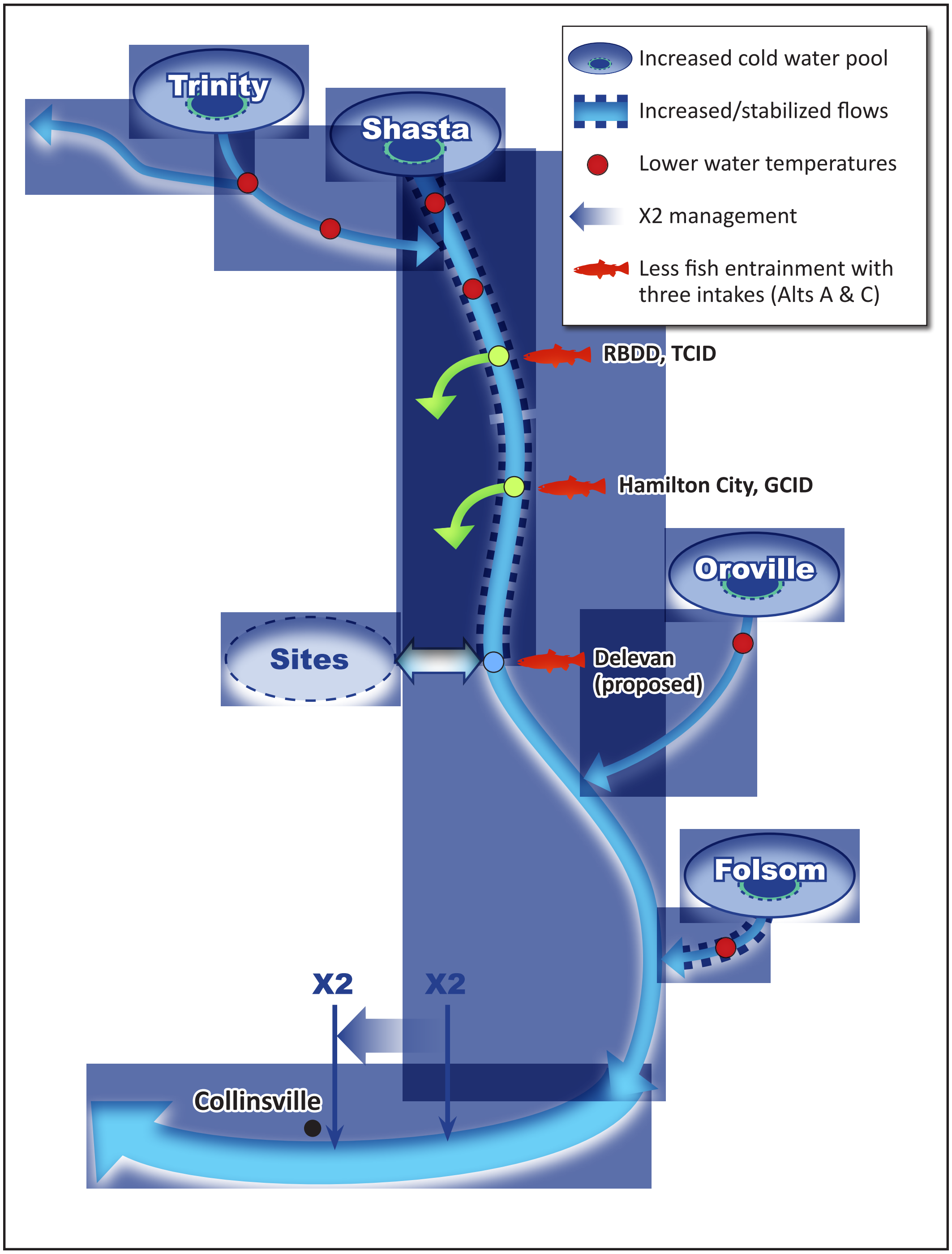

Combined Mortality During Critical Dry Period
Fish Mortality % Difference
0
-5
-10
-15
-20
-25
-30
SALMOD Fall Chinook
SALMOD Late Fall Chinook
SALMOD Winter Chinook
SALMOD Spring Chinook
ALT A
ALT B
ALT C

APPENDIX F-2

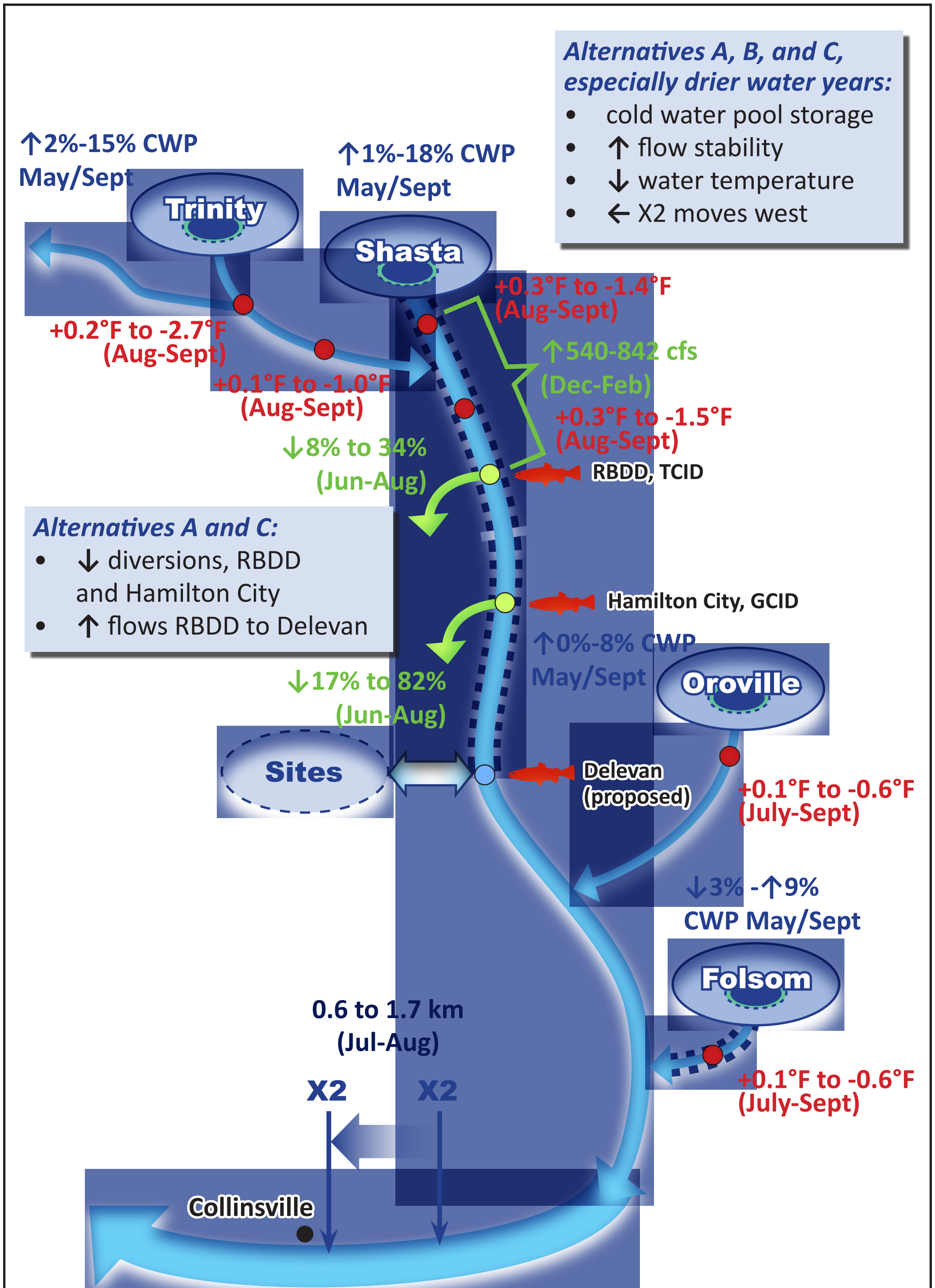
NODOS Fish Evaluation



Reservoirs, Stream Gages, and Diversions

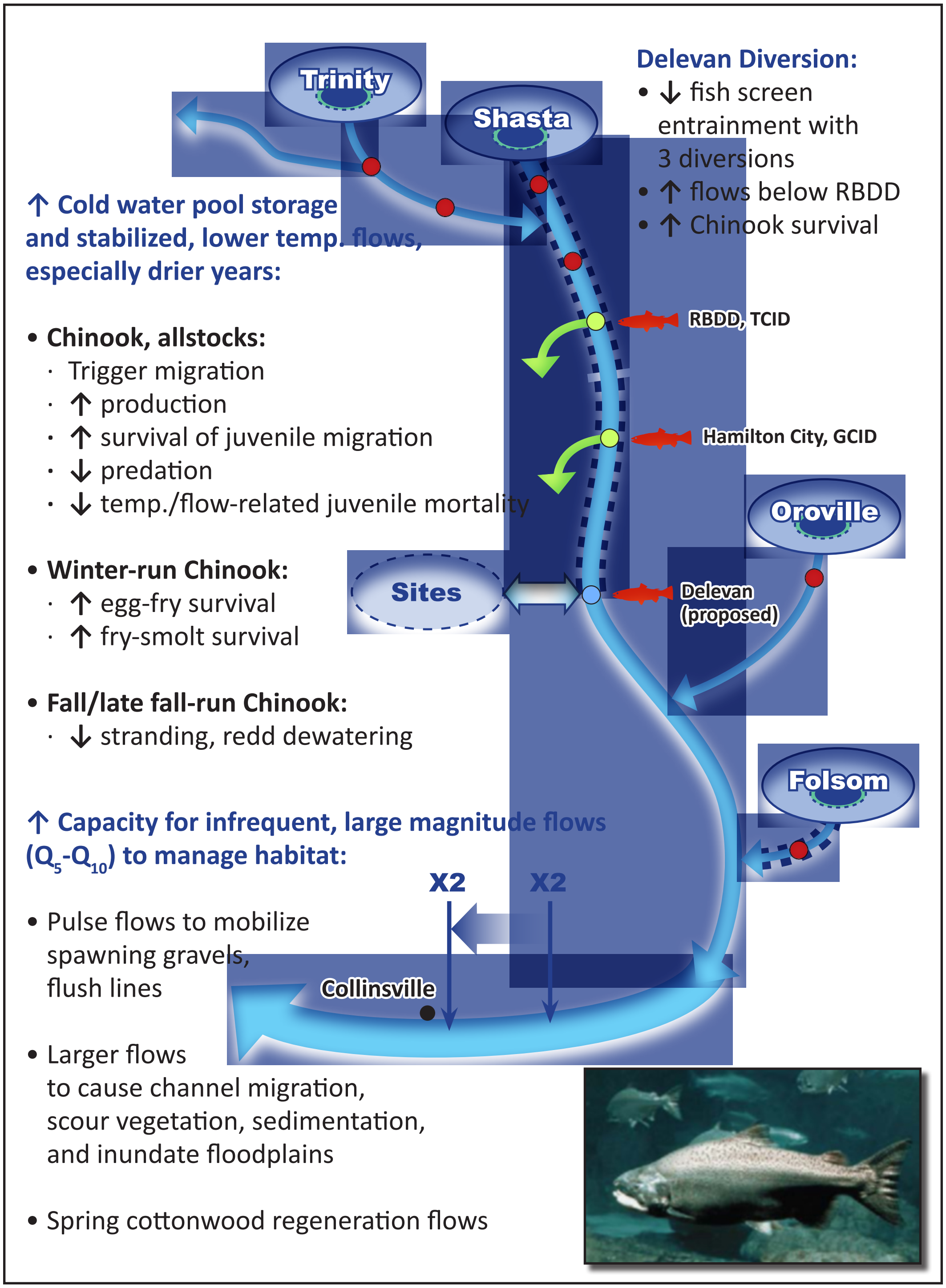


NODOS Aquatic Habitat Enhancements



Source: CH2MHill. 2011. *North-of-the-Delta Off-Stream Storage Administrative Draft Environmental Impact Report/Study and Feasibility Study – Performance Measures (non-economic) – DRAFT.* Memorandum prepared for the NODOS Project Team. CH2MHill. September 19, 2011.

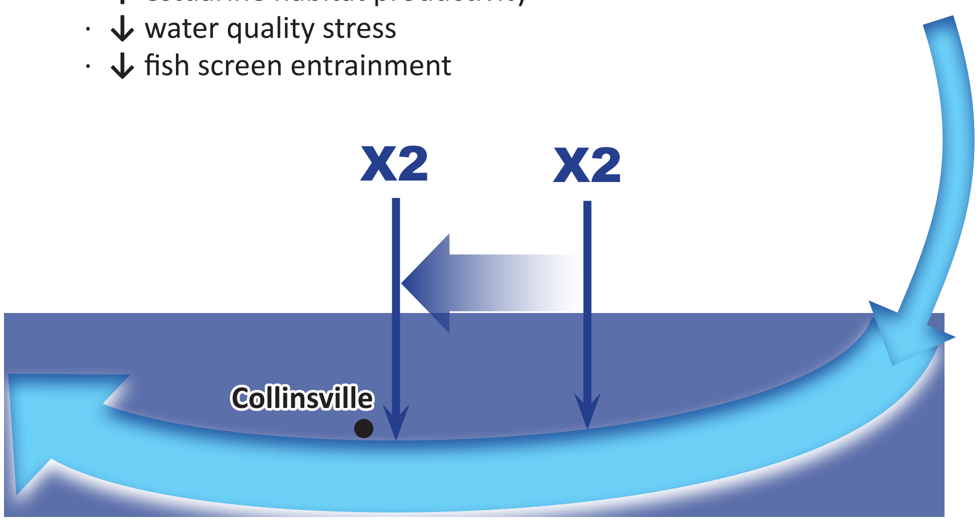
Model Simulation Result Range



Chinook Salmon Conceptual Models

↑ Delta outflow, especially during drier years:

- ← X2 moves west
- ↑ productivity of low salinity zone
- **Salmonids:**
  - ↓ resident time in Delta
  - ↓ predation mortality
- **Delta smelt, longfin smelt, Chinook juveniles/smolt:**
  - ↑ estuarine habitat productivity
  - ↓ water quality stress
  - ↓ fish screen entrainment



Delta Habitat Conceptual Model

APPENDIX G

Hydrology and Water Management

Table of Contents

Page

Tables

Page

Figures

Page

Figures (Continued)

Page

HYDROLOGY AND WATER MANAGEMENT

This appendix presents the hydrologic conditions, problems, needs, and opportunities that serve as the basis for the North-of-the-Delta Offstream Storage (NODOS) Investigation, the planning objectives that were developed, and the development of various water management alternatives that are considered for the Feasibility Report.

Water availability at any location is dependent upon geography, climate, upstream patterns of use, facilities to store and convey water, regulations governing the operations of such facilities, and various other factors. Water use is influenced by the characteristics of the population centers, environmental needs, agriculture, water availability and climate, among other factors.

Problems and opportunities associated with additional storage north of the Delta have been considered in several prior studies. In 2001, the California Federal (CALFED) Record of Decision (ROD) (CALFED, 2000b) identified specific programmatic problems, needs, and opportunities, affirming the need for action. The CALFED investigations are evaluating how potential new surface water storage projects can supplement the storage capacity and add more flexibility to the state's strained water system, and contribute towards long-term, sustainable water resources use that enhances the environment, economy, and communities. The prior studies for the NODOS feasibility studies developed various planning objectives to further the CALFED ROD-identified concerns.

The most recent drought of 2007-2009 in California is similar to that experienced in 1977 (Department of Water Resources [DWR], 2010), but California's current population is 75 percent greater. Our existing water resources infrastructure is already strained to meet competing demands and existing objectives for multiple uses, including water supply, environmental protection, water quality, flood protection, hydropower, and navigation and recreation. Strains on the state's water infrastructure system will only increase with a changing climate and the increasing conflicts between competing interests, while our water supplies become less reliable and the ecosystems further strained.

Hydrology

The study area is dominated by the Sacramento River and the surrounding mountain ranges. The northern coast ranges to the west, the southern Siskiyou Mountains to the north, and the northern Sierra Nevada to the east define the shape of the Sacramento Valley. The alternative evaluation modeling conducted for NODOS is focused on the hydrologic regions designated in the California Water Plan CWP, shown in Figure G-1and briefly described below (CWP, 2009).

Sacramento River and San Joaquin River Valley

The Sacramento Valley contains the Sacramento, Feather, and American River Basins, covering an area of more than 26,000 square miles in the northern portion of the Central Valley. The Sacramento River is the major surface water resource of the Valley, and it carries roughly one-third of California's total runoff water.

Figure G-1. Hydrologic Regions of the State of California

Ground surface elevations in the northern portion of the Sacramento Valley range from approximately 1,070 feet at Shasta Lake to approximately 14,000 feet in the headwaters of the Sacramento River. The Sacramento River headwaters start near Mount Eddy and flow into the Sacramento-San Joaquin Delta (Delta). Several major rivers, such as the Pit, McCloud, Feather, Yuba, and American Rivers, drain into the Sacramento River. Part of the Trinity River flow also is diverted to the Sacramento River. In addition, numerous small and large streams flow into the Sacramento River. Precipitation in this region is unevenly distributed within each water year, with most occurring between November and April and least during the summer. The eastern mountain ranges and high plateau regions of the Sacramento River Basin receive large amounts of precipitation as winter snow. Precipitation also varies widely on an annual basis with long multi-year periods of higher than average and lower than average rates. Runoff and streamflow are affected by both rainfall and snowmelt. Water supply, flood management, and hydropower facilities significantly modify the natural hydrology, as streamflow travels through reservoirs, dams, and developed channels.

In the headwaters area of Sacramento River, total annual precipitation averages between 60 and 70 inches and is as great as 95 inches in the Sierra Nevada and Cascade Range. The total average annual precipitation on the valley floor ranges from 20 inches in the northern end of the valley to 15 inches at the Delta. Table G-1 shows historical average precipitation at locations along the Sacramento River.

Table G-1. Historical Average Monthly Precipitation in the Sacramento River Basin

	Redding[a] Approximate Elevation 500 feet msl		Sacramento[b] Approximate Elevation 20 feet msl	
Month	**(inches)**	**(% of annual)**	**(inches)**	**(% of annual)**
October	2.2	5.6	0.9	5.2
November	4.7	11.9	2.1	12.1
December	7.0	17.7	3.1	17.2
January	8.0	20.2	3.6	20.7
February	5.9	14.9	3.1	17.8
March	5.0	12.6	2.4	13.8
April	3.0	7.6	1.2	6.9
May	1.5	3.8	0.5	2.9
June	1.0	2.5	0.2	1.1
July	0.2	0.5	0.0	0.0
August	0.3	0.8	0.1	0.6
September	0.8	2.0	0.3	1.7
Total	39.6	100	17.4	100

Source: (From SLWRI AdDraft FS, 2011)
Western Regional Climate Center (Ref:)

[a] Period of Record (1931-1979)
[b] Period of Record (1948-present)

msl = feet above mean seal level

The key hydrologic features of the Sacramento River Basin are discussed hereafter for the different subregions**.**

Sacramento River from Keswick to Colusa

The area upstream of Shasta Dam is drained by the Pit River, the McCloud River, Squaw Creek, and the headwaters of the Sacramento River. Flows of the Sacramento River between Shasta Dam and Red Bluff are regulated by Shasta Dam and the power plant, and further regulated downstream at Keswick Dam. Shasta Lake delivers a major share of the total annual water supply developed by the Central Valley Project (CVP). Shasta Lake has a storage capacity of 4.55 million acre-feet (MAF) and the flood control space of approximately 1.3 MAF. In general, flood peaks are reduced in the winter and spring, and discharges are increased during the summer and fall for irrigation, environmental flows, and other uses. Shasta Dam is operated in conjunction with Keswick Dam and Reservoir, located approximately 9 miles downstream from Shasta Dam.

Water from Trinity Lake has been diverted to the Sacramento River Basin with an average annual import of 1.27 MAF (*U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County Trinity River Fishing Restoration EIR/EIS*, 2004). Trinity Lake stores water for release to the Trinity River and for diversion to the Sacramento River via Lewiston Reservoir, Carr Tunnel, Whiskeytown Reservoir, and Spring Creek Tunnel where it comingles in Keswick Reservoir with Sacramento River water released from both the Shasta Dam and Spring Creek Debris Dam. Diversion of Trinity water to the Sacramento Basin provides water supply and hydroelectric power generation for the CVP and assists in water temperature control in the Trinity River and Upper Sacramento River. Trinity River diversions to the Sacramento River are planned to be reduced as part of the 2000 ROD to retain more flows in the Trinity River for fish restoration purposes.

The Sacramento River enters the Sacramento Valley north of Red Bluff, downstream of which numerous major tributaries enter the River. The tributaries influence Sacramento River flows during storms. The major tributary contributing to the streamflows to the reach of Sacramento River between Chico Landing and Colusa is Stony Creek. Several flood management features assist with flood management for the localities.

Funks Creek flows into Funks Reservoir at the Tehama-Colusa (T-C) Canal, with flow contributed from the drainage area of 43 square miles. Stone Corral Creek flows from a drainage area of approximately 38 square miles into the NODOS reservoir area. Many small tributaries in the area were included in the earlier evaluation of the NODOS feasibility studies. The headwaters of Grapevine Creek are on the western side of the Sites Reservoir inundation area and flow north and into the reservoir area north of Sites Lodoga Road. Grapevine Creek flows into Funks Creek approximately 7 miles upstream from Funks Reservoir. The headwaters of Antelope Creek are also on the western side of the NODOS reservoir area, just south of the headwaters of Grapevine Creek. Antelope Creek flows south, and then east and north through the southern portion of the NODOS reservoir area and joins Stone Corral Creek near the town of Sites. To the north, Hunters Creek flows to the east. Southeast of the NODOS reservoir area is Lurline Creek, which flows to the east. Both Hunters and Lurline Creeks flow into the Colusa Basin Drain.

Sacramento River from Colusa to Sacramento and the Sacramento-San Joaquin Delta

The Sacramento River channel downstream from Colusa differs considerably from the section between Keswick and Colusa. The gradient of the river decreases and the channel becomes deeper and narrower, reducing its capacity. The Feather River joins the Sacramento River at Verona, and the American River joins it at Sacramento. The Yuba River is a major tributary to the Feather River. The Sacramento River then flows south, joining with the San Joaquin River in the Delta, and out to the Pacific Ocean. Lake Oroville is a major Department of Water Resources (DWR) storage facility on the Feather River, and Folsom Lake is a major Bureau of Reclamation (Reclamation) storage facility on the American River. Similar to Shasta Lake, Lake Oroville is operated in conjunction with other State Water Project (SWP) facilities as a multipurpose project, for water supply, flood management, power generation, recreation, fish and wildlife enhancement, and salinity control in the Delta.

Sacramento–San Joaquin Delta Hydrology

Surface water resources in the Delta are influenced by the interaction of tributary inflows, tides, Delta hydrodynamics, local diversions and exports, and water transfers. The Delta receives runoff from watersheds that include more than 40 percent of California’s land area and cover approximately 750,000 acres. The Sacramento River, San Joaquin River, and tributaries (Mokelumne, Consumnes, and Calaveras Rivers) discharge into the Delta. Existing surface water conditions in the Delta are the result of the many changes that have occurred over the past 150 years as the Delta and its watershed have developed.

CVP and SWP water deliveries are conveyed through Delta channels to the respective federal and state pumping plants that provide water for exports to the San Joaquin Valley and southern California areas. The C.W. Jones Pumping Plant is located on Old River at Tracy and conveys water to the Delta-Mendota Canal (DMC). The SWP Harvey O. Banks pumping plant lifts water into the California Aqueduct from Clifton Court Forebay. Water is pumped from the Delta to San Luis Reservoir which is an important component for both systems. The Contra Costa Water District (CCWD) diversion points at Old River and Rock Slough are also major diversions in the western Delta. The CVP and SWP export pumping plants exert a considerable influence on water circulation in the Delta by creating a net flow of water from northern regions of the Delta southward through Old River and Middle River (OMR).

Water quality in the Delta is controlled by complex circulation patterns that are affected by inflows, pumping for Delta agricultural operations and exports, operation of flow control structures, and tidal action. Delta outflow varies with precipitation, tributary flows, reservoir releases, and diversion upstream. Tides move water twice daily from San Francisco Bay into the Delta. The location of the mixing zone between freshwater from the Delta and saline water from the Bay varies with the amount of Delta outflow and tides. Saltwater intrusion into the Delta during summer is controlled by tides, freshwater inflows from reservoir releases, and Delta pumping.

San Joaquin River Valley

The San Joaquin River basin includes the Central Valley south of the Delta. This area is drier than the Sacramento Valley, and flows into the Delta from the San Joaquin River and its tributaries are considerably less than those from the Sacramento River. The river is also subject to extreme variations in flow and water quality. The San Joaquin River watershed above Vernalis (the point at which the river enters the Delta) is 13,356 square miles. Inflows from the Merced, Tuolumne, and Stanislaus rivers contribute more than 60 percent of the flows in the San Joaquin River, as measured at Vernalis.

Watersheds of the San Joaquin, Merced, Tuolumne, Stanislaus, Calaveras, and Mokelumne rivers include large areas of high elevation along the western slope of the Sierra Nevada. As a result, these rivers experience significant snowmelt runoff during the late spring and early summer. Before construction of water supply and flood management facilities, flows typically peaked in May and June, and snowmelt runoff caused flooding in most years along all the major rivers. When these snowmelt floodflows reached the valley floor, they spread out over the lowlands, creating several hundred thousand acres of permanent tule marshes and seasonally flooded wetlands.

Numerous dams, reservoirs, and diversions are located on the San Joaquin River and its tributaries. Several reservoirs on the Stanislaus, Tuolumne, Merced, and upper San Joaquin Rivers control the flow of San Joaquin River. The upper San Joaquin River is controlled by the CVP Friant Dam (Millerton Reservoir) with most water diverted to the Kern and Madera Canals. Friant Dam is operated for water supply and flood management. At the dam, water is diverted to the Madera and Friant-Kern Canals to provide irrigation and municipal and industrial (M&I) water supplies to the eastern portion of the San Joaquin Valley. The New Melones Reservoir is located on the Stanislaus River and is part of Reclamation’s CVP system. In addition to flood protection, all of these reservoirs provide water supplies for irrigation uses and, in some cases, hydropower generation. Also, recreation facilities were developed at several of these reservoirs and the dams are operated, in part, to meet downstream fish and wildlife requirements.

The San Joaquin groundwater basin is a regional basin and is the largest in California, extending approximately from the Delta to Bakersfield, and serves as a major source of water to both urban and agricultural users for this area and the Tulare Lake area.

Tulare Lake

The Tulare Lake Basin, in the southern San Joaquin Valley, extends from the southern limit of the San Joaquin River Basin in the north to the Tehachapi Mountains in the south, and from the Sierra Nevada in the east to the Coast Range in the west. The basin’s major rivers—Kings, Kaweah, Tule, and Kern—originate in the Sierra Nevada, flow generally west into the San Joaquin Valley, and end in either lakes or sinks. The valley floor in this region had been a complex series of inter-connecting natural sloughs, canals, and marshes. Except in the wettest years, all of the Tulare Lake hydrologic region’s streams are diverted for irrigation or other purposes. Historically, these streams drained into Tulare Lake, Kern Lake, or adjacent Buena Vista Lake; the latter ultimately drained to Tulare Lake. The largest river in terms of runoff is the Kings River, which originates high in Kings Canyon National Park and generally trends southwest into Pine Flat Lake. Downstream of Pine Flat Dam the river flows south and west toward Tulare Lake. During high water, distributaries of the Kings River flow northwest into the Fresno Slough/James Bypass system (along the historically high-water outlet of Tulare Lake), emptying into the San Joaquin River. The Kaweah River begins in Sequoia National Park, flows west and southwest, and is impounded by Terminus Dam. It subsequently spreads into many distributaries around Visalia and Tulare trending toward Tulare Lake. The Tule River begins in Sequoia National Forest and flows southwest through Lake Success toward Tulare Lake. The Kern River has the largest drainage basin area and produces the second highest runoff. There are many smaller creeks that feed into the main rivers which can present a localized flooding threat during specific storm conditions.

Water agencies in the Tulare Lake Region have been practicing conjunctive use for many years to manage groundwater and assist dry year supplies.

San Francisco Bay Area

The Sacramento and San Joaquin Rivers flow through the Delta into the San Francisco Bay Hydrologic Region (Bay Region). The Bay Region includes numerous watersheds that drain directly in to the San Francisco Bay downstream of the Delta and coastal creek watersheds in Marin and San Mateo Counties that drain directly to the Pacific Ocean. The Guadalupe River and Coyote and Alameda Creeks drain the Coast Range and generally flow northwest until terminating in the San Francisco Bay. The Napa River originates in the Mayacamas Mountains at the northern end of Napa Valley and flows southward into San Pablo Bay.

Streams in the region flow into the Bay estuary or the Pacific Ocean. Water agencies in the Bay Region have relied for nearly a century on imported water supplies from the Sierra Nevada to supply their customers with reliable water. Water from the Mokelumne and Tuolumne Rivers account for an estimated 38 percent of the region’s average annual total water supply.

Central Coast

The Central Coast Hydrologic Region extends from southern San Mateo County in the north to Santa Barbara County in the south. Most of the Central Coast region is within the southern Coast Ranges, which extend from Monterey Bay in the north to Santa Barbara in the south. Many attributes define the Central Coast region including the diverse topography, microclimates, and the picturesque coastline, valleys and communities that drive a thriving agricultural and tourism economy. Topo-graphically, the extent of the Central Coast Region is largely controlled by the presence of the northwest-trending southern Coast Ranges.

The Central Coast Region is subdivided as: the Central Coast Northern Region and the Central Coast Southern Region, with the Monterey-San Luis Obispo county line as the boundary between the two. All of the rivers within the entire region drain into the Pacific Ocean. The main rivers in the Central Coast Northern Region are the San Lorenzo, Pajaro, Salinas, San Benito, Carmel, San Antonio, and Nacimiento.

The Pajaro River is one of the Central Coast region's largest watersheds, enters Monterey Bay and the Pacific Ocean and is well known for its productive agricultural soils and powerful flooding characteristics. The Salinas River watershed, which is the largest in the region, drains more than 40 percent of the Central Coast Region.

The principal watersheds in the Central Coast Southern Region are the Upper Salinas, the Santa Maria—which includes the Huasana, Cuyama, and Sisquoc Rivers, the San Luis Obispo, San Antonio, Santa Ynez, Carrizo Plain, and the Santa Barbara Channel Islands watersheds. As in the northern region, there are coastal watersheds, which are mostly short and steep. The Santa Ynez River Basin is the largest drainage system that is wholly located in Santa Barbara County, draining approximately 40 percent of the mainland part of the county. It is the primary source of water for approximately two-thirds of Santa Barbara County residents. Three dams (Cachuma, Gibraltar, and Jameson) have been constructed on the river to store and divert water to the south county.

Groundwater in the Carmel Valley aquifer, which underlies the alluvial portion of the Carmel River downstream of the San Clemente Dam, and groundwater in the coastal subareas of the Seaside Groundwater Basins provide water supply for the region. Conjunctive use of surface water and groundwater is a long-standing practice in the region.

South Lahontan

The South Lahontan Hydrologic Region is bounded to the north by the drainage divide between Mono Lake and East Walker River; to the west and south by the Sierra Nevada, San Gabriel, San Bernardino, and Tehachapi mountains; and to the east by the state of Nevada. Much of the topography of the South Lahontan Region reflects its active geologic history. The mountains are separated by many alluvial valleys, some of which are quite large. They include Owens Valley, Death Valley, Panamint Valley, and the Indian Wells Valley. Also, the highest and lowest elevation points in the continental United States are found in the north of the region; Mount Whitney with an elevation of 14,495 feet and Death Valley at 282 feet below sea level. The topography in the south is less mountainous and dominated by large and gently sloping valleys—Antelope, Victor, and Apple Valleys. The most well-known of the region's earthquake faults, the San Andreas Fault, is in the south.

Internal drainage and the arid climate account for the presence of many dry lakebeds or playa in the region. Five major watershed areas have been identified for the South Lahontan Region. These are the Antelope Valley, Mojave, Mono Basin, Owens River, and Amargosa watersheds. Major lakes and reservoirs in the region include Mono Lake, June Lake, Convict Lake, Crowley Lake, and Tinemaha Reservoir in the north and Lake Arrowhead, Silverwood Lake, and Lake Palmdale in the south. Most of the perennial rivers are in the north, including the Owens River and Rush Creek. In the south, the Mojave and Amargosa rivers are typically dry for the most of the year. Water flows in the channels of both rivers after heavy rainfall. Most of the water for the Mojave River, whose headwaters are in the San Bernardino Mountains, is from snowmelt. The river is impounded behind the Mojave River Dam, in the Mojave River Forks Reservoir, which is operated for water supply, flood management, water conservation, and recreation. The Mojave River descends from the dam and meanders approximately 120 miles to its terminus at Silver Dry Lake. The Mono

Basin watershed continues to be an important location for more than 300 species of nesting migratory birds. The Owens River watershed and tributaries include various multi-purpose reservoirs. Crowley Lake is one of the largest and most used trout fisheries in California.

South Coast

The South Coast Hydrologic Region is located in the southwestern corner of the state and is California's most urbanized and populous region. More than half of the state's population resides in the region. The region includes all of Orange County and portions of Ventura, Los Angeles, San Bernardino, Riverside, and San Diego counties. Topographically, most of the South Coast region is comprised of several large, undulating coastal and interior plains. Several prominent mountain ranges comprise its northern and eastern boundaries and include the San Gabriel and San Bernardino Mountains. Most of the region's rivers drain into the Pacific Ocean, and many terminate in lagoons or wetland areas that serve as important coastal habitat. Many river segments on the coastal plain, however, have been concrete-lined and in other ways modified for flood control operations.

There are various major rivers and watersheds in the South Coast Hydrologic Region. Many of these watersheds have densely urbanized lowlands with concrete-lined channels and dams controlling floodflows. The headwaters for many rivers, however, are located within coastal mountain ranges and have remained largely undeveloped. There are two of the major watersheds within the South Coast Hydrologic Region: The Ventura River Watershed has one major reservoir, Lake Casitas, which provides water supplies downstream for local urban and agricultural users. The Santa Clara River Watershed's tributaries are Piru, Sespe, San Francisquito, Castaic, and Santa Paula Creeks. Although the Santa Clara River typically has an intermittent flow regime in the main stem, flows can increase rapidly in response to high-intensity rainfall with the potential for severe flooding. Controlled releases of water from Lake Piru supplement surface flows in Ventura County. Other watersheds include: Calleguas Creek, North Santa Monica Bay, Ballona Creek, Los Angeles River, and San Gabriel River. Groundwater provided the bulk of local water supplies to the South Coast Hydrologic Region as it grew during the first half of the 20th Century. Today, conjunctive use is the coordinated operation of multiple water supplies and groundwater remains a vital resource to the region both as a supply source and as a tool for storage.

Sacramento and San Joaquin Valley Hydraulics

Various communities and agricultural lands in the Central Valley are under the threat of flooding along the Sacramento and San Joaquin rivers. United States Army Corps of Engineers (USACE), in partnership with DWR, has worked to assess basin-wide flood management issues and identify options in the two river basins to address these issues. USACE and DWR continue to develop improvements associated with the Sacramento River Bank Protection Project and to assist in local flood damage reduction projects along the Sacramento River. FloodSAFE is a strategic initiative of DWR, under which DWR is currently developing the Central Valley Flood Protection Plan, addressing flood issues throughout the Sacramento and San Joaquin Valleys and the Delta.

A number of flood management projects along the rivers affect the flow and operation of facilities (USACE, 1999). These facilities include dams, reservoirs, levees, and weirs. The state and federal governments have constructed dams in the foothills with reserved flood storage space on the Sacramento, Feather, Yuba, and American River systems. The reservoirs collect and manage flows from the upper watersheds to help reduce damaging flood peaks by holding back floodwater and, ideally, releasing water into the rivers at a slower rate. As stated above, Shasta Lake collects flow in the Upper Sacramento River watershed, Lake Oroville collects flow in the Feather River watershed, and Folsom Lake collects the flow in the American River watershed to help with the flood management goals in the Sacramento River Basin. These reservoirs are operated for flood management and flood flow releases in accordance with USACE guidelines.

The basic flood management system in the Sacramento Valley consists of a series of levees and bypasses, placed to protect preferred areas and take advantage of the natural overflow basins. The management system includes levees along the Sacramento River south of Ord Ferry; levees along the lower portion of the Feather, Bear, and Yuba rivers; and levees along the American River. The levees are set back along the typical stream banks to accommodate design flood capacities. Additionally, three natural basins, Butte, Sutter, and Yolo, run parallel to the Sacramento River and receive excess flows from the Sacramento, Feather, and American Rivers via natural overflow channels and over weirs. When the Sacramento River is high, the three basins form one continuous waterway connecting the Butte, Sutter, and Yolo Basins. During low stages on the Sacramento River, water in these basins can reconnect with the river at several points: the Butte Slough Outfall Gates, the terminus of the Sutter Bypass at Verona, and the east levee toe drain at the terminus of the Yolo Bypass above Rio Vista. The flood management system uses five weirs located along the Sacramento River to divert part of the floodflows to the Butte Basin, Sutter Bypass, and Yolo Bypass. The weirs function as flow relief structures that permit high Sacramento River flows to enter the basin and bypasses. The weirs were designed to begin operation in a certain order: Tisdale Weir, Colusa Weir, Fremont Weir, Moulton Weir, and Sacramento Weir.

The flood management operations are influenced by the natural delay in moving the regulated water down the system. It takes approximately 62 hours for water released from the Shasta Dam on the northern portion of the Sacramento River to reach the Feather River confluence at Verona, and approximately 70 hours, nearly 3 days, to reach the American River confluence at I Street in the City of Sacramento. Similar time delays affect operations of Oroville, New Bullards Bar, and Folsom dams. On the Feather River, water released from Oroville Dam takes 30 hours to reach Verona. Water released from New Bullards Bar Dam on the Yuba River reaches Yuba City in 8 hours. The travel time from Folsom Dam on the American River to the Sacramento River at I Street is approximately 8 hours.

San Joaquin River flood management system includes levees along the San Joaquin River and numerous reservoirs along the San Joaquin River and its tributaries. The Chowchilla Canal Bypass diverts excess San Joaquin River flow and sends it to the Eastside Bypass. In addition to the Chowchilla Canal Bypass flow, the Eastside Bypass intercepts flows from minor tributaries and rejoins the San Joaquin River between Fremont Ford and Bear Creek. However, the channel capacity on the San Joaquin River decreases moving downstream. Several reservoirs in the upper portion of the San Joaquin River watershed are primarily used for water supply and hydroelectric power generation. The operation of these reservoirs affects the inflow to Millerton Lake. Under flood conditions, floodflows can also be diverted into the Friant-Kern and Madera canals when capacity is available and there is a place to release the floodflows. Floodflows in the Friant-Kern Canal may be carried to the Kern River and then through the Kern River Intertie to the California Aqueduct. Floodflows in the Madera Canal may be carried to the Fresno-Chowchilla River system.

Floodflows are diverted from the San Joaquin River at the Chowchilla Canal Bypass. The reach of the river from Chowchilla Canal Bypass to the Mendota Pool is generally dry unless releases are made from Friant Dam for flood management. During flood management operations, most floodflows from upstream of the Chowchilla Canal Bypass are diverted from the San Joaquin River to the Chowchilla Canal Bypass. Floodflows that exceed the capacity of the Chowchilla Canal Bypass continue down the San Joaquin River to the Mendota Pool. This river segment receives flow from the Fresno and Chowchilla Rivers and the Eastside Bypass.

In the San Joaquin River downstream from the Merced River, little water is contributed from the upper San Joaquin River, except during floods, and as such, non-flood management flow patterns result from tributary inflows from the Merced, Tuolumne, and Stanislaus Rivers. During major floods, this segment of the river receives flow from the upstream portions of the San Joaquin, Merced, Tuolumne, Stanislaus, and Fresno Rivers; Ash and Berenda Sloughs; and several smaller tributaries. There are several flood management projects on this river reach. Pine Flat Dam, completed in 1954, is owned, operated, and maintained by USACE. The dam is on the Kings River approximately 28 miles northeast of Fresno and provides flood protection to 200,000 acres of agricultural land in the Tulare Lake area. Various weirs were built to control the flow at different locations. Several smaller flood control projects also have been developed in the Sierra Nevada foothills in the San Joaquin River Basin. These projects generally consist of dry dams constructed to protect downstream metropolitan areas and nearby agricultural lands.

Levees have been constructed from the Delta upstream on the San Joaquin River to the mouth of the Merced River and along several San Joaquin River tributaries. In addition to the federal Lower San Joaquin River and Tributaries Project, an intricate series of minor levees and channel modifications have been constructed which are owned, operated, and maintained by local interests throughout the natural river system. These modifications significantly reduce the threat of flood-related damages to the primarily agricultural lands adjacent to the river.

The travel time for moving floodflows down the river system complicates the management of the flood system. The travel time for water released from Friant Dam on the San Joaquin River is more than five days to the Merced River confluence at Newman and seven days to reach Vernalis. On the Merced River, water released from New Exchequer Dam takes 42 hours to reach the San Joaquin River confluence at Newman. The travel time from Don Pedro Dam on the Tuolumne River to Vernalis is nearly two days. Flow released from New Melones Dam on the Stanislaus River takes just over a day to reach Vernalis.

Existing Water Supply System

While most of the state's snow and rain fall is in the north and eastern mountains, the majority of the state's water use is in the central and southern valleys and along the coast. This usage has created a water supply imbalance considering the differences in runoff and demand between northern and southern California. More than 70 percent of the runoff comes from northern California, but more that 75 percent of M&I and agricultural demand is south of the Delta. Another imbalance is created by timing; because agricultural and M&I demands are highest during summer while most of the rain and snow in the state fall during the spring and winter months, there is an imbalance between when water supply is available in California and when most of it is needed.

Given these variabilities, California's local, state, and federal projects and programs have over time developed a statewide water system to make water available at the right places and times and to move floodwaters. In the past, this system has in general allowed California to meet most of its agricultural, urban and environmental water management objectives (CWP, 2009), along with improved efficiency in more recent years. However, California's growing population, the increased variability in the weather pattern, and new regulations have demonstrated in recent years the limiting nature of existing water supply system to meet the state's current and future projected water needs.

California's water supplies come from both surface and groundwater sources; the proportions of use of the two sources vary widely both spatially and temporally. Major supplies in some region are provided through surface water reservoirs and though direct groundwater pumping.

Existing water supply systems within the study area are briefly described in the following sub-sections (CWP, 2009).

Surface Water Supply

The Sacramento River region is a main water supply source for much of California's water use in various sectors. Basin runoff averages 22.4 MAF per year, providing nearly one-third of the state's total natural runoff.

Major reservoirs in the Central Valley provide water supply, recreation, power, environmental, and flood control benefits. The CVP and the SWP are two major inter-basin water storage and delivery systems that export water to areas south and west of the Delta via natural watercourses and canal systems. The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers. A few of the larger cities in the region take a major share of their water supplies from the major rivers. Additionally, several regional and local entities have also developed surface water storage and diversion system, including inter-basin transfers (e.g., Tuolumne and Mokelumne Aqueducts, Los Angeles Aqueduct, and Colorado River Aqueduct).

Diversions from the Sacramento River upstream from the Feather River average 1.7 MAF annually. Surface water demands along the Sacramento River between Red Bluff and Colusa are more than 2.3 MAF on an average annual basis, including water supplies for Sacramento Valley refuges, agricultural activities, and urban uses.

The CVP and SWP are briefly described below.

CVP

The CVP is the largest water project in the state and delivers water for use in the Sacramento Valley and for export to other regions, covering 29 of California’s 58 counties. CVP facilities include 21 dams and reservoirs with a combined storage capacity of more than 11 MAF, 39 pumping plants, 2 pumping-generating plants, 11 power plants, and more than 500 miles of major canals and aqueducts.

The CVP delivers approximately 7 MAF of water per year. The CVP supplies irrigation water to the Sacramento and San Joaquin Valleys; domestic water to cities and industries in the Sacramento County and the east and south Bay Area; and water to fish hatcheries and wildlife refuges throughout the Central Valley. The CVP irrigates approximately 3.25 million acres of farmland and supplies water to more than 2 million people through more than 250 long-term water contractors. Most of the CVP service area is inside the Central Valley. Approximately 90 percent of south-of-Delta contractual delivery is for agricultural uses. The CVP also provides flood damage reduction, navigation, power, recreation, fish habitat, and water quality benefits.

Major diversions along the Sacramento River occur at the Red Bluff Diversion Dam (RBDD) into the T-C and Corning Canals and at the Glenn-Colusa Irrigation District’s (GCID) Canal at Hamilton City. T-C Canal and the GCID Canal are proposed to be integral parts of the NODOS alternatives. Near Funks Reservoir, the capacity of the existing T-C Canal and GCID Canal are approximately 2,100 cubic feet per second (cfs) and 1,800 cfs, respectively.

The CVP has three primary storage facilities in northern California: Shasta Lake, Trinity (previously Clair Engle) Lake, and Folsom Lake. The major storage facilities south of the Delta are New Melones Reservoir on the Stanislaus River, Millerton Lake on the San Joaquin River, and San Luis Reservoir, which is a pumped-storage reservoir on the west side of the San Joaquin Valley and is shared with the SWP. The DMC is the main conveyance facility of the CVP. This canal conveys water from the C. W. “Bill” Jones Pumping Plant (formerly known as the Tracy Pumping Plant) in the south Delta near Byron to agricultural lands in the San Joaquin Valley.

The Jones Pumping Plant in the Delta consists of six pumps, with a maximum export capacity of 4,600 cfs during the irrigation season, and 4,200 cfs during the winter non-irrigation season (SLWRI, H&H TR, ADFR). Limitations at the Jones Pumping Plant are the result of a DMC freeboard constriction near O’Neill Forebay and current water demand in the upper sections of the DMC. The Jones Pumping Plant is at the end of an earth-lined intake channel approximately 2.5 miles long. Downstream from the Jones Pumping Plant, CVP water flows in the DMC and can be either diverted by the O’Neill Pumping-Generating Plant into the O’Neill Forebay, which serves as a regulatory body for San Luis Reservoir, or can continue down the DMC for delivery to CVP contractors. The O’Neill Pumping-Generating Plant releases flows from the O’Neill Forebay back to the DMC. The O’Neill Pumping-Generating Plant consists of six pump-generating units, with a capacity of 700 cfs each.

The O'Neill Forebay is a joint CVP/SWP facility, with a storage capacity of approximately 56,000 acre-feet (AF). In addition to its interactions with the DMC via the O'Neill Pumping-Generating Plant, it is a part of the SWP California Aqueduct. The William R. Gianelli (Gianelli) Pumping-Generating Plant, also a joint CVP/SWP facility, can pump flows from the O'Neill Forebay into San Luis Reservoir, and also make releases from San Luis Reservoir to the O'Neill Forebay for diversion to either the DMC or the California Aqueduct. Also, several water districts receive diversions directly from the O'Neill Forebay. The Gianelli Pumping-Generating Plant consists of eight units, each with a capacity of 1,375 cfs.

San Luis Reservoir, located on the west side of the San Joaquin Valley, provides offstream storage for excess winter and spring flows diverted from the Delta. It has a total capacity of approximately 2.0 MAF, sized to provide seasonal carryover storage. The CVP share of the storage is 0.96 MAF; the remaining 1.06 MAF are the SWP share. Water stored in San Luis Reservoir is used during spring and summer, when water demands and schedules are greater than the capabilities of the Reclamation and DWR to pump water from the Jones and Banks Pumping Plants. Water is stored in San Luis Reservoir during the fall and winter when the two Delta pumping plants can pump more water from the Delta than is needed to meet water demands, as the reservoir receives very little natural inflow. The CVP share of San Luis Reservoir is typically at its minimum in August and September and at its maximum in April.

South of the O'Neill Forebay, the DMC terminates in the Mendota Pool, approximately 30 miles west of Fresno. From the DMC, the CVP makes diversions to multiple water users and refuges. DMC capacity at the terminus is 3,211 cfs. Parallel to the DMC, the San Luis Canal-California Aqueduct is a joint-use facility for the CVP and SWP. It begins on the southeast edge of the O'Neill Forebay and extends approximately 101.5 miles southeasterly to a point near Kettleman City. Water from the canal serves the San Luis federal service area, mostly for agricultural purposes and for some M&I uses. Water not delivered directly is diverted from the DMC at the O'Neill Pumping Plant into O'Neill Forebay. The majority of the remaining water continues to the southern Central Valley, with some water being diverted to Santa Clara County.

CVP Operation

The CVP reservoirs are operationally integrated and managed to meet the objectives and demands placed on them. A series of rules and regulations in the form of flow requirements, water quality requirements, water supply commitments, and flood control requirements governs operations of the major CVP reservoirs and pumping facilities.

Operation of CVP and SWP affect flow and water temperature in the river reaches downstream of project reservoirs. Reclamation manages coldwater reserve in various lakes to improve fish habitat conditions in the Upper Sacramento River, and releases water from varying lake levels through the power plants to manage and maintain such desired water temperatures in the Sacramento River downstream of the dams. Flood management operations prescribed by USACE also affect flow and temperature in the river reaches downstream of these reservoirs. Releases from the reservoirs for flood management occur either over the spillway during large events or through river outlets for smaller events.

Water from Trinity River stored in Trinity Lake is transferred to the Sacramento River Basin. All releases from Trinity Dam are re-regulated downstream at Lewiston Reservoir to meet downstream flow requirements, and supply exports through Clear Creek tunnel and the Judge Francis Carr Power Plant to Whiskeytown Reservoir. Spring Creek tunnel and power plant conveys the exported water to Keswick Dam, located on the Sacramento River below Shasta Dam. Flood control is not an authorized purpose of Trinity Lake, but Reclamation maintains some vacant storage space in the winter months, consistent with the Department of Safety of Dams (DSOD) guidance. Trinity Lake is also operated to meet temperature objectives for special-status species in the Trinity River and in the Upper Sacramento River.

Shasta Lake is operated in conjunction with other CVP facilities for managing floodwater, storage of water for irrigation and M&I uses, maintenance of navigation flows, recreation needs, protection and conservation of fish in the Sacramento River and Delta, and generation of hydroelectric energy. Shasta Lake has a storage capacity of 4.55 MAF. A storage capacity of up to 1.3 MAF kept available for flood control purposes in accordance with USACE prescribed rule curve; the required flood storage varies seasonally and according to accumulation of seasonal inflow. Releases from Shasta Dam for flood management either occur in the fall, beginning in early October, to reach the prescribed vacant flood space, or to evacuate during or after a storm event to maintain the prescribed vacant flood space in the reservoir. During a storm event, releases for flood management occur either over the spillway during large events or through river outlets for smaller events. Between 1950 and 2006, flows over the spillway occurred in 12 years, or in 21 percent of those 56 years. During the same time interval, releases for flood management (either for seasonal space evacuation or during a flood event, and including spills over the spillway) occurred in about 37 years, or nearly 70 percent of those years.

For downstream water temperature management, the estimated volume of water colder than 52 degrees Fahrenheit (^{o}F) stored in Shasta Lake on or about May 1 is a very useful way to generally relate cold water availability to potential seasonal compliance strategies. As such, Shasta Lake storage is typically at its highest in April and May and at its lowest in October and November. A goal of existing operations is to have an excess of required flood storage space vacant in the flood season and then fill the pool to the maximum extent possible for water supply and other needs in the remainder of the year.

Table G-2 shows the historical average end-of-month reservoir storage at Shasta Lake since 1954 by year type; Table G-3 shows historical average release from Shasta Lake (SLWRI, ADEIS, 2011).

Shasta Lake is also operated to meet a flow requirement in the Sacramento River, at Wilkins Slough near Grimes, at the compliance location known as the Navigation Control Point.

Table G-2. Historical End-of-Month Shasta Lake Storage by Water-Year Type

Year Type	Average End-of-Month Storage (TAF)											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
All Years	2,462	2,475	2,717	3,055	3,384	3,683	3,935	3,956	3,675	3,204	2,831	2,625
Wet	2,796	2,853	3,152	3,513	3,641	3,813	4,131	4,311	4,125	3,696	3,293	3,085
Above Normal	2,387	2,389	2,739	3,208	3,527	3,869	4,290	4,372	4,113	3,604	3,251	3,070
Below Normal	2,399	2,382	2,562	3,102	3,635	3,887	4,225	4,164	3,820	3,313	2,951	2,751
Dry	2,378	2,407	2,648	2,836	3,289	3,746	3,804	3,656	3,225	2,676	2,305	2,103
Critical	2,048	1,990	2,016	2,193	2,638	2,958	3,053	2,951	2,693	2,315	1,968	1,723

(SLWRI ADEIS) Source: DWR CDEC Gage SHA (2008)

Notes:
Period of record: WY 1992 – 2010.
Year types as defined in the Sacramento Valley Water Year Hydrologic Classification Index

CDEC = California Data Exchange Center
TAF = thousand acre-feet
WY = water year

Table G-3. Historical Shasta Lake Releases by Water-Year Type

Year Type	Average Monthly Release (cfs)												Annual Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
All Years	4,691	4,492	5,307	8,446	10,167	9,881	7,135	9,329	10,610	11,519	9,427	6,826	5,917
Wet	4,791	5,010	8,111	17,104	19,395	17,663	10,990	10,327	11,108	11,714	10,583	7,450	8,109
Above Normal	4,524	3,954	3,739	5,826	9,371	11,073	5,828	10,845	11,035	12,259	9,142	6,623	5,702
Below Normal	4,873	4,252	5,085	4,123	10,322	7,591	4,629	8,451	11,729	11,874	9,020	6,619	5,351
Dry	4,794	4,521	3,681	4,111	2,822	3,440	6,023	8,717	11,109	12,300	9,097	6,302	4,663
Critical	4,458	4,294	4,111	3,282	2,467	2,841	4,319	6,717	7,639	8,866	8,209	6,682	3,873

cfs = cubic feet per second
TAF = thousand acre-feet

Reclamation operates Folsom Lake on American River in conjunction with other CVP reservoirs for flood control, fish and wildlife protection, recreation, saltwater intrusion control in the Delta, irrigation and M&I water supplies, and hydroelectric power generation. Releases from Folsom Dam are re-regulated by downstream Nimbus Dam and Lake Natoma, which enters Sacramento River further downstream. In general, water demands for consumptive purposes are during the warm months of the year, late spring through summer, and the minimum flow requirements from Nimbus Dam for fishery management objectives calls for flows during the fall and winter months. Folsom Lake has the highest refill probability in the CVP system—in most normal hydrologic or wetter hydrologic conditions Folsom Lake will need to release water for flood control purposes during the winter or spring months under USACE prescribed rule curve. If hydrologic conditions are not normal or better, and Folsom Lake storage conditions become stressed, water stored in the Shasta-Trinity system is used to meet CVP water demands and objectives that can be met by either CVP water source. The integrated nature of CVP reservoir operations thus can spread a storage shortage from one year at Folsom Lake to the Shasta-Trinity System.

San Luis Reservoir provides offstream storage for excess winter and spring flows diverted from the Delta. During spring and summer, water demands and schedules south of the Delta are greater than the capability of the Reclamation and DWR to pump water from the Jones and Banks Pumping Plants. Water stored in San Luis Reservoir is used to make up the difference when the CVP share of the storage is typically at its lowest in August and September and at its maximum in April.

SWP

The SWP is the largest state-built, multipurpose water project in the country. DWR operates and maintains the SWP, which conveys an annual average of 2.5 MAF of water through 17 pumping plants, 8 hydroelectric power plants, 32 storage facilities, and more than 660 miles of aqueducts and pipelines.

The SWP primarily develops urban water supply from the Feather River watershed within the region for use in the region and for export to other regions. SWP is operated for water supply, flood control, hydropower generation, recreation, fish and wildlife purposes, and for managing salinity intrusion in the Delta.

DWR operates the SWP to export Delta flows and store and transfer water from the Feather River Basin to the San Joaquin Valley, the South Bay, areas north of Suisun Bay, coastal counties, and ultimately to southern California. Releases from Lake Oroville flow down the Feather River into the Sacramento River, then into the Delta. Like CVP, the Delta is a key component in SWP conveyance system and deliveries. Banks Pumping Plant lifts water from Clifton Court Forebay into the California Aqueduct, which channels the water to Bethany Reservoir, a 5,000 AF forebay for the South Bay Pumping Plant. The water delivered to Bethany Reservoir from Banks Pumping Plant is either delivered into the South Bay Aqueduct for use in the San Francisco Bay Area or continues down the California Aqueduct to O'Neil Forebay, Gianelli Pumping-Generating Plant, and San Luis Reservoir, which is jointly operated by Reclamation and DWR. The 444-mile-long California Aqueduct conveys water to the agricultural lands of the San Joaquin Valley and the urban regions of southern California. The west branch of the aqueduct ends in Castaic Lake, and the east branch terminates at Lake Perris in southern California.

SWP Operation

Like CVP, a series of rules and regulations in the form of flow requirements, water quality requirements, water supply commitments, and flood control requirements governs operations of the major SWP reservoirs and pumping facilities.

SWP is managed to maximize the capture of the usable supply released to the Delta from Lake Oroville. DWR operates the Oroville facilities under the Federal Energy Regulatory Commission (FERC) jurisdiction for power generation, which is currently under consideration by FERC for re-licensing. The operating constraints for Lake Oroville are anticipated to change with the issuance of this new 50-year FERC license, which may affect downstream releases and temperature conditions.

In the southern Delta, the SWP diverts water from Clifton Court Forebay for delivery south of the Delta. The Harvey O. Banks Pumping Plant lifts water from Clifton Court Forebay into Bethany Reservoir. The water delivered to Bethany Reservoir flows into the California Aqueduct, the main conveyance facility of the SWP. Along the western San Joaquin Valley, the California Aqueduct transports water through the Gianelli Pumping/Generating Plant for storage in San Luis Reservoir until it is needed for later use.

Deliveries are made from the California Aqueduct to agricultural and M&I contractors. As water flows through the San Joaquin Valley, deliveries of CVP water are made through numerous turnouts to farmlands in the service areas of the CVP. Near Kettleman City, the Coastal Branch Aqueduct splits from the California Aqueduct for water delivery to agricultural areas to the west and municipal and industrial water users in San Luis Obispo and Santa Barbara counties. The remaining water conveyed by the California Aqueduct travels farther in the San Joaquin Valley to agriculture users such as Kern County Water Agency before reaching Edmonston Pumping Plant, which raises the water high enough to travel across the Tehachapi Mountains into Antelope Valley. In Antelope Valley, the Aqueduct divides into the East and West Branches. The East Branch carries water into Silverwood Lake and Lake Perris. Water in the West Branch flows to Quail Lake, Pyramid Lake, and Castaic Lake.

Delta – Water Supply Operation

The Delta is an integral part of both CVP and SWP operation. The hydraulics of the Delta are affected by tidal influences, river inflows, a multitude of agricultural and M&I diversions for use within the Delta itself, and by CVP and SWP exports. Table G-4 shows the historical monthly average total Delta inflow by water-year type.

Delta Exports: The CVP Jones Pumping Plant consists of six pumps, with a maximum export capacity of 4,600 cfs during the irrigation season, and 4,200 cfs during the winter non-irrigation season. Limitations at the Jones Pumping Plant are

Table G-4. Total Historical Delta Inflow by Year Type

Year Type	Average Monthly Release (cfs)												Annual Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
All Years	14,175	14,393	27,607	58,848	65,903	59,310	41,364	34,635	27,197	23,377	20,039	18,417	24,456
Wet	17,008	17,478	44,745	115,602	121,007	106,529	80,054	60,166	42,826	31,164	24,795	23,444	41,303
Above Normal	12,464	13,032	21,753	49,529	58,561	58,862	36,989	39,892	30,631	24,398	22,061	19,005	23,377
Below Normal	13,054	12,937	22,028	37,391	55,617	46,451	26,900	20,893	22,358	21,709	19,333	17,725	19,075
Dry	12,772	13,959	19,683	24,207	24,168	25,838	16,975	16,017	15,091	19,875	17,436	14,929	13,369
Critical	13,411	11,589	15,418	18,260	27,989	18,667	11,977	10,553	10,729	12,223	11,771	12,695	10,573

Source: (SLWRI, ADEIS, 2011) Interagency Ecological Program Dayflow Calculation (2011)

Notes:
Period of record: WY 1992 – 2010
Year types as defined in the Sacramento Valley Water Year Hydrologic Classification Index

cfs = cubic feet per second
TAF = thousand acre-feet
WY = water year

the result of a DMC freeboard constriction near O'Neill Forebay and current water demand in the upper sections of the DMC. The Jones Pumping Plant is at the end of an earth-lined intake channel approximately 2.5 miles long.

The SWP Banks Pumping Plant supplies water for the South Bay Aqueduct (SBA) and the California Aqueduct, with an installed capacity of 10,300 cfs. Under current operational constraints, exports from Banks Pumping Plant are generally limited to a daily average of 6,680 cfs, except between December 15 and March 15, when exports can be increased by 33 percent of San Joaquin River flow. The Banks Pumping Plant exports water from Clifton Court Forebay, a 31,000 AF reservoir that provides storage for off-peak pumping, and moderates the effect of the pumps on the fluctuation of flow and stage in adjacent Delta channels.

CCWD supplies CVP water to its users via a pumping plant at the end of Rock Slough. At Rock Slough, the water is lifted 127 feet into the Contra Costa Canal by a series of four pumping plants. The 47.5-mile-long canal terminates in Martinez Reservoir. The Rock Slough diversion capacity of 350 cfs gradually decreases to 22 cfs at the terminus.

CCWD also has an intake and pumping plant on the Old River for diverting surplus Delta flows to the 100,000 AF Los Vaqueros Reservoir for storage or contract water to CCWD users. CCWD constructed and operates the Los Vaqueros Reservoir. Los Vaqueros is refilled by diversions only when source water chloride concentration is relatively low. Los Vaqueros water is used for water quality blending and delivery during low Delta outflow periods. CCWD also has a third diversion facility in the Delta at the southern end of a 3,000-foot-long channel running due south of Suisun Bay, near Mallard Slough, with a capacity of 39.3 cfs. The Mallard Slough facility is only used during periods of very high Delta outflow.

Delta Outflow: Tributary inflows and export pumping are the principal variables that define the range of hydrodynamic conditions in the Delta, as the tidal inflows are approximately equivalent to tidal outflows during each daily tidal cycle. Excess outflow occurs almost entirely during the winter and spring months. Due to tidal factors and changing channel geometry, Delta outflow is typically a calculated value rather than a directly measured one, as presented in Table G-5.

Groundwater Supply

On an average, groundwater currently supplies approximately 35 percent of California's overall dedicated water supplies in average precipitation years (CWP, 2009, V2). In dry years, this percentage increases to 40 percent or higher statewide, and as high as 60 percent or more in specific regions. The importance of groundwater as a resource varies regionally. Significant groundwater use occurs in the San Joaquin, Tulare Lake, Sacramento Valley, Central Coast, and South Coast regions of California. Over a third of groundwater use in California occurs in the Tulare Lake Basin. In some areas, use of groundwater resources is threatened by high rates of extraction and inadequate recharge, or by contamination of aquifers as a result of land use practices or naturally occurring contaminants.

Table G-5. Calculated Historical Delta Outflow by Year Type

Year Type	Average Monthly Release (cfs)												Annual Total (TAF)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
All Years	5,424	14,518	30,768	52,981	62,052	53,002	37,108	26,492	15,823	8,322	6,569	9,171	19,662
Wet	6,867	9,969	38,735	111,298	117,230	103,527	75,658	54,680	32,121	16,432	10,641	10,715	35,427
Above Normal	5,325	6,242	15,851	41,114	50,914	51,526	30,858	35,013	18,864	9,395	6,977	5,068	16,718
Below Normal	5,462	5,913	15,347	29,704	49,137	36,968	23,579	16,652	11,085	7,009	4,603	5,280	12,672
Dry	4,241	5,916	11,722	17,074	18,830	18,455	11,807	12,051	7,644	5,203	3,714	4,175	7,296
Critical	4,225	5,193	8,854	13,916	24,473	12,020	7,963	6,450	4,821	3,697	3,063	4,300	5,945

Source: (SLWRI, ADEIS, 2011) Interagency Ecological Program Dayflow Calculation (2011)

Notes:
Period of record: WY 1992 – 2010
Year types as defined in the Sacramento Valley Water Year Hydrologic Classification Index

cfs = cubic feet per second
TAF = thousand acre-feet
WY = water year

More than 70 percent of groundwater extraction occur in the Central Valley (Sacramento River, San Joaquin River and Tulare Lake Regions combined) (CWP, 2009, V2); groundwater has historically been important to both urban and agricultural uses, accounting for 41 percent of the region's total annual supply and 35 percent of all groundwater use in the state. Groundwater use in the region represents approximately 10 percent of the state's overall water supply for agricultural and urban uses. Agricultural demand for groundwater, however, dwarfs municipal and industrial demand. According to United States Geological Survey (USGS) analysis, between 1961 and 2003 surface water supplied, on average, approximately 10 MAF per year for irrigation in the Central Valley, and groundwater supplied slightly less than 9 MAF per year (CRS Research for Congress, California Drought Update, Dec 2009, p. 10).

In the Sacramento Valley Groundwater Basin, groundwater is used intensively in some areas but is little used in areas with abundant surface water supplies. Historically, groundwater levels associated with the Sacramento Valley have remained steady, declining moderately during extended droughts and generally recovering to their pre-drought levels during subsequent wetter periods, with the exception of Yolo and Zamora areas that have 1 to 2 feet of land subsidence due to extensive groundwater extraction (CWP, 2009, V 3, Sac Region).

Groundwater accounts for approximately 15 percent of the Bay Region's average annual total water supply. The more heavily used basins include Santa Clara Valley, Livermore Valley, Westside, Nile Cone, Napa-Sonoma Valley, and Petaluma Valley Groundwater Basins. In the Monterey area of the Central Coast Region, nearly all of the region's water supply comes from the Carmel River and groundwater in the Carmel Valley aquifer, and groundwater in the coastal subareas of the Seaside Groundwater Basins.

Areas within the San Joaquin groundwater basin, the largest in California, are heavily groundwater-reliant. Groundwater accounts for approximately 33 percent of the annual supply used for agricultural and urban purposes (CWP, 2009, V 2). Much of the San Joaquin groundwater basin is in overdraft conditions due to extensive groundwater pumping and irrigation, although the extent of overdraft varies widely from region to region. Groundwater use accounts for approximately 41 percent of the annual supply used for agricultural and urban purposes in the Tulare Lake region, and is approximately 35 percent of all groundwater use in the state. Greater reliance on groundwater during dry years results in higher costs for many users and more groundwater overdraft.

Groundwater is an important source of water supply to Southern Central Coast region, where production is concentrated mainly along the coast. Conjunctive use of surface water and groundwater is a long-standing practice in the region. San Luis Obispo County obtains nearly 80 percent of its water from groundwater supplies and approximately 20 percent from reservoirs and other sources. Groundwater is a vital resource to the South Coast region both as a supply source and as a tool for storage. Conjunctive use is the coordinated operation of multiple water supplies. Groundwater production within the greater metropolitan service area is estimated at 1.6 MAF annually. Groundwater is the largest single source of water in the Santa Clara Planning Area, and the primary water supply source in the Santa Ana planning area.

DWR estimates that statewide groundwater overdraft is somewhere between one and two million AF per year. A significant amount of this overdraft occurs in the Central Valley, particularly in the Tulare Lake Basin (Delta Stewart Council [DSC], 2010). Water agencies in the Tulare Lake region have been practicing conjunctive use for many years to manage groundwater and assist dry year supplies (CWP, 2009).

Water Supply and Drought

Water resources vary over the years, and the water uses by various demand sectors vary according to the wetness or dryness of a given year. In general, during a single dry year or two, surface water and groundwater storage can supply most water deliveries, but dry years can strain the storage and result in critically low water reserves. More recently, improved water use efficiency and conservation practices have helped to meet water demands. However, significant water supply and water quality challenges persist. Water supply reliability is most affected during drought conditions.

Various regulations and policies influence the operation of the reservoirs and water supply availability. In general, regulations are updated frequently based on new data and/or other conditions such as litigation. The most recent U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) released biological opinions (BiOps) of 2008 and 2009 requirements that have been considered in recent years' water supply allocation decisions are subject of litigations.

An indicator of California's hydrology and the annual surface water supplies is the amount of water that flows into major rivers of the state. The Sacramento River Basin and San Joaquin River Basin annual unimpaired natural runoff categorized as five water-year classifications, from wet to critical, have been used as indicators of surface water availability. These indices influence decisions regarding annual water requirements for the Delta. Figures G-2 and G-3 (California Drought Update, Dec 2009) present Sacramento River Basin and San Joaquin River Basin unimpaired natural runoff from 1906 to 2009, classified as the five water-year types from wet to critical.

Figures G-2 and G-3 show for Sacramento River Basin, the most recent multi-year below normal conditions were the periods of 1987-1992 and 2007-2009, and for San Joaquin River Basin such periods were 1987-1992, 2001-2004, and 2007-2009. Table G-6 shows the water year type of the recent years for Sacramento River Basin and San Joaquin River Basin (California Drought Update, Dec 2009).

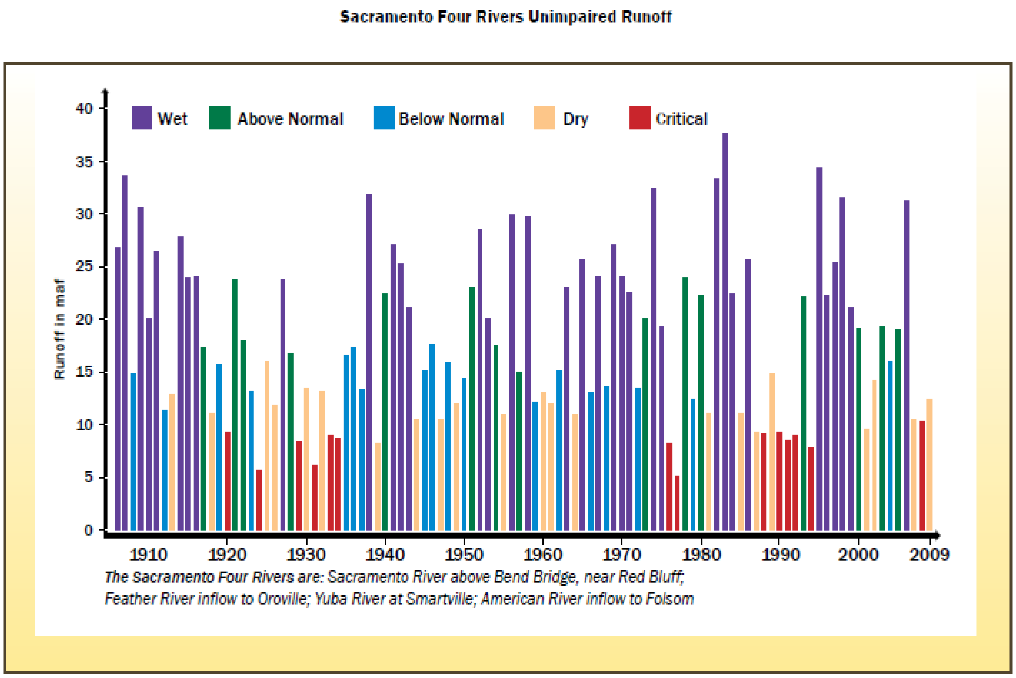


Figure G-2. Sacramento Four Rivers Unimpaired Flow

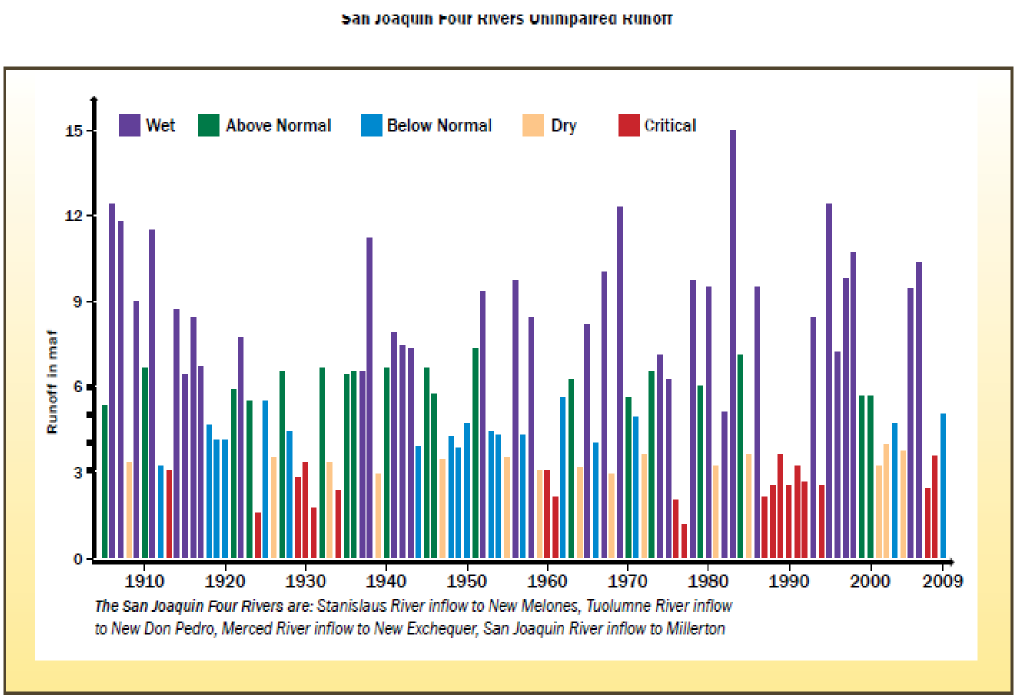


Figure G-3. San Joaquin Four Rivers Unimpaired Flow

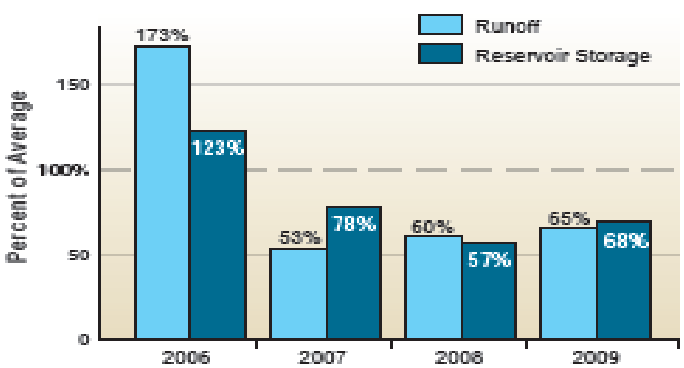
Table G-6. Sacramento and San Joaquin River Runoff and Water-Year Type Based on Data

Water Year	Sacramento River Runoff, MAF	Sacramento River Index	Sacramento River Year Type	San Joaquin River Runoff, MAF	San Joaquin River Index	San Joaquin River Year Type
2006	32.09	0.73	W	10.44	5.9	W
2007	10.28	2.49	D	2051	2.0	C
2008	10.2	3.05	C	3.50	2.1	C
2009	12.91	1.26	D	4.97	2.7	BN
2010[a]	15.6	6.9	BN	6.2	3.5	AN

[a] May 2010 forecast-based

AN = above normal
BN = below normal
C = critical
D = dry
W = wet

The three sequential dry years, 2007 through 2009, marked a period of unprecedented restrictions in CVP and SWP diversions due to both drought and regulatory restrictions to protect listed fish species. Figure G-4 shows statewide runoff for 2006 through 2009 as percentage of average, and end-of-year storage for the state's larger reservoirs: Trinity, Shasta, Oroville, Folsom, Don Pedro, New Melones, and San Luis.



Statewide runoff totals and end-of-water-year storage, 2006 to 2009, for key reservoirs (Trinity, Shasta, Oroville, Folsom, Don Pedro, New Melones, and San Luis) as a percentage of average.

Source: DWR 2009

Figure G-4. Total Statewide Runoff and Key Reservoir Storage End of Water-Years 2006-2009

Figure G-5 shows the effect of three consecutive below normal flow years on reservoir storage of a few selected facilities as of December 2009. This figure presents that storage at some of the larger CVP and SWP reservoirs—particularly Shasta Lake, Lake Oroville and San Luis Reservoir, did not recover from the impacts of two previous dry years.

Figure 8. Reservoir Storage at Selected Facilities

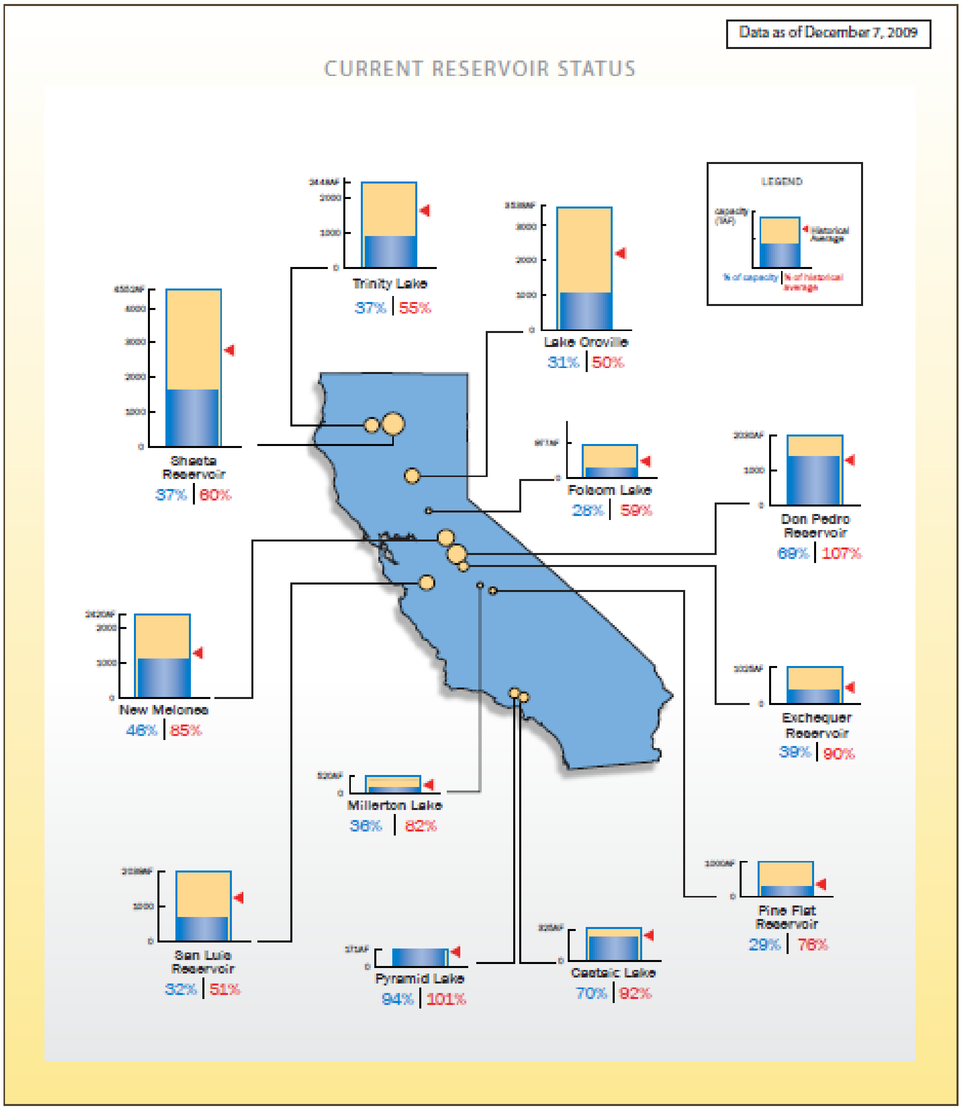


Figure G-5. Reservoir Storage at Selected Facilities on December 7, 2009
(Source: DWR, *California Drought Update*. April 30, 2009.)

Low storage amounts in San Luis Reservoir and in Metropolitan Water District of Southern California's (MWD's) Diamond Valley Lake, both of which rely on water exported from the Delta for filling, reflect the impacts of regulatory restrictions on SWP Delta pumping.

Another indicator of the effect of below-normal flow years is the annual amount of water that is exported and the outflows from the Delta, as shown in Figure G-6 (DSC, 2010). Water from the Delta is used by in-Delta and upstream diverters, for meeting flow requirements for ecosystem health and to prevent salinity intrusion, and exported to southern and central California to supply urban uses and over 700 million acres of irrigated land. The Delta supplies one-quarter of the state's urban water supply and is a major source to two-thirds of California's population (DWR, 2009). Figure G-6 also shows the variability in Delta exports based on water availability in the system. The reduction of flow from the droughts of 1959-1961, 1976-1977, 1987-1992, and 2007-2009 (DWR, 2010) impacts water supply availability from the Delta for urban, agricultural and environmental uses.

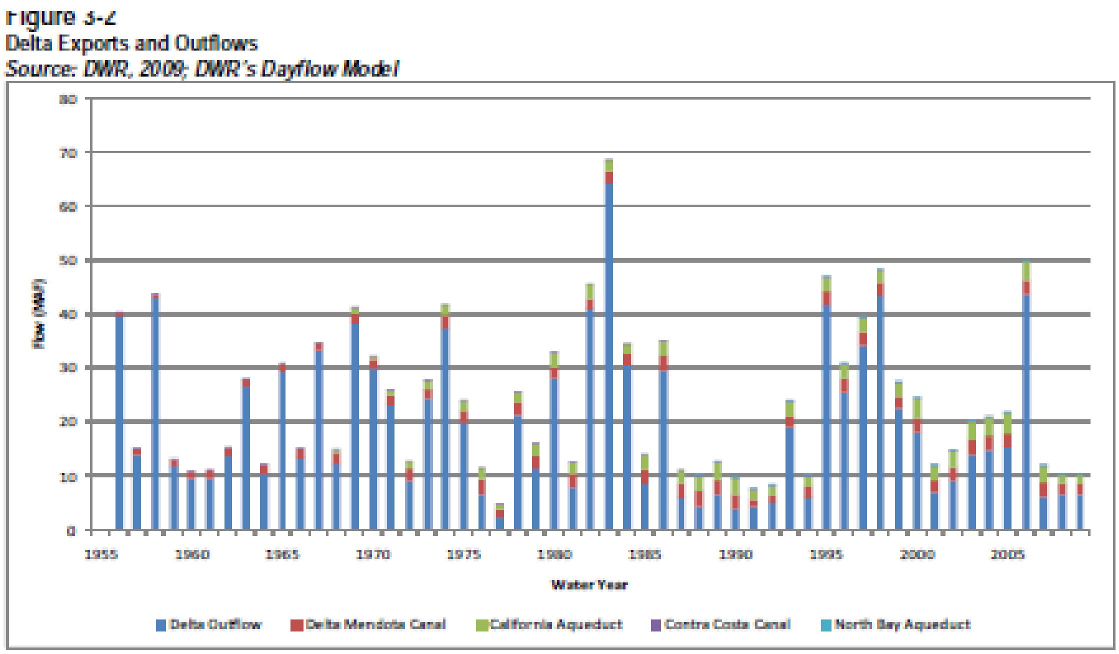


Figure G-6. Annual Delta Exports and Outflows

Decline in groundwater levels during the 2007-2009 period were also observed. Groundwater levels measured in October 2009 in the northern Sacramento shows that groundwater levels were approximately 1 foot lower on average during fall 2009 than they were in October 2008. Also groundwater levels were approximately 6 feet lower during fall 2009 than they were in October 2006, which was the last wet year in the Sacramento Valley, and Redding Basin Valley and Redding Basin. Comprehensive analysis of drought impacts to individual groundwater basins have not been conducted yet. Data availability limitations associated with assessing drought impacts on groundwater conditions make it difficult to generalize impacts at a statewide or large-scale regional level.

The reduced water availability impacts from the drought of 2007-2009, and part of 2010, ended with a widespread flood in early 2011 in many regions of California. The ability of the CVP and SWP to contribute to statewide water supply reliability have been reduced over the past decade due to various protective actions, including the Central Valley Project Improvement Act (CVPIA) (Public Law 102-575), and the *Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (State Water Resources Control Board [SWRCB], 1995), as well as recent court decisions restricting water exports from the Delta. Changed CVP and SWP regulatory conditions in the Delta represent a major difference between past droughts and 2007-2009.

The impact of the 2007-2009 drought on resources and economy were relatively more severe than those experienced during prior dry conditions (California Drought Update, Dec 2009). With the continued population increase and the diminished flexibility for system operation and declining groundwater, the balancing act of water supplies and uses from year to year has already become quite challenging, and may prove to be even more challenging to manage in the future. Potential climate change impacts and other uncertainties add complexities to the already difficult situation. As competition grows during dry years among water users, water management becomes more complex and the challenge to make sure that water is in the right place at the right time is at its greatest during such dry years. The CWP acknowledges that reliability is most challenging during drought conditions, and includes the following as one of the 10 fundamental lessons:

> "California needs additional groundwater and surface water storage capacity. Storage gives water managers tremendous flexibility to meet multiple needs and provide vital reserves in drier years."

Water Demand

Table G-7 presents the estimated water demand and supply (1995-base) for the Central Valley and the state (SLWRI, ADFS, 2011). Table G-8 presents similar estimates of water demand and supply comparison of future condition (year 2020) for the Central Valley and the state. Both tables are primarily based on the 1998 CWP.

As shown in Table G-7, the estimated water demands (applied water) in the state for 1995 for urban, agricultural, and environmental purposes under average and drought year conditions were approximately 80 and 65 MAF, respectively. To address this demand, available total statewide supplies under average and drought year conditions were approximately 78 and 60 MAF, respectively. During average years, approximately 83 percent of the available supplies came from surface water sources and 16 percent from groundwater. In dry years, water from surface water sources declined to approximately 73 percent of the available supplies and nearly all of the remainder came from groundwater. For the Central Valley, the estimated water demands during average and drought years for the Sacramento and San Joaquin River basins were approximately 26 and 24 MAF, respectively. The total estimated water supply for average and drought year conditions was approximately 25 and 22 MAF, respectively. The estimated net water demand (or shortages) for drought year conditions was approximately 1.6 MAF (SLWRI ADFS).

Looking into the future (year 2020), Table G-8 presents that the total estimated water supply for average and drought year conditions for Sacramento River and San Joaquin River Basins would be approximately 26 and 22 MAF, respectively; with a total estimated water demand for average and drought year conditions at approximately 26 and 24 MAF, respectively, estimated net demand for the two river basins in 2020 is approximately 0.2 and 1.7 MAF, respectively. For the state, the estimated net demand for water in 2020 from the two basins is approximately 2.4 and 6.3 MAF, respectively.

Table G-7. Estimated Water Demands, Supplies, and Shortages (1995)

Item	Hydrologic Basin						State of California	
	Sacramento River		San Joaquin River		Two-Basin Total			
	Average Year	Drought Year	Average Year	Drought Year	Average Year	Drought Year	Average Year	Drought Year
Population (million)	2.4		1.6		4.0		32.1	
Urban Use Rate (GPCPD)	28	313	322	327	302	319	244	251
Acres in Production (million)	2.1	2	4.1	9.5				
Agricultural Use (AFPA)	3.8	4.2	3.5	3.6	3.6	3.9	3.5	3.6
Applied Water (MAF)								
Urban	0.8	0.8	0.6	0.6	1.4	1.4	8.8	9.0
Agricultural	8.1	9.1	7.0	7.2	15.1	16.3	33.8	34.5
Environmental	5.8	4.2	3.4	1.9	9.2	6.1	36.9	21.2
Total	**14.7**	**14.1**	**11.0**	**9.7**	**25.7**	**23.8**	**79.5**	**64.7**
Water Supply (MAF)								
Surface Water	11.9	10.0	8.5	6.0	20.5	16.1	65.1	43.5
Groundwater	2.7	3.2	2.2	2.9	4.9	6.1	12.5	15.8
Recycled/Desalted	0	0	0	0	0	0	.3	.3
Total	**14.6**	**13.2**	**10.7**	**8.9**	**25.4**	**22.2**	**77.9**	**59.6**
Shortage (MAF)	**0**	**0.9**	**0.3**	**0.8**	**0.3**	**1.6**	**1.6**	**5.1**

Source: SLWRI, ADFR, 2011, California Water Plan, Bulletin 160-98, 1998.
AFPA = acre-feet per acre
GPCPD = gallons per capita per day
MAF = million acre-feet

Table G-8. Estimated Water Demands, Supplies, and Shortages for 2020

Item	Sacramento and San Joaquin Hydrologic Basins Two-Basin Total		State of California	
	Average Year	Drought Year	Average Year	Drought Year
Population (million)	6.8		47.5	
Urban Use Rate (GPCPD)	274	288	226	233
Acres In Production (million)	4.1		9.2	
Agricultural Use (AFPA)	3.6	3.9	3.4	3.5
Applied Water (MAF)				
Urban	2.1	2.2	12.0	12.4
Agricultural	14.4	15.5	31.5	32.3
Environmental	9.3	6.1	37.0	21.3
Total	**25.8**	**23.9**	**80.5**	**66.0**
Water Supply (MAF)				
Surface Water	20.7	16.0	65.0	43.3
Groundwater	4.9	6.2	12.7	16.0
Recycled/Desalted	0	0	0.4	0.4
Total	**25.6**	**22.2**	**78.1**	**59.7**
Shortage (MAF)	**0.2**	**1.7**	**2.4**	**6.3**

Source: (SLWRI, ADFR, 2011) CWP, Bulletin 160-98, Appendix 6A, Regional Water Budgets with Existing Facilities and Programs, November 1998.

AFPA = acre-feet per acre
GPCPD = gallons per capita per day
MAF = million acre-feet

The CWP 2009 projected an increase in the urban water use for the Sacramento and San Joaquin River Basin areas from the 2005 estimated values for 2050 assuming three future growth scenarios under the Current Trends, Slow and Strategic Growth, and Expansive Growth scenarios; such estimated net increase in water demand are approximately 1.4 MAF, 0.4 MAF and 1.9 MAF, respectively, as presented in Table G-9. The urban water demand growth projections for the three scenarios are influenced by the assumptions of population growth and background water conservation savings.

Table G-9. State Water Demand Change for the Three Growth Scenarios, CWP 2009

Scenario Factors for Urban Water Demand	2005	Future Scenarios –2050		
		Current Trends	Slow and Strategic Growth	Expansive Growth
Population (millions)	36.7	59.5	44.2	69.8
Change in Water Demand from Current (2005), MAF/year:				
Urban		6.0	1.5	9.8
Agriculture		-5.0	-5.8	-4.5
Environmental		1.0	1.8	0.7
Total (Urban, Agricultural, and Environmental)		2.0	- 2.5	6.0

CWP = California Water Plan
MAF = million acre-feet

CVP Contractors

The CVP delivers water in accordance with requirements of water right settlement and exchange contracts with the CVP, water rights agreements with the CVP, water quality requirements established by the SWRCB, refuge water supplies and fish and wildlife requirements in accordance with the CVPIA, water service contractors in the Central Valley, Santa Clara Valley and the San Francisco Bay Area (DSC, p. 3-8, 2010), and recent court decisions restricting water export from the Delta.

The CVP has 273 water service contractors. The CVP provides water to settlement contractors in the Sacramento Valley, exchange contractors in the San Joaquin Valley, agricultural and M&I water service contractors in both the Sacramento and San Joaquin Valleys, and wildlife refuges north and south of the Delta. At certain times of the year, operations of Shasta Lake are driven by water supply needs of the CVP Contractors. The majority of the federal water service contractors have service areas located south of the Delta. Most of their supplies must be conveyed through the Delta before delivery. Allocations vary considerably from year to year. In general, allocations to CVP water service contractors south of the Delta are lower than allocations to service contractors in the Sacramento Valley. Table G-10 presents a detailed summary of CVP annual contract amounts for service areas supplied from the Delta.

CVP Water Allocation

Reclamation balances allocation of CVP water for agricultural, environmental, and M&I purposes. The complex task is driven by numerous factors, including hydrology and water supply conditions as reported by DWR, storage in CVP reservoirs, input from other agencies and organizations, regulations, court decisions, biological opinions, environmental considerations, and operational limitations.

The CVP water service contracts have varying water shortage provisions, some of which are tied to critical year storage in Shasta Lake. Critical year storage in Shasta Lake is defined as a year when the total inflow to Shasta Lake is below 3.2 MAF, or the average inflow for a two-year period is below 4.0 MAF and the total two-year deficiency for deliveries is higher than 0.8 MAF. Historical CVP allocations since 1997 are shown later in this section.

At the beginning of each year, Reclamation evaluates hydrologic conditions throughout California and uses this information to forecast CVP operations, and to estimate the amount of water to be made available to the federal water service contractors for the year (allocations to settlement and exchange contractors are fixed according to unimpaired inflow to Shasta Lake).

Reclamation has a general Water Shortage Policy applicable to most CVP contractors, a few key points of which are presented below (OCAP-BA 2008):

Table G-10. Summary of CVP Contract Amounts for Service Areas South of the Delta

Contractors	CVP Long-Term Contracts: Contract Number	Current Effective Periods	Annual Entitlements (acre-feet)	Types	Water Right, Annual Amount (acre-feet)
Delta-Mendota Canal					
Exchange Contractors	I1r-1144	-	**840,000**		
Central California Irrigation District, Columbia Canal Co., Firebaugh Canal Water District, San Luis Canal Co.				Exchange	
Refuges			**177,297**		
Grassland Water District	01-WC-20-1754	03/01/2001 – 02/28/2026	125,000[a]	Refuge	—
California Department of Fish and Game (total)	01-WC-20-1756	03/01/2001 – 02/28/2026	37,007[a]	Refuge	—
Volta Wildlife Management Area	01-WC-20-1756	03/01/2001 – 02/28/2026	13,000[a]	Refuge	—
Los Banos Wildlife Management Area	01-WC-20-1756	03/01/2001 – 02/28/2026	10,470[a]	Refuge	—
Salt Slough	01-WC-20-1756	03/01/2001 – 02/28/2026	6,680[a]	Refuge	—
China Island	01-WC-20-1756	03/01/2001 – 02/28/2026	6,857[a]	Refuge	—
National Wildlife Refuge in San Joaquin Valley	01-WC-20-1758	03/01/2001 – 02/28/2026	15,290[a]	Refuge	—
Kesterson National Wildlife Refuge	01-WC-20-1758	03/01/2001 – 02/28/2026	10,000[a]	Refuge	—
Freitas	01-WC-20-1758	03/01/2001 – 02/28/2026	5,290[a]	Refuge	—
Irrigation and M&I			**378,872**		—
City of Tracy	Being Negotiated	—	10,000	Irrigation and M&I	—
Banta-Carbona Irrigation District	14-06-200-4305A-LTR1	03/01/2005 – 02/28/2030	20,000	Irrigation and M&I	—
West Side Irrigation District	7-07-20-W0045-LTR1	03/01/2005 – 02/28/2030	5,000	Irrigation and M&I	—
Del Puerto Water District	14-06-200-922-LTR1	03/01/2005 – 02/28/2030	140,210[b]	Irrigation and M&I	—

Table G-10. (Continued)

Contractors	CVP Long-Term Contracts: Contract Number	CVP Long-Term Contracts: Current Effective Periods	CVP Long-Term Contracts: Annual Entitlements (acre-feet)	CVP Long-Term Contracts: Types (acre-feet)	Water Right, Annual Amount (acre-feet)
Delta-Mendota Canal (cont'd)					
Irrigation and M&I (cont'd)					—
West Stanislaus Water District	14-06-200-1072-LTR1	03/01/2005 – 02/28/2030	50,000	Irrigation and M&I	—
Patterson Water District	14-06-200-3598A-LTR1	03/01/2005 – 02/28/2030	16,500	Irrigation and M&I	6,000
Centinella Water District	7-07-20-W0055-LTR1	03/01/2005 – 02/28/2030	2,500	Irrigation and M&I	—
Broadview Water District	14-06-200-8092-LTR1	03/01/2005 – 02/28/2030	27,000	Irrigation and M&I	—
Byron Bethany Irrigation District	NA	NA	20,600	NA	NA
Eagle Field Water District	14-06-200-7754-LTR1	03/01/2005 – 02/28/2030	4,550	Irrigation and M&I	—
Mercy Springs Water District	14-06-200-3365A-LTR1	03/01/2005 – 02/28/2030	2,842	Irrigation and M&I	—
Oro Loma Water District	14-06-200-7823-LTR1	03/01/2005 – 02/28/2030	4,600	Irrigation and M&I	—
DWR Intertie at MP7.70-R	NA	NA	NA	Irrigation and M&I	—
Newman Wasteway Recirculation	NA	NA	NA	Irrigation and M&I	—
Panoche Water District	NA	NA	27,000	Irrigation and M&I	—
San Luis Water District	14-06-200-7773A-LTR1	03/01/2005 – 02/28/2030	45,080	Irrigation and M&I	—
Widren Water District	14-06-200-8018-LTR1	03/01/2005 – 02/28/2030	2,990	Irrigation and M&I	—
Total for Delta-Mendota Canal			**1,396,169**		6,000

Table G-10. (Continued)

Contractors	CVP Long-Term Contracts: Contract Number	Current Effective Periods	Annual Entitlements (acre-feet)	Types	Water Right, Annual Amount (acre-feet)
San Joaquin and Mendota Pool					
Exchange Contractors	I1r-1144		**840,000**	Exchange	—
Central California Irrigation District, Columbia Canal Co., Firebaugh Canal Water District, San Luis Canal Co.				Exchange	
Refuges			**218,098**		
Grassland Water District	01-WC-20-1754	03/01/2001 – 02/28/2026	125,000[a]	Refuge	—
California Department of Fish and Game	01-WC-20-1756	03/01/2001 – 02/28/2026	51,601[a]	Refuge	—
Los Banos Wildlife Management Area	01-WC-20-1756	03/01/2001 – 02/28/2026	10,470[a]	Refuge	—
Salt Slough	01-WC-20-1756	03/01/2001 – 02/28/2026	6,680[a]	Refuge	—
China Island	01-WC-20-1756	03/01/2001 – 02/28/2026	6,857[a]	Refuge	—
Mendota Wildlife Management Area	01-WC-20-1756	03/01/2001 – 02/28/2026	27,594[a]	Refuge	—
National Wildlife Refuge in San Joaquin Valley	01-WC-20-1758	03/01/2001 – 02/28/2026	41,497[a]	Refuge	—
San Luis National Wildlife Refuge	01-WC-20-1758	03/01/2001 – 02/28/2026	19,000[a]	Refuge	—
Kesterson National Wildlife Refuge	01-WC-20-1758	03/01/2001 – 02/28/2026	10,000[a]	Refuge	—
West Bear Creek	01-WC-20-1758	03/01/2001 – 02/28/2026	7,207[a]	Refuge	—
Freitas	01-WC-20-1758	03/01/2001 – 02/28/2026	5,290[a]	Refuge	—
Irrigation and M&I			**106,348**		
Fresno Slough Water District	14-06-200-4019A-LTR1	03/01/2005 – 02/28/2030	4,000	Irrigation and M&I	866
James Irrigation District	14-06-200-700-A-LTR1	03/01/2005 – 02/28/2030	35,300	Irrigation and M&I	9,700
Tranquility Irrigation District	14-06-200-701-A-LTR1	03/01/2005 – 02/28/2030	13,800	Irrigation and M&I	20,200
Hughes	14-06-200-3537A-LTR1	03/01/2005 – 02/28/2030	70[c]	Irrigation and M&I	93

Table G-10. (Continued)

Contractors	CVP Long-Term Contracts: Contract Number	Current Effective Periods	Annual Entitlements (acre-feet)	Types	Water Right, Annual Amount (acre-feet)
San Joaquin and Mendota Pool (cont'd)					
Irrigation and M&I (cont'd)					
Reclamation District 1606	14-06-200-3802A-LTR1	03/01/2005 – 02/28/2030	228	Irrigation and M&I	342
Dudley and Indart[d]	NA	NA	NA	Irrigation and M&I	2,280
Meyers, Marvin, Patricia[d]	NA	NA	NA	Irrigation and M&I	210
Laguna Water District	2-07-20-W0266-LTR1	03/01/2005 – 02/28/2030	800	Irrigation and M&I	—
Tranquility Public Utilities	NA	NA	70	Irrigation and M&I	—
Mid-Valley Water District (no contract)	NA	NA	NA	Irrigation and M&I	—
Terra Linda Farms (Coelho Family Trust)	NA	NA	2,080	Irrigation and M&I	—
Westlands Water District	NA	NA	50,000	Irrigation	—
Wilson, JW (no contract)	NA	NA	NA	Irrigation and M&I	—
Total San Joaquin and Mendota Pool			**1,164,446**		33,691
San Luis Canal/Cross Valley Canal					
Refuges			**64,601**		
California Department of Fish and Game	01-WC-20-1756	03/01/2001 – 02/28/2026	64,601[a]	Refuge	—
O'Neill Forebay Wildlife Refuge	NA	NA	NA	Refuge	—
Irrigation and M&I			**1,703,030**		
Broadview Water District	14-06-200-8092-LTR1	03/01/2005 – 02/28/2030	27,000	Irrigation and M&I	—
San Luis Water District	14-06-200-7773A-LTR1	03/01/2005 – 02/28/2030	80,000	Irrigation and M&I	—

Table G-10. (Continued)

Contractors	CVP Long-Term Contracts				Water Right, Annual Amount (acre-feet)
	Contract Number	Current Effective Periods	Annual Entitlements (acre-feet)	Types	
San Luis Canal/Cross Valley Canal (cont'd))					
Irrigation and M&I(cont'd)					
Veterans Administration Cemetery	3-07-20-W1124-LTR1	03/01/2005 – 02/28/2045	850	Irrigation	—
Panoche Water District	14-06-200-7864A-LTR1	03/01/2005 – 02/28/2030	94,000	Irrigation and M&I	—
Pacheco Water District	6-07-20-W0469-LTR1	03/01/2005 – 02/28/2030	10,080	Irrigation and M&I	6,000
City of Avenal	14-06-200-4619-LTR1	03/01/2005 – 02/28/2045	3,500	M&I	—
City of Coalinga	14-06-200-4173A-LTR1	03/01/2005 – 02/28/2045	10,000	M&I	—
City of Huron	14-06-200-7081A-LTR1	03/01/2005 - 02/28/2045	3,000	M&I	—
Westlands Water District	14-06-200-495A-LTR1	03/01/2005 - 02/28/2030	1,150,000	Irrigation and M&I	—
County of Fresno	14-06-200-8292A-LTR1	03/01/2005 – 02/28/2030	3,000	Irrigation and M&I	—
Hills Valley Irrigation District	14-06-200-8466A-LTR1	03/01/2005 – 02/28/2030	3,346	Irrigation and M&I	—
Kern-Tulare Irrigation District	14-06-200-8601A-LTR1	03/01/2005 – 02/28/2030	40,000	Irrigation and M&I	—
Lower Tule River Irrigation District	14-06-200-8237A-LTR1	03/01/2005 – 02/28/2030	31,102	Irrigation and M&I	—
Pixley Irrigation District	14-06-200-8238A-LTR1	03/01/2005 – 02/28/2030	31,102	Irrigation and M&I	—
Rag Gulch Water District	14-06-200-8367A-LTR1	03/01/2005 – 02/28/2030	13,300	Irrigation and M&I	—
Tri-Valley Water District	14-06-200-8565A-LTR1	03/01/2005 – 02/28/2030	1,142	Irrigation and M&I	—
County of Tulare	14-06-200-8293A-LTR1	03/01/2005 – 02/28/2030	5,308	Irrigation and M&I	—

Table G-10. (Continued)

Contractors	CVP Long-Term Contracts: Contract Number	Current Effective Periods	Annual Entitlements (acre-feet)	Types	Water Right, Annual Amount (acre-feet)
San Luis Canal/Cross Valley Canal (cont'd))					
Irrigation and M&I(cont'd)					
San Benito Country Water District	8-07-20-W0130-LTR1 (interim)	03/01/2001 – 02/28/2002	35,550[d]	Irrigation	—
			8,250[d]	M&I	—
Santa Clara Valley Water District	7-07-20-W0023-LTR1 (interim)	03/01/2001 – 02/28/2002	33,100[d]	Irrigation	—
			119,400[d]	M&I	—
Total for San Luis and Cross Valley Canals			**1,767,631**		6,000
Totals for CVP South of Delta			**3,488,246**		45,691

Data Source: (SLWRI, ADFR, 2011) CVPIA long-term water service contract Web site (Reclamation 2005)

[a] Level 2 contract amount.
[b] Del Puerto contract includes Davis, Hospital, Kern Canon, Salado, Sunflower, Mustang, Orestimba, Foothill, Quinto, and Romero water districts.
[c] CVPIA long-term contract information is not available. Present in historical delivery record.
[d] Interim contract is based on the latest information available from the CVPIA.

CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
DWR = California Department of Water Resources
M&I = municipal & industrial
NA = not available
— = 0

Before allocation of M&I water to a contractor will be reduced, allocation of irrigation water will be reduced to below 75 percent of contract entitlement, as shown in Table G-11. When allocation of irrigation water has been reduced to below 75 percent and still further water supply reductions are necessary, both the M&I and irrigation allocations will be reduced by the same percentage increment. The M&I allocation will be reduced until it reaches 75 percent of adjusted historical use, and the irrigation allocation will be reduced until it reaches 50 percent of contract entitlement. The M&I allocation will not be further reduced until the irrigation allocation is reduced to below 25 percent of contract entitlement, as shown in the following tabulation (Table G-11).

Table G-11. CVP Water Allocation Policy

Irrigation Allocation	M&I Allocation
100%	100%
75	100%
70%	95%
65%	90%
60%	85%
55%	80%
50%-25%	75%

M&I = municipal and industrial

When allocation of irrigation water is reduced to below 25 percent of contract entitlement, Reclamation will reassess both the availability of CVP water supply and CVP water demand. Due to limited water supplies, during these times M&I water allocation to contractors may be reduced to below 75 percent of adjusted historical use. The M&I minimum shortage allocation does not apply to a few specific contracts, such as the contract for the Friant Division; any separate shortage-related contractual provisions prevail.

Table G-12 (California Drought Update, Dec 2009 and SLWRI AD FR H&H, 2011) shows historical CVP allocations since 1998. The largest reductions in CVP water deliveries went to contractors for project water (as opposed to the water rights settlement and exchange contractors) located south of the Delta. Prior to the 2007-2009 drought, the only comparable water delivery reductions to south-of-Delta CVP contractors occurred during 1977 (the single driest year of the state's hydrologic record) when all project water agricultural contractors received 25 percent supplies. South-of-Delta project contractors had no subsequent water delivery deficiencies until 1990 and 1991 (the fifth and sixth years of the 1987-92 drought) when they received 50 percent and 25 percent deliveries, respectively.

Table G-12. Historical CVP Water Supply Allocations – Long-Term Contractors

Year	Year Type	CVP Contract Allocation (%)						
		Agricultural		Urban		Wildlife Refuges		Settlement/ Exchange
		North of Delta	South of Delta	North of Delta	South of Delta	North of Delta	South of Delta	
1997	Wet	90	90	90 - 100	90 - 100	As scheduled	As scheduled	100
1998	Wet	100	100	100	100	100	100	100
1999	Wet	100	70	95	95	100	100	100
2000	Above Normal	100	65	100	90	100	100	100
2001	Dry	60	49	85	77	100	100	100
2002	Dry	100	70	100	95	100	100	100
2003	Above Normal	100	75	100	100	100	100	100
2004	Below Normal	100	70	100	95	100	100	100
2005	Above Normal	100	85	100	100	100	100	100
2006	Wet	100	100	100	100	100	100	100
2007	Dry	100	50	100	75	100	100	100
2008	Critical	40	40	75	75	100	100	100
2009	Dry	40	10	75	60	100	100	100

Source: (SLWRI, ADFR H&H, 2011) Central Valley Project Operations website (Reclamation, 2011).

Notes:
Year types as defined in the Sacramento Valley Water Year Hydrologic Classification Index

CVP = Central Valley Project
TAF = thousand acre-feet

SWP Contractors

Approximately two-thirds of California's estimated 38 million residents benefit from SWP water, which also irrigates approximately 600,000 acres of farmland, mainly in the south San Joaquin Valley (SLWRI, ADFR H&H, 2011). Of the contracted water supply, urban users have received approximately half of the total water delivered over the last 20 years; the remainder is supplied for agricultural use. A total of 29 contracting agencies receive water from the SWP.

The CVP and SWP are intrinsically linked through the Delta; shared responsibilities under their respective water rights and coordinated operations agreements mean that a change in flow from one project could result in a flow change from the other.

The SWP operates under long-term contracts with public water agencies throughout California. These agencies, in turn, deliver water to wholesalers or retailers, or deliver it directly to agricultural and M&I water users. The SWP contracts between DWR and individual state water contractors define several classifications of water available for delivery under specific circumstances. All classifications are considered "project water." Table A (Table G-13) is an exhibit to the SWP long-term water supply contracts. Table A amounts are used to define each contractor's proportion of the available water supply that DWR will allocate and deliver to that contractor. Each year, each contractor may request an amount not to exceed its Table A amount. The Table A amounts are used as a basis for allocations to contractors, but the actual annual supply to contractors is variable and depends on the amount of water available.

Water delivery capabilities are frequently lower than Table A amounts. Table A water is water delivered according to this apportionment methodology and is given first priority for delivery. The total Table A amount has increased since inception of the SWP, and is projected to reach a maximum amount of about 4.2 MAF per year by 2021. The current Table A amount provided each year is about 4.15 MAF (DWR, 2009). Table G-13 presents maximum annual Table A amounts allocated to the 29 SWP contractors.

Table G-13. SWP Water Contracts, Table A

Region	ID #	State Water Project Contractor Agency	Max Annual Entitlement (acre-feet)
Upper Feather River	1	City of Yuba	9,600
	2	County of Butte	3,500
	3	Plumas County Flood Control & Water Conservation District	1,750
	Subtotal		14,850
North Bay Area	4	Napa County Flood Control & Water Conservation District	21,850
	5	Solano County Water Agency	47,206
	Subtotal		69,056
South Bay Area	6	Alameda County Flood Control & Water Conservation District, Zone 7	80,619
	7	Alameda County Water District	42,000
	8	Santa Clara Valley Water District	100,000
			222,619

Table G-13. (Continued)

Region	ID #	State Water Project Contractor Agency	Max Annual Entitlement (acre-feet)
San Joaquin Valley	9	County of Kings	9,000
	10	Dudley Ridge Water District	57,343
	11	Empire West Side Irrigation District	3,000
	12	Kern County Water Agency	998,730
	13	Oak Flat Water District	5,700
	14	Tulare Lake Basin Water Storage District	106,127
			1,179,900
Central Coast	15	San Luis Obispo County Flood Control & Water Conservation District	25,000
	16	Santa Barbara County Flood Control & Water Conservation District	45,486
			70,486
Southern California	17	Antelope Valley-East Kern Water Agency	138,400
	18	Castaic Lake Water Agency*	82,500
	19	Coachella Valley Water District	23,100
	20	Crestline-Lake Arrowhead Water Agency	5,800
	21	Desert Water Agency	38,100
	22	Littlerock Creek Irrigation District	2,300
	23	Mojave Water Agency	75,800
	24	Palmdale Water District	17,300
	25	San Bernardino Valley Municipal Water District	102,600
	26	San Gabriel Valley Municipal Water District	28,800
	27	San Gorgonio Pass Water Agency	6,000
	28	The Metropolitan Water District of Southern California	2,011,500
	29	Ventura County Flood Control District	20,000
	Subtotal		2,559,200
Total State Water Project			4,116,111

*Note: Castaic Lake Water Agency acquired Devil's Den W.D. entitlement in 1992.

The Monterey Agreement, signed by 27 of the 29 SWP water contractors in 1995, restructured the SWP contracts to allocate water based on contractual Table A amounts instead of the amount of water requested for a given year. In times of shortages, the water supply to SWP agricultural and M&I contractors will be reduced equally.

Many contractors also make frequent use of additional contract water types to increase or decrease the amount of water available to the contractors under Table A. Other contract types of water include Article 21 Water, Turnback Pool Water, and Carryover Water.

SWP Water Allocation

The SWP allocation (proportion of Table A to be delivered) for any specific year is made based on a number of factors, including existing storage, current regulatory constraints, projected hydrologic conditions, and desired carryover storage. Since

1995, annual delivery of Table A water has varied between 1.374 MAF (in 2001) and 2.965 MAF (in 2003). Article 21 deliveries have varied between approximately 20 TAF (in 1998) to 309 TAF (in 2000) (DWR 2006). Table G-14 shows historical SWP deliveries since 1997 by year.

The 2009 SWP allocation of 40 percent can be compared with its 1991 allocation of 30 percent urban and zero agricultural, which represents the project's lowest historical percentage of requested deliveries. However, direct comparison of CVP and SWP delivery capabilities under present hydrologic conditions to deliveries during historical drought events are not comparable due to significant new regulatory requirements and environmental goals that have been put in place since prior droughts. Within the recent three-year dry period, for example, the Federal District Court decision in 2007 to require implementation of an interim remedy to protect delta smelt, and other related activities, have significantly curtailed both projects' export capability (DWR, 2009).

Table G-14. Historical SWP Water Allocation

Year	Year Type	Table A		Article 21 (TAF)	Fish and Wildlife (TAF)	Water Rights and Other Contractors (TAF)
		Allocation (%)	Delivery (TAF)			
1997	Wet	—	2,324	21	1315	4.15
1998	Wet	100	1,726	20	2187	2.11
1999	Wet	100	2,379	158	7794	4.32
2000	Above Normal	90	3,201	309	1419	4.03
2001	Dry	39	1,547	43	1614	2.93
2002	Dry	70	2,573	43	1442	3.69
2003	Above Normal	90	2,901	60	1260	2.85
2004	Below Normal	65	2,600	218	1533	2.87
2005	Above Normal	90	—	—	—	—
2006	Wet	100	—	—	—	—
2007	Dry	60	—	—	—	—
2008	Critical	35				
2009	Dry	40				

Source: (SLWRI, ADFR, H&H, 2011) DWR Bulletin 132 1997 through 2006 (DWR 2006; DWR, 2010)

Notes:

Year types as defined in the Sacramento Valley Water Year Hydrologic Classification Index

Delivery information for 2005-2007 not available at time of publication

TAF = thousand acre-feet
— = No data available at time of this report

Water Supply Alternatives Simulation

CALSIM II, a water resources planning model, is used in the NODOS feasibility studies to evaluate the environmental and water supply benefits and impacts of each of the NODOS alternatives. DWR conducted the modeling for the NODOS feasibility studies for existing condition and for future conditions using CALSIM-II and a few other tools. Modeling output used in a comparative analysis will help support the benefits of each of the alternatives considered.

The CALSIM-II assumptions for the Existing Conditions and No Project Alternative are summarized in an October 1, 2010 memorandum *Assumptions for Existing and Future No Action Alternative Conditions CALSIM II and DSM2 Models*. The assumptions for the NODOS alternatives are summarized in a January 5, 2011 document *Definition of Proposed Alternatives for Evaluation in the North-of-the-Delta Offstream Storage Administrative Draft Environmental Impact Report and Statement*. The existing and future conditions are based on the following:

Existing Condition - 2005 Level of Development

Future Condition - 2030 Level of Development

Alternatives Considered

The three best alternatives (Alternative A, Alternative B, and Alternative C) and the No Project Alternative were selected for further analysis based on the result of the net benefits.

No Project Alternative

The terms “No Project Alternative” and “Without Project Future Conditions” are considered synonymous. The No Project Alternative is a plan that is compared against the action alternatives. The No Project Alternative is intended to account for existing facilities, conditions, land uses, and reasonably foreseeable actions expected to occur in the study area. Reasonably foreseeable actions include actions with current authorization, complete funding for design and construction, and complete environmental permitting and compliance. Under the No Project Alternative, no actions would be taken to provide storage north-of-the-Delta to improve water supply or to enhance the survivability of anadromous fish or drinking water quality in the Delta. Details regarding assumptions of the No Project Alternative are presented in the Feasibility Report.

Action Alternatives

For the evaluation of NODOS action alternatives, a simulation of system-wide operations with historic streamflow conditions (i.e., CALSIM-II and related models) was used to determine the benefits provided by Sites Reservoir when integrated with the CVP and SWP systems. The benefits were evaluated under the average and driest hydrologic conditions for primary purposes, including water supply reliability, water quality, hydrologic generation, and ecosystem restoration enhancement. The ability of each action alternative to implement the primary objectives effectively is subject to the primary objectives, each action alternative’s conveyance options included, and the coordinated operation of Sites Reservoir with other existing facilities for the determination of Sites Reservoir releases.

The action alternatives were simulated to meet the primary objectives, with priorities assigned to the objective that vary depending on the water-year type. The modeled reservoir and the system operations use the alternative operating rules through a wide range of hydrologic and operational conditions to determine how the model operates the project for each primary beneficiary.

For most actions associated with the objective of improved survival of anadromous fish and other species, the performance of the action alternative depends on the decisions regarding Shasta Lake storage and Keswick releases, Lake Oroville storage and Folsom Lake storage. To achieve an optimal condition for anadromous fish in the Sacramento River between Keswick and Red Bluff, releases from Shasta Lake must be managed accordingly.

For actions associated with improved water supply and Delta water quality, the performance of the action alternative depends on the decisions regarding Sites Reservoir storage and releases. The releases from Sites Reservoir to the Sacramento River are often constrained by the capacity to convey water to the river or by the amount of storage available in Sites Reservoir. Storage availability is constrained by the releases made for preceding actions and requirements, and Delta export regarding improved water supply may also be constrained by the BiOps.

To optimize the performance of Sites Reservoir for all primary objectives, Shasta Lake, Lake Oroville, Folsom Lake, and Sites Reservoir releases are coordinated. The operation of Sites Reservoir would be integrated with the operation of Shasta Dam for implementing the summer irrigation diversions to meet the local needs as well as to meet the objectives of the NODOS Project. Water from Sites Reservoir would be used to meet the primary objectives. Direct releases of water to the GCID Canal and T-C Canal, would serve up to half of the GCID and Tehama-Colusa Canal Authority (TCCA) contractor’s service areas downstream from Holthouse Reservoir that, without Sites Reservoir, would be delivered entirely by direct diversion from the Sacramento River.

Alternative A (1.27 MAF Sites Reservoir with Delevan Pipeline)

Alternative A would include the Delevan Pipeline to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion), to convey water to and from Sites Reservoir, with a reservoir capacity of 1.27 MAF, using the common features. In Alternative A, the Delevan Pipeline would be formulated with the capacity for a 2,000-cfs diversion and a 1,500-cfs release. Conveyance would terminate at the Holthouse Reservoir Complex that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from the Holthouse Reservoir Complex into Sites Reservoir.

Alternative B (1.81 MAF Sites Reservoir with Release-only Delevan Pipeline)

Alternative B would include the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water to Sites Reservoir, with a reservoir capacity of 1.81 MAF, and the Delevan Pipeline to supplement the conveyance, using the common features. In Alternative B, the Delevan Pipeline would be formulated as release only, with the capacity for a 1,500-cfs release. Conveyance would terminate at the Holthouse Reservoir Complex that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from the Holthouse Reservoir Complex into Sites Reservoir.

Alternative C (1.81 MAF Sites Reservoir with Delevan Pipeline)

Alternative C would include the Delevan Pipeline to supplement the existing T-C Canal (2,100-cfs diversion) and GCID Canal (1,800-cfs diversion) to convey water from Sites Reservoir, with a reservoir capacity of 1.81 MAF, using the common features. In Alternative C, the Delevan Pipeline would be formulated with the capacity for a 2,000-cfs diversion and a 1,500-cfs release. Conveyance would terminate at an enlarged Funks Reservoir that would serve as the forebay and afterbay for the Sites Pumping Plant and be used to regulate demands or releases from Sites Reservoir. The Sites Pumping Plant would lift water from Holthouse Reservoir into Sites Reservoir.

Table G-15 presents the major features and the operational priorities of each of the three alternatives as included in CALSIM II modeling, and Figure G-7 presents the layout of the physical features of the various alternatives.

Models Used

A suite of modeling tools was used to analyze the effects of the NODOS Project on different resource areas. Reclamation, DWR, and their consultants developed a set of “Common Assumptions” studies as part of CALFED known as the Common Assumptions Common Model Package (CACMP). Many of the tools were developed or refined as part of the CALFED Surface Storage Investigation Common Assumptions effort. Each of the CALFED Surface Storage Investigations is using the same tools for a consistent approach and methodology to evaluate the respective projects.

Table G-15. Major Physical Components and Operations Prioritization of NODOS

Major Components	Alternative A	Alternative B	Alternative C
Operations Priority	*A. In years with driest hydrologic conditions* 1. Environmental Enhancement Cold-Water Pool and Temperature Management Actions 2. SWP contractors *B. In years with average hydrologic conditions* 1. Environmental Enhancement Flow Actions 2. Delta Water quality 3. Alternative Level 4 water supply for wildlife refuges 4. CVP contractors 5. Hydropower generation	*A. In years with driest hydrologic conditions* 1. Environmental Enhancement Cold-Water Pool and Temperature Management Actions 2. SWP contractors *B. In years with average hydrologic conditions* 1. Environmental Enhancement Flow Actions 2. Delta Water quality 3. Alternative Level 4 water supply for wildlife refuges 4. CVP contractors 5. Hydropower generation	*A. In years with driest hydrologic conditions* 1. Environmental Enhancement Cold-Water Pool and Temperature Management Actions 2. SWP contractors *B. In years with average hydrologic conditions* 1. Environmental Enhancement Flow Actions 2. Delta Water quality 3. Alternative Level 4 water supply for wildlife refuges 4. CVP contractors 5. Hydropower generation
Sites Reservoir	Reservoir configuration used has a storage capacity of 1.27 MAF, a maximum water surface elevation of 480 feet msl, and an inundation area of approximately 12,000 acres.	Reservoir configuration used has a storage capacity of 1.81 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres.	Reservoir configuration used has a storage capacity of 1.81 MAF, a maximum water surface elevation of 520 feet msl, and an inundation area of approximately 14,000 acres.
Delevan Pipeline	A new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs) The new pipeline would be constructed to convey water from the Sacramento River west to Holthouse Reservoir and returned to the Sacramento River.	Pipeline for only release to the Sacramento River (up to 1,500 cfs); no fish screen or intake included. The new pipeline would be constructed to convey water from Holthouse Reservoir to Sacramento River near Delevan pipeline.	A new point of diversion (2,000 cfs) and release to the Sacramento River (up to 1,500 cfs). The new pipeline would be constructed to convey water from the Sacramento River west to Holthouse Reservoir and returned to the Sacramento River.
T-C and GCID Canals Used to Convey Water to Sites Reservoir	Canals currently used to convey water to TCCA and GCID service areas.		
Modifications to T-C Canal	One additional 250 cfs pump at Red Bluff Pumping Plant		

Table G-15. (Continued)

Major Components	Alternative A	Alternative B	Alternative C
Modifications to GCID Canal	Replacement of 1 siphon		
	Installation of a TRR and pump station		
	Installation of a pipeline from the TRR pump station to Holthouse Reservoir		

cfs = cubic feet per second
CVP = Central Valley Project
GCID = Glenn-Colusa Irrigation District
msl = mean sea level
SWP = State Water Project
TAF = thousand acre-feet
T-C = Tehama-Colusa
TCCA = Tehama-Colusa Canal Authority
TRR = terminal regulating reservoir

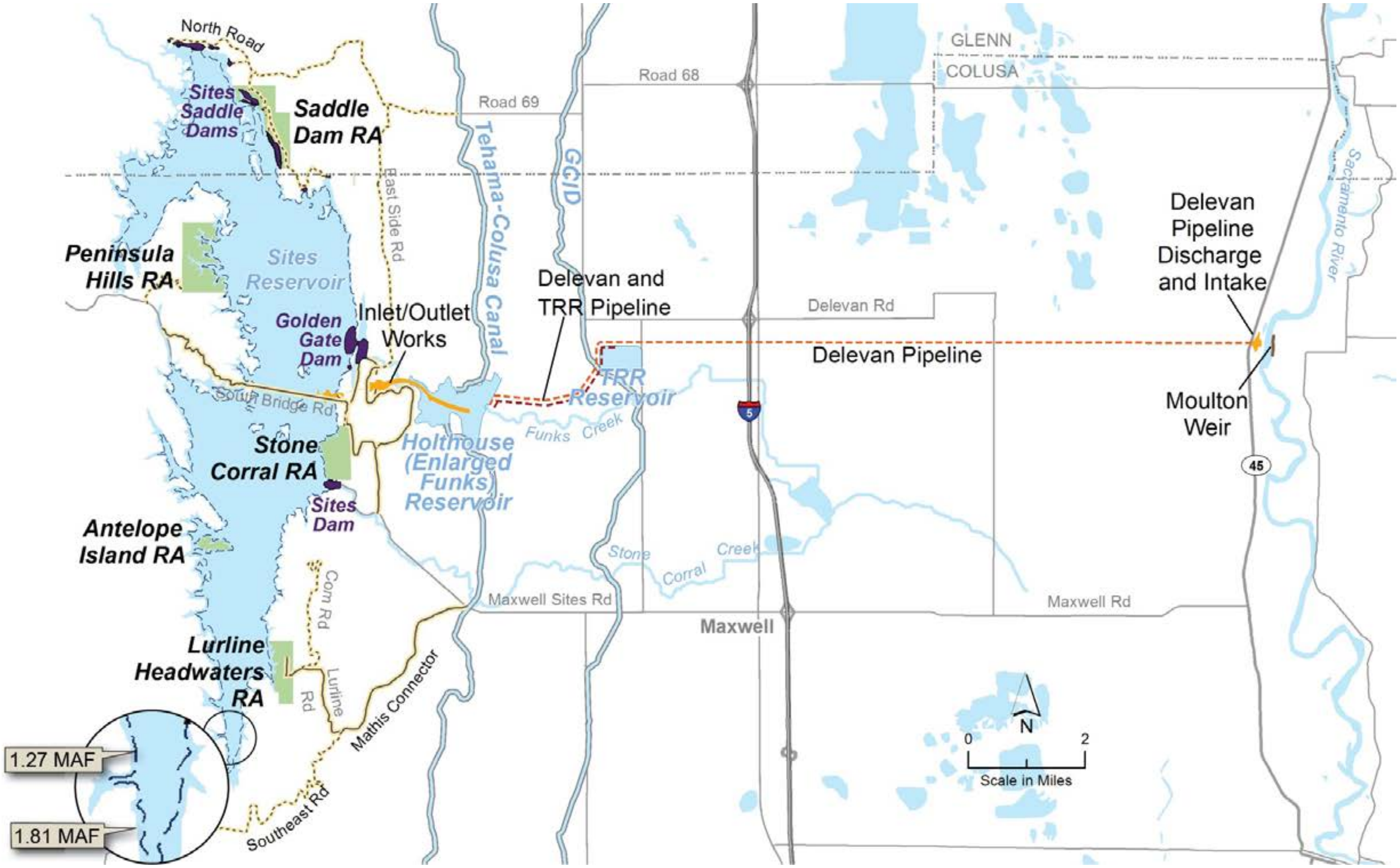


Figure G-7. NODOS Alternatives Features

The CACMP uses different modeling tools, and output from each of these tools for various alternatives can be compared to a common baseline to determine the relative effect of the alternative on the resource area of interest. The following is a partial list of the various models that are used in different analyses:

CVP and SWP Hydrology and System Operations Model (CALSIM II)	Monthly operations model of Central Valley hydrology (under specified climate), reservoir and river flow conditions associated with projected levels of land and water use, riverine and Delta regulatory conditions, including NMFS and USFWS Biological Opinion (BiOps), and CVP, SWP and other existing and proposed project facilities including existing and proposed policies and agreements. However, not all conditions of the BiOps can be implemented in CALSIM II. The NODOS Environmental Impact Report/Environmental Impact Statement (EIR/EIS) includes a detailed description of the actions included in the modeling regarding the USFWS and NMFS BiOps.
Delta Hydrodynamics and Salinity Models (DSM2 HYDRO and QUAL)	HYDRO: One-dimensional hydrodynamics of the Delta; modeling Delta channel flows, stages and cross-section average velocities under tidal conditions (one-dimensional and simplified boundary conditions limit use of results to monthly statistics); QUAL: conserved water quality constituents based on practical salinity (electrical conductivity) calibration; uses outputs from CALSIM II.
Reclamation Temperature and Mortality Models	Monthly average temperature calculations using empirical-based equations for Sacramento, Feather, American, and Stanislaus Rivers. Degree day empirical-based estimates of fraction of population lost each year for winter-, spring-, fall- and late-fall-run Chinook salmon due to thermal conditions only; uses outputs from CALSIM II. It should be noted that the temperature modeling results do not include temperature changes from the releases from Sites Reservoir. A simplifying assumption was made that the proposed reservoir could be managed to release flows at temperatures that correspond to the Sacramento River receiving water condition. A preliminary analysis of temperature effects from releases is provided in Attachment 1 to this appendix.
Power Modules (Long-Term Generation, SWP Power, NODOS Power)	Monthly estimates of power generation and loads for CVP, SWP, and proposed NODOS facilities; simplified factors used to separate peak and non-peak generation and load; estimate of net-revenue based on price forecasts; uses outputs from CALSIM II
Agricultural Economics Models (Statewide Agricultural Production Model or Central Valley Planning Model)	Agricultural production economic model for the Central Valley (SWAP option includes some areas outside of Central Valley); analysis uses a one or multiple set of sample years based on outputs from CALSIM II; considers availability of surface and groundwater supplies.
Urban Economics Models (LCPSIM, SUPEM)	LCPSIM: Urban economics model to determine least-cost solution for supply/demand balance for the South Bay and South Coast regions; SUPEM: Urban water supply valuation for other urban areas utilizing assumptions associated with availability of surface and groundwater supplies; uses outputs from CALSIM II.

Urban Water Quality Models (LCRBWQM and SBWQM for TDS damages)	Estimate of long-term projected damages due to TDS on household, municipal and energy production facilities in the South Coast (LCRBWQM) and South Bay (SBWQM) regions.
Upper Sacramento River Daily Operations Model (USRDOM)	Simulates daily reservoir operations and daily river flows for the Upper Sacramento River from Shasta Dam to Knights Landing, including the facilities and tributaries within this region including the Trinity River section of the CVP and the Sutter Bypass Region including conveyance and storage facilities of the proposed NODOS Project.
Upper Sacramento River Temperature/Water Quality Model (USRWQM)	Simulates the temperature regime of Upper Sacramento River. The NODOS model extends from Keswick Dam to Knights Landing and includes the Sacramento River, RBDD, Black Butte Dam, Stony Creek, T-C Canal, GCID Canal, Colusa Basin Drain, a proposed Delevan Pipeline, enlarged Funks Reservoir, and the proposed Sites Reservoir. Provides estimate of daily average riverine temperature conditions.
Salmonid Population Model (SALMOD)	Emulates dynamics of freshwater life history of anadromous and resident salmonid populations using streamflow, water temperature, and habitat type. Provides potential fish production values reflecting the suitability of riverine habitat for winter, spring, fall and late-fall-run Chinook salmon.

The following section presents a few key assumptions used in CALSIM-II modeling tool for the NODOS feasibility studies. Additional system operations modeling simulations have been completed using Sacramento River daily operations model (USRDOM). As stated earlier, the detailed assumptions for the alternatives' CALSIM-II modeling conducted by DWR are summarized in several memoranda.

Modeling Assumptions for the NODOS Feasibility Studies

For the surface storage investigations, the planning horizon for the future conditions is assumed to be the year 2030. The future conditions include facilities, policies, regulations, programs, and operational assumptions included in the existing conditions plus actions, projects, and programs that are reasonably expected to be in place in the future.

A few highlights of general operational rules in the CALSIM-II Study for the NODOS feasibility studies are listed below:

- Shasta Lake operation – Shasta Lake capacity is 4,552 TAF. The reservoir is operated to achieve certain target end-of-September storage level, to conserve sufficient cold water for meeting temperature criteria (summer to early fall). Storage levels are lowest by October, providing sufficient flood protection and capture capacity during the following wet months. The storage target gradually increases from October to full pool in May. Then, storage is withdrawn for high water demand (municipal, agricultural, fishery, and water quality uses, etc.) during the summer.

- Imports from the Trinity River watershed – Since 1964, Trinity River water has been imported into the Sacramento River basin through Clear Creek and Spring Creek tunnels (capacities of 3,300 and 4,200 cfs, respectively). After meeting the monthly minimum instream flow requirement below Lewiston Lake, and the Trinity Lake end-of-September minimum storage target, Trinity River water is diverted into Whiskeytown Lake. Monthly diversions are based on the beginning-of-month storage in Shasta Lake and Trinity Lake. Operations of the Shasta Lake and Trinity Lake consider various targets and requirements, for example, the minimum flow requirement downstream from Whiskeytown Dam, minimum flow requirement below Keswick Dam, minimum flow requirement below the RBDD, and flow objective for navigation control point at Wilkins Slough, among others.

- Similar to Shasta flood operation rules, rules for other reservoirs are also considered in the system modeling.

Assumptions Regarding NODOS Alternatives Operations

The following are the general assumptions regarding NODOS intake and conveyance system:

- For a given Delevan infrastructure configuration, maximize Sacramento River diversions between the three diversion points

- Diversion Period to Sites Reservoir:
  - T-C Canal: November – March
  - GCID Canal: November – March
  - Delevan Pipeline: June – March (April and May are reserved for maintenance)

- Diversion Priority:
  - T-C Canal
  - GCID Canal
  - Delevan Pipeline

- Conveyance:
  - T-C Canal and headworks: 2,100 cfs pump
  - GCID Canal and headworks: 1,800 cfs pump
  - Sacramento River Pumping/Generating Plant and Delevan Pipeline: 2,000 cfs pump/1,500 cfs release
  - Terminal Regulating Reservoir (TRR), TRR Pumping/Generating Plant, and TRR Pipeline: 1,800 cfs pump/1,500 cfs release

NODOS storage fills during excess flow events throughout the winter and spring and drains during peak release periods throughout the summer and fall; NODOS operation in the model is considered as a part of the CVP and SWP system operation to achieve the established objectives and goals of this project.

The following operations priorities are considered in CALSIM-II modeling of the alternatives:

A. In years with driest hydrologic conditions:
    a. Ecosystem Enhancement Actions (EEA) Cold-Water Pool and Temperature Management Actions
    b. SWP contractors
B. In years with average hydrologic conditions:
    a. EEA Flow Actions
    b. Delta water quality
    c. Alternative Level 4 water supply for wildlife refuges
    d. CVP contractors
    e. Hydropower generation

The EEA included in the proposed action alternatives regarding water operations are described below:

1. Improve the reliability of coldwater pool storage in Shasta Lake to increase Reclamation's operational flexibility to provide suitable water temperatures in the Sacramento River (see Action 2 below). This action would operationally translate into the increase of Shasta Lake May storage levels, with particular emphasis on Below Normal, Dry, and Critical water year-types.

2. Provide releases from Shasta Dam of appropriate water temperatures, to maintain mean daily water temperatures year-round at levels in the Sacramento River between Keswick Dam and RBDD during Below Normal, Dry, and Critical water year-types.

3. Increase the availability of coldwater pool storage in Folsom Lake, by increasing May storage and coldwater pool storage, to allow the Reclamation additional operational flexibility to provide suitable water temperatures in the lower American River. This action would utilize additional coldwater pool storage by providing release from Folsom Dam and subsequently from Nimbus Dam to maintain mean daily water temperatures at levels suitable for juvenile steelhead from May through November during all water year types (not explicitly modeled in CALSIM II).

4. Stabilize flows in the lower American River to minimize dewatering of fall-run Chinook salmon redds in October through March and steelhead redds from January through May. Reduce isolation events (especially flow increases to 4,000 cfs with subsequent reduction lo less than 4,000 cfs) of juvenile anadromous salmonids particularly from October through June. Reduce reliance upon Folsom Lake as a real-time first response facility to meet Delta objectives and demands particularly from January through August to reduce flow fluctuations and water temperature related impacts to fall-run Chinook salmon and steelhead in the lower American River (not explicitly modeled in CALSIM-II).

5. Provide supplemental Delta outflow during summer and fall months (i.e., May through December) to improve X2 position (if possible, west of Collinsville, 81 kilometers).

6. Improve the reliability of coldwater pool storage in Lake Oroville to improve water temperature suitability in the lower Feather River from May through November during all water year types.

7. Stabilize flows in the Sacramento River between Keswick Dam and the RBDD, particularly during fall months.

8. Provide increased flows from spring through fall in the lower Sacramento River by reducing diversions at RBDD (into the T-C Canal) and at Hamilton City (into the GCID Canal), and by providing supplemental flows (at Delevan).

Operations of Shasta Dam depend on conditions in Trinity Lake, Whiskeytown Lake, and Keswick Reservoir, and on requirements for Sacramento River flows and temperature at various locations. Through coordination and cooperation for CVP and SWP management, Shasta Lake carryover storage are managed, and other operational restrictions are considered. Because CALSIM-II lacks temperature simulation capability, additional cold-water releases from Shasta Lake are used as a surrogate for meeting temperature requirements.

Water Supply Reliability

No Project Alternative

Demands for water in the Central Valley and throughout California exceed available supplies, and the need for additional supplies is expected to grow. As presented earlier, the population of California is expected to increase by more than 60 percent by 2050. Significant increases in population also will occur in the Central Valley; population in the Central Valley is expected to increase nearly 130 percent by 2050. As population grows, the demand for water will continue to significantly exceed available supplies. Competition for available water supplies will intensify as water demands increase to support M&I and associated urban growth relative to agricultural uses. Water conservation and reuse efforts are expected to significantly increase over the current efforts, and forced conservation resulting from increasing shortages will continue.

The No Project Alternative would continue providing Level 2 water supply for refuges, water supply for local water users (e.g., TCCA and potentially GCID service areas) and water supply for the CVP and SWP contractors. The CVP and SWP demand is projected to increase for the future condition. The total water supply availability increase would be 228 TAF/year and 30 TAF/year for the long-term and the Dry/Critical-year average conditions, respectively. Results of simulation for the No Project scenario are presented with the three action alternatives in the following section.

Action Alternatives

Table G-16 shows the accomplishments of the NODOS alternatives compared to the No Project Alternative for the long-term average and the Dry/Critical-year average conditions. The water supply benefits of the alternatives would be achieved with the additional storage from Sites Reservoir and related conveyance, and with coordinated/integrated operations of Sites Reservoir with Shasta Lake, Folsom Lake, and Lake Oroville. Figure G-8 shows the accomplishments of the NODOS alternatives compared to the No Project Alternative for the three benefit categories; Figure G-9 shows the total benefit of each alternative for the long-term average and the Dry/Critical-year average conditions. Table G-17 shows the detailed water supply enhancement for the subregions and the various users groups for the alternatives considered.

Table G-16. Benefits Due to NODOS Alternatives – Long-Term and Dry/Critical Years Average Annual in TAF

		Scenarios		
		Alternative A TAF/year	**Alternative B TAF/year**	**Alternative C TAF/year**
Long-Term Average	Water Supply	213	213	246
	Water Quality	128	136	165
	Ecosystem Enhancement Account	84	80	77
Dry/Critical Years Average	Water Supply	355	308	383
	Water Quality	117	119	169
	Ecosystem Enhancement Account	91	98	86
Total Yield Increase	Long-Term Average	425	429	488
	Dry/Critical Years Average	563	526	637

NODOS = North-of-the-Delta Offstream Storage
TAF = thousand acre-feet

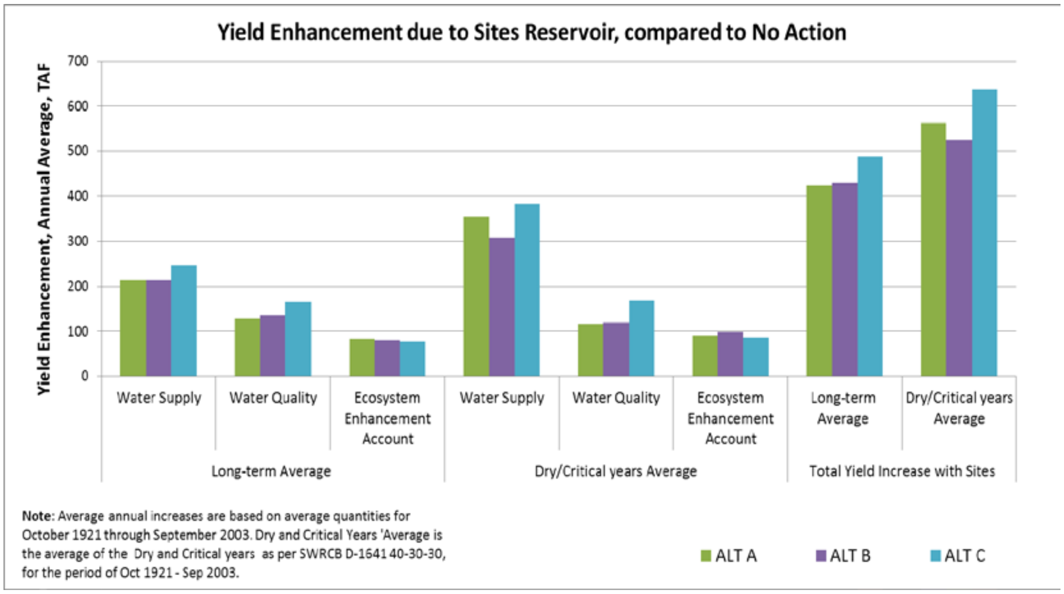


Figure G-8. Benefits Due to NODOS Alternatives Compared to the No Project Alternative – Long-Term and Dry/Critical Years Average, TAF/Year

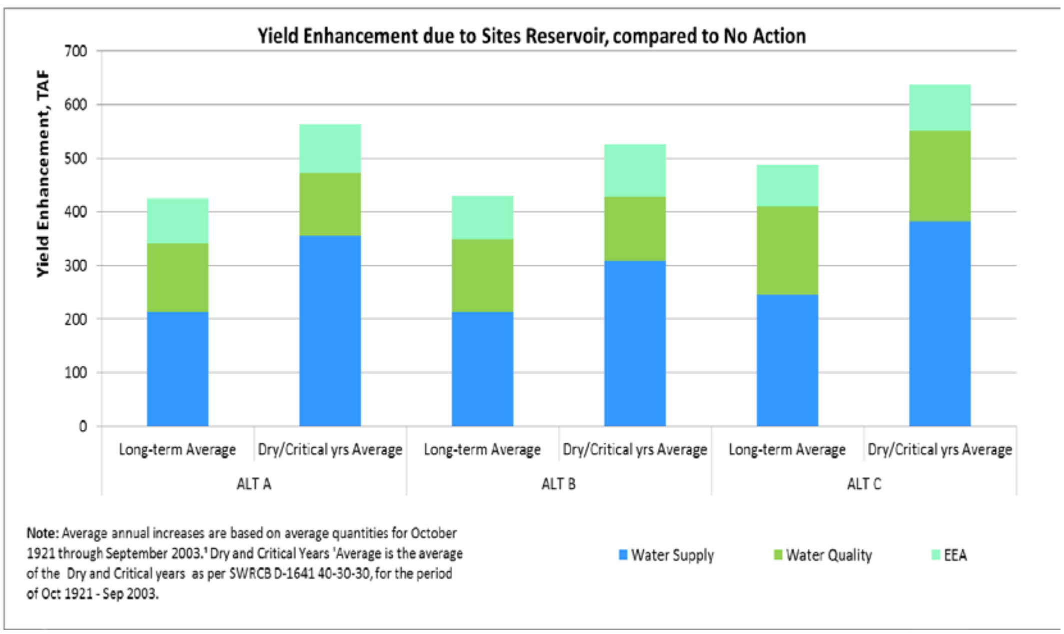


Figure G-9. Benefits Due to NODOS Alternatives in the Three Benefit Categories, Compared to the No Project Alternative – Long-Term and Dry/Critical Years Average, TAF/Year

Table G-17. Benefits Due to NODOS Alternatives – Long-Term and Dry/Critical Years Average, TAF/Year

			No Project Alternative	NODOS Alternative A	NODOS Alternative A Minus No Project	NODOS Alternative B	NODOS Alternative B Minus No Project	NODOS Alternative C	NODOS Alternative C Minus No Project
Water Supply Reliability, Annual Average TAF/Year									
Sacramento River Hydrologic Region									
CVP Settlement	Contract Delivery	Long Term[a]	1,932	1,941	9	1,938	6	1,941	9
		Dry and Critical[b]	1,918	1,932	14	1,923	6	1,932	15
CVP Refuge Level 2	Contract Delivery	Long Term	155	159	4	158	3	160	6
		Dry and Critical	137	141	4	140	2	142	5
CVP M&I	Contract Delivery	Long Term	211	213	2	211	0	213	2
		Dry and Critical	174	175	1	175	0	176	1
CVP Ag	Contract Delivery (does not include Settlement contractors)	Long Term	214	224	10	217	3	224	10
		Dry and Critical	93	103	10	98	5	102	10
SWP FRSA	Contract Delivery	Long Term	1,292	1,292	0	1,292	0	1,290	-1
		Dry and Critical	1,204	1,206	2	1,205	1	1,200	-3
SWP M&I	Contract Delivery	Long Term	23	24	1	24	1	24	1
		Dry and Critical	16	18	2	18	2	19	3
San Joaquin River Hydrologic Region (not including Friant-Kern and Madera Canal Water Users)									
CVP Exchange	Contract Delivery	Long Term	853	853	0	853	0	853	0
		Dry and Critical	814	814	0	814	0	814	0
CVP Refuge Level 2	Contract Delivery	Long Term	261	261	0	261	0	261	0
		Dry and Critical	249	249	0	249	0	249	0
CVP M&I	Contract Delivery	Long Term	16	16	0	16	0	16	0
		Dry and Critical	13	13	0	13	0	13	0

Table G-17. (Continued)

			No Project Alternative	NODOS Alternative A	NODOS Alternative A Minus No Project	NODOS Alternative B	NODOS Alternative B Minus No Project	NODOS Alternative C	NODOS Alternative C Minus No Project
Water Supply Reliability, Annual Average TAF/Year (cont'd)									
San Joaquin River Hydrologic Region (not including Friant-Kern and Madera Canal Water Users) (cont'd)									
CVP Ag	Contract Delivery (does not include Exchange contractors)	Long Term	290	296	6	289	-1	293	3
		Dry and Critical	137	147	10	139	2	143	6
SWP Ag	Contract Delivery (including Article 21)	Long Term	4	4	0	4	0	4	0
		Dry and Critical	3	3	0	3	0	3	0
San Francisco Bay Hydrologic Region									
CVP M&I	Contract Delivery	Long Term	306	306	1	306	0	306	1
		Dry and Critical	334	335	1	334	0	335	1
CVP Ag	Contract Delivery	Long Term	36	37	1	36	0	36	1
		Dry and Critical	17	18	2	17	0	18	1
SWP M&I	Contract Delivery (including Article 21, and transfers to SWP contractors)	Long Term	199	208	9	209	10	209	10
		Dry and Critical	142	160	18	159	18	163	21
Central Coast Hydrologic Region									
SWP M&I	Contract Delivery	Long Term	44	46	2	46	2	46	2
		Dry and Critical	31	36	5	35	4	36	5
Tulare Lake Hydrologic Region (not including Friant-Kern Canal water users)									
CVP Refuge Level 2	Contract Delivery	Long Term	12	12	0	12	0	12	0
		Dry and Critical	11	11	0	11	0	11	0
CVP Ag	Contract Delivery (includes Cross Valley Canal)	Long Term	601	616	14	600	-1	609	8
		Dry and Critical	283	307	25	290	7	299	16

Table G-17. (Continued)

			No Project Alternative	NODOS Alternative A	NODOS Alternative A Minus No Project	NODOS Alternative B	NODOS Alternative B Minus No Project	NODOS Alternative C	NODOS Alternative C Minus No Project
Water Supply Reliability, Annual Average TAF/Year (cont'd)									
Tulare Lake Hydrologic Region (not including Friant-Kern Canal water users) (cont'd)									
SWP M&I	Contract Delivery	Long Term	84	88	4	88	4	88	4
		Dry and Critical	60	68	9	68	8	70	10
SWP Ag	Contract Delivery (including Article 21)	Long Term	657	687	31	690	33	691	35
		Dry and Critical	460	518	58	515	55	526	66
South Lahontan Hydrologic Region									
SWP M&I	Contract Delivery (including Article 21)	Long Term	267	280	13	281	14	281	14
		Dry and Critical	197	227	30	225	28	230	33
South Coast Hydrologic Region									
SWP M&I	Contract Delivery (including Article 21, and transfers to SWP contractors)	Long Term	1,353	1,414	61	1,418	65	1,419	67
		Dry and Critical	990	1,132	141	1,121	131	1,145	154
									0
SWP Ag	Contract Delivery (including Article 21)	Long Term	8	9	0	9	0	9	0
		Dry and Critical	6	7	1	6	1	7	1
Total For All Regions									
Total Supplies	Contract Delivery (CVP, SWP, and other)	Long Term	8,816	8,985	169	8,957	141	8,987	172
		Dry and Critical	7,287	7,621	333	7,558	271	7,633	346
Total Supply/Yield									
CVP M&I	Contract Delivery	Long Term	532	535	3	533	0	535	3
		Dry and Critical	522	524	2	522	0	524	2
CVP Ag	Contract Delivery	Long Term	1,141	1,172	31	1,142	1	1,162	21
		Dry and Critical	529	576	47	543	14	562	33

Table G-17. (Continued)

			No Project Alternative	NODOS Alternative A	NODOS Alternative A Minus No Project	NODOS Alternative B	NODOS Alternative B Minus No Project	NODOS Alternative C	NODOS Alternative C Minus No Project
Total Supply/Yield (cont'd)									
CVP Settlement	Contract Delivery	Long Term	1,932	1,941	9	1,938	6	1,941	9
		Dry and Critical	1,918	1,932	14	1,923	6	1,932	15
CVP Exchange	Contract Delivery	Long Term	853	853	0	853	0	853	0
		Dry and Critical	814	814	0	814	0	814	0
CVP Level 2 Refuge	Contract Delivery	Long Term	428	432	4	431	3	434	6
		Dry and Critical	397	401	4	400	2	402	5
Level 4 Refuge	Delivery	Long Term	0	44	44	72	72	74	74
		Dry and Critical	0	22	22	37	37	37	37
SWP M&I	Contract Delivery (including Article 21, and transfers to SWP contractors)	Long Term	1,969	2,059	91	2,065	96	2,068	99
		Dry and Critical	1,436	1,641	206	1,627	191	1,663	227
SWP FRSA	Contract Delivery	Long Term	1,292	1,292	0	1,292	0	1,290	-1
		Dry and Critical	1,204	1,206	2	1,205	1	1,200	-3
SWP Ag	Contract Delivery (including Article 21)	Long Term	668	700	31	702	34	704	35
		Dry and Critical	468	527	59	524	56	535	67
CVP - Total Water Supply	Contract Delivery	Long Term	4,887	4,978	91	4,969	82	4,999	112
		Dry and Critical	4,180	4,268	88	4,239	60	4,272	92
SWP - Total Water Supply	Contract Delivery	Long Term	3,929	4,051	122	4,059	130	4,063	134
		Dry and Critical	3,107	3,374	267	3,356	248	3,398	291
NODOS Water Quality	Flow	Long Term	0	128	128	136	136	165	165
		Dry and Critical	0	117	117	119	119	169	169

Table G-17. (Continued)

			No Project Alternative	NODOS Alternative A	NODOS Alternative A Minus No Project	NODOS Alternative B	NODOS Alternative B Minus No Project	NODOS Alternative C	NODOS Alternative C Minus No Project
Total Supply/Yield (cont'd)									
NODOS EEA	Flow (single use)	Long Term	0	84	84	80	80	77	77
		Dry and Critical	0	91	91	98	98	86	86
Total	Delivery	Long Term	8,816	9,241	425	9,245	429	9,304	488
		Dry and Critical	7,287	7,850	563	7,813	526	7,924	637

[a] Long Term is the average quantity for the period of October 1921 - September 2003.
[b] Dry and Critical Years Average is the average quantity for the combination of the SWRCB D-1641 40-30-30 Dry and Critical years for the period of Oct ober1921 - September 2003.

Ag = agricultural
CVP = Central Valley Project
EEA = ecosystem enhancement account
FRSA = Feather River Service Area
M&I = municipal and industrial
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project
TAF = thousand acre-feet

Alternative A

Alternative A improves water supply for Level 4 refuges, local water users (e.g., TCCA and potentially GCID service areas) and the CVP and SWP contractors. Table G-16 shows that the long-term and driest periods average increases in water supply (agricultural, M&I, and environmental Levels 2 and 4 supply for refuges) would be 213 TAF/year and 355 TAF/year compared to the No Project Alternative, respectively. With Alternative A, Delta water quality improvement would be achieved with 128 TAF/year and 117 TAF/year, and EEA would be achieved with 84 TAF/year and 91 TAF/year, respectively.

Alternative B

Alternative B provides improved water supply for local water users (e.g., TCCA and potentially GCID service areas) and the CVP and SWP contractors. The long-term and driest periods average increases in water supply (agricultural, M&I, and environmental Levels 2 and 4 supply for refuges) would be 213 TAF/year and 308 TAF/year, respectively (Table G-16). With Alternative B, Delta water quality improvement would be achieved with 136 TAF/year and 119 TAF/year, and the EEA would be achieved with 80 TAF/year and 98 TAF/year, respectively.

Alternative C

Alternative C provides improved water supply for local water users (e.g., TCCA and potentially GCID service areas) and the CVP and SWP contractors. Alternative C provides increases in water supply (agricultural, M&I, and environmental Levels 2 and 4 supply for refuges) 246 TAF/year and 383 TAF/year for average and driest years, respectively (Table G-16). With Alternative C, Delta water quality improvement would be achieved for average and driest years with 165 TAF/year and 169 TAF/year, respectively, and the EEA would be achieved with 77 TAF/year and 86 TAF/year, respectively.

Comparison

General observations from review of Table G-16, Figure G-8, and Figure G-9 include the following.

- Alternative C provides the highest average long-term annual water supply and dry/critical-years water supply, with total water supply increases over the No Project Alternative in these two categories as 246, and 383 TAF/year, respectively.

- All three alternatives provide higher water supply increases over the No Project Alternative during the dry/critical-years average condition, compared to the long-term annual condition.

- Alternatives A and B show very similar average long-term annual water supply gain. However, during the dry/critical-years, Alternative A would provide more water supply compared to Alternative B.

Reservoir Storage, River Flow and Delta Flow Condition

Alternatives A, B and C

Because of the interconnected nature of CVP and SWP operations for meeting shared Sacramento River flow requirements and Delta water quality obligations, changes in reservoirs operation with Sites Reservoir included are shown to affect the operation of the following reservoirs: Trinity, Shasta, Oroville, Folsom, and San Luis.

In addition, Sites Reservoir releases are targeted to enhance the Delta water quality condition and the EEA. Operation of Sites Reservoir in this integrated manner, therefore, would change the reservoir storage, diversions, Delta export, Old and Middle River flows, river flows at different locations throughout the watersheds, Delta outflow, and other factors.

The gain in reservoir storage with the alternatives that contribute towards water supply reliability benefits with the coordinated operations are summarized in Table G-18 and G-19 for the long-term and critical-years average conditions, respectively.

Table G-18. Benefits Due to NODOS Alternatives – Reservoir Average Monthly Storage in a Long-Term Average-Year

Reservoir	Existing	No Project	Alternative A	Alternative B	Alternative C
Trinity	1,540	1,544	1,583	1,586	1,592
Shasta	3,150	3,146	3,202	3,210	3,214
Oroville	2,345	2,315	2,348	2,344	2,344
Folsom	593	585	599	595	598
San Luis (CVP & SWP)	446	481	477	477	469
Sites			822	1,061	1,254
Total	8,074	8,071	9,032	9,272	9,469

CVP = Central Valley Project
NODOS = North-of-the-Delta Offstream
SWP = State Water Project

Table G-19. Benefits Due to NODOS Alternatives – Reservoir Average Monthly Storage in a Critical-Years Average Condition

Reservoir	Existing	No Project	Alternative A	Alternative B	Alternative C
Trinity	846	855	922	920	943
Shasta	1,775	1,796	1,934	1,968	2,009
Oroville	1,370	1,343	1,435	1,415	1,411
Folsom	328	319	337	328	341
San Luis (CVP & SWP)	405	460	474	482	464
Sites			556	658	862
Total	4,724	4,773	5,658	5,771	6,030

CVP = Central Valley Project
NODOS = North-of-the-Delta Offstream
SWP = State Water Project

Under Alternative A, the long-term average storage in Sites Reservoir, Shasta Lake, Folsom Lake, Lake Oroville, and San Luis Reservoir is increased by 961 TAF over the No Project Alternative. Under the driest period conditions, there is an increase of 885 TAF. Alternative B increases such long-term average storage by 1,201 TAF over the No Project Alternative, and the driest period average storage by 998 TAF. Alternative C shows highest increase in the long-term average storage with an increase of 1,398 TAF and in the driest period conditions with an increase of 1,257 TAF.

Figures G-10 and G-11 show the additional storage provided by Sites Reservoir for the three alternatives, and the exceedance plots, respectively.

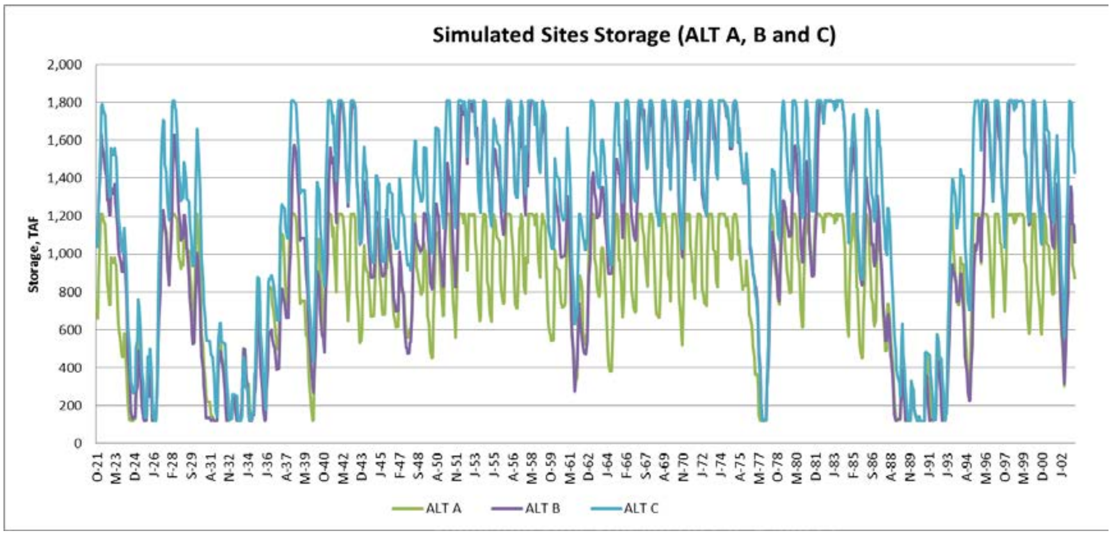


Figure G-10. Simulated Sites Reservoir Content for the Three Alternatives, TAF

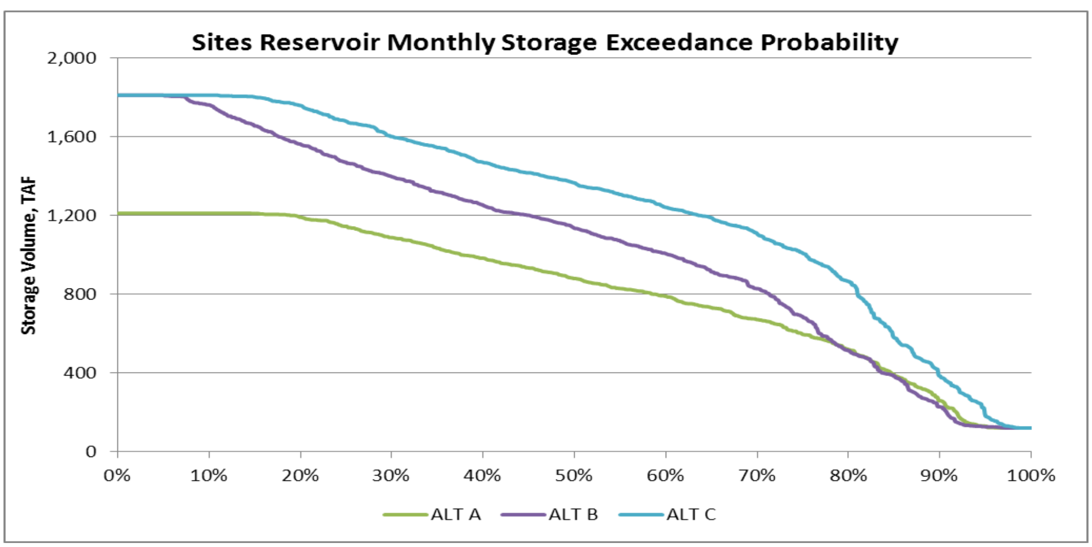


Figure G-11. Simulated Sites Reservoir Content for the Three Alternatives – Exceedance Plot, TAF

Figures G-12 and G-13 show the simulated Sites Reservoir release for the three alternatives as the long-term and dry/critical-years monthly average values. The average monthly release from the Sites Reservoir peaks in July for all three alternatives with approximately 1,600 cfs. During the dry/critical-years period, the Sites Reservoir release' significant contribution starts early, from April for all three alternatives; Alternative B would use the peak release in June and July, and Alternatives A and C would use the peak release in August.

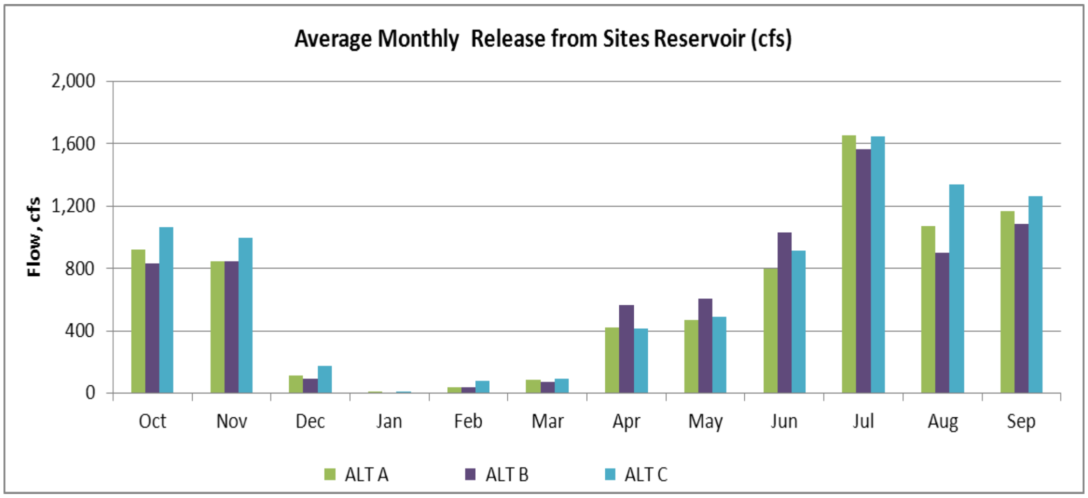


Figure G-12. Simulated Sites Reservoir Release for the Three Alternatives – Long-Term Average, cfs

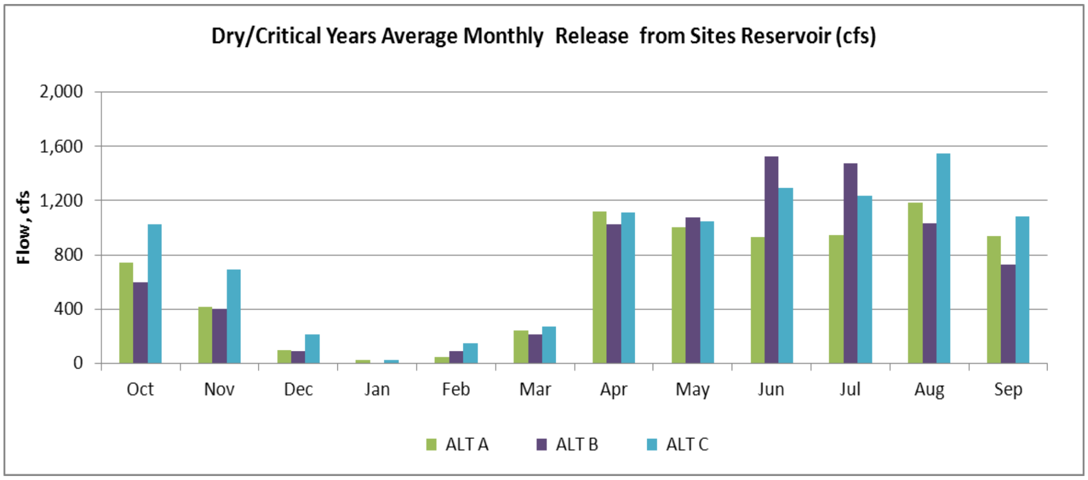


Figure G-13. Simulated Sites Reservoir Release for the Three Alternatives – Dry/Critical Years Average, cfs

Figure G-14 shows the simulated storage plots for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake for all three alternatives compared to the No Project Alternative for the simulation period and the corresponding exceedance plots. The exceedance plots show that in the higher range of monthly storage values, there does not appear to be a significant increase in storage with the action alternatives when compared to the Existing Conditions or No Project Alternative; however, at the lower monthly storage volume ranges, and within 45 to 99 percent probability range of the reservoir storage, the action alternatives show more storage when compared to the Existing Conditions or No Project Alternative.

NODOS action alternatives' operation priorities are managed to help with the reservoir coldwater pools for downstream temperature management in the river to benefit the fish habitat. The end-of-month storage for April for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake in general, are used as indicators to the availability of coldwater pool, which, when released, helps meet downstream temperature targets to benefit the fish habitat, and helps increase the reliability of deliveries to water service contractors.

Figure G-15 shows the individual end-of-April storage plots for Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake for all three alternatives compared to the No Project Alternative and the corresponding exceedance plots. The exceedance plots show that in the higher range of monthly storage values, the action alternatives are not increasing the storage significantly when compared to the Existing Conditions or No Project Alternative; however, at the lower monthly storage volume ranges, and within 65 to 99 percent probability range of the end-of-April reservoir storage, the action alternatives show more storage when compared to the Existing Conditions or No Project Alternative.

Figure G-16 shows the total end-of-April storage content of five reservoirs—Shasta, Oroville, Folsom, Sites and San Luis—for all three alternatives compared to the No Project Alternative. The figure shows that Sites Reservoir April content would increase the total April reservoir content significantly for all three alternatives compared to the No Project Alternative, for the simulation period.

Figure G-17 shows the total annual diversions to Sites Reservoir for the three alternatives for the long-term and dry/critical-years average; Figure G-18 shows such diversion by the different sources. Figure G-18 shows that the diversion sources for Alternative B are T-C Canal and GCID Canal diversions. These figures show that total diversion from the three intakes under the three alternatives are about the same; however, the distribution of such diversion at the three intakes vary, with increased diversion at T-C Canal for all three alternatives; Alternative B would have higher diversion than Alternative A or Alternative C at both T-C Canal and Glenn-Colusa Canal intakes, as Alternative B excludes pumping from the proposed pumping location at Delevan.

Figures G-19 and G-20 show monthly average diversions at the three intakes for the three alternatives in a Wet year and a Critical year. These figures illustrate that Alternatives A and C show similar diversion distribution over the months; and in a Wet-year condition diversion at these three intakes would occur during spring and the irrigation season implying reservoir fill-in, whereas in a Critical year, majority of the diversion would occur during the irrigation season. Figure G-20 shows that the total diversion with the alternatives would be mostly lower during the months of April through June in the driest years compared to the No Project Alternative.

The effect on the amount of total Delta export through both Tracy and Jones Pumping Plants for the three alternatives with Sites Reservoir compared to the Existing Conditions and No Project Alternative is presented in Figures G-21 through G-23 for a Wet-year average, a Long-Term average year, and a Critical-year average condition. Figures G-21 through G-23 show that the monthly exports do not vary considerably among alternatives, except for a few months; the figures also show that April and May export are considerably lower than the export allowed in other months.

In order to meet the specific water quality, quantity, and operational criteria within the Delta as per SWRCB-issued water right permits, CVP and SWP operations are closely coordinated. The April and May Delta export limits as shown in the above figures likely are the result of the implementation of the BiOps, that are not influenced by the addition of Sites Reservoir storage to the system.

Table G-20 presents numeric results of the monthly total Delta export through both Tracy and Jones Pumping Plants for the three alternatives, compared to the Existing Conditions and No Project Alternative in an average condition change compared to the No Project Alternative for each of the three alternatives, and the percentage of such change.

The amount of Delta export is influenced by the OMR flows in the Delta. The model estimated OMR flows present the incorporation of the D-1641 and the BiOps constraints in the operation of the system. Figures G-24 through G-26 present the results for the three action alternatives compared to the Existing Conditions and No Project Alternative for the Wet-year, Long-Term and Critical-years average condition, respectively.

Figure G-24 and Figure G-28 show that the OMR flows for the months of April and May are “positive” in a Wet-year condition compared to the “negative” in a Critical-year condition. Implementation of NODOS action alternatives do not show any significant change compared to the No Project Alternative. A few months show more negative flows with NODOS alternatives compared to those with the No Project Alternative, for example, August and September average flows in a Critical-years average condition and October and November average flows in a Wet-year average condition.

Sacramento River flows at different locations with the operation of NODOS coordinated with the system reservoirs are presented below; only three such locations are presented for such comparison: Sacramento River at Bend Bridge (downstream of Shasta Lake), at Freeport (near the Delta), and the Delta outflow.

Figures G-27 through G-32 show the monthly flow at these three locations for the three alternatives, compared to the Existing Conditions and No Project Alternative, in a Wet-year and a Critical-year condition. Table G-21 presents the numeric flow values of Delta outflow for a Wet-year average condition. These figures show that NODOS action alternatives would not significantly impact the flow condition at these locations along the Sacramento River, compared to the No Project Alternative.

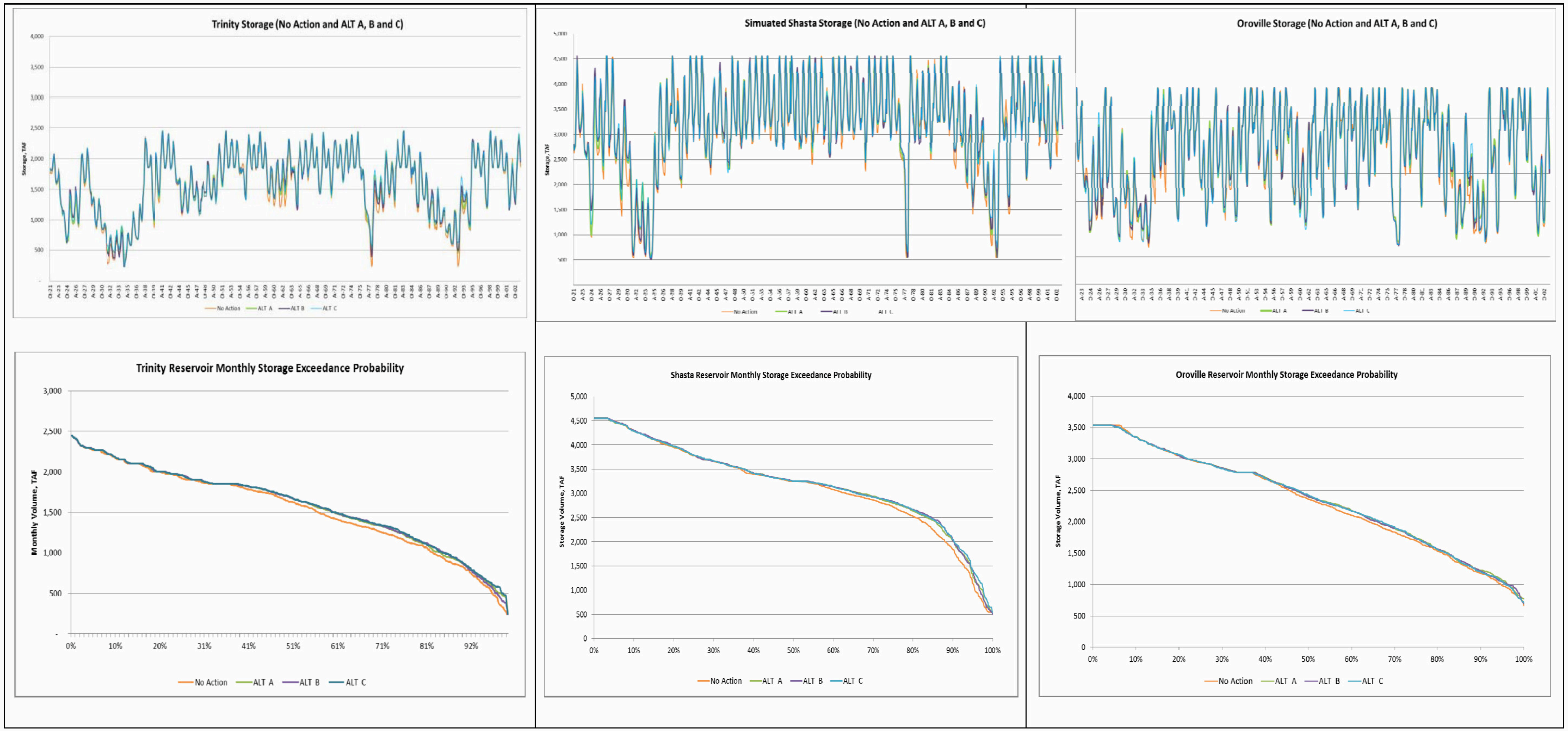


Figure G-14. Simulated Reservoir Content of Trinity Lake, Shasta Lake, and Lake Oroville for the Three NODOS Alternatives and the Exceedance Probability, TAF

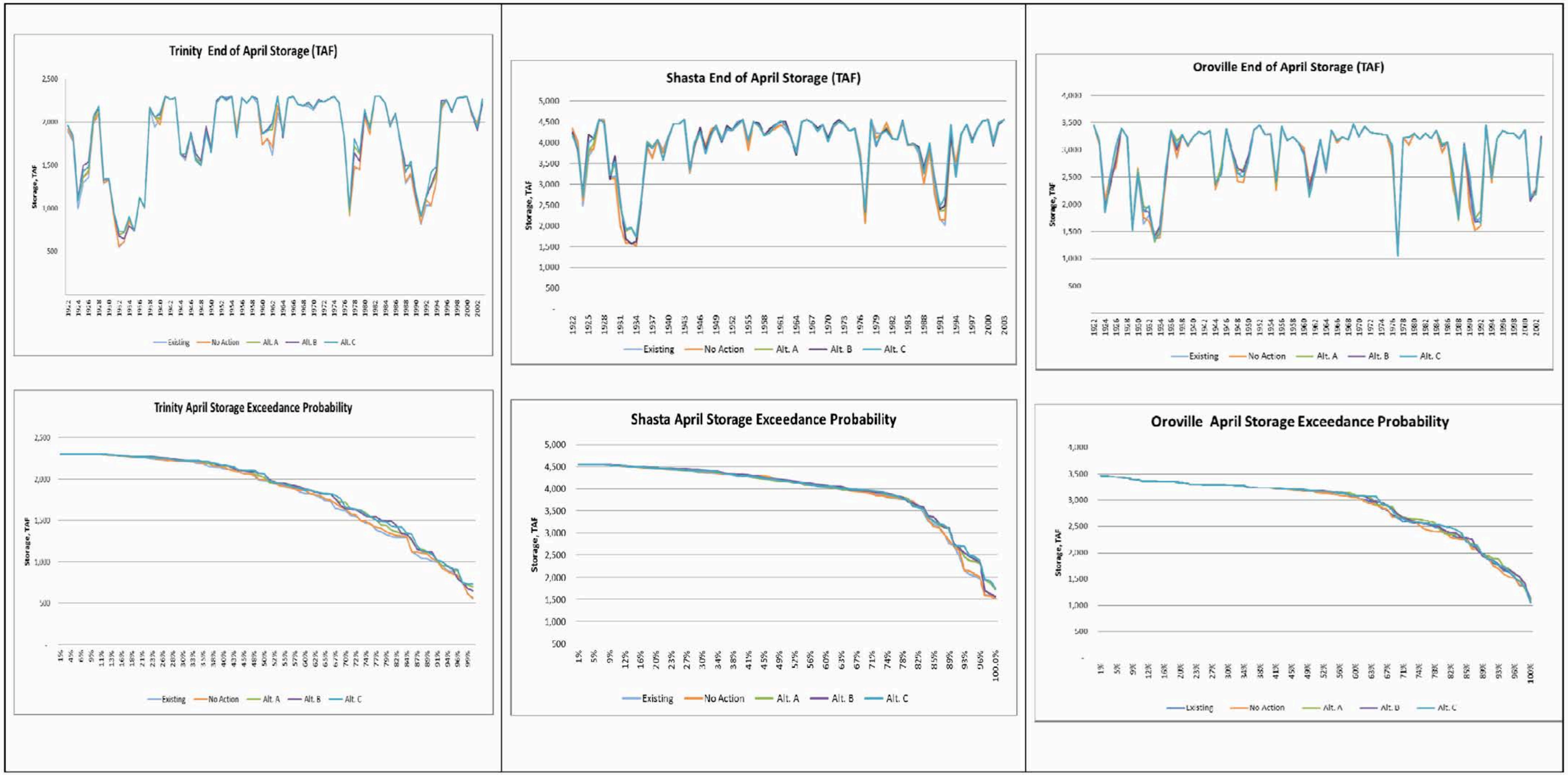


Figure G-15. Simulated End-of-April Reservoir Content of Trinity Lake, Shasta Lake, and Lake Oroville for the Three NODOS Alternatives and the Exceedance Plots, TAF

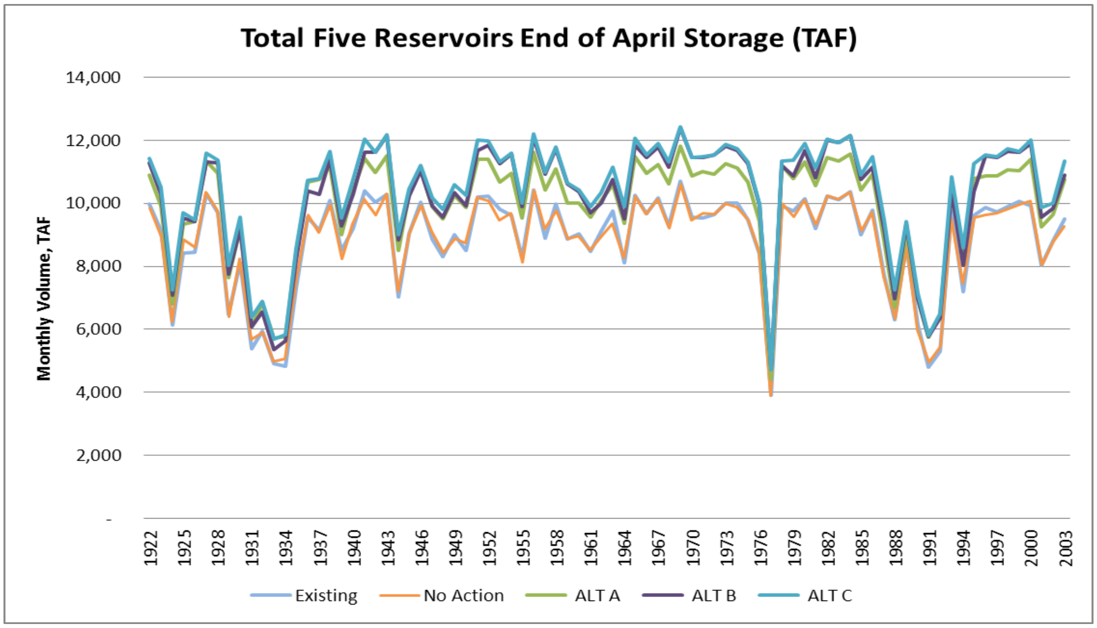


Figure G-16. Simulated Combined End-of-April Storage (TAF) in Lake Trinity, Shasta Lake, Lake Oroville, Sites Reservoir, and Folsom Lake for the Three NODOS Alternatives

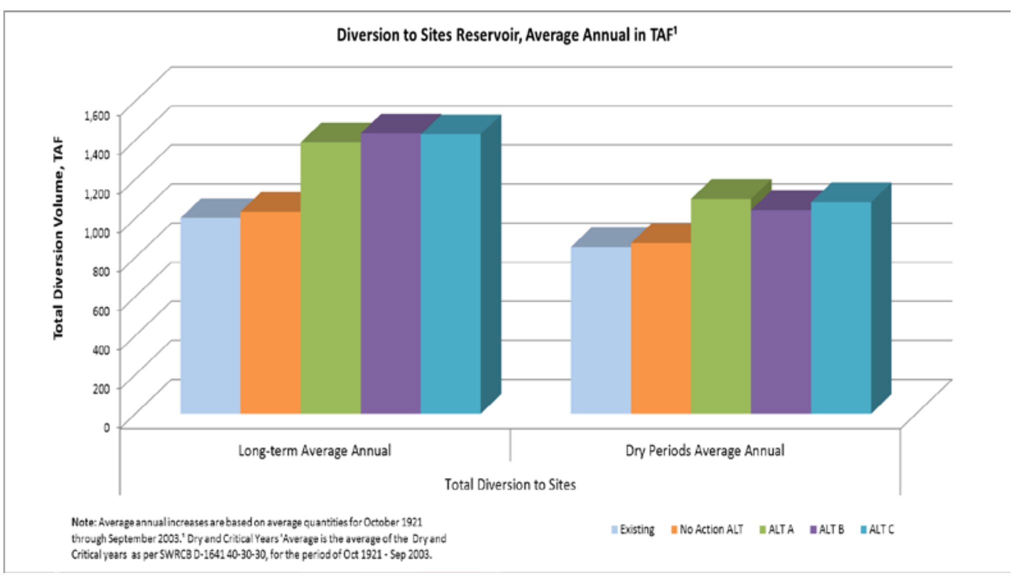


Figure G-17. Simulated Total Annual Diversion (TAF) to Sites Reservoir, Long-Term and Dry/Critical-Years Average

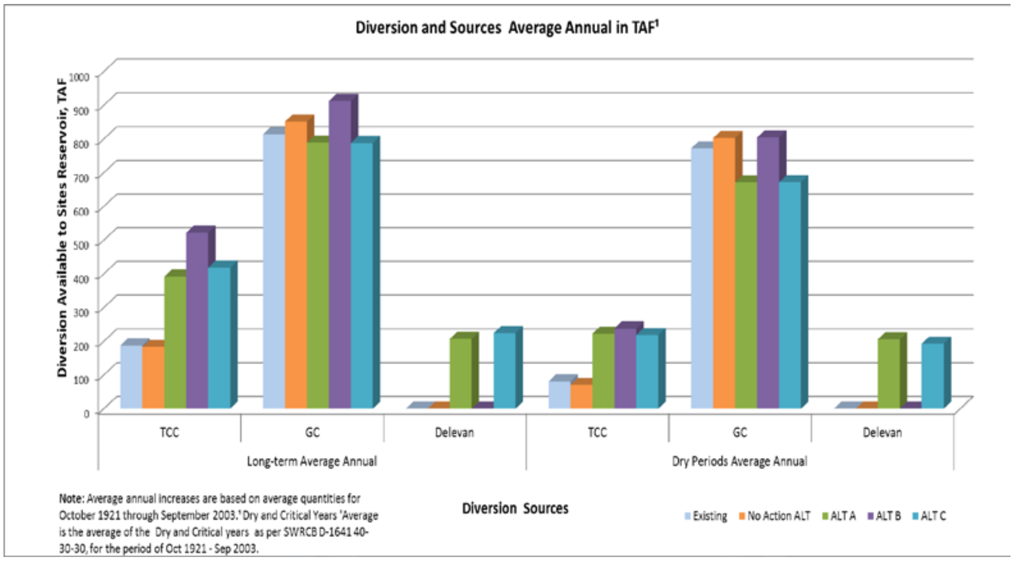


Figure G-18. Simulated Total Annual Diversion to Sites Reservoir, Long-Term and Dry/Critical-Years Average, TAF

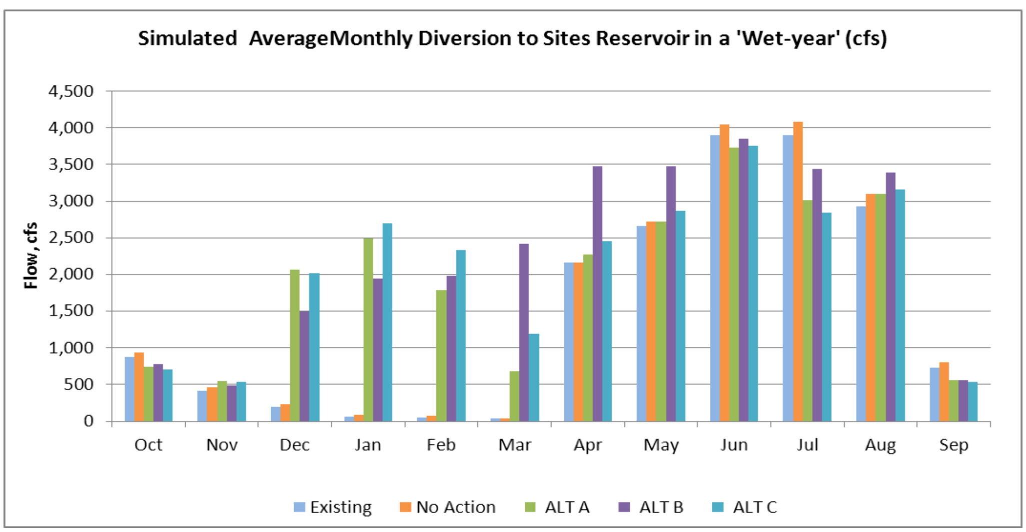


Figure G-19. Monthly Diversion to Sites Reservoir, Wet-Years Average Condition, cfs

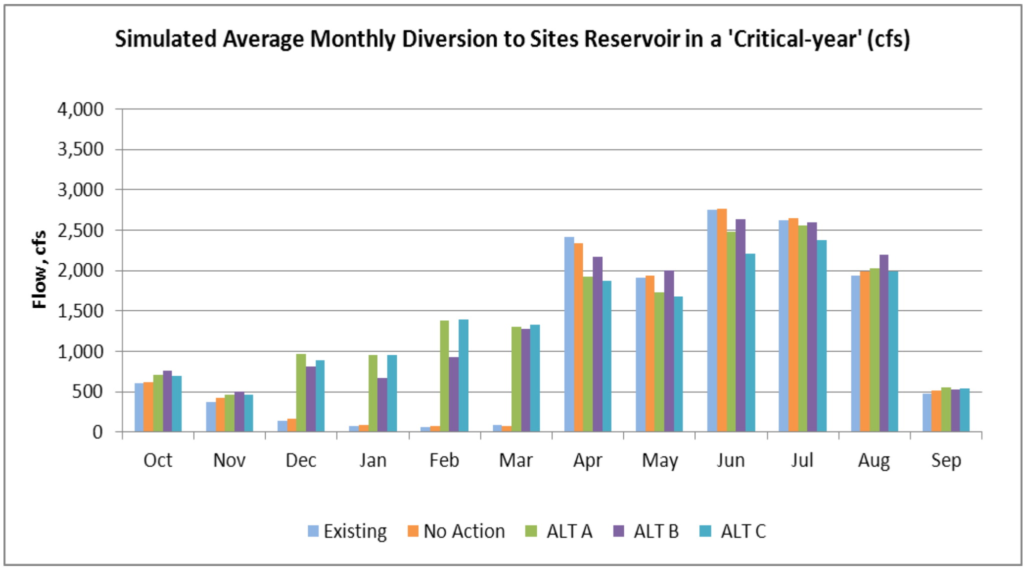


Figure G-20. Monthly Diversion to Sites Reservoir, Critical-Years Average Condition, cfs

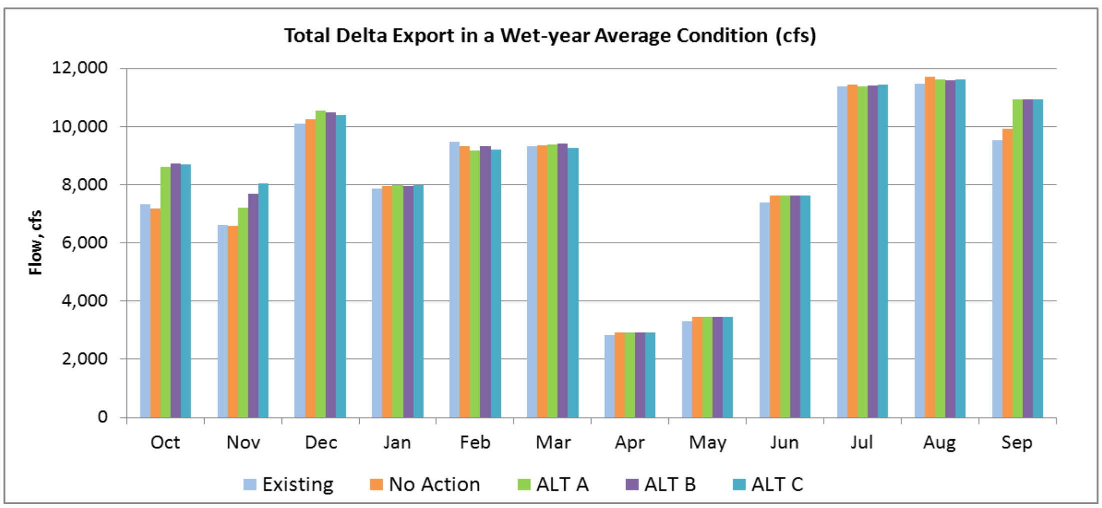


Figure G-21. Monthly Total Delta Export, Wet-Year Average Condition, cfs

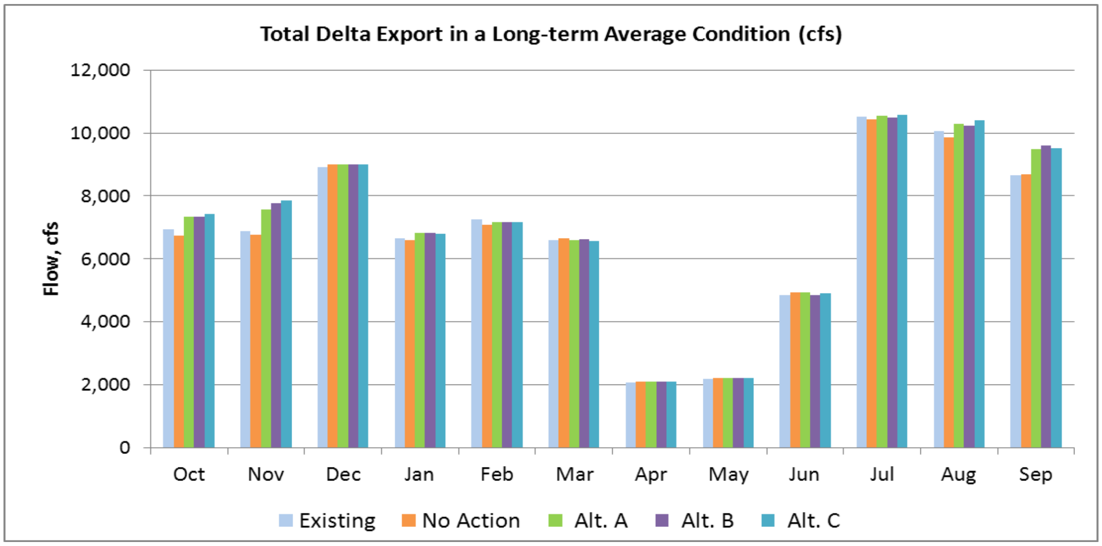


Figure G-22. Monthly Total Delta Export, Long-Term Average Condition, cfs

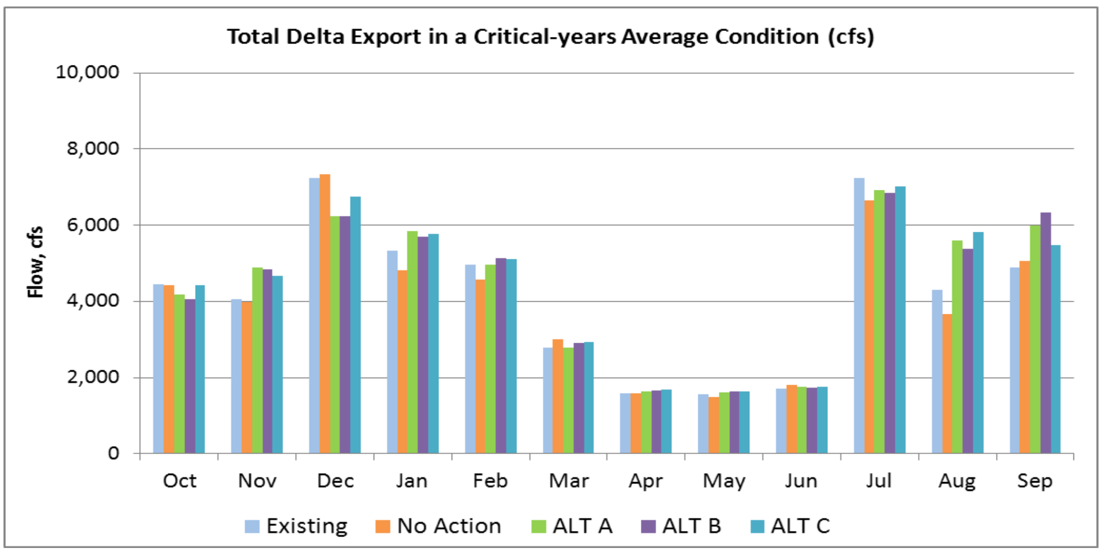


Figure G-23. Monthly Total Delta Export, Critical-Years Average Condition, cfs

Table G-20. Monthly Total Delta Export in an Average Year Condition, and Change from the No Project Alternative, cfs

	Existing	No Project	Alt. A	Alt. B	Alt. C	Alt. A-NA	Alt. B-NA	Alt. C-NA	Alt. A-NA	Alt. B-NA	Alt. C-NA
Oct	6,940	6,735	7,340	7,353	7,417	606	619	683	9%	9%	10%
Nov	6,885	6,772	7,561	7,772	7,865	789	1,000	1,093	12%	15%	16%
Dec	8,906	9,003	8,987	8,993	9,009	-16	-10	6	0%	0%	0%
Jan	6,660	6,607	6,817	6,832	6,811	210	225	204	3%	3%	3%
Feb	7,242	7,090	7,157	7,156	7,167	67	66	77	1%	1%	1%
Mar	6,595	6,641	6,595	6,612	6,555	-46	-29	-86	-1%	0%	-1%
Apr	2,083	2,103	2,110	2,111	2,111	7	8	8	0%	0%	0%
May	2,190	2,223	2,230	2,227	2,232	7	4	10	0%	0%	0%
Jun	4,849	4,939	4,938	4,860	4,902	-1	-79	-37	0%	-2%	-1%
Jul	10,510	10,439	10,530	10,485	10,571	90	46	132	1%	0%	1%
Aug	10,053	9,862	10,294	10,219	10,389	432	356	527	4%	4%	5%
Sep	8,650	8,678	9,486	9,607	9,526	808	929	848	9%	11%	10%
Avg.	6,797	6758	7,004	7,019	7,046	246	261	289			

Alt. = alternative
Avg. = average
NA = not applicable

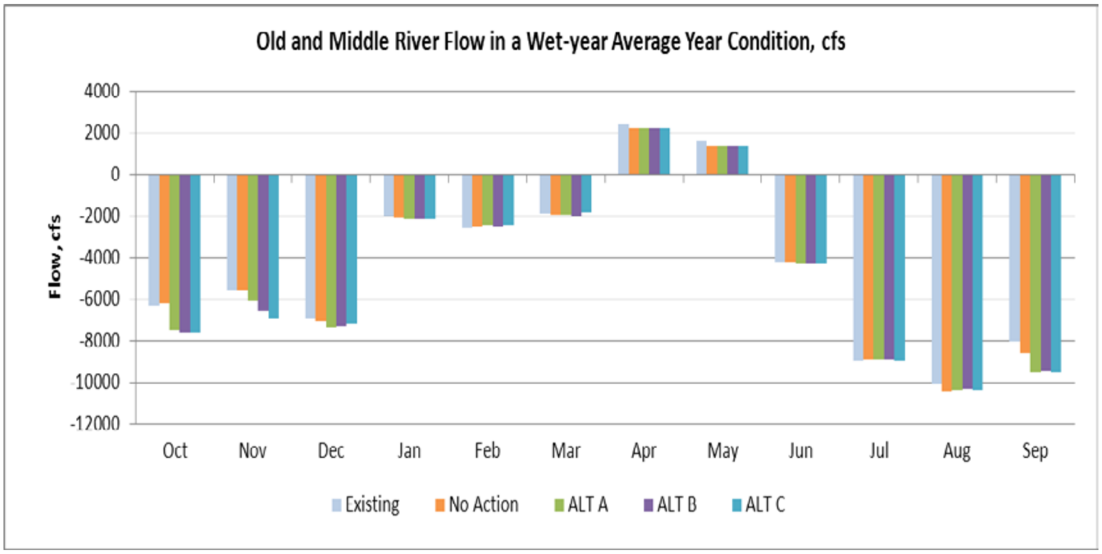


Figure G-24. Monthly Old and Middle River Flow in a Wet-Year Average Condition, cfs

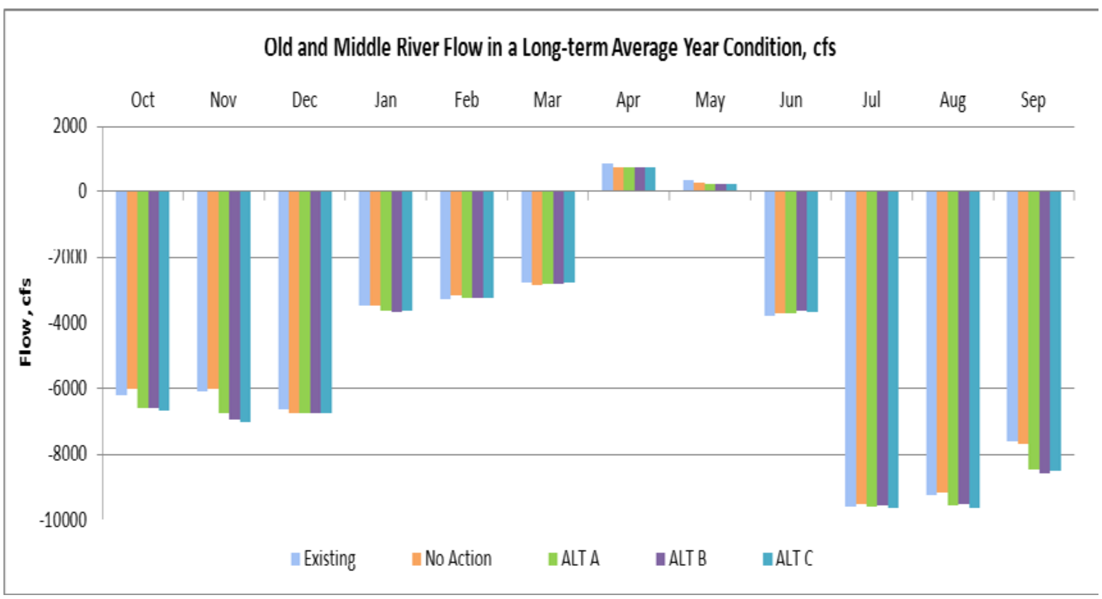


Figure G-25. Monthly Old and Middle River Flow in a Long-Term Average Year Condition, cfs

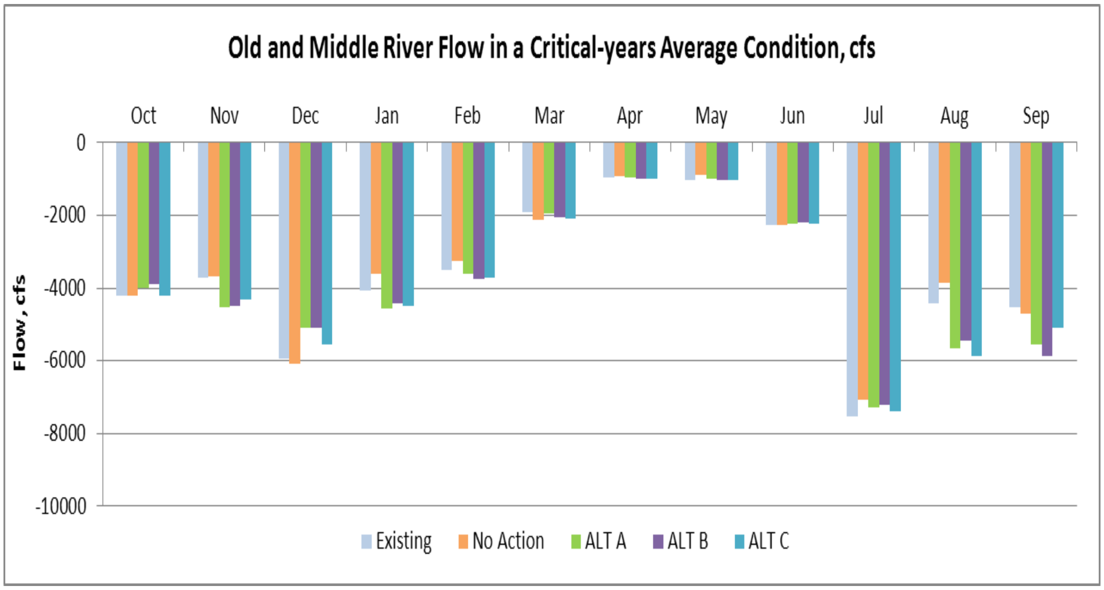


Figure G-26. Monthly Old and Middle River Flow in a Critical-Year, cfs

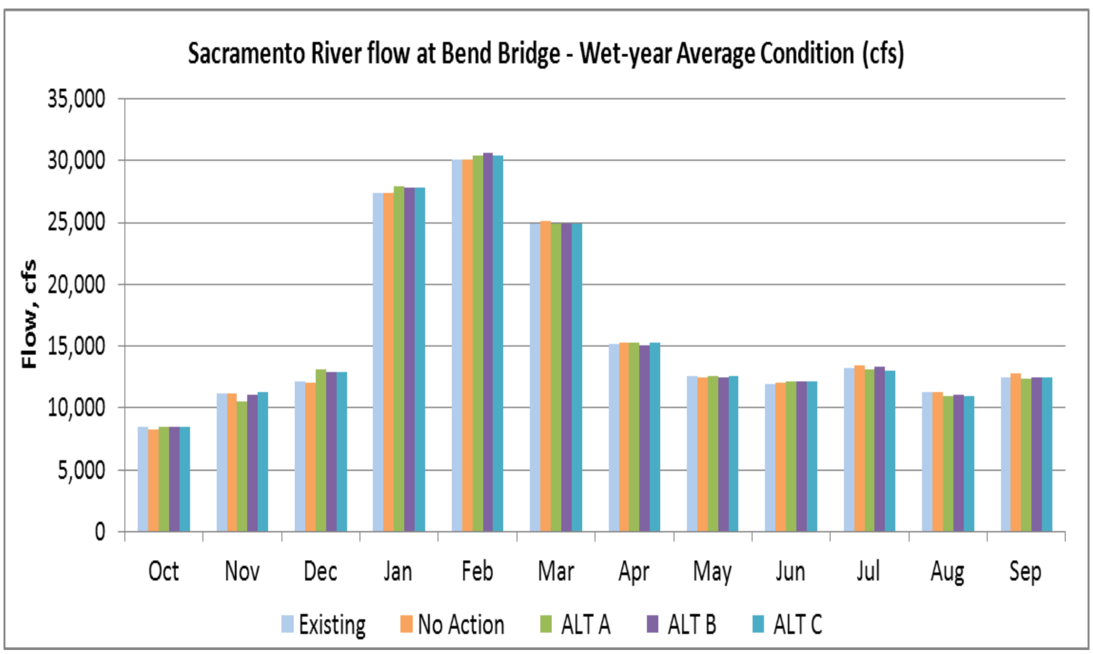


Figure G-27. Sacramento River Flow at Bend Bridge – Wet-Year Monthly Average, cfs

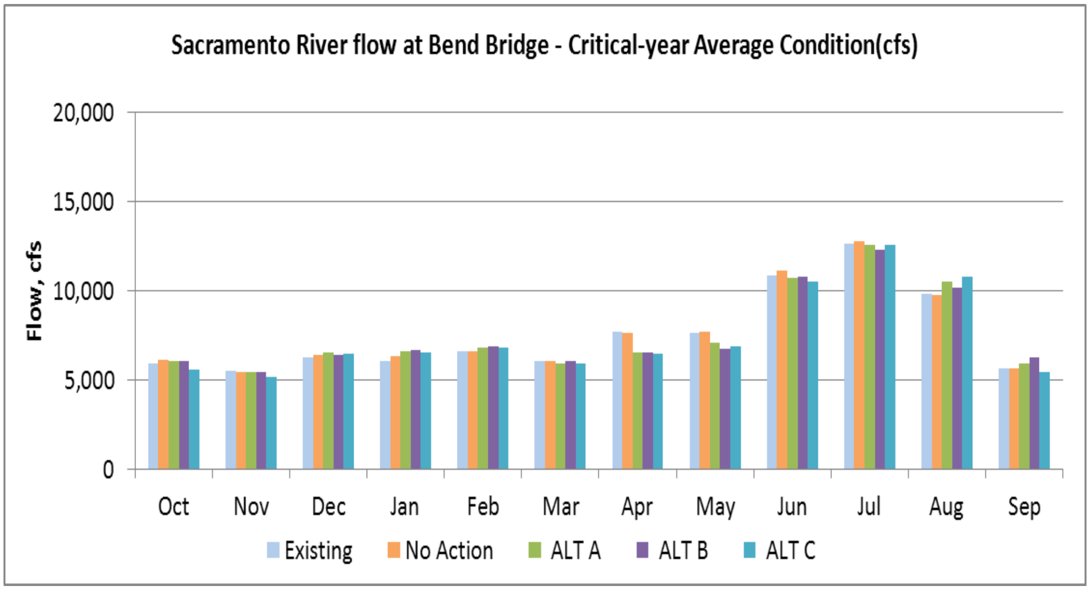


Figure G-28. Sacramento River Flow at Bend Bridge – Critical-Year Monthly Average, cfs

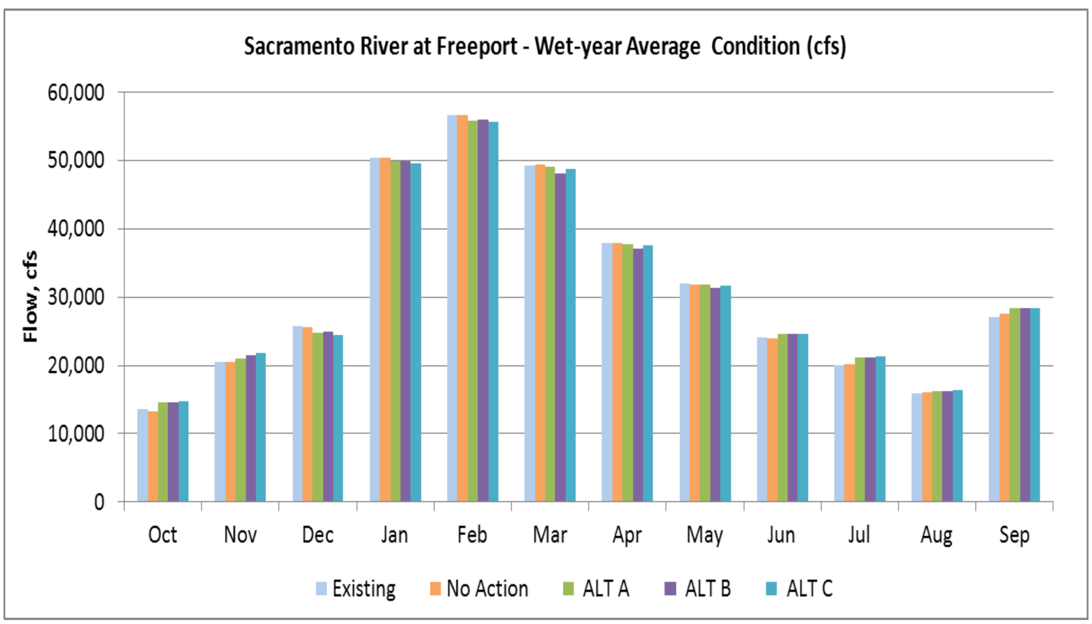


Figure G-29. Sacramento River Flow at Freeport – Wet-Year Monthly Average, cfs

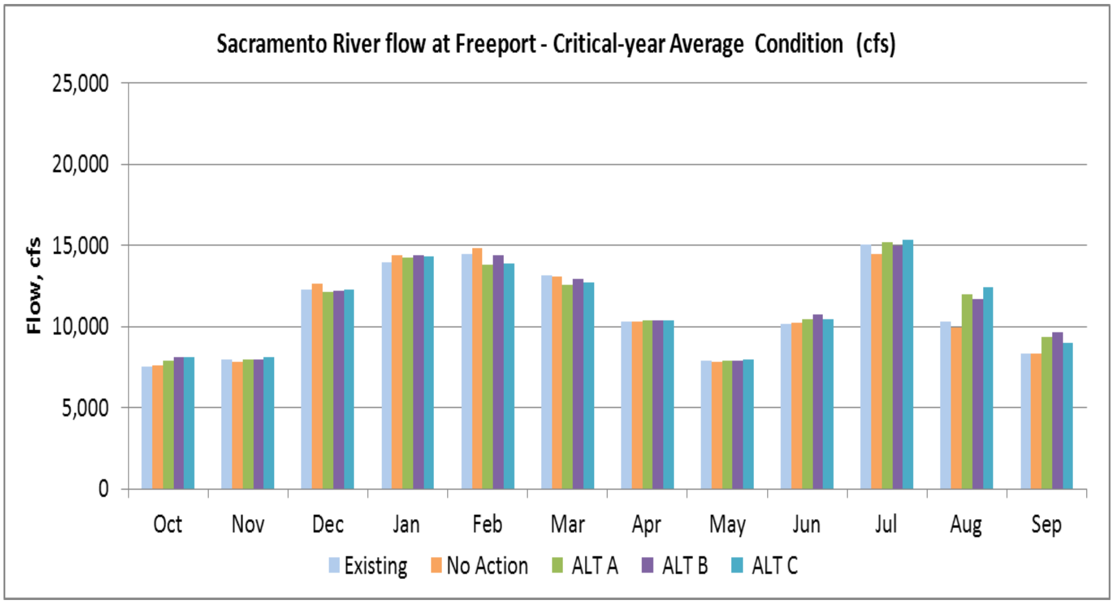


Figure G-30. Sacramento River Flow at Freeport – Critical-Year Monthly Average, cfs

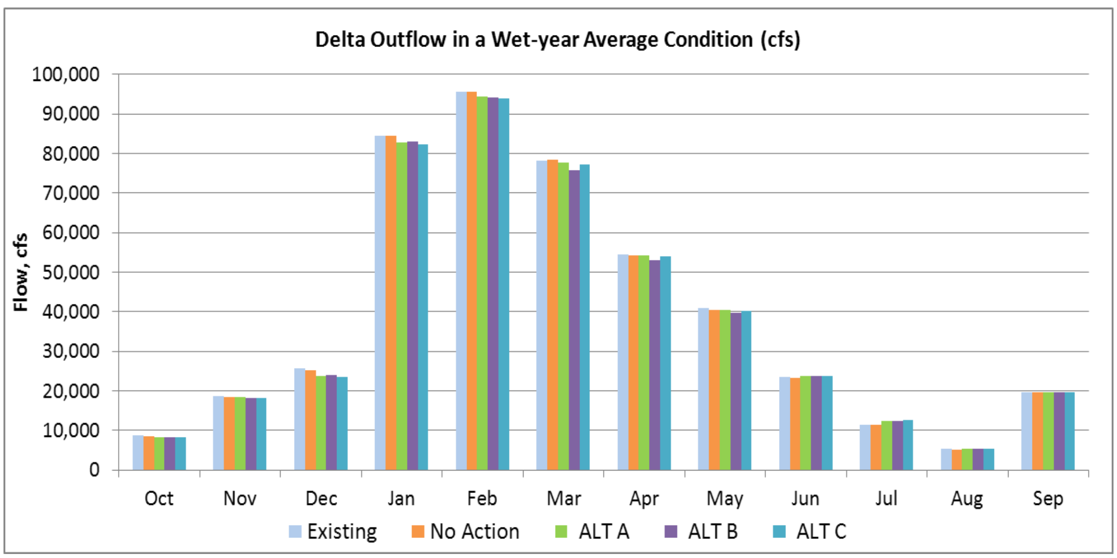


Figure G-31. Delta Outflow – Wet-Year Monthly Average, cfs

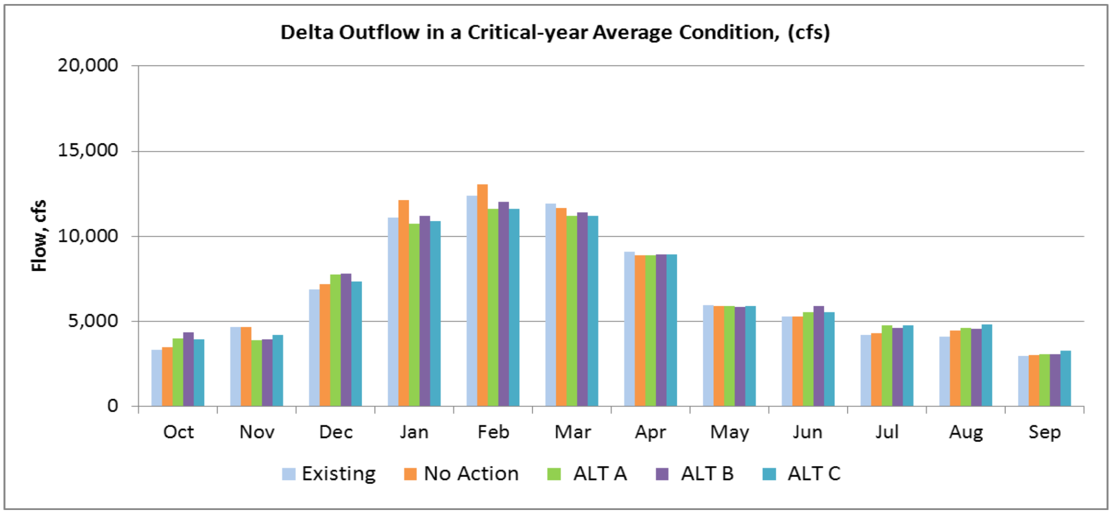


Figure G-32. Delta Outflow – Critical-Year Monthly Average, cfs

Sensitivity Analysis (Climate Change Effect)

This section will be completed upon receipt of DWR modeling results.

Supplemental Flows for Emergency Response

In case of a levee failure in the Delta, Sites Reservoir might be able to release water to help mitigate the damage by providing freshwater to move or help stabilize the intrusion of seawater into the Delta. The relative location of a Sites Reservoir equipped with a direct conduit to the Sacramento River would allow the water released from Sites Reservoir to reach the Delta nearly two days sooner than water released from Shasta Lake.

Flood-Damage Reduction

Even as an offstream reservoir with substantial diversion capabilities, the Sites Reservoir complex cannot remove enough water from the Sacramento River during high flow events to meaningfully affect flood damage reduction efforts downstream. Rather, water storage in Sites Reservoir may allow for additional flood reservation storage at other onstream reservoirs through better coordination of the reservoirs in the Sacramento Valley region. The flood reservation space of Folsom Lake, Lake Oroville, and Shasta Lake could be increased; however, integrated modeling of both water supply alternatives and flood management system may need to be conducted to estimate such reallocation and any impact on water supply commitments from those onstream reservoirs.

Table G-21. Monthly Delta Outflow in a Wet-Year Average Condition, cfs

Month	Existing Conditions (cfs)	Future Condition (2030)			
		No Project Alternative (cfs)	Change from No Project Alternative		
			Alternative A (cfs)	Alternative B (cfs)	Alternative C (cfs)
Oct	8,619	8,387	-140	-227	-165
Nov	18,566	18,519	-225	-235	-287
Dec	25,599	25,088	-1,243	-1,108	-1,543
Jan	84,561	84,405	-1,691	-1,377	-2,143
Feb	95,616	95,517	-1,211	-1,469	-1,588
Mar	78,190	78,395	-730	-2,587	-1,216
Apr	54,405	54,269	-161	-1,324	-336
May	41,030	40,411	12	-625	-153
Jun	23,448	23,163	664	678	675
Jul	11,450	11,329	1,085	1,117	1,177
Aug	5,315	5,031	280	302	414
Sep	19,675	19,685	-150	-80	-148
Monthly Average:	38,873	38,683	-293	-578	-443

cfs = cubic feet per second

References

DSC, 2010. Water Resources White Paper. December.

DWR, 2010. CalFed Storage Investigation. November.

DWR, 2010. Assumptions for Existing and Future No Action Alternative Conditions CALSIM II and DSM2 Models. November.

DWR, 2009. CWP Update.

DWR, 2009. Drought Reports.

USACE, 1999. Central Valley Flood Management System

U. S. Bureau of Reclamation, 2008. OCAP BA. May.

U. S. Bureau of Reclamation, 2011. SLWRI, ADFR and ADEIS.

U. S. Bureau of Reclamation, 2011. Water Plan.

U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Hoopa Valley Tribe, and Trinity County, 2004. Trinity River Fishing Restoration EIR/EIS.

This page intentionally left blank

ATTACHMENT 1

DRAFT TECHNICAL MEMORANDUM CH2MHILL

North-of-the-Delta Off-stream Storage Administrative Draft Environmental Impact Report/Study – Preliminary Temperature Analysis of Proposed Sites Reservoir

PREPARED FOR: NODOS ADEIR/S Team

PREPARED BY: CH2M HILL

DATE: August 10, 2012

Introduction

This memorandum briefly describes the preliminary temperature modeling analysis performed for the Sites Reservoir. As part of the North-of-the-Delta Off-stream Storage (NODOS) ADEIR/EIS, the impact of the proposed Sites Reservoir releases to the Sacramento River temperature conditions downstream of the proposed Delevan pipeline are studied in this analysis.

Objective

The goal of this study is to determine if the releases from the proposed Sites Reservoir would cause significant changes to the Sacramento River temperature conditions downstream of the proposed Delevan Pipeline in the NODOS ADEIRS with action alternatives. If the Sacramento River temperatures are found to be impacted by the Delevan Pipeline releases, then the frequency and magnitude of the impact are determined.

Assumptions

NODOS ADEIRS Alternatives A, B, and C primarily differ in the storage or conveyance capacities. The three proposed alternatives are as follows:

- Alternative A (ALT A) has a 1.2 MAF storage capacity with existing Tehama-Colusa Canal (2,100 cfs) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new Delevan pipeline with a diversion capacity of 2,000 cfs and release capacity of 1,500 cfs.
- Alternative B (ALT B) has a 1.8 MAF storage capacity with existing Tehama-Colusa Canal (2,100 cfs) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new release only Delevan pipeline (release capacity of 1,500 cfs). There are no fish screen intake and pumping plant associated with the new Delevan pipeline.
- Alternative C (ALT C) has a 1.8 MAF storage capacity with existing Tehama-Colusa Canal (2,100 cfs) and Glenn-Colusa Irrigation District Canal (1,800 cfs) and a new Delevan pipeline with a fish screen intake and pumping plant with a diversion capacity of 2,000 cfs and a release capacity of 1,500 cfs.

The scope of this preliminary analysis was limited to the modeling of temperature conditions inside the Sites Reservoir and the temperature conditions of the releases from Sites Reservoir. For the preliminary temperature analysis of the proposed Sites Reservoir, NODOS Alternative C was analyzed assuming that it would result in the worst case impact to the Sacramento River temperature conditions downstream of the proposed Delevan Pipeline.

The physical characteristics and the daily operations of the Sites Reservoir as proposed under ALT C are derived from the ALT C USRDOM simulation. Sites Reservoir inflow temperatures and the Sacramento River downstream temperature targets are derived using the results from the ALT C USRWQM simulation.

Method

A simplistic model was developed as part of this preliminary analysis. A single reservoir model that can simulate the conditions in Sites Reservoir in isolation from the other NODOS conveyance features and the Sacramento River was developed using HEC5Q water quality model for this study. The reservoir operations are simulated in the HEC-5 model which feeds the changes in the storage and flows to the HEC5Q model.

HEC-5 inputs for the Sites Reservoir such as the reservoir levels, storage – capacity – elevation curves and the initial storage are derived from the USRDOM model for the ALT C. Other timeseries inputs such as evaporation rates, inflows and outflows are also derived from the USRDOM model. The inflows to the Sites Reservoir were assumed to be the daily flow from Funks Forebay to the Sites Reservoir simulated in the USRDOM model. The outflow from the Sites Reservoir is specified using daily flow from Sites Reservoir to Funks Forebay as simulated in the USRDOM model. Using the information from the USRDOM ensures that the daily Sites reservoir operations in the preliminary Sites temperature model are consistent with the resulting operations from USRDOM and CALSIM II models of ALT C.

HEC5Q inputs for the Sites Reservoir are derived from the RMA's Sites Water Quality Model or also called as the Colusa Basin Water Quality Model (CBWQM) (RMA, 2005). The Sites Reservoir is simulated as a vertically segmented reservoir in the HEC5Q model. The inputs such as the vertical segmentation, kinetic rates, coefficients and information needed for the thermal calculations in the reservoir are all based on the CBWQM. The centerline elevations of the outlets in the wet well are based on the latest available engineering information of Sites Reservoir (USBR, 2011). Nine outlets are assumed at elevations 340 ft, 350 ft, 370 ft, 390 ft, 410 ft, 430 ft, 450 ft, 470 ft and 490 ft. Figure 1 shows the Sites Reservoir storage varying with water surface elevation within the reservoir for NODOS ALT C. The outlet elevations and the corresponding storage are marked on the plot.

The Sites Reservoir inflow temperature timeseries input is derived from the Sacramento River temperatures at Tehama Colusa Canal intake, Glenn Colusa intake and Delevan Pipeline intake simulated in the USRWQM model of ALT C. Sites Reservoir inflow temperature is estimated by weighting the above three temperatures by amount of flow diverted at each of the three intakes for filling Sites Reservoir.

HEC5Q is capable of simulating reservoir temperature by operating withdrawals to meet the specified tailwater temperature objectives. For the Sites Reservoir Temperature Model, these tailwater target temperatures are specified using the monthly average temperatures in the Sacramento River just upstream of the Delevan Pipeline simulated in the USRWQM model for ALT C.

Results and Analysis

The HEC5Q model was used to simulate the temperature conditions in the reservoir and the releases for the NODOS Alternative C. Sites Reservoir releases to the Sacramento River were blended with the Sacramento River flow just upstream of the proposed Delevan Pipeline to estimate the water temperatures downstream of the Delevan Pipeline. The blended Sacramento River temperatures were compared to tailwater target temperatures used in the model to determine if there was any warming or cooling impact on the Sacramento River temperatures due to the blending of the water from the Sites Reservoir.

Figures 2 to 9 show the 82 year monthly timeseries results in 10 year blocks. Each plot includes two panels. The top panel includes the timeseries of the Sites Reservoir temperatures at elevations 490 ft, 390 ft and 350 ft outlets. If the temperatures at elevations 390 ft are close to elevation 490 ft, then it indicates lack of stratification and less cold water pool volume. In contrary if the temperatures at elevation 390 ft are closer to those at elevation 350 ft and there is significant difference in temperatures at 490 ft and 390 ft, then that condition indicates stratification in the Sites Reservoir and significant amount of cold water pool volume. The top panel also shows the timeseries of the modeled target temperatures, the blended Sacramento River temperatures and the impact due to the blending. The blending impact to the Sacramento River temperature is plotted on the secondary Y-axis. Positive values of the blend impact timeseries indicate that the Sites Reservoir releases temperatures are increasing the river temperatures. Similarly, the negative values in the blend impact timeseries indicate that the releases from the Sites Reservoir are cooling the river temperatures. The bottom panel shows the Sites Reservoir storage, Sites release to the Sacramento River and Sacramento River flow upstream of Delevan Pipeline. The bottom panel also shows the storage corresponding to the elevation of the three outlets (350 ft, 390 ft and 490 ft) as indicated by dashed lines parallel to x-axis. During the times when the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet in the top panel is equal to the surface temperature of the reservoir.

Based on the Figures 2 to 9, there are very few occurrences where the Sites Reservoir releases were cooling the Sacramento River temperatures. WY 1924, 1926, 1929, 1945, 1947, 1949, 1954, 1960, 1964, 1971, 1976, 1985, 1986 show minor cooling impacts in one or more months. All the occurrences show less than 1°F reduction in temperature, except for April 1964, when the River temperatures are less than the target by about 1.22°F. Looking at the conditions in April 1964 from Figure 6, the target temperature is about 58.4°F and the Sites release temperature is about 57.2°F. The reservoir temperature at the top outlet is about 60°F and the bottom outlet is 46.6°F. Considering the end-of-April storage of about 1530 TAF in the Sites Reservoir, the release could have been managed such that the downstream target temperature would have been complied with and any reduction in the river temperatures could have been avoided. In the 82 years modeled, there are less than 5% of the months with a cooling of 0.2°F or more as shown in the Table 1, with several of the months falling in the same year.

In all the years identified above, Sites Reservoir is at high storage condition and Sites Reservoir temperature timeseries show that there is significant stratification in the reservoir. If the releases are made from the appropriate outlet, the downstream target temperatures are complied easily. The model attempts to meet the provided monthly averaged target temperature for the tail water. However, the port optimization logic used to determine which outlets to release the water from in the model, so that the downstream target temperatures are complied includes several limitations. In reality, with the vertical temperature gradients in the Sites Reservoir that existed in the years noted above, it is reasonable to assume that the releases can be managed without causing any cooling impacts to the Sacramento River temperatures.

Conversely, there are more occurrences of warmer River temperatures due to the blending of the Sites releases. These occurrences generally coincide with dry years, when warm releases from the Sites Reservoir with low storage conditions are coupled with low flows in the Sacramento River. The warming is more prevalent in the second or third year in a drought sequence, where the storage in the Sites Reservoir is unable to recuperate. WY 1926, 1931, 1932, 1933, 1934, 1936, 1992 show one or more months with at least 1°F increase in the Sacramento River temperatures because of the blending with the Sites Reservoir releases. As shown in Table 1, there are about 5% of the months in the 82 year period increased River temperatures of at least 0.2°F, with several of those months falling in the same year. In the current operation scheme assumed for ALT C, Sites Reservoir responds to many downstream demands in the dry years, so that the cold water pool in the Shasta Reservoir is protected. This leads to a rapid depletion of the Sites Reservoir storage in a dry year and elimination of any thermal stratification that may have existed. Similar to the minor cooling occurrences due to the limitations in the model's port optimization logic, it is possible to manage the releases from the outlets to meet the downstream temperature targets to avoid warming of the River temperatures in some of the years.

Considering most of the warming events are occurring in the September and October months, as shown in the Table 2, it may be possible to modify the current operational scheme to release Sites Reservoir water to meet local Colusa Basin demands instead of releasing warm water to the River. However, this would lead depletion of Shasta storage so as to meet the downstream demands. Depending on the benefit and biological significance of increasing cold water pool volumes in Shasta Reservoir in dry years versus maintaining the River temperatures downstream of the Delevan Pipeline, some of the warming impacts due to the releases from the Sites Reservoir may be unavoidable.

Conclusions

A preliminary model was developed to simulate temperature conditions in the Sites Reservoir. The model is capable of simulating releases to meet a given tail water temperature target. Sites Reservoir release temperatures simulated by the model were blended with the Sacramento River temperatures from upstream of the Delevan Pipeline. This blended temperature allowed to determine if the Sacramento River temperatures were impacted because of the releases from the Sites Reservoir. The temperature model was simulated for the NODOS ADEIRS Alternative C. It was assumed that the Alternative C would result in the worst case impacts of all the Alternatives.

The results from this preliminary analysis indicated that in about 98 % of the months the Sites Reservoir releases are within a 0.5°F of the receiving Sacramento River water temperatures. Even though the model indicates a small number of months (<5%) with likely cooling impact of 0.2°F or more, the Sites Reservoir temperature results showed that it is possible to avoid such impacts by releasing from appropriate outlets. Only one month showed a cooling of more than 1°F in the 82 years.

In a few years, mainly in an extended drought period when both Sites storage and Sacramento River flow are low, releases from Sites Reservoir are likely to cause warming of the receiving Sacramento River water. In less than 1% of the months the temperatures in the Sacramento River increase by 1°F or more due to the releases from the Sites Reservoir. There are about 5% of the months with likely warming impact of 0.2°F or more, although most of the months are within the same year. The warming impact is mainly found during September and October months.

Limitations

The analysis and the model presented in here should be treated as preliminary. The parameters for the temperature model for the Sites Reservoir were developed using mostly data from the literature and from other reservoirs in the region. The model is not calibrated or validated. The model assumes that the releases from the outlet can be changed to meet the target temperature instantaneously. The target temperatures modeled are monthly averaged River temperatures. The port optimizing logic in the HEC5Q model has limitations. Potential temperature changes within the NODOS conveyance features that are conveying water to and from the Sites Reservoir were not taken into account while computing the Sites inflow temperatures and the blended Sacramento River temperatures.

References

RMA (2005), Upper Sacramento River Models and North of Delta Offstream Storage Model (NODOS), Presentation by Don Smith at DWR.

USBR (2011) Sites Reservoir Golden Gate Dam 1.81 MAF Storage Reservoir Multi-level Inlet/Outlet Tower Structure Sections.

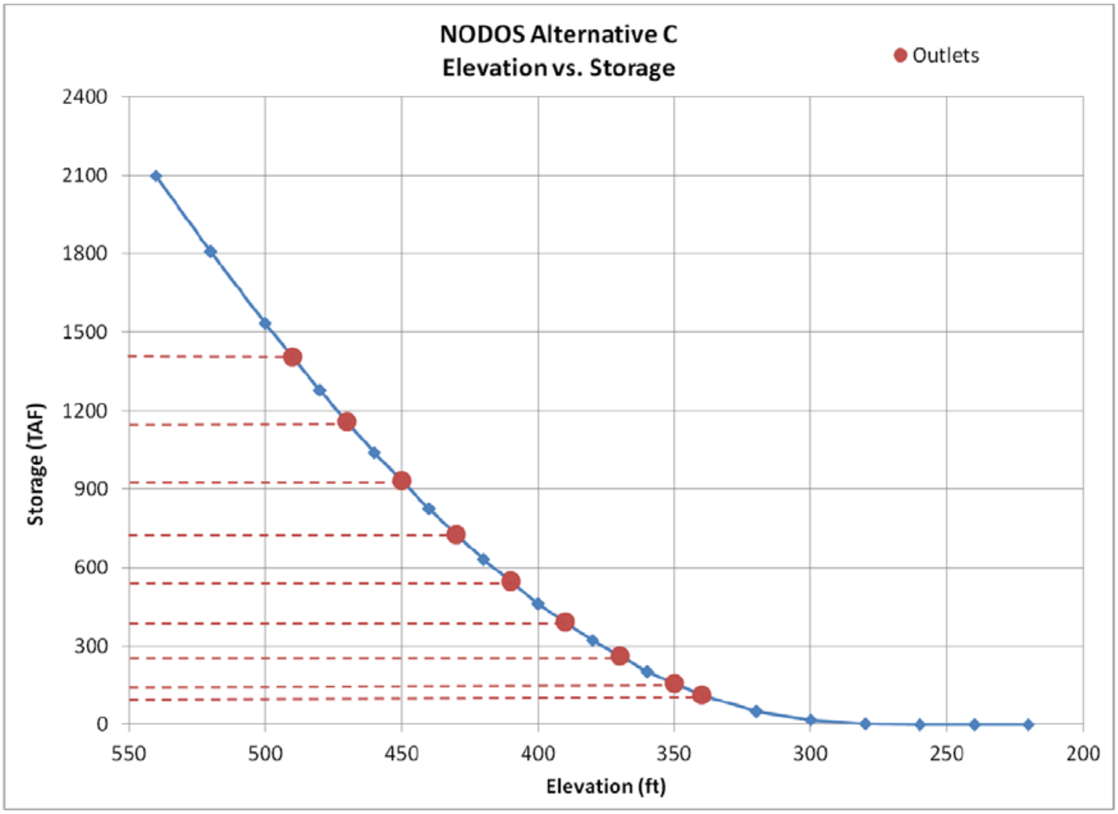


Figure 1: NODOS Alternative C Sites Reservoir storage as a function of the Reservoir elevation, with reservoir outlets marked.

TABLE 1
Probability of exceedance of "Change in Sacramento River Temperature downstream of Delevan Pipeline" due to the blending of releases from the Sites Reservoir

Probability of Exceedance	Change in Sacramento River Temperature (deg-F)[a]
1%	0.9
5%	0.2
10%	0.1
20%	0.0
30%	0.0
40%	0.0
50%	0.0
60%	0.0
70%	0.0
80%	0.0
90%	-0.1
95%	-0.2
99%	-0.4

[a] Negative change indicates cooling of the water temperature and positive change indicates warming.

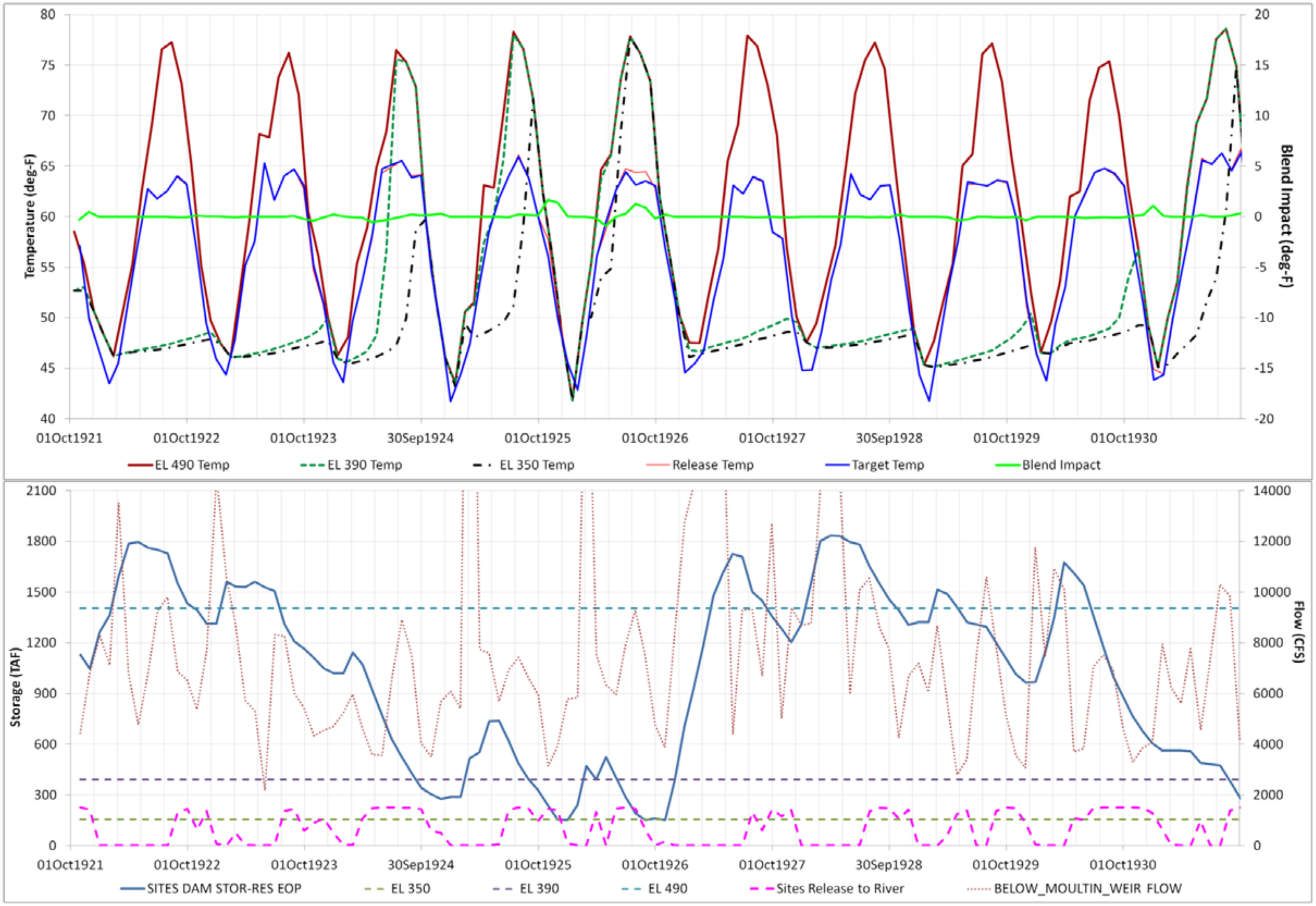


Figure 2: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1922 – 1931. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

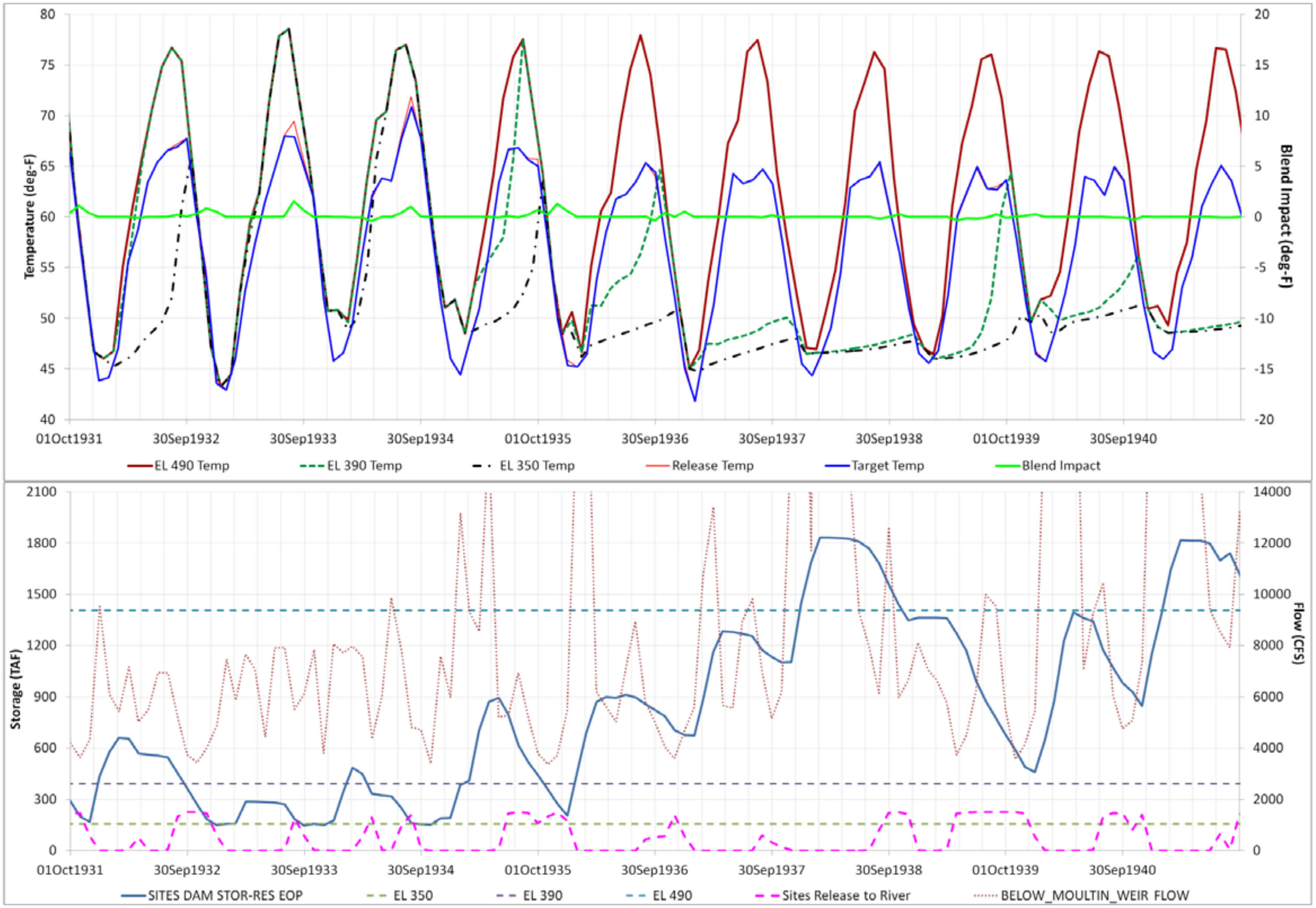


Figure 3: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1932 – 1941. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

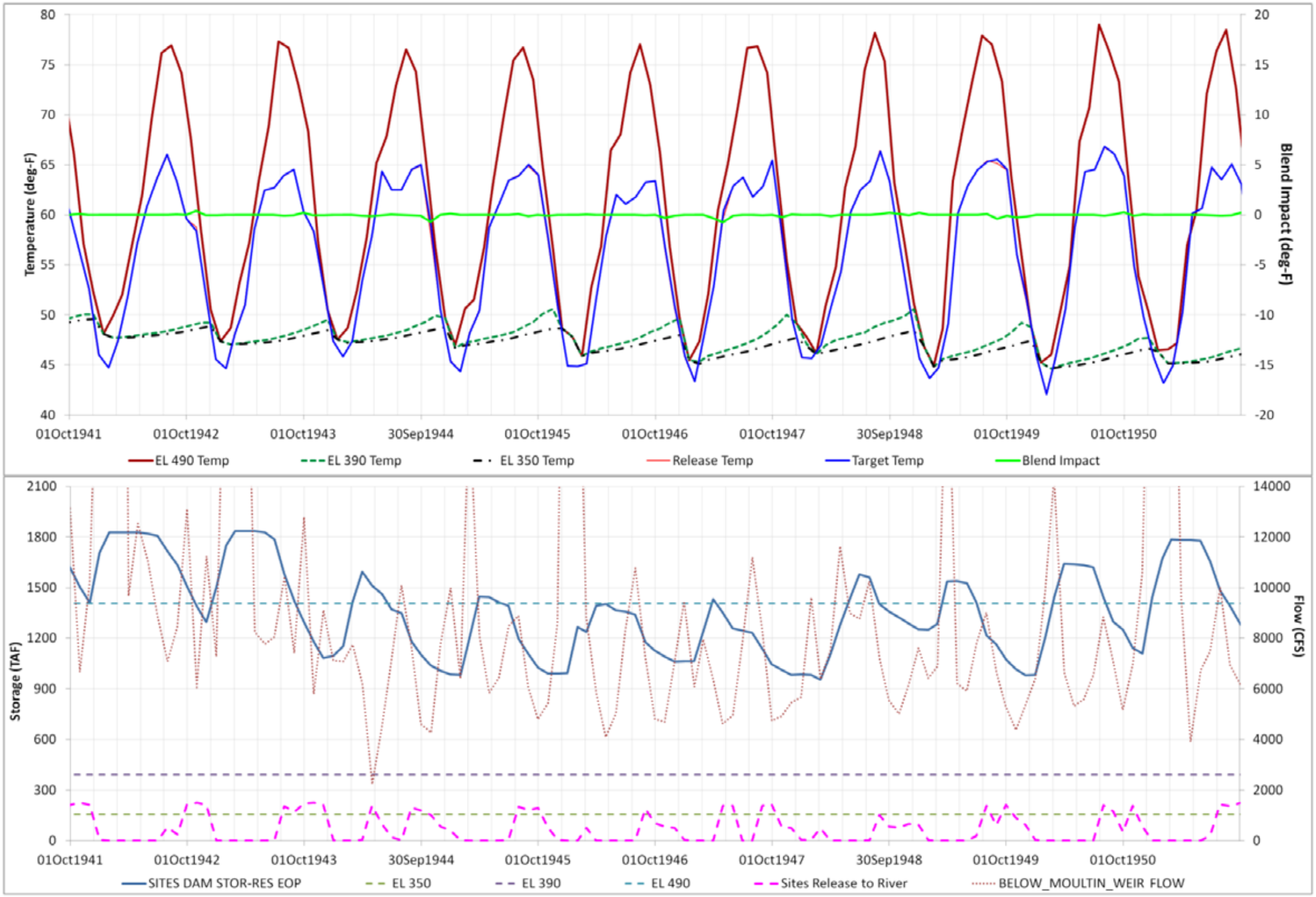


Figure 4: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1942 – 1951. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

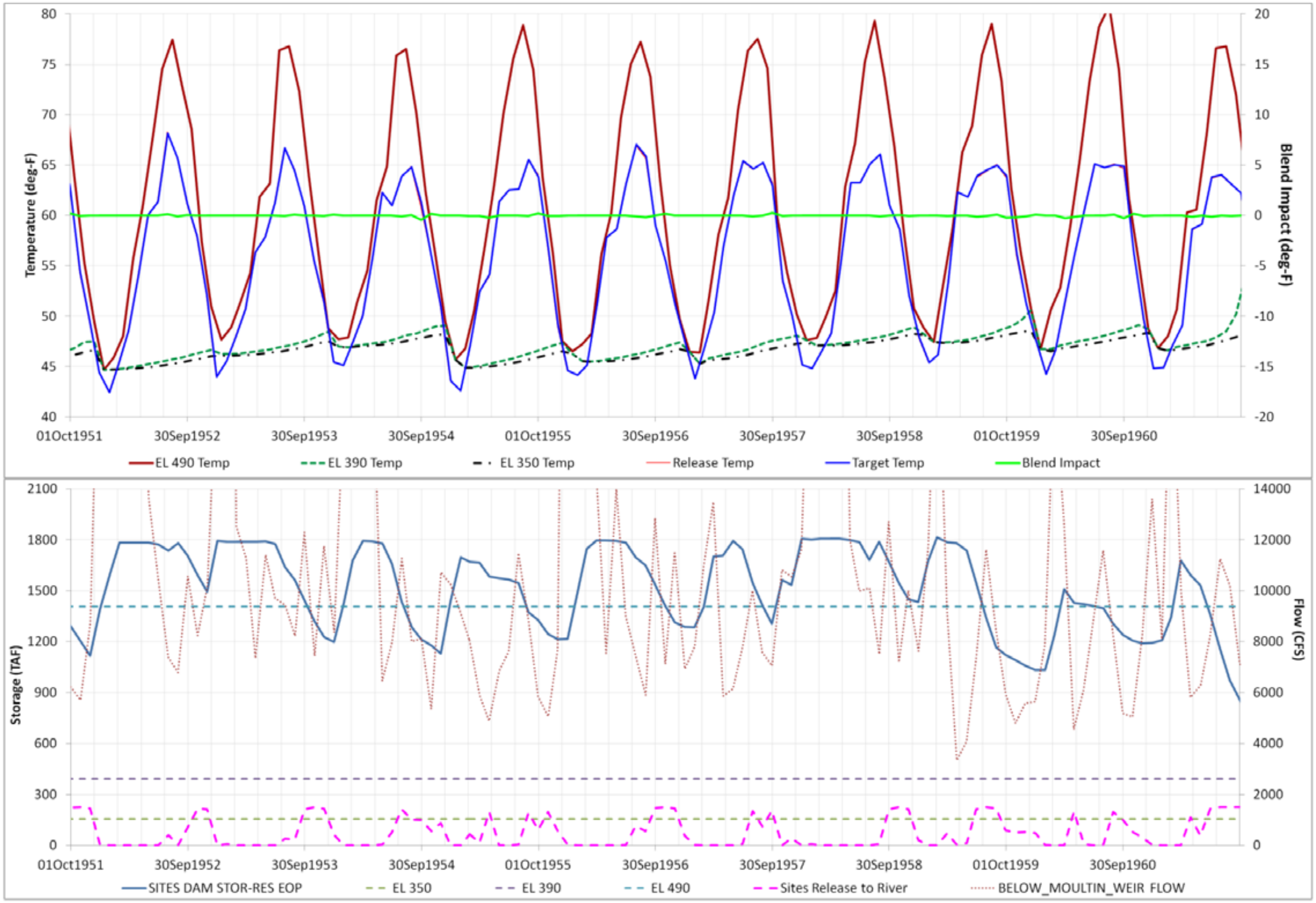


Figure 5: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1952 – 1961. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

NORTH-OF-THE-DELTA OFF-STREAM STORAGE ADMINISTRATIVE DRAFT ENVIRONMENTAL IMPACT REPORT/STUDY – PRELIMINARY TEMPERATURE ANALYSIS OF PROPOSED SITES RESERVOIR

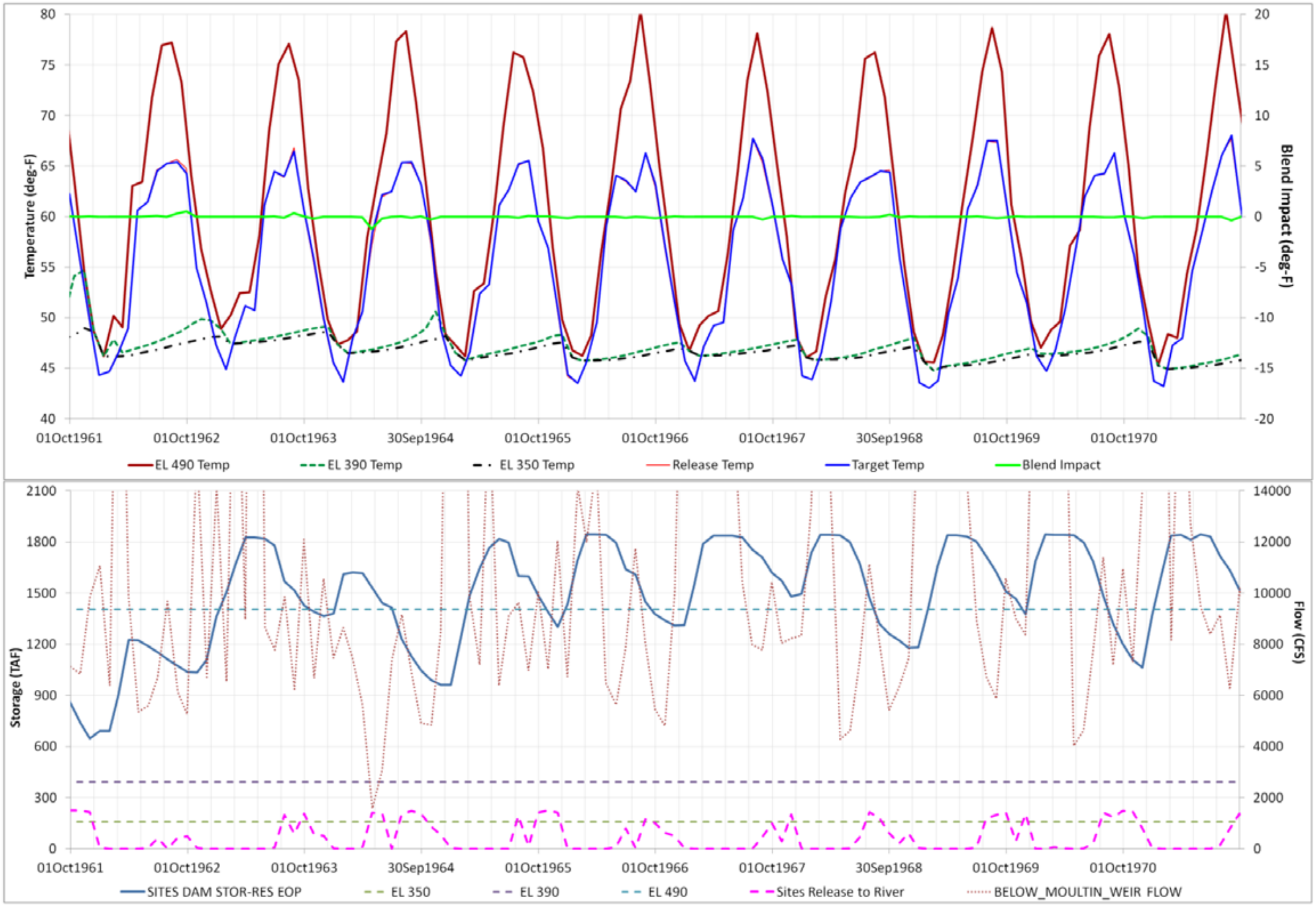


Figure 6: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1962 – 1971. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

NODOS_PRELIMINARY_SITES_TEMPERATURE_ANALYSIS_081012_REV05.DOCX 11

NORTH-OF-THE-DELTA OFF-STREAM STORAGE ADMINISTRATIVE DRAFT ENVIRONMENTAL IMPACT REPORT/STUDY – PRELIMINARY TEMPERATURE ANALYSIS OF PROPOSED SITES RESERVOIR

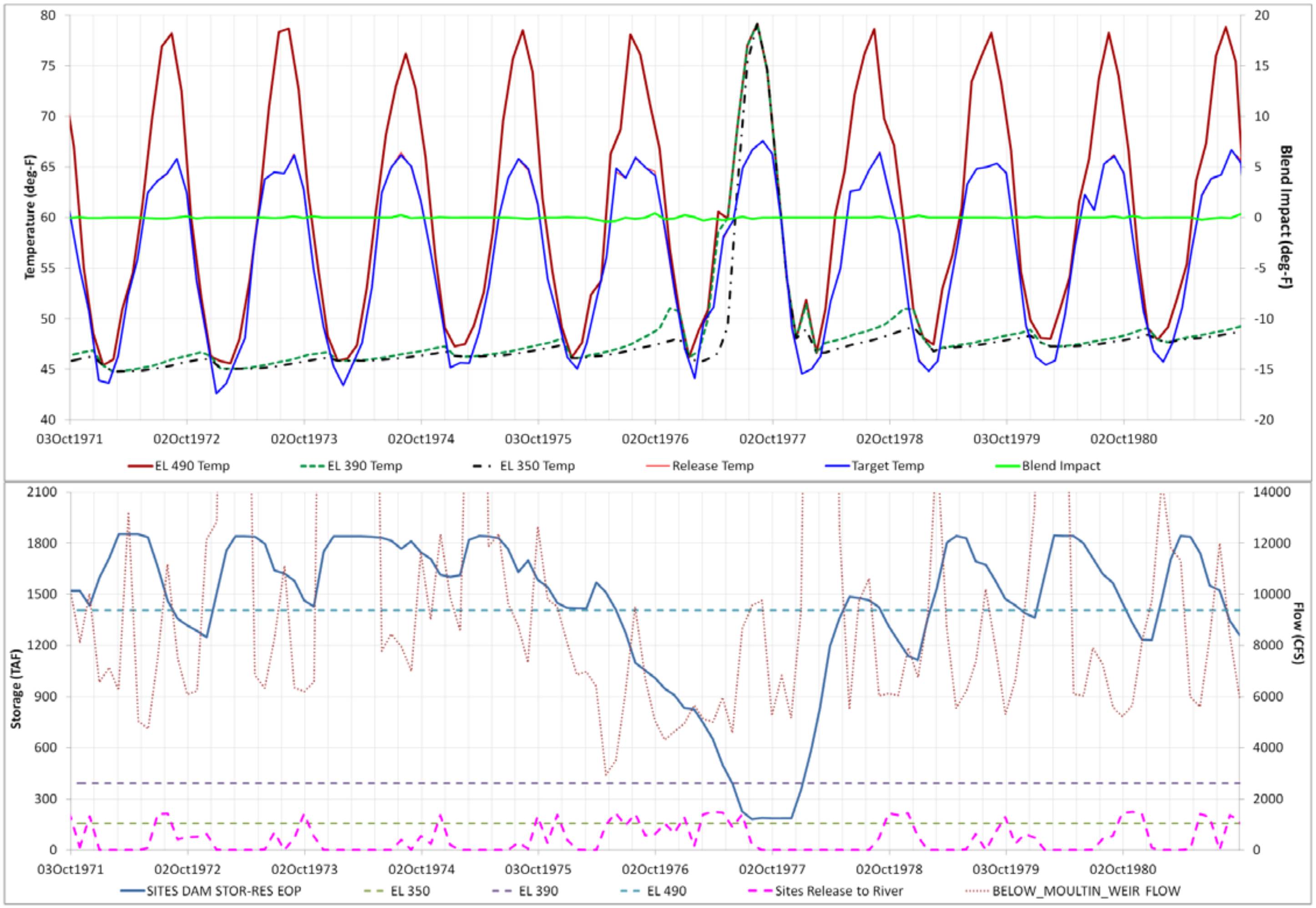


Figure 7: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1972 – 1981. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

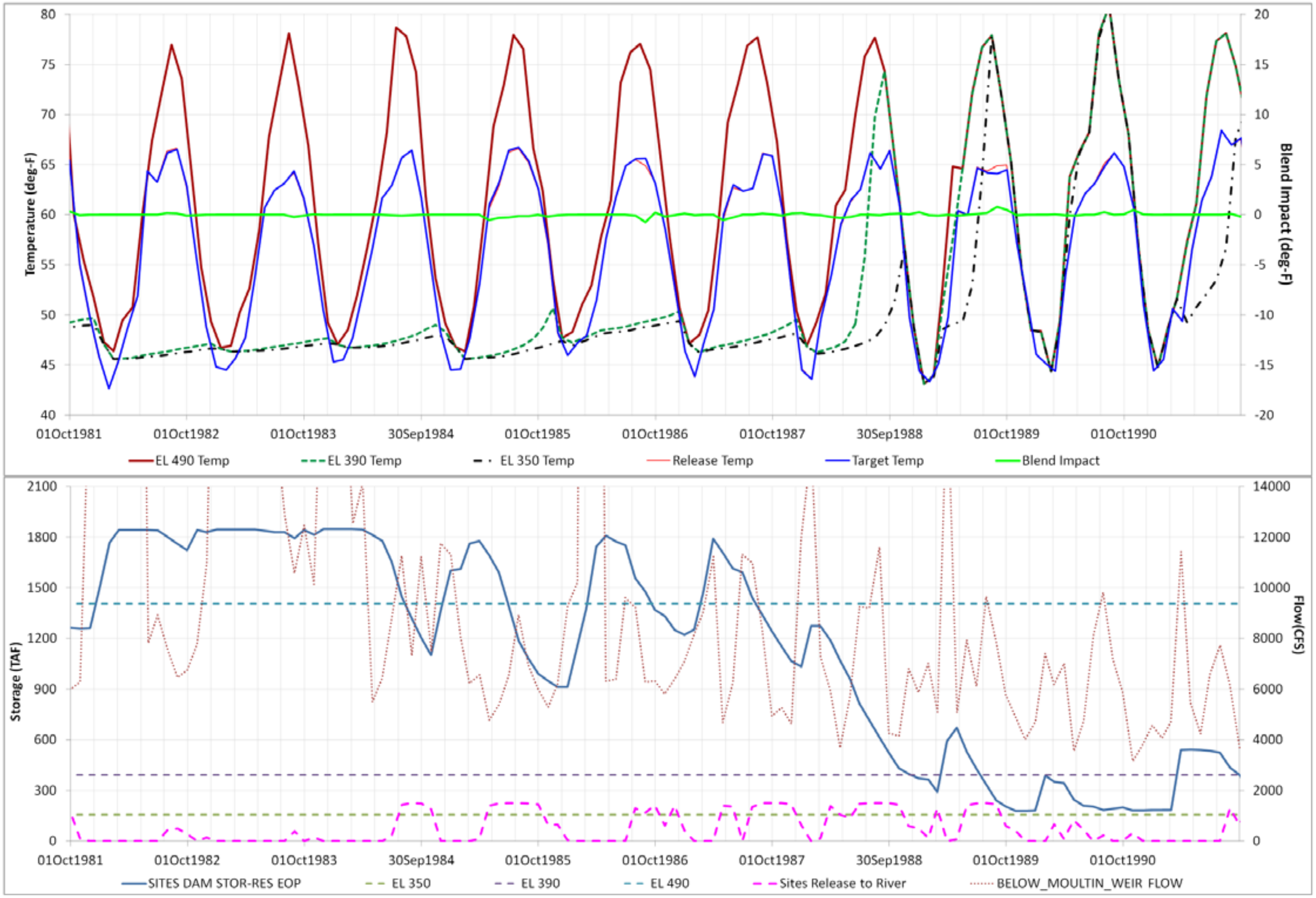


Figure 8: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1982 – 1991. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

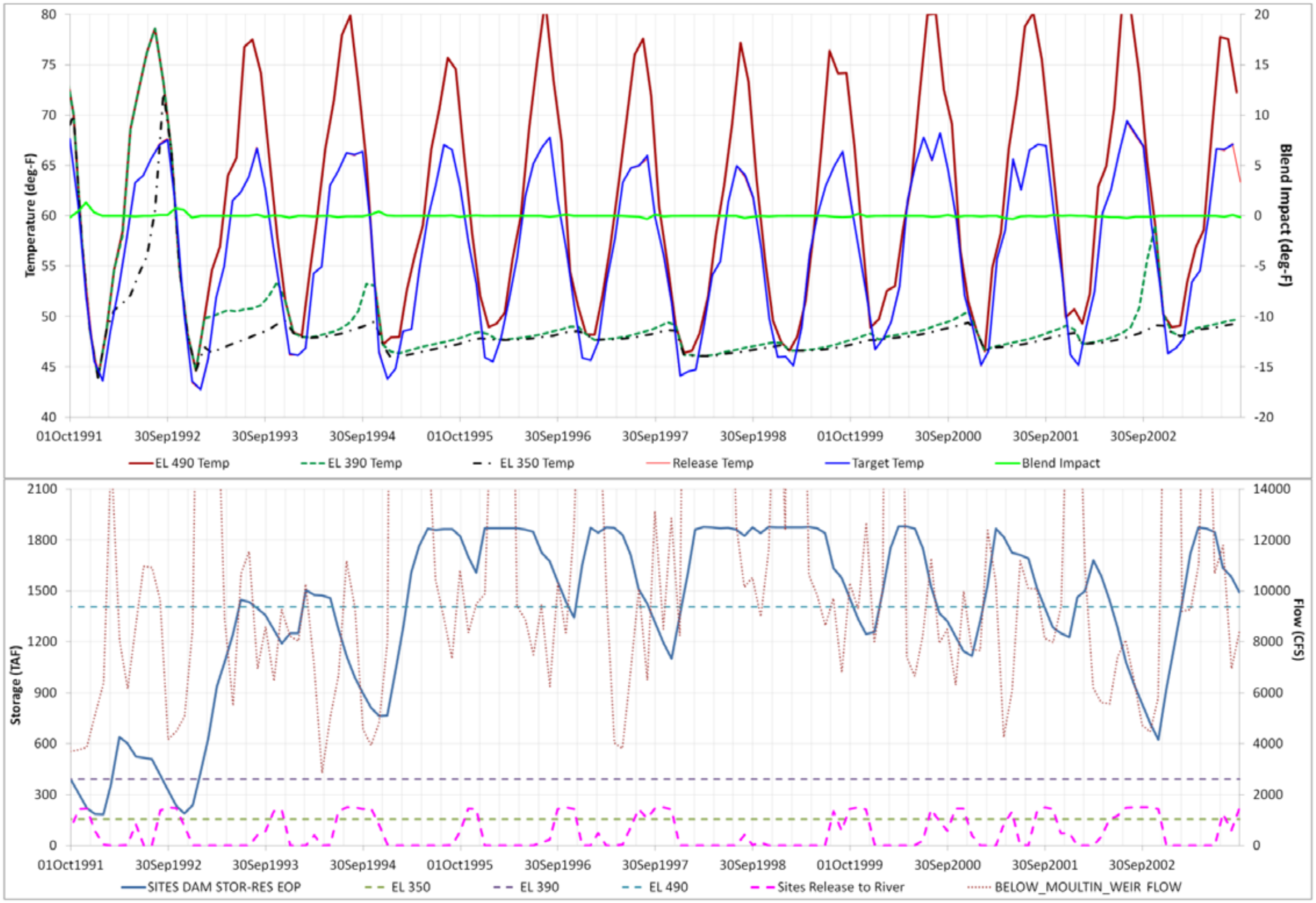


Figure 9: Temperature results for the Sites Reservoir and the Sacramento River downstream of the Delevan Pipeline for the water years 1992 – 2003. Note: When the storage is below an outlet elevation (indicated by dashed lines parallel to x-axis in the bottom panel), the temperature reported for that outlet is equal to the surface temperature of the reservoir.

Table 2: Probability of exceedance of "Change in Sacramento River Temperature downstream of Delevan Pipeline" due to the blending of releases from the Sites Reservoir by month

Probability of Exceedance	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1%	1.2	1.4	0.7	0.0	0.1	0.0	0.0	0.0	0.1	0.6	1.1	0.7
5%	0.5	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.4
10%	0.3	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2
20%	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
30%	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
80%	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	-0.1	-0.1
90%	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.4	-0.2	-0.1	-0.1	-0.2	-0.1
95%	-0.3	-0.1	0.0	0.0	-0.1	-0.2	-0.5	-0.3	-0.1	-0.1	-0.3	-0.2
99%	-0.5	-0.2	-0.2	0.0	-0.1	-0.3	-1.0	-0.4	-0.2	-0.1	-0.5	-0.4

APPENDIX H

Power Planning Study

Table of Contents

Page

Tables

Figures

Page

This page intentionally left blank

EXECUTIVE SUMMARY

The Department of Water Resources (DWR) Power and Risk Office (PARO) Power Planning Branch was tasked by the Division of Statewide Integrated Water Management (DSIWM) to conduct a power planning study for the proposed North-of-Delta Offstream Storage (NODOS) Project. NODOS is in the planning phase, at a feasibility-level stage. The objective of the PARO power planning study is to analyze the proposed action alternatives, from a power planning perspective. NODOS's action alternatives were developed pursuant to National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) Notice of Intent and Notice of Preparation (that were filed and published in November 2001 by the Bureau of Reclamation [Reclamation] and DWR, respectively) to investigate surface storage opportunities north of the Delta. The study objective includes optimization of NODOS power operations, and a financial assessment of NODOS obligations and revenues resulting from its exposure to the energy market. Also, the power planning study will provide a roadmap for the transmission interconnection planning process for the proposed project facilities.

The PARO power planning study is being conducted in multiple phases, as NODOS planning and implementation processes evolve with time. A first phase was completed in 2009, in which the designed capacities and the corresponding operational scenarios for the project's components were analyzed, and some design modifications were recommended. The current (second) phase of the study analyzed the three action alternatives identified for NODOS relative to the "noproject" alternative to optimize power operations (with sustained water operations) to better capture power market opportunities and utilize the inherent excess capacities (resulting from hydrology swings) for the different components of the project. Also in this phase of the study, needed design and operational changes that will add valuable operational flexibilities were identified. Operational flexibilities will be crucial for NODOS to be able to participate in a complex and evolving energy market while sustaining intended water diversions and deliveries. A third phase of the power planning study will follow, subject to DSIWM's desire to explore additional market opportunities (such as renewables integration) that may enhance NODOS' viability and value.

NODOS is an off-stream seasonal storage facility proposed to be built 10 miles west of the town of Maxwell, California. NODOS will be composed of two main reservoirs (Sites and Holthouse/Funks), and a conveyance system that includes a number of physical components (intakes, pumps, canals, pipes, and terminal structures). NODOS is designed to capture the annual seasonal cycle of the Sacramento River, where flood water could be captured, stored, and re-delivered at a later time. The major storage component of NODOS is Sites Reservoir, ranging from a 1.27 (Alternative A) to a 1.81 (Alternatives B and C) million acre-foot (MAF) reservoir. Water would be delivered to and from Sites Reservoir through a network of pumping/generating plants and conveyances. Three diversion points (Alternative B will have two diversion points) along the Sacramento River would be used to capture and divert/pump water to NODOS storage facilities.

DSIWM supplied PARO's Power Planning Branch with the most recent available California Statewide Integrated System (CALSIM) II model runs that describe the intended operations of NODOS, based on the 82 years of historical hydrology record. The CALSIM II results are used to identify a median case, 30-year time-series for NODOS diversions from the Sacramento River, which is the basis for the study analysis. Project operations, constraints, and assumptions, as envisioned by the NODOS Project team, are maintained and further optimized to maximize the value of the project's assets.

Daily pumpback operations are superimposed (where and when possible) to better utilize excess capacities of project facilities (resulting from hydrology swings) and to capture energy market opportunities. The intent is to generate an additional revenue stream that would enhance the project's viability and value. A dispatch profile for the daily pumpback operations is generated based on market opportunities, efficiency of Sites Reservoir pumping/generating plant, and available storage at Holthouse Reservoir.

NODOS Energy Portfolio Value

Two operational scenarios are used to model each of the three action alternatives considered for the project: Incidental and Optimized. For the Incidental scenario, pumping and generating at the different NODOS facilities are driven by water diversions and releases. For the Optimized scenario, pumping and generating at the Sites Reservoir Pumping/Generating Plant are reshaped to minimize pumping costs obligations (pumping in off-peak hours) and to maximize energy generation revenues (generating in super-peak hours) for the project. Also, optimizing operations allowed for the project's excess capacity to be used to superimpose pumpback operations on NODOS operational modes.

For the 30-year planning period, optimizing NODOS operations resulted in additional revenues for the project in net present value (NPV) totaling $72,503,000 for Alternative A, $76,343,000 for Alternative B, and $77,003,000 for Alternative C. For all three action alternatives considered for NODOS, optimizing operations resulted in changing the net project cash flow from a negative to a positive cash flow – an improvement that would significantly enhance the economics of the project. For NODOS Incidental operations, the net total project's power portfolio value (generation revenues minus pumping costs) (for the median case of project diversions) in NPV is $-50,363,000, $-65,077,000, and $-54,206,000 for Alternatives A, B, and C, respectively. Whereas, for NODOS Optimized operations, the net project's power portfolio value in NPV is $22,140,000, $11,269,000, and $22,797,000 for Alternatives A, B, and C, respectively.

Capacity, Ancillary Services, and Renewable Integration

A crucial element of reliable grid operations, and relevant to NODOS operations, is Resource Adequacy (RA). For NODOS, RA obligations are a pseudo financial obligation in pumping/diversion cycle, and a revenue opportunity in generation/ release cycle. For NODOS, RA obligations for the pumping cycle are met through the "self-provided" provisions of current California Independent System Operator (CAISO) tariff, provided that the project meets CAISO participating load requirements. For a generation asset, there are two different levels of participation in CAISO's capacity market – local RA, and system RA, based on the relative location of that specific asset to pre-identified congested local areas within the CAISO-managed grid. Monetizing potential revenues for NODOS from participation in the capacity market is a difficult task. The uncertainty in projecting where and when RA products are needed will render any estimate worthless, at this time. So, a range of values is offered to describe potential revenues for NODOS from RA offerings, and was based on a $2/KW-year (for System RA) to $25.40/KW-year (for local RA products).

CAISO procures ancillary services (AS) to ensure that it has adequate reserve generation capacity to maintain the electric system reliability and system frequency, by matching generation and load at all times under both normal and abnormal operating conditions. For NODOS pumping/generating facilities, if interconnected to CAISO grid, AS would be a significant operations and costs/revenues concern. A preliminary assessment for AS opportunities for NODOS is conducted using the median case CALSIM II deliveries, for the 30-year planning period. For the pumping cycle, NODOS will have the opportunity, as a participating load (meeting CAISO tariff definition), to sell Non-Spin AS into the CAISO market. For the generation cycle, NODOS will have the opportunity to sell Regulation Down AS into the CAISO market. The average values for the off-peak Non-Spin, and on-peak Regulation Down are calculated using, as basis, published clearing prices for the CAISO AS markets. For Alternative CNODOS, the total AS revenues from Non-Spin (the pump mode) for the 30-year planning period in NPV is $4,925,000. The corresponding total AS revenues from Regulation Down (in the generation mode) for the project in NPV is $9,198,000. The total AS revenues from the pumpback operations in NPV is $11,595,000. The NODOS total potential AS revenues in NPV is $25,718,000 for the 30-year planning period. It should be noted that the aforementioned AS revenues are only a measure of potential revenues based on current market trends – granted that the CAISO market will evolve over time to accommodate load growth, renewable integration, regulatory changes, etc.

The California Renewable Energy Resources Act (CRERA), signed by California Governor Brown on April 12, 2011, significantly increased the state's renewable portfolio standard (RPS) targets from 20 percent to 33 percent by 2020. CRERA also expanded the compliance obligations to include virtually all retail sales of electricity in California. In September 2010, CAISO undertook a multi-phase stakeholder process (Renewable Integration Market and Product Review Initiative [RIMPR]), aimed at identifying changes to the energy market structure and at introducing new market products to reliably mitigate the impact of renewable generation (intermittent generation) as it penetrates the market. Other potential breakthroughs in the power sector include developing energy storage technologies and their potential application to pump-storage hydroelectric facilities. Energy storage in hydroelectric facilities is being integrated with intermittent renewable energy facilities to create dispatchable resources and enhancing grid reliability and power quality. Other forces driving the need for energy storage technologies are climate change policies, smart grid initiatives, and the desire to improve utilization of generation and transmission capacities.

For NODOS, there is great potential for the project's generation and pumping assets to participate in providing renewable integration services as the market needs evolve. Although NODOS' potential in renewable energy integration is certain, it is difficult to monetize that potential at this time because of the absence of a clear tradable market for these services. The California Independent System Operator (CAISO) RIMPR may introduce new market products that NODOS can provide, yet sustain its primary water storage and delivery objectives.

Conclusions-Second Phase

Under the median case deliveries of NODOS, the estimated NPV of the project's power portfolio (energy only) for the 30-year planning period in NPV is estimated to be $22,140,000, $11,269,000, and $22,797,000 for Alternatives A, B, and C, respectively. Additional revenues are expected for the project's power portfolio from participation in the Capacity, Resource Adequacy, and Energy Storage markets. However, monetary values for these services are not included in project economics to avoid speculation. More work is needed to improve on the findings of the current phase of the study.

1.0 BACKGROUND

This report summarizes the second phase of the Department of Water Resources (DWR) Power and Risk Office (PARO) Power Planning Study (study) for the proposed NODOS Project, and recommends additional analyses that need to be performed in the next phase of the study. This document reports the assumptions, the modeling approach, and the results of the second phase of the study. Additional analyses and modeling will be needed to further explore operational scenarios and design adjustments for the different project components that would enhance its viability and value. Changes in design parameters and optimization of operational scenarios will add valuable operational flexibilities that will be needed for the project to participate in a complex energy market, yet, maintain water, flood, fish, environmental, and power objectives.

NODOS is an off-stream seasonal storage facility proposed to be built 10 miles west of the town of Maxwell, California. The project is in the planning, feasibility-level stage. NODOS is composed of two main reservoirs, Sites (a new offstream reservoir) and Holthouse (an expansion of the existing Funks Reservoir), and a conveyance system that includes a number of physical components (intakes, pumps, canals, pipes, and terminal structures). The project is designed to capture the annual seasonal cycle of the Sacramento River, where flood water could be stored during the high-flow season and would be released during the low-flow season.

Three alternatives are proposed for NODOS in terms of the configurations, size, and operations of the different project components. The alternatives were formulated to satisfy a set of water and environmental objectives. The assumptions for the three NODOS alternatives are summarized in a January 5, 2011, document titled *Definition of Proposed Alternatives for Evaluation in the North-of-the-Delta Off-stream Storage Administrative Draft Environmental Impact Report and Statement*.

The major storage component of NODOS, and common to all three alternatives, is Sites Reservoir, (a 1.27 million acre-foot [MAF] storage facility for Alternative A, and a 1.8 MAF storage facility for Alternatives B and C) that has up to an approximate 14,000-acre inundation footprint. For example, in Alternatives B and C, Sites Reservoir storage capacity is generated through the construction of two main dams, Golden Gate Dam (310 feet tall) and Sites Dam (290 feet tall), and 9 Saddle Dams (ranging from 40 to 130 feet tall), as shown in Figure H.1-1. Two lower reservoirs (Holthouse and the Terminal Regulating Reservoir [TRR]) are configured to complement the project complex, and to add the needed operational flexibility to the project operations. The existing Funks Reservoir would be enlarged to 6,500 acre-feet (AF) storage capacity by the addition of Holthouse Reservoir and integrated with the rest of the project components. A second reservoir would be a newly constructed, 2,000 AF capacity TRR for the Glenn-Colusa Irrigation District (GCID) canal, to the east of Holthouse Reservoir.

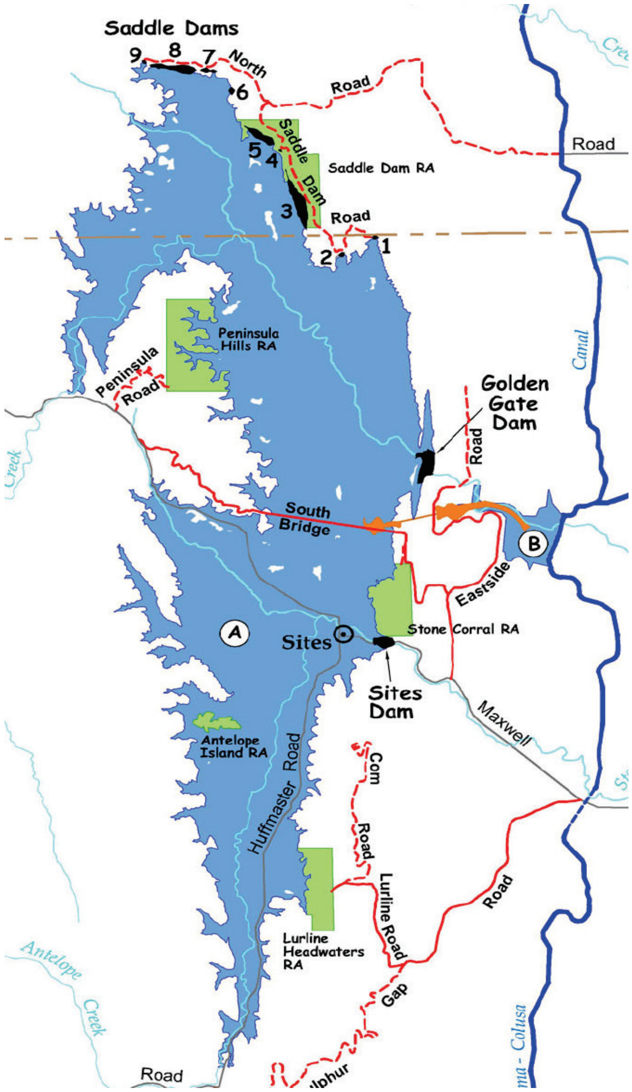


Figure H.1-1. Sites Reservoir Vicinity Map

Water would be delivered to and from Sites Reservoir through a network of pumping/generating plants and conveyances. Under Alternatives A and C, three pumping plants along the Sacramento River would be used to capture and divert water to NODOS. The pumping plants are either existing/modified or new. The Red Bluff Pumping Plant, and Tehama-Colusa (T-C) Canal, a 2,100 cubic feet per second (cfs) capacity plant, would be the project's upper most diversion point on the Sacramento River, near the city of Red Bluff. The project's second diversion point from the Sacramento River would be the GCID Pumping Plant and Canal, a 3,000 cfs capacity plant, and a 3,000 cfs to 1,800 cfs capacity canal. The third diversion point would be a newly constructed Sacramento River Pumping/Generating Plant and Delevan Pipeline, a 2,000 cfs pump, and a 1,500 cfs release capacity plant. Under Alternative B, the Sacramento River diversion pumps are eliminated; however, releases into the Sacramento River would occur with no power generation facilities.

Figure H.2-1 depicts the location of the three Sacramento River diversion points to Sites Reservoir. Holthouse Reservoir would be the lower elevation collection point for the project water diversions from the Sacramento River, and a distribution point for water releases from Sites Reservoir. For Alternative C, the hydraulic capacities of Sites Reservoir Pumping/Generating Plant are 5,900 cfs in pumping mode and 5,100 cfs in generation mode. For Alternative B, the hydraulic capacity for pumping is 3,900 cfs. The TRR would have a 1,800 cfs pump and 1,500 cfs release capacity pumping/generating plant and pipeline to convey flows from the GCID Canal to Holthouse Reservoir.

This page intentionally left blank

2.0 STUDY OBJECTIVE

The objective of the study is to analyze the existing/designed components and operational scenarios of NODOS that resulted from the most recent California Statewide Integrated System (CALSIM) model studies from a power planning perspective. The study is aimed at optimizing NODOS operations to maximize its power portfolio's value (revenues-obligations). Also, the study will provide a transmission planning roadmap for NODOS interconnection with available power grid systems (California Independent System Operator [CAISO], Western Area Power Administration [WAPA], Pacific Gas and Electric (PG&E) and the Sacramento Municipal Utility District [SMUD]) in the area. The study results are meant to complement the work done by the Division of Statewide Integrated Water Management (DSIWM) and their consultants. The study is implemented using 2011 power market information and regulations, and available power portfolio models/tools to better evaluate energy costs and revenues of the project.

In light of the modeling results, the study makes recommendations for modifications in the design parameters and in the operational scenarios/assumptions that may enhance the project's value, and allow for better utilization of the project pumping/generating and storage facilities. Also, the study recommends further analysis needed to study the modified/optimized operational scenarios and design parameters of NODOS.

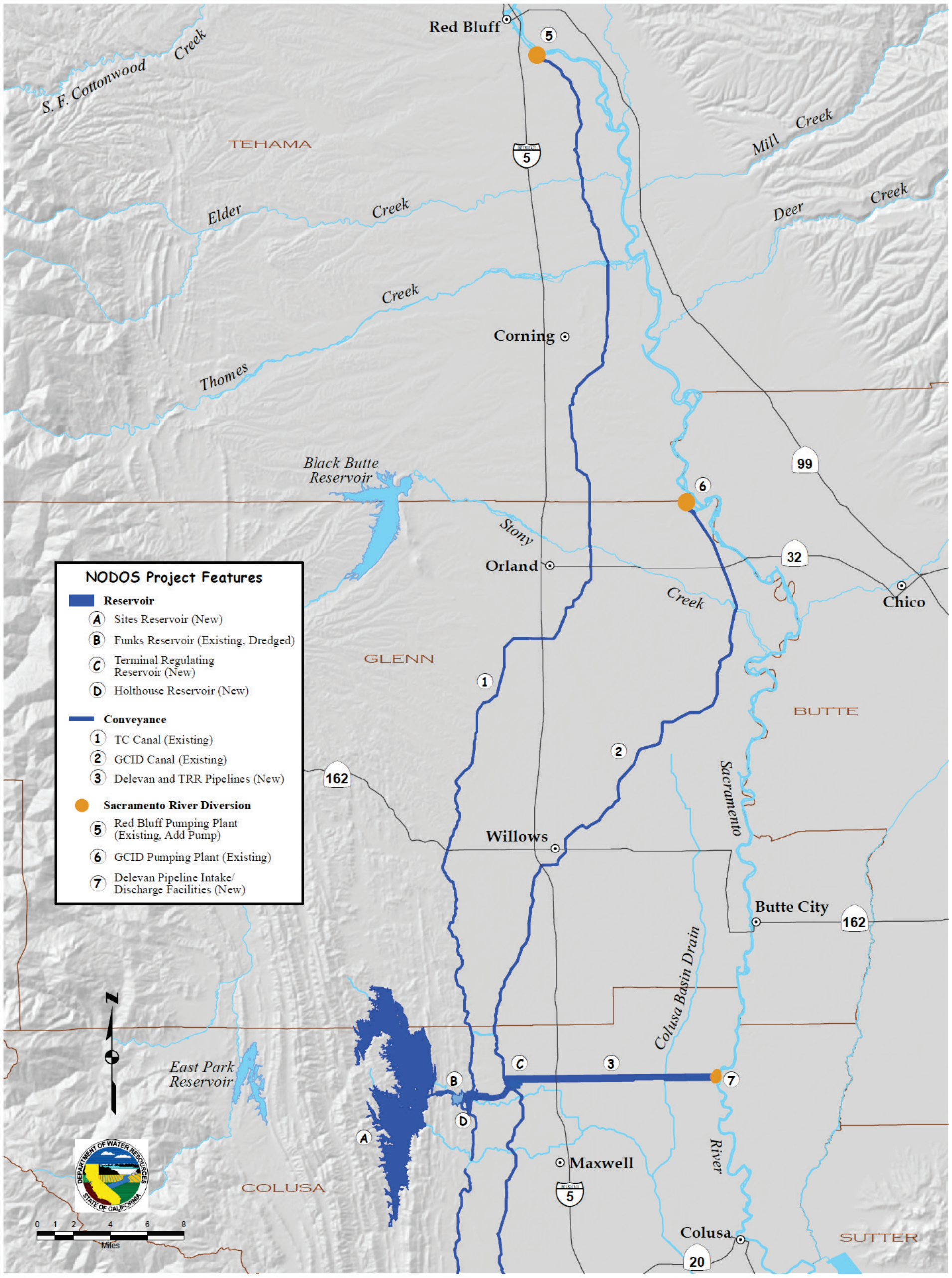


Figure H.2-1. NODOS Components and Interconnection

3.0 MODELING APPROACH

DSIWM supplied PARO's Power Planning Branch with the most recent available CALSIM II runs. The CALSIM II model runs include the No Project Alternative and the three NODOS action alternatives. The CALSIM II model for the No Project Alternative is dated July 5, 2010, with assumptions developed on the basis of the April 1, 2010, Bay Delta Conservation Plan (BDCP) No Project Alternative without climate change. CALSIM II runs describe the intended operations of NODOS, based on the 82 years of historical hydrology record, for each of the three action Alternatives contemplated for the project. PARO used the supplied CALSIM II model results to generate a median case 30-year outlook for NODOS operations. The corresponding high and low cases (30-year outlook) for NODOS diversions from the Sacramento River were also developed, to reflect the uncertainty or "bookends" in water deliveries resulting from natural hydrology swings. For each of the three action alternatives considered in this study, the resulting 30-year operational time-series for all project components are the basis for NODOS' power portfolio value and risk.

For this study, project operations, constraints, and assumptions, as envisioned by the NODOS team, are maintained and further optimized to maximize the power portfolio's value. Optimizing project operations is done to capture market opportunities and price differentials between on-peak and off-peak energy. Current and future power market structure and opportunities are focused on efficient and reliable market design. Optimization of NODOS operations is important to more efficiently and economically use different project assets. A pumpback operation could only be superimposed on NODOS operational modes (diversion and release modes) if pumping and generation for water delivery purpose are optimized (synced with market on-peak and off-peak cycles). Also, optimization of project operations will translate the inherent excess design capacities of the project's components (resulting from hydrology swings) to operational flexibility, and minimize operations and maintenance net costs of the project.

One of the challenges in modeling a proposed project (i.e., future construction of an energy market participating project) is in choosing an appropriate project operations start date, or when the project's assets will be online. The start date will determine the window of time for a price forecast (power and fuel) and the corresponding volatility term structure that the analysis will be based on. The further out the anticipated project operations start date is, the further the price basis used for the analysis would separate from actual market dynamics and current market trends. An alternative approach to overcome this problem is to assume that the project will be operational in the near future and to accordingly value all assets and power needs. Similarly, operational, maintenance, and construction costs would be valued on the same start date basis. Then, costs and revenues would be discounted to a present value consistent with the analysis date. Planned and anticipated future changes to the regulatory environment, power market structure, and market evolution can be reflected in the analysis, on a potential scenario basis. This approach will provide a good comparative framework, and minimize the inherent forecast errors (i.e., speculation) in both projects' power portfolio value and in its construction costs.

Figure H.3-1 is a flowchart depicting a summary of the different steps/tracks (roadmap) taken in translating CALSIM II model runs to an energy portfolio set of assets and contract instruments (time series of monthly pumping and/or generation for each project component). Figure H.3-1 also describes the general modeling approach that was adapted in performing the study on the three proposed action alternatives for NODOS.

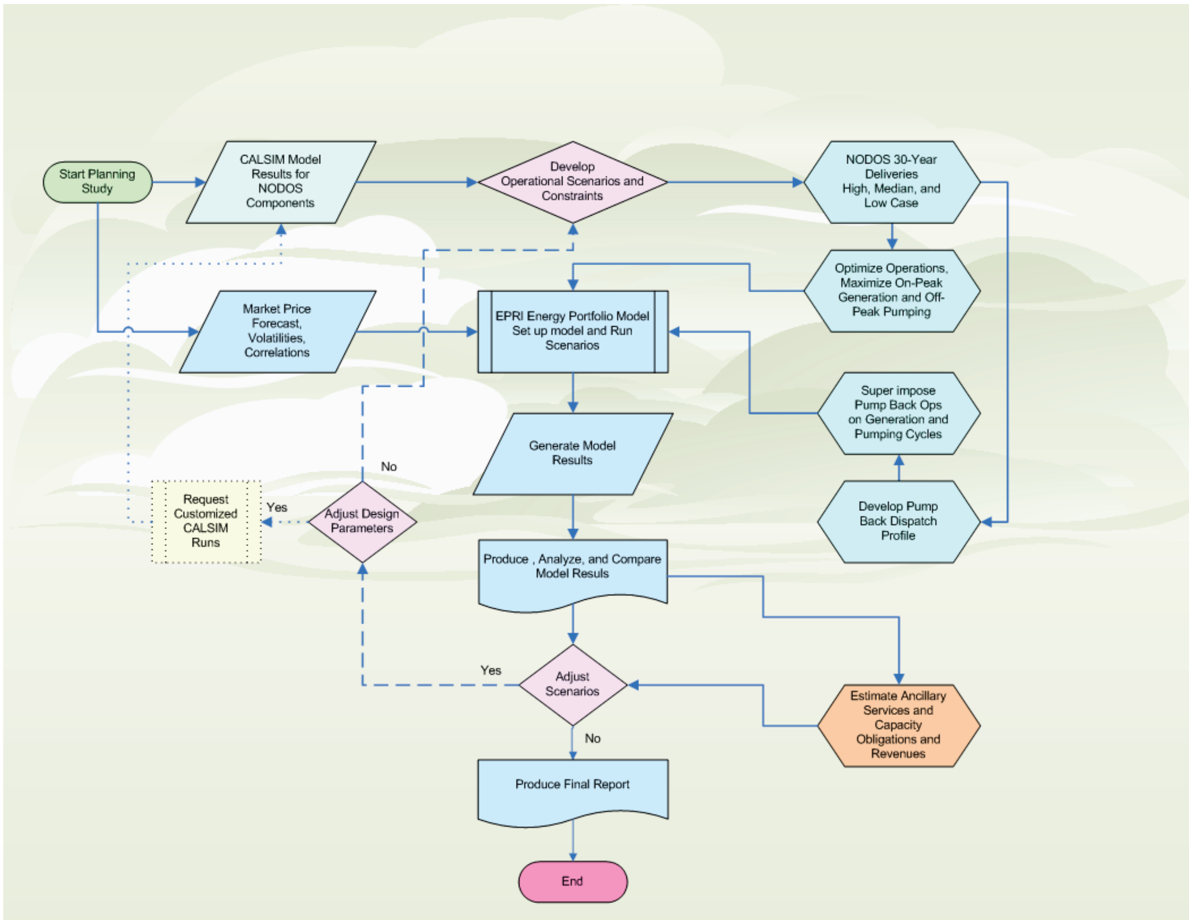


Figure H.3-1. NODOS Project Power Planning Study Flowchart

3.1 EPRI Energy Portfolio Model

Current power portfolio models available to PARO are used to execute the analysis for NODOS. The Electric Power Research Institute (EPRI) Energy Portfolio Model (EPM), version 5, is used for this purpose. EPRI Fast Fit model, version 2.5, is used to describe the needed power and fuel price volatilities term structures, and the correlations between the different energy markets the project will be participating in, or exposed to.

The EPM is a computer software/model designed to help businesses manage value and risk in the energy markets. The EPM is used in the current study to value the different NODOS assets and energy needs. The EPM is a module of a larger suite of individual modules, called the Energy Book System (EBS). Other modules within EBS are EPRI Contract Evaluator, EPRI Risk Manager, EPRI Retail Product Mix, and EPRI Fossil Asset & Project Evaluator. These modules were designed to meet the valuation and risk management needs of a targeted segment of the energy industry. Specifically, businesses with exposure to the energy market with corresponding exposure to a variety of financial risks. Financial risks, among other things, result from the extraordinary volatility in wholesale energy markets, especially price risk and uncertainty in the underlying fuel markets.

The EPM provides a set of templates that facilitates the description and evaluation of common types of power and fuel contracts, including supply contracts, standard and customized forward, and option contracts. It has the capabilities to model a number of physical assets, including full requirements contracts, power and fuel storage facilities, and generation assets. Many other assets can be modeled by combining two or more standard templates. The EPM requires the user to describe prices in the underlying commodity markets. The model characterizes each commodity market by a forward price curve and a term volatility structure. A correlation matrix characterizes the behavior of pairs of commodity markets is also needed by the model. The correlation matrix is an important concept in evaluating portfolio risk, and assets with two underlying markets, such as spread options or generating units. The model can also be used to assess the value and risk implications arising from uncertainty regarding the future level of load and stochastic generation (e.g., “run-of-river” hydroelectric generation).

The EPM calculates the current market value of any number of user specified assets. The EPM can also calculate and report portfolio value, cash flows, and risk exposures. This includes assessing portfolio’s exposure to both underlying commodity markets and customer loads. EPM allows users to manage price and load risk by applying methods that reflect the volatility and correlations between load and price. The market value of a resource depends on the cash flows it is expected to generate over its remaining life. Therefore, the market value of a generating unit depends on the difference between the value of the energy it is expected to produce and the value of the resources required for production. Market values fluctuate over time as conditions in the underlying markets fluctuate. EPM reports the market value of a resource or asset as the value of what it is worth today. One of the benefits of the EPM is that it will allow users to “mark-to-market” periodically each position in their book and thereby track gains and losses as they arise. EPM can report value and risk exposures on a weekly, monthly, quarterly, or annual basis over a user-specified time horizon.

3.2 Energy Forward and REC Price Curves

Three sources of data are used to generate the energy price forecast that would be the basis for energy values for the study. The three sources are forward energy “broker” quotations provided by Tullet Liberty (Tullet)[1], natural gas futures and natural gas futures basis as reported by the New York Mercantile Exchange (NYMEX), and

1 Tullet is, among other things, an energy brokerage company that matches buyers and sellers.

forecasted spot electricity and natural gas prices as provided by Ventyx semi-annual structural forecast (formerly Global Energy Decisions [GED]).[2]

The derived natural gas price curve is made up of Henry Hub (HH) futures prices, adjusted for a specific local hub through using basis prices (for HH to Southern California (SoCal), or HH to the Pacific, Gas and Electric Company [PG&E] Citygate, in this case). Basis prices represent the mark-up or discount in natural gas prices (due to transmission fees, congestion, etc.) at a specific hub, relative to prices at HH. For HH futures, prices are obtained from the NYMEX website, and are current market closing prices for the date when the forward curve is being generated. There are 12 to 13 years of HH futures prices that are available through the NYMEX. These prices are extrapolated to cover the 25-year period that matches the Ventyx structural forecast period. The extrapolation is done through computing the growth/escalation rate of the last 4 years of the current market price quotations, and using the computed growth/escalation rate to extend the last year's available market prices.

For basis prices, there are two data sources: one is market basis prices, the other, a structural forecast of basis prices provided by Ventyx. Ventyx provides monthly basis prices for 25 years to match its structural forecast period, reflecting potential changes in the energy market and their impacts on a specific local hub prices (relative to HH prices). Market basis are available from the NYMEX website, with basis prices available for three to five years (depending on the hub location, whether it is SoCal or PG&E Citygate). The basis price forward curve is extrapolated to generate prices for a 25-year period by taking the last year's monthly quoted basis prices and repeating those prices for every month out to 25 years.

For SWP natural gas price forecast process, the average of the extended market basis and the structural basis (from Ventyx) is then taken and added to the Henry Hub extrapolated forward curve. The resulting natural gas forward curves for either SoCal or PG&E Citygate hubs will be used in the study, where appropriate. Figure H.3-2 shows the resulting natural gas forward curve for PG&E Citygate, which is used for the NODOS Power Planning Study.

[2] Ventyx is forecasting the actual day-ahead cash price that will occur in the sport markets in the future, not the price at which futures or forward contracts should be priced.

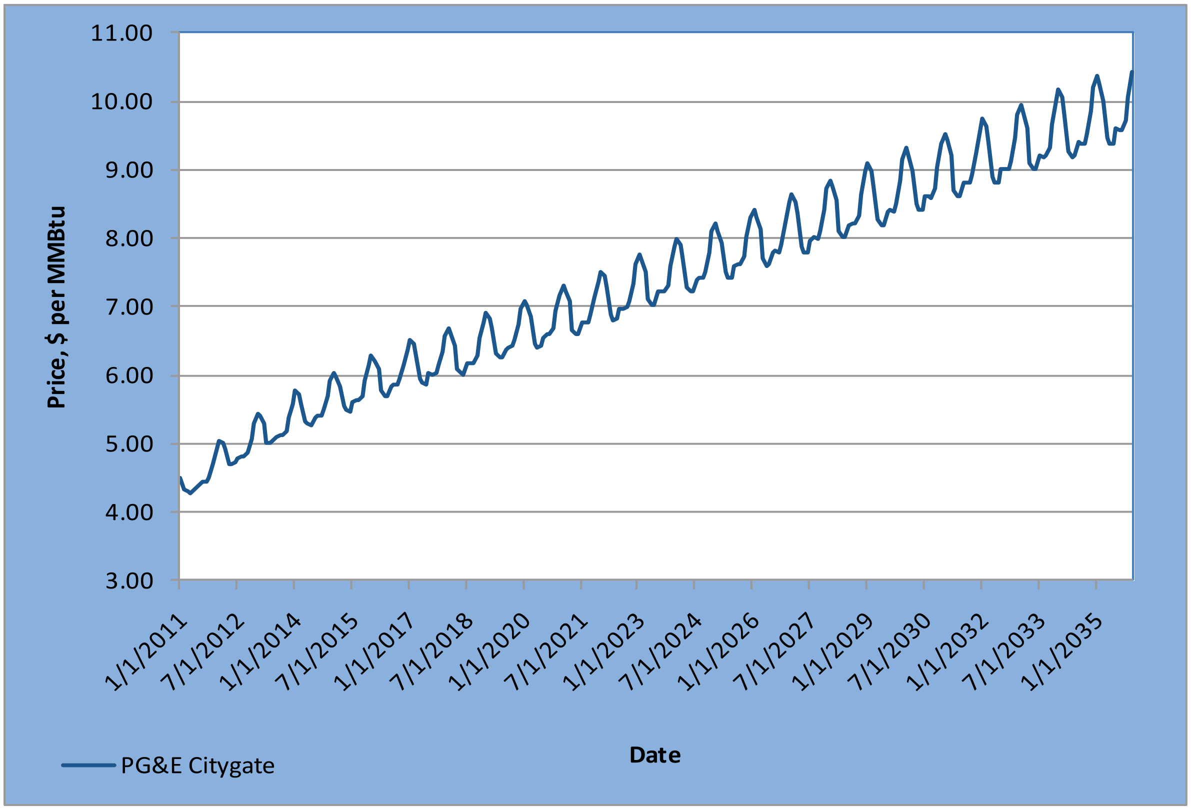


Figure H.3-2. Natural Gas Price Forecast, Forward Curve for 2011 through 2040

For the power price forecast, the derived power forward price curve is comprised of two segments: market forwards, and synthetic forwards. The first segment uses the most current Tullet energy forwards quotations, for NP-15 and SP-15 market's different products (on-peak, off-peak). This segment runs anywhere between 12 to 24 months (data availability is dependent on time of year that the power forecast is generated).

The second segment of the price curve is the "synthetic" portion. The synthetic segment continues where the first segment stops, to complete the 25-year period to match the natural gas forecast period. There are two approaches that are being used to derive the synthetic portion of the forward curve. One approach is to calculate power prices using the natural gas forecasted prices (as described above) multiplied by historical implied heat rates.[3] The other approach is to multiply the forecasted natural gas prices by a forecasted heat rate, reported as part of the structural forecast, by Ventyx. The average of those two generated power forward price curves yields the resulting synthetic forward curve that make up the second segment of the power price forward curve. The same process is repeated for each of the CAISO markets and its specific products (on-peak and off-peak), with the appropriate underlying fuel

[3] Historical implied heat rates were calculated from 2004 - 2008 historical price data (five years). Daily prices were averaged into monthly prices. The heat rate is calculated as the respective period's power price divided by the respective period's gas price.

markets. The resulting power forward curve for NP-15 is shown in Figure H.3-3, and is used for the NODOS Power Planning Study.

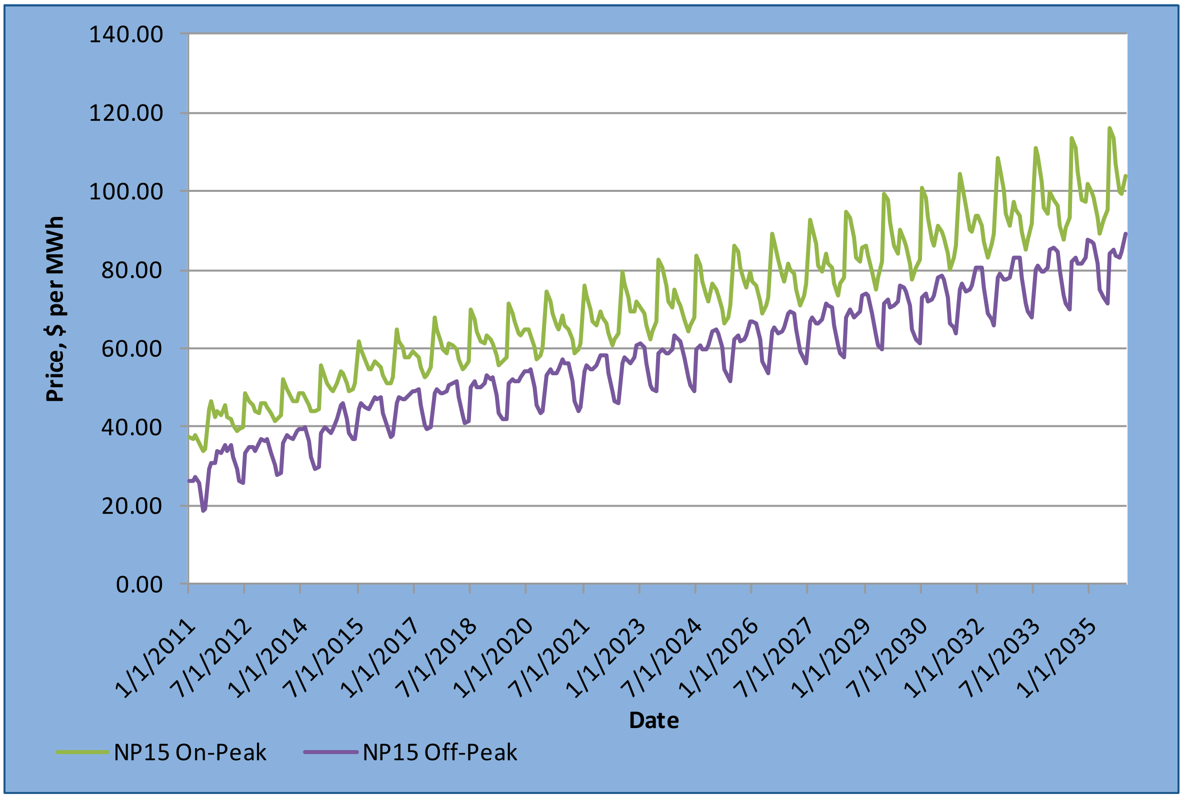


Figure H.3-3. Power Price Forecast, Forward Curve for 2010 through 2039

For the Sacramento River (Alternatives A and C) and TRR generating plants future planned capacity (less than 30 megawatts [MW]) qualify both plants to meet the RPS certification requirements, and allow both plants to participate in the Renewable Energy Credit market (REC), a product of the RPS and the Assemble Bill (AB) 32 greenhouse gas (GHG) mandates. For the purpose of this study, power generation for these two plants was valued based on the forecasted energy prices for the CAISO markets that the plants would participate in or have indirect exposure to (NP-15 market for power and PG&E Citygate market for natural gas), and the additional value that would be realized from the RECs that the two plants will produce. Hence, the power price forecast was adjusted to reflect the forecasted value of the RECs in Western Electricity Coordinating Council (WECC) region as reported by Ventyx Spring 2011 forecast. The reported REC values are used to generate a power curve adjusted to reflect the total value of a megawatt hour (MWh) (energy+REC) generated at the TRR and Sacramento River generating plants. Figure H.3-4 shows the REC values as reported in the Ventyx Spring 2011 forecast, and compared to the forecasted values from two previous Ventyx forecasts.

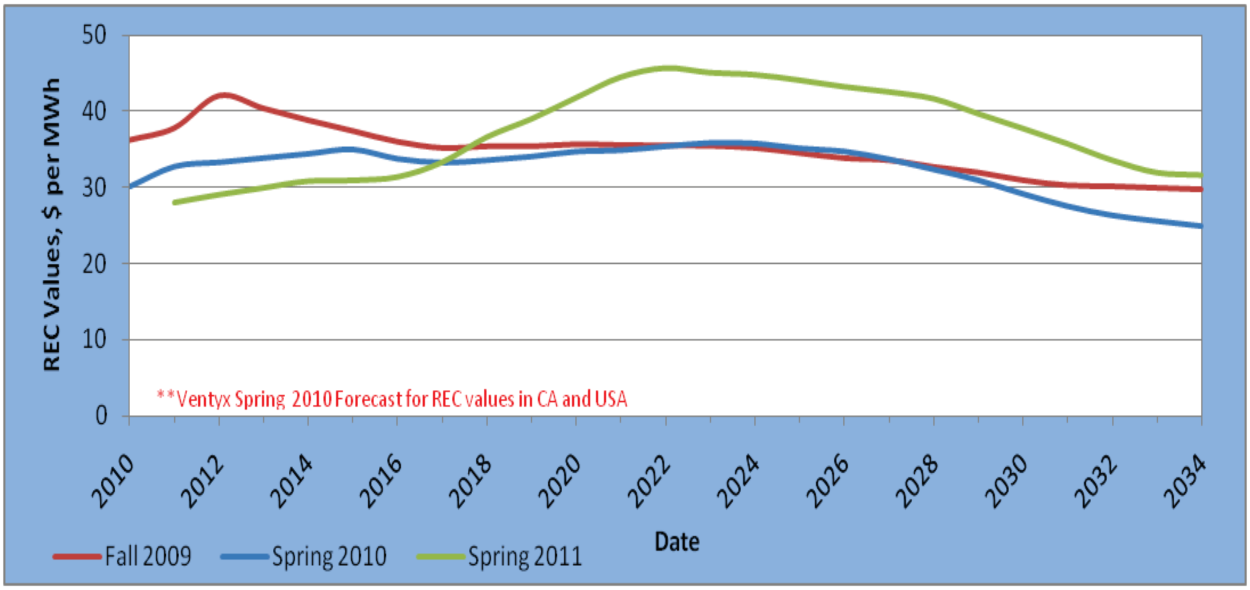


Figure H.3-4. Renewable Energy Credit Forecast for the WECC Region for 2011 through 2034

This page intentionally left blank

4.0 NODOS PROJECT FORMULATION, ALTERNATIVES, AND OPERATIONS

4.1 NODOS Project Alternatives

This section is a synopsis describing the NODOS development process, and is extracted from the main report titled *Definition of Proposed Alternatives for Evaluation in the North-of-the-Delta Offstream Storage Administrative Draft Environmental Impact Report and Statement*. More details on the evolution of NODOS are discussed in the aforementioned report.

Pursuant to National Environmental Policy Act [NEPA] and California Environmental Quality Act (CEQA), a Notice of Intent and Notice of Preparation were filed and published in November 2001 by Reclamation and DWR respectively, to investigate surface storage opportunities north of the Delta. The purpose of including a reasonable range of alternatives in the environmental impact report (EIR) and or environmental impact statement (EIS) is to offer a clear basis for choice by the decision makers and the public as to whether to proceed with a proposed action or project. NEPA and CEQA require that EIS and EIRs consider a reasonable range of feasible alternatives that could meet the project objectives and accomplish the project purpose and need while avoiding or minimizing environmental impacts. NEPA and CEQA also require that a No Project (NEPA) and No Project (CEQA) Alternative be analyzed. NEPA and CEQA requirements are discussed in greater detail in Chapter 1 of the NODOS EIR/EIS.

Three different configurations for NODOS were combined with the anadromous fish measures and new hydropower facilities to develop the action alternatives summarized in Table H.4-1 (Table 2-8). The alternatives include a No Project Alternative plan and three Action Alternative plans. It was anticipated that these alternative plans and the No Project Alternative would provide a reasonable range of alternatives for further refinement and detailed analysis in the Feasibility Report and EIS/EIR, to meet the requirements of NEPA, CEQA, other pertinent federal, state, and local laws, regulations, and policies; and the Principles and Guidelines (P&Gs) presented in the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council [WRC],1983).

The following sections provide further details on the components of the alternatives:

- No Project Alternative—The No Project Alternative assumes that no actions would be taken to provide storage north-of-the-Delta to improve water supply reliability, to enhance the survivability of anadromous fish or drinking water quality in the Delta, or to improve flexible generation.

- Alternative A: 1.27 MAF Sites Reservoir with Delevan Pipeline – Alternative A includes a 1.27 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing T-C and GCID canals and a new Delevan Pipeline (2,000-cfs diversion/1,500-cfs release). This alternative also includes new hydropower facilities and a program to address the three anadromous fish measures.

- Alternative B: 1.81 MAF Sites Reservoir with Release-only Delevan Pipeline – Alternative B includes a 1.81 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing T-C and GCID canals, and a new release-only Delevan Pipeline (1,500-cfs release). This alternative also includes new hydropower facilities and a program to address the three anadromous fish measures.

- Alternative C: 1.81 MAF Sites Reservoir with Delevan Pipeline – Alternative C includes a 1.81 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing T-C and GCID canals and a new Delevan Pipeline (2,000-cfs diversion/1,500-cfs release). This alternative also includes new hydropower facilities and a program to address the three anadromous fish measures.

Table H.4-1. NODOS Project Action Alternatives, Priorities, and Objectives

Alternative	A	B	C
Storage Capacity			
Sites Reservoir	1.27 MAF	1.81 MAF	1.81 MAF
Conveyance Capacities *(to Sites Reservoir)*[1]			
Tehama-Colusa Canal	2,100 cfs	2,100 cfs	2,100 cfs
Glenn Colusa Irrigation District Canal	1,800 cfs	1,800 cfs	1,800 cfs
New Delevan Pipeline[2] Diversion Release	 2,000 cfs 1,500 cfs	 0 cfs[3] 1,500 cfs	 2,000 cfs 1,500 cfs
Operations Priorities *(Primary Planning Objectives)*			
Long Term *(all years)*	EESA[4] Power[5]	EESA[4] Power[5]	EESA[4] Power[5]
Driest Periods *(drought years)*	M&I	M&I	M&I
Average to Wet Periods *(non-drought years)*	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural
Nonoperational Actions			
Ecosystem Enhancement Fund	✔	✔	✔
Physical Features			
Golden Gate and Sites Dams	✔	✔	✔
Number of Saddle Dams	6	9	9
Recreation Areas	Up to 5	Up to 5	Up to 5
Road Relocations and South Bridge	✔	✔	✔
Sites PG Plant Capacities	5,900-cfs pumping capacity 5,100-cfs generating capacity	3,900-cfs pumping capacity 5,100-cfs generating capacity	5,900-cfs pumping capacity 5,100-cfs generating capacity
Sites Electrical Swtichyard	✔	✔	✔
Tunnel from Sites PG Plant to Sites Inlet/Outlet Structure	✔	✔	✔
Sites Reservoir Inlet/Outlet Structure	✔	✔	✔
Field Office Maintenance Yard	✔	✔	✔
Holthouse Reservoir Complex	✔	✔	✔
Pump Installation at the Red Bluff Pumping Plant	✔	✔	✔
GCID Canal Facilities Modifications	✔	✔	✔
GCID Connection to the TRR	✔	✔	✔

Table H.4-1 (Continued)

TRR	✔	✔	✔
TRR PG Plant	✔	✔	✔
TRR Pipeline	✔	✔	✔
Delevan Transmission Line	Sites Power Plant to PG&E line plus PG&E line to Sacramento River	Sites Power Plant to PG&E line	Sites Power Plant to PG&E line plus PG&E line to Sacramento River
Delevan Pipeline	✔	✔	✔
Delevan Pipeline Intake Facilities (Fish Screen and PG Plant)	2,000-cfs diversion capacity; 1,500-cfs release capacity		2,000-cfs diversion capacity; 1,500-cfs release capacity
Delevan Pipeline Discharge Facility		1,500-cfs release capacity	

Notes:

1. Diversions through the TC Canal, GCID Canal, and Delevan Pipeline are allowed in any month of the year; however, November through March is generally the season that Sites Reservoir will be filled.
2. New Delevan Pipeline can be operated June through March (April and May are reserved for maintenance).
3. A pump station, intake, and fish screens are not included for the Delevan Pipeline for Alternative B. For Alternative B, the Delevan Pipeline will be operated for releases only from Sites Reservoir to the Sacramento River year round.
4. Ecosystem Enhancement Storage Account (EESA) related operations are a function of specific conditions, and operating criteria that are defined uniquely for each action.
5. Includes dedicated pump/generation facilities with an additional dedicated after-bay/fore-bay of 6.5 TAF in Holthouse Reservoir (enlarged Funks Reservoir) used for managing conveyance of water between Sites Reservoir and river diversion locations.

Key:

cfs = cubic feet per second
CVP = Central Valley Project
EESA = ecosystem enhancement storage account
MAF = million acre-feet
M&I = municipal and industrial
SWP = State Water Project
TAF = thousand acre-feet

Figure H.4-1 illustrates the major features of the various action alternatives.

4.2 NODOS Project Operations – Water Operations

For evaluation of NODOS action alternatives, the project team used a generally consistent operations strategy for each alternative. The operations strategy is reflected in the operations simulation modeling that is the primary planning tool to determine many of the project benefits and impacts. The ability of each action alternative to implement the strategy effectively is subject to the conveyance options included and the coordinated operation of Sites Reservoir with other existing facilities.

The strategy has four components: (1) operating criteria for diversion of flows from the Sacramento River to fill Sites Reservoir; (2) operating criteria to achieve benefits associated with the primary objectives in drought (driest periods) and other hydrologic conditions; (3) integration and (4) coordination of Sites Reservoir releases with releases from Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake.

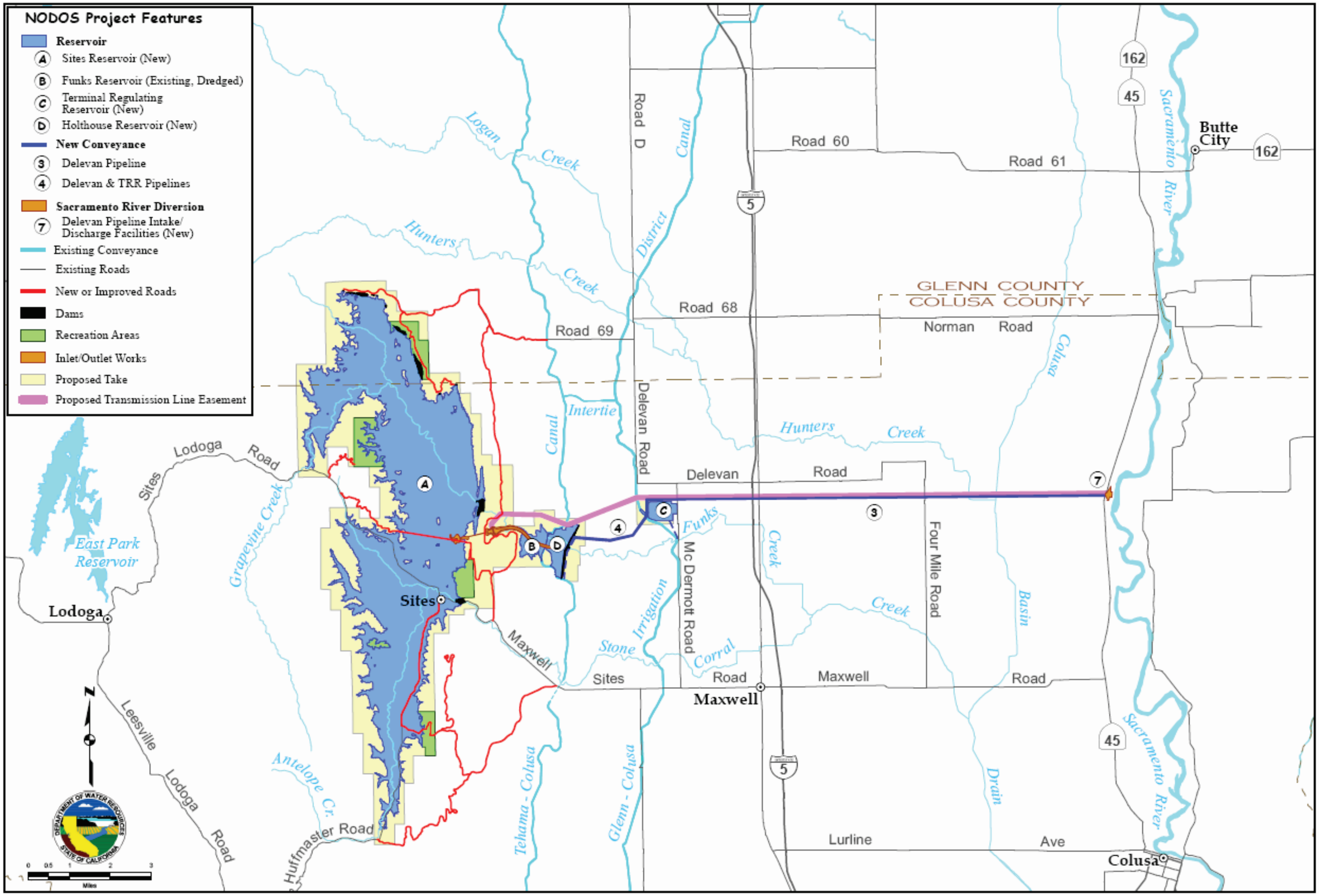


Figure H.4-1. Major Features of the Actions Alternatives

Each action alternative would be operated to divert Sacramento River flows to maximize the filling of Sites Reservoir as long as those flows were not needed to meet (1) existing Central Valley Project (CVP) and State Water Project (SWP) and other water rights diversions; (2) existing regulatory requirements including State Water Resources Control Board (SWRCB) D-1641, Central Valley Project Improvement Act (CVPIA) 3406(b)(2), 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) and 2009 National Marine Fisheries Service (NMFS) BiOp and other instream flow requirements; and (3) flow conditions to minimize the impact of diversion operations on achieving the primary objectives for anadromous fish survival and Delta water quality. A schedule of flow criteria for Sacramento River flows at Red Bluff, Hamilton City, Wilkens Slough, and Freeport are used to limit the impact of diversion operations. An additional set of criteria are used to identify and restrict diversions during potential pulse flow conditions to protect out-migrating anadromous fish.

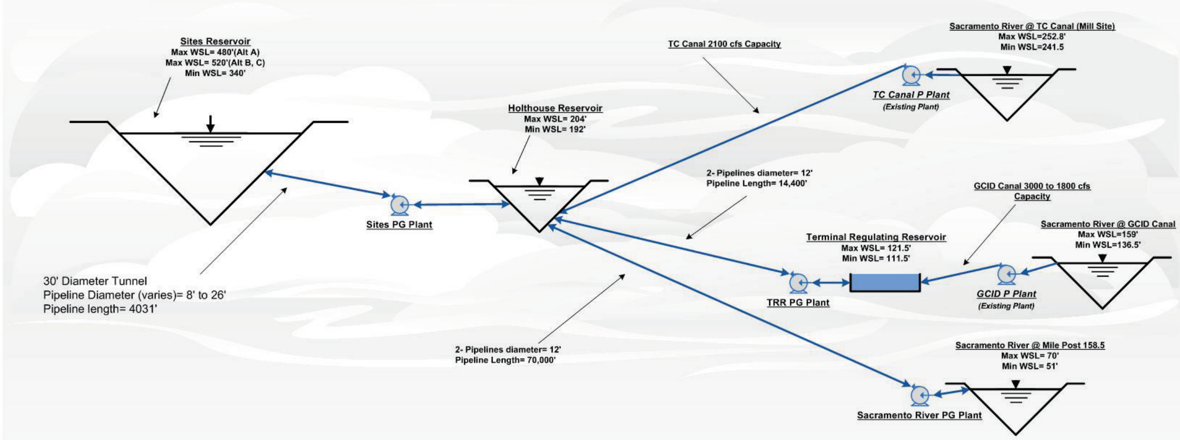
Each action alternative would be operated to achieve benefits associated with the primary objectives in drought (driest periods) and other hydrologic conditions. For purposes of Sites Reservoir operation, drought (driest periods) hydrologic conditions are identified as the sequence of years in which the Sacramento River 40-30-30 year type classification (SWRCB D-1641) in two consecutive years is Critical following Critical, Dry or Above Normal, or Dry following Critical or Dry, or Above Normal following Critical year types. In drought (driest periods) hydrologic conditions, the priority operation is coldwater pool conservation in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake and regulation of summer flows for best use of cold water for control of temperature conditions adverse to anadromous fish and increasing Delta export and SWP project allocations to improve water supply reliability to South-of-the-Delta municipal and industrial (M&I) water users. During these times, Sites Reservoir stored water is released into the system as rapidly as possible to meet these needs.

In other hydrologic conditions (non-drought), approximately one-third of Sites Reservoir stored water is used each summer and fall to manage Delta water quality to improve Delta water quality at M&I intakes, to improve flows for Delta fisheries habitat based on X2 position, and to stabilize fall flows for improving spawning and rearing success of anadromous fish. Water quality for M&I users is improved both by improving Delta water quality at M&I intakes in non-drought conditions as well as increasing Delta exports in drought conditions (Total dissolved solid [TDS] levels in exports from the Delta are often lower than other supplies such as from the Colorado River; therefore, there is a blending improvement by increased flows from the Delta).

Each action alternative would be operated to integrate and coordinate the releases from Sites Reservoir with releases from Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Often, and especially in drought (driest periods) hydrologic conditions, releasing from Sites Reservoir allows releases from other reservoirs to be reduced while still meeting requirements for minimum instream flow objectives and Delta salinity control objectives. Through this reduction in releases, storage can be conserved in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake, providing greater flexibility for management of releases. This improvement in storage conditions throughout the system of reservoirs adds significantly to the operational flexibility to meet the primary objectives in the most effective way possible.

4.3 NODOS Project Operations – Power Operations

The NODOS Project team supplied PARO with the physical and operational attributes of the project components which are the basis for this study. The schematic drawing in Figure H.4-2shows the different NODOS Project components and the relative location and interconnection of the different components to each other and to the Sacramento River.



Plant Mode	Pumping Mode					Generation Mode		
Plant Name	TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Planned Capacity, MW	6	3.39	19.68	65.65	181.35	123	9.8	10.8
Planned Capacity, cfs	2250	3000	1890	2000	5900	5100	1500	1500

*** Note: Under Alt B, the Sacramento River will have no diversion pumps and only release facilities (No Pumping or Generation facilities)

Figure H.4-2. NODOS Project, Schematic of Conveyance and Storage Interconnection

For NODOS operations and for the purpose of this study, the base assumptions and scenarios used in developing the CALSIM II model are maintained for the different project components. The CALSIM II model was used to simulate the operations of NODOS, as a component of the integrated CVP and SWP operations. More details on the CALSIM II model formulation are available in Appendix 6A and 6B of the NODOS EIR/EIS Appendix. The CALSIM II model is a tool that was setup to emulate the operations strategy set forth for the project, and to help determine many of the project benefits and impacts.

For the purpose of modeling the power operations of NODOS, three modes for project operations are identified: Diversion mode (pumping from the Sacramento River to fill up Sites Reservoir); Release mode (generation incidental to water releases from Sites Reservoir to meet NODOS water release objectives); and a Pumpback mode (to better utilize residual capacities of the different project components). NODOS pumpback operations are meant to enhance the project economics by capturing opportunities offered by the energy market (energy price differentials between on-peak and off-peak hours, and ancillary services [AS]), and to provide the support/products needed to integrate renewable energy (wind, solar, etc.).

In modeling the power needs for the diversion mode, an optimization strategy is developed to minimize the energy costs of pumping operations, yet, maintain NODOS water operations objectives. Hence, flat monthly pumping operations are maintained (where/when applicable, 24 hours a day, 7 days a week), for all three diversion points along the Sacramento River. Once water is diverted from the Sacramento River into Holthouse Reservoir, the rest of the diversion operations (i.e., pumping into Sites Reservoir) could be optimized to better utilize Sites pumping plant capacity, and the available storage in Holthouse Reservoir. It would be more economical to retain the on-peak diversions from the Sacramento River in Holthouse Reservoir (as scheduled) and to pump that water into Sites Reservoir in the off-peak hours (on a daily basis). The intent of reshaping the diversion mode is to avoid high on-peak (and super peak) electricity prices. Therefore, all pumping operations into Sites Reservoir are optimized to occur (if possible) during the off-peak hours (including shoulder hours immediately before the transitions to on-peak occurs). Moreover, this shift in operations will provide an opportunity to superimpose pumpback operations cycle on the NODOS diversion mode. In an optimized mode and in the on-peak (or super peak) hours, Sites Pumping/Generating Plant will be available for generation. In the off-peak hours, the residual pumping capacity will be available to pump the water back into Sites Reservoir.

For the water Release mode (Generation mode) of NODOS, an optimization strategy is developed to maximize generation revenues from the project's generation assets. For this strategy and to the extent physically possible, all intended daily water releases from Sites Reservoir into Holthouse Reservoir will occur during the on-peak (or super peak) hours to capture the most value the energy market offers for NODOS generation. Incidental to the on-peak releases from Sites Reservoir into Holthouse Reservoir, water will be released into the TRR, T-C Canal, and the Sacramento River up to the capacities of these facilities (and within the planned limits for the water release). The residual water in Holthouse Reservoir (from the On-Peak Sites Reservoir releases) would be released during the Off-Peak hours to satisfy water delivery obligations of NODOS. A key requirement for this strategy to be effective is that Holthouse Reservoir active storage would be made available before the beginning of the next On-Peak cycle (i.e. next day's cycle). Optimizing the Release (generation) mode will better utilize Sites Reservoir generation capacity (maximize revenues), and provide an opportunity to superimpose a Pumpback mode on the Release mode.

A third component of NODOS power operations is a daily pumpback operations cycle. For periods when NODOS is in neither Diversion nor in Release modes, Sites Reservoir pumping and generation assets can operate in a pure Pumpback mode to take advantage of energy price differentials between the on-peak and off-peak hours, and AS market needs. Under a pure Pumpback mode, water would be released from Sites Reservoir into Holthouse Reservoir during the on-peak (or super peak) hours to generate energy and would be pumped back into Sites Reservoir in the off-peak hours to complete the pumpback cycle. The pumpback operations could be a standalone operation and/or superimposed on the Diversion and Release modes when the energy market economics relative to the Sites Reservoir Plant's efficiency (cycle efficiency) are conducive to do that. At Sites Reservoir, the extent of the pure pumpback operations and pumpback operations incidental to NODOS Diversion and Release modes are driven by market economics, pumping/generating cycle efficiency, residual pumping capacity, residual generation capacity, and residual storage capacity in Holthouse Reservoir.

5.0 POWER PORTFOLIO MODEL

Current power portfolio models available to PARO are used to execute the analysis for NODOS. The operations of NODOS' different assets are translated to a representative set of financial instruments and are input into the EPM model. The model is used to monetize the probabilistic value of NODOS power portfolio for each of the action alternatives and operational scenarios used in the study. EPRI Fast Fit model, version 2.5, is used to describe the needed power and fuel price volatilities term structures, and the correlations between the different energy markets NODOS will be participating in, or exposed to.

Using the most current CALSIM II model runs, a median case (seasonal cycle) operational time-series is defined for each of the three action alternatives considered for the project. The median case time-series (sequential) period matches the 30-year planning period for the project. The time-series is derived from the 82-year time-series from the most current CALSIM II runs. The total water diversions (in AF) from the Sacramento River into Sites Reservoir is used as a criteria for isolating the 30-year time-series that represents the median case project's operations, for each of the three action alternatives considered for the project. Moving averages and frequency analysis are used to reduce the 82-year record to 53 potential scenarios for the operations of the project. Then, the 53 scenarios are ranked, and the median of these scenarios is identified with the corresponding 30-year time-series that generated its value. The underlying 30-year time-series for all project's components is also identified and grouped, to represent NODOS operations.

Time-series representing NODOS water diversions and releases are translated into pumping and generation capacities and Energy (MW and MWh) for each of the project components, using the appropriate design parameters and the physical attributes of the system. Figures H.5-1 through Figure H5-7 show the median case time-series, for the 30-year planning period, for the Optimized operations of each NODOS component, in terms of utilized capacity in MW (which is the input to the EPM model), for Alternative C.

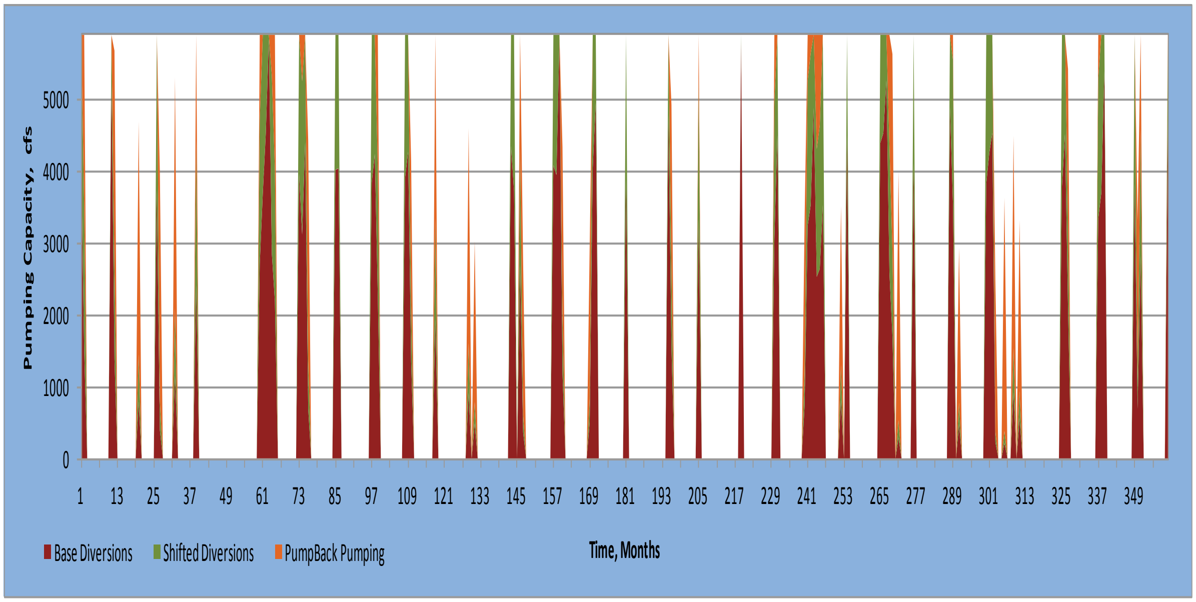


Figure H.5-1. NODOS Project, Sites Reservoir Operations - Diversion Mode, Alternative C

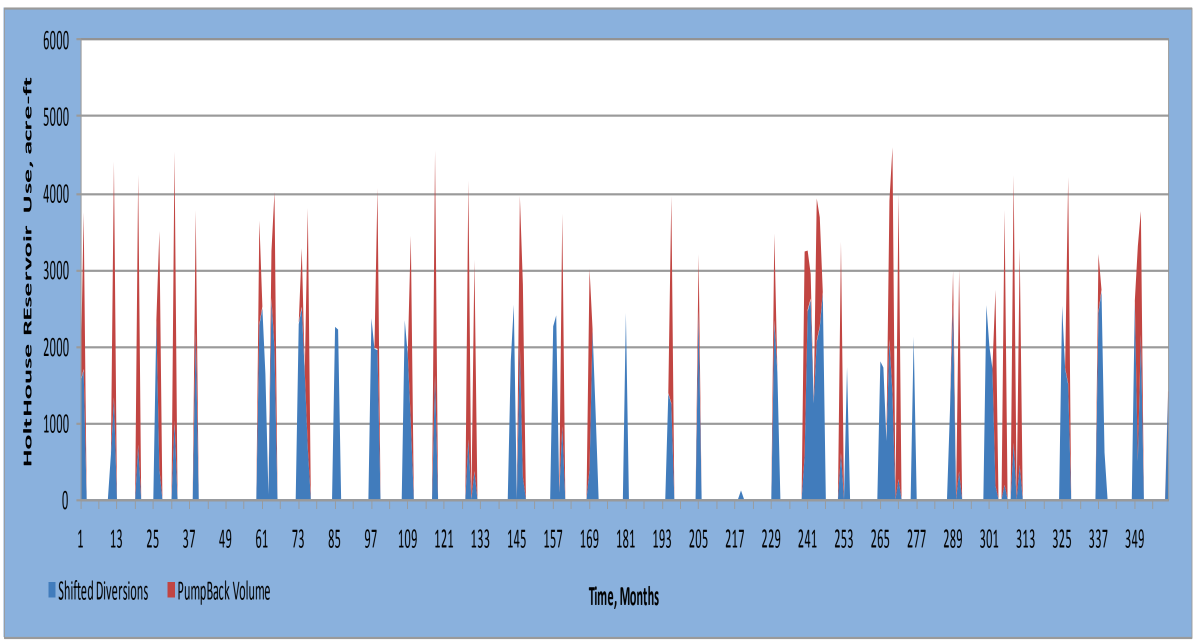


Figure H.5-2. NODOS Project, Holthouse Reservoir Operations - Diversion Mode, Alternative C

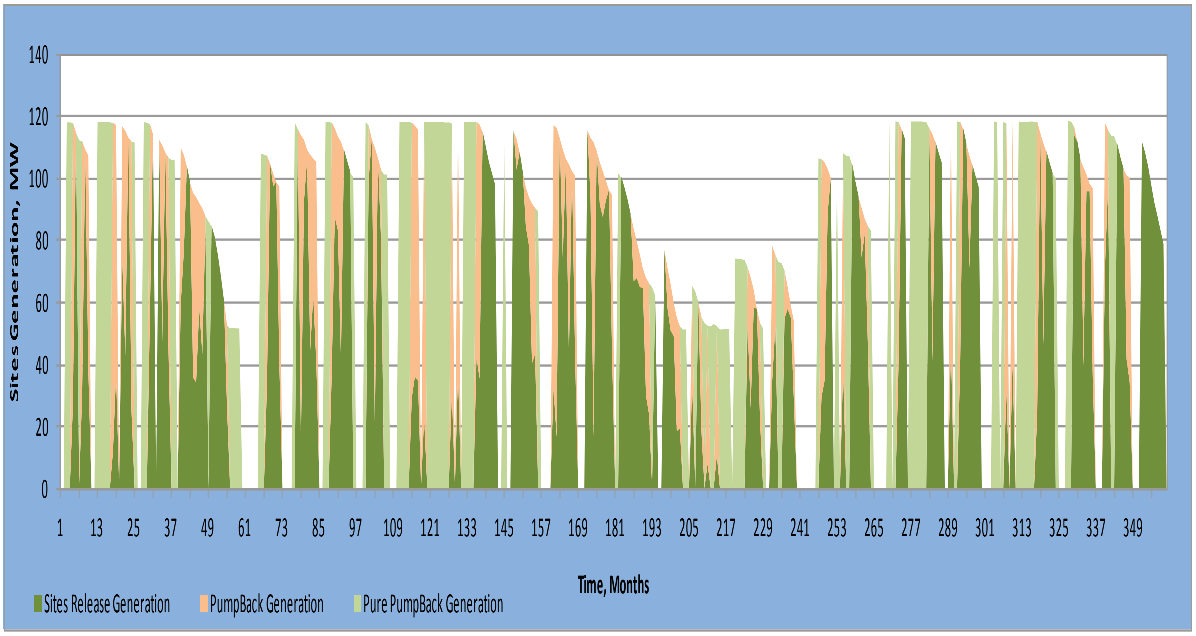


Figure H.5-3. NODOS Project, Sites Reservoir Operations - Release and Pumpback Modes, Alternative C

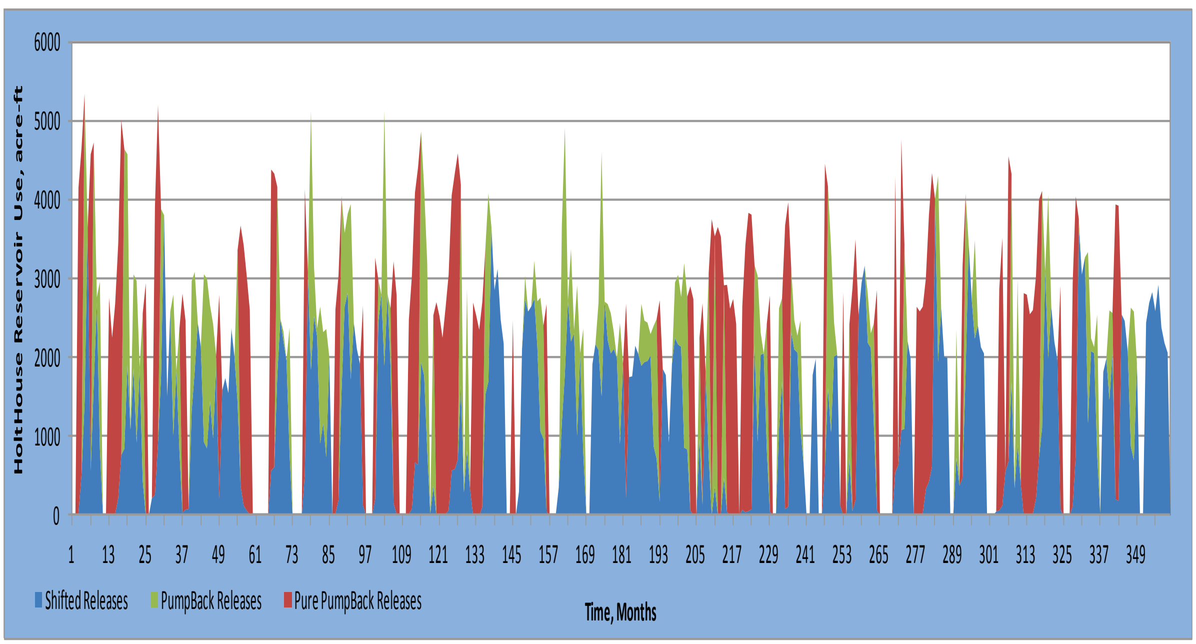


Figure H.5-4. NODOS Project, Holthouse Reservoir Operations - Diversion Mode, Alternative C

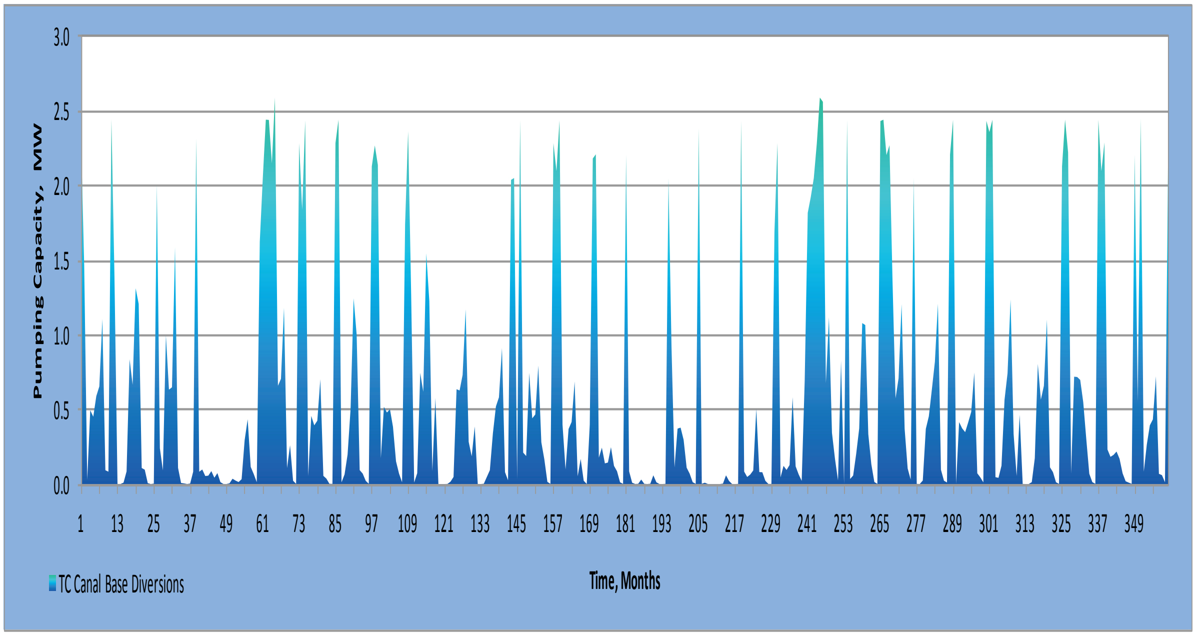


Figure H.5-5. NODOS Project, T-C Canal Pumping Plant Operations, Alternative C

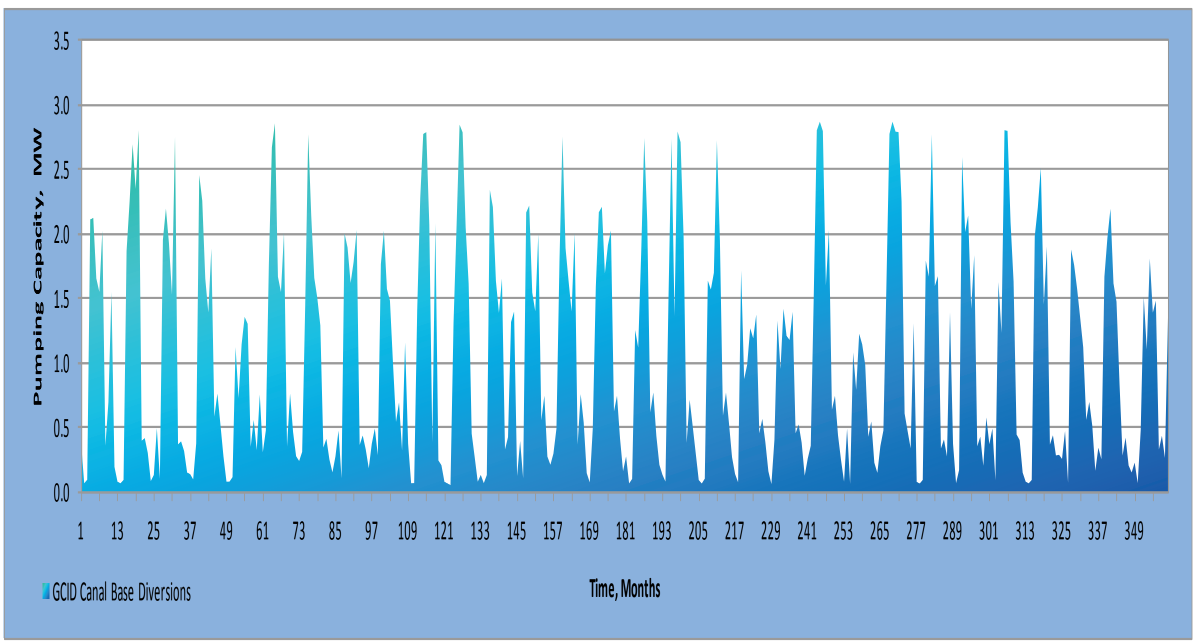


Figure H.5-6. NODOS Project, GCID Canal Pumping Plant Operations, Alternative C

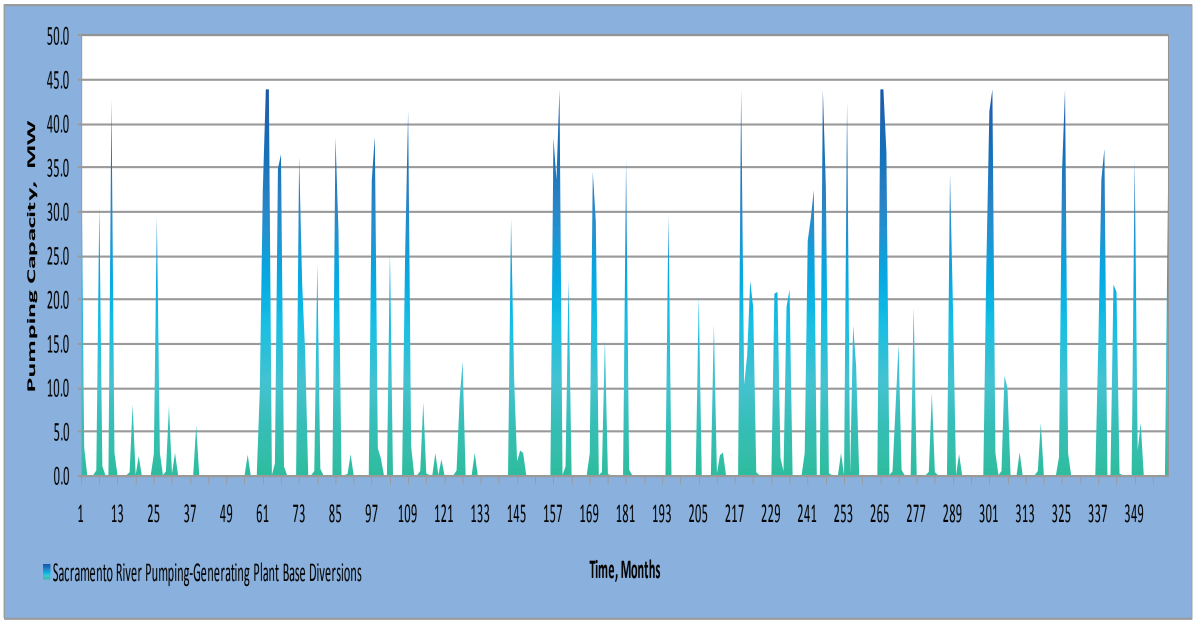


Figure H.5-7. NODOS Project, Sacramento River Pumping Plant Operations, Alternative C

Tables H.5-1 through H.5-4 summarize of the monthly, 30-year planning period pumping and generation capacities used to model the median case of NODOS operations (See Appendix C for complete version of Tables H.5-1 through H.5-4) for Alternative C. Two operational scenarios are used to model each of the three action alternatives considered for the project: Incidental and Optimized. For the Incidental scenario, pumping and generating at the different NODOS facilities are driven by water diversions and releases. For the Optimized scenario, pumping and generating at the Sites Reservoir Pumping/Generating Plant are optimized to minimize pumping costs obligations and maximize energy generation revenues for the project. The modeling results are presented for both the Incidental and the Optimized operational scenarios to report the energy portfolio value and describe the gain (monetary value) from optimizing NODOS operations. The information in the aforementioned tables is the input data needed to run the EPM model. Different financial instruments were used in the EPM model to represent the power portfolio and to estimate the value of energy and risk associated with the operations of the project.

Table H.5-1. NODOS Project Pumping and Generation Time Series, Incidental, Alternative C

		Incidental Pumping and Generation to Water Releases (no shaping)							
Plant Mode		Incidental Pumping , MW					Incidental Generation, MW		
Plant Name		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Installed Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Installed Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
1	744	2.28	0.37	2.73	39.11	118.75	0.00	0.00	0.00
2	672	1.46	0.06	0.00	3.13	44.87	0.00	0.00	0.00
3	744	0.03	0.09	0.00	0.00	0.11	0.05	0.00	0.00
4	720	0.49	2.11	0.00	0.00	0.63	0.37	0.00	0.00
5	744	0.45	2.12	0.00	0.00	0.00	2.52	0.40	0.40
6	720	0.59	1.66	0.00	0.53	0.00	36.39	7.38	6.41
7	744	0.65	1.55	0.00	30.75	0.18	60.89	7.30	0.00
8	744	1.10	2.03	0.00	1.01	0.00	12.45	0.60	4.96
9	720	0.09	0.35	0.00	0.00	0.00	23.79	1.52	9.10
10	744	0.08	0.69	0.00	0.00	0.00	12.94	0.16	5.11
11	720	2.44	1.55	12.30	42.85	151.73	9.86	0.00	0.00
12	744	1.39	0.19	0.00	2.52	41.50	0.02	0.00	0.00
13	744	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
14	672	0.00	0.06	0.00	0.00	0.00	9.91	0.00	0.00
15	744	0.01	0.09	0.00	0.00	0.09	2.12	0.00	0.00
16	720	0.08	1.87	0.00	0.00	0.81	26.21	0.00	0.00
17	744	0.83	2.25	0.32	0.33	1.53	1.43	0.05	0.00
18	720	0.66	2.70	0.00	8.05	0.00	0.71	1.26	0.07
19	744	1.31	2.35	0.00	0.00	0.00	3.19	1.21	3.96
20	744	1.20	2.81	6.01	2.17	23.49	49.02	0.00	0.31

CALSIM II Model Results = Monthly Pumping- Generating Operations 82-yr
Power Planning Study Results= Incidental and Optimized Operations, 30-yr Median Case Deliveries

Table H.5-2. NODOS Project Pumping and Generation T-Series, Optimized Pumping, Alternative C

Plant Mode		Optimized Pumping					
Plant Name		Sites					
Installed Capacity, MW		181.35					
Installed Capacity, cfs		MaxQ=5900 cfs					
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
1	744	79.00	32924	169.89	55732	2305	5900
2	672	0.00	0	104.73	30207	0	5900
3	744	0.00	0	0.00	0	0	0
4	720	0.00	0	0.00	0	0	0
5	744	0.00	0	0.00	0	0	0
6	720	0.00	0	0.00	0	0	0
7	744	0.00	0	0.00	0	0	0
8	744	0.00	0	0.00	0	0	0
9	720	0.00	0	0.00	0	0	0
10	744	0.00	0	0.00	0	0	0
11	720	110.00	45589	168.00	63794	3336	5900
12	744	0.00	0	80.24	30910	0	5680
13	744	0.00	0	0.00	0	0	0
14	672	0.00	0	0.00	0	0	0
15	744	0.00	0	0.00	0	0	0
16	720	0.00	0	0.00	0	0	0
17	744	0.00	0	0.00	0	0	0
18	720	0.00	0	0.00	0	0	0
19	744	0.00	0	0.00	0	0	0
20	744	0.00	0	42.96	17481	0	4695

CALSIM II Model Results = Monthly Pumping- Generating Operations 82-yr
Power Planning Study Results= Incidental and Optimized Operations, 30-yr Median Case Deliveries

Table H.5-3. NODOS Project Pumping and Generation T-Series, Optimized Generation, Alternative C

Plant Mode		Optimized Genration, MW				
Plant Name		Sites				
Installed Capacity, MW		123.00				
Installed Capacity, cfs		MaxQ=5100 cfs				
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	On-Peak, cfs	Off-Peak, cfs
1	744	0.00	0	0.00	0	0
2	672	0.00	0	0.00	0	0
3	744	0.00	0	0.00	0	0
4	720	0.00	0	0.00	0	0
5	744	26.47	9818	0.00	1141	0
6	720	114.95	39777	0.00	5100	0
7	744	0.00	0	0.00	0	0
8	744	30.10	9261	0.00	1366	0
9	720	107.43	28368	0.00	5009	0
10	744	37.38	8916	0.00	1771	0
11	720	0.00	0	0.00	0	0
12	744	0.00	0	0.00	0	0
13	744	0.00	0	0.00	0	0
14	672	0.00	0	0.00	0	0
15	744	0.00	0	0.00	0	0
16	720	0.00	0	0.00	0	0
17	744	0.00	0	0.00	0	0
18	720	11.70	3508	0.00	503	0
19	744	36.38	10349	0.00	1579	0
20	744	0.00	0	0.00	0	0

CALSIM II Model Results = Monthly Pumping- Generating Operations 82-yr
Power Planning Study Results= Incidental and Optimized Operations, 30-yr Median Case Deliveries

Table H.5-4. NODOS Project Pumping and Generation T-Series, Pumpback Operations, Alternative C

Plant Mode		Pump Back Operations, MW								
Plant Name		With Pump cycle			With Gen Cycle			Pure Pump Back		
Installed Capacity, MW		123.00			123.00			123.00		
Installed Capacity, cfs		MaxQ=5100 cfs			MaxQ=5100 cfs			MaxQ=5100 cfs		
Month	# of Hours	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs
1	744	0.00	0	0	0.00	0	0	0.00	0	0
2	672	51.61	16049	2226	0.00	0	0	0.00	0	0
3	744	0.00	0	0	0.00	0	0	118.32	35905	5100
4	720	0.00	0	0	0.00	0	0	118.34	34870	5100
5	744	0.00	0	0	91.65	33991	3959	0.00	0	0
6	720	0.00	0	0	0.00	0	0	0.00	0	0
7	744	0.00	0	0	0.00	0	0	112.55	33216	5100
8	744	0.00	0	0	82.05	25251	3734	0.00	0	0
9	720	0.00	0	0	1.96	518	91	0.00	0	0
10	744	0.00	0	0	70.16	16733	3329	0.00	0	0
11	720	0.00	0	0	0.00	0	0	0.00	0	0
12	744	117.71	26633	5100	0.00	0	0	0.00	0	0
13	744	0.00	0	0	0.00	0	0	118.39	24019	5100
14	672	0.00	0	0	0.00	0	0	118.39	17722	5100
15	744	0.00	0	0	0.00	0	0	118.39	23223	5100
16	720	0.00	0	0	0.00	0	0	118.41	27197	5100
17	744	0.00	0	0	0.00	0	0	118.34	36952	5100
18	720	0.00	0	0	106.45	31919	4597	0.00	0	0
19	744	0.00	0	0	81.00	23044	3521	0.00	0	0

CALSIM II Model Results = Monthly Pumping- Generating Operations 82-yr
Power Planning Study Results= Incidental and Optimized Operations, 30-yr Median Case Deliveries

Daily pumpback operations of NODOS facilities are modeled in three components. The three components are pumpback operations incidental to its Diversion mode, incidental to its Release mode, and pure pumpback operations. For the purpose of this study, the pure Pumpback mode is limited to the months that the monthly average diversions into NODOS are less than 200 cfs. For each month of the 30-year planning period, the available generation and pumping capacities at the Sites Pumping/ Generating Plant are estimated based on the available head (level of storage) at Sites Reservoir (from the previous month's operations). Then a dispatch profile for the daily pumpback operations is generated based on market opportunities, pumping/ generation cycle efficiency, available pumping/generating capacities, and available storage at Holthouse Reservoir. Through the use of a complex modeling scheme, Sites Reservoir pumping/generating plant is economically dispatched in the NP-15 CAISO market. Ultimately, the model is set up to utilize NODOS pumpback potential based on the plant's availability and market economics. The median case dispatch profile for the pumpback operations for Alternative C of NODOS is depicted in Figures H.5-1 and H.5-4.

Additional information needed to run the EPM model includes forward energy prices, volatility term structure, correlations (between different underlying energy markets), delivery hours, and generation blocks. All necessary information are either generated through the EPM model's graphic user interface, or externally developed and input into the model.

This page intentionally left blank

6.0 MODELING RESULTS

6.1 Power Portfolio Energy Value

Table H.6-1 is a summary of the EPM modeling results (energy value and risk) for Alternatives A, B, and C considered in this study. The results in Table H.6-1 are in $1,000 of NPV, for the 30-years planning period, for each of the project's cycles and components. For the purposes of this study, NPV is defined as the current market value of the net portfolio's cash flows in $1,000 of present value. The results are grouped based on the operational cycle of the project facilities. The basic assumption is that pumping at all project diversion points along the Sacramento River is incidental to water operations (flat operations). Also assumed, pumping and generating at Sites Reservoir Pumping/Generating Plant can be optimized and may include a pumpback operations component. Optimizing operations is conditional to maintaining NODOS water delivery objectives at all times. During pumpback operations, power generation is mainly driven by the plant's availability and energy market price signals. As mentioned previously, two operational scenarios are used to model each of the three action alternatives: Incidental and Optimized. For the Incidental scenario, pumping and generating at the different NODOS facilities are driven by water diversions and releases (no reshaping). For the Optimized scenario, pumping and generating at the Sites Reservoir Pumping/Generating Plant are optimized to minimize pumping obligations (costs) and maximize project energy generation revenues. The modeling results are presented for both the Incidental and the Optimized operational scenarios in Table H.6-1 to report the energy portfolio value, and describe the monetary value of optimizing NODOS operations. Revenues from pumpback operations are presented separately to allow for better breakdown of costs and revenues from project's water diversions and releases. In studying the modeling results, it is important to remember that modeling of project operations is meant to monetize the energy costs and revenues, and not the water use benefits of the project. It should be noted that pumping costs and generating revenues are impacted by water surface elevations at Sites Reservoir, resulting from the different configurations and system-wide water operations for each of the three action alternatives for NODOS (Alternative A compared to Alternative C). It is also noteworthy that pumpback operations will net more revenues under alternatives with less water deliveries (Alternative A compared to Alternative C) because of the fact that NODOS assets would be less utilized, and more opportunity (percent of time) exist for pumpback operations.

Table H.6-1. NODOS Project, Summary Modeling Results, NPV ($1000)

Portfolio NPV Comparison- Modeled CALSIM Deliveries Scenarios						
Pumping-Generation Site	CALSIM Deliveries					
Planning Alternative	Alt A		Alt B		Alt C	
Operations Strategy	Incidental	Optimized	Incidental	Optimized	Incidental	Optimized
NODOS Pumping	Period Total, NPV ($1000)					
TC Canal Pumping	-6,085	-6,085	-7,511	-7,511	-5,786	-5,786
GCID Pumping	-10,083	-10,083	-11,519	-11,519	-9,964	-9,964
Sac River Pumping	-53,500	-53,500	N/A	N/A	-59,196	-59,196
TRR Pumping	-9,939	-9,939	-16,454	-16,454	-11,839	-11,839
Sites Pumping	-149,357	-137,397	-147,694	-133,100	-172,219	-157,841
Subtotal	-228,964	-217,004	-183,178	-168,584	-259,004	-244,626
			Preliminary Results			
NODOS Generation	Period Total, NPV ($1000)					
Sites Genenration	109,077	121,405	111,262	125,493	134,216	149,580
TRR Generation	19,651	20,400	6,839	7,146	20,385	21,243
Sac River Generation	49,873	49,873	N/A	N/A	50,197	50,197
Subtotal	178,601	191,678	118,101	132,639	204,798	221,020
NODOS PumpBack Operations	Period Total, NPV ($1000)					
PumpBack during Diversion cycle	N/A	7,031	N/A	13,999	N/A	7,444
PumpBack During Release Cycle	N/A	23,000	N/A	18,299	N/A	21,564
Pure PumpBack Operations Cycle	N/A	17,435	N/A	14,916	N/A	17,395
Subtotal		47,466		47,214		46,403
NODOS Project Portfolio Value	-50,363	22,140	-65,077	11,269	-54,206	22,797
NODOS Project Optimization Potential		72,503		76,346		77,003
NODOS Risk Metrics	Period Total, NPV ($1000)					
Value-at-Risk	1,863	2,336	1,523	2,425	1,644	2,504
Cash-Flow-at-Risk	94,976	96,161	112,192	117,079	107,668	113,228

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 06/17/2011
Report updated at 03:40:00 PM.
Sac River Generation is not optimized to minimize the impact of headloss at higher releases thru the plant

For Alternative A Incidental operations, the 30-year total pumping costs (for the median case of diversions) of NODOS in NPV are $228,964,000, whereas the corresponding energy generation revenues incidental to Project releases in NPV are $178,601,000. For Alternative A Optimized operations, the 30-year total pumping costs (for the median case diversions) of NODOS in NPV are $217,004,000, whereas the corresponding energy generation revenues from optimized project releases in NPV are $191,678,000. For the Optimized operations, additional revenues in NPV of $47,466,000 would be realized from the pumpback operations (daily operations). Pumpback operations and revenues are a combination of pumpback operations superimposed on the generation and pumping cycles, and pure pumpback operations in months that the project's average diversion is less than 200 cfs (i.e., project assets are not in use). It should be noted that for the Incidental operations, the assumption was that no pumpback operations will take place (project assets are tied up in flat operations).

For Alternative B Incidental operations, the 30-year total pumping costs (for the median case of diversions) of NODOS in NPV are $183,178,000, whereas the corresponding generation revenues incidental to project releases in NPV are $118,101,000. For Alternative B Optimized operations, the 30-year total pumping costs (for the median case of diversions) of NODOS in NPV are $168,584,000, whereas the corresponding generation revenues from optimized project releases in NPV are $132,639,000. For the Optimized operations, additional revenues in NPV of $47,214,000 would be realized from the pumpback operations (daily operations).

For Alternative C Incidental operations, the 30-year total pumping costs (for the median case of diversions) of NODOS in NPV are $259,004,000, whereas the corresponding generation revenues incidental to project releases in NPV are $204,798,000. For Alternative C Optimized operations, the 30-year total pumping costs (for the median case of diversions) of NODOS in NPV are $244,626,000, whereas the corresponding generation revenues from optimized project releases in NPV are $221,020,000. For the Optimized operations, additional revenues in NPV of $46,403,000 would be realized from the pumpback operations (daily operations).

For the 30-year planning period, optimizing NODOS operations (as described in Section 4.3) resulted in additional revenues for the project in NPV totaling $72,503,000 for Alternative A, $76,343,000 for Alternative B, and $77,003,000 for Alternative C. For all three action alternatives considered for NODOS, optimizing operations resulted in changing the net project cash flow from a negative to a positive cash flow which would significantly enhance the economics of the project. For NODOS Incidental operations, the net total project's power portfolio value (generation revenues minus pumping costs) (for the median case of diversions) in NPV is $-50,363,000, $-65,077,000, and $-54,206,000 for Alternatives A, B, and C, respectively. Whereas, for NODOS Optimized operations, the net project's power portfolio value (generation revenues-pumping cost) (for the median case of diversions) in NPV is $22,140,000, $11,269,000, and $22,797,000 for Alternatives A, B, and C, respectively.

Table H.6-1 provides a summary breakdown of the contributions of each component, and in each operational mode (pumping, generating, and pumpback cycles).

Tables H.6-2 and H.6-3 show the NODOS power portfolio annual cash flow present value, in present value in $1,000s for the median case of deliveries under Alternative C of the project (complete version of these tables for all three action alternatives are in Appendix B). The annual cash flows are reported, in present value, through the 30-year planning period of the project. The cumulative value of the cash flows in present value for each project component represents the NPV of that component. The sum of the NPV of all project components is the net total value of the project for that specific alternative and specific operational scenario.

Table H.6-2. NODOS Project, Modeling Results, Annual Cashflow, Incidental Ops, Alternative C

Cash Flow Report for the NODOS Project, CALSIM 30-Yr Planning Period, Alt C (Incidental Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	-5,788	-279	-128	-180	-80	-82	-411	-251	-238
GCID Pumping	-9,968	-306	-375	-347	-349	-231	-431	-355	-335
Sac River Pumping	-59,196	-3,040	-273	-1,227	-155	-370	-5,674	-2,940	-1,998
TRR Pumping	-11,839	-410	-204	-295	-28	-180	-1,057	-657	-159
Sites Pumping	-172,219	-9,319	-823	-4,546	-1,836	-1,298	-11,927	-9,489	-6,630
Subtotal	**-259,010**	**-13,354**	**-1,803**	**-6,595**	**-2,448**	**-2,161**	**-19,500**	**-13,692**	**-9,360**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Genereration	134,217	3,210	2,997	5,049	6,577	4,109	3,477	4,764	6,204
TRR Generation	20,385	723	438	981	765	1,128	807	1,246	963
Sac River Genenration	50,193	1,191	1,147	1,384	3,310	2,147	1,742	1,635	1,880
Subtotal	**204,795**	**5,124**	**4,582**	**7,414**	**10,652**	**7,384**	**6,026**	**7,645**	**9,047**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PumpBack During Release Cycle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pure PumpBack Operations Cycle	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NODOS Project Total	**-54,215**	**-8,230**	**2,779**	**819**	**8,204**	**5,223**	**-13,474**	**-6,047**	**-313**

30-year Planning Period

NPV, is the current market value of the Net Portfolio's Cash flows in $1000

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Table H.6-3. NODOS Project, Modeling Results, Annual Cashflow, Optimized Ops, Alternative C

Cash Flow Report for the NODOS Project, CALSIM 30-Yr Planning Period, Alt C (Optimized Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	-5,788	-279	-128	-180	-80	-82	-411	-251	-238
GCID Pumping	-9,968	-306	-375	-347	-349	-231	-431	-355	-335
Sac River Pumping	-59,196	-3,040	-273	-1,227	-155	-370	-5,674	-2,940	-1,998
TRR Pumping	-11,839	-410	-204	-295	-28	-180	-1,057	-657	-159
Sites Pumping	-157,842	-8,578	-627	-3,872	-1,587	-1,105	-10,846	-8,646	-5,958
Subtotal	**-244,633**	**-12,613**	**-1,607**	**-5,921**	**-2,199**	**-1,968**	**-18,419**	**-12,849**	**-8,688**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Genereration	149,578	4,268	3,456	5,915	7,547	4,251	4,017	5,702	7,137
TRR Generation	21,249	781	480	1,032	799	1,151	843	1,307	1,015
Sac River Genenration	50,193	1,191	1,147	1,384	3,310	2,147	1,742	1,635	1,880
Subtotal	**221,020**	**6,240**	**5,083**	**8,331**	**11,656**	**7,549**	**6,602**	**8,644**	**10,032**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	7,445	213	470	623	96	49	214	239	0
PumpBack During Release Cycle	21,566	1,717	1,412	563	824	276	401	1,371	998
Pure PumpBack Operations Cycle	17,395	323	1,571	775	278	642	1,054	0	410
Subtotal	**46,406**	2,253	3,453	1,961	1,198	967	1,669	1,610	1,408
NODOS Project Total	**22,793**	**-4,120**	**6,929**	**4,371**	**10,655**	**6,548**	**-10,148**	**-2,595**	**2,752**

30-year Planning Period

NPV, is the current market value of the Net Portfolio's Cash flows in $1000

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Figures H.6-1 and H.6-2 graphically depict the Alternative C NODOS power portfolio cash flows in each delivery period for the 30-year horizon modeled in EPM, for the median case of deliveries, and for both Incidental and Optimized operations. The solid diamond markers represent the present value of the portfolio's cash flow for a specific period. And the high and low error bars correspond to the upper and lower percentiles of the cash flow distribution estimated using the Monte-Carlo simulation. The error bars correspond to the 95 percent and 5 percent confidence limits of the cash flow distribution for that specific period.

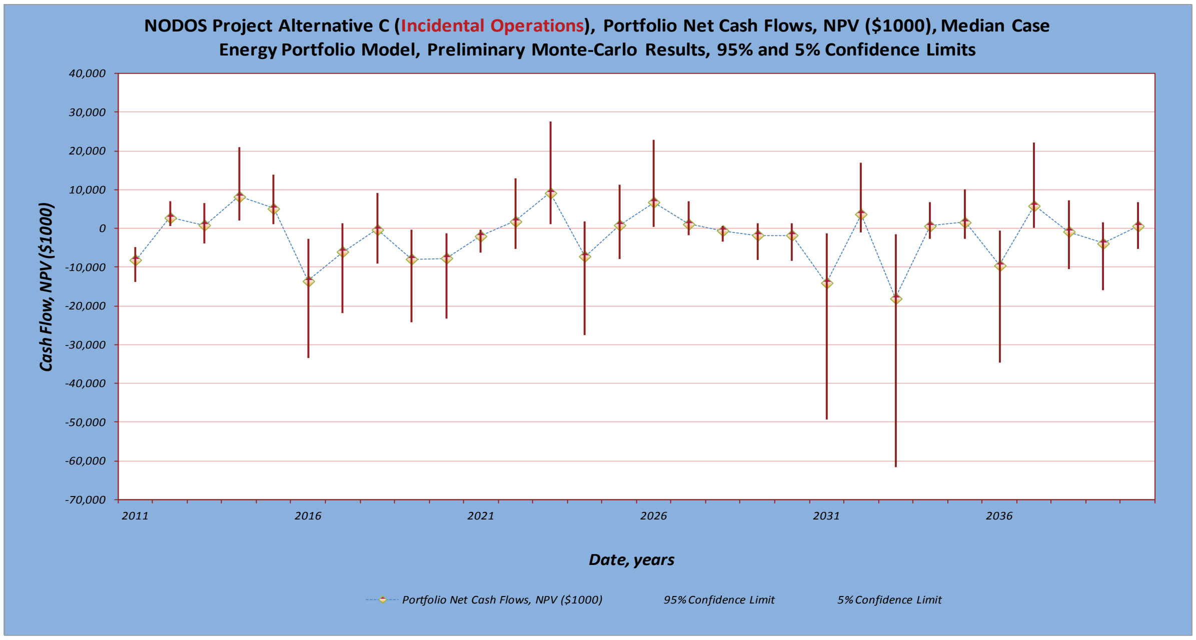


Figure H.6-1. NODOS Project, Portfolio Cash Flow at Risk, Incidental Operations, Alternative C

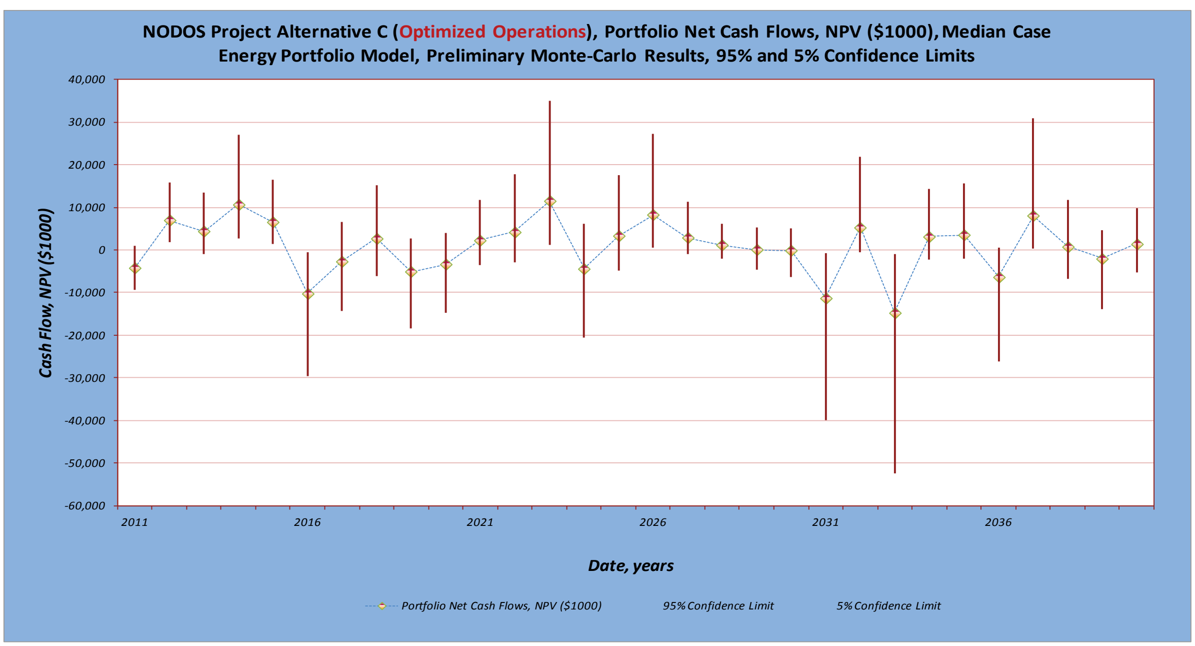


Figure H.6-2. NODOS Project, Portfolio Cash Flow at Risk, Optimized Operations, Alternative C

6.2 Power Portfolio Risk Metrics

EPM model results also include a description of the financial risk resulting from uncertainty and volatility of the underlying fuel and power markets in which NODOS will be participating. The EPM model produces risk metrics associated with a portfolio of assets that correspond to the exposure of an individual asset in a portfolio, or risk metrics that describe the collective risk associated with the portfolio, as a whole. The EPM model uses a Monte-Carlo-based algorithm (random generation-based) to generate a pre-assumed log-normal distribution of the expected cash flow of an asset. The generated distribution is based on the specific period's marginal volatility, time to delivery, and the analysis date. The number of draws for the Monte-Carlo approximation (2,000 draws are being used for this study), the specified confidence level (95 percent is being used for this study), the volatility and correlations of the underlying markets, and the holding period (all are input parameters to EPM) are the basis for the Monte-Carlo generated distribution of the cash flow of an asset. Financial risk associated with an asset or a portfolio of assets could be measured from the Monte-Carlo generated distribution.

Two commonly used risk metrics in describing the financial risk associated with a portfolio are the Value-at-Risk and Cash-Flow-at-Risk. Value-at-Risk is a measure of the potential for loss on a portfolio of assets or an asset value, within a specified holding period. Value-at-Risk is a commonly used risk metric to describe the risk associated with the value of a portfolio of assets within a short period of time (days). A second risk metric is a Cash-Flow-at-Risk, and is defined as the maximum loss that could be realized over a specified holding period at a specified confidence level. Other risk metrics, such as Price Exposure, could also be reported as partial output of the EPM risk report. Price Exposure measures an asset exposure to a specific price risk, and reports how many dollars of the value of that asset is at stake.

For Alternative C, the power portfolio cumulative probability distribution is depicted in Figure H.6-3 for both the Incidental and Optimized operations. The Monte-Carlo simulation provides the cumulative probability distribution of NODOS power portfolio's cash flows around its mean value. On Figure H.6-3, the Cash-Flow-at-Risk could be measured from the difference in NPV of portfolio cash flows between the 50 percent and the zero percent probabilities for the pre-specified confidence level (95 percent in this case). Cash-Flow-at-Risk for a specific period could also be generated. The annual Cash-flow-at-Risk is graphically depicted on Figures H.6-1 and H.6.2 as the difference between the diamond markers and the lower end of the error bar for that specific period. Value-at-Risk and Cash-Flow-at-Risk of NODOS are summarized for the three action alternatives in Table H.6-1.

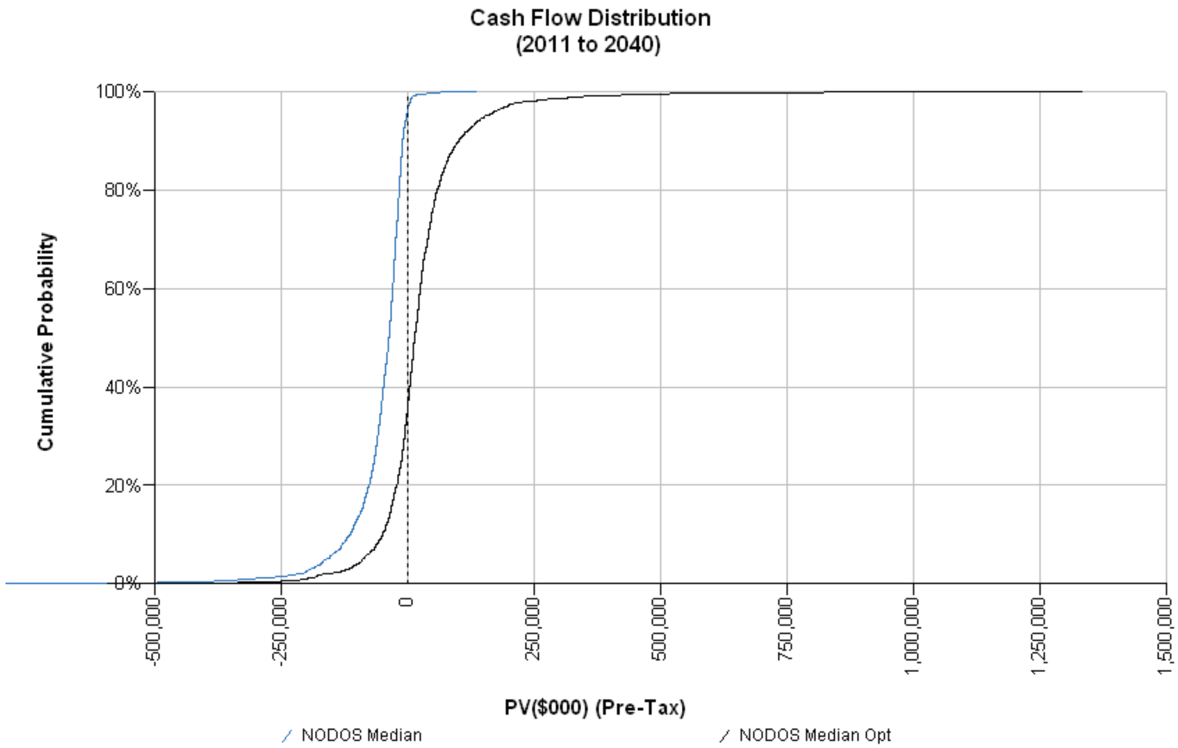


Figure H.6-3. NODOS Project, Cumulative Cash Flow Distribution Comparison

This page intentionally left blank

7.0 NODOS PROJECT CAPACITY AND ANCILLARY SERVICES

7.1 Capacity Value Analysis

CAISO is charged, under both California law and by the Federal Energy Regulatory Commission (FERC), with the responsibility of maintaining and operating a reliable grid system (transmission system) – a system that is under their operational control. System reliability is a very complex subject, as it is inextricably intertwined with market economics (a subject that is beyond the scope of this study). Nevertheless, a crucial element of reliable grid operations relevant to NODOS operations is resource adequacy (RA). CAISO, through their FERC-approved tariff, along with RA requirements adopted by California Public Utilities Commission (CPUC) mandates, intend to establish a process that ensures that capacity procured for RA purposes is available when and where it is needed. For NODOS, RA obligations are a pseudo financial obligation in pumping/diversion cycle (self-provided), and a revenue opportunity in generation/release cycle.

There are several ways through which capacity value of a power asset can be harnessed. One way is the consideration of RA capacity value utilization. The State of California has embraced an RA mandate/regime (AB380) in order to make power resources available when and where they are needed, and to promote investment in new resources and maintenance of existing facilities. CPUC governs the RA program for entities under its jurisdiction and CAISO monitors the RA program implementation by utilities, including publicly owned utilities and government agencies. Currently, RA capacity is being traded bilaterally through a solicitation and bidding process and the price of capacity negotiation is opaque. However, the CAISO tariff requires CAISO to procure capacity as a backstop should a load serving entity fail to meet its RA obligation showings and for within the month exceptional dispatch requirements. The RA obligation showings take place in an annual showing, as well as monthly showings. FERC has authorized CAISO to charge or pay the default RA capacity procurement price of $67.5/kilowatt (kW)-year (pending FERC approval). In terms of capacity rate determination needed to estimate RA revenues and/or obligations, three options can be considered:

1) Bilateral trade capacity value: It is not transparent and the rate at which the capacity is procured is unknown. It could be lower in some months and higher during summer months (seasonal trend).

2) Default Capacity Procurement Mechanism (CPM) procurement rate: The FERC-approved CAISO tariff rate of $67.5/kW-year (pending FERC approval) is the backstop procurement rate. It is constant for all the months, and represents an implied cap on RA value in the CAISO market. This default rate is subject to change in future stakeholder processes at CAISO and subsequent FERC approval. Also, there is little chance that an asset can realize this level of capacity payment because of the narrow CAISO capacity market at the CPM rate.

3) Based on escalated 2009 California Energy Commission (CEC) costs of generation technologies: Capacity value would be the revenue stream from selling capacity needed to make an economic/feasible investment in a simple cycle generation unit. Modeling a 100 MW simple cycle generation unit using the escalated 2009 CEC costs of generation technologies revealed a capacity revenue requirement of $25.40/kW-year.

It is assumed that NODOS will offer capacity in the CAISO market to participants that need to secure capacity resource to meet their RA obligations. For a generation asset, there are two different levels of participation (local RA, and system RA) in CAISO's capacity market based on the relative location of that specific asset to pre-identified local congested areas within the CAISO-managed grid. NODOS facilities and their potential interconnection location to the CAISO grid do not currently fall in one of the congested local areas where the generation assets can sell local RA products. Moreover, the CAISO market currently has sufficient system RA with very little monetary value for assets to capture from capacity offerings. However, system RA needs, system configuration, and assets geographical distribution are changing all the time. There may be some future opportunities for NODOS to participate in the RA market as the CAISO market evolves to integrate the 33 percent Renewables target in 2020. Monetizing potential revenues for NODOS from participation in the Capacity market is a difficult task. The uncertainty in projecting where and when RA products are needed will render any estimate worthless at this time. A range of values is offered to describe potential revenues for NODOSRA offerings, and was based on a $2/kW-year (from recent market offerings) to $25.40/kW-year (as described in #3 above).

NODOS RA obligations resulting from its pumping load are met through the self-provided provisions of current CAISO tariff, providing that it meets CAISO participating load requirements. In reality, NODOS would meet its RA obligations in the pumping mode through a load dropping scheme and would satisfy CAISO's RA requirements. For the Alternative C pumping mode, the monetary value of meeting RA obligations, which can be described as avoided cost, has a range in NPV of $1,666,000 to $20,944,000 for the Incidental operations and $827,000 to $10,338,000 for the Optimized operations, for the median case deliveries and the 30-year planning period. The significant difference in the RA obligations between the Incidental and the Optimized operations is the result of avoiding pumping during the super peak hours (which determines an asset's RA obligations in CAISO) in the Optimized pumping mode.

For the NODOS generation mode, the corresponding potential Capacity revenues are estimated at a NPV of $946,080 to $11,826,000 for the Incidental operations, and $2,572,000 to $32,149,000 for the Optimized operations. Optimizing NODOS operations would result in a significant increase in generation assets utilization during the super peak hours (and enhance its RA offerings potential). The Pumpback mode for NODOS would be in sync with CAISO's Capacity market optimal values (super peak generation hours) and least obligations (off--peak load). The pumpback operations can add to the NODOS RA potential revenues in NPV between $3,040,000 and $38,000,000. It should be noted that estimates for Capacity revenues are projections that are highly dependent (and uncertain) on whether the CAISO market will evolve with the need to secure RA resources (to integrate Renewables) from assets similar to NODOS.

7.2 Ancillary Services Potential

CAISO procures AS to ensure that it has adequate reserve generation capacity to maintain the electric system reliability and system frequency, by matching generation and load at all times under both normal and abnormal operating conditions. In their restructured electricity market (Post MRTU), CAISO obtains AS services through a competitive bidding process. On a daily basis, CAISO procures four primary AS services (regulation, spinning reserves, non-spinning reserves, and replacement reserves), in day-ahead and in hour-ahead markets. The two additional AS that CAISO procures are black-start and voltage support services, which are procured on a long term basis. The four primary AS are procured on separate basis, in a competitive open market environment, designed as being an integral component of the energy market. The Primary AS markets are defined by CAISO, as follows:

> 1-Regulation: Generation that is online and synchronized with the CAISO-controlled grid so that the energy can be increased or decreased instantly through automatic generation control (AGC), directly by the CAISO monitoring system. Regulation is used to maintain continuous balancing of resources and loads within the CAISO-controlled grid, as well as maintains frequency during normal operating conditions.
>
> 2-Spinning Reserve: Generation that is online, or “spinning,” with additional capacity that is capable of ramping over a specified range within 10 minutes and running for at least 2 hours.
>
> 3-Non-Spinning Reserve: Generation that is available but not online, that is capable of being synchronized and ramping to a specified level within 10 minutes, and capable of producing dispatched energy for at least 2 hours.
>
> 4-Replacement Reserves: Generation that is capable of starting up if not already operating, synchronized with CAISO controlled grid and ramping to a specified load within 1 hour, and running for at least 2 hours.

The two remaining AS (voltage support and black-start) are procured primarily through the Reliability Must Run (RMR) contracts. CAISO is responsible for conducting a competitive market of the four primary AS on behalf of the market participants.

For NODOS pumping/generating facilities, if interconnected to the CAISO grid, AS would be a significant operations and costs/revenues concern. For NODOS to participate in the CAISO AS market, the CAISO tariff requires a participating generator to undergo a certification process- the process details are beyond the scope of this study. CAISO tariff states that a participating generator is a generator or other seller of energy or AS through a scheduling coordinator over the CAISO grid from a generating unit with a rated capacity of one MW or greater, or from a generating unit providing AS and/or Imbalance Energy through an aggregation arrangement approved by CAISO, a criteria that NODOS will clearly meet. CAISO accepts market bids for energy and AS only from scheduling coordinators on behalf of the participating generator.

A preliminary assessment for AS opportunities for NODOS is conducted using the median case CALSIM II deliveries for the 30-year planning period. Although the opportunity exists for NODOS facilities to participate in providing AS in the CAISO day-ahead and hour-ahead markets, analysis focuses on the day-ahead market opportunities. More thorough analysis will be conducted in the next phase of the study as NODOS evolves into an advanced stage and more granular details are developed through improved modeling efforts (daily, and hourly time steps) for project operations. In general, participation in the AS market is an opportunity to translate inherent operational flexibilities, and excess capacities into revenue opportunities. For NODOS, the ultimate priority is to maintain the intended seasonal water cycle diversions/deliveries that the project was designed to capture. Therefore, revenue opportunities from participation in the AS market will have to be designed as an incidental activity to satisfying the intended project's operations. More operational scenarios will be considered in the next phase of the study where operations would be optimized to capture the most revenues the market offers for both energy and AS, coincidently.

The restructured CAISO market (post MRTU) is still evolving and price signals have not necessarily matured to reflect long-term market trends for AS prices. Moreover, CAISO's renewable integration initiative and market redesign will have great impact on AS needs and prices. New CAISO AS products (such as fast ramping) may provide an exceptional opportunity for hydro installation, such as NODOS, to capture and participate in. For the current study, the best available approach to value NODOS potential revenues from AS markets is to use recent historical AS clearing prices for the CAISO market as a reference (available on CAISO's OASIS website).

For the pumping cycle, NODOS will have the opportunity as a participating load (meeting CAISO tariff definition) to sell Non-Spin AS (as described in #3 above) into the CAISO market. However, the AS participation will be limited to the Sites Reservoir pumping plant, so that water diversions from the Sacramento River could be maintained, at all times. The assumption is that when the pump load at Sites Reservoir pumping plant gets dropped by CAISO, water diversions from the Sacramento River could be stored temporarily in Holthouse Reservoir until CAISO needs the service. A two-hour maximum period is anticipated for a Non-Spin AS. Stored water at Holthouse Reservoir could then be pumped into Sites Reservoir at a later time within the same day. CALSIM II runs indicate that in months with potentially highest water diversions from the Sacramento River it is possible to use excess pumping capacity at Sites Reservoir to accommodate the Non-Spin AS participation. More detailed analysis is needed for the pumping cycle in the next phase of the study to develop AS participation strategies. Figure H.7-1 depicts the Non-Spin AS potential in MWh, for Sites Reservoir pumping plant, for Alternative C.

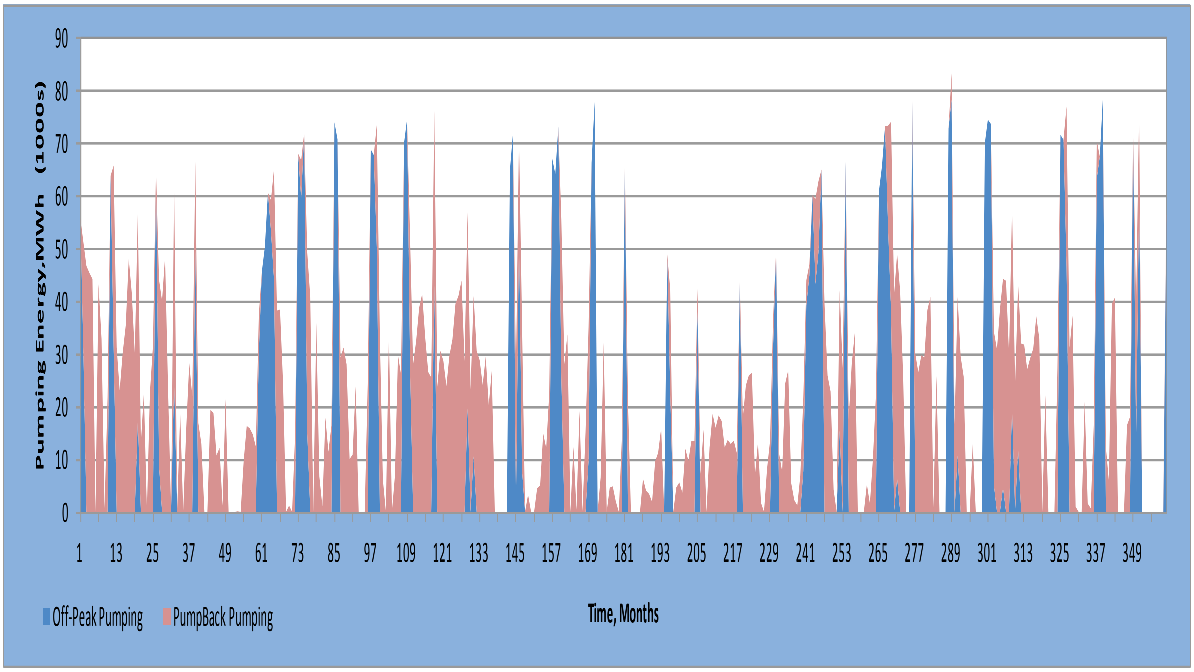


Figure H.7-1. Ancillary Service Potential, Sites Reservoir Pumping Cycle, Median Case

For the generation cycle, NODOS will have the opportunity to sell Regulation Down AS (as described in #1 above) in the CAISO market. NODOS water Release mode was optimized (in this study) to capture the most value for its incidental generation that the market offers. Hence, water releases from Sites Reservoir are designed to occur in the on-peak (or super peak) hours. Accordingly, NODOS generation facilities are assumed to sell Regulation Down AS, mostly in the on-peak (and super peak) hours and to a lesser extent in the off-peak hours. The assumption is that Regulation Down AS for NODOS, if called upon, represents a temporary delay in water releases and could be rectified within few hours. Also, it is assumed that NODOS facilities will be equipped with an automatic generation control (AGC) system and that the generation units would be of the type that could quickly be ramped down to satisfy CAISO requirements for this type of AS support. Participating in the Regulation Down AS market may result in foregoing some of the on-peak generation revenues. More detailed analysis will be conducted in the next phase of the study to estimate the value of lost opportunity resulting from shifting generation needed by AS dispatch. The AS participation impact on NODOS revenues need to be done in the context of the frequency at which CAISO calls upon this type of AS support. Figure H.7-2 depicts the Regulation Down AS potential for NODOS generation facilities in MWh, for Alternative C.

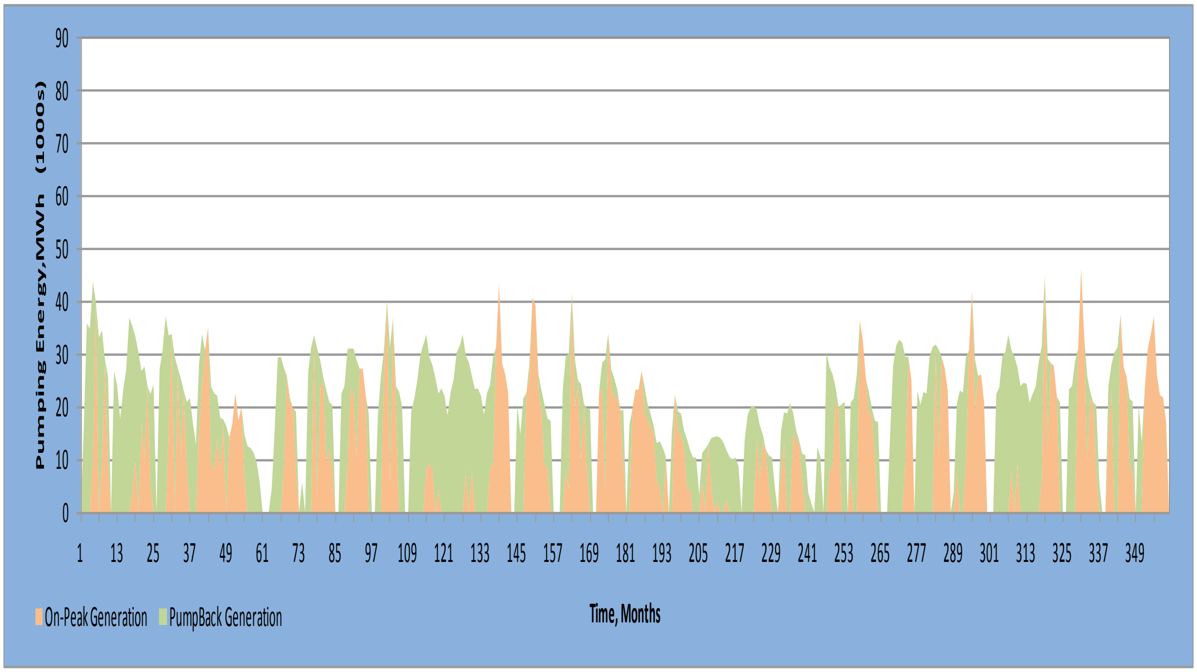


Figure H.7-2. Ancillary Service Potential, NODOS Project Generation Cycle, Median Case

The average values for the off-peak Non-Spin, and on-peak Regulation Down are calculated using published clearing prices for the CAISO AS markets. For NODOS, the total AS revenues from Non-Spin (the pump mode) for the 30-year planning period in NPV is $4,925,000. The corresponding total AS revenues from Regulation Down (in the generation mode) for the project in NPV is $9,198,000. The total AS revenues from the pumpback operations in NPV is $11,595,000. NODOS' total potential AS revenues in NPV is $25,718,000 for the 30-year planning period. It should be noted that the aforementioned AS revenues are only a measure of potential revenues based on current market trends, granted that the CAISO market will evolve overtime to accommodate load growth, renewable integration, regulatory changes, etc.

7.3 Renewable Integration

The California Renewable Energy Resources Act (CRERA), signed by California Governor Brown on April 12, 2011, significantly increased the state's renewable portfolio standard (RPS) targets from 20 percent to 33 percent by 2020. CRERA also expanded the compliance obligations to include virtually all retail sales of electricity in California. In September 2010, CAISO undertook a multi-phase stakeholder process (Renewable Integration Market and Product Review Initiative [RIMPR]), aimed at identifying changes to the energy market structure and at introducing new market products to reliably mitigate the impact of Renewable generation (Intermittent generation) as it penetrates the market. Recently CAISO has refocused its RIMPR from an expansive market design changes to a more incremental phased approach. CAISO is focused on developing a high-level roadmap addressing short-, medium-, and long-term market enhancement to meet renewable integration needs.

Other emerging developments in the power sector include energy storage technologies. This includes using pump-storage hydroelectric facilities to share off-peak energy for use during the on-peak periods or to provide AS. This includes supporting the use of intermittent renewable energy facilities into dispatchable resources and enhancing grid reliability and power quality. Other forces driving the need for energy storage technologies are climate change policies, smart grid initiatives, and the desire to improve utilization of generation and transmission capacities.

For NODOS, there is great potential for the project's generation and pumping assets to participate in providing renewable integration services as the market needs evolve. Hydropower assets have a unique feature that is not available from other energy storage technologies, fast ramping that can simultaneously provide both high capacity and energy. Although NODOS potential in renewable energy integration is certain, it is difficult to monetize that potential at this time because of the absence of a clear tradable market for these services. CAISO RIMPR may introduce new market products that NODOS can provide, yet sustain its primary water storage and delivery objectives.

The inherent nature of excess capacity for hydropower installations resulting from hydrology swings provide the opportunity to participate in providing energy storage services and the need to better utilize the excess capacity of project's assets (to enhance project economics). NODOS multi-purpose objectives will further enhance its chances in competing in the market as an energy storage asset (as project costs are socialized among multiple objectives) relative to more costly technologies. The limiting factors for NODOS participation are the inherent priorities of meeting the water delivery obligations over market driven power operations of the project's assets.

This page intentionally left blank

8.0 RECOMMENDATIONS AND NEXT STEPS

This NODOS Power Planning Study is meant to provide a feasibility-level assessment of the designed project components and operational scenarios from a power planning perspective. Three action alternatives, each with different configuration and components capacities, are considered and analyzed. Power planning perspective is important in capturing the impacts of the energy market economies and regulatory mandates and will be consequential to the costs and revenues for NODOS to be adopted and built. Although NODOS is envisioned to provide off-stream storage needed to support CVP and SWP operations and functions, its power portfolio is a major component in determining the project's ultimate viability. More work is needed to improve on the findings of the current phase of the study, including:

- Use anticipated CALSIM II modeling results (reflecting latest BiOp) for daily operations to refine the optimization of NODOS operations.
- Use available market information (i.e., LMP prices and trends) to optimize NODOS operations. Update the AS duration curves to reflect CAISO locational markets, and potential future markets resulting from the need to integrate Renewables.
- Integrate CAISO's RIMPR changes to the energy market in optimizing and valuing NODOS power portfolio.
- Explore and propose modifications to the physical and operational attributes of the power generation complex in light of the modeling results. Consider the change in designed capacities needed to correspond to the optimized operations, and needed project flexibilities.
- Identify operational scenarios and design modifications that could be modeled to optimize the project's operations and to enhance its value.
- Consider scenarios reflecting climate change impacts on NODOS operations, design needs, and ultimate viability.
- Propose a sensitivity analysis process that would describe the impact of adjusting design parameters, operational and financial uncertainty, on the project's value.
- Look into trends in technologies and setups that represent current practice in designing hydropower projects. Many recently designed pump-storage facilities are using separate pumping and generating facilities to increase efficiency and add operational flexibility.
- Consider a 50-year planning period that is more consistent with the lifecycle of hydropower project components.

This page intentionally left blank

Attachment A – Transmission Interconnection Road Map

Transmission Interconnection Process

PARO's Transmission Planning Branch prepared a description of the normal process that DWR has taken when exploring transmission interconnection options for new or existing facilities. The discussion below should serve as a roadmap for the transmission interconnection process for NODOS.

Preliminary Details

Before PARO can initiate its actions for obtaining physical interconnection and transmission service for DWR facilities, the following need to be ascertained:

1. Estimated peak capacity needs (MWs) at facilities' start-up and during construction

2. Planned load growth for future enlargements at said facilities

3. Probable location of Point of Interconnection to high-voltage system

4. Identification of all potential transmission providers

Transmission Provider Studies

All of the major transmission service providers in California require various engineering studies which evaluate the impact of a proposed facility on the overall high-voltage system. These studies, usually known as System Impact Studies (SIS), are of value to DWR for two reasons. First, the reports resulting from these studies can be utilized in any EIR/EIS documentation for discussion of transmission impacts (i.e., line routing and substations). Second, the studies, a necessary first level of review required by any of the potential transmission service providers, give a good indication of which provider represents the preferred option. However, it must be noted that any cost estimates provided at the SIS stage are considered preliminary and non-binding.

Once DWR has reviewed the various SIS reports and validated their findings, DWR must initiate the second stage of the transmission planning studies (typically called a Facility Study). These studies build upon the SIS and identify specific hardware that will be needed to implement the transmission service interconnection. Typically, one can assume that the Facility Study will provide accurate cost estimates that could be used in determining the economics of the project.

Transmission Service Request

Once the results of the various studies (i.e., SIS and Facility Study) are compiled, DWR can determine which provider it will seek an interconnection with, and subsequent transmission service. Typically, DWR will need to arrange for an interconnection service agreement and a transmission service agreement.

Route and Construction

Once DWR completes the transmission interconnection agreements, actual construction-related activities begin. These activities include ordering and receiving equipment; land acquisition and permitting; and actual construction.

It is important to note that there must be adequate lead time for all of the activities described above before the new DWR facility is expected to be on-line. To illustrate this, Table H.A-1 represents a typical timeline.

Table H.A-1. A Typical Timeline for New Transmission Interconnection

Phase	Action	PARO's Role	Duration
Preliminary Details			
	Assessing Project Needs (e.g., location and loads)	Support DWR's project team where necessary	(unknown, but for purposes of this timeline, completion of Preliminary Details is T_0)
Transmission Provider Studies			
	Coordination with Transmission Providers	Prepare necessary letters and documentation. Facilitate groundwork discussions between DWR and Providers.	2 months
	Formal Studies (System Impact Studies and Facility Studies)	Prepare necessary documentation. Negotiate study agreements. Facilitate payments for studies. Monitor process. Assist DOE-Electrical Engineering in reviewing results. Submit recommendations to management identifying which transmission option is preferable.	Up to 2 years
Transmission Service Requests			
	Formal Request to Preferred Transmission Provider	Prepare necessary documentation for request. Negotiate transmission interconnection agreement. Negotiate transmission service agreement. Facilitate upfront payments as required by agreements.	1 year
Construction Phase			
	DWR to order required hardware for its side of interconnection and for Provider to order hardware for their side.	Assist DWR project team and Department of Energy-Electrical Engineering as necessary	3 years
	Install DWR's hardware; Provider installs on their side of interconnection, per agreements	Assist DWR project team and Department of Energy-Electrical Engineering as necessary	2 years
Online Date** Assuming no major obstacles to Timeline **			8 years after preliminary project details are complete

Attachment B – NODOS Project Power Operations, Modeling Results

Table H.B-1. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative A

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Incidental Operations) Deliveries Cas

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	**-6,080**	-285	-115	-276	-321	-105	-180	-152	-188
GCID Pumping	**-10,085**	-319	-268	-383	-433	-357	-350	-387	-341
Sac River Pumping	**-53,500**	-2,821	-2,867	-1,926	-1,689	-667	-1,109	-2,531	-1,383
TRR Pumping	**-9,937**	-530	-85	-204	-1,254	-190	-81	-552	-597
Sites Pumping	**-149,355**	-8,238	-3,209	-5,500	-10,489	-848	-4,019	-4,825	-5,680
Subtotal	**-228,957**	**-12,193**	**-6,544**	**-8,289**	**-14,186**	**-2,167**	**-5,739**	**-8,447**	**-8,189**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Geneneration	**109,079**	3,825	3,961	4,215	4,083	3,420	5,604	2,330	7,173
TRR Generation	**19,649**	528	1,333	510	969	544	777	761	1,223
Sac River Genenration	**49,875**	2,395	2,591	2,465	1,448	1,662	2,706	1,821	3,621
Subtotal	**178,603**	**6,748**	**7,885**	**7,190**	**6,500**	**5,626**	**9,087**	**4,912**	**12,017**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PumpBack During Release Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pure PumpBack Operations Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NODOS Project Total	**-50,354**	**-5,445**	**1,341**	**-1,099**	**-7,686**	**3,459**	**3,348**	**-3,535**	**3,828**

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Incidental – Operations based on water diversions and releases.

Table H.B-1. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative A (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Incidental Operations) Deliveries Case (Cont.)

9	10	11	12	13	14	15	16	17	18	19
-303	-262	-123	-413	-214	-249	-180	-352	-197	-276	-232
-463	-329	-364	-391	-340	-343	-299	-446	-360	-382	-357
-2,682	-1,584	-999	-2,887	-2,268	-2,768	-1,223	-3,367	-1,146	-1,509	-816
-880	-154	-83	-477	-187	-191	-92	-572	-391	-297	-341
-8,511	-4,654	-2,829	-10,341	-4,830	-6,085	-4,499	-9,575	-4,863	-6,585	-5,663
-12,839	**-6,983**	**-4,398**	**-14,509**	**-7,839**	**-9,636**	**-6,293**	**-14,312**	**-6,957**	**-9,049**	**-7,409**
3,016	4,255	5,263	5,063	4,476	3,517	4,900	4,016	5,829	4,217	3,911
448	793	757	673	1,071	679	1,019	326	708	539	618
1,478	2,033	2,996	2,191	1,879	1,508	1,645	2,011	2,255	1,494	1,424
4,942	**7,081**	**9,016**	**7,927**	**7,426**	**5,704**	**7,564**	**6,353**	**8,792**	**6,250**	**5,953**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-7,897	**98**	**4,618**	**-6,582**	**-413**	**-3,932**	**1,271**	**-7,959**	**1,835**	**-2,799**	**-1,456**

Table H.B-1. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative A (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Incidental Operations) Deliveries Case (Cont.)

20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
-248	-118	-158	-71	-61	-266	-159	-168	-240	-83	-85
-342	-356	-313	-306	-182	-332	-242	-252	-272	-300	-276
-2,973	-261	-1,142	-558	-1,338	-3,348	-2,035	-1,064	-3,502	-529	-508
-401	-197	-255	-13	-145	-735	-137	-121	-350	-259	-166
-6,740	-679	-3,443	-1,224	-1,016	-7,681	-4,392	-3,731	-7,159	-1,220	-827
-10,704	**-1,611**	**-5,311**	**-2,172**	**-2,742**	**-12,362**	**-6,965**	**-5,336**	**-11,523**	**-2,391**	**-1,862**
2,877	2,299	3,610	3,646	1,110	3,319	2,661	3,755	1,689	570	469
661	313	672	524	839	502	703	565	449	60	85
997	930	951	2,158	599	1,345	875	1,120	836	265	176
4,535	**3,542**	**5,233**	**6,328**	**2,548**	**5,166**	**4,239**	**5,440**	**2,974**	**895**	**730**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-6,169	**1,931**	**-78**	**4,156**	**-194**	**-7,196**	**-2,726**	**104**	**-8,549**	**-1,496**	**-1,132**

Incidental – Operations based on water diversions and releases.

Table H.B-2. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative A

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Optimized Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	-6,080	-285	-115	-276	-321	-105	-180	-152	-188
GCID Pumping	-10,085	-319	-268	-383	-433	-357	-350	-387	-341
Sac River Pumping	-53,500	-2,821	-2,867	-1,926	-1,689	-667	-1,109	-2,531	-1,383
TRR Pumping	-9,937	-530	-85	-204	-1,254	-190	-81	-552	-597
Sites Pumping	-137,398	-7,693	-2,879	-4,892	-9,329	-678	-3,718	-4,443	-5,301
Subtotal	**-217,000**	**-11,648**	**-6,214**	**-7,681**	**-13,026**	**-1,997**	**-5,438**	**-8,065**	**-7,810**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Geneneration	121,405	4,764	4,397	4,861	4,493	3,786	6,027	2,731	7,921
TRR Generation	20,396	580	1,377	546	982	605	803	769	1,237
Sac River Genenration	49,875	2,395	2,591	2,465	1,448	1,662	2,706	1,821	3,621
Subtotal	**191,676**	**7,739**	**8,365**	**7,872**	**6,923**	**6,053**	**9,536**	**5,321**	**12,779**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	7,031	101	0	0	366	384	152	0	368
PumpBack During Release Cycle	22,998	1,176	984	578	617	557	926	1,150	204
Pure PumpBack Operations Cycle	17,435	152	1,083	1,100	274	1,359	117	876	0
Subtotal	**47,464**	1,429	2,067	1,678	1,257	2,300	1,195	2,026	572
NODOS Project Total	**22,140**	**-2,480**	**4,218**	**1,869**	**-4,846**	**6,356**	**5,293**	**-718**	**5,541**

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Incidental – Operations based on water diversions and releases.

Table H.B-2. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative A (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Optimized Operations) Deliveries Case (Cont.)

9	10	11	12	13	14	15	16	17	18	19
-303	-262	-123	-413	-214	-249	-180	-352	-197	-276	-232
-463	-329	-364	-391	-340	-343	-299	-446	-360	-382	-357
-2,682	-1,584	-999	-2,887	-2,268	-2,768	-1,223	-3,367	-1,146	-1,509	-816
-880	-154	-83	-477	-187	-191	-92	-572	-391	-297	-341
-7,979	-4,007	-2,701	-9,343	-4,431	-5,506	-4,200	-8,921	-4,680	-6,060	-5,222
-12,307	**-6,336**	**-4,270**	**-13,511**	**-7,440**	**-9,057**	**-5,994**	**-13,658**	**-6,774**	**-8,524**	**-6,968**
3,294	4,652	5,941	5,441	4,921	4,065	5,416	4,667	6,450	4,763	4,030
466	825	788	672	1,094	728	1,060	354	735	528	638
1,478	2,033	2,996	2,191	1,879	1,508	1,645	2,011	2,255	1,494	1,424
5,238	**7,510**	**9,725**	**8,304**	**7,894**	**6,301**	**8,121**	**7,032**	**9,440**	**6,785**	**6,092**
171	380	121	722	93	181	120	186	166	554	299
837	906	590	662	1,020	846	691	751	371	839	821
497	623	264	0	512	874	518	452	481	178	547
1,505	1,909	975	1,384	1,625	1,901	1,329	1,389	1,018	1,571	1,667
-5,564	**3,083**	**6,430**	**-3,823**	**2,079**	**-855**	**3,456**	**-5,237**	**3,684**	**-168**	**791**

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-2. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative A (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt A (Optimized Operations) Deliveries Case (Cont.)

20	21	22	23	24	25	26	27	28	29	30
-248	-118	-158	-71	-61	-266	-159	-168	-240	-83	-85
-342	-356	-313	-306	-182	-332	-242	-252	-272	-300	-276
-2,973	-261	-1,142	-558	-1,338	-3,348	-2,035	-1,064	-3,502	-529	-508
-401	-197	-255	-13	-145	-735	-137	-121	-350	-259	-166
-6,354	-543	-3,073	-1,125	-986	-7,247	-4,139	-3,517	-6,784	-1,018	-629
-10,318	**-1,475**	**-4,941**	**-2,073**	**-2,712**	**-11,928**	**-6,712**	**-5,122**	**-11,148**	**-2,189**	**-1,664**
3,189	2,557	4,147	4,121	1,007	3,544	2,859	4,275	1,911	661	514
695	345	714	540	865	525	731	593	466	52	83
997	930	951	2,158	599	1,345	875	1,120	836	265	176
4,881	**3,832**	**5,812**	**6,819**	**2,471**	**5,414**	**4,465**	**5,988**	**3,213**	**978**	**773**
170	397	471	142	58	148	212	83	149	384	453
1,090	1,066	705	908	328	861	1,031	673	639	609	562
476	957	335	287	964	233	291	293	746	1,474	1,472
1,736	2,420	1,511	1,337	1,350	1,242	1,534	1,049	1,534	2,467	2,487
-3,701	**4,777**	**2,382**	**6,083**	**1,109**	**-5,272**	**-713**	**1,915**	**-6,401**	**1,256**	**1,596**

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-3. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative B

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Incidental Operations)Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	**-7,508**	-118	-154	-156	-89	-223	-179	-231	-186
GCID Pumping	**-11,520**	-346	-356	-341	-302	-306	-288	-429	-436
Sac River Pumping	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TRR Pumping	**-16,451**	-69	-576	-357	-71	-45	-158	-763	-443
Sites Pumping	**-147,695**	-1,167	-4,894	-1,321	-1,747	-1,645	-2,469	-4,482	-4,074
Subtotal	**-183,174**	**-1,700**	**-5,980**	**-2,175**	**-2,209**	**-2,219**	**-3,094**	**-5,905**	**-5,139**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Geneneration	**111,264**	4,644	5,875	117	2,159	696	2,165	3,841	1,508
TRR Generation	**6,840**	1	824	0	0	43	0	429	3
Sac River Genenration	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**118,104**	**4,645**	**6,699**	**117**	**2,159**	**739**	**2,165**	**4,270**	**1,511**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PumpBack During Release Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pure PumpBack Operations Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NODOS Project Total	**-65,070**	**2,945**	**719**	**-2,058**	**-50**	**-1,480**	**-929**	**-1,635**	**-3,628**

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Incidental – Operations based on water diversions and releases.

Table H.B-3. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative B (Cont'd)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Incidental Operations)Deliveries Case (Cont.)

9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
-342	-367	-117	-438	-538	-395	-230	-164	-271	-197	-227
-524	-478	-436	-529	-541	-386	-305	-412	-405	-406	-413
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-1,067	-977	0	-1,260	-1,841	-696	-164	-194	-503	-141	-316
-6,558	-8,746	0	-7,909	-13,152	-8,759	-4,990	-3,798	-3,854	-3,220	-3,142
-8,491	**-10,568**	**-553**	**-10,136**	**-16,072**	**-10,236**	**-5,689**	**-4,568**	**-5,033**	**-3,964**	**-4,098**
1,152	5,084	6,489	3,551	4,164	5,899	8,109	4,598	3,151	3,845	3,936
5	282	42	5	261	716	1,033	10	382	8	5
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,157	**5,366**	**6,531**	**3,556**	**4,425**	**6,615**	**9,142**	**4,608**	**3,533**	**3,853**	**3,941**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-7,334	**-5,202**	**5,978**	**-6,580**	**-11,647**	**-3,621**	**3,453**	**40**	**-1,500**	**-111**	**-157**

Table H.B-3. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative B (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Incidental Operations)Deliveries Case (Cont.)

20	21	22	23	24	25	26	27	28	29	30
-295	-207	-270	-347	-413	-167	-291	-120	-258	-304	-214
-410	-400	-391	-403	-436	-313	-301	-312	-334	-330	-251
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-766	-295	-732	-723	-1,216	-333	-742	-64	-692	-956	-291
-6,095	-2,066	-6,661	-6,706	-10,470	-2,796	-7,128	-1,787	-6,679	-7,579	-3,801
-7,566	**-2,968**	**-8,054**	**-8,179**	**-12,535**	**-3,609**	**-8,462**	**-2,283**	**-7,963**	**-9,169**	**-4,557**
1,179	3,161	3,444	5,318	2,858	4,657	5,028	3,151	3,864	4,200	3,421
6	10	392	95	167	403	558	7	295	485	373
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,185	**3,171**	**3,836**	**5,413**	**3,025**	**5,060**	**5,586**	**3,158**	**4,159**	**4,685**	**3,794**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-6,381	**203**	**-4,218**	**-2,766**	**-9,510**	**1,451**	**-2,876**	**875**	**-3,804**	**-4,484**	**-763**

Incidental – Operations based on water diversions and releases.

Table H.B-4. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative B

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Optimized Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	**-7,508**	-118	-154	-156	-89	-223	-179	-231	-186
GCID Pumping	**-11,520**	-346	-356	-341	-302	-306	-288	-429	-436
Sac River Pumping	**0**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TRR Pumping	**-16,451**	-69	-576	-357	-71	-45	-158	-763	-443
Sites Pumping	**-133,104**	-947	-4,203	-1,078	-1,537	-1,439	-2,190	-3,949	-3,520
Subtotal	**-168,583**	**-1,480**	**-5,289**	**-1,932**	**-1,999**	**-2,013**	**-2,815**	**-5,372**	**-4,585**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Geneneration	**125,490**	5,854	6,830	0	2,625	843	2,526	4,442	1,700
TRR Generation	**7,145**	0	841	0	0	56	0	441	0
Sac River Genenration	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**132,635**	**5,854**	**7,671**	**0**	**2,625**	**899**	**2,526**	**4,883**	**1,700**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	**13,999**	20	286	49	174	175	326	457	756
PumpBack During Release Cycle	**18,298**	1,192	546	0	672	270	376	284	666
Pure PumpBack Operations Cycle	**14,916**	362	0	1,663	435	1,072	540	83	663
Subtotal	**47,213**	1,574	832	1,712	1,281	1,517	1,242	824	2,085
NODOS Project Total	**11,265**	**5,948**	**3,214**	**-220**	**1,907**	**403**	**953**	**335**	**-800**

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-4. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative B (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Optimized Operations) Deliveries Case (Cont.)

9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
-342	-367	-117	-438	-538	-395	-230	-164	-271	-197	-227
-524	-478	-436	-529	-541	-386	-305	-412	-405	-406	-413
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-1,067	-977	0	-1,260	-1,841	-696	-164	-194	-503	-141	-316
-5,845	-7,775	0	-7,060	-11,879	-7,992	-4,511	-3,456	-3,406	-2,878	-2,904
-7,778	**-9,597**	**-553**	**-9,287**	**-14,799**	**-9,469**	**-5,210**	**-4,226**	**-4,585**	**-3,622**	**-3,860**
1,371	5,729	7,600	4,158	4,633	6,715	8,526	5,363	3,397	4,436	4,491
0	311	39	0	270	774	1,062	1	403	0	0
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,371	**6,040**	**7,639**	**4,158**	**4,903**	**7,489**	**9,588**	**5,364**	**3,800**	**4,436**	**4,491**
244	772	0	335	967	549	587	510	141	352	199
1,105	931	270	678	760	717	282	864	664	1,126	563
841	180	494	189	0	581	733	354	1,206	290	479
2,190	1,883	764	1,202	1,727	1,847	1,602	1,728	2,011	1,768	1,241
-4,217	**-1,674**	**7,850**	**-3,927**	**-8,169**	**-133**	**5,980**	**2,866**	**1,226**	**2,582**	**1,872**

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-4. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative B (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt B (Optimized Operations) Deliveries Case (Cont.)

20	21	22	23	24	25	26	27	28	29	30
-295	-207	-270	-347	-413	-167	-291	-120	-258	-304	-214
-410	-400	-391	-403	-436	-313	-301	-312	-334	-330	-251
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-766	-295	-732	-723	-1,216	-333	-742	-64	-692	-956	-291
-5,415	-1,854	-6,117	-6,206	-9,717	-2,434	-6,617	-1,663	-6,112	-6,957	-3,443
-6,886	**-2,756**	**-7,510**	**-7,679**	**-11,782**	**-3,247**	**-7,951**	**-2,159**	**-7,396**	**-8,547**	**-4,199**
1,372	3,690	3,635	5,951	3,120	5,035	5,321	3,539	4,283	4,557	3,748
0	1	413	100	179	427	599	0	330	498	400
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,372	**3,691**	**4,048**	**6,051**	**3,299**	**5,462**	**5,920**	**3,539**	**4,613**	**5,055**	**4,148**
685	267	420	767	1,251	1,066	415	323	694	540	672
1,015	832	534	381	502	328	376	894	519	399	552
512	783	656	0	371	344	437	548	345	174	581
2,212	1,882	1,610	1,148	2,124	1,738	1,228	1,765	1,558	1,113	1,805
-3,302	**2,817**	**-1,852**	**-480**	**-6,359**	**3,953**	**-803**	**3,145**	**-1,225**	**-2,379**	**1,754**

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-5. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative C

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Incidental Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	**Period Total**	**Period Total, NPV ($1000)**							
TC Canal Pumping	**-5,788**	-279	-128	-180	-80	-82	-411	-251	-238
GCID Pumping	**-9,968**	-306	-375	-347	-349	-231	-431	-355	-335
Sac River Pumping	**-59,196**	-3,040	-273	-1,227	-155	-370	-5,674	-2,940	-1,998
TRR Pumping	**-11,839**	-410	-204	-295	-28	-180	-1,057	-657	-159
Sites Pumping	**-172,219**	-9,319	-823	-4,546	-1,836	-1,298	-11,927	-9,489	-6,630
Subtotal	**-259,010**	**-13,354**	**-1,803**	**-6,595**	**-2,448**	**-2,161**	**-19,500**	**-13,692**	**-9,360**
NODOS Generation	**Period Total**	**Period Total, NPV ($1000)**							
Sites Generation	**134,217**	3,210	2,997	5,049	6,577	4,109	3,477	4,764	6,204
TRR Generation	**20,385**	723	438	981	765	1,128	807	1,246	963
Sac River Genenration	**50,193**	1,191	1,147	1,384	3,310	2,147	1,742	1,635	1,880
Subtotal	**204,795**	**5,124**	**4,582**	**7,414**	**10,652**	**7,384**	**6,026**	**7,645**	**9,047**
PumpBack Operations	**Period Total**	**Period Total, NPV ($1000)**							
PumpBack during Diversion cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PumpBack During Release Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pure PumpBack Operations Cycle	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Subtotal	**N/A**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NODOS Project Total	**-54,215**	**-8,230**	**2,779**	**819**	**8,204**	**5,223**	**-13,474**	**-6,047**	**-313**

Notes

Cash Flow reported pre-tax in PV($000).

Evaluation performed 07/07/2011

Report updated at 10:28:53 AM.

Incidental – Operations based on water diversions and releases.

Table H.B-5. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative C (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Incidental Operations) Deliveries Case (Cont.)

9	10	11	12	13	14	15	16	17	18	19
-312	-268	-126	-207	-166	-264	-164	-71	-120	-71	-93
-344	-450	-416	-385	-345	-409	-407	-343	-432	-342	-252
-3,942	-1,761	-795	-1,225	-192	-3,931	-2,180	-1,088	-812	-1,161	-2,917
-534	-484	-291	-654	-91	-860	-516	-54	-536	-13	-460
-11,595	-7,078	-1,585	-6,587	-2,531	-11,282	-7,146	-2,959	-3,105	-1,604	-2,584
-16,727	**-10,041**	**-3,213**	**-9,058**	**-3,325**	**-16,746**	**-10,413**	**-4,515**	**-5,005**	**-3,191**	**-6,306**
5,826	1,414	806	7,843	8,524	6,353	7,552	6,942	3,492	1,109	2,006
1,135	114	166	1,136	764	906	534	719	246	525	956
1,788	725	300	1,965	3,199	2,232	3,166	3,548	2,462	955	1,542
8,749	**2,253**	**1,272**	**10,944**	**12,487**	**9,491**	**11,252**	**11,209**	**6,200**	**2,589**	**4,504**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-7,978	**-7,788**	**-1,941**	**1,886**	**9,162**	**-7,255**	**839**	**6,694**	**1,195**	**-602**	**-1,802**

Incidental – Operations based on water diversions and releases.

Table H.B-5. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative C (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Incidental Operations) Deliveries Case (Cont.)

20	21	22	23	24	25	26	27	28	29	30
-153	-413	-149	-386	-145	-186	-195	-79	-212	-164	-195
-252	-419	-182	-460	-289	-278	-321	-251	-219	-232	-211
-2,317	-4,387	-1,716	-4,178	-1,078	-1,082	-2,570	-174	-1,728	-2,664	-1,621
-419	-899	-96	-1,227	-307	-145	-359	-11	-123	-425	-345
-3,603	-11,419	-2,922	-14,986	-3,397	-5,246	-7,031	-153	-6,238	-7,077	-6,223
-6,744	**-17,537**	**-5,065**	**-21,237**	**-5,216**	**-6,937**	**-10,476**	**-668**	**-8,520**	**-10,562**	**-8,595**
2,521	2,095	5,820	2,373	4,445	6,343	675	4,916	5,690	4,591	6,494
818	324	951	136	536	552	107	439	643	729	898
1,589	1,028	1,961	763	963	1,712	187	1,242	1,315	1,416	1,699
4,928	**3,447**	**8,732**	**3,272**	**5,944**	**8,607**	**969**	**6,597**	**7,648**	**6,736**	**9,091**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
-1,816	**-14,090**	**3,667**	**-17,965**	**728**	**1,670**	**-9,507**	**5,929**	**-872**	**-3,826**	**496**

Incidental – Operations based on water diversions and releases.

Table H.B-6. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative C

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Optimized Operations) Deliveries Case

Pumping-Generation Site	NPV	Year Project in Service							
		1	2	3	4	5	6	7	8
NODOS Pumping	Period Total	Period Total, NPV ($1000)							
TC Canal Pumping	-5,788	-279	-128	-180	-80	-82	-411	-251	-238
GCID Pumping	-9,968	-306	-375	-347	-349	-231	-431	-355	-335
Sac River Pumping	-59,196	-3,040	-273	-1,227	-155	-370	-5,674	-2,940	-1,998
TRR Pumping	-11,839	-410	-204	-295	-28	-180	-1,057	-657	-159
Sites Pumping	-157,842	-8,578	-627	-3,872	-1,587	-1,105	-10,846	-8,646	-5,958
Subtotal	-244,633	-12,613	-1,607	-5,921	-2,199	-1,968	-18,419	-12,849	-8,688
NODOS Generation	Period Total	Period Total, NPV ($1000)							
Sites Geneneration	149,578	4,268	3,456	5,915	7,547	4,251	4,017	5,702	7,137
TRR Generation	21,249	781	480	1,032	799	1,151	843	1,307	1,015
Sac River Genenration	50,193	1,191	1,147	1,384	3,310	2,147	1,742	1,635	1,880
Subtotal	221,020	6,240	5,083	8,331	11,656	7,549	6,602	8,644	10,032
PumpBack Operations	Period Total	Period Total, NPV ($1000)							
PumpBack during Diversion cycle	7,445	213	470	623	96	49	214	239	0
PumpBack During Release Cycle	21,566	1,717	1,412	563	824	276	401	1,371	998
Pure PumpBack Operations Cycle	17,395	323	1,571	775	278	642	1,054	0	410
Subtotal	46,406	2,253	3,453	1,961	1,198	967	1,669	1,610	1,408
NODOS Project Total	22,793	-4,120	6,929	4,371	10,655	6,548	-10,148	-2,595	2,752

Notes
Cash Flow reported pre-tax in PV($000).
Evaluation performed 07/07/2011
Report updated at 10:28:53 AM.

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-6. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative C (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Optimized Operations) Deliveries Case (Cont.)

9	10	11	12	13	14	15	16	17	18	19
-312	-268	-126	-207	-166	-264	-164	-71	-120	-71	-93
-344	-450	-416	-385	-345	-409	-407	-343	-432	-342	-252
-3,942	-1,761	-795	-1,225	-192	-3,931	-2,180	-1,088	-812	-1,161	-2,917
-534	-484	-291	-654	-91	-860	-516	-54	-536	-13	-460
-10,672	-6,153	-1,130	-6,082	-2,220	-10,507	-6,726	-2,694	-2,811	-1,345	-2,474
-15,804	-9,116	-2,758	-8,553	-3,014	-15,971	-9,993	-4,250	-4,711	-2,932	-6,196
6,177	1,648	894	8,639	9,115	7,129	8,656	7,731	3,916	1,161	2,323
1,176	124	173	1,185	795	946	556	716	248	528	974
1,788	725	300	1,965	3,199	2,232	3,166	3,548	2,462	955	1,542
9,141	2,497	1,367	11,789	13,109	10,307	12,378	11,995	6,626	2,644	4,839
160	473	681	0	333	208	186	0	131	32	0
1,140	1,322	740	383	594	1,073	655	487	619	606	645
221	1,453	2,318	598	394	0	0	0	190	803	738
1,521	3,248	3,739	981	1,321	1,281	841	487	940	1,441	1,383
-5,142	-3,371	2,348	4,217	11,416	-4,383	3,226	8,232	2,855	1,153	26

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

Table H.B-6 NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative C (Cont.)

Cash Flow Report for the NODOS Project, CALSIM 30-Year Planning Period, Alt C (Optimized Operations) Deliveries Case (Cont.)

20	21	22	23	24	25	26	27	28	29	30
-153	-413	-149	-386	-145	-186	-195	-79	-212	-164	-195
-252	-419	-182	-460	-289	-278	-321	-251	-219	-232	-211
-2,317	-4,387	-1,716	-4,178	-1,078	-1,082	-2,570	-174	-1,728	-2,664	-1,621
-419	-899	-96	-1,227	-307	-145	-359	-11	-123	-425	-345
-3,457	-10,359	-2,867	-13,926	-3,286	-4,787	-6,582	0	-5,916	-6,730	-5,899
-6,598	**-16,477**	**-5,010**	**-20,177**	**-5,105**	**-6,478**	**-10,027**	**-515**	**-8,198**	**-10,215**	**-8,271**
2,884	2,361	6,410	2,476	5,053	6,876	724	5,207	6,100	5,010	6,795
846	343	977	142	575	587	116	470	671	766	927
1,589	1,028	1,961	763	963	1,712	187	1,242	1,315	1,416	1,699
5,319	**3,732**	**9,348**	**3,381**	**6,591**	**9,175**	**1,027**	**6,919**	**8,086**	**7,192**	**9,421**
127	440	0	1,007	0	213	1,080	0	174	47	249
521	552	502	253	633	417	659	663	538	1,002	0
483	559	496	853	1,007	166	921	973	169	0	0
1,131	1,551	998	2,113	1,640	796	2,660	1,636	881	1,049	249
-148	**-11,194**	**5,336**	**-14,683**	**3,126**	**3,493**	**-6,340**	**8,040**	**769**	**-1,974**	**1,399**

Optimized – Operations shaped to minimize pumping costs and maximize revenue from energy generation.

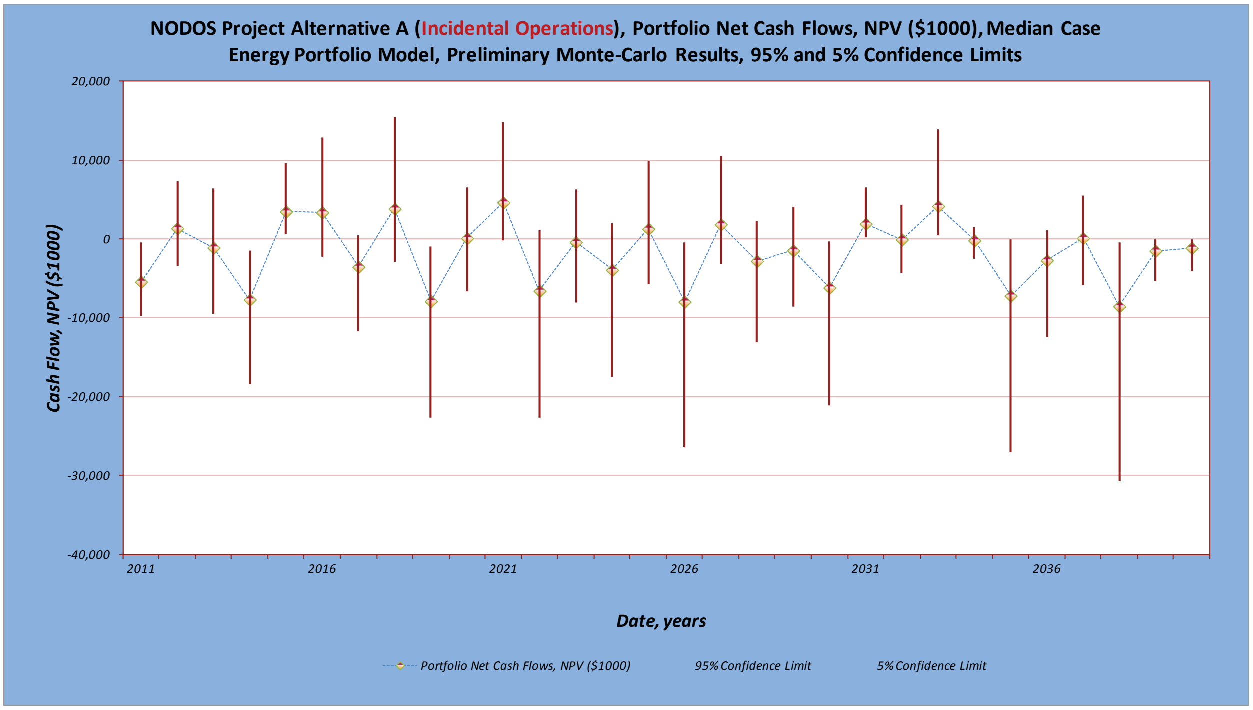


Figure H.B-1. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative A

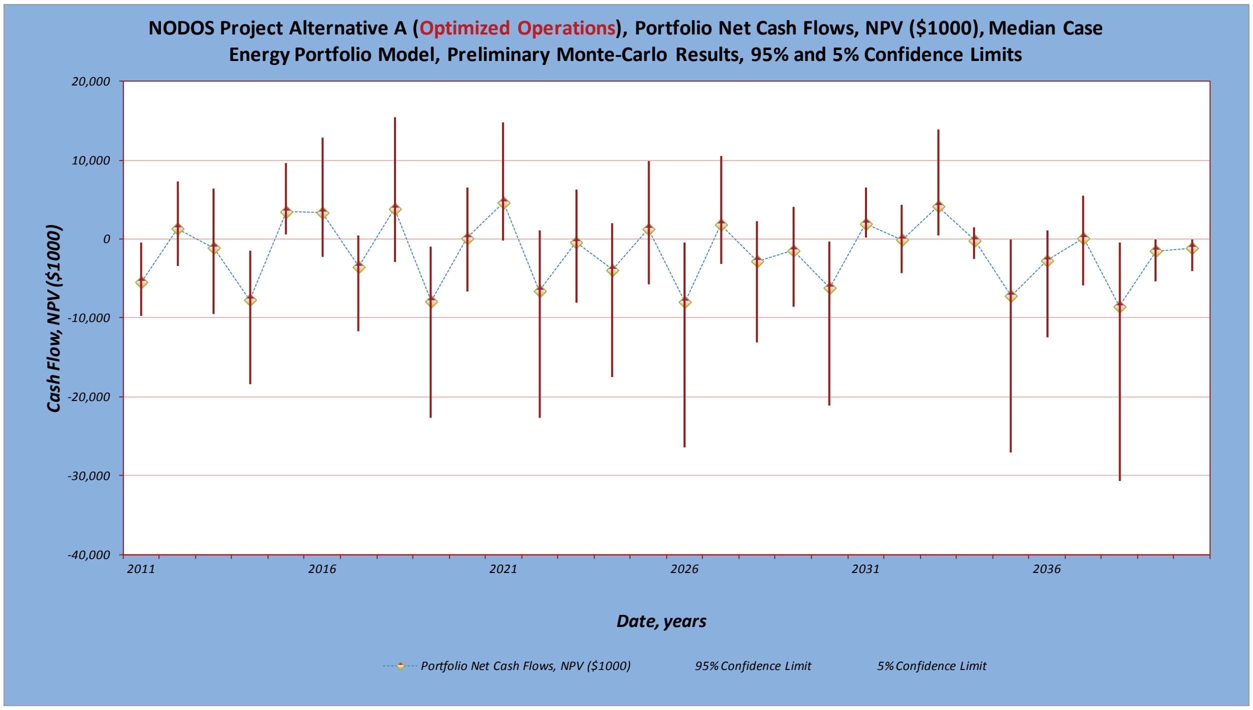


Figure H.B-2. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative A

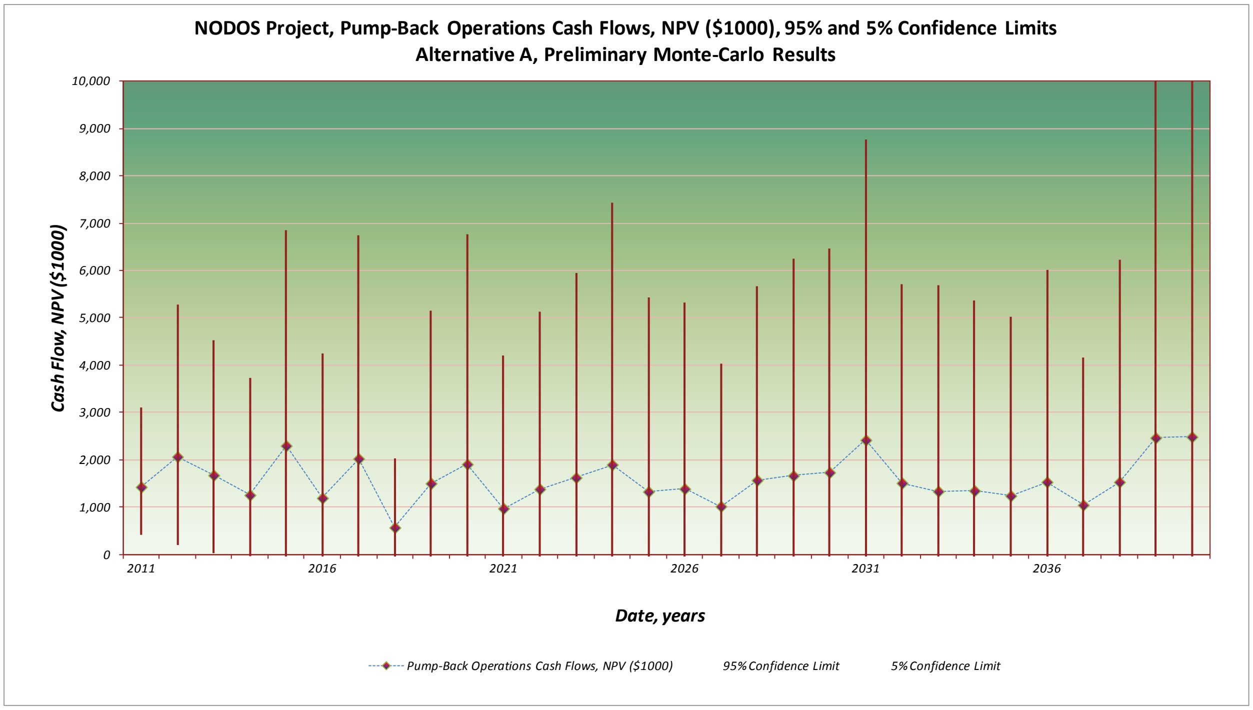


Figure H.B-3. NODOS Project, Power Portfolio-Annual Cash Flow, "Pumpback," Alternative A

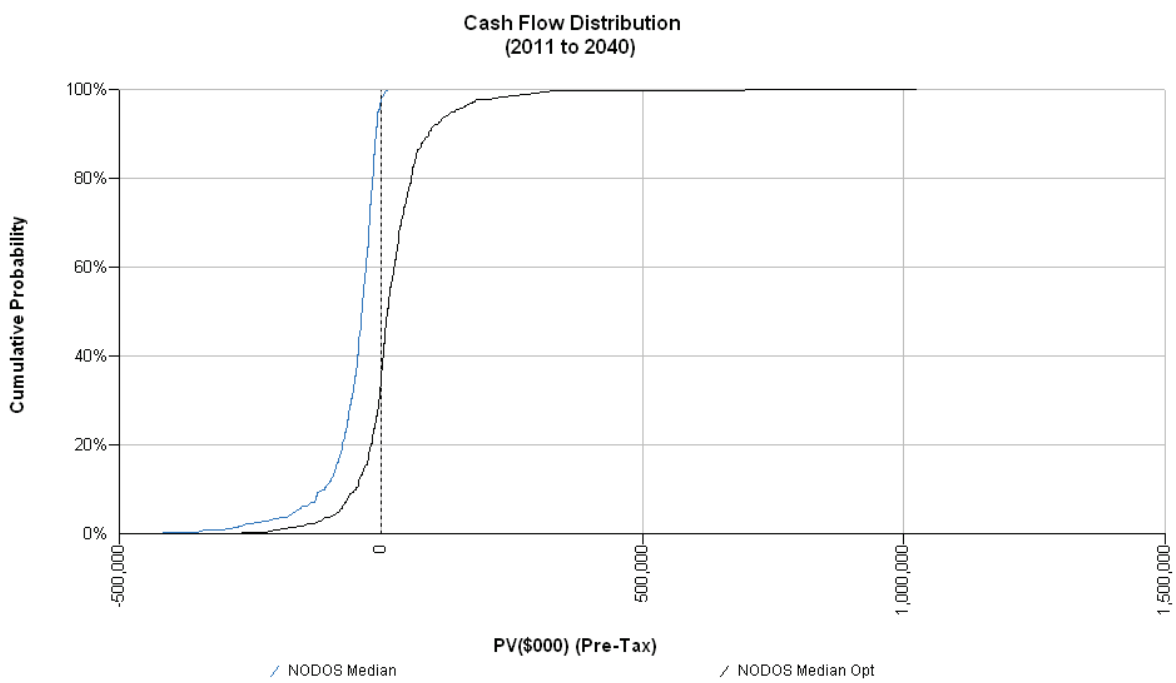


Figure H.B-4. NODOS Project, Power Portfolio Cumulative Probability Distribution, Alternative A "Incidental" vs. "Optimized"

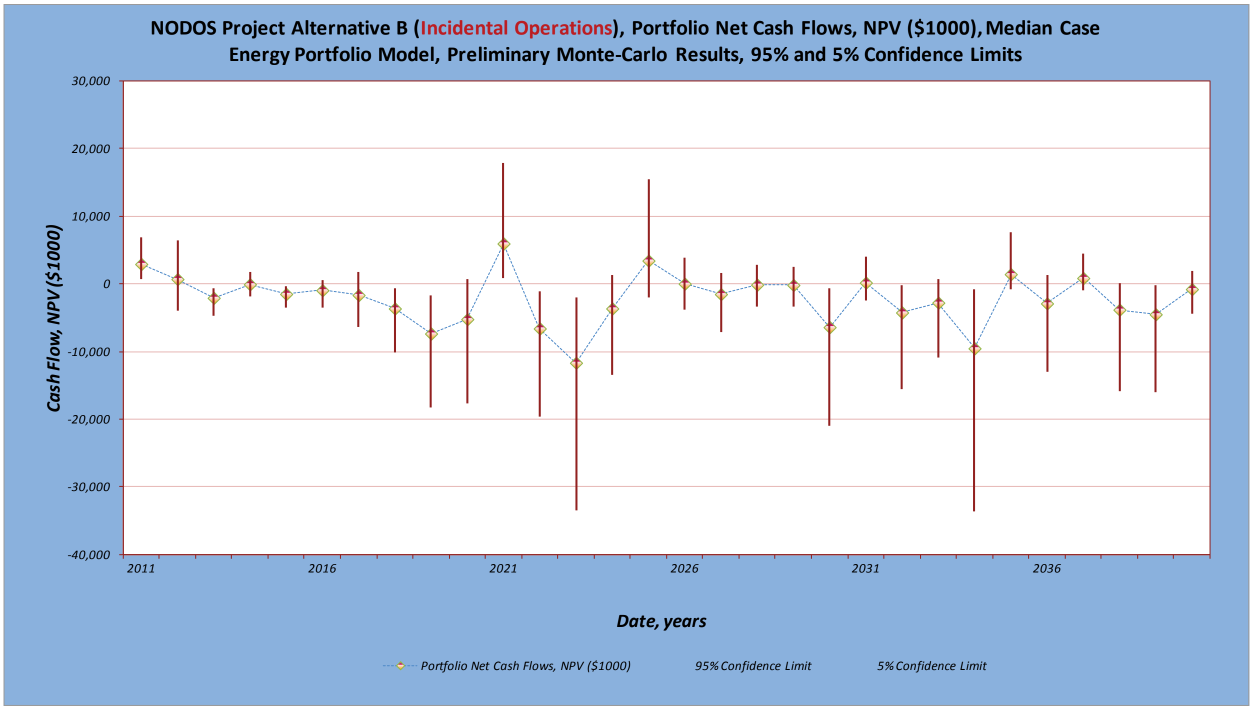


Figure H.B-5. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative B

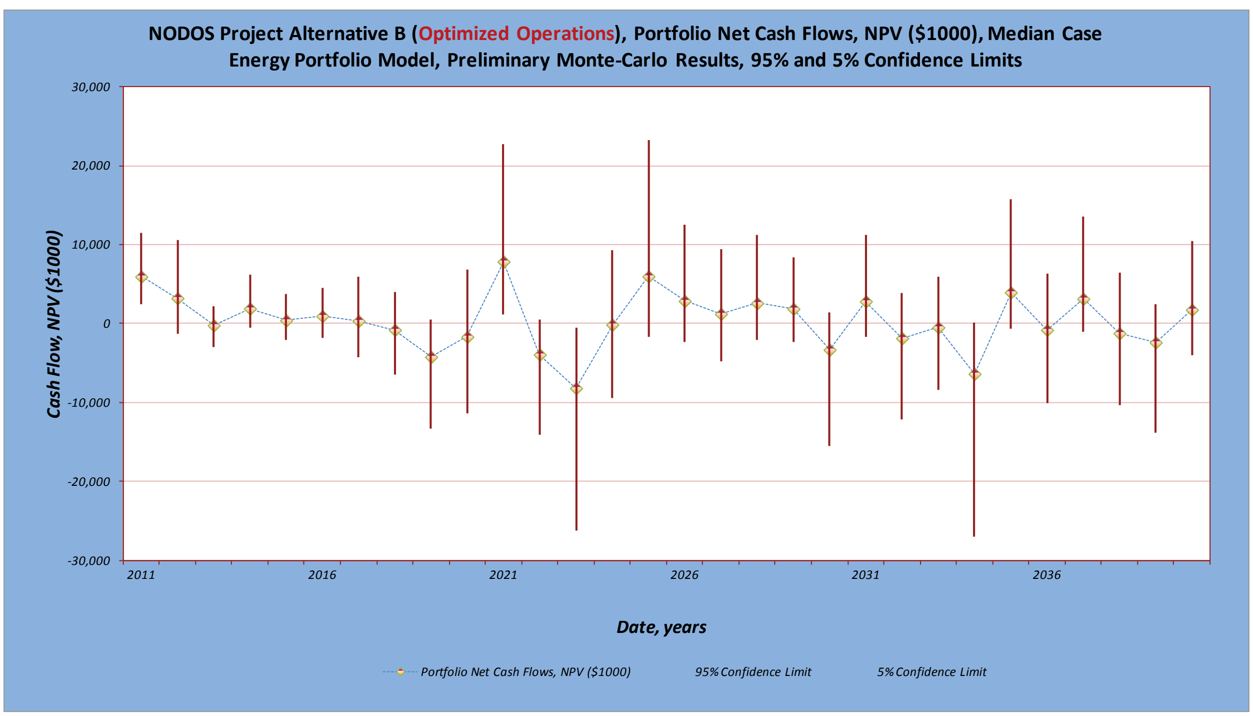


Figure H.B-6. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative B

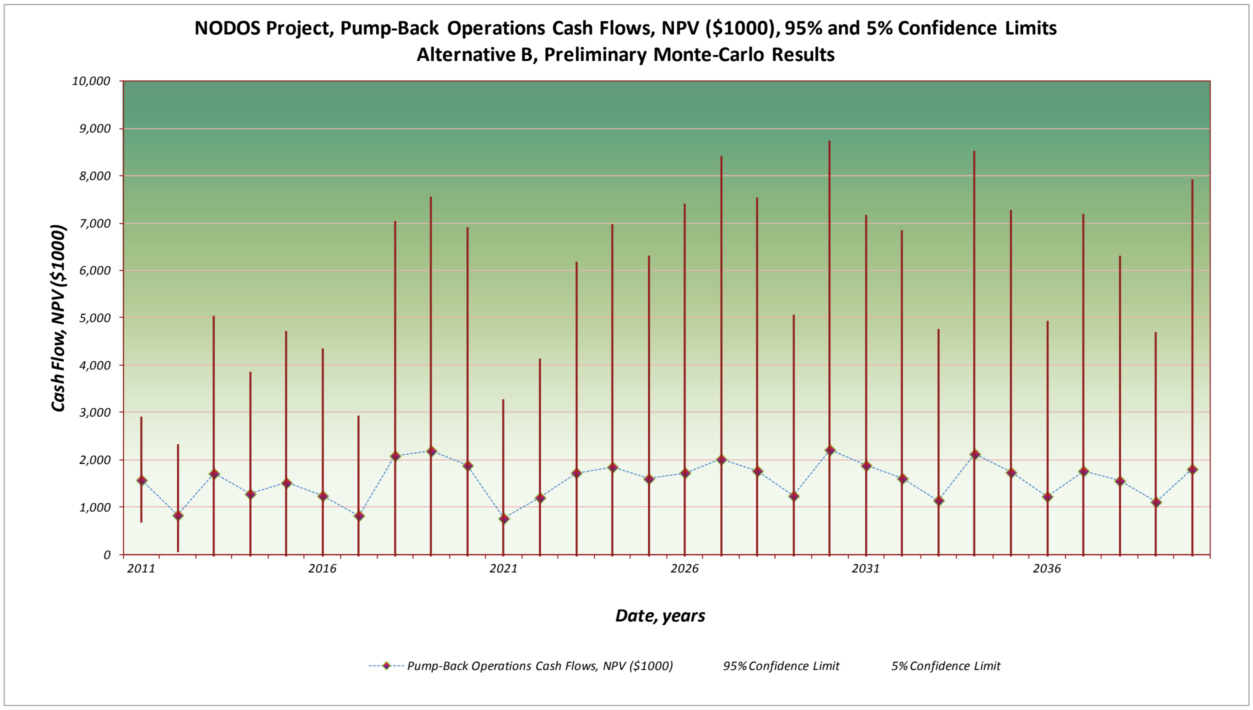


Figure H.B-7. NODOS Project, Power Portfolio-Annual Cash Flow, "Pumpback," Alternative B

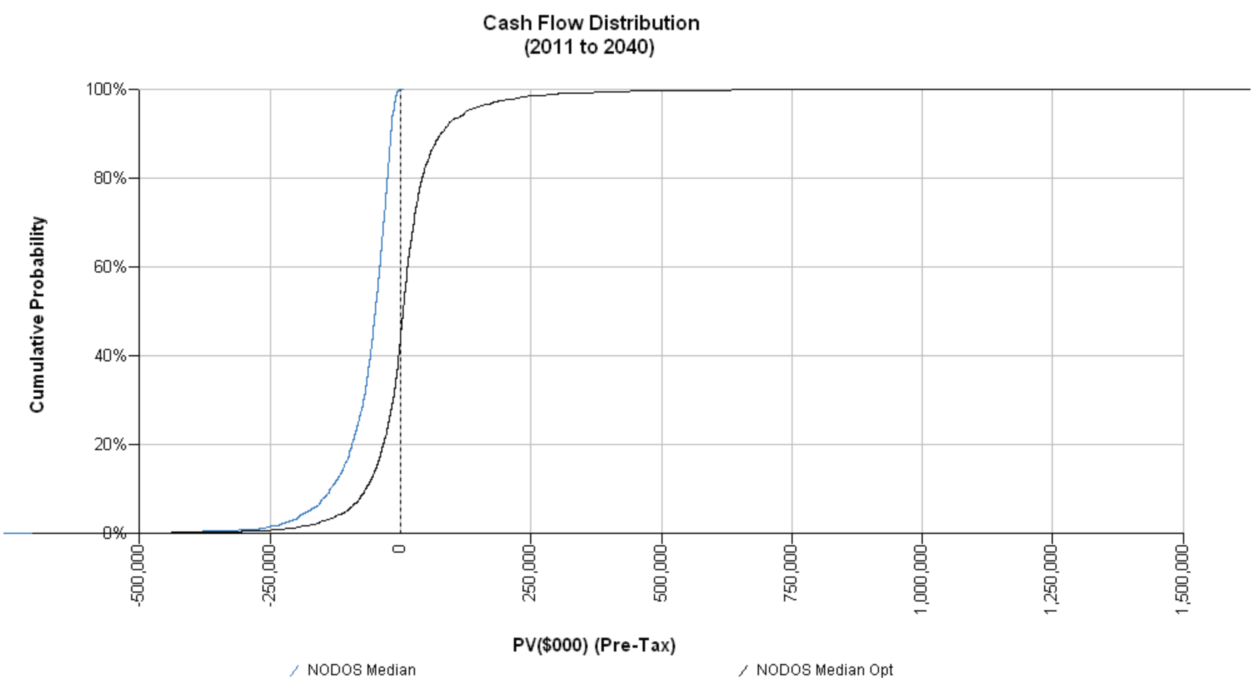


Figure H.B-8. NODOS Project, Power Portfolio Cumulative Probability Distribution, Alternative B "Incidental" vs. "Optimized"

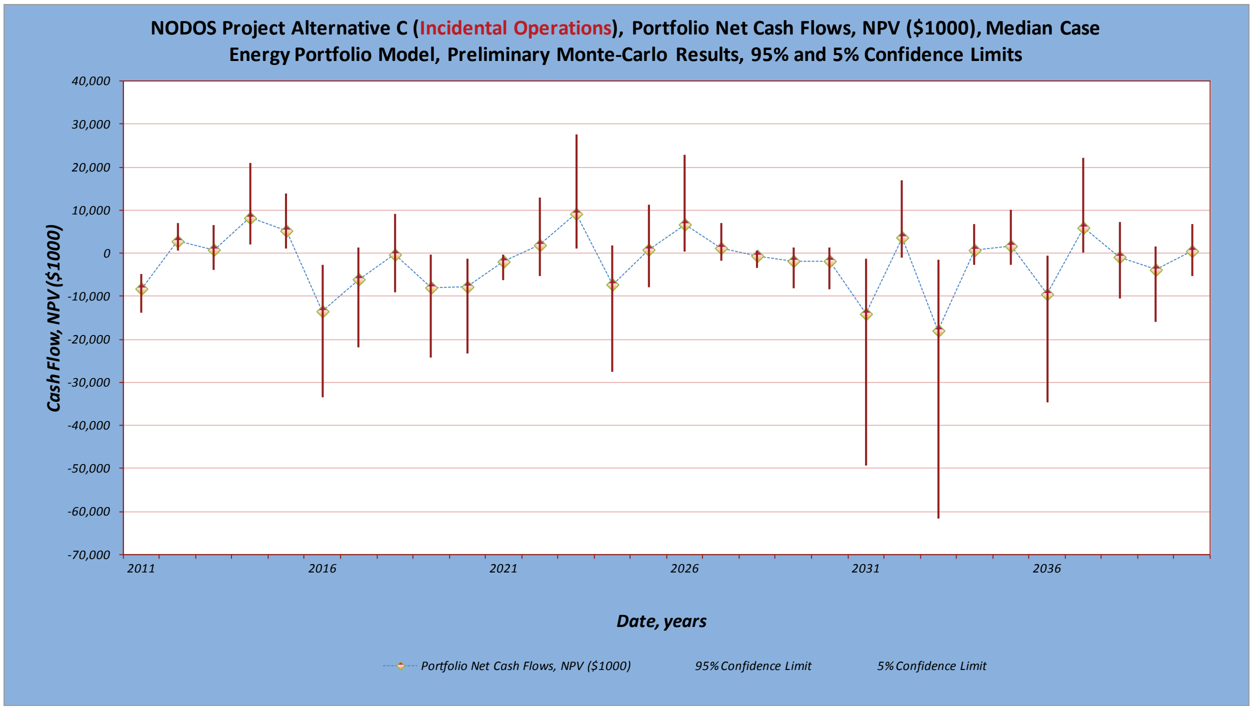


Figure H.B-9. NODOS Project, Power Portfolio-Annual Cash Flow, "Incidental," Alternative B

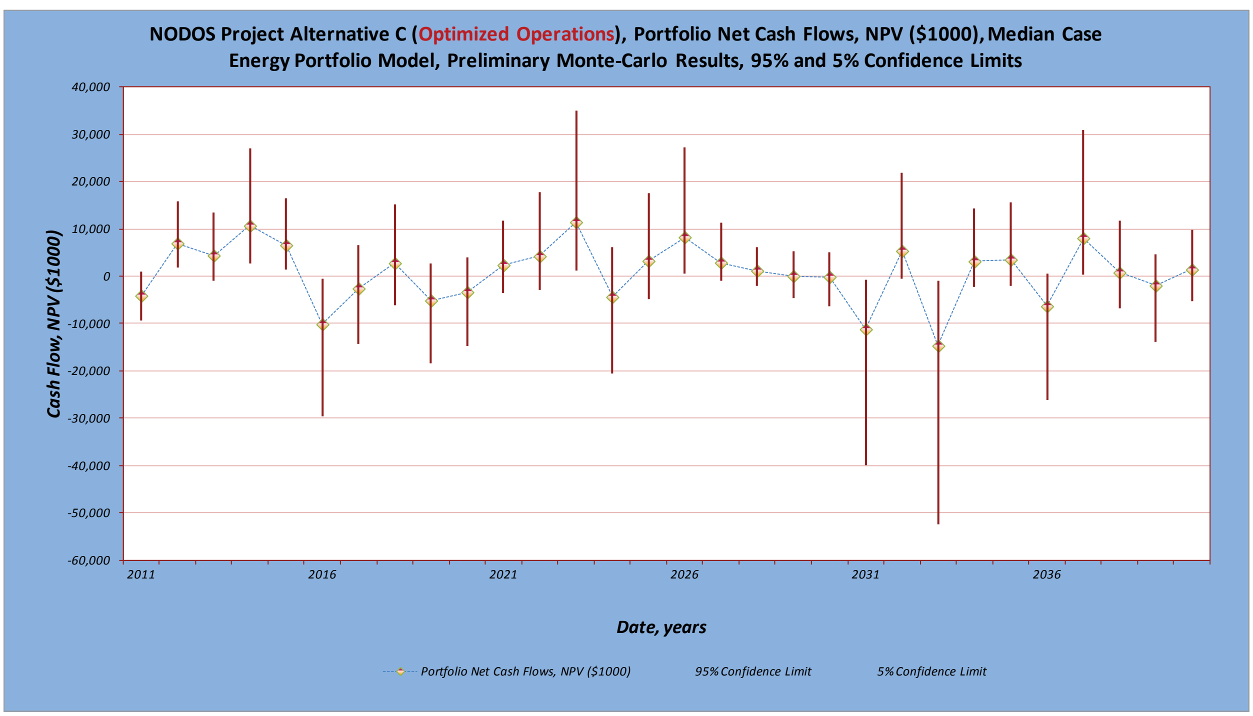


Figure H.B-10. NODOS Project, Power Portfolio-Annual Cash Flow, "Optimized," Alternative C

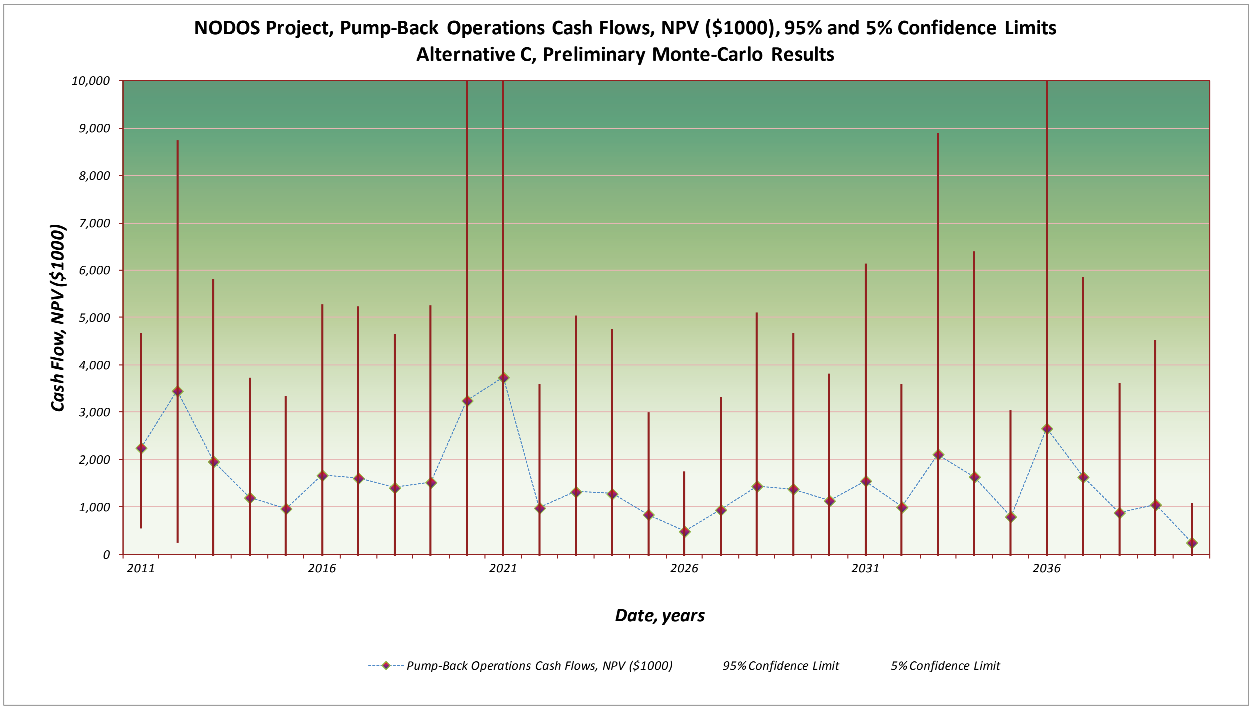


Figure H.B-11. NODOS Project, Power Portfolio-Annual Cash Flow, "Pumpback," Alternative C

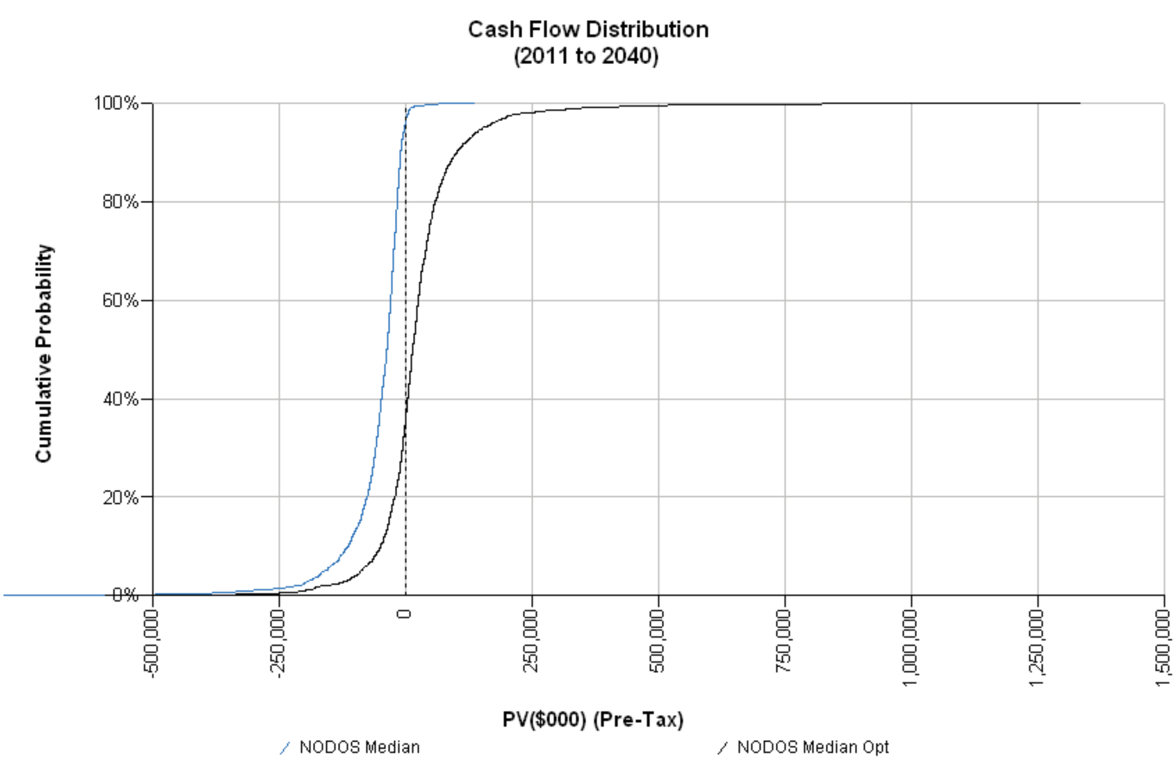


Figure H.B-12 NODOS Project, Power Portfolio Cumulative Probability Distribution, Alternative C "Incidental" vs. "Optimized"

This page intentionally left blank

Attachment C – NODOS Project Power Operations

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)

		Incidental Pumping and Generation to Water Releases (no shaping)							
		Incidental Pumping , MW					Incidental Generation, MW		
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
1	744	2.28	0.37	2.73	39.11	118.75	0.00	0.00	0.00
2	672	1.46	0.06	0.00	3.13	44.87	0.00	0.00	0.00
3	744	0.03	0.09	0.00	0.00	0.11	0.05	0.00	0.00
4	720	0.49	2.11	0.00	0.00	0.63	0.37	0.00	0.00
5	744	0.45	2.12	0.00	0.00	0.00	2.52	0.40	0.40
6	720	0.59	1.66	0.00	0.53	0.00	36.39	7.38	6.41
7	744	0.65	1.55	0.00	30.75	0.18	60.89	7.30	0.00
8	744	1.10	2.03	0.00	1.01	0.00	12.45	0.60	4.96
9	720	0.09	0.35	0.00	0.00	0.00	23.79	1.52	9.10
10	744	0.08	0.69	0.00	0.00	0.00	12.94	0.16	5.11
11	720	2.44	1.55	12.30	42.85	151.73	9.86	0.00	0.00
12	744	1.39	0.19	0.00	2.52	41.50	0.02	0.00	0.00
13	744	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
14	672	0.00	0.06	0.00	0.00	0.00	9.91	0.00	0.00
15	744	0.01	0.09	0.00	0.00	0.09	2.12	0.00	0.00
16	720	0.08	1.87	0.00	0.00	0.81	26.21	0.00	0.00
17	744	0.83	2.25	0.32	0.33	1.53	1.43	0.05	0.00
18	720	0.66	2.70	0.00	8.05	0.00	0.71	1.26	0.07
19	744	1.31	2.35	0.00	0.00	0.00	3.19	1.21	3.96
20	744	1.20	2.81	6.01	2.17	23.49	49.02	0.00	0.31
21	720	0.11	0.39	0.00	0.00	0.00	21.02	1.70	5.27
22	744	0.10	0.41	0.00	0.00	0.00	13.78	2.46	2.36
23	720	0.01	0.30	0.00	0.00	0.00	6.01	1.54	9.11
24	744	0.00	0.08	0.00	0.00	0.00	0.32	0.71	2.00
25	744	0.00	0.13	0.00	2.41	5.12	0.00	0.04	0.00
26	696	2.00	0.49	3.95	29.40	108.94	0.00	0.00	0.00
27	744	0.24	0.10	0.00	2.52	11.82	0.12	0.00	0.00
28	720	0.09	1.95	0.00	0.00	0.86	0.32	0.00	0.00
29	744	0.99	2.20	0.00	0.41	0.88	0.16	0.31	0.00
30	720	0.63	1.93	0.00	7.86	0.00	1.48	5.96	0.00
31	744	0.65	1.53	0.00	0.16	0.00	24.09	7.18	2.93
32	744	1.58	2.76	5.85	2.52	33.19	12.00	0.08	1.01
33	720	0.11	0.37	0.00	0.00	0.00	34.96	1.71	9.09
34	744	0.01	0.39	0.00	0.00	0.00	34.33	2.41	2.74
35	720	0.00	0.31	0.00	0.00	0.00	28.76	1.59	9.11
36	744	0.00	0.15	0.00	0.00	0.00	6.54	1.06	3.97
37	744	0.00	0.13	0.00	0.00	0.00	0.36	0.06	0.20
38	672	0.08	0.09	0.00	0.00	0.02	0.00	0.00	0.00
39	744	2.31	0.37	1.01	5.64	66.64	0.00	0.00	0.56
40	720	0.08	2.46	0.00	0.00	0.00	0.29	0.00	8.07
41	744	0.10	2.26	0.00	0.00	0.00	0.00	0.51	9.07
42	720	0.05	1.65	0.00	0.00	0.00	14.39	7.29	8.00
43	744	0.06	1.39	0.00	0.00	0.00	58.89	7.39	9.10
44	744	0.09	1.89	0.00	0.00	0.00	35.51	0.43	5.36
45	720	0.04	0.58	0.00	0.00	0.00	9.79	0.05	5.68
46	744	0.07	0.76	0.00	0.00	0.00	0.00	0.07	8.31
47	720	0.01	0.52	0.00	0.00	0.00	8.93	0.05	6.11
48	744	0.00	0.27	0.00	0.00	0.00	0.00	0.05	9.06
49	744	0.00	0.08	0.00	0.00	0.00	0.00	0.00	1.42
50	672	0.01	0.08	0.00	0.00	0.00	0.00	0.02	9.10
51	744	0.04	0.11	0.00	0.00	0.00	0.03	0.39	9.00
52	720	0.02	1.12	0.00	0.00	0.00	0.12	7.07	9.05
53	744	0.01	0.73	0.00	0.00	0.00	0.21	5.26	7.61
54	720	0.03	1.14	0.00	0.00	0.00	1.12	7.40	9.11
55	744	0.29	1.36	0.00	0.00	0.00	11.20	4.49	2.76
56	744	0.43	1.30	0.00	2.31	2.02	0.54	0.26	0.00
57	720	0.12	0.35	0.00	0.00	0.05	24.83	0.00	0.00
58	744	0.07	0.56	0.00	0.00	0.02	36.54	0.00	0.00
59	720	0.01	0.32	0.00	0.00	0.01	30.75	0.00	0.00
60	744	1.62	0.75	5.83	9.62	39.96	10.00	0.00	0.00

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)

		Incidental Pumping and Generation to Water Releases (no shaping)							
		Incidental Pumping , MW					Incidental Generation, MW		
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
61	744	2.05	0.30	2.27	32.51	66.47	0.00	0.00	0.00
62	672	2.44	0.47	3.95	44.01	94.21	0.37	0.00	0.00
63	744	2.44	1.76	18.06	44.01	139.51	8.38	0.00	0.00
64	720	2.15	2.67	8.65	0.00	73.77	1.27	0.00	0.00
65	744	2.58	2.86	6.00	1.33	59.19	12.80	0.00	0.00
66	720	0.66	1.67	0.00	34.96	0.29	57.85	7.32	0.00
67	744	0.70	1.55	0.00	36.59	0.26	55.69	7.30	0.00
68	744	1.18	2.01	0.00	0.97	0.00	24.53	0.61	4.70
69	720	0.11	0.35	0.00	0.00	0.00	9.42	1.41	9.07
70	744	0.26	0.76	0.00	0.00	0.00	8.08	0.14	9.11
71	720	0.02	0.46	0.00	0.00	0.00	7.69	0.05	9.08
72	744	0.00	0.27	0.00	0.00	0.00	0.49	0.05	5.07
73	744	2.28	0.24	1.85	36.37	101.85	0.00	0.00	0.00
74	696	1.83	0.31	2.24	21.80	84.98	0.00	0.00	0.00
75	744	2.43	1.44	13.64	13.93	128.23	0.00	0.00	0.00
76	720	0.05	2.77	6.11	0.00	20.69	24.83	0.00	0.00
77	744	0.46	2.14	0.00	0.00	0.31	1.31	0.40	0.36
78	720	0.39	1.66	0.00	0.46	0.00	0.69	7.38	5.82
79	744	0.42	1.50	0.00	24.05	0.02	1.49	7.55	0.00
80	744	0.70	1.29	0.00	0.70	0.00	24.47	5.07	6.56
81	720	0.06	0.34	0.00	0.00	0.00	16.73	1.84	9.07
82	744	0.04	0.41	0.00	0.00	0.00	8.43	2.36	2.42
83	720	0.00	0.25	0.00	0.00	0.00	0.54	1.21	5.86
84	744	0.00	0.15	0.00	0.00	0.00	0.00	0.09	4.70
85	744	2.28	0.27	1.81	38.52	110.89	0.00	0.00	0.15
86	672	2.44	0.47	3.81	27.81	118.63	0.00	0.00	0.00
87	744	0.01	0.10	0.00	0.00	0.08	0.00	0.00	0.00
88	720	0.06	2.00	0.00	0.00	0.65	22.95	0.02	0.00
89	744	0.20	1.89	0.00	0.14	0.00	18.21	0.69	0.00
90	720	0.50	1.62	0.00	2.37	0.00	51.29	7.19	0.18
91	744	1.24	1.78	0.00	0.00	0.00	53.56	5.96	4.41
92	744	1.00	2.03	0.00	0.00	0.00	33.01	0.44	5.38
93	720	0.09	0.36	0.00	0.00	0.00	22.72	1.72	9.08
94	744	0.07	0.43	0.00	0.00	0.00	20.96	2.56	9.00
95	720	0.02	0.33	0.00	0.00	0.00	18.60	1.56	9.10
96	744	0.00	0.18	0.00	0.00	0.00	0.13	0.09	0.83
97	744	2.12	0.37	2.73	33.66	102.75	0.00	0.00	0.00
98	672	2.26	0.49	3.95	38.61	120.06	0.00	0.00	0.00
99	744	2.13	0.28	1.83	3.05	66.87	0.00	0.05	0.00
100	720	0.17	1.77	0.00	1.92	0.31	0.81	0.67	0.44
101	744	0.52	2.02	0.00	0.00	0.00	8.85	0.51	9.10
102	720	0.48	1.57	0.00	0.00	0.00	11.56	7.32	9.07
103	744	0.50	1.48	0.00	25.43	0.00	50.55	7.64	0.05
104	744	0.38	1.00	0.00	0.00	0.00	10.53	5.80	9.11
105	720	0.15	0.54	0.00	0.00	0.00	7.69	0.44	8.86
106	744	0.07	0.69	0.00	0.00	0.01	0.47	0.00	0.69
107	720	0.01	0.32	0.00	0.00	0.01	0.02	0.00	0.00
108	744	1.74	1.16	9.45	24.98	104.10	0.00	0.00	0.00
109	744	2.36	0.37	2.73	41.51	122.79	0.00	0.00	0.00
110	672	1.27	0.06	0.00	3.30	40.30	0.00	0.00	0.00
111	744	0.01	0.07	0.00	0.00	0.06	0.01	0.00	0.00
112	720	0.07	1.41	0.00	0.00	0.49	0.15	0.00	0.00
113	744	0.74	2.28	0.82	0.45	3.38	0.25	0.00	0.00
114	720	0.62	2.78	0.00	8.31	3.58	5.01	0.00	0.00
115	744	1.54	2.79	0.00	0.17	0.00	61.68	0.03	4.53
116	744	1.22	2.07	0.00	0.00	0.00	13.23	0.12	4.81
117	720	0.09	0.38	0.00	0.00	0.00	24.86	1.27	2.75
118	744	0.58	2.08	12.35	2.48	57.67	10.14	0.00	0.19
119	720	0.00	0.24	0.00	0.00	0.00	9.07	0.86	1.32
120	744	0.00	0.20	0.00	1.78	3.96	0.08	0.06	0.04

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Incidental Pumping and Generation to Water Releases (no shaping)							
		Incidental Pumping , MW					Incidental Generation, MW		
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
121	744	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
122	696	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
123	744	0.02	0.05	0.00	0.00	0.08	1.70	0.00	0.00
124	720	0.05	1.31	0.00	0.00	0.40	26.04	0.00	0.00
125	744	0.63	2.06	0.00	0.51	0.64	26.32	0.00	0.00
126	720	0.63	2.85	0.00	8.60	0.40	20.96	0.02	0.00
127	744	0.73	2.79	0.00	12.94	5.98	47.01	0.00	0.06
128	744	1.17	2.05	0.00	0.00	0.00	23.16	0.03	4.06
129	720	0.28	1.61	9.01	0.00	27.36	16.57	0.10	0.35
130	744	0.19	0.45	0.00	0.00	0.00	7.31	2.36	1.31
131	720	0.39	0.26	0.00	2.52	14.65	0.36	0.20	0.03
132	744	0.00	0.08	0.00	0.00	0.00	0.00	0.61	0.00
133	744	0.00	0.13	0.00	0.00	0.00	0.00	0.03	0.00
134	672	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.00
135	744	0.05	0.13	0.00	0.00	0.19	0.00	0.06	0.00
136	720	0.09	2.34	0.00	0.00	0.00	0.00	1.17	0.00
137	744	0.34	2.21	0.00	0.00	0.00	0.58	0.48	0.07
138	720	0.52	1.64	0.00	0.00	0.00	10.08	7.38	2.08
139	744	0.58	1.39	0.00	0.00	0.00	58.38	7.39	9.08
140	744	0.91	1.65	0.00	0.00	0.00	3.47	2.28	9.00
141	720	0.08	0.33	0.00	0.00	0.00	32.00	1.71	9.02
142	744	0.03	0.42	0.00	0.00	0.00	26.50	2.29	9.01
143	720	2.03	1.32	9.80	29.23	111.92	25.39	0.00	0.00
144	744	2.05	1.40	11.39	11.23	102.39	0.00	0.00	0.00
145	744	0.03	0.12	0.00	1.54	4.07	0.00	0.00	0.00
146	672	2.44	0.39	3.37	2.80	77.77	0.00	0.00	0.00
147	744	0.21	0.10	0.00	2.52	10.65	0.04	0.00	0.83
148	720	0.19	2.17	0.00	0.00	0.00	0.90	0.00	9.10
149	744	0.74	2.22	0.00	0.00	0.00	12.56	0.32	9.00
150	720	0.44	1.55	0.00	0.00	0.00	48.11	7.45	9.00
151	744	0.47	1.40	0.00	0.00	0.00	6.27	7.33	9.00
152	744	0.79	2.00	0.00	0.00	0.00	45.16	0.50	9.00
153	720	0.28	0.55	0.00	0.00	0.00	18.63	0.05	9.08
154	744	0.16	0.74	0.00	0.00	0.00	10.04	0.07	6.03
155	720	0.01	0.27	0.00	0.00	0.00	7.02	0.05	6.04
156	744	0.00	0.21	0.00	0.00	0.00	0.40	0.00	0.33
157	744	2.28	0.29	2.40	38.48	98.32	0.00	0.00	0.00
158	672	2.09	0.49	3.95	33.70	101.78	0.00	0.00	0.00
159	744	2.43	1.79	17.87	44.01	164.58	0.02	0.00	0.00
160	720	0.40	2.76	7.08	0.00	35.14	0.10	0.01	0.00
161	744	0.10	1.89	0.00	0.97	0.00	0.12	1.31	0.00
162	720	0.37	1.64	0.00	22.33	0.00	1.07	7.42	0.13
163	744	0.42	1.40	0.00	0.00	0.00	19.12	7.39	9.06
164	744	0.69	2.01	0.00	0.00	0.00	11.44	0.52	8.71
165	720	0.05	0.36	0.00	0.00	0.00	27.67	1.37	9.10
166	744	0.17	0.76	0.00	0.00	0.00	13.82	0.16	5.68
167	720	0.02	0.54	0.00	0.00	0.00	28.63	0.11	9.11
168	744	0.00	0.14	0.00	0.00	0.00	9.69	0.90	4.06
169	744	0.40	0.07	0.00	2.48	12.99	0.00	0.06	0.18
170	696	2.18	0.49	3.95	34.58	107.91	0.00	0.00	0.00
171	744	2.21	1.59	15.14	28.93	142.42	0.07	0.00	0.00
172	720	0.18	2.17	0.00	0.00	0.00	0.84	0.00	9.10
173	744	0.24	2.21	0.00	0.32	0.00	10.58	0.47	9.11
174	720	0.14	1.69	0.00	15.48	0.00	36.58	7.12	0.00
175	744	0.14	1.91	0.00	0.10	0.00	57.37	4.22	9.10
176	744	0.25	2.03	0.00	0.00	0.00	29.93	0.19	9.00
177	720	0.12	0.62	0.00	0.00	0.00	14.59	0.00	9.00
178	744	0.09	0.74	0.00	0.00	0.00	1.20	0.00	9.00
179	720	0.01	0.41	0.00	0.00	0.00	5.18	0.00	9.08
180	744	0.00	0.16	0.00	0.00	0.00	0.27	0.00	5.83

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Incidental Pumping and Generation to Water Releases (no shaping)							
		Incidental Pumping , MW					Incidental Generation, MW		
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
181	744	2.20	0.27	1.81	36.03	96.72	0.00	0.00	0.06
182	672	0.09	0.06	0.00	0.62	3.12	0.00	0.00	0.97
183	744	0.01	0.10	0.00	0.00	0.00	0.06	0.30	9.11
184	720	0.00	1.25	0.00	0.00	0.00	0.31	5.66	8.43
185	744	0.00	1.12	0.00	0.00	0.00	0.46	5.64	7.74
186	720	0.03	1.86	0.00	0.00	0.00	6.87	5.94	9.06
187	744	0.00	2.74	0.00	0.00	0.00	24.34	0.31	9.00
188	744	0.00	2.09	0.00	0.00	0.00	26.02	0.00	9.00
189	720	0.00	0.61	0.00	0.00	0.00	34.04	0.00	9.00
190	744	0.06	0.77	0.00	0.00	0.00	11.53	0.00	9.08
191	720	0.01	0.43	0.00	0.00	0.00	27.28	0.00	5.60
192	744	0.00	0.21	0.00	0.00	0.00	0.00	0.00	4.77
193	744	0.00	0.13	0.00	0.00	0.00	0.00	0.00	1.15
194	672	0.00	0.08	0.00	0.00	0.00	0.00	0.00	9.07
195	744	2.04	1.49	14.25	29.72	84.73	0.08	0.00	0.00
196	720	0.92	2.74	5.74	0.00	30.93	0.82	0.29	0.86
197	744	0.11	1.36	0.00	0.00	0.00	11.40	5.66	9.10
198	720	0.37	2.80	0.00	0.00	0.00	34.49	0.38	9.00
199	744	0.38	2.71	0.00	0.00	0.00	57.44	0.00	9.00
200	744	0.30	1.98	0.00	0.00	0.00	27.13	0.00	9.06
201	720	0.11	0.38	0.00	0.00	0.00	25.02	0.00	5.53
202	744	0.07	0.71	0.00	0.00	0.00	23.24	0.00	5.30
203	720	0.01	0.51	0.00	0.00	0.00	12.76	0.00	0.37
204	744	0.00	0.30	0.00	0.00	0.00	0.60	0.00	0.00
205	744	2.38	0.09	0.46	20.31	50.80	0.00	0.00	0.04
206	672	0.00	0.06	0.00	0.00	0.00	0.00	0.00	6.09
207	744	0.01	0.10	0.00	0.00	0.00	0.60	0.30	0.85
208	720	0.00	1.64	0.00	0.00	0.00	9.95	5.43	7.25
209	744	0.00	1.57	0.00	0.00	0.00	0.00	0.78	4.43
210	720	0.00	1.70	0.00	17.20	0.00	3.11	7.05	0.03
211	744	0.00	2.73	0.00	0.19	0.00	45.31	0.40	2.29
212	744	0.00	1.94	0.00	2.26	2.32	20.78	0.00	0.02
213	720	0.00	0.59	0.00	2.56	2.67	31.82	0.00	0.20
214	744	0.06	0.77	0.00	0.00	0.00	2.29	0.00	3.03
215	720	0.02	0.53	0.00	0.00	0.00	26.26	0.00	0.20
216	744	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00
217	744	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
218	696	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
219	744	2.43	1.72	17.28	44.01	96.17	0.19	0.00	0.00
220	720	0.08	0.87	0.00	10.30	0.99	0.32	4.75	0.00
221	744	0.05	0.98	0.00	13.69	0.03	3.44	5.57	0.00
222	720	0.06	1.27	0.00	22.13	0.02	55.63	7.41	0.00
223	744	0.09	1.19	0.00	19.13	0.01	54.45	6.89	0.00
224	744	0.50	1.37	0.00	0.31	0.00	11.73	0.43	9.09
225	720	0.08	0.45	0.00	0.00	0.00	8.66	0.00	5.98
226	744	0.08	0.56	0.00	0.00	0.00	0.70	0.00	9.08
227	720	0.02	0.38	0.00	0.00	0.00	3.98	0.00	9.06
228	744	0.00	0.16	0.00	0.00	0.00	0.13	0.00	5.42
229	744	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.34
230	672	1.68	0.40	3.25	20.69	45.79	0.01	0.00	0.00
231	744	2.28	1.33	13.03	20.89	84.23	0.05	0.32	0.00
232	720	0.04	0.95	0.00	1.92	0.00	0.72	4.84	0.18
233	744	0.12	1.42	0.00	0.44	0.00	10.76	2.65	7.32
234	720	0.09	1.21	0.00	19.18	0.01	43.30	6.99	0.00
235	744	0.13	1.18	0.00	21.16	0.00	2.84	6.97	0.00
236	744	0.58	1.40	0.00	0.00	0.00	10.17	0.29	9.11
237	720	0.12	0.45	0.00	0.00	0.00	33.12	0.00	9.00
238	744	0.06	0.52	0.00	0.00	0.00	10.00	0.00	9.05
239	720	0.02	0.38	0.00	0.00	0.00	0.00	0.00	6.81
240	744	0.69	0.12	0.00	2.52	10.43	0.00	0.00	0.47

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)										
		Incidental Pumping and Generation to Water Releases (no shaping)								
		Incidental Pumping , MW					Incidental Generation, MW			
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River	
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
241	744	1.81	0.25	1.81	26.74	52.44	0.00	0.00	0.00
242	672	1.92	0.35	2.80	29.25	66.46	0.00	0.00	0.00
243	744	2.05	1.53	14.45	32.51	106.44	0.06	0.00	0.00
244	720	2.28	2.80	6.38	0.00	59.97	0.95	0.00	0.00
245	744	2.58	2.87	9.43	0.00	66.00	0.43	0.00	0.00
246	720	2.56	2.80	2.00	44.01	93.44	4.15	0.37	0.00
247	744	0.68	1.60	0.00	32.69	0.14	11.56	7.01	0.00
248	744	1.12	2.03	0.00	0.19	0.00	0.20	0.43	4.06
249	720	0.34	0.63	0.00	0.00	0.00	20.20	0.05	5.40
250	744	0.17	0.74	0.00	0.00	0.00	12.75	0.07	9.11
251	720	0.02	0.44	0.00	0.00	0.00	30.24	0.05	9.10
252	744	0.83	0.24	0.00	2.52	20.73	5.62	0.00	0.90
253	744	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
254	672	2.44	0.49	3.95	42.65	119.89	0.00	0.00	0.00
255	744	0.03	0.06	0.00	0.00	0.00	0.07	0.33	3.98
256	720	0.06	1.08	0.00	17.08	0.10	1.34	6.18	0.04
257	744	0.20	0.79	0.00	12.36	0.21	1.34	5.03	0.17
258	720	0.37	1.22	0.00	0.00	0.00	18.91	7.47	9.10
259	744	1.08	1.14	0.00	0.00	0.00	39.28	6.38	9.00
260	744	1.06	0.98	0.00	0.00	0.00	1.13	2.81	9.00
261	720	0.33	0.42	0.00	0.00	0.00	33.79	0.16	9.08
262	744	0.13	0.54	0.00	0.00	0.00	11.90	0.00	9.06
263	720	0.01	0.22	0.00	0.00	0.00	28.11	0.00	7.09
264	744	0.00	0.14	0.00	0.00	0.00	0.31	0.00	0.45
265	744	2.43	0.35	2.73	44.01	99.98	0.00	0.00	0.00
266	696	2.44	0.47	3.95	44.01	112.93	0.02	0.00	0.00
267	744	2.20	1.61	15.84	36.81	143.24	0.00	0.00	0.00
268	720	2.27	2.78	6.95	0.00	74.96	18.05	0.00	0.00
269	744	1.36	2.87	9.14	0.42	50.75	26.97	0.00	0.00
270	720	0.57	2.80	0.00	7.66	0.47	33.72	0.00	0.00
271	744	0.71	2.79	0.00	14.90	8.70	2.39	0.00	0.00
272	744	1.20	2.25	1.24	0.59	4.76	8.10	0.00	0.25
273	720	0.37	0.61	0.00	0.00	0.00	9.73	0.18	5.24
274	744	0.10	0.47	0.00	0.00	0.00	19.11	2.42	9.06
275	720	0.03	0.33	0.00	0.00	0.00	15.15	1.64	9.09
276	744	2.05	1.31	11.27	19.16	120.51	19.86	0.00	0.00
277	744	0.00	0.07	0.00	0.00	0.00	0.76	0.00	0.00
278	672	0.00	0.06	0.00	0.00	0.00	0.80	0.00	0.00
279	744	0.02	0.09	0.00	0.00	0.08	12.16	0.00	0.00
280	720	0.37	1.79	0.00	0.00	0.21	29.75	0.00	0.00
281	744	0.45	1.67	0.00	0.36	0.54	5.83	0.01	0.00
282	720	0.63	2.77	0.00	9.40	0.53	0.31	0.79	0.00
283	744	0.82	1.60	0.00	0.33	0.00	0.02	7.09	1.23
284	744	1.21	1.67	0.00	0.00	0.00	0.08	2.73	2.30
285	720	0.10	0.33	0.00	0.00	0.00	0.08	1.85	9.08
286	744	0.02	0.40	0.00	0.00	0.00	0.01	2.44	9.00
287	720	0.01	0.27	0.00	0.00	0.00	0.01	1.34	9.09
288	744	2.20	1.39	12.30	34.39	134.95	0.00	0.00	0.00
289	744	2.44	0.37	2.73	18.72	104.81	0.00	0.00	0.20
290	672	0.00	0.06	0.00	0.00	0.00	0.00	0.00	4.76
291	744	0.41	0.17	0.00	2.41	14.36	0.00	0.00	0.12
292	720	0.37	2.60	0.00	0.00	0.41	0.00	0.02	0.00
293	744	0.35	2.01	0.00	0.00	0.00	0.49	0.52	0.34
294	720	0.41	2.14	0.00	0.00	0.00	6.26	4.46	6.54
295	744	0.48	1.42	0.00	0.00	0.00	59.33	7.20	9.09
296	744	0.75	1.83	0.00	0.00	0.00	12.49	0.92	8.47
297	720	0.07	0.35	0.00	0.00	0.00	10.00	1.60	9.04
298	744	0.05	0.43	0.00	0.00	0.00	13.76	2.50	9.00
299	720	0.01	0.20	0.00	0.00	0.00	24.50	0.94	9.10
300	744	2.43	0.57	3.27	23.77	97.81	9.17	0.00	0.00

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Incidental Pumping and Generation to Water Releases (no shaping)							
		Incidental Pumping , MW					Incidental Generation, MW		
		TC Canal	GCID Canal	TRR	Sac River	Sites	Sites	TRR	Sac River
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35	123.00	9.33	10.80
Plant Capacity, cfs		2250	3000	1890	2000	5900	5100	1500	1500
Month	# of Hours	All Hours					All Hours		
301	744	2.35	0.37	2.67	41.51	116.77	0.00	0.00	0.00
302	672	2.44	0.49	3.95	44.01	132.32	0.00	0.00	0.00
303	744	0.05	0.09	0.00	2.52	6.79	0.05	0.00	0.00
304	720	0.04	1.63	0.00	0.00	0.43	0.07	0.00	0.00
305	744	0.12	1.23	0.00	0.44	0.57	3.25	0.00	0.00
306	720	0.56	2.81	0.00	11.35	6.40	56.59	0.00	0.00
307	744	0.74	2.80	0.00	9.88	0.02	4.18	0.00	0.00
308	744	1.23	2.09	0.00	0.00	0.00	19.96	0.03	4.24
309	720	0.34	1.63	9.01	0.00	27.49	17.67	0.15	0.41
310	744	0.05	0.44	0.00	0.00	0.00	9.66	2.32	1.30
311	720	0.46	0.40	0.00	2.59	16.87	9.01	0.19	0.06
312	744	0.00	0.15	0.00	0.00	0.00	0.35	0.94	0.00
313	744	0.00	0.08	0.00	0.00	0.00	0.00	0.05	0.00
314	696	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
315	744	0.01	0.09	0.00	0.00	0.12	0.07	0.00	0.00
316	720	0.17	1.98	0.55	0.00	2.44	0.83	0.00	0.00
317	744	0.80	2.20	0.00	0.45	0.58	10.90	0.08	0.00
318	720	0.56	2.51	0.00	5.94	0.00	27.20	1.64	0.22
319	744	0.66	1.45	0.00	0.00	0.00	25.47	7.07	9.10
320	744	1.10	1.90	0.00	0.00	0.00	12.09	0.54	5.80
321	720	0.11	0.36	0.00	0.00	0.00	33.38	1.70	9.08
322	744	0.08	0.44	0.00	0.00	0.00	33.47	2.53	9.00
323	720	0.01	0.28	0.00	0.00	0.00	24.74	1.33	9.10
324	744	0.00	0.29	0.00	2.04	3.96	1.42	0.08	0.54
325	744	2.12	0.25	2.02	34.58	101.13	0.00	0.00	0.00
326	672	2.44	0.47	3.81	44.01	128.19	0.00	0.00	0.00
327	744	2.22	0.07	0.00	2.52	62.50	0.00	0.00	0.00
328	720	0.07	1.88	0.00	0.00	0.57	1.59	0.00	0.00
329	744	0.72	1.76	0.00	0.00	0.62	26.42	0.46	0.08
330	720	0.72	1.57	0.00	0.00	0.00	2.41	7.32	1.93
331	744	0.70	1.35	0.00	0.00	0.00	0.99	7.60	9.10
332	744	0.55	1.12	0.00	0.00	0.00	26.88	5.91	8.00
333	720	0.30	0.56	0.00	0.00	0.00	18.20	0.36	5.62
334	744	0.07	0.70	0.00	0.00	0.00	1.03	0.07	9.06
335	720	0.01	0.51	0.00	0.00	0.00	0.03	0.11	9.08
336	744	0.00	0.16	0.00	0.00	0.00	0.00	1.00	3.86
337	744	2.44	0.34	2.40	15.21	84.68	0.00	0.00	0.20
338	672	2.09	0.25	1.68	33.70	100.03	0.00	0.00	0.00
339	744	2.28	1.67	16.46	37.23	156.42	0.04	0.00	0.00
340	720	0.23	1.97	0.00	0.00	0.47	0.15	0.00	7.61
341	744	0.18	2.20	0.00	0.00	0.00	0.18	0.40	9.09
342	720	0.20	1.62	0.00	21.74	0.00	0.21	7.38	0.26
343	744	0.22	1.47	0.00	20.87	0.00	0.50	7.60	0.00
344	744	0.17	0.83	0.00	0.16	0.00	9.80	6.01	9.10
345	720	0.07	0.28	0.00	0.00	0.00	9.92	1.84	9.00
346	744	0.02	0.42	0.00	0.00	0.00	0.00	2.44	9.08
347	720	0.01	0.20	0.00	0.00	0.00	5.08	1.03	4.50
348	744	0.00	0.15	0.00	0.00	0.00	0.14	0.08	4.61
349	744	2.20	0.22	1.36	36.01	100.53	0.00	0.00	0.08
350	672	0.55	0.06	0.00	2.80	18.81	0.00	0.00	0.00
351	744	2.44	0.48	3.54	5.95	79.66	0.02	0.42	0.18
352	720	0.08	1.51	0.00	0.00	0.00	0.14	6.66	3.39
353	744	0.26	1.10	0.00	0.00	0.00	0.15	5.54	8.32
354	720	0.39	1.81	0.00	0.00	0.00	0.36	6.56	8.80
355	744	0.43	1.39	0.00	0.00	0.00	0.67	7.39	9.03
356	744	0.72	1.48	0.00	0.00	0.00	8.98	3.19	9.00
357	720	0.07	0.33	0.00	0.00	0.00	0.26	1.74	9.00
358	744	0.06	0.43	0.00	0.00	0.00	9.34	2.49	9.00
359	720	0.01	0.26	0.00	0.00	0.00	0.17	1.25	9.09
360	744	2.13	1.35	11.80	32.29	100.44	1.74	0.00	0.00

Table H.C-1. NODOS Project, Power Operations, "Incidental," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
1	744	2.28	0.37	2.73	39.11	79.00	32924	169.89	55732	2305	5900
2	672	1.46	0.06	0.00	3.13	0.00	0	104.73	30207	0	5900
3	744	0.03	0.09	0.00	0.00	0.00	0	0.00	0	0	0
4	720	0.49	2.11	0.00	0.00	0.00	0	0.00	0	0	0
5	744	0.45	2.12	0.00	0.00	0.00	0	0.00	0	0	0
6	720	0.59	1.66	0.00	0.53	0.00	0	0.00	0	0	0
7	744	0.65	1.55	0.00	30.75	0.00	0	0.00	0	0	0
8	744	1.10	2.03	0.00	1.01	0.00	0	0.00	0	0	0
9	720	0.09	0.35	0.00	0.00	0.00	0	0.00	0	0	0
10	744	0.08	0.69	0.00	0.00	0.00	0	0.00	0	0	0
11	720	2.44	1.55	12.30	42.85	110.00	45589	168.00	63794	3336	5900
12	744	1.39	0.19	0.00	2.52	0.00	0	80.24	30910	0	5680
13	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
14	672	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
15	744	0.01	0.09	0.00	0.00	0.00	0	0.00	0	0	0
16	720	0.08	1.87	0.00	0.00	0.00	0	0.00	0	0	0
17	744	0.83	2.25	0.32	0.33	0.00	0	0.00	0	0	0
18	720	0.66	2.70	0.00	8.05	0.00	0	0.00	0	0	0
19	744	1.31	2.35	0.00	0.00	0.00	0	0.00	0	0	0
20	744	1.20	2.81	6.01	2.17	0.00	0	42.96	17481	0	4695
21	720	0.11	0.39	0.00	0.00	0.00	0	0.00	0	0	0
22	744	0.10	0.41	0.00	0.00	0.00	0	0.00	0	0	0
23	720	0.01	0.30	0.00	0.00	0.00	0	0.00	0	0	0
24	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
25	744	0.00	0.13	0.00	2.41	0.00	0	0.00	0	0	0
26	696	2.00	0.49	3.95	29.40	27.00	10797	172.65	65326	795	5900
27	744	0.24	0.10	0.00	2.52	0.00	0	24.06	8791	0	3985
28	720	0.09	1.95	0.00	0.00	0.00	0	0.00	0	0	0
29	744	0.99	2.20	0.00	0.41	0.00	0	0.00	0	0	0
30	720	0.63	1.93	0.00	7.86	0.00	0	0.00	0	0	0
31	744	0.65	1.53	0.00	0.16	0.00	0	0.00	0	0	0
32	744	1.58	2.76	5.85	2.52	0.00	0	60.36	24705	0	5308
33	720	0.11	0.37	0.00	0.00	0.00	0	0.00	0	0	0
34	744	0.01	0.39	0.00	0.00	0.00	0	0.00	0	0	0
35	720	0.00	0.31	0.00	0.00	0.00	0	0.00	0	0	0
36	744	0.00	0.15	0.00	0.00	0.00	0	0.00	0	0	0
37	744	0.00	0.13	0.00	0.00	0.00	0	0.00	0	0	0
38	672	0.08	0.09	0.00	0.00	0.00	0	0.00	0	0	0
39	744	2.31	0.37	1.01	5.64	0.00	0	122.47	49721	0	5900
40	720	0.08	2.46	0.00	0.00	0.00	0	0.00	0	0	0
41	744	0.10	2.26	0.00	0.00	0.00	0	0.00	0	0	0
42	720	0.05	1.65	0.00	0.00	0.00	0	0.00	0	0	0
43	744	0.06	1.39	0.00	0.00	0.00	0	0.00	0	0	0
44	744	0.09	1.89	0.00	0.00	0.00	0	0.00	0	0	0
45	720	0.04	0.58	0.00	0.00	0.00	0	0.00	0	0	0
46	744	0.07	0.76	0.00	0.00	0.00	0	0.00	0	0	0
47	720	0.01	0.52	0.00	0.00	0.00	0	0.00	0	0	0
48	744	0.00	0.27	0.00	0.00	0.00	0	0.00	0	0	0
49	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
50	672	0.01	0.08	0.00	0.00	0.00	0	0.00	0	0	0
51	744	0.04	0.11	0.00	0.00	0.00	0	0.00	0	0	0
52	720	0.02	1.12	0.00	0.00	0.00	0	0.00	0	0	0
53	744	0.01	0.73	0.00	0.00	0.00	0	0.00	0	0	0
54	720	0.03	1.14	0.00	0.00	0.00	0	0.00	0	0	0
55	744	0.29	1.36	0.00	0.00	0.00	0	0.00	0	0	0
56	744	0.43	1.30	0.00	2.31	0.00	0	0.00	0	0	0
57	720	0.12	0.35	0.00	0.00	0.00	0	0.00	0	0	0
58	744	0.07	0.56	0.00	0.00	0.00	0	0.00	0	0	0
59	720	0.01	0.32	0.00	0.00	0.00	0	0.00	0	0	0
60	744	1.62	0.75	5.83	9.62	0.00	0	69.90	29896	0	5900

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
61	744	2.05	0.30	2.27	32.51	10.00	4113	106.95	45669	457	5900
62	672	2.44	0.47	3.95	44.01	34.00	13189	123.00	50360	1412	5900
63	744	2.44	1.76	18.06	44.01	104.00	43177	140.80	60633	3648	5900
64	720	2.15	2.67	8.65	0.00	0.00	0	138.53	53345	0	5900
65	744	2.58	2.86	6.00	1.33	0.00	0	108.93	44142	0	5900
66	720	0.66	1.67	0.00	34.96	0.00	0	0.00	0	0	0
67	744	0.70	1.55	0.00	36.59	0.00	0	0.00	0	0	0
68	744	1.18	2.01	0.00	0.97	0.00	0	0.00	0	0	0
69	720	0.11	0.35	0.00	0.00	0.00	0	0.00	0	0	0
70	744	0.26	0.76	0.00	0.00	0.00	0	0.00	0	0	0
71	720	0.02	0.46	0.00	0.00	0.00	0	0.00	0	0	0
72	744	0.00	0.27	0.00	0.00	0.00	0	0.00	0	0	0
73	744	2.28	0.24	1.85	36.37	20.00	8120	152.22	67971	635	5900
74	696	1.83	0.31	2.24	21.80	0.00	0	143.63	59366	0	5900
75	744	2.43	1.44	13.64	13.93	55.00	23698	172.10	71988	1638	5900
76	720	0.05	2.77	6.11	0.00	0.00	0	40.42	14898	0	4432
77	744	0.46	2.14	0.00	0.00	0.00	0	0.00	0	0	0
78	720	0.39	1.66	0.00	0.46	0.00	0	0.00	0	0	0
79	744	0.42	1.50	0.00	24.05	0.00	0	0.00	0	0	0
80	744	0.70	1.29	0.00	0.70	0.00	0	0.00	0	0	0
81	720	0.06	0.34	0.00	0.00	0.00	0	0.00	0	0	0
82	744	0.04	0.41	0.00	0.00	0.00	0	0.00	0	0	0
83	720	0.00	0.25	0.00	0.00	0.00	0	0.00	0	0	0
84	744	0.00	0.15	0.00	0.00	0.00	0	0.00	0	0	0
85	744	2.28	0.27	1.81	38.52	21.00	8845	163.33	73970	644	5900
86	672	2.44	0.47	3.81	27.81	24.00	9226	173.72	70772	699	5900
87	744	0.01	0.10	0.00	0.00	0.00	0	0.00	0	0	0
88	720	0.06	2.00	0.00	0.00	0.00	0	0.00	0	0	0
89	744	0.20	1.89	0.00	0.14	0.00	0	0.00	0	0	0
90	720	0.50	1.62	0.00	2.37	0.00	0	0.00	0	0	0
91	744	1.24	1.78	0.00	0.00	0.00	0	0.00	0	0	0
92	744	1.00	2.03	0.00	0.00	0.00	0	0.00	0	0	0
93	720	0.09	0.36	0.00	0.00	0.00	0	0.00	0	0	0
94	744	0.07	0.43	0.00	0.00	0.00	0	0.00	0	0	0
95	720	0.02	0.33	0.00	0.00	0.00	0	0.00	0	0	0
96	744	0.00	0.18	0.00	0.00	0.00	0	0.00	0	0	0
97	744	2.12	0.37	2.73	33.66	18.00	7913	158.32	68850	595	5900
98	672	2.26	0.49	3.95	38.61	34.00	13186	167.51	67759	1037	5900
99	744	2.13	0.28	1.83	3.05	0.00	0	119.48	49857	0	5900
100	720	0.17	1.77	0.00	1.92	0.00	0	0.00	0	0	0
101	744	0.52	2.02	0.00	0.00	0.00	0	0.00	0	0	0
102	720	0.48	1.57	0.00	0.00	0.00	0	0.00	0	0	0
103	744	0.50	1.48	0.00	25.43	0.00	0	0.00	0	0	0
104	744	0.38	1.00	0.00	0.00	0.00	0	0.00	0	0	0
105	720	0.15	0.54	0.00	0.00	0.00	0	0.00	0	0	0
106	744	0.07	0.69	0.00	0.00	0.00	0	0.00	0	0	0
107	720	0.01	0.32	0.00	0.00	0.00	0	0.00	0	0	0
108	744	1.74	1.16	9.45	24.98	19.00	7737	157.67	70028	584	5900
109	744	2.36	0.37	2.73	41.51	39.00	17062	170.19	74590	1193	5900
110	672	1.27	0.06	0.00	3.30	0.00	0	65.01	27098	0	4141
111	744	0.01	0.07	0.00	0.00	0.00	0	0.00	0	0	0
112	720	0.07	1.41	0.00	0.00	0.00	0	0.00	0	0	0
113	744	0.74	2.28	0.82	0.45	0.00	0	0.00	0	0	0
114	720	0.62	2.78	0.00	8.31	0.00	0	0.00	0	0	0
115	744	1.54	2.79	0.00	0.17	0.00	0	0.00	0	0	0
116	744	1.22	2.07	0.00	0.00	0.00	0	0.00	0	0	0
117	720	0.09	0.38	0.00	0.00	0.00	0	0.00	0	0	0
118	744	0.58	2.08	12.35	2.48	0.00	0	99.71	42968	0	5900
119	720	0.00	0.24	0.00	0.00	0.00	0	0.00	0	0	0
120	744	0.00	0.20	0.00	1.78	0.00	0	0.00	0	0	0

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
121	744	0.00	0.07	0.00	0.00	0.00	0	0.00	0	0	0
122	696	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
123	744	0.02	0.05	0.00	0.00	0.00	0	0.00	0	0	0
124	720	0.05	1.31	0.00	0.00	0.00	0	0.00	0	0	0
125	744	0.63	2.06	0.00	0.51	0.00	0	0.00	0	0	0
126	720	0.63	2.85	0.00	8.60	0.00	0	0.00	0	0	0
127	744	0.73	2.79	0.00	12.94	0.00	0	0.00	0	0	0
128	744	1.17	2.05	0.00	0.00	0.00	0	0.00	0	0	0
129	720	0.28	1.61	9.01	0.00	0.00	0	48.12	19704	0	4599
130	744	0.19	0.45	0.00	0.00	0.00	0	0.00	0	0	0
131	720	0.39	0.26	0.00	2.52	0.00	0	23.63	10551	0	3028
132	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
133	744	0.00	0.13	0.00	0.00	0.00	0	0.00	0	0	0
134	672	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
135	744	0.05	0.13	0.00	0.00	0.00	0	0.00	0	0	0
136	720	0.09	2.34	0.00	0.00	0.00	0	0.00	0	0	0
137	744	0.34	2.21	0.00	0.00	0.00	0	0.00	0	0	0
138	720	0.52	1.64	0.00	0.00	0.00	0	0.00	0	0	0
139	744	0.58	1.39	0.00	0.00	0.00	0	0.00	0	0	0
140	744	0.91	1.65	0.00	0.00	0.00	0	0.00	0	0	0
141	720	0.08	0.33	0.00	0.00	0.00	0	0.00	0	0	0
142	744	0.03	0.42	0.00	0.00	0.00	0	0.00	0	0	0
143	720	2.03	1.32	9.80	29.23	38.00	15959	152.23	64901	1289	5900
144	744	2.05	1.40	11.39	11.23	11.00	4597	162.87	71909	336	5900
145	744	0.03	0.12	0.00	1.54	0.00	0	0.00	0	0	0
146	672	2.44	0.39	3.37	2.80	0.00	0	125.48	52377	0	5900
147	744	0.21	0.10	0.00	2.52	0.00	0	17.85	7924	0	2727
148	720	0.19	2.17	0.00	0.00	0.00	0	0.00	0	0	0
149	744	0.74	2.22	0.00	0.00	0.00	0	0.00	0	0	0
150	720	0.44	1.55	0.00	0.00	0.00	0	0.00	0	0	0
151	744	0.47	1.40	0.00	0.00	0.00	0	0.00	0	0	0
152	744	0.79	2.00	0.00	0.00	0.00	0	0.00	0	0	0
153	720	0.28	0.55	0.00	0.00	0.00	0	0.00	0	0	0
154	744	0.16	0.74	0.00	0.00	0.00	0	0.00	0	0	0
155	720	0.01	0.27	0.00	0.00	0.00	0	0.00	0	0	0
156	744	0.00	0.21	0.00	0.00	0.00	0	0.00	0	0	0
157	744	2.28	0.29	2.40	38.48	15.00	6403	142.61	67053	534	5900
158	672	2.09	0.49	3.95	33.70	12.00	4496	152.64	64183	388	5900
159	744	2.43	1.79	17.87	44.01	114.00	49328	166.67	73136	3521	5900
160	720	0.40	2.76	7.08	0.00	0.00	0	59.05	25310	0	4340
161	744	0.10	1.89	0.00	0.97	0.00	0	0.00	0	0	0
162	720	0.37	1.64	0.00	22.33	0.00	0	0.00	0	0	0
163	744	0.42	1.40	0.00	0.00	0.00	0	0.00	0	0	0
164	744	0.69	2.01	0.00	0.00	0.00	0	0.00	0	0	0
165	720	0.05	0.36	0.00	0.00	0.00	0	0.00	0	0	0
166	744	0.17	0.76	0.00	0.00	0.00	0	0.00	0	0	0
167	720	0.02	0.54	0.00	0.00	0.00	0	0.00	0	0	0
168	744	0.00	0.14	0.00	0.00	0.00	0	0.00	0	0	0
169	744	0.40	0.07	0.00	2.48	0.00	0	21.23	9662	0	2982
170	696	2.18	0.49	3.95	34.58	23.00	9025	157.75	66366	728	5900
171	744	2.21	1.59	15.14	28.93	68.00	28352	169.64	77821	1988	5900
172	720	0.18	2.17	0.00	0.00	0.00	0	0.00	0	0	0
173	744	0.24	2.21	0.00	0.32	0.00	0	0.00	0	0	0
174	720	0.14	1.69	0.00	15.48	0.00	0	0.00	0	0	0
175	744	0.14	1.91	0.00	0.10	0.00	0	0.00	0	0	0
176	744	0.25	2.03	0.00	0.00	0.00	0	0.00	0	0	0
177	720	0.12	0.62	0.00	0.00	0.00	0	0.00	0	0	0
178	744	0.09	0.74	0.00	0.00	0.00	0	0.00	0	0	0
179	720	0.01	0.41	0.00	0.00	0.00	0	0.00	0	0	0
180	744	0.00	0.16	0.00	0.00	0.00	0	0.00	0	0	0

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
181	744	2.20	0.27	1.81	36.03	12.00	5037	147.63	67241	406	5900
182	672	0.09	0.06	0.00	0.62	0.00	0	0.00	0	0	0
183	744	0.01	0.10	0.00	0.00	0.00	0	0.00	0	0	0
184	720	0.00	1.25	0.00	0.00	0.00	0	0.00	0	0	0
185	744	0.00	1.12	0.00	0.00	0.00	0	0.00	0	0	0
186	720	0.03	1.86	0.00	0.00	0.00	0	0.00	0	0	0
187	744	0.00	2.74	0.00	0.00	0.00	0	0.00	0	0	0
188	744	0.00	2.09	0.00	0.00	0.00	0	0.00	0	0	0
189	720	0.00	0.61	0.00	0.00	0.00	0	0.00	0	0	0
190	744	0.06	0.77	0.00	0.00	0.00	0	0.00	0	0	0
191	720	0.01	0.43	0.00	0.00	0.00	0	0.00	0	0	0
192	744	0.00	0.21	0.00	0.00	0.00	0	0.00	0	0	0
193	744	0.00	0.13	0.00	0.00	0.00	0	0.00	0	0	0
194	672	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
195	744	2.04	1.49	14.25	29.72	34.00	14349	104.81	48925	1629	5900
196	720	0.92	2.74	5.74	0.00	0.00	0	52.69	22293	0	4927
197	744	0.11	1.36	0.00	0.00	0.00	0	0.00	0	0	0
198	720	0.37	2.80	0.00	0.00	0.00	0	0.00	0	0	0
199	744	0.38	2.71	0.00	0.00	0.00	0	0.00	0	0	0
200	744	0.30	1.98	0.00	0.00	0.00	0	0.00	0	0	0
201	720	0.11	0.38	0.00	0.00	0.00	0	0.00	0	0	0
202	744	0.07	0.71	0.00	0.00	0.00	0	0.00	0	0	0
203	720	0.01	0.51	0.00	0.00	0.00	0	0.00	0	0	0
204	744	0.00	0.30	0.00	0.00	0.00	0	0.00	0	0	0
205	744	2.38	0.09	0.46	20.31	0.00	0	81.44	38034	0	5900
206	672	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
207	744	0.01	0.10	0.00	0.00	0.00	0	0.00	0	0	0
208	720	0.00	1.64	0.00	0.00	0.00	0	0.00	0	0	0
209	744	0.00	1.57	0.00	0.00	0.00	0	0.00	0	0	0
210	720	0.00	1.70	0.00	17.20	0.00	0	0.00	0	0	0
211	744	0.00	2.73	0.00	0.19	0.00	0	0.00	0	0	0
212	744	0.00	1.94	0.00	2.26	0.00	0	0.00	0	0	0
213	720	0.00	0.59	0.00	2.56	0.00	0	0.00	0	0	0
214	744	0.06	0.77	0.00	0.00	0.00	0	0.00	0	0	0
215	720	0.02	0.53	0.00	0.00	0.00	0	0.00	0	0	0
216	744	0.00	0.27	0.00	0.00	0.00	0	0.00	0	0	0
217	744	0.00	0.14	0.00	0.00	0.00	0	0.00	0	0	0
218	696	0.00	0.07	0.00	0.00	0.00	0	0.00	0	0	0
219	744	2.43	1.72	17.28	44.01	63.00	27300	97.79	44276	3321	5900
220	720	0.08	0.87	0.00	10.30	0.00	0	0.00	0	0	0
221	744	0.05	0.98	0.00	13.69	0.00	0	0.00	0	0	0
222	720	0.06	1.27	0.00	22.13	0.00	0	0.00	0	0	0
223	744	0.09	1.19	0.00	19.13	0.00	0	0.00	0	0	0
224	744	0.50	1.37	0.00	0.31	0.00	0	0.00	0	0	0
225	720	0.08	0.45	0.00	0.00	0.00	0	0.00	0	0	0
226	744	0.08	0.56	0.00	0.00	0.00	0	0.00	0	0	0
227	720	0.02	0.38	0.00	0.00	0.00	0	0.00	0	0	0
228	744	0.00	0.16	0.00	0.00	0.00	0	0.00	0	0	0
229	744	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
230	672	1.68	0.40	3.25	20.69	0.00	0	74.99	30949	0	5900
231	744	2.28	1.33	13.03	20.89	30.00	13084	110.82	49858	1404	5900
232	720	0.04	0.95	0.00	1.92	0.00	0	0.00	0	0	0
233	744	0.12	1.42	0.00	0.44	0.00	0	0.00	0	0	0
234	720	0.09	1.21	0.00	19.18	0.00	0	0.00	0	0	0
235	744	0.13	1.18	0.00	21.16	0.00	0	0.00	0	0	0
236	744	0.58	1.40	0.00	0.00	0.00	0	0.00	0	0	0
237	720	0.12	0.45	0.00	0.00	0.00	0	0.00	0	0	0
238	744	0.06	0.52	0.00	0.00	0.00	0	0.00	0	0	0
239	720	0.02	0.38	0.00	0.00	0.00	0	0.00	0	0	0
240	744	0.69	0.12	0.00	2.52	0.00	0	16.90	7764	0	3385

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
241	744	1.81	0.25	1.81	26.74	0.00	0	85.64	39246	0	5900
242	672	1.92	0.35	2.80	29.25	0.00	0	106.79	44920	0	5900
243	744	2.05	1.53	14.45	32.51	46.00	19305	128.90	60108	1782	5900
244	720	2.28	2.80	6.38	0.00	0.00	0	102.39	43300	0	5900
245	744	2.58	2.87	9.43	0.00	0.00	0	116.26	49260	0	5900
246	720	2.56	2.80	2.00	44.01	7.00	2622	156.90	64975	205	5900
247	744	0.68	1.60	0.00	32.69	0.00	0	0.00	0	0	0
248	744	1.12	2.03	0.00	0.19	0.00	0	0.00	0	0	0
249	720	0.34	0.63	0.00	0.00	0.00	0	0.00	0	0	0
250	744	0.17	0.74	0.00	0.00	0.00	0	0.00	0	0	0
251	720	0.02	0.44	0.00	0.00	0.00	0	0.00	0	0	0
252	744	0.83	0.24	0.00	2.52	0.00	0	33.08	15429	0	3516
253	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
254	672	2.44	0.49	3.95	42.65	37.00	14399	157.61	66411	1203	5900
255	744	0.03	0.06	0.00	0.00	0.00	0	0.00	0	0	0
256	720	0.06	1.08	0.00	17.08	0.00	0	0.00	0	0	0
257	744	0.20	0.79	0.00	12.36	0.00	0	0.00	0	0	0
258	720	0.37	1.22	0.00	0.00	0.00	0	0.00	0	0	0
259	744	1.08	1.14	0.00	0.00	0.00	0	0.00	0	0	0
260	744	1.06	0.98	0.00	0.00	0.00	0	0.00	0	0	0
261	720	0.33	0.42	0.00	0.00	0.00	0	0.00	0	0	0
262	744	0.13	0.54	0.00	0.00	0.00	0	0.00	0	0	0
263	720	0.01	0.22	0.00	0.00	0.00	0	0.00	0	0	0
264	744	0.00	0.14	0.00	0.00	0.00	0	0.00	0	0	0
265	744	2.43	0.35	2.73	44.01	32.00	13717	134.70	60951	1211	5900
266	696	2.44	0.47	3.95	44.01	34.00	13163	147.37	65690	1136	5900
267	744	2.20	1.61	15.84	36.81	78.00	33497	160.62	73228	2481	5900
268	720	2.27	2.78	6.95	0.00	0.00	0	126.55	54101	0	5900
269	744	1.36	2.87	9.14	0.42	0.00	0	86.30	37793	0	5633
270	720	0.57	2.80	0.00	7.66	0.00	0	0.00	0	0	0
271	744	0.71	2.79	0.00	14.90	0.00	0	16.02	6471	0	3998
272	744	1.20	2.25	1.24	0.59	0.00	0	0.00	0	0	0
273	720	0.37	0.61	0.00	0.00	0.00	0	0.00	0	0	0
274	744	0.10	0.47	0.00	0.00	0.00	0	0.00	0	0	0
275	720	0.03	0.33	0.00	0.00	0.00	0	0.00	0	0	0
276	744	2.05	1.31	11.27	19.16	28.00	11987	173.34	77976	823	5900
277	744	0.00	0.07	0.00	0.00	0.00	0	0.00	0	0	0
278	672	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
279	744	0.02	0.09	0.00	0.00	0.00	0	0.00	0	0	0
280	720	0.37	1.79	0.00	0.00	0.00	0	0.00	0	0	0
281	744	0.45	1.67	0.00	0.36	0.00	0	0.00	0	0	0
282	720	0.63	2.77	0.00	9.40	0.00	0	0.00	0	0	0
283	744	0.82	1.60	0.00	0.33	0.00	0	0.00	0	0	0
284	744	1.21	1.67	0.00	0.00	0.00	0	0.00	0	0	0
285	720	0.10	0.33	0.00	0.00	0.00	0	0.00	0	0	0
286	744	0.02	0.40	0.00	0.00	0.00	0	0.00	0	0	0
287	720	0.01	0.27	0.00	0.00	0.00	0	0.00	0	0	0
288	744	2.20	1.39	12.30	34.39	64.00	27835	162.93	72784	2032	5900
289	744	2.44	0.37	2.73	18.72	0.00	0	164.67	78249	0	5900
290	672	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
291	744	0.41	0.17	0.00	2.41	0.00	0	23.32	10683	0	2935
292	720	0.37	2.60	0.00	0.00	0.00	0	0.00	0	0	0
293	744	0.35	2.01	0.00	0.00	0.00	0	0.00	0	0	0
294	720	0.41	2.14	0.00	0.00	0.00	0	0.00	0	0	0
295	744	0.48	1.42	0.00	0.00	0.00	0	0.00	0	0	0
296	744	0.75	1.83	0.00	0.00	0.00	0	0.00	0	0	0
297	720	0.07	0.35	0.00	0.00	0.00	0	0.00	0	0	0
298	744	0.05	0.43	0.00	0.00	0.00	0	0.00	0	0	0
299	720	0.01	0.20	0.00	0.00	0.00	0	0.00	0	0	0
300	744	2.43	0.57	3.27	23.77	7.00	3058	151.33	70031	240	5900

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period (Cont.)									
		Optimized Pumping (for Sites Plant)									
		Incidental Pumping , MW				Optimized Pumping					
		TC Canal	GCID Canal	TRR	Sac River	Sites					
Plant Capacity, MW		6.00	3.39	19.68	65.65	181.35					
Plant Capacity, cfs		2250	3000	1890	2000	MaxQ=5900 cfs					
Month	# of Hours	All Hours				On-Peak, MW	On-Peak, MWh	Off-Peak, MW	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
294	720	0.41	2.14	0.00	0.00	0.00	0	0.00	0	0	0
295	744	0.48	1.42	0.00	0.00	0.00	0	0.00	0	0	0
296	744	0.75	1.83	0.00	0.00	0.00	0	0.00	0	0	0
297	720	0.07	0.35	0.00	0.00	0.00	0	0.00	0	0	0
298	744	0.05	0.43	0.00	0.00	0.00	0	0.00	0	0	0
299	720	0.01	0.20	0.00	0.00	0.00	0	0.00	0	0	0
300	744	2.43	0.57	3.27	23.77	7.00	3058	151.33	70031	240	5900
301	744	2.35	0.37	2.67	41.51	29.00	12669	162.28	74506	929	5900
302	672	2.44	0.49	3.95	44.01	40.00	15499	172.58	73664	1183	5900
303	744	0.05	0.09	0.00	2.52	0.00	0	11.15	5049	0	2490
304	720	0.04	1.63	0.00	0.00	0.00	0	0.00	0	0	0
305	744	0.12	1.23	0.00	0.44	0.00	0	0.00	0	0	0
306	720	0.56	2.81	0.00	11.35	0.00	0	11.49	4607	0	3631
307	744	0.74	2.80	0.00	9.88	0.00	0	0.00	0	0	0
308	744	1.23	2.09	0.00	0.00	0.00	0	0.00	0	0	0
309	720	0.34	1.63	9.01	0.00	0.00	0	46.15	19797	0	4496
310	744	0.05	0.44	0.00	0.00	0.00	0	0.00	0	0	0
311	720	0.46	0.40	0.00	2.59	0.00	0	28.13	12148	0	3318
312	744	0.00	0.15	0.00	0.00	0.00	0	0.00	0	0	0
313	744	0.00	0.08	0.00	0.00	0.00	0	0.00	0	0	0
314	696	0.00	0.06	0.00	0.00	0.00	0	0.00	0	0	0
315	744	0.01	0.09	0.00	0.00	0.00	0	0.00	0	0	0
316	720	0.17	1.98	0.55	0.00	0.00	0	0.00	0	0	0
317	744	0.80	2.20	0.00	0.45	0.00	0	0.00	0	0	0
318	720	0.56	2.51	0.00	5.94	0.00	0	0.00	0	0	0
319	744	0.66	1.45	0.00	0.00	0.00	0	0.00	0	0	0
320	744	1.10	1.90	0.00	0.00	0.00	0	0.00	0	0	0
321	720	0.11	0.36	0.00	0.00	0.00	0	0.00	0	0	0
322	744	0.08	0.44	0.00	0.00	0.00	0	0.00	0	0	0
323	720	0.01	0.28	0.00	0.00	0.00	0	0.00	0	0	0
324	744	0.00	0.29	0.00	2.04	0.00	0	0.00	0	0	0
325	744	2.12	0.25	2.02	34.58	9.00	3952	157.91	71608	298	5900
326	672	2.44	0.47	3.81	44.01	41.00	15731	167.78	70659	1235	5900
327	744	2.22	0.07	0.00	2.52	0.00	0	98.16	46553	0	5425
328	720	0.07	1.88	0.00	0.00	0.00	0	0.00	0	0	0
329	744	0.72	1.76	0.00	0.00	0.00	0	0.00	0	0	0
330	720	0.72	1.57	0.00	0.00	0.00	0	0.00	0	0	0
331	744	0.70	1.35	0.00	0.00	0.00	0	0.00	0	0	0
332	744	0.55	1.12	0.00	0.00	0.00	0	0.00	0	0	0
333	720	0.30	0.56	0.00	0.00	0.00	0	0.00	0	0	0
334	744	0.07	0.70	0.00	0.00	0.00	0	0.00	0	0	0
335	720	0.01	0.51	0.00	0.00	0.00	0	0.00	0	0	0
336	744	0.00	0.16	0.00	0.00	0.00	0	0.00	0	0	0
337	744	2.44	0.34	2.40	15.21	0.00	0	134.73	63240	0	5900
338	672	2.09	0.25	1.68	33.70	0.00	0	160.16	67438	0	5900
339	744	2.28	1.67	16.46	37.23	88.00	38029	171.22	78474	2642	5900
340	720	0.23	1.97	0.00	0.00	0.00	0	0.00	0	0	0
341	744	0.18	2.20	0.00	0.00	0.00	0	0.00	0	0	0
342	720	0.20	1.62	0.00	21.74	0.00	0	0.00	0	0	0
343	744	0.22	1.47	0.00	20.87	0.00	0	0.00	0	0	0
344	744	0.17	0.83	0.00	0.16	0.00	0	0.00	0	0	0
345	720	0.07	0.28	0.00	0.00	0.00	0	0.00	0	0	0
346	744	0.02	0.42	0.00	0.00	0.00	0	0.00	0	0	0
347	720	0.01	0.20	0.00	0.00	0.00	0	0.00	0	0	0
348	744	0.00	0.15	0.00	0.00	0.00	0	0.00	0	0	0
349	744	2.20	0.22	1.36	36.01	5.00	2152	155.47	72959	165	5900
350	672	0.55	0.06	0.00	2.80	0.00	0	29.63	12640	0	3312
351	744	2.44	0.48	3.54	5.95	0.00	0	129.66	59419	0	5900
352	720	0.08	1.51	0.00	0.00	0.00	0	0.00	0	0	0
353	744	0.26	1.10	0.00	0.00	0.00	0	0.00	0	0	0
354	720	0.39	1.81	0.00	0.00	0.00	0	0.00	0	0	0
355	744	0.43	1.39	0.00	0.00	0.00	0	0.00	0	0	0
356	744	0.72	1.48	0.00	0.00	0.00	0	0.00	0	0	0
357	720	0.07	0.33	0.00	0.00	0.00	0	0.00	0	0	0
358	744	0.06	0.43	0.00	0.00	0.00	0	0.00	0	0	0
359	720	0.01	0.26	0.00	0.00	0.00	0	0.00	0	0	0
360	744	2.13	1.35	11.80	32.29	43.00	18665	125.96	56310	1763	5900

Table H.C-2. NODOS Project, Power Operations, "Optimized," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period									
		Optimized Generation (except Sac River)									
		Optimized Genration, MW									
		Sites					TRR				
Plant Capacity, MW		123.00					9.33				
Plant Capacity, cfs		MaxQ=5100 cfs					MaxQ=1500 cfs				
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	On-Peak, cfs	Off-Peak, cfs	On-Peak	On-Peak, MWh	Off-Peak	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
1	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
2	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
3	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
4	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
5	744	26.47	9818	0.00	1141	0	0.81	300	0.00	0	116	0
6	720	114.95	39777	0.00	5100	0	9.18	3820	4.41	1341	1500	650
7	744	0.00	0	0.00	0	0	9.18	3967	4.17	1301	1500	613
8	744	30.10	9261	0.00	1366	0	1.44	443	0.00	0	207	0
9	720	107.43	28368	0.00	5009	0	4.07	1074	0.00	0	597	0
10	744	37.38	8916	0.00	1771	0	0.49	117	0.00	0	70	0
11	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
12	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
13	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
14	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
15	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
16	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
17	744	0.00	0	0.00	0	0	0.12	36	0.00	0	17	0
18	720	11.70	3508	0.00	503	0	2.99	896	0.00	0	435	0
19	744	36.38	10349	0.00	1579	0	3.13	890	0.00	0	455	0
20	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
21	720	73.73	16890	0.00	3217	0	5.19	1188	0.00	0	772	0
22	744	42.77	10242	0.00	1886	0	7.19	1722	0.00	0	1108	0
23	720	113.26	23951	0.00	5100	0	5.57	1071	0.00	0	833	0
24	744	24.86	4980	0.00	1128	0	2.63	526	0.00	0	381	0
25	744	0.00	0	0.00	0	0	0.15	32	0.00	0	21	0
26	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
27	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
28	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
29	744	0.00	0	0.00	0	0	0.72	228	0.00	0	104	0
30	720	55.68	15888	0.00	2412	0	9.18	3820	0.51	154	1500	73
31	744	114.37	33872	0.00	5100	0	9.18	3820	4.13	1355	1500	607
32	744	0.00	0	0.00	0	0	0.23	58	0.00	0	32	0
33	720	112.59	27407	0.00	5100	0	5.20	1193	0.00	0	773	0
34	744	47.37	10873	0.00	2179	0	7.33	1683	0.00	0	1133	0
35	720	108.36	22980	0.00	5100	0	5.82	1100	0.00	0	873	0
36	744	44.75	8756	0.00	2133	0	3.95	772	0.00	0	579	0
37	744	0.00	0	0.00	0	0	0.22	45	0.00	0	32	0
38	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
39	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
40	720	59.31	15142	0.00	2748	0	0.01	2	0.00	0	1	0
41	744	76.05	23901	0.00	3604	0	1.20	378	0.00	0	173	0
42	720	103.82	30822	0.00	5100	0	9.18	3673	4.46	1428	1500	657
43	744	98.69	35142	0.00	5100	0	9.18	3967	4.40	1373	1500	648
44	744	35.70	8912	0.00	1906	0	1.28	321	0.00	0	185	0
45	720	34.10	8196	0.00	1847	0	0.15	37	0.00	0	22	0
46	744	57.88	13884	0.00	3205	0	0.22	52	0.00	0	31	0
47	720	43.29	8585	0.00	2441	0	0.19	38	0.00	0	27	0
48	744	83.43	16702	0.00	4838	0	0.17	34	0.00	0	25	0
49	744	0.00	0	0.00	0	0	0.01	2	0.00	0	2	0
50	672	84.60	14199	0.00	5100	0	0.10	15	0.00	0	15	0
51	744	81.09	16769	0.00	5100	0	1.58	287	0.00	0	229	0
52	720	75.45	22665	0.00	5100	0	9.18	3820	3.57	1085	1500	522
53	744	68.61	17346	0.00	5078	0	9.18	3640	0.00	0	1500	0
54	720	60.69	19927	0.00	5100	0	9.18	3673	4.75	1519	1500	702
55	744	26.07	7296	0.00	2520	0	9.18	3072	0.00	0	1500	0
56	744	0.00	0	0.00	0	0	0.80	194	0.00	0	115	0
57	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
58	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
59	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
60	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
61	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
62	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
63	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
64	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
65	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
66	720	0.00	0	0.00	0	0	9.18	3820	4.26	1295	1500	626
67	744	0.00	0	0.00	0	0	9.18	3967	4.17	1301	1500	613
68	744	33.53	8541	0.00	1588	0	1.77	450	0.00	0	255	0
69	720	104.80	25858	0.00	5100	0	4.25	997	0.00	0	624	0
70	744	97.44	20764	0.00	4885	0	0.49	105	0.00	0	71	0
71	720	98.93	19752	0.00	5100	0	0.20	38	0.00	0	28	0
72	744	39.29	7697	0.00	2053	0	0.17	34	0.00	0	25	0
73	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
74	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
75	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
76	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
77	744	0.00	0	0.00	0	0	1.11	295	0.00	0	160	0
78	720	116.08	33681	0.00	5100	0	9.18	3820	4.41	1341	1500	650
79	744	12.71	3456	0.00	566	0	9.18	3820	5.09	1671	1500	757
80	744	92.42	23688	0.00	4189	0	9.18	3510	0.00	0	1500	0
81	720	105.93	24806	0.00	4940	0	5.46	1278	0.00	0	815	0
82	744	43.98	9470	0.00	2080	0	7.60	1636	0.00	0	1182	0
83	720	61.83	12134	0.00	2960	0	4.36	856	0.00	0	642	0
84	744	40.16	7744	0.00	1940	0	0.34	65	0.00	0	48	0
85	744	0.00	0	0.00	0	0	0.01	1	0.00	0	1	0
86	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
87	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
88	720	0.00	0	0.00	0	0	0.07	14	0.00	0	10	0
89	744	36.08	9464	0.00	1554	0	1.96	513	0.00	0	283	0
90	720	87.47	23404	0.00	3838	0	9.18	3820	3.89	1183	1500	570

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period									
		Optimized Generation (except Sac River)									
		Optimized Genration, MW									
		Sites					TRR				
Plant Capacity, MW		123.00					9.33				
Plant Capacity, cfs		MaxQ=5100 cfs					MaxQ=1500 cfs				
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	On-Peak, cfs	Off-Peak, cfs	On-Peak	On-Peak, MWh	Off-Peak	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
91	744	83.15	22736	0.00	3733	0	9.18	3820	0.92	303	1500	133
92	744	40.92	10549	0.00	1864	0	1.26	324	0.00	0	181	0
93	720	109.03	27268	0.00	5100	0	5.24	1204	0.00	0	779	0
94	744	105.44	27309	0.00	5100	0	7.91	1762	0.00	0	1241	0
95	720	102.03	22247	0.00	5100	0	5.44	1084	0.00	0	811	0
96	744	0.00	0	0.00	0	0	0.36	67	0.00	0	51	0
97	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
98	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
99	744	0.00	0	0.00	0	0	0.18	33	0.00	0	25	0
100	720	0.00	0	0.00	0	0	2.19	476	0.00	0	317	0
101	744	99.28	25998	0.00	4321	0	1.43	375	0.00	0	206	0
102	720	112.81	40225	0.00	5100	0	9.18	3820	4.26	1295	1500	627
103	744	18.14	5165	0.00	838	0	9.18	3820	5.33	1749	1500	794
104	744	106.72	36952	0.00	5100	0	9.18	3964	0.00	0	1500	0
105	720	80.02	18565	0.00	3965	0	1.36	316	0.00	0	196	0
106	744	0.00	0	0.00	0	0	0.01	2	0.00	0	1	0
107	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
108	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
109	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
110	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
111	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
112	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
113	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
114	720	0.00	0	0.00	0	0	0.00	1	0.00	0	1	0
115	744	29.13	8322	0.00	1255	0	0.07	19	0.00	0	9	0
116	744	35.99	9057	0.00	1565	0	0.35	88	0.00	0	50	0
117	720	34.68	8364	0.00	1523	0	3.72	898	0.00	0	544	0
118	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
119	720	22.52	4280	0.00	967	0	3.20	608	0.00	0	466	0
120	744	0.00	0	0.00	0	0	0.22	43	0.00	0	31	0
121	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
122	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
123	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
124	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
125	744	0.00	0	0.00	0	0	0.00	1	0.00	0	1	0
126	720	0.00	0	0.00	0	0	0.05	14	0.00	0	7	0
127	744	0.00	0	0.00	0	0	0.01	2	0.00	0	1	0
128	744	30.78	7768	0.00	1328	0	0.09	24	0.00	0	13	0
129	720	0.00	0	0.00	0	0	0.31	73	0.00	0	44	0
130	744	36.97	8095	0.00	1590	0	7.49	1639	0.00	0	1161	0
131	720	0.00	0	0.00	0	0	0.74	146	0.00	0	107	0
132	744	0.00	0	0.00	0	0	2.27	451	0.00	0	329	0
133	744	0.00	0	0.00	0	0	0.13	24	0.00	0	19	0
134	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
135	744	0.00	0	0.00	0	0	0.24	47	0.00	0	35	0
136	720	42.00	8550	0.00	1806	0	4.05	825	0.00	0	595	0
137	744	35.37	8860	0.00	1533	0	1.43	358	0.00	0	206	0
138	720	114.97	31383	0.00	5100	0	9.18	3820	4.41	1341	1500	650
139	744	110.08	43424	0.00	5100	0	9.18	3967	4.42	1380	1500	651
140	744	105.18	28286	0.00	5100	0	6.15	1624	0.00	0	928	0
141	720	101.49	26228	0.00	5100	0	4.95	1201	0.00	0	734	0
142	744	97.90	22678	0.00	5100	0	7.20	1599	0.00	0	1109	0
143	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
144	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
145	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
146	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
147	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
148	720	115.33	22648	0.00	5100	0	0.01	2	0.00	0	1	0
149	744	102.85	25725	0.00	4649	0	0.95	237	0.00	0	137	0
150	720	108.36	40709	0.00	5100	0	9.18	3820	4.60	1400	1500	680
151	744	102.07	39357	0.00	5100	0	9.18	3820	4.53	1486	1500	668
152	744	84.45	22642	0.00	4429	0	1.38	369	0.00	0	198	0
153	720	78.32	19242	0.00	4249	0	0.15	37	0.00	0	22	0
154	744	40.20	8887	0.00	2228	0	0.23	52	0.00	0	34	0
155	720	43.23	8471	0.00	2433	0	0.18	36	0.00	0	26	0
156	744	0.00	0	0.00	0	0	0.01	2	0.00	0	1	0
157	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
158	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
159	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
160	720	0.00	0	0.00	0	0	0.04	8	0.00	0	6	0
161	744	31.99	8081	0.00	1389	0	3.81	962	0.00	0	557	0
162	720	16.58	4298	0.00	724	0	9.18	3820	4.52	1375	1500	667
163	744	113.17	41701	0.00	5100	0	9.18	3820	4.67	1532	1500	690
164	744	73.98	19663	0.00	3446	0	1.44	382	0.00	0	207	0
165	720	105.13	24772	0.00	5039	0	4.10	966	0.00	0	602	0
166	744	41.50	9651	0.00	2020	0	0.51	119	0.00	0	73	0
167	720	101.83	20423	0.00	5071	0	0.39	77	0.00	0	55	0
168	744	41.48	8087	0.00	2093	0	3.40	663	0.00	0	496	0
169	744	0.00	0	0.00	0	0	0.22	42	0.00	0	31	0
170	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
171	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
172	720	115.39	22937	0.00	5091	0	0.01	2	0.00	0	1	0
173	744	93.27	23388	0.00	4201	0	1.39	349	0.00	0	201	0
174	720	16.68	4325	0.00	759	0	9.18	3673	4.01	1282	1500	587
175	744	109.02	34042	0.00	5100	0	9.18	2851	0.00	0	1500	0
176	744	91.68	23640	0.00	4438	0	0.55	141	0.00	0	79	0
177	720	87.43	21680	0.00	4355	0	0.01	2	0.00	0	1	0
178	744	92.81	21708	0.00	4767	0	0.00	0	0.00	0	0	0
179	720	96.32	19354	0.00	5100	0	0.00	0	0.00	0	0	0
180	744	42.40	8678	0.00	2282	0	0.00	0	0.00	0	0	0

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period										
		Optimized Generation (except Sac River)										
		Optimized Genration, MW										
		Sites					TRR					
Plant Capacity, MW		123.00					9.33					
Plant Capacity, cfs		MaxQ=5100 cfs					MaxQ=1500 cfs					
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	On-Peak, cfs	Off-Peak, cfs	On-Peak	On-Peak, MWh	Off-Peak	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
181	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
182	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
183	744	100.32	19619	0.00	5100	0	1.26	225	0.00	0	181	0
184	720	96.97	23261	0.00	5100	0	9.18	3758	0.00	0	1500	0
185	744	93.13	23270	0.00	5100	0	9.18	3873	0.00	0	1500	0
186	720	88.48	26857	0.00	5100	0	9.18	3673	0.95	303	1500	136
187	744	66.82	18909	0.00	4062	0	0.82	233	0.00	0	118	0
188	744	67.84	17461	0.00	4336	0	0.00	0	0.00	0	0	0
189	720	64.94	15999	0.00	4385	0	0.00	0	0.00	0	0	0
190	744	64.71	14914	0.00	4653	0	0.00	0	0.00	0	0	0
191	720	29.84	5754	0.00	2237	0	0.00	0	0.00	0	0	0
192	744	23.80	4832	0.00	1828	0	0.00	0	0.00	0	0	0
193	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
194	672	62.34	10530	0.00	5100	0	0.00	0	0.00	0	0	0
195	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
196	720	0.00	0	0.00	0	0	1.09	210	0.00	0	157	0
197	744	76.82	22376	0.00	5100	0	9.18	3820	0.14	47	1500	20
198	720	57.92	15592	0.00	4155	0	1.02	273	0.00	0	146	0
199	744	50.86	14430	0.00	3934	0	0.00	0	0.00	0	0	0
200	744	49.13	12700	0.00	4184	0	0.00	0	0.00	0	0	0
201	720	18.46	4611	0.00	1700	0	0.00	0	0.00	0	0	0
202	744	19.15	4294	0.00	1862	0	0.00	0	0.00	0	0	0
203	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
204	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
205	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
206	672	33.15	5700	0.00	2584	0	0.00	0	0.00	0	0	0
207	744	0.00	0	0.00	0	0	1.19	224	0.00	0	171	0
208	720	60.15	12885	0.00	5100	0	9.18	3623	0.00	0	1500	0
209	744	18.31	4650	0.00	1683	0	2.26	575	0.00	0	328	0
210	720	0.00	0	0.00	0	0	9.18	3820	3.49	1062	1500	510
211	744	7.76	2125	0.00	747	0	1.08	295	0.00	0	155	0
212	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
213	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
214	744	10.53	2361	0.00	1019	0	0.00	0	0.00	0	0	0
215	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
216	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
217	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
218	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
219	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
220	720	0.00	0	0.00	0	0	9.18	3187	0.00	0	1500	0
221	744	0.00	0	0.00	0	0	9.18	3833	0.00	0	1500	0
222	720	0.00	0	0.00	0	0	9.18	3820	4.50	1369	1500	664
223	744	0.00	0	0.00	0	0	9.18	3820	3.37	1104	1500	491
224	744	52.16	14166	0.00	3726	0	1.18	319	0.00	0	169	0
225	720	25.89	6264	0.00	1937	0	0.00	0	0.00	0	0	0
226	744	58.30	13450	0.00	4648	0	0.00	0	0.00	0	0	0
227	720	57.96	11828	0.00	5100	0	0.00	0	0.00	0	0	0
228	744	22.39	4505	0.00	2132	0	0.00	0	0.00	0	0	0
229	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
230	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
231	744	0.00	0	0.00	0	0	1.29	234	0.00	0	185	0
232	720	34.73	6786	0.00	2264	0	9.18	3241	0.00	0	1500	0
233	744	52.31	13170	0.00	3539	0	7.35	1852	0.00	0	1137	0
234	720	0.00	0	0.00	0	0	9.18	3820	3.34	1015	1500	487
235	744	0.00	0	0.00	0	0	9.18	3820	3.57	1171	1500	522
236	744	54.83	14690	0.00	3978	0	0.80	215	0.00	0	115	0
237	720	57.85	13805	0.00	4540	0	0.00	0	0.00	0	0	0
238	744	55.02	12624	0.00	4750	0	0.00	0	0.00	0	0	0
239	720	28.27	5799	0.00	2670	0	0.00	0	0.00	0	0	0
240	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
241	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
242	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
243	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
244	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
245	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
246	720	0.00	0	0.00	0	0	1.04	268	0.00	0	150	0
247	744	0.00	0	0.00	0	0	9.18	3967	3.36	1048	1500	490
248	744	29.45	7625	0.00	1410	0	1.24	321	0.00	0	178	0
249	720	34.74	8655	0.00	1681	0	0.15	37	0.00	0	21	0
250	744	89.04	20474	0.00	4405	0	0.22	52	0.00	0	32	0
251	720	99.90	19911	0.00	5085	0	0.18	36	0.00	0	26	0
252	744	0.00	0	0.00	0	0	0.01	2	0.00	0	2	0
253	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
254	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
255	744	37.91	7301	0.00	1783	0	1.27	245	0.00	0	183	0
256	720	0.00	0	0.00	0	0	9.18	3820	1.11	336	1500	159
257	744	0.00	0	0.00	0	0	9.18	3485	0.00	0	1500	0
258	720	104.33	36480	0.00	5100	0	9.18	3673	4.94	1581	1500	732
259	744	98.74	32606	0.00	5100	0	9.18	3967	1.58	492	1500	227
260	744	94.07	25323	0.00	5100	0	7.51	1957	0.00	0	1166	0
261	720	74.53	18711	0.00	4198	0	0.45	114	0.00	0	65	0
262	744	81.87	18474	0.00	4797	0	0.00	0	0.00	0	0	0
263	720	46.93	9605	0.00	2827	0	0.00	0	0.00	0	0	0
264	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
265	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
266	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
267	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
268	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
269	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
270	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period										
		Optimized Generation (except Sac River)										
		Optimized Genration, MW										
		Sites					TRR					
Plant Capacity, MW		123.00					9.33					
Plant Capacity, cfs		MaxQ=5100 cfs					MaxQ=1500 cfs					
Month	# of Hours	On-Peak, MW	On-Peak, MWh	Off-Peak, MW	On-Peak, cfs	Off-Peak, cfs	On-Peak	On-Peak, MWh	Off-Peak	Off-Peak, MWh	On-Peak, cfs	Off-Peak, cfs
271	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
272	744	0.00	0	0.00	0	0	0.01	2	0.00	0	1	0
273	720	39.49	9833	0.00	1699	0	0.51	126	0.00	0	73	0
274	744	115.77	29580	0.00	5100	0	7.53	1681	0.00	0	1168	0
275	720	112.68	25157	0.00	5100	0	5.51	1138	0.00	0	823	0
276	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
277	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
278	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
279	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
280	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
281	744	0.00	0	0.00	0	0	0.04	10	0.00	0	6	0
282	720	0.00	0	0.00	0	0	2.14	566	0.00	0	309	0
283	744	114.00	31223	0.00	4997	0	9.18	3820	3.87	1271	1500	567
284	744	41.12	11119	0.00	1832	0	7.08	1915	0.00	0	1088	0
285	720	111.58	29405	0.00	5100	0	5.22	1292	0.00	0	776	0
286	744	108.05	27368	0.00	5100	0	7.61	1690	0.00	0	1185	0
287	720	104.87	23057	0.00	5100	0	4.52	940	0.00	0	667	0
288	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
289	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
290	672	44.93	7777	0.00	1930	0	0.00	0	0.00	0	0	0
291	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
292	720	0.00	0	0.00	0	0	0.07	14	0.00	0	10	0
293	744	39.25	9773	0.00	1688	0	1.54	383	0.00	0	222	0
294	720	115.88	30744	0.00	5100	0	9.18	2951	0.00	0	1500	0
295	744	111.21	41959	0.00	5100	0	9.18	3820	4.17	1369	1500	613
296	744	71.02	19229	0.00	3373	0	2.50	677	0.00	0	363	0
297	720	104.21	25922	0.00	5100	0	4.71	1125	0.00	0	697	0
298	744	100.48	26170	0.00	5100	0	7.51	1739	0.00	0	1165	0
299	720	97.04	20826	0.00	5100	0	3.19	666	0.00	0	465	0
300	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
301	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
302	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
303	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
304	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
305	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
306	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
307	744	0.00	0	0.00	0	0	0.00	1	0.00	0	1	0
308	744	30.56	7977	0.00	1318	0	0.09	24	0.00	0	13	0
309	720	0.00	0	0.00	0	0	0.43	107	0.00	0	62	0
310	744	39.67	9216	0.00	1706	0	7.02	1630	0.00	0	1077	0
311	720	0.00	0	0.00	0	0	0.69	139	0.00	0	99	0
312	744	0.00	0	0.00	0	0	3.32	688	0.00	0	484	0
313	744	0.00	0	0.00	0	0	0.18	37	0.00	0	26	0
314	696	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
315	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
316	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
317	744	0.00	0	0.00	0	0	0.25	59	0.00	0	35	0
318	720	23.25	6178	0.00	999	0	4.35	1155	0.00	0	640	0
319	744	114.72	44921	0.00	5100	0	9.18	3967	3.53	1100	1500	515
320	744	46.49	12154	0.00	2125	0	1.52	397	0.00	0	219	0
321	720	108.60	28380	0.00	5100	0	4.80	1196	0.00	0	710	0
322	744	104.95	27788	0.00	5100	0	7.52	1754	0.00	0	1168	0
323	720	101.55	21904	0.00	5100	0	4.62	935	0.00	0	681	0
324	744	0.00	0	0.00	0	0	0.29	60	0.00	0	41	0
325	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
326	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
327	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
328	720	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
329	744	0.00	0	0.00	0	0	1.42	344	0.00	0	205	0
330	720	114.02	30329	0.00	4975	0	9.18	3820	4.26	1295	1500	626
331	744	111.93	46332	0.00	5100	0	9.18	3967	5.01	1562	1500	743
332	744	106.26	33580	0.00	5100	0	9.18	3820	0.77	254	1500	112
333	720	39.50	9862	0.00	1940	0	1.04	260	0.00	0	150	0
334	744	95.91	21612	0.00	4828	0	0.23	52	0.00	0	33	0
335	720	95.91	20290	0.00	4972	0	0.36	75	0.00	0	51	0
336	744	36.55	7652	0.00	1921	0	3.49	731	0.00	0	510	0
337	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
338	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
339	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
340	720	70.99	14394	0.00	3069	0	0.01	2	0.00	0	1	0
341	744	97.37	23550	0.00	4292	0	1.24	300	0.00	0	179	0
342	720	0.00	0	0.00	0	0	9.18	3820	4.41	1341	1500	650
343	744	0.00	0	0.00	0	0	9.18	3967	5.01	1562	1500	743
344	744	110.95	37580	0.00	5100	0	9.18	3820	1.05	345	1500	151
345	720	106.59	27640	0.00	5100	0	5.13	1284	0.00	0	763	0
346	744	103.07	25765	0.00	5100	0	7.50	1696	0.00	0	1164	0
347	720	41.59	8835	0.00	2096	0	3.44	731	0.00	0	502	0
348	744	34.23	7200	0.00	1740	0	0.28	59	0.00	0	40	0
349	744	0.00	0	0.00	0	0	0.00	1	0.00	0	0	0
350	672	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
351	744	0.00	0	0.00	0	0	1.56	313	0.00	0	226	0
352	720	111.64	23536	0.00	5100	0	9.18	3820	2.42	734	1500	350
353	744	108.17	30984	0.00	5100	0	9.18	3782	0.00	0	1500	0
354	720	103.69	33849	0.00	5100	0	9.18	3820	2.13	647	1500	308
355	744	97.74	37197	0.00	5100	0	9.18	3820	4.67	1533	1500	691
356	744	92.10	26094	0.00	5100	0	8.07	2198	0.00	0	1270	0
357	720	87.78	22203	0.00	5100	0	5.06	1220	0.00	0	752	0
358	744	83.17	21860	0.00	5100	0	7.37	1736	0.00	0	1139	0
359	720	78.59	17399	0.00	5100	0	4.14	883	0.00	0	608	0
360	744	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period								
		Pump Back Operations, MW								
		With Pump cycle			With Gen Cycle			Pure Pump Back		
Plant Capacity, MW		123.00			123.00			123.00		
Plant Capacity, cfs		MaxQ=5100 cfs			MaxQ=5100 cfs			MaxQ=5100 cfs		
Month	# of Hours	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs
1	744	0.00	0	0	0.00	0	0	0.00	0	0
2	672	51.61	16049	2226	0.00	0	0	0.00	0	0
3	744	0.00	0	0	0.00	0	0	118.32	35905	5100
4	720	0.00	0	0	0.00	0	0	118.34	34870	5100
5	744	0.00	0	0	91.65	33991	3959	0.00	0	0
6	720	0.00	0	0	0.00	0	0	0.00	0	0
7	744	0.00	0	0	0.00	0	0	112.55	33216	5100
8	744	0.00	0	0	82.05	25251	3734	0.00	0	0
9	720	0.00	0	0	1.96	518	91	0.00	0	0
10	744	0.00	0	0	70.16	16733	3329	0.00	0	0
11	720	0.00	0	0	0.00	0	0	0.00	0	0
12	744	117.71	26633	5100	0.00	0	0	0.00	0	0
13	744	0.00	0	0	0.00	0	0	118.39	24019	5100
14	672	0.00	0	0	0.00	0	0	118.39	17722	5100
15	744	0.00	0	0	0.00	0	0	118.39	23223	5100
16	720	0.00	0	0	0.00	0	0	118.41	27197	5100
17	744	0.00	0	0	0.00	0	0	118.34	36952	5100
18	720	0.00	0	0	106.45	31919	4597	0.00	0	0
19	744	0.00	0	0	81.00	23044	3521	0.00	0	0
20	744	117.06	30336	5100	0.00	0	0	0.00	0	0
21	720	0.00	0	0	43.21	9898	1883	0.00	0	0
22	744	0.00	0	0	72.76	17424	3214	0.00	0	0
23	720	0.00	0	0	0.00	0	0	0.00	0	0
24	744	0.00	0	0	87.23	17476	3972	0.00	0	0
25	744	0.00	0	0	0.00	0	0	111.82	24228	5100
26	696	0.00	0	0	0.00	0	0	0.00	0	0
27	744	118.37	27002	5100	0.00	0	0	0.00	0	0
28	720	0.00	0	0	0.00	0	0	118.40	30783	5100
29	744	0.00	0	0	0.00	0	0	118.24	37268	5100
30	720	0.00	0	0	62.04	17703	2688	0.00	0	0
31	744	0.00	0	0	0.00	0	0	0.00	0	0
32	744	113.64	29327	5100	0.00	0	0	0.00	0	0
33	720	0.00	0	0	0.00	0	0	0.00	0	0
34	744	0.00	0	0	63.44	14561	2921	0.00	0	0
35	720	0.00	0	0	0.00	0	0	0.00	0	0
36	744	0.00	0	0	62.19	12168	2967	0.00	0	0
37	744	0.00	0	0	0.00	0	0	106.12	21699	5100
38	672	0.00	0	0	0.00	0	0	106.12	16857	5100
39	744	64.59	12765	3023	0.00	0	0	0.00	0	0
40	720	0.00	0	0	50.80	12968	2352	0.00	0	0
41	744	0.00	0	0	31.64	9945	1496	0.00	0	0
42	720	0.00	0	0	0.00	0	0	0.00	0	0
43	744	0.00	0	0	0.00	0	0	0.00	0	0
44	744	0.00	0	0	59.76	14918	3194	0.00	0	0
45	720	0.00	0	0	59.96	14411	3253	0.00	0	0
46	744	0.00	0	0	34.29	8226	1895	0.00	0	0
47	720	0.00	0	0	47.15	9352	2659	0.00	0	0
48	744	0.00	0	0	4.54	909	262	0.00	0	0
49	744	0.00	0	0	0.00	0	0	86.32	16425	5100
50	672	0.00	0	0	0.00	0	0	0.00	0	0
51	744	0.00	0	0	0.00	0	0	0.00	0	0
52	720	0.00	0	0	0.00	0	0	0.00	0	0
53	744	0.00	0	0	0.30	75	22	0.00	0	0
54	720	0.00	0	0	0.00	0	0	0.00	0	0
55	744	0.00	0	0	26.69	7470	2580	0.00	0	0
56	744	0.00	0	0	0.00	0	0	51.71	12550	5100
57	720	0.00	0	0	0.00	0	0	51.80	12177	5100
58	744	0.00	0	0	0.00	0	0	51.69	11311	5100
59	720	0.00	0	0	0.00	0	0	51.71	9538	5100
60	744	29.78	5764	2614	0.00	0	0	0.00	0	0
61	744	0.00	0	0	0.00	0	0	0.00	0	0
62	672	0.00	0	0	0.00	0	0	0.00	0	0
63	744	0.00	0	0	0.00	0	0	0.00	0	0
64	720	21.65	4453	1078	0.00	0	0	0.00	0	0
65	744	62.20	15993	2967	0.00	0	0	0.00	0	0
66	720	0.00	0	0	0.00	0	0	108.19	29377	5100
67	744	0.00	0	0	0.00	0	0	107.90	29540	5100
68	744	0.00	0	0	74.02	18855	3512	0.00	0	0
69	720	0.00	0	0	0.00	0	0	0.00	0	0
70	744	0.00	0	0	4.31	918	215	0.00	0	0
71	720	0.00	0	0	0.00	0	0	0.00	0	0
72	744	0.00	0	0	58.24	11408	3047	0.00	0	0
73	744	0.00	0	0	0.00	0	0	0.00	0	0
74	696	37.40	5655	1771	0.00	0	0	0.00	0	0
75	744	0.00	0	0	0.00	0	0	0.00	0	0
76	720	117.98	26279	5100	0.00	0	0	0.00	0	0
77	744	0.00	0	0	0.00	0	0	118.26	31364	5100
78	720	0.00	0	0	0.00	0	0	0.00	0	0
79	744	0.00	0	0	101.38	27565	4534	0.00	0	0
80	744	0.00	0	0	20.16	5168	911	0.00	0	0
81	720	0.00	0	0	3.45	808	160	0.00	0	0
82	744	0.00	0	0	63.77	13731	3020	0.00	0	0
83	720	0.00	0	0	44.73	8779	2140	0.00	0	0
84	744	0.00	0	0	65.31	12594	3160	0.00	0	0
85	744	0.00	0	0	0.00	0	0	0.00	0	0
86	672	0.00	0	0	0.00	0	0	0.00	0	0
87	744	0.00	0	0	0.00	0	0	118.39	22538	5100
88	720	0.00	0	0	0.00	0	0	118.41	23979	5100
89	744	0.00	0	0	82.14	21545	3546	0.00	0	0
90	720	0.00	0	0	28.84	7715	1262	0.00	0	0

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period								
		Pump Back Operations, MW								
		With Pump cycle			With Gen Cycle			Pure Pump Back		
Plant Capacity, MW		123.00			123.00			123.00		
Plant Capacity, cfs		MaxQ=5100 cfs			MaxQ=5100 cfs			MaxQ=5100 cfs		
Month	# of Hours	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs
91	744	0.00	0	0	30.53	8348	1367	0.00	0	0
92	744	0.00	0	0	70.97	18295	3236	0.00	0	0
93	720	0.00	0	0	0.00	0	0	0.00	0	0
94	744	0.00	0	0	0.00	0	0	0.00	0	0
95	720	0.00	0	0	0.00	0	0	0.00	0	0
96	744	0.00	0	0	0.00	0	0	100.55	18718	5100
97	744	0.00	0	0	0.00	0	0	0.00	0	0
98	672	0.00	0	0	0.00	0	0	0.00	0	0
99	744	95.41	18075	4152	0.00	0	0	0.00	0	0
100	720	0.00	0	0	0.00	0	0	118.42	25780	5100
101	744	0.00	0	0	17.97	4706	779	0.00	0	0
102	720	0.00	0	0	0.00	0	0	0.00	0	0
103	744	0.00	0	0	91.90	26158	4262	0.00	0	0
104	744	0.00	0	0	0.00	0	0	0.00	0	0
105	720	0.00	0	0	22.98	5333	1135	0.00	0	0
106	744	0.00	0	0	0.00	0	0	101.46	22892	5100
107	720	0.00	0	0	0.00	0	0	101.47	20045	5100
108	744	0.00	0	0	0.00	0	0	0.00	0	0
109	744	0.00	0	0	0.00	0	0	0.00	0	0
110	672	118.01	19007	5100	0.00	0	0	0.00	0	0
111	744	0.00	0	0	0.00	0	0	118.43	21487	5100
112	720	0.00	0	0	0.00	0	0	118.45	24925	5100
113	744	0.00	0	0	0.00	0	0	118.54	29803	5100
114	720	0.00	0	0	0.00	0	0	118.54	31824	5100
115	744	0.00	0	0	89.03	25433	3845	0.00	0	0
116	744	0.00	0	0	81.13	20414	3535	0.00	0	0
117	720	0.00	0	0	81.30	19606	3577	0.00	0	0
118	744	111.02	25316	4826	0.00	0	0	0.00	0	0
119	720	0.00	0	0	96.02	18245	4133	0.00	0	0
120	744	0.00	0	0	0.00	0	0	118.39	23505	5100
121	744	0.00	0	0	0.00	0	0	118.48	22043	5100
122	696	0.00	0	0	0.00	0	0	118.48	18349	5100
123	744	0.00	0	0	0.00	0	0	118.48	22796	5100
124	720	0.00	0	0	0.00	0	0	118.49	25175	5100
125	744	0.00	0	0	0.00	0	0	118.43	30376	5100
126	720	0.00	0	0	0.00	0	0	118.26	31548	5100
127	744	0.00	0	0	0.00	0	0	118.32	33758	5100
128	744	0.00	0	0	87.19	22001	3772	0.00	0	0
129	720	118.12	28386	5100	0.00	0	0	0.00	0	0
130	744	0.00	0	0	81.45	17835	3510	0.00	0	0
131	720	118.46	23255	5100	0.00	0	0	0.00	0	0
132	744	0.00	0	0	0.00	0	0	118.53	23522	5100
133	744	0.00	0	0	0.00	0	0	118.53	22136	5100
134	672	0.00	0	0	0.00	0	0	118.53	18531	5100
135	744	0.00	0	0	0.00	0	0	118.53	22646	5100
136	720	0.00	0	0	76.49	15569	3294	0.00	0	0
137	744	0.00	0	0	82.15	20579	3567	0.00	0	0
138	720	0.00	0	0	0.00	0	0	0.00	0	0
139	744	0.00	0	0	0.00	0	0	0.00	0	0
140	744	0.00	0	0	0.00	0	0	0.00	0	0
141	720	0.00	0	0	0.00	0	0	0.00	0	0
142	744	0.00	0	0	0.00	0	0	0.00	0	0
143	720	0.00	0	0	0.00	0	0	0.00	0	0
144	744	0.00	0	0	0.00	0	0	0.00	0	0
145	744	0.00	0	0	0.00	0	0	111.76	20366	5100
146	672	93.63	14687	4185	0.00	0	0	0.00	0	0
147	744	116.47	21510	5100	0.00	0	0	0.00	0	0
148	720	0.00	0	0	0.00	0	0	0.00	0	0
149	744	0.00	0	0	10.02	2505	451	0.00	0	0
150	720	0.00	0	0	0.00	0	0	0.00	0	0
151	744	0.00	0	0	0.00	0	0	0.00	0	0
152	744	0.00	0	0	12.86	3447	671	0.00	0	0
153	720	0.00	0	0	15.76	3872	851	0.00	0	0
154	744	0.00	0	0	51.78	11447	2872	0.00	0	0
155	720	0.00	0	0	47.39	9286	2667	0.00	0	0
156	744	0.00	0	0	0.00	0	0	89.59	17327	5100
157	744	0.00	0	0	0.00	0	0	0.00	0	0
158	672	0.00	0	0	0.00	0	0	0.00	0	0
159	744	0.00	0	0	0.00	0	0	0.00	0	0
160	720	116.91	23091	5100	0.00	0	0	0.00	0	0
161	744	0.00	0	0	85.31	21551	3711	0.00	0	0
162	720	0.00	0	0	99.92	25898	4376	0.00	0	0
163	744	0.00	0	0	0.00	0	0	0.00	0	0
164	744	0.00	0	0	35.56	9452	1654	0.00	0	0
165	720	0.00	0	0	1.28	302	61	0.00	0	0
166	744	0.00	0	0	63.22	14701	3080	0.00	0	0
167	720	0.00	0	0	0.59	117	29	0.00	0	0
168	744	0.00	0	0	59.55	11609	3007	0.00	0	0
169	744	101.06	19436	5100	0.00	0	0	0.00	0	0
170	696	0.00	0	0	0.00	0	0	0.00	0	0
171	744	0.00	0	0	0.00	0	0	0.00	0	0
172	720	0.00	0	0	0.21	43	9	0.00	0	0
173	744	0.00	0	0	20.02	5019	899	0.00	0	0
174	720	0.00	0	0	95.12	24662	4341	0.00	0	0
175	744	0.00	0	0	0.00	0	0	0.00	0	0
176	744	0.00	0	0	13.74	3542	662	0.00	0	0
177	720	0.00	0	0	15.01	3723	745	0.00	0	0
178	744	0.00	0	0	6.52	1525	333	0.00	0	0
179	720	0.00	0	0	0.00	0	0	0.00	0	0
180	744	0.00	0	0	52.33	10708	2818	0.00	0	0

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period										
		Pump Back Operations, MW								
		With Pump cycle			With Gen Cycle			Pure Pump Back		
Plant Capacity, MW		123.00			123.00			123.00		
Plant Capacity, cfs		MaxQ=5100 cfs			MaxQ=5100 cfs			MaxQ=5100 cfs		
Month	# of Hours	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs
181	744	0.00	0	0	0.00	0	0	0.00	0	0
182	672	0.00	0	0	0.00	0	0	101.85	16660	5100
183	744	0.00	0	0	0.00	0	0	0.00	0	0
184	720	0.00	0	0	0.00	0	0	0.00	0	0
185	744	0.00	0	0	0.00	0	0	0.00	0	0
186	720	0.00	0	0	0.00	0	0	0.00	0	0
187	744	0.00	0	0	17.15	4852	1038	0.00	0	0
188	744	0.00	0	0	12.02	3094	764	0.00	0	0
189	720	0.00	0	0	10.65	2625	715	0.00	0	0
190	744	0.00	0	0	6.26	1442	447	0.00	0	0
191	720	0.00	0	0	38.14	7357	2863	0.00	0	0
192	744	0.00	0	0	42.50	8628	3272	0.00	0	0
193	744	0.00	0	0	0.00	0	0	65.02	12235	5100
194	672	0.00	0	0	0.00	0	0	0.00	0	0
195	744	0.00	0	0	0.00	0	0	0.00	0	0
196	720	79.25	15231	5100	0.00	0	0	0.00	0	0
197	744	0.00	0	0	0.00	0	0	0.00	0	0
198	720	0.00	0	0	13.25	3567	945	0.00	0	0
199	744	0.00	0	0	15.15	4297	1166	0.00	0	0
200	744	0.00	0	0	10.82	2797	916	0.00	0	0
201	720	0.00	0	0	36.78	9188	3400	0.00	0	0
202	744	0.00	0	0	33.21	7445	3238	0.00	0	0
203	720	0.00	0	0	0.00	0	0	51.30	10368	5100
204	744	0.00	0	0	0.00	0	0	51.40	10365	5100
205	744	17.27	3270	1464	0.00	0	0	0.00	0	0
206	672	0.00	0	0	32.27	5549	2516	0.00	0	0
207	744	0.00	0	0	0.00	0	0	63.68	11979	5100
208	720	0.00	0	0	0.00	0	0	0.00	0	0
209	744	0.00	0	0	37.06	9412	3417	0.00	0	0
210	720	0.00	0	0	0.00	0	0	53.44	14280	5100
211	744	0.00	0	0	44.83	12279	4353	0.00	0	0
212	744	0.00	0	0	0.00	0	0	52.33	14072	5100
213	720	0.00	0	0	0.00	0	0	53.12	13251	5100
214	744	0.00	0	0	41.90	9398	4081	0.00	0	0
215	720	0.00	0	0	0.00	0	0	51.31	10505	5100
216	744	0.00	0	0	0.00	0	0	51.40	9908	5100
217	744	0.00	0	0	0.00	0	0	51.47	10392	5100
218	696	0.00	0	0	0.00	0	0	51.47	8596	5100
219	744	0.00	0	0	0.00	0	0	0.00	0	0
220	720	0.00	0	0	0.00	0	0	74.29	13652	5100
221	744	0.00	0	0	0.00	0	0	74.22	18465	5100
222	720	0.00	0	0	0.00	0	0	74.05	19938	5100
223	744	0.00	0	0	0.00	0	0	73.82	20281	5100
224	744	0.00	0	0	19.31	5244	1374	0.00	0	0
225	720	0.00	0	0	42.18	10205	3163	0.00	0	0
226	744	0.00	0	0	5.72	1319	452	0.00	0	0
227	720	0.00	0	0	0.00	0	0	0.00	0	0
228	744	0.00	0	0	31.12	6263	2968	0.00	0	0
229	744	0.00	0	0	0.00	0	0	51.68	10410	5100
230	672	25.24	4430	2178	0.00	0	0	0.00	0	0
231	744	0.00	0	0	0.00	0	0	0.00	0	0
232	720	0.00	0	0	43.48	8496	2836	0.00	0	0
233	744	0.00	0	0	23.14	5827	1561	0.00	0	0
234	720	0.00	0	0	0.00	0	0	73.15	18731	5100
235	744	0.00	0	0	0.00	0	0	72.86	20686	5100
236	744	0.00	0	0	15.54	4163	1122	0.00	0	0
237	720	0.00	0	0	7.19	1715	560	0.00	0	0
238	744	0.00	0	0	4.08	937	350	0.00	0	0
239	720	0.00	0	0	25.75	5282	2430	0.00	0	0
240	744	54.87	10762	5100	0.00	0	0	0.00	0	0
241	744	18.22	3630	1457	0.00	0	0	0.00	0	0
242	672	9.33	1571	641	0.00	0	0	0.00	0	0
243	744	0.00	0	0	0.00	0	0	0.00	0	0
244	720	61.66	12334	3363	0.00	0	0	0.00	0	0
245	744	42.02	10327	2171	0.00	0	0	0.00	0	0
246	720	0.00	0	0	0.00	0	0	0.00	0	0
247	744	0.00	0	0	0.00	0	0	106.74	30403	5100
248	744	0.00	0	0	76.89	19906	3690	0.00	0	0
249	720	0.00	0	0	70.51	17567	3419	0.00	0	0
250	744	0.00	0	0	14.12	3246	695	0.00	0	0
251	720	0.00	0	0	0.29	57	15	0.00	0	0
252	744	100.32	20345	5100	0.00	0	0	0.00	0	0
253	744	0.00	0	0	0.00	0	0	100.75	20962	5100
254	672	0.00	0	0	0.00	0	0	0.00	0	0
255	744	0.00	0	0	70.43	13562	3317	0.00	0	0
256	720	0.00	0	0	0.00	0	0	107.50	21604	5100
257	744	0.00	0	0	0.00	0	0	107.39	26099	5100
258	720	0.00	0	0	0.00	0	0	0.00	0	0
259	744	0.00	0	0	0.00	0	0	0.00	0	0
260	744	0.00	0	0	0.00	0	0	0.00	0	0
261	720	0.00	0	0	16.08	4036	902	0.00	0	0
262	744	0.00	0	0	5.21	1175	303	0.00	0	0
263	720	0.00	0	0	37.77	7731	2273	0.00	0	0
264	744	0.00	0	0	0.00	0	0	83.46	17150	5100
265	744	0.00	0	0	0.00	0	0	0.00	0	0
266	696	0.00	0	0	0.00	0	0	0.00	0	0
267	744	0.00	0	0	0.00	0	0	0.00	0	0
268	720	74.13	14680	3311	0.00	0	0	0.00	0	0
269	744	117.66	27733	5100	0.00	0	0	0.00	0	0
270	720	0.00	0	0	0.00	0	0	118.49	31685	5100

Table H.C-3. NODOS Project, Power Operations, "Pumpback," Alternative C (Cont.)

		NODOS Project- Alternative C -CALSIM Model Run-Median Deliveries, 30-year Planning Period								
		Pump Back Operations, MW								
		With Pump cycle			With Gen Cycle			Pure Pump Back		
Plant Capacity, MW		123.00			123.00			123.00		
Plant Capacity, cfs		MaxQ=5100 cfs			MaxQ=5100 cfs			MaxQ=5100 cfs		
Month	# of Hours	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs	On-Peak	On-Peak, MWh	PumpBack Q cfs
271	744	118.69	32591	5100	0.00	0	0	0.00	0	0
272	744	0.00	0	0	0.00	0	0	118.67	32172	5100
273	720	0.00	0	0	78.95	19656	3401	0.00	0	0
274	744	0.00	0	0	0.00	0	0	0.00	0	0
275	720	0.00	0	0	0.00	0	0	0.00	0	0
276	744	0.00	0	0	0.00	0	0	0.00	0	0
277	744	0.00	0	0	0.00	0	0	118.62	23092	5100
278	672	0.00	0	0	0.00	0	0	118.62	20383	5100
279	744	0.00	0	0	0.00	0	0	118.62	22845	5100
280	720	0.00	0	0	0.00	0	0	118.63	22549	5100
281	744	0.00	0	0	0.00	0	0	118.56	29457	5100
282	720	0.00	0	0	0.00	0	0	118.38	31368	5100
283	744	0.00	0	0	2.36	646	103	0.00	0	0
284	744	0.00	0	0	73.26	19810	3268	0.00	0	0
285	720	0.00	0	0	0.00	0	0	0.00	0	0
286	744	0.00	0	0	0.00	0	0	0.00	0	0
287	720	0.00	0	0	0.00	0	0	0.00	0	0
288	744	0.00	0	0	0.00	0	0	0.00	0	0
289	744	18.69	3804	815	0.00	0	0	0.00	0	0
290	672	0.00	0	0	73.68	12754	3170	0.00	0	0
291	744	118.60	23012	5100	0.00	0	0	0.00	0	0
292	720	0.00	0	0	0.00	0	0	118.64	22677	5100
293	744	0.00	0	0	79.21	19725	3412	0.00	0	0
294	720	0.00	0	0	0.00	0	0	0.00	0	0
295	744	0.00	0	0	0.00	0	0	0.00	0	0
296	744	0.00	0	0	36.44	9866	1727	0.00	0	0
297	720	0.00	0	0	0.00	0	0	0.00	0	0
298	744	0.00	0	0	0.00	0	0	0.00	0	0
299	720	0.00	0	0	0.00	0	0	0.00	0	0
300	744	0.00	0	0	0.00	0	0	0.00	0	0
301	744	0.00	0	0	0.00	0	0	0.00	0	0
302	672	0.00	0	0	0.00	0	0	0.00	0	0
303	744	118.56	22303	5100	0.00	0	0	0.00	0	0
304	720	0.00	0	0	0.00	0	0	118.59	23686	5100
305	744	0.00	0	0	0.00	0	0	118.51	29583	5100
306	720	118.67	30302	5100	0.00	0	0	0.00	0	0
307	744	0.00	0	0	0.00	0	0	118.41	33734	5100
308	744	0.00	0	0	87.49	22840	3782	0.00	0	0
309	720	118.20	29401	5100	0.00	0	0	0.00	0	0
310	744	0.00	0	0	78.78	18303	3394	0.00	0	0
311	720	118.28	23845	5100	0.00	0	0	0.00	0	0
312	744	0.00	0	0	0.00	0	0	118.56	24576	5100
313	744	0.00	0	0	0.00	0	0	118.51	24408	5100
314	696	0.00	0	0	0.00	0	0	118.51	20799	5100
315	744	0.00	0	0	0.00	0	0	118.51	22455	5100
316	720	0.00	0	0	0.00	0	0	118.63	23824	5100
317	744	0.00	0	0	0.00	0	0	118.54	28545	5100
318	720	0.00	0	0	95.21	25295	4101	0.00	0	0
319	744	0.00	0	0	0.00	0	0	0.00	0	0
320	744	0.00	0	0	65.03	16998	2975	0.00	0	0
321	720	0.00	0	0	0.00	0	0	0.00	0	0
322	744	0.00	0	0	0.00	0	0	0.00	0	0
323	720	0.00	0	0	0.00	0	0	0.00	0	0
324	744	0.00	0	0	0.00	0	0	100.35	20908	5100
325	744	0.00	0	0	0.00	0	0	0.00	0	0
326	672	0.00	0	0	0.00	0	0	0.00	0	0
327	744	117.26	23227	5100	0.00	0	0	0.00	0	0
328	720	0.00	0	0	0.00	0	0	118.71	23956	5100
329	744	0.00	0	0	0.00	0	0	118.60	28621	5100
330	720	0.00	0	0	2.87	764	125	0.00	0	0
331	744	0.00	0	0	0.00	0	0	0.00	0	0
332	744	0.00	0	0	0.00	0	0	0.00	0	0
333	720	0.00	0	0	64.27	16047	3160	0.00	0	0
334	744	0.00	0	0	5.44	1226	272	0.00	0	0
335	720	0.00	0	0	2.49	526	128	0.00	0	0
336	744	0.00	0	0	60.40	12644	3179	0.00	0	0
337	744	27.64	5544	1408	0.00	0	0	0.00	0	0
338	672	0.00	0	0	0.00	0	0	0.00	0	0
339	744	0.00	0	0	0.00	0	0	0.00	0	0
340	720	0.00	0	0	47.04	9537	2031	0.00	0	0
341	744	0.00	0	0	18.39	4448	808	0.00	0	0
342	720	0.00	0	0	0.00	0	0	114.08	30382	5100
343	744	0.00	0	0	0.00	0	0	113.78	31287	5100
344	744	0.00	0	0	0.00	0	0	0.00	0	0
345	720	0.00	0	0	0.00	0	0	0.00	0	0
346	744	0.00	0	0	0.00	0	0	0.00	0	0
347	720	0.00	0	0	59.57	12654	3004	0.00	0	0
348	744	0.00	0	0	65.97	13876	3360	0.00	0	0
349	744	0.00	0	0	0.00	0	0	0.00	0	0
350	672	107.78	20088	5100	0.00	0	0	0.00	0	0
351	744	65.83	13198	3012	0.00	0	0	0.00	0	0
352	720	0.00	0	0	0.00	0	0	0.00	0	0
353	744	0.00	0	0	0.00	0	0	0.00	0	0
354	720	0.00	0	0	0.00	0	0	0.00	0	0
355	744	0.00	0	0	0.00	0	0	0.00	0	0
356	744	0.00	0	0	0.00	0	0	0.00	0	0
357	720	0.00	0	0	0.00	0	0	0.00	0	0
358	744	0.00	0	0	0.00	0	0	0.00	0	0
359	720	0.00	0	0	0.00	0	0	0.00	0	0
360	744	0.00	0	0	0.00	0	0	0.00	0	0

North of Delta Off-Stream Storage (NODOS) Project Benefits Study

By

Nan Zhang
Energy Exemplar, LLC
3013 Douglas Blvd, Suite 120
Roseville, CA 95661

Eric Toolson
Pinnacle Consulting, LLC
8746 Pathfinder CT
Orangevale, CA 95662

Submitted to the

U.S. Department of the Interior,
Bureau of Reclamation
2800 Cottage Way
Sacramento, CA 95825

November 2013

Acknowledgements

Many thanks go to the following individuals for their insightful comments and their contributions to this study.

- Mary Johannis – Bureau of Reclamation
- Sharon Mchale – Bureau of Reclamation
- Ronald Ganzfried –Bureau of Reclamation
- Eric Vogler – Bureau of Reclamation
- Jeff Herrin – URS Corp
- Joe Barnes – URS Corp
- Nik Carlson – URS Corp
- Ghassan Alqaser – California Department of Water Resources
- Tao Guo – Energy Exemplar, LLC
- Wenxiong Huang – Energy Exemplar, LLC

Table of Contents

List of Figures

List of Tables

1. Introduction

The economic viability study of the proposed North-of-Delta Off-Stream storage (NODOS) pump storage project was originally completed by the United States Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) in early 2013. This document summarizes an update to that study performed for Reclamation, by Energy Exemplar (EE) and Pinnacle Consulting (Pinnacle), consulting firms specializing in the evaluation of power generation assets in California and in the Western Electricity Coordinating Council (WECC) system, which includes the provinces of Alberta and British Columbia, the northern portion of Baja California, Mexico, and all or portions of 14 Western states in the United States including California.

The NODOS project is a potential storage facility designed for improved water supply reliability and Delta water quality (see www.usbr.gov/mp/nodos). The NODOS ***pump-storage project*** evaluation, which is the focus of this Appendix, analyzes the economic viability of enhancing the power operation of the NODOS project to provide pump storage sufficient for daily pump-back operations to facilitate reliable operation of the electric grid in California. The evaluation consists of a base and alternative case as summarized below:

> ***Base Case –*** uses existing Funks reservoir as the afterbay with a 1000 acre-feet of active storage.
>
> ***Alternative Case –*** expands the existing Funks reservoir to 6,500 acre-feet of active storage, with several other relatively minor project enhancements. The expanded reservoir is called Holthouse. In the DWR evaluation, this option is referred to as "Alternative C".

2. Purpose and Need of Project

The NODOS pump storage project is needed to provide peaking power and ancillary services in California. California has passed legislation which requires 33 percent of the electricity to serve customers be provided from defined renewable resources. Much of this renewable generation (such as solar photovoltaic and wind) is intermittent and not dispatchable. This means it may be available during the partial- or- off-peak hours, but cannot be counted upon to be available during all of the peak hours. Hence, additional new generation that is dispatchable and flexible will be required for the peak period. In addition to the peak-energy need, significant new renewable resources will also require additional ancillary services, or operational capacity that is available to compensate for the variability of the renewable resources in order to allow for the reliable operation of the electric grid.

3. Purpose of Update

There are several primary reasons for the update including the following:

- Perform an economic valuation using an hourly, rather than a monthly sub-period model.

- Use a simulation model which directly models and co-optimizes Ancillary Services (AS)[1].
- Evaluate any enhancements to the long-term planning capacity due to additional Holthouse storage.

The previous study performed with DWR used a model that was based on two monthly time steps – on-peak and off-peak. This is a valid approach used frequently when hourly data may not be available or the simulation tool is not capable of hourly modeling. And while the monthly sub-period modeling is credible and acceptable, it is not considered as accurate as an hourly model which provides for anywhere from 672 (28 days) to 744 (31 days) hours or period of simulation each month, as compared to two periods for the monthly sub-period model. Particularly for a storage project, it is critical to pick up the hourly fluctuations in market prices for both generation and pumping. Thus, an hourly model can provide for a more accurate economic assessment.

A second major reason for the update is that the model used for the hourly simulations, PLEXOS, (developed by Energy Exemplar)[2] is capable of accurately representing the simultaneous commit and dispatch process utilized by the California Independent System Operator (CAISO). The CAISO procedure (which is performed for the day-ahead market) results in hourly energy as well as ancillary service prices. Using PLEXOS in this manner allows a resource to be accurately credited with AS contribution and revenue, thus providing a more accurate valuation.

The third reason is to evaluate any changes to the long-term planning capacity credit. All firm resources have a defined capacity capability which is used to meet required resource planning margins. California has a resource adequacy requirement, which mandates (12 months out) that 15 percent capacity in excess of projected peak load be available to the grid. This planning reserve margin is mandated in order to assure adequate resources are available to reliably meet the system electric load given uncertainties regarding load and increasing uncertainties regarding the availability of generation at the time it is needed most.

4. Description of Base and Alternative Cases

The base case represents the water storage project as defined in 2006 and includes Sites pumping and once-through power generation. This evaluation allows for an accurate analysis of the incremental benefits achieved by the alternative case as compared to the base case. The alternative case represents the pumped-storage configuration that allows for a more optimal daily pump-back operation. These two cases are identical from a Sites powerhouse perspective. Each of these two configurations contains the following equipment:

[1] Ancillary Services (AS) are different types of operating reserves and include regulation-up, regulation-down, spin, and non-spin. Similar to energy, these reserves have specific hourly market-clearing prices and differ in terms of their ability to respond to system uncertainties.

[2] See www.energyexemplar.com.

Table 1 Sites Pumping-Generating Equipment

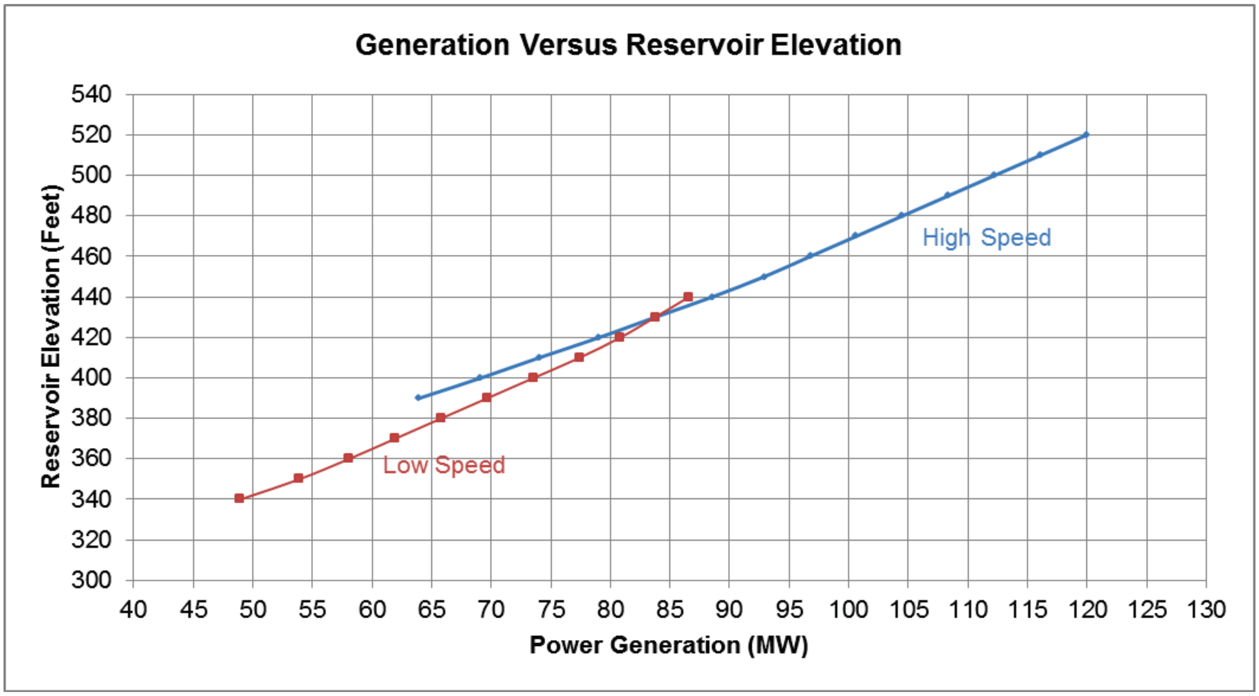
Unit Type	Number of Units	Net Head (feet)	Pumping Capacity/Unit (cfs)	Generating Capacity/Unit (cfs)	Motor Power/Unit (MW)	Generating Power/Unit (MW)
Pump -- Francis Vane Dual-Speed	2 (+1 standby)	330	870	n/a	27.6	n/a
		202	870	n/a	16.9	n/a
Pump -- Francis Vane Dual-Speed	2	330	435	n/a	13.8	n/a
		202	435	n/a	8.4	n/a
Pump / Turbine Reversible Francis, Dual-Speed	4 (+1 standby)	330 / 310	663	1020	19.7	24.6
		202 / 182	663	1020	11.6	14.5
Pump / Turbine Reversible Francis, Dual-Speed	2	330 / 310	332	510	9.9	12.3
		202 / 182	332	510	5.8	7.2
Total			**5,926**	**5,100**		

Source: DWR

The Sites pumped storage efficiency curves for the generating and the pumping modes of operation are provided by URS Corp and are shown in Figure 1 and Figure 2. These curves are the same for both the Base and the Alternative cases. At different reservoir elevations, the maximum generation output and the maximum pumping load are different, consistent with the maximum generation and pumping corresponding to that elevation shown in Figure 1 and Figure 2.

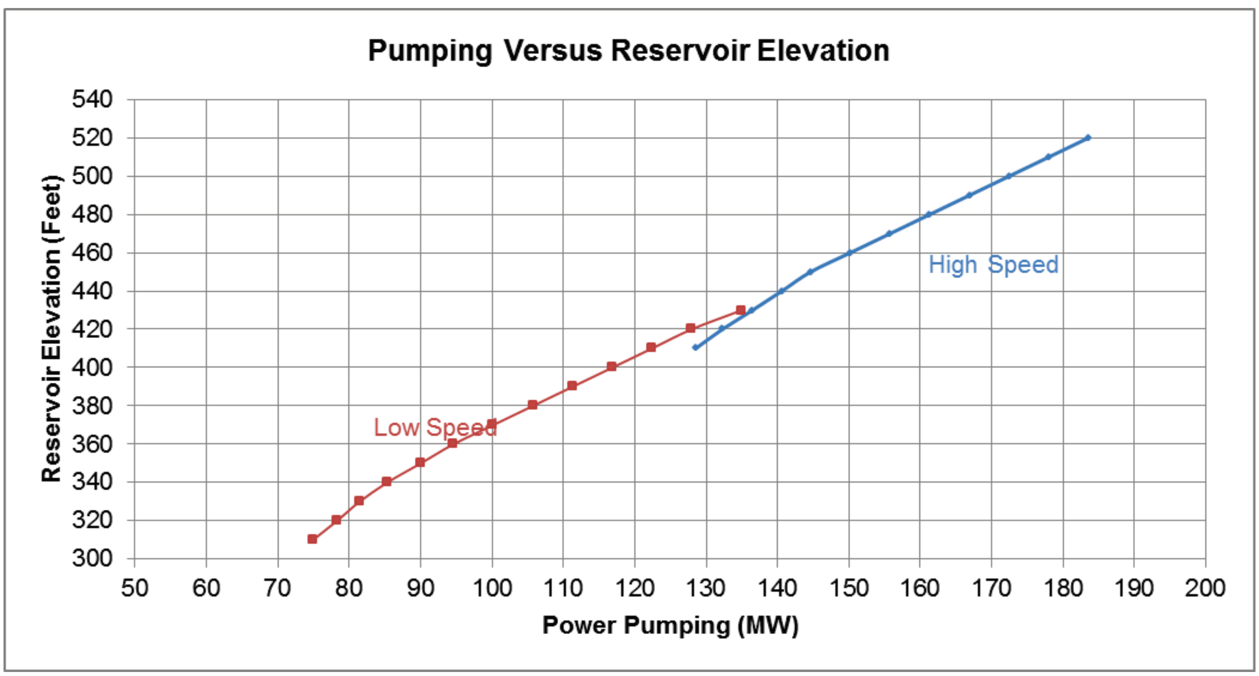
These two curves are translated into the PLEXOS simulation model as a series of pumped storage units with different efficiency points, as shown in Figure 3. Constraints are placed in the model to make sure each pumped storage unit is running at its desired water level and there are no two or more units operating at any time, which would result in a duplicate operation. This modeling technique was used for two reasons. First, it reduces the PLEXOS execution time significantly. Second, it simplified the modeling from 10 units to essentially one unit with 18 different efficiencies.

Figure 1 Sites Plant Generating Efficiency



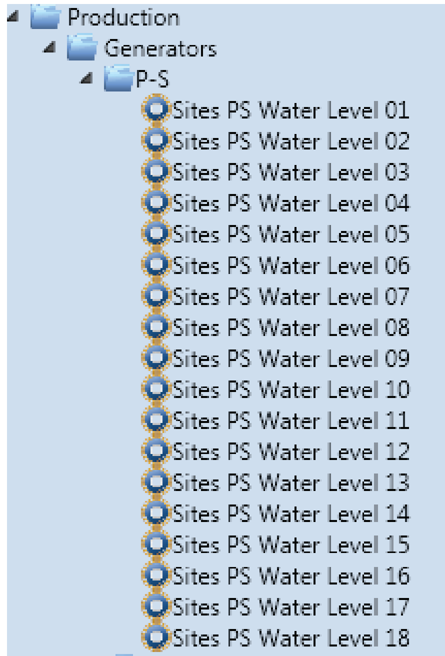
Source: URS Corp

Figure 2 Sites Plant Pumping Efficiency



Source: URS Corp

Figure 3 Sites Pump Storage Representation in PLEXOS



Since PLEXOS uses the volume model to represent the storage, the original efficiency curve was converted from an Elevation vs Megawatt (MW) representation to the Volume vs MW representation. The conversion curve from Elevation to the Volume was also provided by URS Corp, and is shown in Figure 4.

Although the pumping and generation equipment is identical between the base and alternative cases, the pumped storage case, (i.e., the "alternative" case) requires the following capital modifications to the base case [3] to enable a robust daily pump-back operation:

1. Enlarge Funks (Holthouse) Reservoir from its current 1000 acre-feet active storage (originally 2,000 acre-feet, but now reduced due to siltation) to 6,500 acre feet. This modification is the most significant capital expenditure.

2. Increase length and depth of channel connecting Sites powerhouse with enlarged Funks Reservoir.

3. Modify Delevan and the Terminal Regulating Reservoir (TRR) pipelines to function with enlarged Funks Reservoir (could be a cost reduction depending on alignment selected).

4. Relocate WAPA transmission line to span the enlarged Funks Reservoir.

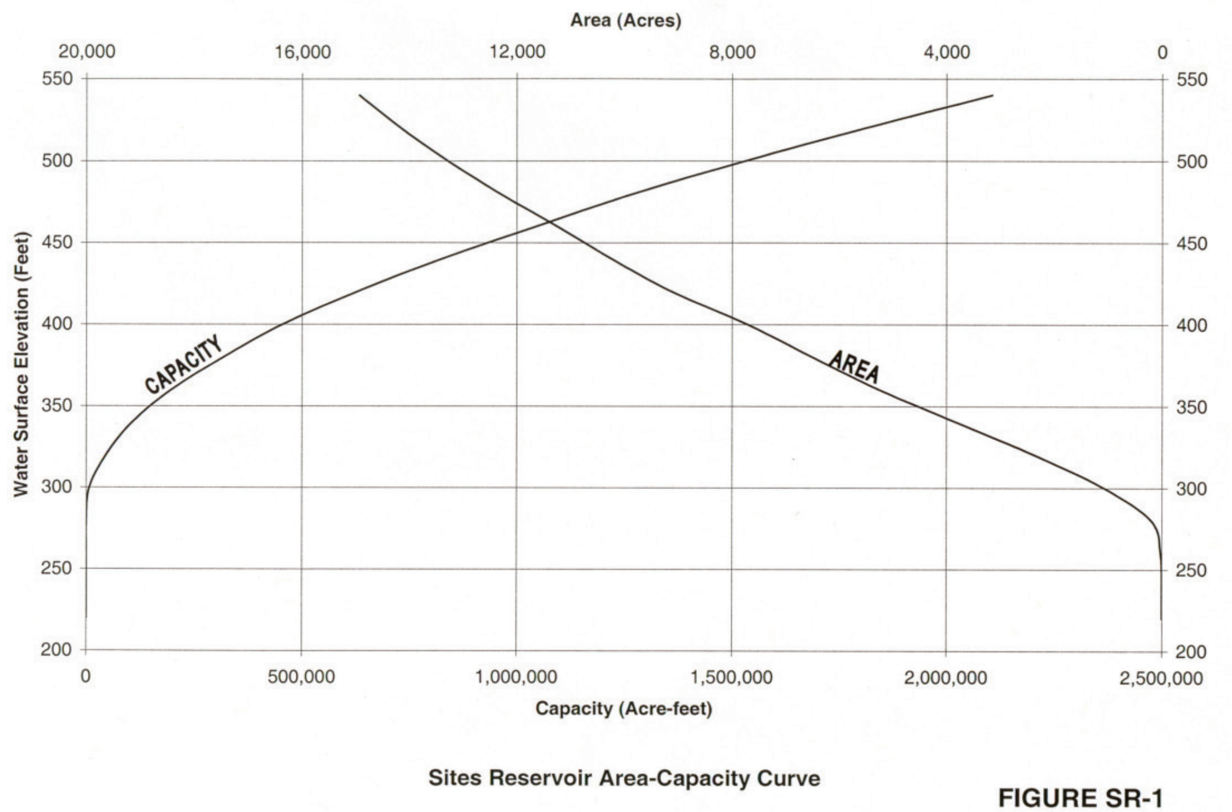
5. Develop pumping facilities to convey water to TC Canal downstream of Funks, when Funks is too low to provide water by gravity.

[3] Email from Joseph Barnes to Eric Toolson dated September 26, 2013 and entitled "Base Case for Power Generation" and subsequent conversations.

The estimated incremental costs for the Sites pumped storage alternative are currently estimated as follows:

- Incremental Capital Cost -- $120 million in 2012 dollars
- Incremental Fixed Operations and Maintenance (O&M) -- $0.5 million in 2012 dollars

Figure 4 Sites Reservoir Elevation to Volume Conversion Curve



Source: URS Corp

5. Description of Benefits

The Sites pumped storage project would provide the following benefits:

- Energy
- Ancillary Services (operating capacity)
- Planning Capacity

The derivation of each of these benefits is described below.

Energy and Ancillary Services Benefits – The energy production for the base case was determined by DWR and adhered to all water storage and other physical constraints. The energy production for the alternative case is a direct output from the PLEXOS model simulation. The energy production from both cases is valued by using the same market prices.

PLEXOS dispatches the Sites Pumped storage against the energy and ancillary services' market prices and maximizes the profit. As stated in the previous paragraph, the energy production for the base case was fixed, whereas the energy production for the alternative case was determined by PLEXOS. The pumped storage units are mostly pumping during the off-peak hours and generating during the on-peak hours whenever it is economic to go through this cycle. Also, PLEXOS determines the optimal timing and the amount of capacity to bid into the ancillary services market. Because of the co-optimization structure of the PLEXOS algorithm, it determines the best solution considering the energy market pricing and ancillary market pricing simultaneously.

Although this study only focuses on the benefits and costs of the daily pump-back operation at Sites power house, the study utilizes the monthly water diversion and release simulation between the Funks/Holthouse Reservoir and the other project facilities as a constraint. In this way, on a monthly basis the correct elevations are enforced on the pump-storage project operation to assure consistency between the water and power simulation for this project. The evenly distributed hourly water diversion to or release from Funks/Holthouse reservoir are derived from the DWR simulations.

Planning Capacity Benefits – The two types of capacity benefits derived from the pump-storage project are operating and planning reserves. Operating reserves are generally considered to have the same meaning as ancillary services and are described in the previous section. Planning reserves are described in this section. In the WECC, balancing authorities are encouraged to have a specified level of planning capacity or reserves for the future in order to ensure resource adequacy and the ability to operate the grid reliably. These reserve amounts are usually calculated using detailed, probabilistic, regional models. In California, there is a mandated planning reserve margin, which requires utilities or other electric service providers to own or control generation equal to roughly 115 percent of their expected peak hourly load.

There are a variety of ways to evaluate the value of planning capacity. If the need is just for a single year, one can look to the current planning reserve market. If the need, however, extends for more than 5 to 10 years, generally the cost of the least expensive peaking unit (minus market revenue from energy and AS sales) is considered to be a valid proxy for the cost of future capacity. The least-cost central-station generating resource is commonly considered to be a Combustion Turbine (CT). And in California, aero-derivative CTs are now being built (rather than traditional industrial frame CTs) due to future renewable energy integration needs.[4]

6. Simulation Methodology

The energy and ancillary services benefits are estimated using the PLEXOS market simulation model. The PLEXOS® Integrated Energy Model, developed by Energy Exemplar LLC, is a proven power market simulation software that uses cutting-edge mathematical programming and stochastic optimization

[4] Aero-derivative CTs are reportedly similar to aircraft engines and are much more flexible than larger industrial-frame CTs.

techniques, combined with the latest user-interface and data handling approaches to provide the most comprehensive, easy-to-use and robust analytical framework for power market modelers. It is widely used by many users for the following purposes:

- Price Forecasting
- Power Market Simulation and Analysis
- Detailed Operational Planning and Optimization of Power Plants and Grid
- Trading and Strategic Decision Support
- Generation and Transmission Capacity Expansion Planning (Investment Analysis)
- Renewable Integration Analysis
- Co-optimization of Ancillary Services and Energy Dispatch
- Transmission Analysis and Congestion Management
- Portfolio Optimization and Valuation
- Risk Management and Stochastic Optimization

The PLEXOS software has many distinguishing capabilities which are particularly useful in performing this NODOS Study.

- **Hourly and sub-hourly dispatch time-step.** The 1, 10, 15, 30 minutes and hourly time steps are available.
- **Simultaneous optimization.** All decision variables are determined at the same time, thereby providing a fully-optimized resource solution. This algorithm encompasses the same algorithms used by many independent system operators to clear their day-ahead market.
- **Ancillary service modeling.** PLEXOS simultaneously solves for all specified ancillary services including hard-to-model parameters such as regulation-up, regulation-down, load following, and any user-defined ones.
- **Comprehensive modeling for Hydro and Pumped storage.** PLEXOS can model comprehensive setup for a hydro system, from run-of-river, hydro with storage, to cascade hydro system with complex waterway and inflow definition. Pumped storage units can be modeled with generator efficiency, round-trip efficiency and head effects at different water level.
- **Integrated resource and transmission optimization.** PLEXOS fully co-optimizes complex Security Constrained Unit Commitment and Economic Dispatch with DC-OPF representation of regional transmission network and resource portfolios in the marketplace, including both energy and ancillary service production.
- **User-defined constraints and variables.** The user can add any linear or piecewise-linear constraint with a few simple steps in less than five minutes. This is a tremendous advantage over the traditional, time-consuming process of requiring the software developer to implement the constraint, test, document, etc. The user can also add user-defined decision variables, either linear or integer, and in this way enhance, expand or modify the intrinsic mathematical program at will.

The energy and ancillary service co-optimization is the basis of the PLEXOS algorithm. The PLEXOS Mixed Integer Programming Algorithm (MIP) produces the optimal decision on the generation and reserve provisions from each generator to meet the system energy demand and reserve requirements.

The hourly (or even sub-hourly) simulation is important for evaluating the benefits of the pumped storage plant. The pumped storage plant makes profits by pumping the water into upper reservoir during the off-peak hours and releasing water during on-peak hours to generate power. It is important to capture the price difference at each individual hour to make the decision on when to pump and when to generate in order to maximize the profit.

In this study, the PLEXOS model is configured to dispatch against the energy and ancillary service market prices.

The energy prices and ancillary services prices used in this study (which are described in Section 7) are input into the PLEXOS model. The Sites pumped storage facility (with physical constraints) is modeled in PLEXOS to pump and dispatch based on the market prices. PLEXOS automatically finds the optimized way to allocate the capacity into Energy market and Ancillary Service market to make the maximum profit. The simulation is based on an hourly chronological dispatch for 30 different hydrological years.

Ancillary services are used to provide sufficient generating capacity to ensure the power system can be operated in a reliable and stable manner on a four-second by four-second basis. A pumped storage power plant is very valuable in providing ancillary services due to its ability to provide flexible generation, which can be ramped up and down very quickly. This capability becomes increasing important, given the high percentage of renewable penetration mandated for California by the year 2020.

When a generator is to provide the upward ancillary services, the same amount of capacity is withheld from contributing to the energy market. How much capacity is contributing to the energy market and how much capacity is providing ancillary services to reach the maximum profit is a complex software optimization. Similarly, when a generator is to provide the downward ancillary services, the generator is operated at least the same amount of capacity above its minimum capacity.

Additional modeling constraints were also incorporated to correctly represent energy and ancillary service sales. Specifically, these constraints include the following:

- The maximum energy and regulation-up sales in any given hour cannot exceed the maximum generating capacity available in that hour.
- Regulation-up sales will be called upon roughly 20 percent of the time to provide energy. Thus, if 100 MW of regulation-up sales are desirable in a given hour, 20 percent of that amount, or 20 MW would be sold as energy associated to the 80 MW regulation-up sales.
- The reservoir storage must be available to provide energy for the full amount of regulation-up sales for a given hour, if the Sites pumped storage is called up to provide energy.

In summary, the derivation of the benefits for the two cases is summarized in Table 2 below:

Table 2 Source of Benefit Derivation for the Base and Alternative Cases

Benefit	Base Case (1,000 AF)	Alternative Case (6,500 AF)
Energy	DWR	PLEXOS
Ancillary Services	PLEXOS	PLEXOS
Planning Capacity	Spreadsheet	Spreadsheet

Given the time and resource constraints of this study, the energy benefits for the base case were not optimized in PLEXOS. Since the storage in this case is very limited (1,000 acre-feet [AF]), the energy benefits are not expected to be significantly greater than those derived in the DWR study. In a later phase of the study, it may be interesting to allow PLEXOS to optimize the energy output in the base case subject to all the water storage and physical constraints.

7. PLEXOS' Assumptions [5]

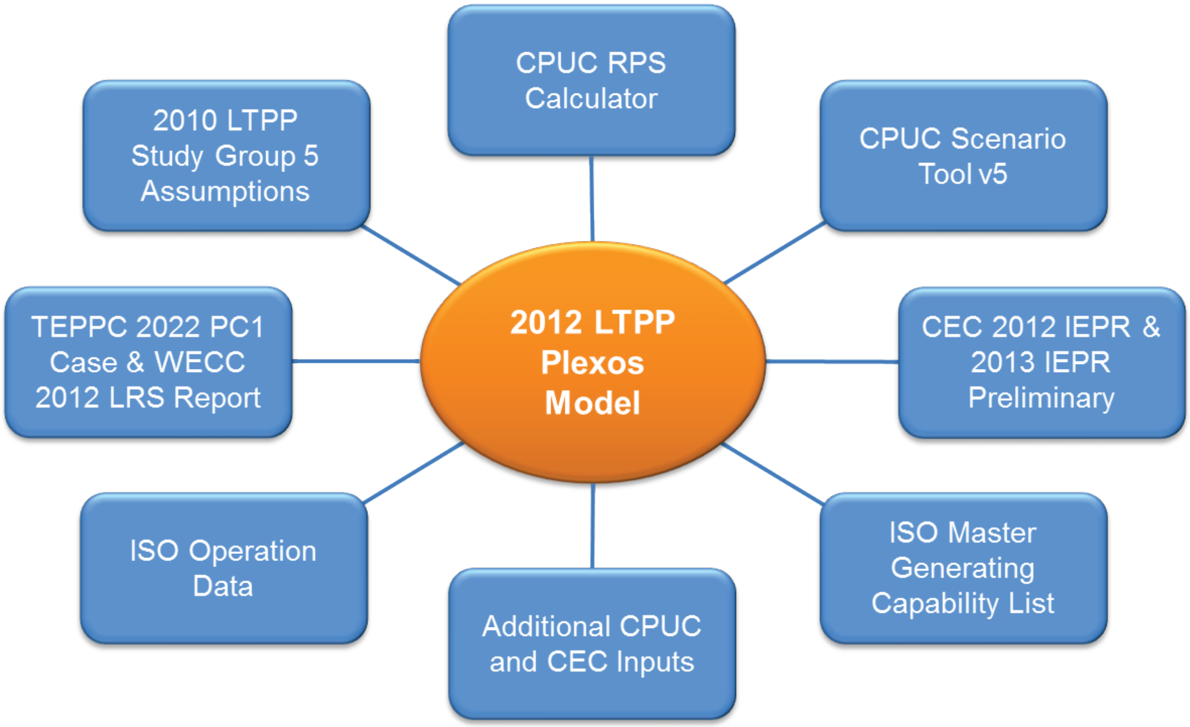
Under the California Assembly Bill 57 (PU Code 454.5), which passed in 2002 after the California energy crisis, the Investor-Owned Utilities (IOUs) resumed electricity procurement. Every 2 years, the California Public Utilities Commission (CPUC) holds a ***Long-Term Procurement Plan (LTPP)*** proceeding to review and adopt the IOUs' 10-year procurement plans. The LTPP evaluates the utilities' need for new resources and establishes rules for rate recovery of procurement transactions[6].

For the 2012 LTPP, the CPUC requested that the California ISO conduct a system operational flexibility modeling study. PLEXOS was selected to perform this study for the California ISO to study the system situation in year of 2022[7].

For this NODOS benefit study, several assumptions and outputs from this 2012 LTPP study were used in the PLEXOS modeling because this study reflects the inputs from multiple resources and has been reviewed by multiple stakeholders in the California power sector, as shown in Figure 5. WECC's Transmission Expansion Planning Policy Committee (TEPPC) oversees and maintains a public database for production cost and related analysis[8]. In the 2012 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 within California were further updated with CPUC's inputs from 2010 LTPP assumptions, Renewable Portfolio Standards (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.

[5] This section discusses the primary assumption changes which differ from the DWR work done previously.
[6] See http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/index_2012.htm
[7] See http://www.caiso.com/informed/Pages/StakeholderProcesses/RenewableIntegrationMarketProductReviewPhase2.aspx
[8] See https://www.wecc.biz/committees/BOD/TEPPC/Pages/TEPPC_Home.aspx

Figure 5 LTPP Assumptions from Multiple Sources



Source: R.12-03-014: LTPP Track II Workshop – Operating Flexibility Modeling Results

Year of Study:

2022 -- Same year as in 2012 LTPP study, assuming the major electricity mandates such as 33 percent renewable portfolio standard, greenhouse gas legislation, once-through cooling retirement, replacement for SONGS nuclear plant retirement, are all in place in California.

Gas price:

The PG&E gas burner tip prices are from the 2012 LTPP study base case, and are provided by California Energy Commission, which is shown in Table 3.

CO2 price:

CO2 price in 2022 is also provided by California Energy Commission (CEC).

Nominal Dollars: $**26.13/US Short ton**

2012 Dollars: $**21.89/US Short ton**

Energy and Ancillary Services Prices:

Energy and Ancillary Services prices are the simulation output from the PLEXOS 2012 LTPP simulation, as shown in Table 4. Here we only list the regulation up and regulation down prices because they are the highest among the ancillary services prices and Sites is capable of providing these services.

Table 3 PG&E Gas Price Assumption in 2022

	Nominal $	2012 $
Jan-22	5.38	4.50
Feb-22	5.08	4.25
Mar-22	4.97	4.17
Apr-22	5.12	4.29
May-22	5.28	4.42
Jun-22	5.36	4.49
Jul-22	5.43	4.55
Aug-22	5.04	4.23
Sep-22	4.99	4.18
Oct-22	5.18	4.34
Nov-22	5.58	4.68
Dec-22	5.64	4.73
Annual Avg	5.25	4.40

Source: 2012 LTPP Base Case Input

Table 4 PG&E Energy and Ancillary Service Prices from 2012 LTPP Run

	Energy $/MWh Nominal	Energy 2012$/MWh	RegUp $/MW Nominal	RegUp 2012$/MW	RegDn $/MW Nominal	RegDn 2012$/MW
Jan-22	50.45	42.27	7.21	6.04	0.23	0.19
Feb-22	47.05	39.41	6.69	5.61	0.33	0.28
Mar-22	42.10	35.27	7.44	6.24	0.71	0.60
Apr-22	37.41	31.34	7.57	6.35	1.55	1.30
May-22	37.34	31.29	7.88	6.61	1.90	1.59
Jun-22	42.53	35.63	8.71	7.29	2.45	2.05
Jul-22	58.15	48.72	10.48	8.78	0.36	0.30
Aug-22	48.16	40.34	6.25	5.24	0.10	0.08
Sep-22	48.84	40.91	8.18	6.85	0.23	0.19
Oct-22	50.38	42.21	10.15	8.51	0.74	0.62
Nov-22	51.68	43.30	9.61	8.05	0.87	0.73
Dec-22	54.40	45.58	7.94	6.65	0.37	0.31

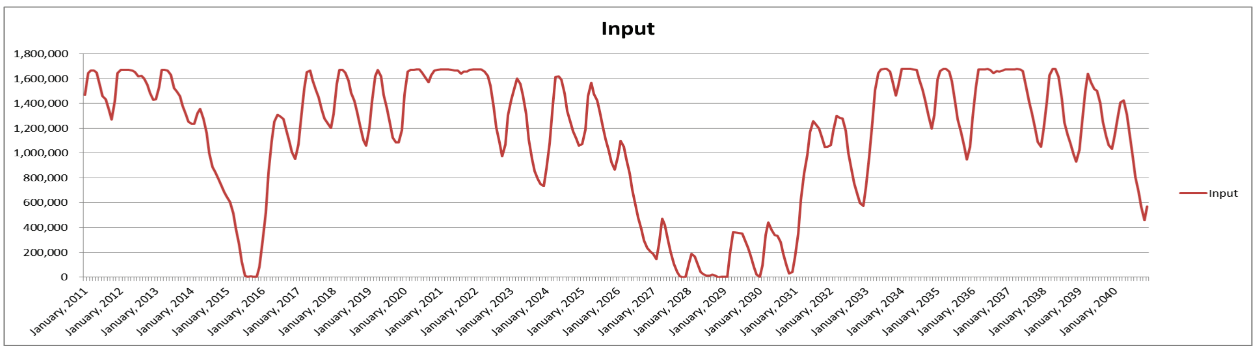
Source: 2012 LTPP Base Case Result

Water Year Consideration:

Weather is an important factor in California affecting the water operation and pumped storage operations. During a dry year, there is not enough water to be diverted to the upper reservoir during the off-peak season, and therefore the low elevation of the upper reservoir will limit the maximum generation output of the pumped storage operation.

From the DWR simulation, a 30-year historical water- year window was used. The monthly Sites Reservoir storage volume is the output from that study, as shown in Figure 6, and is the input constraint for the PLEXOS simulation.

Figure 6 Active Monthly Sites Reservoir Volume for 30 Hydrological Years

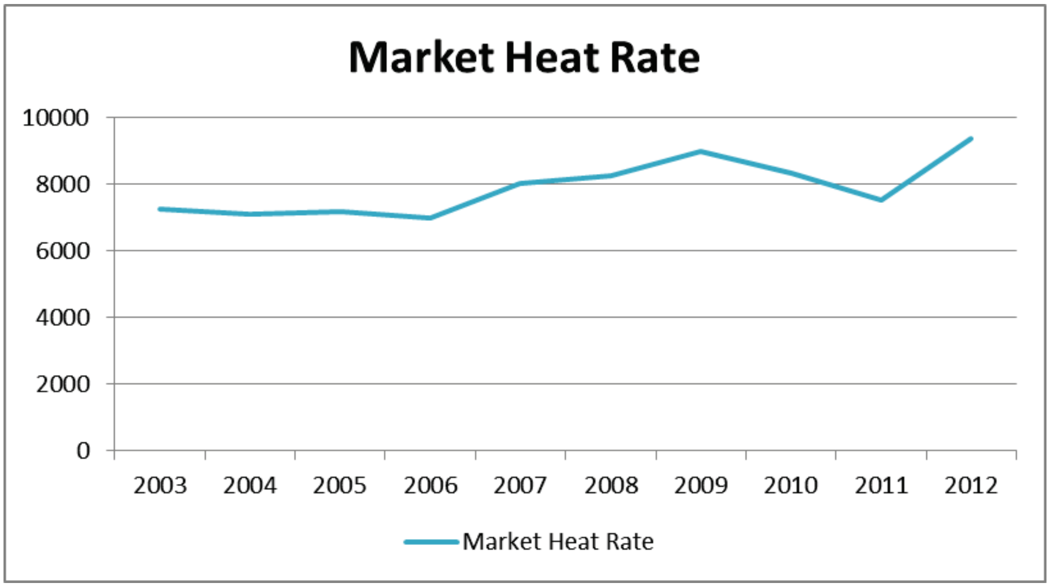


Source: DWR Simulation Result

In PLEXOS model, that monthly information is translated to a flat hourly water diversion or release to/from the Funks/Holthouse Reservoir for the applicable monthly sub-period. The Sites pumped storage facility is dispatched against the market prices, but also honors the water operation obligation for different hydrological years. The results from these 30 hydrological years are averaged into a single year result to avoid the result being biased to any certain type of hydro condition.

Another impact from the water condition is the energy market price. It is intuitive to think in a dry year condition, the available hydro generation to the system is much less than usual. Therefore a portion of base load generation is removed from the system generation supply stack. That forces the system to switch on more expensive generators in order to compensate for the loss of the hydro energy. As a result, energy prices are higher during droughts than during periods of normal generation.

Figure 7 Recent Year Market Heat Rate (BTU/KWh) – Load Adjusted



2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
D	AN	BN	AN	W	D	C	D	BN	W	BN

Historical Water year type from DWR: W- Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critical Historical Energy Price Source: CAISO; Historical Gas Price Source: ICE index; Historical load: CEC Market Heat Rate is calculated by **Energy Price / Gas Price * (Load Adjustment factor)** Load Adjustment factor is the factor to divide each year's annual load by the 2012 annual load.

Exactly measuring the water condition impact on the energy price is difficult, as the energy price is a result of a complex unit commitment and dispatch problem at a given system condition. However, the annual average energy price in California is largely affected by three key factors, the natural gas price, the total system load and the hydro condition. The hydro condition impact can be roughly estimated by removing the other two factors. Although historical information is limited to recent years, the load adjusted market heat rates in recent years can be calculated and are plotted in Figure 7, where we can see the water condition does make a difference on the market heat rates (2012 is an outlier because the gas price was too low in that year).

From the observation of historical heat rates, four types of water conditions are categorized in our study, and the adjustment factor for the energy price is listed below. Those factors are applied to the hourly energy prices according to the water year type of each of the 30 hydrological years in this study.

Table 5 Adjustment Factor for 4 Different Water Year Combinations

WY Type*	Factor
N-N	1.000
N-D	1.115
D-N	1.159
D-D	1.196

*The first letter represents the previous year water type as DWR definition.
The second letter represents the current year water type.
N stands for Normal and Wet, including Wet, Above Normal, and Below Normal.
D stands for Dry, including Dry, and Critical.

The water year condition impact on the Ancillary Service prices are unknown and hard to measure, therefore there is no adjustment applied to Ancillary Service prices for different water conditions.

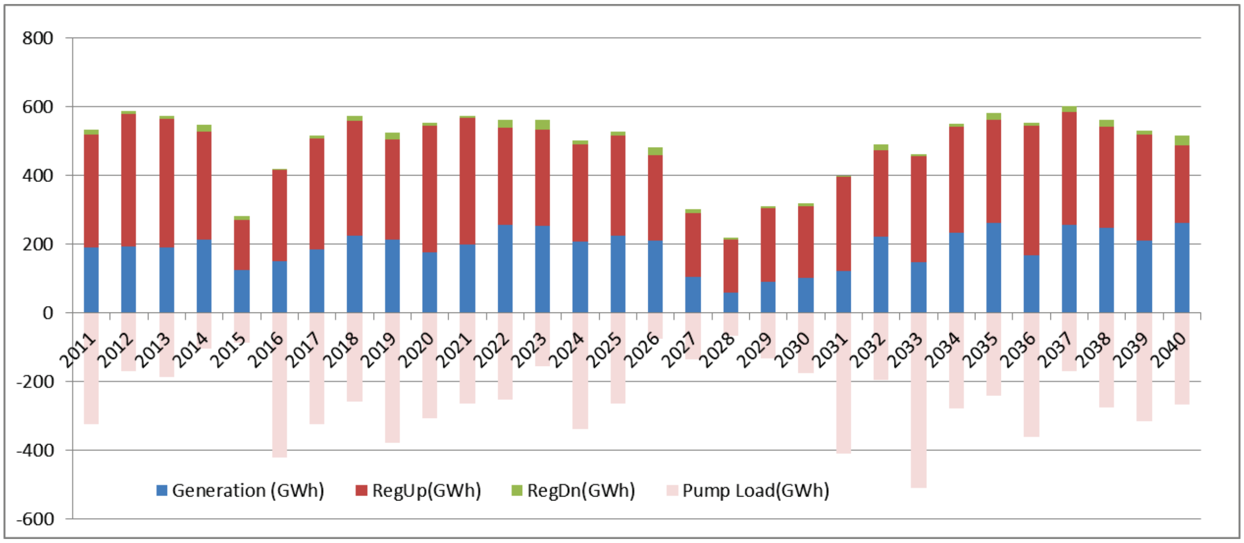
8. Year 2022 Draft Results

Energy and Ancillary Services – For the Alternative Case, the annual Sites pumped storage operation for the 30 hydrological years is plotted in Figure 8, and the net revenue for each hydrological year is plotted in Figure 9. The averaged summary from the 30 years of results is placed in Table 8. For the base case, the DWR provided the incidental pumping and generating schedule for each month of the 30 hydrological years. This schedule is multiplied by the power prices in this study to derive the Energy benefits or costs for the base case.

As discussed in previous section, the software model PLEXOS was used to determine the optimal energy and ancillary services sales in the alternative case (6,500 AF). The energy production for the base case (1,000 AF) was derived by DWR based on their simulation. To make the results compatible, the same market energy prices for the alternative case were used in the base case. In other words, the generation amount and timing was developed by DWR, but the pricing for this energy was made consistent with the alternative case and relied on the LTPP hourly energy prices.

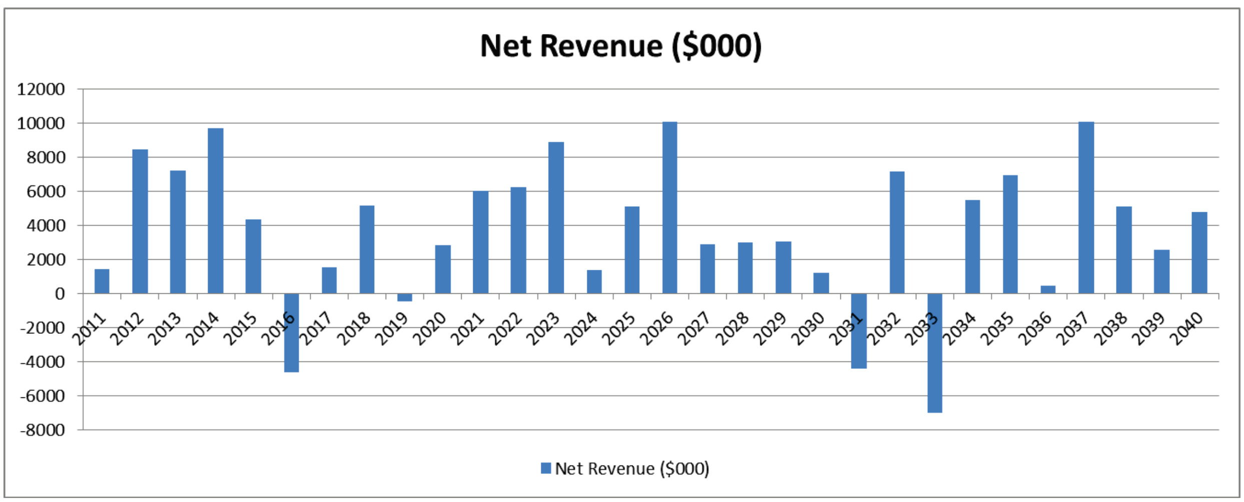
The ancillary service production for both cases was determined in PLEXOS using its energy/ancillary services co-optimization capability. For the base case, the generation production pattern determined by DWR was fixed and the remaining capacity was available for regulation-up sales subject to the constraints discussed on page 14 (which apply to both the base as well as the alternative case). This approach may result in an overstatement of the potential ancillary service benefits for the base case since no pump storage energy production is modeled. If there are pump storage opportunities in the base case with limited storage, then the ancillary services would likely be reduced but the net energy benefits would be increased, thus mitigating the potential AS overstatement.

Figure 8 Annual Pump Load, Generation and A/S Contribution for Each Hydrological Year*



*The horizontal axis indicates the hydrological year matching DWR's result, not the calendar year.

Figure 9 Annual Sites Pump Storage Net Revenue for Each Hydrological Year (2012 $000)



*Net Revenue = Energy Revenue + A/S Revenue – Pumping Cost

Planning Capacity –As discussed in Section 5, Description of Benefits, the value of long-term capacity is often viewed as the least-cost source of capacity, minus any energy or ancillary services net revenues from the market. In other words, in order to induce developers to build and maintain long-term peaking facilities, these developers would need to recover at a minimum as a capacity payment, all forward-looking capital and fixed operating costs, minus the profit they made in the energy and ancillary service market. That methodology is summarized in Table 6 below:

Table 6 Value of Planning Capacity per Kilowatt (kw)-Year

Parameter	Units	Value
CA CT capital cost	2012 $/kw-year	$ 155
CA CT fixed O&M	"	$ 35
Total annual fixed costs	"	$ 190
CA CT NP15 net revenue	"	$ 38
Peak hour derate	percent	5 %
Value of planning capacity	2012 $/kw-year	$ 160

The California Independent System Operator (in their annual market report[9]) estimated the total annual fixed cost of a California-built combustion turbine to be $190/kilowatt (kw)-year (includes both annual capital and fixed O&M costs). [10] The net revenue from energy and AS sales was estimated to be $38/kw-year. Adjusting for a 5 percent reduction in capacity during the peak hour, results in a planning capacity value of $160/kw-year in 2012 dollars.

The second part of this exercise is to estimate the difference in planning capacity for the base and alternative cases. Since both cases have the identical generating equipment and capability in the Sites powerhouse, one might conclude that there is no difference in long-term planning capacity. However the pump storage alternative has more active storage at Funks/Holthouse reservoir, thus allowing the pump storage option to generate longer.

In Figure 10 below, the peak week in 2012 is modeled with the two generating alternatives being evaluated in this report (pumping loads are not shown).[11]

During some hours of the week, both alternatives are able to generate 118 MW. Due to limited storage, that level of generation is available for only two hours for the base case (1,000 AF). However, in the alternative case (6,500 AF), that level of generation is available up to eight hours. To reflect this difference between the capabilities to maintain generation across the peak hours, the average generation for the four-hours of 3, 4, 5, and 6 pm was determined and compared. These results are shown in Table 7 below.

The difference between the two cases is 33.3 MW. At $160/kw-yr, this differential in capacity is $5.33 million in 2012 dollars.

A summary of the benefits is contained in Table 8.

[9] "CAISO 2012 Annual Report on Market Issues & Performance". http://www.caiso.com/Documents/2012AnnualReport-MarketIssue-Performance.pdf.

[10] It is not clear at this point whether the $190/kw-year represents an industrial or aero combustion turbine. The CAISO states that they received this information from the California Energy Commission (CEC) and is equivalent to whatever the CEC used in their generation analysis.

[11] "Peak week" is considered to be the week in the summer when the CA loads are highest. This week changes from year-to-year, but in 2012, this occurs in the last week of July. In this case, the 2012 hydrology is used and 2012 is considered a very dry year.

Figure 10 Hourly Generation during Peak-Load Week and Low Hydro Conditions for the Base and Alternative Cases [12]

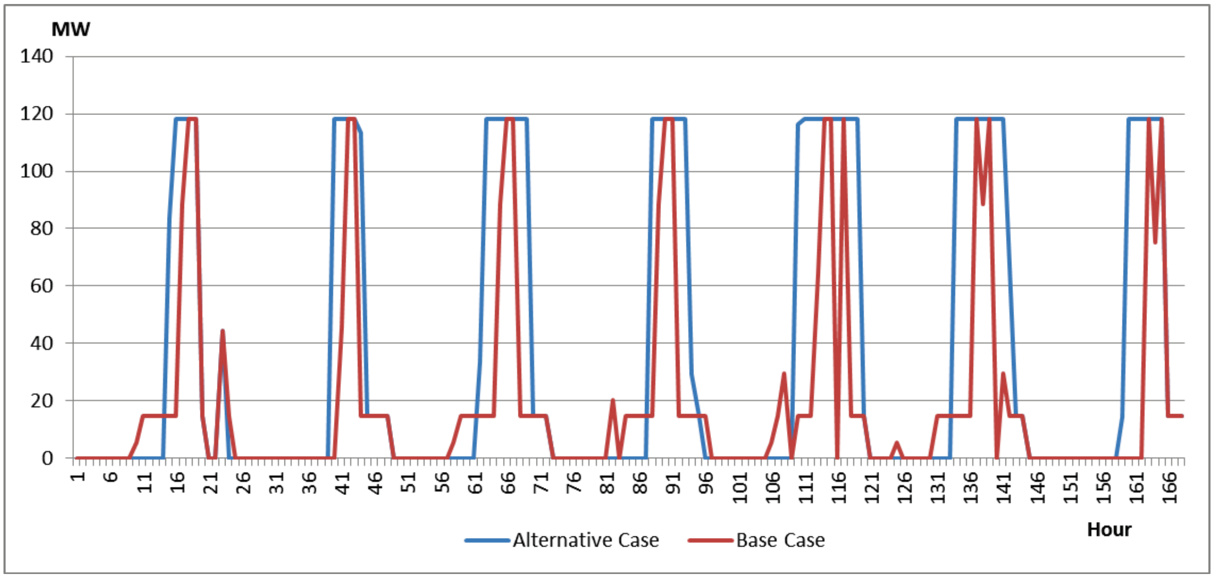


Table 7 Comparison of Planning Capacities

Alternative	Average 4-Hour Duration	Units
Base Case (1,000 AF)	84.8	MW
Alternative Case (6,500 AF)	118.1	MW
Difference	33.3	MW

Table 8 Summary of Annual Benefits for Expected-Gas-Price Case (2012 $)

Net Benefit	Base Case (1,000 AF)	Pump Storage (6,500 AF)	Value (mil. $)
Energy	$ -1.56 mil.	$ 1.37 mil.	$ 2.93 mil.
Ancillary Services	$ 1.68 mil.	$ 2.45 mil.	$ 0.77 mil.
Capacity	$ 13.57 mil.	$ 18.9 mil.	$ 5.33 mil.
Total	$ 13.69 mil.	$ 22.72 mil.	$ 9.03 mil.

The total annual benefits are estimated to be $9.03 million in 2012 dollars as shown in Table 8. If we make the conservative assumption that the benefits will escalate at inflation or a greater rate, and that the costs between now and the project online date will escalate at inflation or a lower rate, we can compare the annual benefits and costs to determine the economic viability of the proposed pump storage project.

[12] In order to determine the maximum energy output, the ancillary services market was removed from this simulation for this given week.

Table 9 Summary of Annual Costs, Benefits, and Overall BCR (2012 $)

Parameter	Value
Incremental capital cost [13]	$120 million
Federal real discount rate	3.75 percent
Economic life [14]	100 Years
Capital recovery factor	3.8 percent
Annual capital cost	$4.56 million
Incremental fixed O&M [15]	$0.5 million
Annual fixed cost	$5.06 million
Annual benefit	$9.03 million
Net Annual Benefit	$3.97 million
Benefit-Cost Ratio	1.78

9. Comparison with DWR Results

Before comparing the PLEXOS results to the DWR simulation result, it is appropriate to list several key differences between the two models and the two assumptions.

- PLEXOS is a production cost model and details in the hourly and sub-hourly optimized unit commitment and economic dispatch. Although PLEXOS is capable for doing stochastic studies, only deterministic runs have been performed for this evaluation due to the time constraint. DWR's model is focused on a probabilistic Monte-Carlo based approach. The hourly optimization might not be as intensive as in PLEXOS model.
- DWR's simulation is based on the view of a generally higher gas forecast. At the timing that the study was accomplished, the massive Shale gas production, commonly referred to as fracking, had not yet been fully implemented; therefore higher gas prices are forecasted in that study. Pumped storage plant will benefit from a higher gas price because that will enlarge the difference between on-peak and off-peak energy prices, assuming the market heat rate does not change too much. Therefore the Pumped storage has more room to arbitrage the price difference.
- The water year treatment is different in two models. DWR selected a 30 water year window and projected that window into the simulation horizon. If that window shifts a few years it might derive a quite different result. There was also no adjustment to energy prices for different water conditions. In PLEXOS, the simulation result is based on the average of the 30

[13] Source --- URS.

[14] The economic life represents the period of time over which the asset is assumed to be available and useful. If a present-value calculation were performed, the period over which the costs and benefits would be compared, is 100 years. If there is no assumed real escalation rate for the costs or benefits, the Benefit-To-Cost ratio is the same when comparing the present value or the annual costs and benefits.

[15] Source -- URS

hydrological years so the bias to a certain type of water condition is largely removed. Also the Energy prices are adjusted for water years as described in the Section 7.

Table 10 DWR Simulation Result

Pumping-Generation Site	CALSIM Deliveries					
Planning Alternative	Alternative A		Alternative B		Alternative C	
Operations Strategy	Incidental	Optimized	Incidental	Optimized	Incidental	Optimized
NODOS Pumping	Period Total, Annual Revenues ($1,000s)					
Tehama-Colusa Canal Pumping	-341	-341	-421	-421	-325	-325
Glenn-Colusa Irrigation District Pumping	-566	-566	-646	-646	-559	-559
Sacramento River Pumping	-3,001	-3,001	N/A	N/A	-3,320	-3,320
Terminal Regulating Reservoir Pumping	-557	-557	-923	-923	-664	-664
Sites Pumping	-8,377	-7,706	-8,284	-7,465	-9,659	-8,853
Subtotal	-12,842	-12,171	-10,274	-9,455	-14,527	-13,720
	Preliminary Results					
NODOS Generation	Period Total, Annual Revenues ($1,000s)					
Sites Generation	6,118	6,809	6,240	7,039	7,528	8,390
Terminal Regulating Reservoir Generation	1,102	1,144	384	401	1,143	1,191
Sacramento River Generation	2,797	2,797	N/A	N/A	2,815	2,815
Subtotal	10,017	10,751	6,624	7,439	11,487	12,396
NODOS Pumpback Operations	Period Total, Annual Revenues ($1,000s)					
Pumpback During Diversion cycle	N/A	394	N/A	785	N/A	418
Pumpback During Release Cycle	N/A	1,290	N/A	1,026	N/A	1,209
Pure Pumpback Operations Cycle	N/A	978	N/A	837	N/A	976
Subtotal		2,662		2,648		2,603
NODOS Total Net Revenues	-2,825	1,242	-3,650	632	-3,040	1,279
NODOS Project Optimization Potential		4,067		4,282		4,319

Source: DWR

Table 10 is the simulation result from the DWR study. At the last column, it indicates the annual benefit for the NODOS project (from energy market only) Alternative C is $4.319 million in terms of 2010 dollars. Using an inflation rate derived from California Energy Commission, 2.71 percent, it is equivalent to $**4.436 million** in 2012 dollars. From PLEXOS results shown in Table 8, if not considering the A/S benefits and capacity benefits, the equivalent NODOS Alternative C benefits from the Energy market is $**2.93 million** in 2012 dollars. It is worth noting that if the plant were dispatched in the energy only market, the total revenue would be larger than $2.93 million because this would be the only market the pump storage could take advantage of. Because the PLEXOS co-optimizes both energy and ancillary services market, some capacity will be withheld to contribute to ancillary services market to increase profit. Because DWR did not consider the AS market during their simulation, the results are not perfectly comparable for revenues just from the energy market.

10. Sensitivities

Because the gas price would have a big impact on our evaluation compared to other factors, a pair of sensitivity studies was performed to assess the value of the Sites pumped storage operation under a high gas price scenario and a low gas price scenario. For the high gas scenario, we adopted the 2022 gas price forecast as in the DWR study, which is $6.27/MMBtu in 2012 dollar. This can be viewed as a case with stricter regulation in fracking and more gas demand from the power sector due to the future expansion of the gas fired plants nationwide. A low gas price of $3.7/MMBtu was derived by the research from other public resources[16]. A conversion factor was calculated to scale up the original $4.40/MMBtu to the high gas and low gas prices. Then the conversion factor was applied to energy prices assuming the market heat rate is constant.

The results for the high gas study are summarized below in Table 11. The results for the low gas study are summarized in Table 12.

Table 11 Summary of Annual Benefits for High-Gas-Price Case

Net Benefit	Base Case (1,000 AF)	Pump Storage (6,500 AF)	Value (mil. $)
Energy	$ -2.22 mil.	$ 2.89 mil.	$ 5.11 mil.
Ancillary Services	$ 1.21 mil.	$ 1.77 mil.	$ 0.56 mil.
Capacity	$ 13.57 mil.	$ 18.9 mil.	$ 5.33 mil.
Total	$ 12.56 mil.	$ 23.56 mil.	$ 11.0 mil.

Table 12 Summary of Annual Benefits for Low-Gas-Price Case

Net Benefit	Base Case (1,000 AF)	Pump Storage (6,500 AF)	Value (mil. $)
Energy	$ -1.31 mil.	$ 0.22 mil.	$ 1.53 mil.
Ancillary Services	$ 1.53 mil.	$ 2.23 mil.	$ 0.70 mil.
Capacity	$ 13.57 mil.	$ 18.9 mil.	$ 5.33 mil.
Total	$ 12.56 mil.	$ 23.56 mil.	$ 7.56 mil.

11. Conclusions

Based on the analysis summarized in this study, the pump storage project appears to be economically viable with a relatively strong Benefit-to-Cost Ratio of 1.8. There also several factors which could impact the economic viability. These factors are summarized below:

16 http://www.energy.ca.gov/2013_energypolicy/documents/2013-10-01_workshop/presentations/03_Weng-Gutierrez_Electricity_Rate_Assumptions.pdf

- As demonstrated in the previous section, the results are quite sensitive to changes in gas prices. However, even in the low-gas-price case, the project still has annual benefits of $7.56 million compared to annual costs of $5.06 million.

- This analysis was based on a 33 percent renewable energy requirement in 2020. However, over the 100-year economic life of the project, it is likely that the renewable requirement will be increased to 40 or 50 percent, or higher. Increased renewables requires increased ancillary services requirements and a likely increase in AS prices. Since this project provides a significant amount of AS, these increased needs for ancillary services would be expected to increase the net benefit.

- As more renewables are added to the generation mix in the WECC, more hours will result in an "overgeneration" situation, which already exists in the Northwest resulting from the simultaneous hydro and wind production in the spring and early summer. Market prices during overgeneration conditions are typically very low and often negative. These "overgeneration" prices have not been fully captured in this analysis and would increase the differential between off-peak and on-peak prices, thus further benefiting the alternative project.

- Changes in the CO2 emission rate are also expected to have an impact on the economic viability of the NODOS pump storage project, but not as large as the impact of the gas price. If CO2 emission prices are higher than those forecast for this study, the energy benefits would likely be decreased as approximately 1.3 MWh of pumped energy is required for each 1 MWh of generation. Thus, the pricing differential between off- and on-peak would be decreased.