Chapter 2
Water Resources and Related Conditions

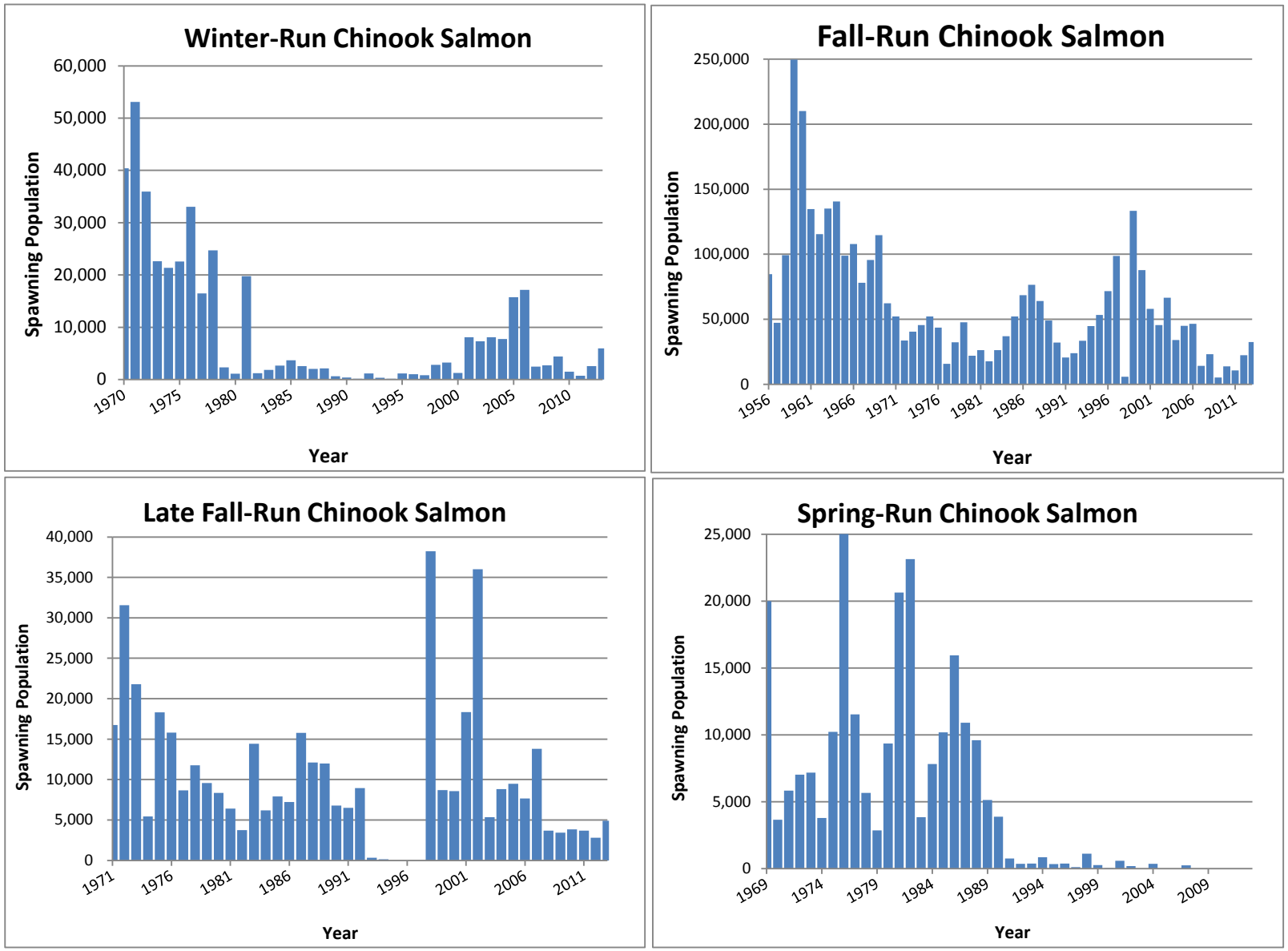
This chapter addresses an initial and essential step in the SLWRI planning process – identifying and assessing existing and likely future conditions – to establish an understanding and basis for comparing the potential effects of alternative plans. This step includes describing water resources problems, needs, and opportunities to be addressed, and inventorying, forecasting, and analyzing the specified existing and likely future conditions in the study area. Identified problems, needs, and opportunities serve as the basis for planning objectives, which guide the formulation of alternative plans. The plan formulation process for Federal water resources studies and projects is specified in the P&Gs (WRC 1983), and is further described in Chapter 3, "Plan Formulation."

Water and Related Resources Problems, Needs, and Opportunities

Based on the overall feasibility study authority, Public Law 96-375, and concerns expressed about existing and likely future water and related resources issues, the following is a description of identified major water resources problems, needs, and opportunities in the primary SLWRI study area.

Anadromous Fish Survival

The Sacramento River system supports four separate runs of Chinook salmon: fall-, late fall-, winter-, and spring-run. The adult populations of the four runs of salmon and other important fish species that spawn in the upper Sacramento River have declined considerably over the last 40 years (Figure 2-1) (CDFW 2014a). Several fish species in the upper Sacramento River have been listed as endangered or threatened, as defined by the ESA: Sacramento River winter-run Chinook salmon (endangered), Central Valley spring-run Chinook salmon (threatened), Central Valley steelhead (threatened), and the Southern Distinct Population Segment of North American green sturgeon (threatened). Two of these species also are listed as endangered or threatened, as defined by the CESA: Sacramento River winter-run Chinook salmon (endangered) and Central Valley spring-run Chinook salmon (threatened).



Source: CDFW, 2014

Figure 2-1. Chinook Salmon Historic Spawning Populations in Sacramento River

Numerous factors have contributed to these declines, including unstable water temperature, loss of historic spawning areas and suitable rearing habitat, water diversions from the Sacramento River, drought conditions, reduction in suitable spawning gravels, fluctuations in river flows, toxic acid mine drainage, high rates of predation, unsustainable fish harvests, and unsuitable ocean conditions. One of the most significant environmental factors affecting Chinook salmon is unsuitable water temperature in the Sacramento River (NMFS 2009b, 2014). Water temperatures that are too high or, less commonly, too low, can be detrimental to the various life stages of Chinook salmon. Elevated water temperatures can negatively impact holding and spawning adults, egg viability and incubation, preemergent fry, and rearing juveniles and smolts, significantly diminishing the next generation of returning spawners. Stress caused by high water temperatures also may reduce the resistance of fish to parasites, disease, and pollutants.

Releases of cold water stored behind Shasta Dam can significantly improve seasonal water temperatures in the Sacramento River for anadromous fish during critical periods. The NMFS *2014 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* states that prolonged droughts depleting the cold-water stored in Shasta Reservoir, or some related failure to manage cold-water storage, could put populations of anadromous fish at risk of severe population decline or extirpation in the long-term (NMFS 2009b, 2014). The risk associated with a prolonged drought conditions is especially high in the Sacramento River, as Shasta Reservoir is intended to maintain only one year of carryover storage. The recovery plan emphasizes that, under current conditions, even two consecutive years of drought could reduce Shasta Reservoir storage to levels insufficient to support the Sacramento River winter-run Chinook salmon spawning and incubation season.

Conversely, water that is too cold is detrimental to the rapid growth of rearing juveniles. Following construction of Shasta Dam, water released in the spring was unusually cold and prevented the characteristic rapid growth of fall-run and late fall-run juvenile Chinook salmon. Reduced growth rates result in increased risk for predation and entrainment at unscreened and inadequately screened diversions.

Various Federal, State, and local projects are addressing each of the aforementioned factors contributing to anadromous fish population declines. Recovery actions range from changing the timing and magnitude of reservoir releases to changing the temperature of released water. In May 1990, the State Water Board issued Water Rights Order 90-5, which included temperature objectives for the Sacramento River to protect winter-run Chinook salmon. This order was reinforced by the 1993, 2004, and 2009 NMFS BO for winter-run Chinook salmon, which established certain operating parameters for Shasta Reservoir. The State Water Board action and the NMFS BOs set minimum

flows in the river downstream from Keswick Dam and minimum Shasta Reservoir carryover storage targets primarily to affect water temperatures during key periods.

In addition to flow requirements, structural changes were made at Shasta Dam to change the temperature of released water, such as construction of a temperature control device (TCD), completed in 1997. The TCD can be used to selectively draw water from different depths within the lake, including the deepest, to help maintain river water temperatures beneficial to salmon. The TCD is effective in helping to reduce winter-run Chinook salmon mortality in some critical years,[1] and for fall- and spring-run Chinook salmon in below-normal water years.

However, implementing requirements in the Trinity River ROD (Reclamation 2000), as amended, may diminish the water temperature improvements provided by the TCD at Shasta Dam. One of the major elements of the Trinity River ROD is reducing the average annual export of Trinity River water from 74 percent to 52 percent of the flow (Reclamation 2000). This reduces flow from the Trinity River basin into Keswick Reservoir, and then into the Sacramento River. Because water diverted from the Trinity River is generally cooler than flows released from Shasta Dam, implementing the Trinity River ROD offsets some of the benefits derived from the TCD.

With the exception of spring-run Chinook salmon, the average Chinook salmon spawning population in the Sacramento River since 1999 has increased compared with the previous 20 years (1979 to 1998) (CDFW 2014a). This increase in salmon populations is likely due primarily to minimum release requirements at Shasta Dam and the TCD. Additionally, changes in operating the RBDD and the RBPP have benefited Chinook salmon populations in the Sacramento River. However, there is a continual need for cool water in the Sacramento River, especially in dry and critical years, to promote anadromous fish survival and reduce the risk of extinction.

In the future, effects of climate change on operations at Shasta Lake could potentially result in changes to water temperature, flow, and ultimately, fish survival. As described in the Climate Change Modeling Appendix, climate change could result in higher reservoir releases because of an increase in winter and early spring inflow into the lake from high intensity storm events. The change in reservoir releases could be necessary to manage flood events resulting from these potentially larger storms. Climate change could also cause reduced end-of-September carryover storage volumes, resulting in lower lake levels for a portion of the year and a smaller cold-water pool, which could lead to warmer water temperature and reduced water quality within Shasta Reservoir. Most importantly, it is expected that climate change may result in increased water

[1] Throughout this document, water year types are defined according to the Sacramento Valley Index Water Year Hydrologic Classification unless specified otherwise.

temperatures downstream from Shasta Dam, particularly in summer months, and more frequent wet and drought (particularly extended drought) years. Increased water temperatures and extended drought periods may compound the threats to anadromous fish in the Sacramento River.

Water Supply Reliability

California's water supply system faces critical challenges, with demands exceeding supplies for urban, agricultural, and environmental water uses across the State. The *California Water Plan Update 2013* (DWR 2014b) concludes that California is facing one of the most significant water crises in its history; drought impacts are growing and climate change is affecting statewide hydrology. Despite significant physical improvements in water resource systems and in system management over the past few decades, California still faces unreliable water supplies, continued depletion and degradation of groundwater resources, habitat and species declines, and unacceptable risks from flooding (DWR 2014b). Compounding these issues, Reclamation's *Water Supply and Yield Study* (Reclamation 2008b) describes dramatic increases in population, land use changes, regulatory requirements, and limitations on storage and conveyance facilities, further straining available water supplies and infrastructure to meet water demands. The resulting unmet water demands have led to increases in competition for water supplies among urban, agricultural, and environmental uses.

The following subsections discuss identified key issues related to water supply reliability in California, including current and estimated water shortages, anticipated effects of population growth and climate change on water supply and demand, and limitations on system flexibility. The final subsection discusses strategies for meeting future statewide water supply needs.

Estimated Water Supply Shortages

Projecting accurate and quantified water supply and shortages in California is complex; numerous variables exist and, just as important, numerous opinions have been expressed regarding these variables. Table 2-1 displays estimated water demands, available supplies, and shortages for the Central Valley and the State under existing conditions (Reclamation 2008b). Current water supply shortages for the State are estimated at 2.3 and 4.1 MAF for average and dry years, respectively. As shown in Table 2-2, without further investment in water management and infrastructure, future shortages are expected to increase to approximately 4.9 and 6.1 MAF in average and dry years, respectively, by 2030. Representative demands for dry and average years were based on water use data from the *California Water Plan Update 2005* (DWR 2005), adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies. Shortages were determined on a regional basis, considering that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another.

Table 2-1. Estimated Water Demands, Supplies, and Shortages Under Existing Conditions

Item	Hydrologic Basin						State of California	
	Sacramento		San Joaquin		Two-Basin Total			
	Average Year[1,2]	Dry Year[1,2]	Average Year[1,2]	Dry Year[1,2]	Average Year[1,2]	Dry Year[1,2]	Average Year[1,2]	Dry Year[1,2]
Population (million)[3]	2.9		2.0		4.9		36.9	
Water Demand (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.9	9.0
Agricultural	8.7	8.7	7.0	7.0	15.7	15.7	34.2	34.2
Environmental	11.9	9.4	3.1	2.3	15.0	11.7	17.5	13.9
Total	***21.5***	***19.0***	***10.7***	***9.9***	***32.2***	***28.9***	***60.6***	***57.1***
Water Supply (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.8	8.4
Agricultural	8.7	8.6	6.9	7.0	15.6	15.6	33.2	32.0
Environmental	11.5	8.7	2.5	1.8	14.0	10.5	17.5	12.6
Total	***21.1***	***18.2***	***10.0***	***9.4***	***31.1***	***27.6***	***60.6***	***53.0***
Total Shortage (MAF)[4]	**0.4**	**0.8**	**0.7**	**0.5**	**1.1**	**1.3**	**2.3**	**4.1**

Notes:

[1] Water demands, supplies, and shortages are from the 2008 Reclamation Water Supply and Yield Study (Reclamation 2008b).

[2] Representative dry and average year supplies and demands were based on adjusted water use and supply data from the *California Water Plan Update 2005* (DWR 2005).

[3] Year 2005 population estimates are from the California Department of Finance (2010a).

[4] Total shortages are calculated as the sum of shortages for each water demand category by region (e.g., North Coast, Sacramento River) and, therefore, may not equal the difference between total demands and supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another. Detailed estimates of shortages for each region can be found in the 2008 Reclamation Water Supply and Yield Study in Table A-1 (dry year) and Table A-2 (average year). For categories where supply is greater than demand, the shortage is equal to zero.

Key:
MAF = million acre-feet

Table 2-2. Estimated Water Demands, Supplies, and Shortages for 2030

Item	Sacramento and San Joaquin Hydrologic Basins (Two-Basin Total)		State of California	
	Average Year[1,2]	Dry Year[1,2]	Average Year[1,2]	Dry Year[1,2]
Population (million)[3]	10.5		49.2	
Water Demand (MAF)				
Urban	2.4	2.5	11.9	12.0
Agricultural	15.0	15.0	31.4	31.4
Environmental	14.9	11.7	17.5	14.0
Total	***32.3***	***29.2***	***60.8***	***57.4***
Water Supply (MAF)				
Urban	1.5	1.5	8.4	8.0
Agricultural	15.6	15.6	32.8	31.5
Environmental	14.0	10.5	16.3	12.6
Total	***31.1***	***27.6***	***57.5***	***52.1***
Total Shortage (MAF)[4] (MAF)[4]	**1.8**	**2.2**	**4.9**	**6.1**

Notes:

[1] Water demands, supplies, and shortages are from the 2008 Reclamation Water Supply and Yield Study (Reclamation 2008b).

[2] Representative dry and average year supplies and demands were based on water use and supply data from the *California Water Plan Update 2005* (DWR 2005), adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies.

[3] Year 2030 Population estimates are from the California Department of Finance (2007).

[4] Total shortages are calculated as the sum of shortages for each water demand category by region (e.g., North Coast, Sacramento River) and, therefore, may not equal the difference between demands and supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another. Detailed estimates of shortages for each region can be found in the 2008 Reclamation Water Supply and Yield Study in Table A-4 (dry year) and Table A-5 (average year). For categories where supply is greater than demand, the shortage is equal to zero.

Key:
MAF = million acre-feet

Potential Effects of Population Growth on Water Demands

A major factor in California's future water picture is population growth. California's population is expected to increase by just over 60 percent relative to 2005 levels by 2050 (California Department of Finance 2007), potentially redirecting some agricultural water supplies to urban uses. A portion of the increased population in the Central Valley would occur on lands currently used for irrigated agriculture. Water that would have been needed for these lands for irrigation would instead be used to serve replaced urban demands. However, this would only partially offset the agricultural-to-urban water conversion needed to meet projected urban water demands, since much of the growth would occur on nonirrigated agricultural lands.

The *California Water Plan Update 2013* (DWR 2014b) estimates changes in future water demands by 2050 considering three different population growth scenarios as well as climate change. Table 2-3 shows results of this study for an average water year (DWR 2014b). The first scenario (Current Trends) assumes

that recent population growth trends will continue until 2050. The second scenario (Lower than Current Trends) assumes that population growth will be slower than currently projected. The third scenario (Higher than Current Trends) assumes that population growth will be faster than currently projected, with nearly 70 million people living in California in 2050. Estimated reductions in agricultural water demands in Table 2-3 represent decreases in future agricultural water demands due to conversion from agricultural to urban land uses. Under the Higher than Current Trends scenario, as much as 1.8 MAF of increased demand is projected. This would be in addition to the current water shortages estimated in Table 2-1.

Table 2-3. Estimated Annual Change in Water Demand in California for 2050 Considering Different Population Growth Scenarios

Item	Current Trends	Lower than Current Trends	Higher than Current Trends
Population (million)	51.0	43.9	69.4
Irrigated Crop Acreage (million)	8.9	9.0	8.6
Water Demand Change[1] (MAF)			
Urban	2.9	1.3	6.1
Agricultural	-3.6	-3.0	-4.3
Total	**-0.7**	**-1.7**	**1.8**

Source: DWR 2014b

Note:

[1] Estimated water demand change is the difference between the average demands for 2043—2050 relative to 1998—2005. A positive value indicates an increase in water demand, while a negative value indicates a decrease in water demand.

Key:
MAF = million acre-feet

Potential Effects of Climate Change

Another potentially significant factor affecting water supply reliability is climate change. Potential effects of climate change are many and complex (DWR 2006), varying through time and geographic location across the State (Reclamation 2011e). Changes in geographic distribution, timing, and intensity of precipitation are projected for the Central Valley (Reclamation 2011e), which could broadly impact rainfall runoff relationships important for flood management as well as water supply. Additionally, there is potential for climate change to increase annual water demand compared to a repeat of historical climate (DWR 2014b). Other possible impacts range from potential sea level rise, which could impact coastal areas and water quality, to impacts to overall system storage for water supply.

A reduction in total system storage is widely predicted to occur with climate change. Precipitation held in snowpacks makes up a significant quantity of total annual supplies needed for urban, agricultural, and many environmental uses. It is expected that in the future, climate change may significantly reduce water

held in snowpacks in the Sierra Nevada (Reclamation 2011e, DWR 2014b). Further potential for reductions in water conservation space in existing reservoirs in the Central Valley is anticipated because of increasing needs for additional space for flood management purposes stemming from shifts in the timing of flood runoff and magnitude of extreme events. These potential reductions could significantly impact available water supplies, especially for reservoirs immediately upstream from large urban areas such as Folsom Lake on the American River, which is upstream from the greater Sacramento metropolitan area. During drought periods, supplies could be further reduced, and expected shortages would be substantially greater. For additional information on potential climate change implications for water supply reliability, please see the Climate Change Modeling Appendix to the accompanying EIS.

System Flexibility

In addition to concerns about future water supply and demand, California's Federal and State water systems lack flexibility in timing, location, and capacity to meet the multiple objectives of the projects. CVP and SWP flexibility has diminished with population growth and increased environmental and ecosystem commitments and requirements (Reclamation 2008b). Complicating this issue is the variability associated with water resources in California. Precipitation in California is seasonably, temporally, and spatially variable, and urban, agricultural, and environmental water users have variable needs for quantity, quality, timing, and place of use.

California's water systems face the threat of too much water during floods, and too little water to meet demands during dry and critical water years. Chronic water shortages have led to increases in groundwater usage, which has led to groundwater overdraft in many regions across the State. Groundwater overdraft can cause permanent declines in groundwater levels, long-term reductions in groundwater supplies, land subsidence, decreases in water quality, a greater potential for salt water intrusion, and lasting environmental impacts. Challenges are greatest during dry years, when water supplies are less available (DWR 2014b).

Increasing CVP/SWP operational constraints have led to growing competition for limited system resources between various users and uses. Urban and required environmental water uses have each increased, resulting in increased competition and conflicting demands for limited water supplies. For example, the CVPIA, implemented in 1993, dedicated 800,000 acre-feet of CVP water supplies to the environment as well as additional water supplies for the Trinity River and wildlife refuges. Current BOs by NMFS and USFWS, resulting in increased Delta pumping constraints and other operational restrictions, coupled with drought conditions, have even further decreased CVP deliveries. As competition for limited resources between various uses grows, water management flexibility and adaptability will be even more necessary in the future.

Strategies to Address Water Supply Needs

As noted by Reclamation's *Water Supply and Yield Study* (Reclamation 2008b), the *California Water Plan Update 2013* (DWR 2014b), and CALFED Programmatic ROD (CALFED 2000a), an integrated portfolio of solutions, regional and statewide, is needed to meet future water supply needs. The *Water Supply and Yield Study* stated that a "variety of storage and conveyance projects and water management actions have the potential to help fill [the] gap" between water supply and demand in California. The *California Water Plan Update 2013* concluded that to improve public safety, foster environmental stewardship, and support economic stability, California must continue its commitment to integrated water management, promote better alignment of government agency efforts at all levels, and encourage greater investment in innovation and infrastructure, including increased surface storage. Accordingly, California must invest in reliable, high quality, and affordable water conservation; efficient water management; and development of water supplies. Major efforts by multiple agencies are needed to address the complex water resources issues in the State, as demands are expected to continue to exceed supplies in the future.

To avoid major impacts to the overall economy, environment, and standard of living in California, actions to conserve existing supplies and optimize the use of existing facilities will be needed. Additionally, development of additional water sources and increased storage and delivery capability are critical for providing reliable water supplies for expanding M&I uses and to maintain adequate supplies for agricultural and environmental purposes.

Ecosystem Resources

The health of the Sacramento River ecosystem, as elsewhere in the Central Valley, has been impacted in the last century by conflicts over the use of limited natural resources, particularly water resources. Many of California's rivers and streams have been harnessed for beneficial uses such as hydropower, flood damage reduction, and water supply, contributing to a decline in habitat and native species populations, and a resulting increase in endangered or threatened species listings under the ESA and CESA. Climate change is expected to place additional stress on California's native species and habitats.

Construction of Shasta Dam has had both negative and positive effects on environmental resources in the region. While construction of the dam displaced valuable riverine and upland habitat and blocked access to upstream riverine habitat for some species, it also created shoreline and shallow water habitat for aquatic, terrestrial, and avian species in the reservoir area. For example, Shasta Lake is home to a substantial concentration of nesting bald eagles in California.

Shasta Lake Area

Various activities have impacted natural resources upstream from Shasta Dam, within the lake, on adjacent lands, and in and near tributary streams. Historical mining, ore processing practices and resulting acid mine drainage, and fire suppression are among the activities causing the greatest challenges to

ecosystem resources in this area. Although mines in this area are no longer operational and are currently undergoing remediation, they continue to remain a documented source of metals, acidity, and sediments in the reservoir area. In addition, fire suppression activities have resulted in an accumulation of vegetation cover in the watershed and a decrease in the return intervals of natural fires, both of which potentially affect erosion processes and sediment delivery to tributaries and increase the likelihood of higher intensity fires (USFS 2011). To guide management of the Shasta-Trinity National Forest (STNF), the USFS has prepared the *Shasta-Trinity National Forest Land and Resource Management Plan* (USFS 1995). Primary goals of the *Shasta-Trinity National Forest Land and Resource Management Plan*, which was implemented in 1995, are to integrate a mix of management activities that allows use and protection of forest resources; meets the needs of guiding legislation; and addresses local, regional, and national issues. The *Shasta-Trinity National Forest Land and Resource Management Plan* is intended to guide implementation of the *Aquatic Conservation Strategy of the Northwest Forest Plan* (USFS 1994) for protection and management of riparian and aquatic habitats adjacent to Shasta Lake.

Opportunities exist to further support ongoing USFS programs. These opportunities include improving and restoring environmental conditions by developing self-sustaining natural habitat in the area of Shasta Lake and its tributaries to benefit fish and wildlife resources.

Downstream from Shasta Dam

Land and water resources development has caused major resource problems and challenges in the Sacramento River basin, including decreases in anadromous fish and wildlife populations and losses of riparian, wetland, floodplain, and shaded riverine habitat. These decreases and losses have resulted in reduced populations of many plant and animal species.

The quantity, quality, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine habitat along the Sacramento River have been severely limited through confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Modification of seasonal flow patterns by dams and water diversions also has inhibited the natural channel-forming processes that drive riparian habitat succession. It is estimated that less than 5 percent of the historical riparian vegetation within the Sacramento River basin remains today (USFWS 2014).

Decreases in the quality and quantity of habitat have resulted in reduced populations of various fish and wildlife species. The low populations and questionable sustainability of these species have led to an increase in listings under the ESA and CESA in recent years. Introduction of nonnative species has also contributed to the decline in native animal and plant species. In addition, lack of linear continuity of riparian habitat has impacted the movement of wildlife species among habitat areas, adversely affecting dispersal, migration,

emigration, and immigration. For many species, this has resulted in reduced wildlife numbers and population viability.

Ecosystem restoration along the Sacramento River has been the focus of several ongoing programs, including the Senate Bill 1086 Program, CVPIA, CALFED, and Central Valley Habitat Joint Venture. These and numerous local programs have been established to address ongoing conflicts over the use of limited resources within the Central Valley. Much effort has been directed in the upper Sacramento River region above the RBPP toward restoring or improving anadromous fisheries, which provide recreational and commercial values in addition to their environmental value. Despite these efforts, a significant need remains to conserve and restore ecosystem resources along the Sacramento River.

Endangered and threatened fish and wildlife populations, critical habitat, and sensitive Delta ecosystems are also declining. The decline is especially pronounced in the case of pelagic fish species in the Delta, including delta smelt, striped bass, threadfin shad, and longfin smelt. Monitoring results indicate that the threatened delta smelt population continues to remain at or near all-time lows. In 2006, the USFWS was petitioned to upgrade the status of delta smelt to endangered (Center for Biological Diversity, et al. 2006). In 2010, the USFWS conducted their 5-year review and found delta smelt warranted the upgrade in status, however, the listing was precluded by other higher priority-listing actions (Volume 75, Federal Register (FR), page 17667 (75 FR 17667 (April 7, 2010))). Longfin smelt were petitioned for listing as endangered in 2007 (Center for Biological Diversity, et al. 2007). The USFWS found that the Bay-Delta distinct population segment of longfin smelt does warrant listing, however, as with the delta smelt, the listing is precluded by other higher priority actions. Therefore, longfin smelt have been added to the candidate list (77 FR 19756 (April 2, 2012)).

In recognition of the challenges facing water management in California, and the need to develop new strategies for a sustainable Delta ecosystem that would continue to support its economic functions, various planning efforts are underway. Current planning efforts, such as the BDCP and Delta Habitat Conservation and Conveyance Program are focused on developing ecological solutions to protect Delta fisheries while providing a sustainable and reliable water conveyance system for the CVP and SWP.

Flood Management

Large and small communities and agricultural lands in the Central Valley are subject to flooding from the Sacramento River and its tributaries. USACE, in partnership with DWR, has worked to assess basin-wide flood management issues and identify options in the Sacramento River basin to address these issues. Measures to reduce high flows in the Sacramento River include spilling floodwater into bypass areas through historical overflow areas, streams, conveyance canals, and weirs. The comprehensive flood control system in the

Sacramento River basin includes river, canal, and stream channels, levees, flood relief bypasses, weirs, flood relief structures, a natural overflow area, outfall gates, and drainage pumping plants. 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. DWR is currently working on the implementation of the *Central Valley Flood Protection Plan* (DWR 2012), which was adopted in 2012 to address flood issues throughout the Sacramento and San Joaquin valleys and the Delta.

Flooding poses risks to human life, health, and safety. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety. In addition, urban development in flood-prone areas has exposed the public to the risk of flooding.

Physical impacts from flooding occur to residential, agricultural, commercial, industrial, institutional, and public property. Damages occur to buildings, contents, automobiles, and outside property, including agricultural crops, equipment, and landscaping. Physical damages include cleanup costs and costs to repair roads, bridges, sewers, power lines, and other infrastructure components. Nonphysical flood losses include income losses, losses of public and social services, and the cost of emergency services, such as flood fighting and disaster relief.

Even though a project to enlarge Shasta Dam and Reservoir has the potential to improve flood management along the upper Sacramento River, operational practices, forecasting uncertainties, and other influencing factors exist that can inhibit flood management operations. Explicit rules for the operation of Shasta Dam during the flood season are provided in the Shasta Dam and Lake Flood Control Diagram (USACE 1977); however, these operations can be difficult to achieve during a flood event. This is primarily due to the extreme inflow volumes to Shasta Reservoir that can occur over long periods, numerous points of inflow along the river downstream from Shasta Dam, and multiple points of operational interest downstream (such as Hamilton City and other rural communities). The primary downstream control point along the Sacramento River that determines reservoir releases under real-time operations is Bend Bridge.

Other unofficial factors enter into flood management decisions at Shasta Dam, such as peak flows at Hamilton City or other rural communities that are at risk of flooding. These factors, combined with the uncertainty of storm forecasting, could lead to a reduction in flood operation flexibility at Shasta Dam. Should this occur, it could cause a cascading impact on effective flood management downstream to the Delta. Accordingly, there is a need to review flood control operations at Shasta Dam.

Hydropower

While California is the second largest consumer of electricity in the nation, it is also the most energy efficient. Although California has 12 percent of the nation's population, it uses only 7 percent of the nation's electricity (DOE 2014), making California the most energy-efficient State per capita in the nation. Even so, demands for electricity are growing at a rapid pace.

California's peak demand for electricity is expected to increase at a rate of approximately 1.5 percent per year through 2022, from about 60,000 megawatts (MW) in 2011 to about 70,000 MW by 2022 (California Energy Commission 2012). There are, and will continue to be, increasing demands for new electrical energy supplies, including clean energy sources, such as hydropower. Executive Orders S-14-08 and S-21-09, issued in 2008 and 2009, respectively, established a goal of using renewable energy sources, including hydropower, for 33 percent of the State's energy consumption by 2020 (California Public Utilities Commission 2011). Senate Bill X1-2, signed by Governor Edmund G. Brown, Jr., in April 2011, codified the requirement for power retailers to meet the 33 percent renewable target by 2020. To meet renewable energy goals, significant increases in non-dispatchable intermittent renewable resources, such as wind and solar generation, will need to be added to California's power system. This means that other significant flexible generation resources will be needed to support and integrate renewable generation. Adding to the need for additional energy sources, existing nuclear power plants are nearing the end of their design lives and some may be offline within the next 10 to 20 years. For example, the San Onofre Nuclear Generating Station in San Diego County is in the process of decommissioning.

Recreation

As the population of the State continues to grow, demands will increase significantly for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. According to the *California Water Plan Update 2013* (DWR 2014b), the Central Valley is experiencing dramatic population growth, but currently has insufficient access to recreation opportunities. Further increases in demand, accompanied by relatively static recreation resources, will cause additional issues at existing recreation areas. These challenges will be especially pronounced at Shasta Lake, which is one of the most visited recreation destinations in the state and in the region. Even under current levels of demand, USFS, which manages recreation at Shasta Lake, has expressed concern about seasonal capacity problems at existing marinas and USFS facilities. A significant and increasing need exists to improve recreation-related facilities and conditions at Shasta Lake.

Water Quality

The Sacramento River and the Delta support fish and wildlife while providing water supplies for urban, agricultural, and environmental uses across the State. The Sacramento River downstream from Keswick Dam is critical habitat for the migration and reproduction of Chinook salmon (NMFS 2009b) and the Delta is

one of the largest ecosystems for fish and wildlife habitat and production in the United States (Regional Water Boards, State Water Board, and CalEPA 2006). However, saltwater intrusion, municipal discharges, agricultural drainage, and water project flows and diversions have led to water quality issues within the Delta, particularly related to salinity, that have resulted in significant declines in pelagic populations (Regional Water Boards, State Water Board, and CalEPA 2006). In the Sacramento River and its tributaries, water temperatures, which are vital for anadromous fish survival, are affected by variations in climate and rainfall as well as operating conditions of various Federal, State, and local water supply systems. Additionally, urban and agricultural runoff, and runoff and seepage from abandoned mining operations, have resulted in elevated levels of pesticides, phosphorous, mercury, and other metals in the Sacramento River.

Several environmental flow goals and objectives in the Central Valley, including the Delta, have been established through legal mandates to address the impacts of water operations and water quality deterioration on the Sacramento River basin and Delta ecosystems and on endangered and threatened fish populations. Planning efforts, such as the BDCP, are intended to allow implementation of projects that restore and protect water supply and reliability, water quality, and ecosystem health in the Delta to proceed within a stable regulatory framework. Additional operational flexibility is needed to provide further opportunities to improve Sacramento River and Delta water quality conditions. Increasing storage in Shasta Reservoir could provide increased CVP operational flexibility to meet water quality goals in the Delta, as well as provide more cold-water storage in critical years to improve Sacramento River water temperatures.

Existing and Likely Future Resources Conditions in Study Area

One of the most important elements of any water resources evaluation is defining existing resource conditions in the study area, and how these conditions may change in the future. The magnitude of change not only influences the scope of the problems, needs, and opportunities, but the extent of related resources that could be influenced by possible actions taken to address them. Defining the existing and likely future conditions is critical in establishing the basis for comparing potential alternative plans consistent with the P&G, NEPA, California Environmental Quality Act (CEQA), and Reclamation policy guidance, including Reclamation Directives and Standards.

The following section briefly discusses existing conditions in the study area, including existing infrastructure, the physical environment, the biological environment, cultural resources, and socioeconomic resources. Because of the potential influence of the proposed modification of Shasta Dam, and subsequent water deliveries over a large geographic area, the SLWRI includes both a primary and extended study area, as described in Chapter 1. Figure 1-4 shows the geographic extent of the primary study area. The discussion of existing

conditions focuses on the primary study area, but also provides information about water resources facilities and water deliveries in the extended study area. Additional information is provided in the "Affected Environment" sections of each resource chapter in the accompanying EIS.

Existing Conditions Summary

The following sections summarize existing conditions for reservoir area infrastructure and physical, biological, cultural, and socioeconomic resources within the SLWRI study area. Additional information is included in the "Affected Environment" sections of each resource chapter in the accompanying EIS. Appendices to the accompanying EIS present further, detailed information, including the Engineering Summary Appendix, Physical Resources Appendix, Biological Resources Appendix, Cultural Resources Appendix, and Socioeconomics Appendix.

Reservoir Area Infrastructure

Figure 2-2. Shasta Dam and Reservoir Looking North Toward Mount Shasta

Existing infrastructure in the primary study area includes Shasta Dam and Reservoir, associated water management facilities, numerous recreation amenities, and various other public and private infrastructure (Reclamation 2003c), as described below.

Shasta Dam and Reservoir Shasta Dam and Reservoir (Figure 2-2) are located on the upper Sacramento River in Northern California, about 9 miles northwest of the City of Redding; the dam and entire reservoir are within Shasta County. Shasta Dam is a curved, gravity-type, concrete structure that rises 533 feet above the streambed with a total height above the foundation of 602 feet. The dam has a crest width of about 41 feet and a length of 3,460 feet. The spillway has a discharge capacity of 186,000 cubic feet per second (cfs) at pool elevation of 1,065 feet above mean sea level (elevation 1,065). Table 2-4 summarizes the pertinent data and features of Shasta Dam and Reservoir.[2]

[2] Two elevation datum are referenced in text and figures herein and in the accompanying EIS. The National Geodetic Vertical Datum of 1929 (NGVD29) is used in reference to Shasta Dam and appurtenant facility designs. The North American Vertical Datum of 1988 (NAVD88) is used in reference to Shasta Reservoir inundation pool elevations, and the elevations of potential reservoir area infrastructure that may need to be modified or relocated to accommodate increased water levels, consistent with a 2001 aerial survey of the reservoir area that referenced the NAVD88 datum. The NGVD88 is 2.66 feet higher than NGVD29.

Table 2-4. Pertinent Data[1] – Shasta Dam and Reservoir and Keswick Dam and Reservoir

General			
Drainage Areas (excluding Goose Lake basin)		**Mean Annual Runoff (1908 – 2006)**	
Sacramento River at Shasta Dam	6,421 sq-mi	Sacramento R. at Shasta Dam	5,737,000 acre-feet
Sacramento River at Keswick Dam	6,468 sq-mi	Sacramento R. near Red Bluff	8,421,000 acre-feet
Sacramento River near Red Bluff	8,900 sq-mi	Sacramento River maximum flows	
Sacramento River near Ord Ferry	12,250 sq-mi	At Shasta Lake (January 16, 1974)	216,000 cfs
Pit River at Big Bend	4,710 sq-mi	Near Red Bluff (February 28, 1940)	291,000 cfs
McCloud River above Shasta Lake	604 sq-mi	At Ord Ferry (February 28,1940)	370,000 cfs
Sacramento River at delta above Shasta Lake	425 sq-mi		
Shasta Dam and Reservoir			
Shasta Dam (concrete gravity)		**Shasta Reservoir**	
Crest elevation	1,077.5 feet	Full pool elevation	1,067.0 feet
Freeboard above full pool	10.5 feet	Minimum operating level elevation	840.0 feet
Height above foundations	602 feet	Take line elevation	Irregular
Height above streambed	487 feet	Surface area	
Length of crest	3,500 feet	Minimum operating level	6,700 acres
Width of crest	30 feet	Full pool	29,500 acres
Slope, upstream	Vertical	Take line	90,000 acres
Slope, downstream	1 on 0.8 cu-yd	Storage capacity	
Structure volume	8,430,000 cu-yd	Minimum operating level	587,000 acre-feet
Normal tailwater elevation	585 feet	Full pool	4,552,000 acre-feet
Spillway (gated ogee)		**Shasta Powerplant**	
Crest length		Main units	
Full pool	360 feet	5 turbines, Francis type	515,000 hp (total)
Net	330 feet	5 units @ 142 MW	710 MW (total)
Crest gates (steel drum)		Station units	
Number and size	3@110 feet x 28 feet	2 generators, 2,500 kW each	5,000 kW (total)
Top elevation when lowered	1,037.0 feet	Elevation centerline turbines	586 feet
Top elevation when raised	1,065.0 feet	Maximum tailwater elevation	632.5 feet
Discharge capacity at pool (elevation 1,065 feet)	186,000 cfs	Total discharge capacity at pool (elevation 1,065 feet)	14,500 cfs

Table 2-4. Pertinent Data[1] – Shasta Dam and Reservoir and Keswick Dam and Reservoir (contd.)

Shasta Dam and Reservoir (contd.)			
Spillway (gated ogee) (contd.)		**Shasta Powerplant (contd.)**	
Flashboard gates	3@110 feet x 2 feet	Total discharge at pool (827.7 feet)	16,000 cfs
Top elevation when lowered	1,067.0 feet	Power outlets (15-foot steel penstocks)	
Bottom elevation when raised	1,069.5 feet	5 with invert elevation of intake	807.5 feet
Outlets (102-inch-diameter conduit with 96-inch-diameter wheel-type gate)			
4 with invert elevation	737.75 feet	Capacity at elevation 1,065	81,800 cfs
8 with invert elevation	837.75 feet	Capacity at elevation 827.7	12,200 cfs
6 with invert elevation	937.75 feet		
Keswick Dam and Reservoir			
Keswick Dam (concrete gravity)		**Keswick Reservoir**	
Crest elevation	595.5 feet	Elevation – maximum operating level	587.0 feet
Freeboard above maximum operating level	8.5 feet	Elevation – minimum operating level	574.0 feet
Height of dam above foundation	159 feet	Surface area at maximum operating level	643 acres
Height of dam above streambed	119 feet	Storage capacity	
Length of crest	1,046 feet	At maximum operating level	23,800 acre-feet
Width of crest	20 feet	At minimum operating level	16,300 acre-feet
Volume	197,000 cu-yd	**Keswick Powerplant**	
Normal tailwater elevation	487 feet	3 generator units	105,000 kW (total)
Spillway (gated ogee)			
Crest length	200 feet		
Crest gates (fixed wheel)	4 gates, 50 feet x 50 feet each		
Discharge capacity at pool (elevation 587 feet)	248,000 cfs		

Note:
[1] Elevations for Shasta Dam and appurtenant facilities and Keswick Dam are based on the National Geodetic Vertical Datum of 1929 (NGVD29).
Key:
cfs = cubic feet per second
cu-yd = cubic yard
elevation = elevation in feet above mean sea level
hp = horsepower
kW = kilowatt
MW = megawatt
R = River
sq-mi = square mile

Figure 2-3 shows the relationship between Shasta Reservoir surface area and storage capacity at various water surface elevations. At full pool, Shasta Lake has a storage capacity and water surface area of 4.55 MAF and 29,500 acres, respectively. Seasonal flood control storage space in Shasta Reservoir is about 1.3 MAF. Shasta Dam operations are summarized later in this chapter in the section on "Physical Environment."

Shasta Powerplant consists of five main generating units and two station service units with a combined capacity of 715,000 kilowatts (kW). Several elevation and plan views of Shasta Dam and Powerplant are provided in the Engineering Summary Appendix to the accompanying EIS. These drawings were prepared before construction of the existing temperature control facilities on the upstream face of the dam.

Construction of the existing TCD at Shasta Dam was completed in 1997. It is a multilevel water intake structure located on the upstream face of the dam. The TCD allows operators to draw water from the top of the reservoir during the winter and spring when surface water temperatures are cool, and from deeper in the reservoir in the summer and fall when surface water is warm. It also improves oxygen and sediment levels in downstream river water. The TCD helps Reclamation fulfill contractual obligations for both water delivery and power generation while managing habitat conditions for fish, such as Chinook salmon, that require cooler water temperatures.

Keswick Dam and Reservoir Shasta Dam is operated in conjunction with Keswick Dam and Reservoir, located about 9 miles downstream from Shasta Dam. In addition to regulating outflow from Shasta Dam, Keswick Dam controls runoff from 45 square miles of drainage area. Keswick Dam is a concrete, gravity-type structure with a spillway over the center of the dam. The spillway has a discharge capacity of 248,000 cubic feet per second (cfs) at a full pool elevation of 587 feet above mean sea level (elevation 587). Storage capacity of Keswick Reservoir below the top of the spillway gates at full pool is 23,800 acre-feet. The powerplant has a nameplate generating capacity of 105,000 kW and can pass about 15,000 cfs at full pool. Table 2-4 summarizes the pertinent data and features of Keswick Dam and Reservoir.

Physical Environment

Elements of the existing physical environment described in this section include topography, geology, and soils; geomorphology, sedimentation, and erosion; climate and air quality; hydrology; water quality; noise and vibration; hazardous materials; and agricultural and important farmlands.

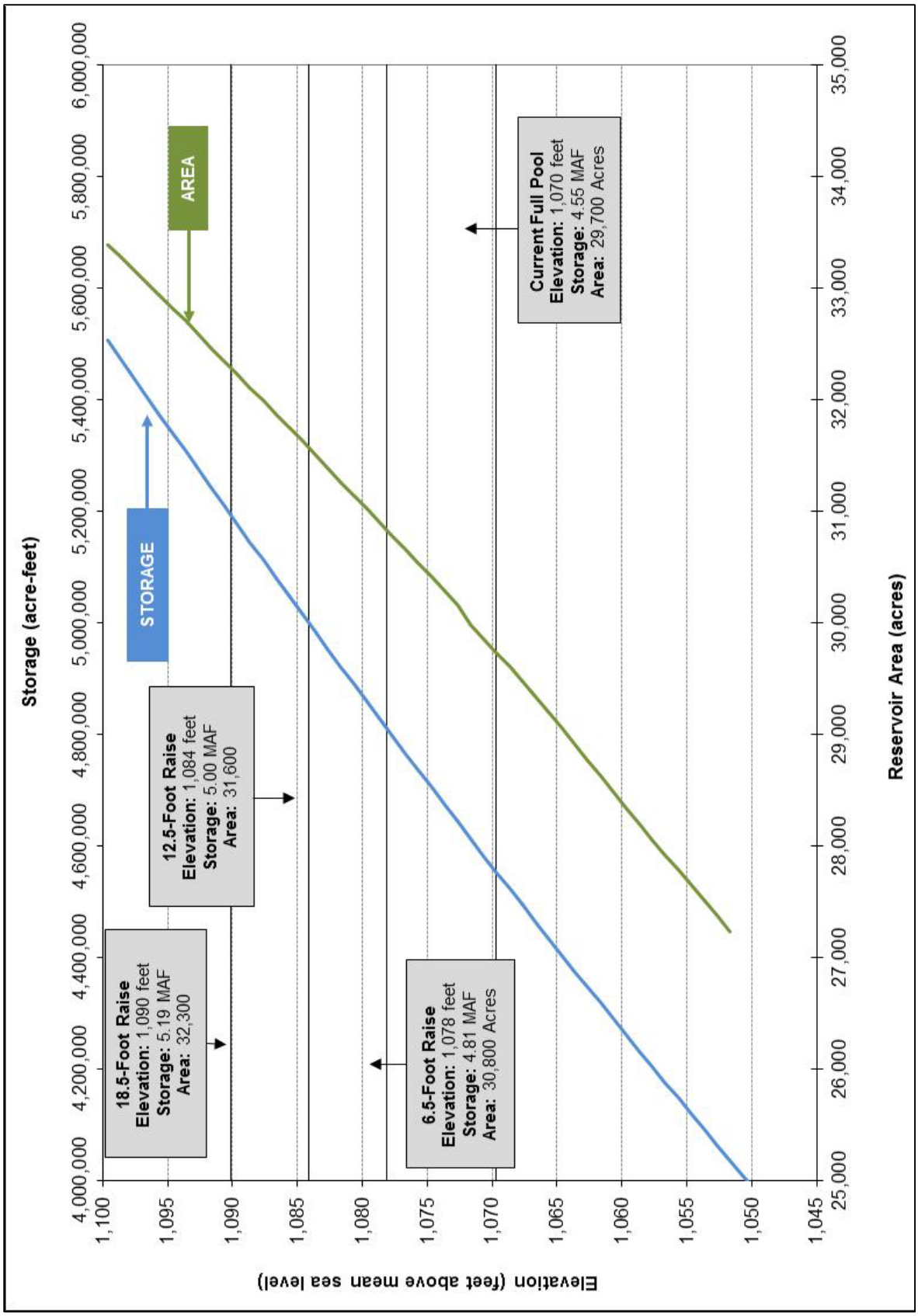


Figure 2-3. Shasta Reservoir Area-Capacity Relationships (elevations based on NAVD88)

Topography, Geology, and Soils Shasta Dam and Lake are located on the northern edge of the Central Valley. The topography of the area surrounding Shasta Lake is generally steep and mountainous. Ground surface elevations near Shasta Lake range from above elevation 14,000 at Mount Shasta to approximately elevation 1,070 at Shasta Lake. Other topographic features in the primary study area include major tributary drainages above Shasta Dam – the Sacramento, McCloud, and Pit rivers, and Squaw Creek, as well as several smaller drainages. Downstream from Shasta Dam are numerous major tributaries to the Sacramento River. Much of the extended study area is contained within the Central Valley, which is almost completely enclosed by mountains and has only one outlet, through San Francisco Bay, to the Pacific Ocean. Topography in the extended study area is dominated by the flat expanses of the Sacramento River basin, Delta, and San Joaquin River basin. Topography of the Delta includes a network of over 700 miles of interconnecting waterways with more than 600 islands and tracts, with land surfaces ranging from about elevation 20 to more than 20 feet below mean sea level.

The geology of the study area is highly complex, containing portions of five geomorphic provinces: the Klamath Mountain, Coast Range, Great Valley, Cascade Range, and Modoc Plateau. Shasta Lake is located within the Klamath Mountain Geomorphic Province at the north end of the Sacramento Valley. Geology of the Klamath Mountains to the north and west of the study area, including Shasta Lake and its tributaries, comprises older bedrock materials, sedimentary basin deposits, and volcanic deposits. Alluvial deposits overlay a large portion of this area, and soils are mainly derived from metamorphic rock and deep alluvium. Limestone caves provide habitat for several cave-dwelling species in the area. The segment of the study area along the Sacramento River downstream to the location of the RBPP encompasses portions of the Klamath Mountain, Great Valley, and Cascade Range geomorphic provinces. The Cascade Range to the east comprises primarily volcanic formations and volcanic sedimentary deposits. The Great Valley Geomorphic Province (also referred to as the Central Valley) is a large structural trough formed between the uplands of the California Coast Range to the west and the Sierra Nevada to the east. This trough is filled with a sequence of sediments ranging in age from Jurassic to Recent.

Principal formations downstream along the Sacramento River to Red Bluff include the Tehama, Riverbank, Chico, and Red Bluff formations, which contain marine and nonmarine sedimentary rocks eroded from the surrounding Cascade Range and Klamath Mountains. The deep alluvial and aeolian soils of the Central Valley floor comprise some of the best agricultural land in the State. Delta soils comprise primarily intertidal deposits of soft mud and peat, with organic peat soils up to 60 feet deep in some areas.

Geomorphology, Sedimentation, and Erosion Much of the area around Shasta Lake and adjacent to the lower reaches of its tributaries is characterized by active and historic mass wasting processes. The steep hillsides and coarse

soils are subject to mud flows, debris flows, slides, and other forms of mass erosion. The Sacramento River between Shasta Lake and Red Bluff is characterized by steep, vertical banks, and the river is primarily confined to its channel with limited overbank floodplain areas, resulting in limited channel migration and meander. Downstream from Red Bluff, the Sacramento River is active and sinuous, meandering across alluvial deposits within a wide meander belt. Natural geomorphic processes in the Sacramento River and Delta have been highly modified by changes to upstream hydrology (reservoirs and stream flow regulation) and construction of levees, channels, and other physical features.

Watersheds for many of the tributaries of Shasta Lake have been significantly altered by a number of factors that cause sediment influxes and accelerated erosion, including logging and hydraulic mining; construction of dams, roads, reservoirs, and channel modifications; wildfires; and agricultural and urban activities. Slides and sheet wash typically supply debris and sediments to the tributary streams of Shasta Lake during the rainy season. Because much of the terrain is steep, landslides are common and vary in intensity. In addition to sediment carried into Shasta Lake via tributaries, shoreline erosion contributes to a portion of sediment deposition in the reservoir. Shoreline erosion is caused by seasonal changes in reservoir water levels and, to some extent, by recreational activities in and around the lake. The shoreline below full pool elevation is generally steep and devoid of vegetation that might otherwise help stabilize soils.

Shasta and Keswick dams have a significant influence on sediment transport in the upper Sacramento River because they block sediment that would normally have been transported downstream. The result has been a net loss of coarse sediment, including salmon spawning gravels, in the Sacramento River below Keswick Dam. In alluvial river sections, bank erosion and sediment deposition cause river channel migrations that are vital to maintaining instream and riparian habitats, but which can cause loss of agricultural lands and damage to roads and other structures. In the Sacramento River, these processes are most important in the major alluvial section of the river, which begins downstream from the RBPP. The river channel in the reach from Keswick Dam to RBPP is constrained by erosion-resistant formations and therefore is more stable.

Climate and Air Quality The northern half of the Central Valley is located in the Sacramento Valley Air Basin (SVAB). The Mediterranean climate of the SVAB is characterized by hot, dry summers and cool, rainy winters. Average temperatures range from about 60 degrees Fahrenheit (°F) in low valley regions to about 40°F in mountain areas. Characteristic of SVAB winters are periods of dense and persistent low-level fog, which are prevalent between storms. Precipitation on the valley floor occurs mostly during winter as rain. Average annual precipitation throughout the Sacramento River basin is 36 inches. Total annual precipitation at higher elevations is as much as 95 inches in the northern Sierra Nevada and the Cascade Range. In the primary study area, measurements

recorded at the Shasta Dam station show that normal annual precipitation is approximately 61 inches. Summer air temperatures range from an average low of 62°F to an average high of 95°F. Winter air temperatures range from an average low of 39°F to an average high of 57°F.

In the SVAB, air pollutants can become concentrated during the summer because of inversion layers forming in the lower elevations, subsequently lowering air quality. Winter winds disperse pollutants, often resulting in clear weather and better air quality over most of the region. Much of the SVAB is designated as nonattainment with respect to the National and State ozone and particulate matter (PM) standards; the urban Sacramento and Marysville/Yuba City areas are designated as nonattainment for National and State carbon monoxide standards.

Hydrology Hydrologic features of the study area include perennial, intermittent, and ephemeral stream channels, and natural water bodies and wet meadowlands. The hydrology and climate of the primary study area make it favorable to water resources development; consequently, streamflow hydrology on the upper Sacramento River and major tributaries to Shasta Lake has been significantly modified by the development of water management and hydropower facilities. The following subsections discuss historical flows and storage at Shasta Reservoir, historical flows in the Sacramento River below Keswick Dam, and flood control operations for Shasta Dam and Reservoir.

Historical Flows and Storage at Shasta Reservoir Mean monthly inflow, outflow, and storage at Shasta Reservoir are shown in Table 2-5. The highest average monthly inflow period for Shasta is January through March. Winter and early spring inflows are stored for later release during the summer irrigation season.

Table 2-5. Mean Monthly Inflow, Outflow, and Storage at Shasta Reservoir

Month	Inflow[1] (TAF)	Outflow[2] (TAF)	Storage[3] (TAF)
January	799	587	3,143
February	836	628	3,366
March	889	511	3,732
April	693	421	3,981
May	537	524	3,965
June	339	536	3,730
July	247	615	3,326
August	223	571	2,967
September	220	377	2,808
October	263	301	2,770
November	365	331	2,793
December	585	465	2,911
Total	**5,991**	**5,868**	NA
Average	**499**	**489**	**3,291**

Notes:
[1] Computed data from 1944 through 2002.
[2] Recorded data from 1944 through 2002.
[3] Computed data from 1956 through 2005.
Key:
NA = not applicable
TAF = thousand acre-feet

Historical Flows in the Sacramento River Historical streamflow in the Sacramento River below Keswick Dam is shown in Figure 2-4. Since 1964, an annual average of 1.27 MAF of Trinity River flow has been exported to the Sacramento River through CVP facilities, or approximately 17 percent of the flows measured in the Sacramento River at Keswick Dam. Trinity River diversions to the Sacramento River were reduced as part of the 2000 Trinity River ROD (as amended) to retain more flows in the Trinity River for fish and associated habitat restoration purposes (Reclamation 2000).

Flood Control A storage space of up to 1.3 MAF is kept available for flood control purposes in Shasta Reservoir in accordance with the Shasta Dam and Lake Flood Control Diagram, as prescribed by USACE (1977). As prescribed by the diagram, seasonal flood storage space requirements increase from zero on October 1 to 1.3 MAF on December 1 and are maintained until December 23. From December 23 to June 15, the required flood storage space varies according to the accumulation of seasonal inflow. This variable space allows water to be stored for conservation purposes unless it is required for flood damage reduction purposes, based on basin wetness parameters and the level of seasonal inflow.

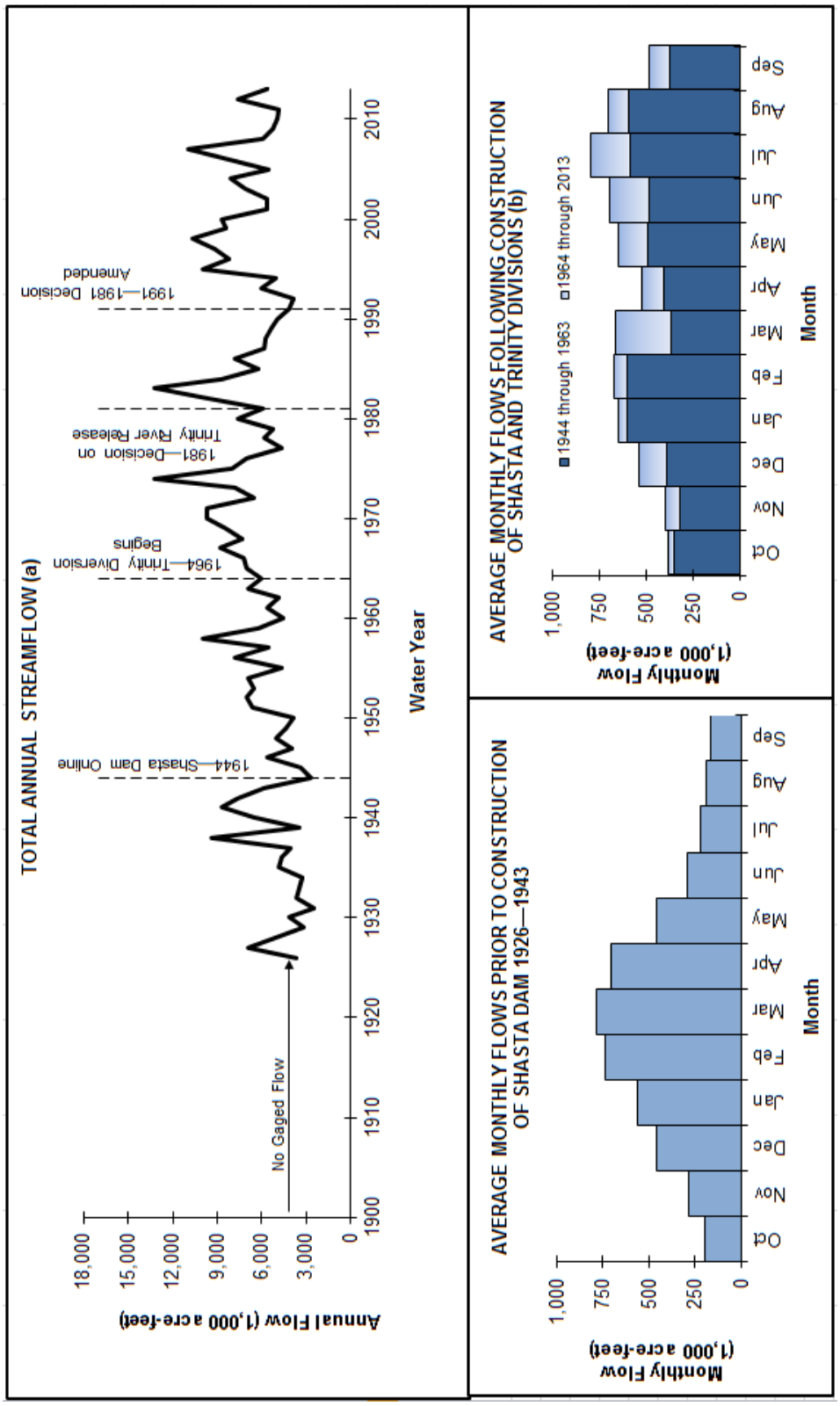
Daily flood management operations consist of determining the required flood storage space reservation, and scheduling releases in accordance with flood operating criteria. This requires forecasting flood runoff both above and below the dam. Rapidly changing inflows are continually monitored, and forecasts of the various inflows are adjusted, as required. The large size of the flood pool at

Shasta Reservoir can necessitate prolonged flood release operations over many weeks as operators vacate the pool before the next storm event.

A goal of existing operations is to maintain vacant flood storage space consistent with flood control requirements in the flood season, then then fill the pool to the maximum extent possible for water supply and other needs in the remainder of the year. Figure 2-5 is a plot showing historical monthly storage in Shasta Reservoir for 1953 through 2013.

Table 2-6 shows the historical annual inflow, storage, and outflow history for Shasta Reservoir from 1945 through 2013. Releases for flood damage reduction purposes typically occur in the fall, to reach the prescribed vacant flood space beginning in early October, and/or later in the winter and spring to evacuate space during or after a storm event to maintain the prescribed vacant flood space in the reservoir. Releases for flood management occur over the spillway during large events or through river outlets for smaller events. As shown in Table 2-6, from about 1950 through 2013, flows over the spillway occurred in 14 years, or in 20 percent of post-1950 years.

For large flood events rarer than about 1 chance in 100 in any given year, inflows to Shasta Lake can exceed the ability of the reservoir to store the inflow volume and maintain the estimated downstream safe channel-carrying capacity of 79,000 cfs. Under these circumstances, outflows would need to be increased to prevent uncontrolled conditions. Between Keswick Dam and the RBPP, intermittent levees help prevent flooding of low-lying lands along the Sacramento River.



Source: California Data Exchange Center 2014

Notes:

(a) Full year of streamflow data for USGS Station 11370500 was 1939. Data for 1926–1963 are from USGS Station 1136950.

(b) Upper portion of bar represents incremental increase in average monthly flows since Water Year 1964, due to releases from the Trinity River Division.

Figure 2-4. Historical Streamflow in Sacramento River Below Keswick Dam

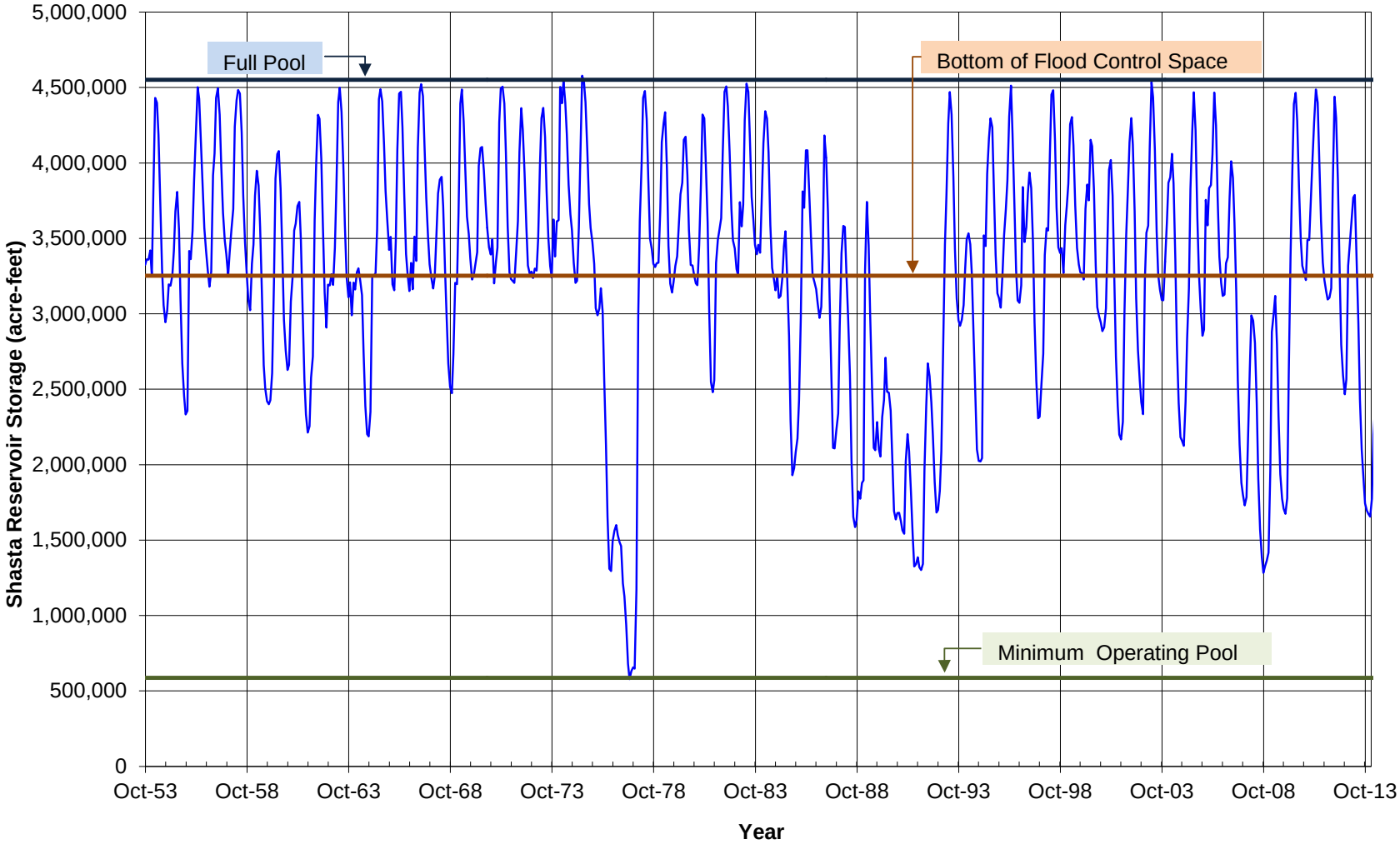


Figure 2-5. Monthly Average Storage in Shasta Reservoir

Table 2-6. Historical Shasta Dam and Reservoir Flood Management Releases

Water Year	Total Inflow (TAF)	End of Sept. Storage (TAF)	Outflows (TAF)				Water Year	Total Inflow (TAF)	End of Sept. Storage (TAF)	Outflows (TAF)			
			Total	Powerplant	Spillway	Outlets				Total	Powerplant	Spillway	Outlets
1945	4,858	*	3,462	2,624	0	839	1980	6,415	3321	6,139	4,773	0	1,366
1946	5,906	*	5,599	3,898	0	1700	1981	4,103	2480	4,845	4,845	0	0
1947	3,908	*	3,964	3,571	0	393	1982	9,013	3486	7,910	6,464	253	1,193
1948	5,416	*	4,958	4,244	0	714	1983	10,794	3617	10,576	7,123	1	3,452
1949	4,318	*	4,303	4,303	0	0	1984	6,667	3240	6,944	6,514	0	429
1950	4,133	*	3,784	3,781	1	2	1985	3,971	1978	5,154	5,152	2	0
1951	6,316	*	6,486	5,696	0	790	1986	7,546	3211	6,225	4,383	0	1,842
1952	7,785	*	6,800	5,625	9	1166	1987	3,944	2108	4,957	4,800	0	157
1953	6,540	3,300	6,408	5,067	0	1341	1988	3,931	1,586	4,368	3,973	0	395
1954	6,541	3,059	6,826	5,941	0	885	1989	4,745	2,096	4,154	3,951	0	203
1955	4,112	2,455	4,612	4,612	0	0	1990	3,616	1,637	3,999	3,707	0	292
1956	8,834	3,569	7,606	4,926	12	2668	1991	3,051	1,340	3,286	2,666	0	620
1957	5,368	3,485	5,341	4,841	17	483	1992	3,622	1,683	3,204	1,755	0	1,449
1958	9,698	3,473	9,610	6,672	13	2,924	1993	6,825	3,102	5,316	3,728	0	1,588
1959	5,086	2,504	5,952	5,631	0	321	1994	3,087	2,102	4,002	3,252	0	750
1960	4,733	2,756	4,380	4,380	0	0	1995	9,638	3,136	8,511	5,187	0	3,324
1961	5,071	2,333	5,402	5,402	0	0	1996	6,846	3,089	6,781	3,703	0	3,078
1962	5,262	2,908	4,582	4,582	0	0	1997	7,424	2,308	8,106	5,808	0	2,298
1963	7,003	3,242	6,575	6,077	13	485	1998	10,294	3,441	9,072	6,698	2	2,372
1964	3,905	2,202	4,849	4,849	0	0	1999	7,196	3,328	7,202	6,379	0	824
1965	6,983	3,612	5,475	4,581	0	894	2000	6,839	2,985	7,074	5,573	0	1,501
1966	5,299	3,263	5,544	5,544	0	0	2001	4,141	2,200	4,824	4,823	0	1
1967	7,404	3,506	7,066	6,131	0	935	2002	5,052	2,558	4,590	4,590	0	0
1968	4,772	2,670	5,515	5,138	0	377	2003	6,363	3,159	5,659	5,409	0	250
1969	7,668	3,528	6,714	5,421	0	1293	2004	5,738	2,183	6,615	5,617	0	998
1970	7,902	3,440	7,885	5,477	4	2404	2005	5,639	3,035	4,692	4,475	0	217
1971	7,328	3,275	7,402	6,824	1	578	2006	9,241	3,205	8,964	6,608	0	2,356
1972	5,078	3,267	5000	5000	0	0	2007	3,957	1,879	5189	5166	0	23
1973	6,167	3,317	6026	5583	0	443	2008	3,984	1,385	4220	4178	0	42
1974	10,796	3,658	10364	6796	0	3568	2009	4,533	1,774	4309	4105	186	18
1975	6,405	3,570	6384	6153	0	231	2010	5,646	3,319	4107	4004	0	103
1976	3,611	1,295	5813	5813	0	0	2011	6,468	3,341	6577	5703	0	874
1977	2,628	631	3247	3247	0	0	2012	3,971	2591.6	5211	5209	0	1
1978	7,837	3,428	4944	4538	0	407	2013	3,998	1,906	4588	4587	0	1
1979	4,022	3,141	4203	4203	0	0	**Average**	**5,898**	**2,766**	**5804**	**4958**	**7**	**839**

Source: Reclamation 2007b, Reclamation 2014b

Key:
* = reservoir filling
Sept. = September
TAF = thousand acre-feet

Shasta Lake collects flow in the upper Sacramento River watershed, but many uncontrolled tributaries, including Cow Creek, Battle Creek, Cottonwood Creek, and Thomes Creek, enter the Sacramento River downstream from the dam (USACE 1999). Stream gages located on various uncontrolled tributaries help the operators of Shasta Dam adjust releases to accommodate downstream peak flows. However, the influence of Shasta Dam's operation on reducing peak flood flows on the Sacramento River diminishes with distance downstream, largely because of these uncontrolled tributaries.

Downstream from the RBPP, flood management projects along the Sacramento River affect the flow and operation of facilities. Major reservoirs include Folsom Lake on the American River, Lake Oroville on the Feather River, and Black Butte Reservoir on Stony Creek. Levees associated with the Sacramento River Flood Control Project begin intermittently downstream from the RBPP and become continuous along both banks between Colusa and the Delta. Weirs located along the Sacramento River divert high flows to overflow basins and bypasses including Butte Basin, Sutter Bypass, and Yolo Bypass (Figure 2-6).

Water Quality Principal water quality issues in the primary study area include water temperatures in the Sacramento River between Keswick Dam and the RBPP, turbidity in Shasta Lake, and acid mine drainage and associated heavy metal contamination. The Central Valley Water Board determined that the 25-mile-long reach of the Sacramento River from Keswick Dam downstream to Cottonwood Creek is impaired because levels of dissolved metals periodically exceed levels identified to protect aquatic organisms (Central Valley Regional Water Board 2002a).

Water quality in the lower part of the Sacramento River and in the Delta may be affected by urban and agricultural runoff, acid mine drainage, stormwater discharges, and water project flows and diversions. The Sacramento River downstream from the RBPP was listed as an impaired water body under Section 303(d) of the CWA, and water quality was an identified objective of CALFED. Parameters of concern in this reach included diazinon, mercury, and unknown sources of toxicity (Central Valley Water Board 2002b). In the Delta, water quality can also be affected by saltwater intrusion. Water quality issues within the Delta, particularly those related to salinity, have resulted in significant declines in pelagic populations (Regional Water Boards, State Water Board, and Cal/EPA 2006). Potential changes in hydrology and sea levels due to climate change could further affect water quality within the Delta.

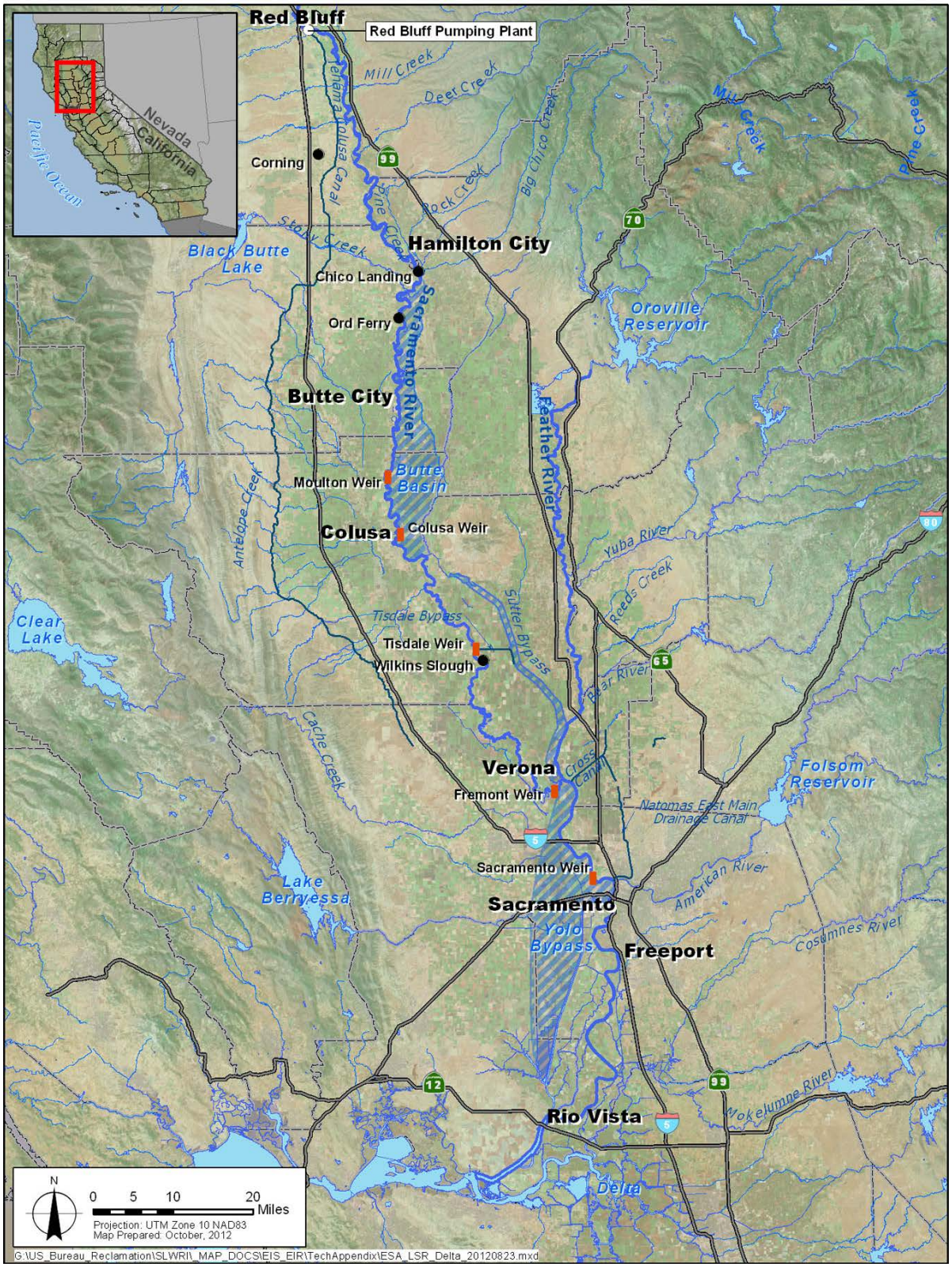


Figure 2-6. Sacramento River Overflow Basins and Bypasses South of the Red Bluff Pumping Plant

Noise and Vibration The area immediately surrounding Shasta Dam and Lake, where the majority of project construction would occur, is in an undeveloped canyon of the Sacramento River in Shasta County. Various recreational uses and sensitive receptors are present throughout the vicinity. Existing noise sources are associated with local roadway traffic, I-5 traffic, railway traffic, Redding Municipal Airport aircrafts, boats and personal watercraft on Shasta Lake, and stationary noise sources (e.g., mechanical equipment at the existing dam facility). Existing vibration sources in the SLWRI study area are primarily associated with local construction, roadway traffic, and trains.

Hazardous Materials Metals are present in inactive and abandoned mines around Shasta Lake and in the Sacramento River watershed. A records search for the primary study area identified one known contaminated site, which appears on the Federal National Priorities List/Superfund: the Iron Mountain Mine. The continuous release of metals from the Iron Mountain Mine since the 1940s is believed to have contributed to a steady decline in the fisheries population in the Sacramento River. In addition, several other former mining operations may currently impact environmental conditions in the primary study area. Of these, Bully Hill is the closest abandoned mine to the current shoreline; portions of mine tailings and a debris dam are periodically inundated by the reservoir.

Agricultural and Important Farmlands Within the primary study area, the valleys of the Sacramento River and its tributaries contain some of the most productive agricultural land in Shasta County. Many hundreds of acres of land in these valleys are classified as prime farmland, unique farmland, or farmland of statewide importance. Although there is little agricultural development immediately adjacent to Shasta Lake, agricultural lands are present in the upper watersheds of several tributaries, primarily to the east of the reservoir. In the extended study area, the Sacramento River basin downstream from the RBPP to the Delta, the Delta, the San Joaquin River basin to the Delta, portions of the American River basin, and the CVP and SWP water service areas are all rich in agricultural resources.

Biological Resources Environment

Biological resources in the region result from a wealth and diversity of climatic and vegetative associations within and adjacent to the study areas. Influences from the coastal mountains, southern Cascades, northern Sierra Nevada, Great Basin, and Central Valley provide for a unique mix of biota. The study area supports a variety of habitats, including riparian, grasslands, oak woodlands, chaparral, scrub, vernal pools, seasonal and permanent wetlands, estuaries, tidal sloughs, and marshes. Each of these habitats supports its own unique assemblage of vegetation and wildlife species.

Much of the area, especially within the Central Valley, has been modified by past and present land uses. Before human settlement, this region was dominated

by riparian vegetation within the annual floodplains, with stands of valley oak and interior live oak on higher ground. The extensive oak forests and riparian/wetland habitats hosted a diverse and abundant wildlife community. Deforestation, water development, flood protection, and expansion of agriculture onto the floodplains in the early to mid-1800s substantially altered the historical floodplain and channel vegetation.

Agriculture is currently the primary land use in the Central Valley; much of the remaining habitat exists as a mosaic of fragmented upland communities or narrow strips of riparian habitat along the Sacramento River and its tributary creeks and sloughs. Although the remaining riparian habitat along the Sacramento River corridor is limited, it supports wildlife, and also supplies shade, cover, and transported nonnative material to the adjacent streamside environment, benefiting the floral and faunal species that are closely associated with the riparian environment.

Fisheries and Aquatic Resources Shasta Lake and Keswick Reservoir fish species include native and introduced warm-water and cold-water species. Shasta Lake tributary species comprise planted and wild trout and several native species. Major nonfish aquatic animal species assemblages of the study area include the lake floor macroinvertebrates of Shasta Lake, the Sacramento River, and tributaries to Shasta Lake, and zooplankton of the reservoirs.

The Sacramento River between Keswick Dam and the RBPP has a stable, largely confined channel with little meander. Riffle habitat with gravel substrates and deep pool habitats are abundant compared to reaches downstream from the RBPP. Immediately below Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation and no functioning riparian ecosystems. Water temperatures are generally cool, even in late summer, because of regulated releases from Shasta Reservoir and Keswick Reservoir. Near Redding, the river enters the valley and the floodplain broadens. Historically, this area appears to have had wide expanses of riparian forests, but much of the river's riparian zone is currently subject to urban encroachment, particularly in the Anderson/Redding area.

The Sacramento River supports a variety of anadromous fishes, including four runs of Chinook salmon, steelhead, green sturgeon, white sturgeon, striped bass, American shad, and Pacific lamprey. Resident species include rainbow trout, hardhead, California roach, Sacramento sucker, Sacramento pikeminnow, and various species of nonnative catfish, sunfish, and black bass. The population of the four runs of salmon, and other important fish species (including steelhead) that also spawn upstream from Red Bluff, have significantly declined since the 1950s.

Vegetation and Habitat Types Shasta Lake is surrounded by mountainous terrain forested primarily by brushy, hardwood stands, chaparral, oak woodlands, mixed conifer forests, and ponderosa-pine-dominated conifer

stands. Vegetation diversity tends to be high in the area, due largely to the favorable climate and varying geology. Elevation and sun exposure create variation in the forest stands around the lake. Shoreline vegetation around Shasta Lake provides important cover for aquatic species, and shade to maintain cooler water temperatures. The Shasta Lake area also supports nonnative plant species introduced to the region by early settlers. Some of the more invasive exotic species out-compete native vegetation.

Vegetation in the upper Sacramento River watershed upstream from Shasta Lake can be separated into seven basic vegetation types: Douglas fir-mixed conifer forest, mixed conifer, ponderosa pine, canyon oak woodland, black oak woodland, gray pine woodland, and chaparral. Lower elevation vegetation consists of a mix of chaparral and hardwoods; mid-elevation slopes are within a transitional zone that contains both the chaparral/hardwood mix and a mixed conifer component; and higher elevation sites are dominated by a mixed conifer overstory with brush species in the understory, primarily in open areas. An exception is in the riparian corridors, where conifers can span from lower to upper elevations.

Although the Central Valley historically contained an estimated 1,400,000 acres of wetlands, only about 123,000 acres remain today. Along most of the Sacramento River and its tributaries, the once productive and extensive riparian areas have been greatly reduced. Riparian and wetland habitats provide food and shelter to aquatic fauna and help attenuate high flows. Wetlands occupy many areas along Sacramento River waterways, and are extensive in the Delta. Grasslands and wooded upland communities are more abundant in this reach of the primary study area, which also includes some agricultural lands. Open-water areas occur mainly on the larger waterways, where waterways converge, and in reservoirs.

The Delta includes extensive areas of fresh and brackish tidal marsh, and submerged aquatic plant communities. Additional natural plant communities occur in the extended study area outside the Central Valley and adjacent foothills, but are not a focus of this study. Urban and agricultural and urban vegetation occupies nearly 70 percent of the Central Valley, and a larger portion of terrestrial habitats in the Delta. Urban area plant communities (landscaping) also occupy an increasingly greater portion of the extended study area.

Wildlife A variety of wildlife is present in the areas surrounding Shasta Lake and lower reaches of its tributaries, and includes black-tailed deer, elk, black bear, mountain lion, bobcat, gray squirrel, rabbit, and turkey. Avian species include quail, falcon, eagle, turkey, dove, pigeon, hawk, woodpecker, ash-throated flycatcher, Hutton's and warbling vireos, and house sparrow. The area provides excellent habitat for deer and elk, and suitable habitat for numerous bat species, although few bat sightings have been confirmed. Several other wildlife species inhabited this area before European settlement but were extirpated by over-hunting or because they were seen as threats; these species included

grizzly bear, wolf, and various species of elk. Shasta Lake is home to the largest concentration of nesting bald eagles in California.

The variety of habitats along the Sacramento River from Shasta Dam to the RBPP supports a wide range of wildlife species. Composition, abundance, and distribution of wildlife are directly related to the accessibility of these habitats. The range of wildlife species present includes a variety of waterfowl, raptors, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats within the upper Sacramento River study area. Many of the wildlife species are unable to adapt to other habitat types or altered habitat conditions and are therefore most susceptible to habitat loss and degradation. Species that depend on riparian woodland, oak woodland, marsh, and grassland habitats have declined. The region also supports a variety of exotic species, some of which are detrimental to survival of native species.

Special-Status Species Special-status species primarily include plants and animals in the study area that are legally protected or are otherwise considered sensitive by Federal, State, or local resource conservation agencies and organizations. These include species that are Federally listed and/or State-listed as rare, threatened, or endangered; species considered as candidates or proposed for listing; species identified by CDFW as species of special concern; species identified as species of concern by USFWS; plants considered by the California Rare Plant Ranking System (formerly known as California Native Plant Society Lists) to be rare, threatened, or endangered; and species afforded protection under local planning documents. Within the primary study area, 32 special-status species were identified for which generally suitable habitat was determined to be present.

Wild and Scenic Rivers The National Wild and Scenic Rivers Act of 1968, as amended (Public Law 90-542; 16 USC 1271 – 1287), established the National Wild and Scenic Rivers System, which identifies rivers of the nation that possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. This act preserves the free-flowing condition of rivers that are designated, and protects their local environments. The California Wild and Scenic Rivers Act of 1972, as amended (California Public Resources Code (PRC) Section 5093.50 – 5093.70), aims to preserve designated rivers possessing extraordinary scenic, recreation, fishery, or wildlife values.

Although the McCloud River is not formally designated as a Federal or State wild and scenic river, Section 5093.542 of the PRC specifies that the McCloud River should be maintained in its free-flowing condition, and its wild trout fishery protected from 0.25 miles below McCloud Dam downstream to the McCloud River Bridge.

Raising Shasta Dam would inundate portions of the lower McCloud River. Section 5093.542 (c) may limit assistance or cooperation from State departments or agencies in planning or constructing any water impoundment facility that could adversely affect the free-flowing condition of the McCloud River or on its wild trout fishery, with the exception of participation by DWR in studies involving the feasibility of enlarging Shasta Dam. Section 5093.542(d) states, "All state agencies exercising powers under any other provision of law with respect to the protection and restoration of fishery resources shall continue to exercise those powers in a manner to protect and enhance the fishery" of the protected segments of the McCloud River. Participation by various State agencies in planning and potential construction activities associated with modifying Shasta Dam and Reservoir, including related permitting and approval processes, varies by an agency's mandate and PRC Section 5093.542. CDFW has taken the position that it must participate in preparing the EIS to comply with Section 5093.542(d). Other State agencies, including DWR and the State Water Resources Control Board, have participated to a limited extent or expressed their intent to participate in the SLWRI. The CALFED Program Plan (CALFED 2000c) concluded that although Section 5093.542 sought to protect the free-flowing condition of the McCloud River, it also provided for investigations of enlarging Shasta Dam. The CALFED Programmatic ROD also specified that legal issues to allow State agency cooperation in Shasta Lake expansion studies were to be resolved by 2000.

Cultural Resources Environment

Investigations have revealed repeated occupation of the Shasta Lake area as early as 8,000 years ago. From available information, it is believed that at least 210 archaeological sites are currently inundated by Shasta Reservoir at full pool elevation 1,070. The records search identified 261 cultural resources within the study area, including 190 prehistoric sites, 45 historic-era resources, and 26 resources with both prehistoric and historic-era components.

The study area was the focus of intensive Native American occupation during historic times, with a variety of religious, economic, historic, and other values identified by Native American groups. Ten groups, including those listed by the Native American Heritage Commission, represent Native American interests in the study area. They include the Grindstone Indian Rancheria, Paskenta Band of Nomlaki Indians, Pit River Environmental Council, Pit River Tribe of California, Redding Rancheria, Shasta Indian Nation, United Tribe of Northern California, Inc., Winnemem Wintu Tribe, Wintu Educational and Cultural Council, and the Wintu Tribe of Northern California Toyon-Wintu Center. Notably, the Pit River Tribe and Winnemem Wintu live within the Shasta Lake area, where they continue to actively practice many aspects of their traditional culture. Both groups have relayed that a complex cultural landscape of village sites, ceremonial areas, burial sites, and resource areas intersects the study area. Several sites of cultural and religious significance to the Winnemem Wintu, a Native American group, are located within the study area. Documented locations include some 155 ancestral villages within the Shasta Lake area. At

least 81 village locations are known along the lower McCloud River and lower Pit River. An additional 73 villages are known to have existed on the eastern side of the Sacramento River. The California Native American Heritage Commission has identified several locations of particular concern in the study area.

Settlement in the study area by whites began when trappers recognized the grazing potential of the land in the northern Sacramento River valley in the 1830s and 1840s. Mineral exploration, which included gold, silver, and, most influential to the region, copper, began with the Gold Rush of 1849. The lumber industry began in the region in the 1850s. Ranching (cattle and sheep) and agriculture (grain and fruit) have been practiced from the mid-nineteenth century onward. Railroads and State highways cross the study area. National efforts to preserve forests and other natural resources began in the late nineteenth century and continue today. Historic-era structures in the study area include, among others, seven bridges, one dam, one railroad bridge and grade, and one aerial-tramway.

Socioeconomic Resources Environment

The sections below describe social and economic resources in the SLWRI study area, including population, land use, employment and labor force, business and industrial activity, local government and finance, public health and safety, recreation and public access, aesthetics and visual resources, traffic and transportation, utilities and public services, and water supply.

Population California's population totaled an estimated 37 million in 2005. Approximately 2.9 million and 2.0 million of this population resided in the Sacramento River and San Joaquin River basins, respectively (California Department of Finance 2010a). The growth rate in the Sacramento River and San Joaquin River basins was over 11 and 14 percent from 2000 to 2005, respectively, significantly greater than the statewide rate of 8 percent for the same period. About three-fourths of the population in the Sacramento River basin resides in or near the City of Sacramento. The estimated population in the Sacramento River valley region in 2005 was approximately 2.6 million people with about three-fourths of this total residing in the greater Sacramento metropolitan area. Similarly, most of the population of the CVP service area is concentrated within urban areas. The CVP water service area includes various M&I water contractors and water districts that serve portions of the Sacramento, Stockton, and Bay Area metropolitan areas. Outside these population centers, most of the CVP water service area is rural, with irrigated agriculture the predominant land use and economic driver.

In Shasta County, Redding serves as the primary center for development and economic activity, while Red Bluff, although much smaller than Redding, plays that role in Tehama County. Because of the area's limited urbanization, residents live a more rural lifestyle than in many other areas of California. In total, the populations of Shasta and Tehama counties make up less than 1

percent of the total population in California. Although Shasta and Tehama counties are still comparatively small, both counties have grown substantially over the past 15 years.

Land Use Primary land uses in the vicinity of Shasta Lake include public and private lands managed for habitat and wildlife, residential, and some commercial industry uses. Portions of the STNF are located within Shasta County. Primary land uses along the Sacramento River between Shasta Dam and the RBPP include urban, residential, and agricultural. Land use in the extended study area varies greatly because of the differences in demographics and environment. Major urban development is concentrated in the Sacramento River valley along the transportation corridor provided by I-5, State Route 99, and the UPRR. Within 5 to 8 miles to the east and west of this corridor, development is characterized by rural communities. Development in the upland areas consists of agriculture, grazing, and timber operations, with small rural community centers and individual homes dispersed throughout.

Employment and Labor Force Trends in employment and the labor force are key considerations for rural communities like those in the primary study area, and offer insight into the area economy. Trends in unemployment within Shasta and Tehama counties indicate the economy within the primary study area is in transition, with the economy shifting away from natural-resource-based industries and agriculture, and employment opportunities diminishing. At the same time, agriculture and its related support activities remain comparatively strong and provide employment opportunities in the remainder of the CVP water service area.

Business and Industrial Activity Established industries near the study area include the nonfarm industries of trade, transportation, and utilities, professional and business services, and government services. Tourism, recreation, and related hospitality industries are a major source of economic development in the primary study area. Shasta Lake and the Sacramento River play a central role in the tourism industry and the appeal of the region to prospective businesses and investors. The economy in the vicinity of Shasta Lake has historically depended on natural resources.

Local Government and Finance Rural jurisdictions generally dominate the primary study area. Local officials allocate financial resources for a diverse collection of activities, including providing police and public safety, reviewing development, and providing educational services within their jurisdictions. The two largest sources of revenue for most local jurisdictions are property taxes and funding received from the Federal and State governments. These two sources provide a relatively stable revenue base for funding local programs. Public health and safety, social services of various forms, and education represent the biggest expenditures at the local level. These activities serve as a safety net for the local population and are frequently the most visible local programs.

Public Health and Safety At Shasta Lake, water hazards are generally associated with recreational use; water management operations at a reservoir the size of Shasta Lake typically do not pose specific hazards to humans because water levels do not fluctuate rapidly. Downstream from Shasta Dam, water-related hazards may be associated with rapid increases in flow in the Sacramento River, as during flood events. Operations at Shasta and Keswick dams have historically helped to dampen rapid changes in flow in the Sacramento River, particularly in the reach between Shasta Dam and the RBPP. Downstream from the RBPP, Shasta Dam has a decreasing influence on flow conditions and associated water-related hazards.

Recreation and Public Access Much of the outdoor recreation and tourism in Shasta County is related to Shasta Lake. The Whiskeytown-Shasta-Trinity NRA was established by an Act of Congress in November 1965. The area comprises three separate units: Whiskeytown Lake, Shasta Lake, and Trinity Lake. The Shasta Lake and Trinity Lake units of the NRA are within the STNF, and recreation is managed by USFS; the Whiskeytown Lake Unit is administered by the National Park Service. Among the facilities that are administered by USFS within the Shasta Lake Unit of the NRA are 10 marinas with 1,075 houseboats; 625 are privately owned and 450 are owned by a marina and rented on a weekly or weekend basis. Also, 18 developed public campgrounds have a total of 246 sites. USFS maintains 11 group or boat-in campgrounds and also operates launching ramps and beach and picnic areas. A map with locations of the major recreation facilities in the Shasta Lake Unit of the Whiskeytown-Shasta-Trinity NRA is shown in Figure 2-7.

The area along the Sacramento River from Shasta Dam to the RBPP contains many recreation resources and public access sites. These include day use sites, boat launches, trail accesses, fishing accesses, recreational vehicle parks, wildlife areas, and undeveloped open space areas. Beyond Lake Red Bluff and the RBPP on the Sacramento River, it is not expected that recreation or public access would be affected by implementation of the project and, therefore, an in-depth review of recreation activities and facilities downstream is not presented in this analysis.

Aesthetics and Visual Resources Visual resources in the study area include views of and from Shasta Dam and Lake, and viewsheds or viewpoints along the Sacramento River downstream from Shasta Dam to the RBPP. Several highways located in the primary study area are designated, or are eligible for designation, as State or County Scenic Highways. California's Scenic Highway Program was created to preserve and protect scenic highway corridors from change that would diminish the aesthetic value of lands adjacent to the highways. Potential Class A visual features include Federal and State park and recreation areas, such as the Whiskeytown-Shasta-Trinity NRA and Lassen Volcanic National Park. Mount Shasta, Mount Lassen, and the Sutter Buttes are prominent mountains in the study area.

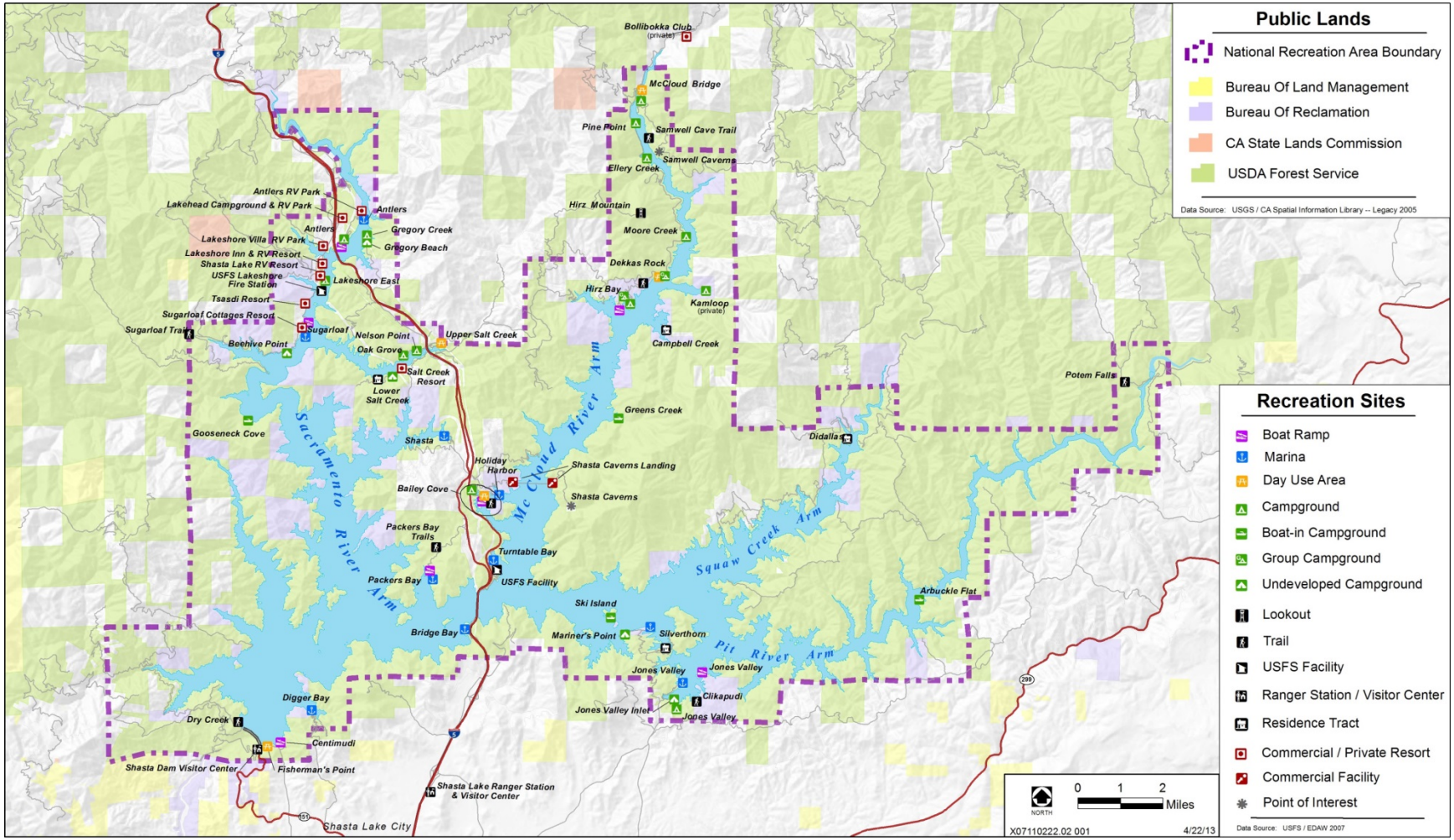


Figure 2-7. Shasta Lake Recreation Facilities

Traffic and Transportation Major transportation routes in the study area include I-5, and State Routes 20, 29, 36, 70, 99, 162, and 299. Excluding Chico, traffic within the central and northern portions of the Central Valley is usually moderate to light. Southern Pacific Railroad is the main rail line serving the Sacramento River basin area as a whole. The UPRR and Western Pacific Railroad both have rail lines serving the vicinity of Shasta Lake and the upper Sacramento River area. The UPRR main line follows the I-5 alignment and crosses Shasta Reservoir at the Pit River Bridge. Travel and navigation by water in the primary study area are primarily for recreational purposes. The extended study area includes numerous major and minor transportation features, including several rail lines, commercial and industrial ports, and a deep-water ship channel that runs from the Delta to the Port of Sacramento.

Utilities and Public Services Various county and local agencies provide the primary study area with solid waste and wastewater removal and management, emergency services, public safety, and law enforcement services. Pacific Gas and Electric Company (PG&E) is responsible for providing electrical and natural gas service to the primary study area. Gas is delivered to the study area through portions of PG&E's 40,000 miles of natural gas pipelines. Many areas scattered throughout Shasta and Tehama counties are served by individual septic systems.

Water Supply The CVP is the largest water storage and delivery system in California, covering 29 of 58 counties in the State. The CVP consists of 20 reservoirs capable of storing over 11 MAF of water, 11 powerplants, 500 miles of major canals and aqueducts, and many tunnels, conduits, and power transmission lines (Reclamation 2004b). CVP water is used to irrigate about 3 million acres of farmland and supplies water to more than 2.5 million people and businesses through more than 250 long-term water contracts (Reclamation 2008b, 2011c). Most of the CVP service area lies within the Central Valley. About 90 percent of south-of-Delta contractual delivery is for agricultural uses.

The SWP provides water to 25 million Californians and 750,000 acres of irrigated farmland (DWR 2014a), with water deliveries allocated 70 percent to M&I use and 30 percent to agricultural use (DWR 2008b). The SWP includes 34 storage facilities, reservoirs, and lakes; 20 pumping plants; four pumping-generating plants; five hydroelectric powerhouses; and about 700 miles of open canals and pipelines (DWR 2014a). SWP water is delivered under long-term contracts to 29 public water agencies throughout the State, including the San Joaquin Valley, Tulare basin, and Southern California service areas (DWR 2014a).

It is estimated that water demands (applied water) in the State in 2005 for urban, agricultural, and environmental purposes were about 83 MAF, including water dedicated to wild and scenic rivers (DWR 2009, 2014b). Approximately 54 MAF of water was available in 2005 from statewide water management projects, including the CVP and SWP, as well as local projects. Approximately

12 MAF was available from groundwater. The remaining water supply came from reused or recycled water sources.

Environmental Justice Environmental justice considerations include disproportionate adverse impacts to minority and low income populations, and Native American populations. In the primary study area**,** Shasta and Tehama counties are not considered environmental justice communities from minority population or low income population perspectives. The Sacramento River and its major tributaries, particularly the Pit and McCloud rivers, were the focus of intensive Native American occupation during historic times, with a variety of religious, economic, historic, and other values identified here for Native American groups. Ten groups, including those listed by the Native American Heritage Commission, represent Native American interests in the study area. The extended study area, including the CVP and SWP service areas, encompasses 36 of California's 58 counties, accounting for 91 percent of California's population in 2010 (Department of Finance 2010b). Minority groups have been steadily increasing and such ethnic diversification is expected to continue.

Summary of Likely Future Conditions

Identification of the magnitude of potential water resources and related problems, needs, and opportunities in the study area is based not only on the existing conditions highlighted above but also on an estimate of how these conditions may change in the future. Predicting future conditions is complicated by a variety of factors, including uncertainty regarding future regulatory requirements, and ongoing programs and projects affecting the study area, as described in the following sections.

Likely Future Conditions Without Project Implementation

Predicting future changes to the physical, biological, cultural, and socioeconomic environments in the primary and extended study areas is additionally complicated by ongoing programs and projects and potential changes in regulatory requirements. Several ecosystem restoration, water quality, water supply, and levee improvement projects are likely to be implemented in the future. Collectively, these efforts may improve ecosystem resources, Delta water quality, water supply, and levees. Much of this improvement would be based on separate opportunities that are not integrated in a single plan or part of an approved and funded program.

The baselines for analysis of future conditions without project implementation include reasonably foreseeable actions with current authorization, complete funding for design and construction, and complete environmental permitting and compliance. However, other programs currently in the planning phases could also potentially influence the SLWRI in the future. Prominent examples include the State's Delta Plan and the BDCP. These projects and programs have not been included in the evaluation of the alternative plans for the SLWRI because there has not been a specific decision to implement them at this time.

The following sections summarize likely future conditions without project implementation for physical, biological, cultural, and socioeconomic resources within the study area. Additional, detailed information is included in the accompanying EIS, including the Physical Resources Appendix, Biological Resources Appendix, Cultural Resources Appendix, and Socioeconomics Appendix.

Physical Resources Environment Basic physical conditions in the primary and extended study areas are expected to remain relatively unchanged in the future. Continued development in urban and suburban areas is expected. Ongoing restoration efforts along rivers are expected to marginally improve natural riverine processes. Without major physical changes to the river systems, hydrologic conditions may remain unchanged. However, the region's hydrology could be altered should there be significant changes in global climatic conditions; scientific work in this field of study is continuing. Without major changes in hydrology, topography, or geology, sedimentation and erosion are also likely to remain unchanged.

Much effort has been expended to control the levels and types of herbicides, fungicides, and pesticides that can be used in the environment. Further, efforts are underway to better manage the quality of runoff from urban environments to the major stream systems. However, water quality conditions are expected to remain unchanged and similar to existing conditions.

It is unclear to what extent potential changes to the region's climate could occur in association with global climate change. As the population continues to grow and agricultural lands are converted to urban and industrial uses, a general degradation of air quality conditions could occur. However, because of technological innovation and stringent regulations, air quality could improve over time. While similar types and sources of hazardous materials and waste are likely to be present in the future, increasing population will likely increase the potential for hazardous waste issues. Similarly, increasing population will likely affect increases in environmental noise and vibration.

Biological Resources Environment Efforts are underway by numerous agencies and groups to restore various biological conditions throughout the primary and extended study areas. Accordingly, major areas of wildlife habitat, including wetlands and riparian vegetation areas, are expected to be protected and restored. However, as population and urban growth continues, and land uses are converted to urban centers, many wildlife and plant species especially dependent on woodland, oak woodland, and grassland habitats may be adversely affected.

Through the significant efforts of Federal and State wildlife agencies, populations of special-status species in the riverine and nearby areas are estimated to generally remain as under existing conditions. Although increases in anadromous and resident fish populations in the Sacramento River could

continue through implementation of projects (including CVPIA actions and programs), such as the Battle Creek Salmon and Steelhead Restoration Project, some degradation will likely occur through actions that reduce Sacramento River flows or elevate water temperatures such as implementation of the Trinity River ROD. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

No rivers or streams in the primary study area are expected to be added to the list of Federal and/or State wild and scenic rivers. The McCloud River is expected to be managed under existing federal and state statues and policies.

Cultural Resources Environment In the vicinity of Shasta Lake, any archaeological, historic, or ethnographic resources currently affected by erosion due to reservoir fluctuations would continue to be impacted. Artifacts located around the perimeter of the existing reservoir will continue to be subject to collection by recreationalists. Similarly, conditions related to the cultural environment downstream from Shasta Dam are unlikely to change significantly.

Socioeconomic Resources Environment The State's population is estimated to increase from approximately 37 million in 2005 to approximately 44 million by 2020, and to about 60 million by 2050. Between now and 2050, Shasta and Tehama counties are expected to continue their historic growth trends. According to the California Department of Finance (2007, 2010a), Shasta County's population is expected to increase by approximately 86 percent by 2050 to a total of approximately 332,000 residents (2005 population was 179,000). This represents an expected increase in population that is almost 20 percent greater than for the State as a whole. The population of Tehama County is expected to more than double by 2050, with population increasing from approximately 60,000 (in 2005) to 124,000 (California Department of Finance 2007, 2010a).

To support these expected increases in population, some conversion of agricultural and other rural land to urban uses is anticipated. More transportation routes are likely to be constructed to connect the anticipated population increase in the Central Valley to transportation infrastructure. Anticipated increases in population growth will also impact visual resources as areas of open space on the valley floor are converted to urban uses.

Increases in population will increase demands for electric, natural gas, and wastewater utilities; public services such as fire, police protection, and emergency services; and water-related and communication infrastructure. The increase in population and aging "baby boomer" generation will increase the need for health services. The region's superior outdoor recreational opportunities and moderate housing cost opportunities are expected to attract increasing numbers of retirees from outside the region and State. An increasing population will produce employment gains, particularly in retail sales, personal

services, finance, insurance, and real estate. Recreation is expected to remain an important element of the community and economy in the region.

Anticipated increases in population growth in the Central Valley will also significantly increase demands on water resources systems for additional and reliable Central Valley water supplies, energy supplies, water-related facilities, recreational facilities, and flood management facilities.