Chapter 2 Problems, Needs, and Opportunities

This chapter discusses specific water resources problems, needs, and opportunities that are used to direct the development of the NODOS/Sites Reservoir Project Investigation alternatives.

Identification Process

The identification of problems, needs, and opportunities began with the CALFED ROD. This section discusses some of the key processes and plans that have guided the process of identifying problems, needs, and opportunities.

CALFED Record of Decision

Many prior studies have suggested the potential benefits that could be obtained from new surface water storage north of the Delta. The CALFED ROD 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
- Levee system integrity for levees in the Delta

The NODOS project has the potential to address all of these needs, except for levee system integrity in the Delta. The NODOS project does not appreciably affect levees in the Delta.

Public Scoping

Comments received during the aforementioned public scoping meetings also informed the identification of problems, needs, and opportunities. Public scoping was conducted in accordance with the P&Gs (WRC 1983), NEPA, and CEQA. This process provided an opportunity for interested and affected agencies, groups, and persons to offer early input into the planning process. Specifically, P&Gs Section IV states, "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." This requirement is complementary with both NEPA (40 C.F.R. Parts 1501.1–1501.8) and CEQA (California Public Resources Code Section 21000 et seq.) regulations.

On November 5, 2001, the State NOP was filed with the State Clearinghouse, and on November 9, 2001, the Federal NOI was published in the *Federal Register*. The formal scoping process for the NODOS project began with the publication of the NOP and NOI, and concluded on February 8, 2002. During the scoping period, one tribal and three public scoping meetings were held. The Authority recently held a supplemental NOP from February 2, 2017 to March 2, 2017.

The study team received 57 comments that addressed various 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 were more general 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. These comments have been considered in the definition of problems, needs, and opportunities; the development of the planning objectives; and the identification of measures to meet those objectives. This effort is documented in the IAIR (Reclamation and DWR 2006b).

California Water Action Plan

The Governor issued the *California Water Action Plan* in January 2014 (NRA, CDFA, and CalEPA 2014). It is intended to be a 5-year roadmap toward achieving sustainable water management in California. The plan was updated in 2016 (NRA, CDFA, and CalEPA n.d.).

Although the plan comprehensively addresses water resources planning for the State, it was primarily a response to the deficiencies in drought preparedness that have been exposed over the last 5 years. In 2016, California ended its fifth consecutive year of below-average rainfall and snowpack (9 of the preceding 10 years also had below-average rainfall). This extended drought produced chronic and exceptional shortages in municipal and industrial, environmental, agricultural, and wildlife refuge water supplies, and led to historically low groundwater levels. Calendar years 2014 and 2015 saw record-low water allocations for CVP and SWP contractors (see Drought Contingency Plan [Reclamation and DWR 2016]). The California Water Action Plan provides a response that is informed by both the conditions observed throughout this drought and the anticipated future requirements due to climate change.

The extent of the recent drought has highlighted the vulnerability of California's water supply system to long-term drought and climate change. In January 2015, the Governor declared a drought State of Emergency. Effects of the drought in the Central Valley included the subsidence of agricultural lands as aquifers were depleted. Streams that salmon and steelhead depend on experienced higher temperatures and other water quality issues in the absence of rain. Communities throughout the state focused on boosting water conservation efforts and developing new sources of supply to alleviate the impacts of the drought. The problems and needs considered in the NODOS Investigation are far more apparent as a result of the drought than they were 6 years ago.

An update to the California Water Action Plan released in 2016 reaffirms the goals from the original plan. From the 2016 update (NRA, CDFA, and CalEPA n.d.),

> "There is broad agreement that the state's water management system is currently unable to satisfactorily meet both ecological and human needs, too exposed to wet and dry climate cycles and natural disasters, and inadequate to handle the additional pressures of future population growth and climate change. Solutions are complex and expensive, and they require the cooperation and sustained commitment of all Californians working together. To be sustainable, solutions must strike a balance between the need to provide for public health and safety (e.g., safe drinking water, clean rivers and beaches, flood protection), protect the environment, and support a stable California economy."

Several of the actions included in the *California Water Action Plan 2016 Update* were considered in the identification of problems, needs, and opportunities for this study (NRA, CDFA, and CalEPA n.d.). These actions include the following:

- Increase regional self-reliance and integrated water management across all levels of government
- Achieve co-equal goals for the Delta
- Protect and restore important ecosystems
- Manage and prepare for dry periods
- Expand water storage capacity and improve groundwater management
- Provide safe water for all communities
- Increase flood protection
- Increase operational and regulatory efficiency

Proposition 1, Water Quality, Supply, and Infrastructure Improvement Act of 2014

In November 2014, Proposition 1 was approved by California voters. It authorizes $7.545 billion in general obligation bonds to fund various water-related programs, including $2.7 billion for new water storage projects. The program supports the California Water Action Plan. Like the California Water Action Plan, passage of the bond was notably influenced by the effects of the drought. The bond focuses on providing funds to secure public benefits, and to the extent that the NODOS project can provide these public benefits, could potentially be leveraged to support the construction of the project.

This bond funding can only be used to cover costs related to the “public benefits” associated with water storage projects, including restoring habitats, improving water quality, reducing damage from floods, responding to emergencies, and improving recreation. Local governments and other entities that rely on the water storage project would be responsible for paying the remaining project costs. These costs would generally be associated with private benefits (such as water provided to their customers or hydropower generation). Eligible water storage projects for Proposition 1 bond funding include surface storage projects identified in the CALFED ROD (including the NODOS project), groundwater storage projects and groundwater contamination prevention or remediation projects that provide water storage benefits, conjunctive use and reservoir reoperation projects, and local and regional storage projects that improve the operation of water systems in the state and provide public benefits.

Projects that could be funded by a State water bond would be selected by the California Water Commission through the WSIP, which includes a competitive public process, ranking potential projects based on the expected return for public investment as measured by the magnitude of the public benefits provided. The public benefit categories include:

- Ecosystem improvements, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including ecosystems and fish and wildlife in the Delta
- Water quality improvements in the Delta—or in other river systems—that provide important public trust resources or that clean up and restore groundwater resources
- Flood control benefits, including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California’s water and flood management system
- Emergency response, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism
- Recreational purposes, including, but not limited to, those recreational pursuits generally associated with the outdoors

These public benefit categories were also considered in the identification of problems, needs, and opportunities for this study.

Sustainable Groundwater Management Act

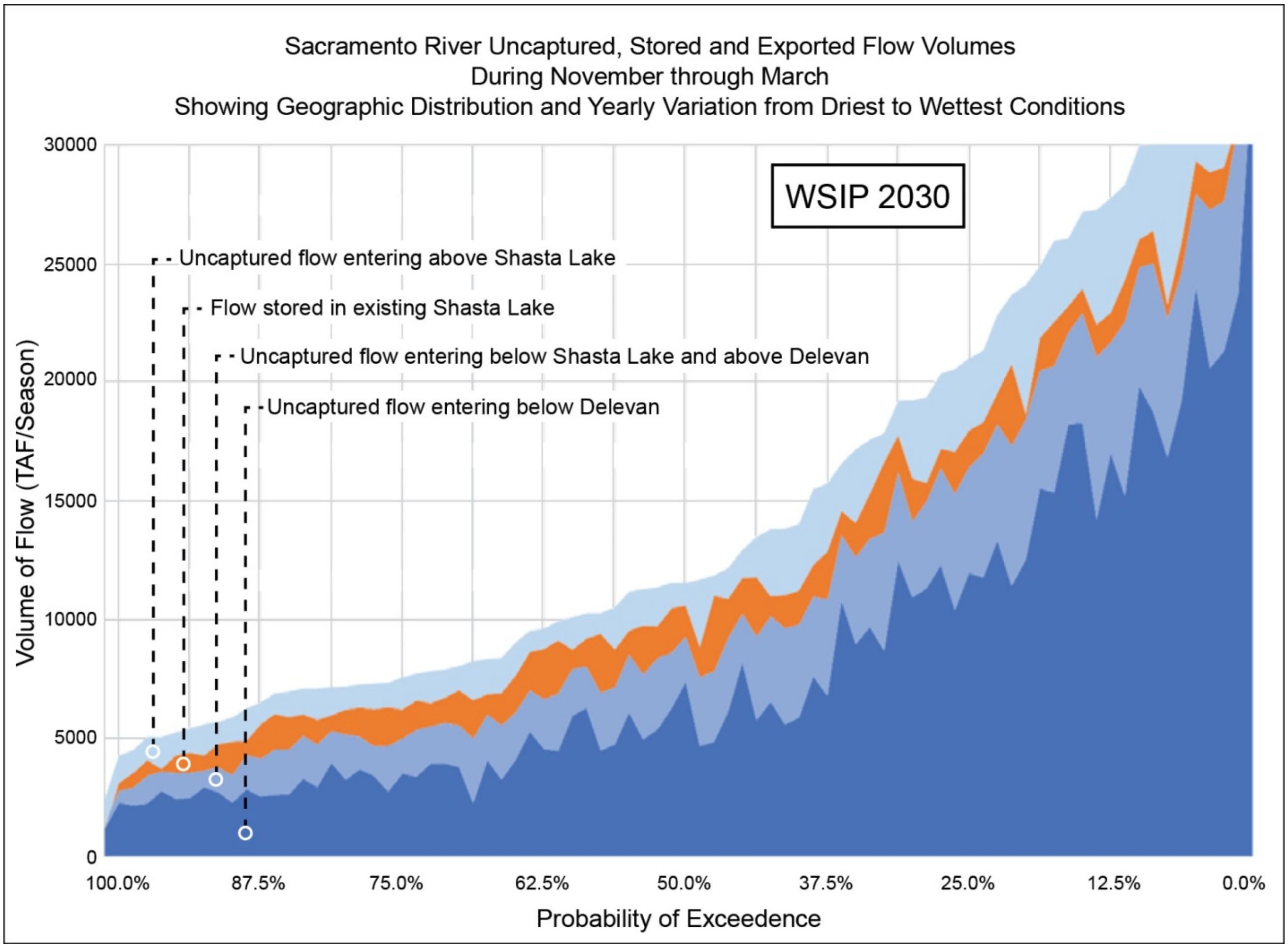
In 2014, California enacted legislation known as the Sustainable Groundwater Management Act (SGMA). The act provides a framework for sustainable management of groundwater supplies, including the formation of local groundwater sustainability agencies. These agencies must assess conditions in their local water basins and adopt locally based groundwater management plans. In addition, SGMA protects existing surface water and groundwater rights. This framework encourages better groundwater management that could contribute to reliable water supplies regardless of drought or climate change effects. SGMA is important to NODOS project planning in three specific ways:

1. Groundwater is likely to become more costly. The historic use of groundwater in California has been relatively free of regulatory constraints and their associated costs. Compliance costs for groundwater pumping will alter the cost of water and its associated economic benefit.
2. Water agencies throughout the Central Valley (both north and south of the Delta) need to adaptively manage both surface and groundwater resources to achieve a sustainable water supply. The use of surface water in lieu of groundwater, particularly during wet years, provides increased opportunity for groundwater recharge. Regional management of these resources throughout watersheds is also becoming increasingly important.
3. The planning of surface water projects should include an evaluation of opportunities to support groundwater recharge.

Availability of Water for North-of-the-Delta Storage

The Sacramento River is the largest surface water resource in California, carrying roughly one-third of total runoff water in the state into the Delta. Its drainage area includes the Sacramento, Feather, and American River Basins, covering an area of more than 26,000 square miles.

The amount of water that could potentially be diverted into storage is a primary consideration in siting offstream storage. Generally, the availability of water increases at locations farther south in the Sacramento River Valley, as additional tributaries enter the Sacramento River. Fifteen gauged tributaries enter the Sacramento River between Keswick Dam (downstream of Shasta Dam) and the city of Colusa, appreciably increasing the river flow. Average monthly streamflow in the Sacramento River downstream of Keswick Reservoir varies between 6,248 cubic feet per second (cfs) in October and 10,154 cfs in February. By the time the river reaches Hamilton City, the average monthly downstream flow in the Sacramento River increases to 6,619 cfs in October and 20,300 cfs in February. Figure 2-1 depicts the flow in the Sacramento River.



Source: CH2M Hill 2016a.

Figure 2-1. Sacramento River Flow Volumes November through March, Showing Geographic Distribution and Yearly Variation from Driest to Wettest Conditions

Annual diversions from the Sacramento River upstream of the confluence with the Feather River average approximately 1.7 million acre-feet (MAF). Major diversions occur at the Red Bluff Pumping Plant (RBPP) into the Tehama-Colusa (T-C) and Corning Canals, and at the Glenn-Colusa Irrigation District (GCID) Canal at Hamilton City. Surface water demands exceed the average annual diversions, with an average annual demand of 2.3 MAF, including water supplies for Sacramento Valley refuges, and agricultural activities between Red Bluff and Colusa.

Problems, Needs, and Opportunities for the NODOS Investigation

Water Supply and Water Supply Reliability

The CVP and SWP are two of the largest water storage and conveyance projects in the world. By the time construction of the initial facilities for both systems concluded in the 1970s, the two systems combined to provide notable flexibility for water resources management in California. This operational flexibility has eroded over the last 40 years due to:

- Increased usage of water in the source watersheds
- Increased usage of water contract allocations to meet growing agriculture and municipal and industrial (M&I) water demands
- Increased environmental requirements to meet endangered species and wildlife refuge supply commitments

In addition, potential climate change effects are anticipated to further diminish the ability of these projects to sustain their current levels of water supply. According to the *Sacramento and San Joaquin Basins Study Climate Impact Assessment* (Reclamation 2014c), overall 21st century projected impacts include increases in unmet demands, end of September storage, and Delta exports. Factors contributing to these impacts include earlier releases of excess runoff that would limit overall storage capacity and sea level rise requiring additional Delta outflow.

The challenge is especially acute and the consequences are exacerbated during multiple dry years, as evidenced by the 1976–1977, 1987–1992, 2007–2009, and 2012–2016 droughts. The Preferred Program Alternative in the CALFED ROD identified a need for up to 6 MAF of new storage in California, including up to 3 MAF of storage north of the Delta.

The *California Water Plan Update 2013* (DWR 2013) noted the following:

> "California's changing and increasingly competing demands for water come from many sectors. All uses generally can be characterized as urban, agricultural, or environmental. The state's population continues to grow, and the trend has been toward faster growth in warmer inland regions. From 1990 to 2010, California's population increased from about 30 million to about 37.3 million. The California Department of Finance projects that this trend indicates a state population of roughly 51 million by 2050.

The Current Trends and Expansive Growth scenarios without climate change indicate an additional 3.6 MAF/year of water would be needed by 2050 to stop groundwater overdraft statewide. The effects of potential climate change (including potential loss of snowpack) have been projected to further increase the need for water. The ability of the CVP and SWP to respond to these demands will likely be constrained by existing conveyance facilities, area-of-origin water right protections, and environmental impacts.

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

Table 2-1. Statewide Water Balance (MAF)

	2001 (72%)	**2002 (81%)**	**2003 (93%)**	**2004 (94%)**	**2005 (127%)**	**2006 (127%)**	**2007 (62%)**	**2008 (77%)**	**2009 (77%)**	**2010 (104%)**
Applied Water Use										
Urban	8.6	9.1	9.0	9.5	9.0	9.5	9.6	9.3	8.9	8.3
Irrigated Agriculture	33.7	35.9	32.8	36.1	31.2	33.3	36.9	37.0	36.0	32.9
Managed Wetlands	1.3	1.6	1.5	1.6	1.4	1.6	1.6	1.6	1.5	1.5
Required Delta Flow	4.5	4.8	6.4	6.5	7.0	10.1	4.5	4.5	4.7	5.3
Instream Flow	6.8	6.6	6.9	7.0	7.8	8.5	6.5	6.2	6.3	6.8
Wild & Scenic Rivers	9.8	21.9	29.5	23.0	26.2	44.8	18.1	19.5	18.1	25.1
Total Uses	**64.7**	**79.9**	**86.1**	**83.7**	**82.6**	**107.8**	**77.2**	**78.1**	**75.5**	**79.9**
Depleted Water Use (stippling)										
Urban	7.0	6.7	6.3	6.4	6.1	6.2	6.2	6.1	5.8	5.2
Irrigated Agriculture	26.0	26.2	24.3	26.8	22.7	24.2	27.1	27.6	26.6	23.8
Managed Wetlands	0.9	0.8	0.7	0.8	0.7	0.8	0.9	1.1	0.8	1.0
Required Delta Outflow	4.5	4.8	6.4	6.5	7.0	10.1	4.5	4.5	4.7	5.3
Instream Flow	2.2	2.6	2.7	2.7	3.3	6.1	4.4	2.2	4.1	4.4
Wild & Scenic Rivers	6.9	17.5	22.8	18.9	18.7	33.8	14.7	15.4	13.2	18.5
Total Uses	**47.5**	**58.6**	**63.2**	**62.1**	**58.5**	**81.32**	**57.8**	**56.9**	**55.2**	**58.2**
Dedicated and Developed Water Supply										
Instream	8.0	29.9	34.7	32.7	32.3	49.2	22.8	21.2	21.4	27.4
Local Projects	15.4	2.6	4.2	3.2	6.0	9.3	8.0	8.8	7.9	8.8
Local Imported Deliveries	0.8	0.8	0.8	0.8	0.9	1.1	1.5	1.2	1.3	1.1
Colorado Project	5.2	5.0	4.5	4.8	4.2	4.6	4.7	4.9	4.6	4.7
Federal Projects	6.8	7.3	7.1	6.9	7.2	7.4	6.6	6.1	5.7	6.4
State Project	2.1	2.9	3.1	3.2	3.4	3.7	3.3	1.9	1.8	2.2
Groundwater Extraction	17.6	17.5	15.5	17.7	12.0	13.1	18.8	20.0	20.1	14.7
Inflow & Storage	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Reuse & Seepage	8.5	13.6	15.8	14.0	16.3	19.2	11.1	13.5	12.3	14.1
Recycled Water	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Total Supplies	**64.7**	**79.9**	**86.0**	**83.7**	**82.6**	**107.9**	**77.1**	**77.9**	**75.4**	**79.8**

Source: Adapted from California Water Plan Update 2013 (DWR 2013).
MAF = million acre-feet

Water Supply

The Sacramento River Basin's CVP water service and settlement contractors are susceptible to dry-year deficiencies and are especially vulnerable to droughts. During extended droughts, decreased reduced water availability eventually force water users to either replace surface water supply by using groundwater, if they have this capability, or remove agricultural acreage from production (DWR 2005). Additional use of groundwater supplies during droughts may result in adverse impacts, such as reduced groundwater quality or ground subsidence; and groundwater overdraft.

The CALFED ROD 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."

California depends on groundwater for a major portion of its annual water supply, especially during extended droughts. In the Sacramento River Hydrologic Region (NODOS project location), groundwater contributes about 31 percent of the total water supply. Groundwater meets about one-third of the agricultural water demands and half of the urban water demands in the region (DWR 2013).

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. There is a need for increased dependability (i.e., timing) of water delivery to the people receiving it. As one of CALFED's four primary interrelated objectives, water supply reliability integrates the water supply elements of storage, conveyance, and quality. Federal, State, Local, and regional governments and water suppliers have a role in ensuring water resource sustainability and improving water supply reliability for the existing and future population and the environment. The decline in water supply reliability poses an opportunity to add new surface storage to improve CVP/SWP system operations, and thereby increase water supply reliability.

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, but it is experiencing an ecosystem crisis where anadromous salmonids, 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 and then releasing it during drier periods.

The NODOS feasibility studies focus on the use of offstream storage to capture runoff associated with major storm events to improve water supply reliability. Water stored in the winter during high-flow conditions in the Sacramento River would be available for use throughout the year. In addition, increased storage would allow more water to be carried over in storage from year to year. Additional water in an offstream storage reservoir would not incur new flood capacity constraints. This water would be especially helpful in mitigating the effects of drought or multiple dry years and the potential effects of climate change. Potential climate change effects include sea level rise, changes in precipitation, less snowpack, and changes in the timing of runoff. Offstream storage can capture runoff water when it is available without having to maintain storage capacity for flood control purposes, and then release the water when it is needed for water supply or environmental purposes.

Water supply needs that can potentially be supported directly by the NODOS project include:

- Agricultural water supply reliability (CVP water contractors, SWP water contractors, and local agricultural water districts)
- M&I water supply reliability (CVP water contractors, SWP water contractors, and local agencies)

Climate Change and Water Supply Reliability

Climate change threatens to further reduce water supply reliability throughout California. Sea level rise along the coast is beginning to threaten Delta water supplies and estuarine habitat as seawater intrudes into the Delta.

As a result of climate change, the Central Valley may experience more runoff during storm events in the future, but see less extended runoff from melting snowpack. The Northern California mountain snowpack is melting earlier in the spring and is projected to decrease over time. Storage in the Sierra and Trinity snowpack is particularly vulnerable to climate change. Estimates indicate that a rise of 3 degrees Celsius in California would result in the loss of snow at lower elevations, increasing 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). According to 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 are estimated to occur in the Central Valley.

The *Sacramento and San Joaquin Basins Study* (Reclamation 2016b) developed and evaluated five representative climate futures. Under the Central Tendency climate scenario, unmet demands, end-of-September storage, and CVP/SWP exports were negatively impacted. The report includes a risk and reliability assessment.

Some existing reservoirs rely heavily on snowmelt and could be affected by natural snowpack decreases.

Summary of Problems, Needs, and Opportunities for Water Supply and Water Supply Reliability

Table 2-2 summarizes the problems, needs, and opportunities associated with water supply and water supply reliability.

Table 2-2. Problems, Needs, and Opportunities: Water Supply and Water Supply Reliability

Problem	Need	Opportunity
Water supply reliability for municipal and industrial, agriculture, and wildlife refuges has decreased appreciably, resulting in loss of system resiliency.	Need improved water supply reliability to meet current and future challenges associated with increasing population, agriculture production, environmental needs, and climate change.	The NODOS project provides an additional water source that could improve: • Agricultural water supply reliability (CVP water contractors, SWP water contractors, and local agricultural water districts) • M&I water supply reliability (CVP water contractors, SWP water contractors, and local agencies)

CVP = Central Valley Project
M&I = municipal and industrial
NODOS = north-of-the-Delta offstream storage
SWP = State Water Project

Incremental Level 4 Water Supply for Wildlife Refuges

In accordance with Section 3406(d) of the Central Valley Project Improvement Act (CVPIA) (Title 34 P.L. 102-575), Reclamation and the United States Fish and Wildlife Service (USFWS), in coordination with the National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW) and DWR, work toward an annual goal of supplying 555,515 acre-feet (AF) of water to 19 Federal and State wildlife refuges in the Central Valley as part of the Refuge Water Supply Program (RWSP). This target quantity of water is referred to as "full Level 4," and is the amount of water required for optimum habitat management 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 the 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 RWSP has delivered an average of 364,985 AF of Level 2 water annually since 1993.

Incremental Level 4 water equals 133,264 AF, which 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 the annual hydrology, water availability, water market pricing, and funding. The RWSP 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.

Summary of Problems, Needs, and Opportunities for Incremental Level 4 Water Supply for Wildlife Refuges

Table 2-3 summarizes the problems, needs, and opportunities associated with incremental Level 4 water supply for wildlife refuges. With increasing unmet demands resulting from climate change, the long-term delivery of incremental Level 4 water supply for refuges is likely to decline in the future.

Table 2-3. Problems, Needs, and Opportunities: Incremental Level 4 Water Supply for Wildlife Refuges

Problem	Need	Opportunity
Maintaining CVPIA water supply requirements for Federal and State wildlife refuges.	Need reliable water supplies to provide for optimum habitat in the refuges.	The NODOS project provides an additional water source that can be used for consistent delivery of incremental Level 4 water to the refuges.

CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
NODOS = north-of-the-Delta offstream storage
SWP = State Water Project

Sustainable Hydropower Generation

Pumped storage hydropower generation is a well-established technology that is an attractive alternative to the fossil-fuel-powered electrical-generating facilities that are widely used as peaking or load-following resources. The intermittent nature of renewable energy from solar, wind, and some other green technologies means that renewable energy often lacks responsiveness to meet peak demand and follow loads. Therefore, there is an opportunity to add pumped storage hydropower to support the firming of solar and wind resources to provide stable grid operation and reliable supply for customers.

Pumped storage produces electricity to supply high peak demands by moving water between reservoirs at different elevations. At times of low electrical demand, excess capacity in the grid is used to pump water into the higher reservoir. When the demand increases, 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
- Clean peak power: Renewable generation (wind and solar power) easily integrated

Hydropower generation associated with the operation of the offstream storage reservoir could be used to support the development of renewable energy (i.e., solar and wind). Federal and State policy initiatives promoting renewable energy include:

- An MOU for hydropower between the Department of Energy, DOI, and the Department of the Army: Signed in March 2010 and extended in March 2015 for another 5 years of continued collaboration between the agencies, this MOU helps meet the nation’s needs for reliable, affordable, and environmentally sustainable hydropower development by supporting the goals of doubling renewable energy generation by 2020, and improving the Federal permitting processes for clean energy, as established in the President’s Climate Action Plan (Executive Office of the President 2013).

- California Executive Order S-3-05: Signed in June 2005, it established the following GHG emission reduction targets for California:
  - By 2010, reduce GHG emissions to 2000 levels
  - By 2020, reduce GHG emissions to 1990 levels
  - By 2050, reduce GHG emissions to 80 percent below 1990 levels
- Assembly Bill (AB) 32, California Global Warming Solutions Act of 2006: AB 32 requires reductions in GHG emissions to 1990 levels by 2020 (a reduction of approximately 15 percent).
- California Senate Bill (SB) X1-2: Signed in April 2011, SB X1-2 directs the California Public Utilities Commission's Renewable Energy Resources Program to increase the amount of electricity generated from eligible renewable energy resources per year by 33 percent by December 31, 2020.
- California Executive Order B-30-15: Signed in April 2015, this order added the intermediate target to reduce GHG emissions to 40 percent below 1990 levels by 2030.
- California Senate Bill 32: Signed into California state law in September 2016, SB 32 requires reductions in GHG emissions to 1990 levels by 2030 (a reduction of approximately 80 percent).

Summary of Problems, Needs, and Opportunities for Sustainable Hydropower Generation

Table 2-4 summarizes the problems, needs, and opportunities associated with sustainable hydropower generation. Hydropower generation at Sites Reservoir is likely to be unchanged to slightly improved with future climate change.

Table 2-4. Problems, Needs, and Opportunities: Sustainable Hydropower Generation

Problem	Need	Opportunity
Demands for power in the state are expected to increase as population, industry, and associated infrastructure growth occurs in the future.	Need new power sources that can meet California's stringent GHG regulations.	The NODOS project provides new pumped storage hydropower to meet the state's need for additional sustainable energy supplies.

GHG = greenhouse gas
NODOS = north-of-the-Delta offstream storage

Survival of Anadromous Fish and Other Aquatic Species

Anadromous fish hatch and develop in freshwater and migrate to spend a large part of their life cycle in brackish water or saltwater. Anadromous fish eventually return to freshwater to spawn at their location of origin. Sacramento River system anadromous fish include native species (e.g., steelhead, North American green sturgeon, four runs of Chinook salmon, and 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 stream 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 by water supply operations in the Sacramento River:

- 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
- Steelhead: Central Valley (evolutionarily significant unit [ESU]) (Federal Threatened Species)
- North American green sturgeon – Southern Distinct Population Segment (DPS): (Federal Threatened Species)

In addition, the following non-listed fish species may also be affected by water operations:

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

Cold-water Pool

Anadromous fish and other aquatic species in the Sacramento River watershed are sensitive to water temperature. When California reservoirs are relatively full, 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 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 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, the Central Valley steelhead has different freshwater incubation and rearing requirements than do several salmon species, because steelhead require longer periods in freshwater. Therefore, 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.

Similar issues exist in the Trinity, American, and Feather River watersheds. Systemwide integration of a NODOS project could potentially provide temperature-related benefits in these watersheds as well, but the greatest opportunity that could be addressed by a NODOS project is in the reach of the Sacramento River between Keswick Dam and Red Bluff Pumping Plant.

Stabilization of Fall Flows

In addition to a need for better temperature management, there is also a need to improve flows for anadromous fish migration. In 2009, NMFS released a proposed Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014). The proposed recovery strategy has many components, including the need to restore ecological flows throughout the Sacramento River Basin. There is a particular need to stabilize fall flows in the reach of the Sacramento River between Keswick Dam and RBPP to minimize dewatering of fall-run Chinook salmon redds, particularly during fall months. By exchanging water in NODOS for water in Lake Shasta, fall flows could be augmented in the portion of the Sacramento River downstream from Keswick Dam.

A similar need exists for stabilizing flows in the lower American River to minimize the dewatering of fall-run Chinook salmon and steelhead redds, and to reduce isolation events for juvenile anadromous salmonids.

Summary of Problems, Needs, and Opportunities for Improved Survivability of Anadromous Fish and Other Aquatic Species

Table 2-5 summarizes the problems, needs, and opportunities associated with anadromous fish and other aquatic species. The need for additional coldwater increases as temperature rises under climate change scenarios and the coldwater pool becomes more difficult to maintain.

Table 2-5. Problems, Needs, and Opportunities: Survivability of Anadromous Fish and Other Aquatic Species

Problem	Need	Opportunity
Populations of anadromous and endemic fish species in the Sacramento Valley river system and the Bay-Delta are declining due to warmer water temperatures and low flows.	Need additional cold water and increased flows for anadromous fish migration, spawning, and rearing.	The NODOS project provides an additional water source that could be cooperatively operated with the CVP and SWP systems to provide water to help stabilize river flows in the fall, and facilitate the release of additional cold water (from Shasta and Oroville) to benefit Sacramento River anadromous fish and other aquatic species.

CVP = Central Valley Project
NODOS = north-of-the-Delta offstream storage
SWP = State Water Project

Water Quality

Improved water quality in the Delta is needed for drinking water, agriculture, and environmental restoration. *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 reduce conflict among water users for diversion from the highest-water-quality locations. It also emphasized the importance of meeting water quality standards in both storage and conveyance systems. The NODOS Investigation considers the need to improve water quality by providing increased flows of high-quality water during periods when water quality is impaired.

Delta Environmental Water Quality

Achieving the co-equal goals of water supply and protection and restoration of the ecosystem for the Delta is one of the ten actions in the *California Water Action Plan 2016 Update* (NRA, CDFA, and CalEPA n.d.). Delta fisheries are sensitive to a variety of water quality constituents. For example, Delta smelt require a water source with a solution electrical conductivity (EC_w) of less than 12,000 EC_w to reproduce. In addition, there is strong opinion that the survival of Delta smelt increases as X2[1] moves west of Collinsville and downstream toward San Francisco Bay. State Water Resources Control Board (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 freshwater of sufficient quality and temperature to meet the biological needs of Delta smelt and other Delta species.

Urban and Agricultural Water Quality Improvements

The Delta system is the diversion point for drinking water for millions of Californians, and it is critical to California’s agricultural sector.

[1] X2 is a Delta management tool that is defined as the distance in kilometers from the Golden Gate Bridge to the location where the tidally averaged near-bottom salinity in the Delta measures 2 parts per thousand.

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 San Francisco Bay. This period is also outside of the peak loading time related to agricultural drainage. Addressing the USFWS Biological Opinion (BiOp) and NMFS BiOp (USFWS 2008; NMFS 2009) 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. Improving water quality in these months can reduce water supply treatment costs for M&I use for CVP and SWP contractors.

Reduced water quality in exports for San Joaquin Valley agricultural use exacerbates the problems caused by high salinity in agricultural drainage. Using higher-quality water with less salt for irrigation reduces the amount of water that needs to be applied to crops and reduces the pollutant load in agricultural runoff throughout the San Joaquin River watershed.

Summary of Problems, Needs, and Opportunities for Water Quality

Table 2-6 summarizes the problems, needs, and opportunities associated with water quality. Water quality in the Delta would degrade severely with sea level rise. Water quality problems could overwhelm the capacity of existing or future storage to respond to system needs if the sea level rises significantly.

Table 2-6. Problems, Needs, and Opportunities: Water Quality

Problem	Need	Opportunity
Delta water quality concerns associated with flows, salinity, water temperature, and toxins negatively affect Delta fisheries and water supplies for urban and agricultural needs.	Need additional water of sufficient quantity, quality, and temperature to meet drinking water, agricultural, and environmental needs.	The NODOS project provides an additional water source that could be cooperatively operated with the CVP and SWP systems to facilitate several ecosystem restoration and enhancement actions to improve conditions in the Delta and Sacramento River watershed.

CVP = Central Valley Project
NODOS = north-of-the-Delta offstream storage
SWP = State Water Project

Recreation

In Colusa and Glenn Counties, there are existing recreational opportunities for the public at East Park Reservoir in western Colusa County, and Stony Gorge Reservoir in western Glenn County. These reservoirs are relatively remote, and smaller than the proposed Sites Reservoir. As population increases in the Sacramento Valley, demands for flat water and land-based recreation are expected to increase. Reservoirs provide an opportunity to develop new recreational facilities. Recreation in the immediate vicinity of a new reservoir could include hiking, fishing, camping, boating, and mountain biking. The NODOS Investigation considers various recreational opportunities, including multiple recreation area locations and day-use facilities.

Summary of Problems, Needs, and Opportunities for Recreation

Table 2-7 summarizes the problems, needs, and opportunities associated with recreation.

Table 2-7. Problems, Needs, and Opportunities: Recreation

Problem	Need	Opportunity
Demands for flat-water, river, and land-based recreation are expected to increase as population increases in the region.	Need additional recreation areas to meet the region's increased demands.	The NODOS project provides a new reservoir with recreation areas that could help meet current and future demands.

NODOS = north-of-the-Delta offstream storage

Flood-Damage Reduction

Flooding in the Colusa Basin watershed typically takes place between October and April. The primary cause of flooding is inadequate conveyance capacities in the Colusa Basin Drain and in the many ephemeral streams throughout the watershed. Flood flows from the foothill streams are prone to sudden surges that flow swiftly into the Colusa Basin Drain.

Although the NODOS Investigation is evaluating offstream storage, the construction of any new reservoir provides an opportunity to capture and attenuate flood flows associated with ephemeral watersheds that can be important over a short period. Potential flood-damage reduction benefits in the Stone Corral Creek and Funks Creek watersheds and in downstream areas, such as the community of Maxwell and the Colusa Basin Drain, are being considered.

Summary of Problems, Needs, and Opportunities for Flood-Damage Reduction

Table 2-8 summarizes the problems, needs, and opportunities associated with flood-damage reduction. Flood damage reduction benefits resulting from the construction of dams on the east side of the Sacramento Valley should be resilient to the effects of climate change.

Table 2-8. Problems, Needs, and Opportunities: Flood-Damage Reduction

Problem	Need	Opportunity
Flooding occurs in the Colusa Basin watershed between October and April.	Need to capture or attenuate the sudden surges associated with flooding in the watershed.	The NODOS project provides a new reservoir that could capture and attenuate flood flows, thereby providing flood-damage reduction to the community of Maxwell and the Colusa Basin Drain.

NODOS = north-of-the-Delta offstream storage

Supplemental Flows for Emergency Response

The Delta system is the diversion point for drinking water for over 20 million Californians and is critical to California's agricultural sector. Levee failure in the Delta can jeopardize this water supply by allowing saltwater to enter the CVP and SWP pumping plants south of the Delta.

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 2007) acknowledge notable risks in the Delta region. Seismic risk, high-water conditions, sea level rise, and land subsidence threaten levee integrity throughout the Delta. A major earthquake could potentially result in the simultaneous failing and flooding of as many as 20 islands in the Delta. Although earthquakes could potentially affect multiple islands, 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. Climate change could cause even 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. Recent studies have projected that 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 2009).

In the event of a levee failure in the Delta, there is a need for adequate freshwater flows to move or help stabilize the intrusion of seawater. North-of-the-Delta storage with a direct conduit to the Sacramento River would potentially allow the water released from the NODOS project to reach the Delta within 2 days (Reclamation and DWR 2008), sooner than water released from Shasta Lake (approximately 4 days).

Summary of Problems, Needs, and Opportunities for Supplemental Flows for Emergency Response

Table 2-9 summarizes the problems, needs, and opportunities associated with supplemental flows for emergency response.

Table 2-9. Problems, Needs, and Opportunities: Supplemental Flows for Emergency Response

Problem	Need	Opportunity
Levee failure in the Delta can jeopardize a major water source by allowing saltwater to enter the CVP and SWP pumping plants south of the Delta.	Need adequate freshwater flows to move or help stabilize the intrusion of seawater in the Delta.	The NODOS project provides an additional water source that could be used for releases to respond to specific types of emergencies, including emergency water supply for maintenance of Delta salinity following a levee failure.

CVP = Central Valley Project
NODOS = north-of-the-Delta offstream storage
SWP = State Water Project

Cooperative Operations to Achieve Project Objectives

Achieving the increases in water supply deliveries in the CVP and SWP service areas and providing benefits to anadromous fish will require cooperative operations for the NODOS facilities with the CVP and SWP facilities. The Authority has formed an Operations Work Group to develop Principles of Agreement for operations with Reclamation and DWR. Successfully completing this agreement is necessary to address the problems, needs, and opportunities and to deliver the project benefits. Completing this agreement is further discussed in Chapter 6, Alternative Development.

Existing Water Resources Facilities in Study Area

Central Valley Project

Reclamation owns the CVP, which delivers about 7 MAF annually to 253 CVP contractors for agricultural use (6.2 MAF), urban use (0.5 MAF), and wildlife refuge use (0.3 MAF) (Reclamation 2008b, 2017a). Initial Federal authorization of the CVP was included in the 1935 Rivers and Harbors Act, and construction began in the late 1930s. When the Rivers and

Harbors Act was reauthorized in 1937, Reclamation took over CVP construction and operation with three project purposes:

- To regulate rivers and improve flood control and navigation
- To provide water for irrigation and domestic use
- To generate power

Under later reauthorizations and through legislation for specific project additions, more project purposes were added, including recreation, fish and wildlife enhancement, and water quality improvements. The CVP supplies irrigation water to the Sacramento and San Joaquin Valleys, to industries in Sacramento, to cities and industries in the eastern and southern San Francisco Bay Area, and to fish hatcheries and refuges throughout the Central Valley. The CVP comprises 20 dams and reservoirs, 39 pumping plants, 2 pumping-generating plants, 11 power plants, and 500 miles of major canals, conduits, and tunnels. The Jones Pumping Plant, a major CVP pumping plant in the south Delta, conveys water to the Delta-Mendota Canal. The CVP supplies water for one-third of the agricultural land in California (about 5 million acres), and delivers water to meet the needs of 1 million households in California annually. The pertinent features of the CVP relative to the NODOS Investigation are described in the rest of this section.

Shasta Dam and Reservoir

Shasta Dam and Reservoir are Federally owned. Shasta Dam is a concrete gravity dam on the Sacramento River, about 12 miles northwest of Redding. It controls floodwaters and stores surplus winter runoff for irrigation in the Sacramento and San Joaquin Valleys, maintains navigation flows, provides instream flows for the conservation of fish in the Sacramento River and water for M&I use, protects the Sacramento–San Joaquin Delta from the intrusion of saline ocean water, and generates hydroelectric power.

Shasta Dam is over 600 feet high and is the second-largest dam (by mass) in the U.S. Shasta Lake has a capacity of more than 4 MAF, and is the largest man-made reservoir in California. The Shasta Power Plant is below Shasta Dam on the Sacramento River. Shasta Reservoir delivers about 55 percent of the total annual water supply developed by the CVP.

Keswick Dam and Reservoir

Keswick Dam and Reservoir are Federally owned CVP features. Keswick Dam is on the Sacramento River, about 9 miles downstream from Shasta Dam. It is a concrete gravity structure that contains a 23.8 thousand acre-feet (TAF) afterbay for Shasta Lake. The dam stabilizes the uneven water releases from the power plants and has a facility to trap migratory fish that operates with Coleman Fish Hatchery, which is 25 miles downstream on Battle Creek.

Tehama-Colusa Canal

The T-C Canal is Federally owned. The canal is 110 miles long and serves 14 water districts. Through an operation, maintenance, and replacement (OM&R) agreement with Reclamation, the Tehama-Colusa Canal Authority operates and maintains the T-C Canal (and the Corning Canal). The T-C Canal travels south from the RBPP through Tehama, Glenn, and Colusa Counties, and into Yolo County. It terminates about 2 miles south of Dunnigan in Yolo County. The initial capacity of the canal is 2,530 cfs, diminishing to 1,700 cfs at the terminus. Canal flows are regulated by Funks Reservoir, which is along the canal about 66 miles downstream from RBPP. The canal capacity at Funks Reservoir is 2,100 cfs. The RBPP currently has space for two additional pumps.

The T-C Canal diverts water from the Sacramento River through a modern fish screen and pumping plant at Red Bluff. The Red Bluff Diversion Dam Fish Passage Improvement Project was completed in 2012. It appreciably improved fish passage and the reliability of irrigation water deliveries. The new pumping plant and flat-plate fish screen deliver up to 2,500 cfs into the T-C and Corning Canals.

Funks Dam and Reservoir

Funks Dam and Reservoir are Federally owned CVP features. Funks Reservoir is formed by an earth-filled dam on Funks Creek in Colusa County, about 7 miles northwest of Maxwell. The reservoir can hold 2.25 TAF, with a surface area of 232 acres at an elevation of 205 feet. A 40-foot-high compacted earthfill dam impounds the reservoir on the east. The dam forms the downstream bank of the T-C Canal as it crosses Funks Creek; it is used to regulate canal demands or releases.

The T-C Canal runs through Funks Reservoir with an inlet at the northeastern end, adjacent to the dam spillway, and an outlet to the southeast. The spillway overflow discharge capacity is 25,000 cfs with all gates fully open. Because the watershed receives little runoff, Funks Reservoir serves as an offstream regulatory reservoir filled by diversions from the Sacramento River via the T-C Canal.

Colusa Basin Drain

Reclamation District 2047 and the Colusa Basin Drainage District operate the Colusa Basin Drain (CBD). The CBD provides water for agriculture and other beneficial uses, including wildlife habitat and warm-water fisheries. It collects water from more than 450,000 acres of agricultural land and diverts water from irrigation district canals. Runoff from 11 streams draining the western foothill and valley floor watersheds contributes flow to the CBD. The CBD flows southward through Glenn, Colusa, and Yolo Counties and enters the Sacramento River at Knights Landing. The Sacramento River levee system serves to isolate the historic Colusa Basin drainage system, except when flood flows on the Sacramento River exceed 300,000 cfs near Ord Ferry. In general, CBD conveys flood flows from November through March, and agricultural irrigation and drainage flows from April through October. The northern half of the CBD does not have levees. Beginning south of Colusa, left-bank levees extend southward to CBD’s confluence with the Sacramento River. Reclamation Districts 108 and 787 pump the drainage from interior lands that are surrounded by levees to either the Sacramento River or the CBD. The drainage area at State Route (SR) 20 is 973 square miles, and the average annual runoff is 497 TAF.

Glenn-Colusa Irrigation District Canal

GCID owns, operates, and maintains the GCID Canal, a 65-mile-long irrigation canal that supplies water from the Sacramento River. The water moves into a complex system of more than 900 miles of laterals and drains for delivery to more than 1,200 farms on about 141,000 acres of agricultural land. In addition, GCID conveys water to 20,000 acres of wildlife habitat in the Sacramento, Delevan, and Colusa National Wildlife Refuges (NWRs).

GCID’s Hamilton City pump station is at the headworks of the GCID Canal, about 100 miles north of Sacramento. The pump station is on an oxbow off of the main stem of the Sacramento River. Water passes through the fish screens, where a portion of it is pumped into GCID’s main irrigation canal. The remaining flow in the oxbow passes by the screens and then back into the main stem of the Sacramento River.

GCID diverts a maximum of 3,000 cfs from the Sacramento River at the Hamilton City pump station, with the peak demand in the spring, often at the same time as the peak out-migration of juvenile salmon. GCID, in partnership with Reclamation, completed fish screens at its Hamilton City pump station in 2000. The United States Army Corps of Engineers (USACE) built a gradient facility on the main stem to restore and stabilize the river channel and surface water elevations at the fish screen to improve fish passage conditions and screen performance.

State Water Project

DWR operates and maintains the SWP, which delivers water to 29 agricultural and urban contractors in the Central Valley, the San Francisco Bay Area, the central coast, and Southern California. The SWP delivers water for agricultural, municipal, and industrial uses, providing water to 20 million Californians and 660,000 acres of irrigated farmland. It comprises 20 pumping plants, 5 hydroelectric power plants, 33 storage facilities, and more than 660 miles of aqueducts and pipelines.

The SWP operates under long-term contracts with public water agencies from Sutter, Butte, and Plumas Counties in the north to Alameda, Santa Clara, and Napa Counties in the Bay Area, through the San Joaquin Valley, and finally to Southern California. These agencies, in turn, deliver water to wholesalers or retailers, or deliver it directly to agricultural and urban water users. The SWP was designed to deliver about 4.2 MAF of water per year. The maximum that has been supplied in one year is 3.71 MAF (DWR 2005).

The SWP facilities include major diversion facilities and pumps (Clifton Court Forebay and Banks Pumping Plant) in the south Delta and the California Aqueduct, which extends from the south Delta to Southern California.

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