RECLAMATION
Managing Water in the West

CALIFORNIA'S CENTRAL VALLEY PROJECT: HISTORIC ENGINEERING FEATURES TO 1956

A MULTIPLE PROPERTY DOCUMENTATION FORM
June 2007

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

NPS Form 10-900-B OMB No. 1024-0018
(March 1992)

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

_X_ New Submission ___ Amended Submission

A. Name of Multiple Property Listing

California's Central Valley Project, Historic Engineering Features to 1956

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

- California's Pre-CVP Agricultural Economy, 1850-1935
- Pre-CVP Water Issues, 1850-1935
- CVP Authorizations I, 1920-1940: Shasta, Delta, Friant Divisions
- CVP Authorizations II, 1940-1956: American River Division
- Planning And Construction of Historic CVP Features: 1937 to 1956
- CVP Engineering Features 1957-2000: An Overview

The geographical area for all contexts are the following California Counties: Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, El Dorado, Fresno, Glenn, Kern, Kings, Lassen, Madera, Mariposa, Merced, Modoc, Monterey, Nevada, Placer, Plumas, Sacramento, San Benito, San Joaquin, Santa Clara, Santa Cruz, Shasta, Sierra, Siskiyou, Stanislaus, Tehama, Trinity, Tuolumne, Yolo, and Yuba.

C. Form Prepared by

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City or Town: Denver State: CO Zip Code: 80225-0007

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation.

_______________________________________ ___________

Bureau of Reclamation, Federal Preservation Officer Date
Thomas Lincoln

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

_______________________________________ ___________

Signature of the Keeper Date

Table of Contents for Written Narrative

Provide the following information on continuation sheets. Cite the letter and the title before each section of the narrative. Assign page numbers according to the instructions for continuation sheets in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B.) Fill in page numbers for each section in the space below.

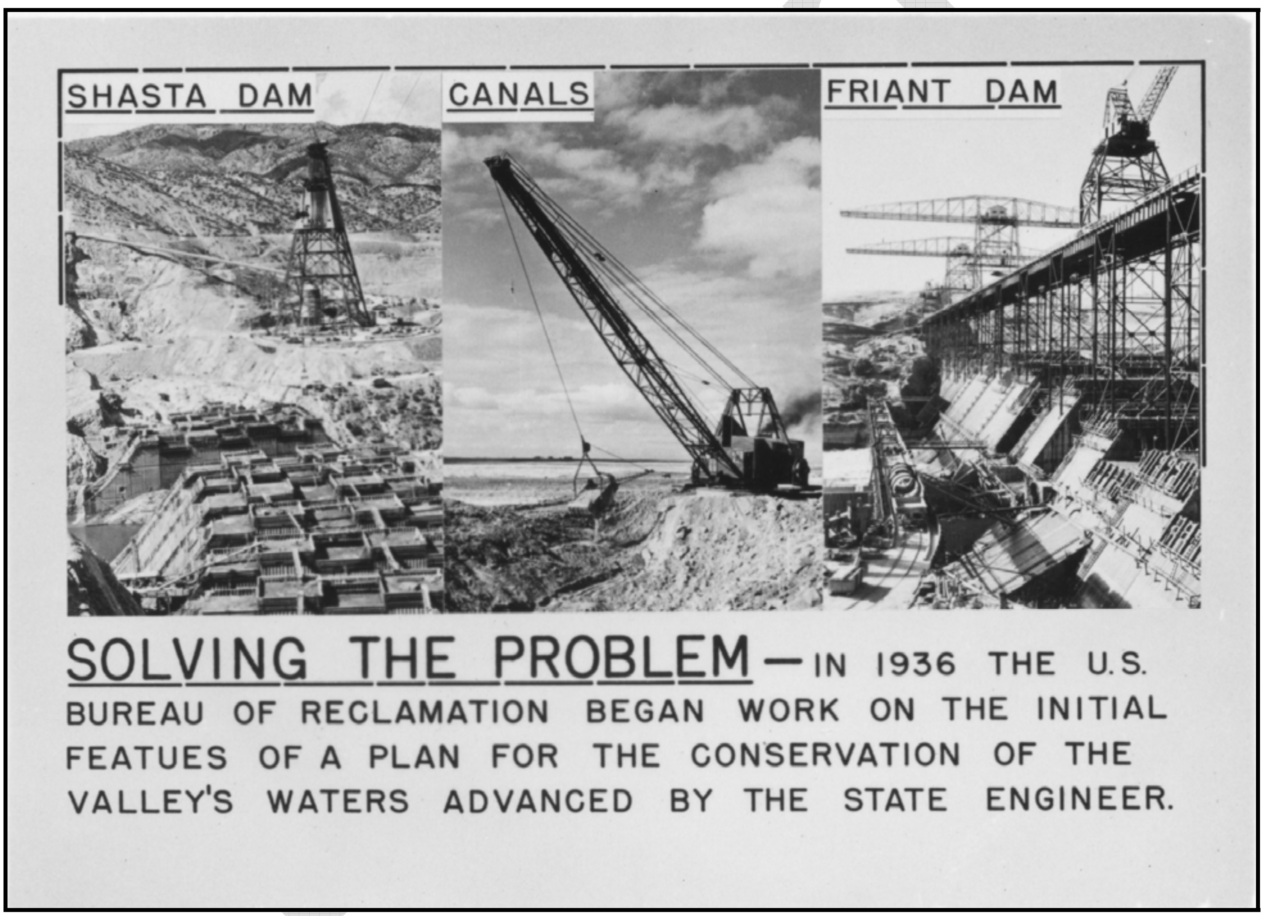
Section **Page Numbers**

INTRODUCTION: THE NATIONAL SIGNIFICANCE OF THE CENTRAL VALLEY PROJECT

As the most ambitious Federal water storage, transfer, and delivery system conceived and implemented in American history, California's enormous Central Valley Project (CVP) forever altered the physiographic and socioeconomic landscape of America's third largest and most populous state. More than providing water for irrigation and municipal purposes, the CVP also addressed problems of flood control, river navigability, and saltwater intrusion into freshwater areas. With many features built and operated by the U.S. Bureau of Reclamation (Reclamation), the CVP also provides water for hydroelectric generation, fish and wildlife protection, waterfowl conservation, and recreational needs. Few, if any, American reclamation projects can point to such an extensive array of purposes and services.

The CVP began as a state plan conceived just after World War I; however, the state failed to muster the necessary financial resources to begin construction, and called upon the Federal government for assistance. Although scaled back from original designs, the CVP facilitated the transfer of fresh water from Central Valley California's wettest regions to driest regions, a colossal geographic redistribution of a scarce resource through a complicated series of dams, reservoirs, channels, canals, and pumping plants. As one of the project's top priorities, the CVP also checked the centuries-long cycle of floods that devastated communities and towns, especially along the Sacramento and American Rivers. It is estimated that the CVP has prevented billions of dollars in flood damages to urban and rural areas over the past five decades.

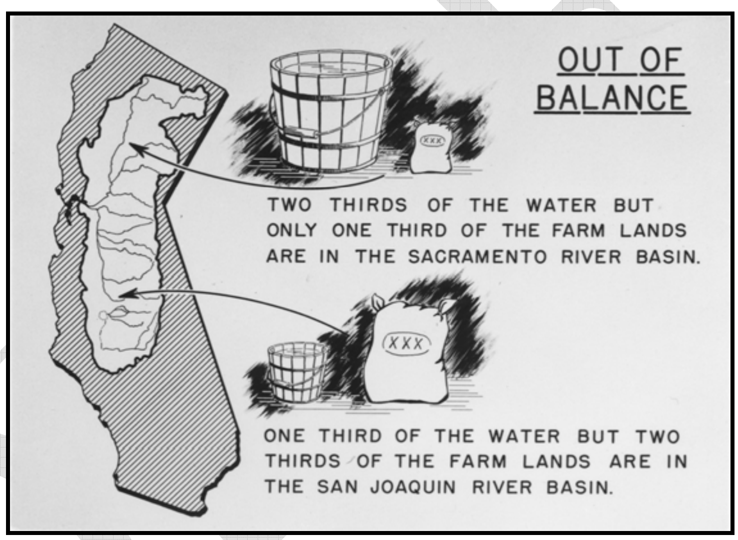
Furthermore, it is the sheer scope of what the CVP has done to help enhance California's post-World War II agricultural economy that stands out. By far America's most agriculturally productive state, in 2002 California contained 4% of the nation's farms and generated 13% of America's farm receipts—over twice as much as Texas, America's next most agriculturally productive state. The numbers are more impressive as geographic focus is narrowed: as of 2002, Central Valley farms produced 57% of California's agricultural output, so much that if the six most productive Central Valley counties (all served by the CVP) combined to form an independent state, it would rank number one in American agricultural output. Even though the CVP alone is not responsible for these impressive numbers, it certainly boosted California's Central Valley agricultural economy to its current national and global eminence.



"Solving the Problem": Bureau of Reclamation Slide, 1945

PHYSICAL SETTING

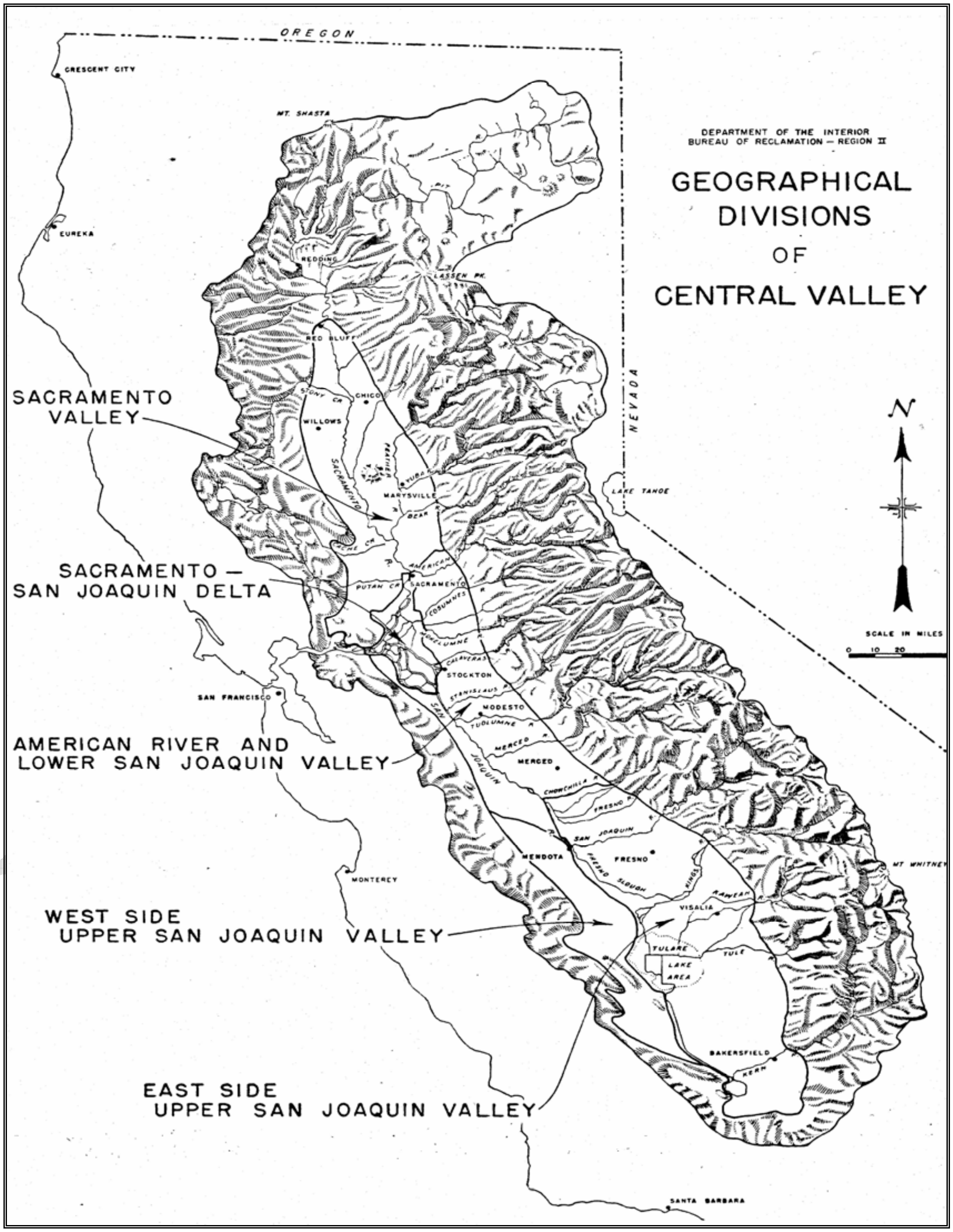
Like a huge, depressed, elongated bowl, California's Central Valley is literally surrounded by mountains across its roughly 450 mile length from Red Bluff in the north to Bakersfield in the south. Two major mountain-fed rivers and their numerous tributaries split this alluvial plain: the Sacramento River drains the northern section (Sacramento Valley), while the San Joaquin River (along with Tulare Basin tributary streams) drains the southern section (San Joaquin Valley). Both rivers converge southwest of Sacramento into a delta ecosystem before the water flows through Suisun Bay and into San Francisco Bay, the enclosed basin's only outlet (Map 1).



(courtesy Bureau of Reclamation)

Hot, dry summers and moist, cool winters characterize the Central Valley's climate, with frequent droughts and floods occurring on record. Average rainfall amounts decrease when moving from north to south: Red Bluff receives about 23 inches of rain a year, while Bakersfield averages only about 6 inches of rain annually. The surrounding mountains, especially the wet coastal ranges in the north and the northern Sierra Nevada, get about 80 inches of precipitation

Map 1: Geographic Divisions, Central Valley



annually; this amount decreases to about 35 inches when moving toward the southern Sierra Nevada and coastal mountains. As a result, the Sacramento River's annual flow is much higher than the San Joaquin River's, creating a naturally disproportionate flow of water into the delta.

This disproportionate share of water—that the Sacramento Valley contains only one-third of the Central Valley's agricultural lands but two-thirds of the total water, while the larger San Joaquin Valley contains two-thirds of the agricultural lands but only one-third of the total water—provided an impetus to transfer and balance out agricultural water distributions through a series of dams, diversions, pumping stations, and canals. Other impelling factors were the valley's frequent floods and droughts. In flood stage, both rivers, especially the Sacramento with its greater flow volume, wreaked havoc on communities like Red Bluff and Sacramento. Frequent floods on the American River also devastated Sacramento and its surrounding communities. Excess salinity also created problems. During drought years, diminished river currents affected the Delta by allowing salt water from San Francisco Bay to intrude, destroying farmlands and threatening municipal and industrial water supplies.

Yet problems existed in solving issues of flooding, saltwater intrusion, and inequitable distribution. Since private and state irrigation concerns could not muster the funding nor engineering expertise to design, construct, and maintain a large scale water transfer and distribution infrastructure, in the mid-1930s the Federal government, armed with New Deal public works relief funds, began building the CVP. Constructed in piecemeal fashion over the next six decades by Reclamation and the United States Army Corps of Engineers (USACE), extensive Federal involvement addressed many of the major issues previously discussed. The project's construction and operation, however, produced more problems of a contemporary nature, such as increased agricultural pollution, threatened ecosystems (especially in the Delta), and blocked fish passages—problems that government agencies at every level, along with corporate and private concerns, are currently attempting to address and resolve.

WESTERN WATER ISSUES AND THE ORIGINS OF THE FEDERAL RECLAMATION PROGRAM

In a larger context, issues behind solving California's Central Valley water problems did not exist in a vacuum. By the end of the 19th century, it was apparent throughout the arid West that private irrigation interests lacked the financial resources and engineering acumen to design and construct large-scale water storage, transfer, and delivery systems. The limits of successful smaller cooperative efforts had been reached; time and again, ill-financed, grandiose projects boosted by optimistic speculators failed. All of the easily irrigable lands had been developed and the vast arid expanse of remaining lands required complex, expensive irrigation systems. Even those opposed to government intervention understood the need for state or Federal irrigation support.

The first Federal law to address the unique water supply conditions in the arid West (defined here as lands west of the 100th meridian, excluding the wetter coastal climates of far western California, Oregon, and Washington) was the act of 26 July 1866. Passed largely due to the efforts of Senator William "Big Bill" Stewart of Nevada, the legislation was aimed primarily at the mining industry, where conflicts over water use in hydraulic mining operations had escalated. The law, which was written broad enough to include agriculture and other uses, acknowledged local control over water usage.

In the 1870s, the Congress passed numerous acts to help facilitate the settlement of arid lands. Among the most important were the Timber Culture Act of 1873, which required settlers to plant 40 out of 160 acres with trees under the credence that trees encouraged rainfall, and the Desert Lands Act of 1877, which gave settlers 640 acres of arid land on the condition that proof of irrigation be demonstrated within three years. Yet neither of these Federal laws that relied on individual initiative succeeded in establishing widespread irrigation.

At the forefront of a national irrigation movement was decorated, one-armed Civil War veteran (and noted explorer of the Colorado River basin) John Wesley Powell. In attempting to secure a greater federal presence in the development of irrigation systems, Powell passionately stressed that private enterprise lacked the financial resources, engineering acumen, or public interest to construct the reservoirs and delivery systems needed to expand western irrigation. His tireless advocacy for a greater Federal presence, however, was repeatedly disputed by those in favor of unchecked western expansion or states' rights.

In 1881, Powell became head of the United States Geological Service (USGS) and, under his direction, the agency began extensively surveying and mapping the United States. Congress passed a joint resolution in March 1888 that not only authorized a survey of arid western lands, but also allowed for the withdrawal of all lands deemed irrigable. The resolution further provided that lands could be reopened to settlement under the provisions of the Homestead Act by Presidential proclamation. In October 1888, at the onset of a western drought, Powell secured an initial modest amount of $100,000 from Congress to begin the irrigation survey of arid western lands. Five months later, in March 1889, Congress appropriated an additional $250,000 for this work. Surveys were conducted of canal routes and reservoir sites in seven western states. A total of 150 canal routes were identified and 30 million acres were deemed irrigable. In the summer of 1889, Powell was invited to accompany the U.S. Senate Committee on the Irrigation and Reclamation of Arid Lands on a tour to view the West's irrigation needs.

Much criticism was levied at Powell, including members of the Arid Lands committee, for his policy of withdrawing from settlement all lands feasible for irrigation until further directed by Congress. Fierce negative reaction, engendered by speculative and grazing interests, resulted in the 1890 repeal of a portion of the Joint Resolution allowing for the land withdrawals, except for the reservoir sites themselves. Survey funding was also cut. Despite these setbacks, the USGS continued to study water resources in the arid west in the 1890s.

Until 1890, broad public support for an organized irrigation movement did not exist. After 1890, however, public attitudes towards irrigation and reclamation of arid lands started to shift. The worsening drought plaguing western lands and devastating farmers was the catalyst for a series of National Irrigation Congresses, first held in Salt Lake City in 1891. These congresses did much to draw attention to the need for a greater Federal government role in the reclamation of arid western lands.

In 1892, Congress passed the last major irrigation legislation prior to the Reclamation Act of 1902. The Carey Act asserted the responsibility of the States rather than the Federal government to oversee irrigation development. The law granted each western state up to one million acres of public domain on condition that the lands be irrigated and occupied. Following the approval by the Secretary of the Interior of a State's request for participation, settlers on the segregated arid lands were given 10 years to cultivate at least 20 acres out of each 160 acre tract. Once proof of irrigation and settlement was submitted to the Interior Secretary, the lands would be turned over to the state and, in turn, patented to the settlers. Yet the Carey Act was unsuccessful, mostly because the states, much like private irrigation concerns, did not have monetary resources or engineering expertise to implement large-scale irrigation projects.

PASSAGE OF THE RECLAMATION ACT OF 1902

By 1900, it had become evident that the array of incentives for local and State development of large-scale irrigation works had not produced significant results, and the failure of the Carey Act exemplified this lack of success. Support for a greater Federal presence was growing among western congressional members, and among those at the forefront was Nevada Representative Francis G. Newlands. A wealthy Californian, Newlands moved to Carson City in 1888, and Reno one year later. Active in Nevada's economic and political affairs, in 1892 Newlands was elected to the U.S. Congress where he served as a representative until 1903, when he was elected as a Senator. From the onset of his political career, Newlands, like Powell, became a tireless advocate and spokesperson for the reclamation of arid lands.

Unlike most western promoters, Newlands advocated rational planning and orderly, efficient economic development as vital to successful irrigation enterprises. He applied these Progressive principals to his own projects by hiring professional engineers and geologists to conduct detailed studies and develop plans. As a leading proponent for reclamation in the 1890s, Newlands initially fought for State sponsorship of irrigation projects. Over the decade's course, however, he became convinced that State governments and private concerns were incapable of planning and implementing large-scale irrigation projects, and called for a greater Federal presence.

At the annual meeting of the National Irrigation Association held in Chicago in November, 1900, Newlands and two other leaders in the national reclamation movement, George W. Maxwell and Francis H. Newell, spoke in strong support of proposals under consideration for the Federal construction of irrigation works. This team of three—politician, publicist, and engineer—worked separately and together throughout 1900 and 1901 to garner congressional and public support for federally-sponsored reclamation projects.

On 26 January 1901, Newlands introduced legislation in Congress for a national reclamation program. The bill, drafted with assistance from Newell and Maxwell, however, failed to pass. On the other hand, the momentum and support for Federal sponsorship of irrigation had grown, and the movement received a huge boost when Vice-President Theodore Roosevelt assumed the presidency in September 1901 after President William McKinley's assassination.

A native New Yorker that lived and traveled in the West, Roosevelt had firsthand knowledge of its arid conditions, and acted quickly to establish a Federal reclamation program. In his message to Congress at the December 1901 opening session, he became the first President to recommend Federal legislation for the reclamation of arid western lands. Backed by strong presidential support, a committee of seventeen congressmen, one from each western state, convened under the chairmanship of Representative Newlands and drafted an irrigation bill. Introduced to Congress by Newlands, the bill quickly passed through both houses and was signed into law by Roosevelt on 17 June 1902.

The terms of the Newlands Act, commonly referred to as the Reclamation Act of 1902, authorized the Secretary of the Interior to locate and construct irrigation works in the 17 western states and territories.[*] Funding for the construction of these projects was to come from the sale of public lands within the benefiting western states and territories. Following completion of project facilities, project lands would be opened for settlement under provisions of various homestead laws in tracts no larger than 160 acres. The 160 acre limitation was designed to prevent land speculation and to encourage homesteading by individuals and families, a major focus of western irrigation supporters. Subscribing to the "Jeffersonian ideal" of the small family farmer as the backbone of agrarian America, Newlands adamantly believed that families, not corporations, should be the beneficiaries of Federal reclamation works. Settlers were required to reclaim at least one-half of their land for agriculture. Project construction costs were to be repaid over a period of time by project settlers. The agency established to administer the act's provisions was initially called the United States Reclamation Service, a sub-agency within the USGS. Frederick H. Newell, an irrigation engineering authority previously with the USGS, was named the new bureau's Chief Engineer.

[*] Texas (after 1906), Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Idaho, Washington, Oregon, Nevada, and California

Unlike the other western states, California was initially not a big recipient of Reclamation's services, because most California lands that carried agricultural potential were already settled, with many established small and large farms drawing water off small-scale private irrigation systems. From the Reclamation Act's 1902 authorization to the CVP's 1935 authorization, the Secretary of the Interior and Congress authorized 45 other projects of varying sizes in the seventeen western states (Table 1). Of these 45 projects, Congress okayed only four California projects before the CVP: the Klamath Project (shared with Oregon) in 1905, the Orland Project in 1907, the Boulder Canyon Project (with the All American Canal) in 1928, and the Truckee Storage Project (in the Lake Tahoe basin) the same year as the CVP.

In addition to the Truckee Storage system and the CVP, ten other Reclamation projects were formed in 1935, ranging from Montana's diminutive Frenchtown Project near Missoula (just under 5,000 irrigated acres), to Washington's Columbia Basin Project, which includes America's largest concrete dam in mass, the over one-mile-wide Grand Coulee Dam. All of the other projects authorized that year are diminutive when compared to the total irrigated acreage numbers that, when completed and operational, the nearly 3.2 million acres of irrigable lands the combined Columbia Basin and Central Valley projects would eventually serve.

Table 1: Reclamation Projects Authorized Before CVP (bold indicates CA Projects)

Year	Project	State(s)	Total Irrigable Acreage (1992 data)
1903	North Platte (Sweetwater)	Nebraska/Wyoming	331,461
	Salt River	Arizona	261,365
	Milk River	Montana	120,383
	Uncompahgre	Colorado	76,297
	Newlands	Nevada	73,859
1904	Belle Fourche	South Dakota	57,068
	Lower Yellowstone	Montana/ND	54,004
	Buford-Trenton	North Dakota	10,671
	Shoshone	Montana/WY	104,799
	Minidoka	Idaho	1,168,866
1904	Yuma	Arizona	68,091
1905	**Klamath**	**Oregon/California**	**240,412**
	Yakima	Washington	463,845
	Carlsbad	New Mexico	25,055
	Huntley	Montana	30,304
	Okanogan	Washington	5,038
	Boise	Idaho	397,157
	Umatilla	Oregon	30,583
	Strawberry Valley	Utah	44,571
	Rio Grande	New Mexico/TX	196,557
1906	Sun River	Montana	93,236
1907	**Orland**	**California**	**20,434**
1911	Grand Valley	Colorado	33,868
1917	Yuma Auxiliary	Arizona	3,400
1918	Pick-Sloan Missouri Basin	Wyoming (Riverton)	70,882
1925	Colorado River Levee	Arizona	None
1926	Owyhee	Idaho	118,249
	Vale	Oregon	34,993
1927	Weber River	Utah	108,975
1928	**Boulder Canyon (All American Canal)**	**California**	**599,919**
	Boulder Canyon (Hoover)	Arizona/Nevada	None
1930	Bitter Root	Montana	16,655
1931	Baker	Oregon	26,881
1933	Hyrum	Utah	6,800

Year	Project	State(s)	Total Irrigable Acreage (1992 data)
1935	Frenchtown	Montana	4,867
	Kendrick (Casper-Alcova)	Wyoming	24,265
	Ogden River	Utah	24,801
	Moon Lake	Utah	72,106
	Humboldt	Nevada	37,506
	Parker-Davis	Arizona	n/a
	Provo River	Utah	48,156
	Truckee Storage	**California**	**28,980**
	Sanpete	Utah	14,746
	Columbia Basin	Washington	557,530
	Burnt River	Oregon	15,616
	Central Valley	**California**	**2,624,285**

Source: Bureau of Reclamation Dataweb (http://www.usbr.gov/dataweb/projects/index.html)

CALIFORNIA'S PRE-CVP AGRICULTURAL ECONOMY, 1850-1935[†]

Although a small scale agricultural economy existed in California in the early years of statehood, the nineteenth century's last three decades witnessed the emergence of a sophisticated, highly commercialized agricultural economy. This was especially apparent in the Central Valley, where enterprising businessmen and farmers understood the agricultural potential held by the valley's fertile soils, horticultural advantages of a two season climate, and water delivery potential from the Sacramento River to the north and the San Joaquin River to the south. Land speculators, businessmen, and ranchers realized that adapting new machinery technologies to California's environment was crucial to unlocking the state's agricultural wealth. The result, as famed California journalist Carey McWilliams noted, were the "factories in the fields," a form of commercialized farming that foreshadowed similar patterns across America in ensuing decades.

[†] L. B. Christiansen and R.W. Gaines, Central *Valley Project: Its Historical Background and Economic Impacts,* (Sacramento: Bureau of Reclamation, Mid-Pacific Region, July 1981); Gerald D. Nash, "Stages of California's Economic Growth, 1870-1970: An Interpretation." *California Historical Quarterly* 51 (Winter 1972); Walter Packard, *The Economic Implications of the Central Valley Project,* (Los Angeles: Adcraft, 1942).

During this time, two agricultural products rose to the forefront: wheat and fruit. The former was especially prolific, for California wheat farmers grew hard, dry, white wheat that proved popular with overseas markets, especially the United Kingdom. California's topography and dry summers allowed grains to be easily harvested, while summer heat cured wheat and precluded spoilage. The long summers also enabled farmers to let their grains stand for extended periods, even after ripening. As a result, this made for huge ranches and farms as big as 70,000 acres. It also sparked innovation. California wheat farmers devised huge plows pulled by dozens of horses. Ripe grains were handled by new header-thresher machines that combined harvesting and threshing into a single operation, with some powered by portable steam engines. Farmers across America soon adopted many of these technologies after their California peers.

Around 1880—the same year Colusa County dentist Dr. Hugh Glenn raised over one million bushels of wheat on his 66,000 acre spread along the Sacramento River—many agriculturalists in the Central Valley (and southern California) converted to fruit and vegetables. Rising land prices, exacerbated by the state's expanding population, fueled this conversion, making wheat less profitable. Increasing competition from the Mississippi Valley and Russia also contributed to wheat's California decline. By 1900, many large scale wheat ranches had already converted to fruit and/or vegetable farms: oranges, lemons, peaches, apricots, plums, pears, grapes, lettuce, asparagus, tomatoes, and various kinds of nuts thrived in the salubrious California climate.

Like wheat, technological and scientific innovations also helped fruit and vegetables achieve economic eminence. In 1883, the State Board of Horticulture was formed, and was instrumental in introducing beneficial insects and imposing quarantines on various blights. Diseases that could erase entire harvests, like white scale, were eradicated through scientific knowledge. California fruit and vegetable growers also benefited from an increasing network of private and state irrigation canals. The most important factor, however, was the development and subsequent use of the refrigerated railcar. This simple invention did more to expand California's fruit and vegetable production and distribution than any other factor. California growers were now able to reach distant eastern markets, something previously impossible to accomplish. Without access to these new markets across America, it is doubtful that California's fruit and vegetable industry could have grown so greatly in such a relatively brief period of time.

California's population continued to increase at the turn of the century, especially in the urban areas. This resulted in an economy that stretched beyond agriculture into the manufacturing, petroleum, and service industries. Nonetheless, the state's agricultural economy continued to flourish, to meet the needs of burgeoning urban markets in the north and south. From 1900 to 1940, the number of California fruit and vegetable farms doubled; citrus production, mostly centered in the state's southern reaches, increased nearly tenfold during this period. One key event that helped fuel this boom was the 1905 establishment of the California Fruit Growers Exchange, which greatly facilitated the business's marketing aspect.

Additionally, the expansion of local banking services provided the capital needed to further this agricultural expansion, and lessen the state's reliance on outside capital. Founded in 1904 in San Francisco by A.P. Giannini, the Banca D'Italia (Bank of Italy) is one of the best examples of creative innovations in finance. This son of Italian immigrants expanded on a flexible financial concept that worked its way across America in ensuing decades: branch banking. So popular and successful was Giannini's branch bank system that by 1919 it was California's largest bank, by 1927 it was America's third largest financial institution, and by 1945 the Bank of America (name changed in the 1930s) was the world's largest commercial and savings bank. More significantly, Giannini's financial institution checked a century-long chronic shortage of investment capital to California's burgeoning agricultural economy.

Coupled with important technological and financial innovations, the growth of Californian and American cities gave enormous momentum to agricultural and dairy farming. From 1900 to 1940, the production of grapes, raisins, prunes, plums, walnuts, apricots, cherries, peaches and pears—to name a few—increased more than tenfold; even cotton gained a foothold in the San Joaquin Valley. By 1940, California was shipping in excess of 100,000 railroad cars of fruit and vegetables out of state annually. Innovations in drying, processing, and canning fueled this foodstuffs boom; by World War II's end, an increasingly larger percentage of the total exported California food crop was either dried, processed, or canned. Thus, important advances in technology, science, and finance helped California's agricultural economy expand and flourish into a model for the rest of America to emulate.

PRE-CVP WATER ISSUES, 1850-1935[‡]

Although the Spanish had established colonial missions in California as early as the seventeenth century, two major historic events in 1848 created the California of today: Mexico's defeat in the Mexican-American War, which gave California to the United States for $10 million, and the discovery of gold at Sutter's Mill. In 1840, Swiss born entrepreneur John Sutter settled a tract of land near the confluence of the Sacramento and American Rivers at the future site of California's capital, Sacramento. After only a year in California, Sutter had gained the favor of the governing Mexican officials and was awarded a large land grant and Mexican citizenship. Much like other forts established in the American West during the pre-Civil War era, Sutter's soon became a destination for American overland immigration.

[‡] *Central Valley Project.* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); Steven M. Avella, *Sacramento: Indomitable City*, (San Francisco: Arcadia Publishing, 2003); Norris Hundley, Jr., *The Great Thirst, Californians and Water, 1770s-1990s,(*Berkeley: Univ. of California Press, 1992); Robert Kelley, *Battling the Inland Sea*, (Berkeley: Univ. of California Press, 1989); Office of History, U.S. Army Corps of Engineers, *Engineers and Irrigation: Report of the Board of Commissioners on the Irrigation of the San Joaquin, Tulare, and Sacramento Valleys of the State of California, 1873,* (Honolulu: Univ. Press of the Pacific, 2005 [reprint]).

In early 1848, Sutter began construction of a saw mill near Coloma, California on the South Fork of the American River, northeast of Sacramento. During construction of the mill, workers found gold. Covert efforts by Sutter to keep the discovery a secret failed and soon thousands of fortune seekers headed towards the Sacramento area. The flood of people that descended upon California in the gold rush of the late 1840s and early 1850s was enormous; in 1846, the population of Sacramento was about 150 people, six years later that number had risen to 12,000. In 1849, 80,000 people had arrived in California, with an estimated 300,000 people arriving by 1854.

The gold rush also signaled the beginning of California's water problems. The Sacramento/San Joaquin Delta had always been subject to flooding, but extensive hydraulic mining operations exacerbated the problem. Hydraulic miners washing gold from the earth swept debris into streams and rivers, forcing the water to overflow into the surrounding areas. To combat the problem, levees were built to keep the streams and rivers in their beds. Nonetheless, silt and debris would accumulate in the river channels forcing rivers to rise, and the levees would then be raised to counter the rising water. Finally, the river beds between the levees were higher than the surrounding lands.

In 1850, California became a state and legislators began to enact laws to deal with the state's most precious resource, water. Their first move was to establish riparian water rights based on English Common Law. This law stated that owners of land bordering streams or bodies of water held the rights to reasonable amounts of that water, and those who owned lands that did not border any bodies of water had no rights to this water. As a result, this severely restricted the number of landowners who had unfettered access to California's water supplies.

Moving with urgency, the first California Legislature appointed the State Surveyor General as the entity responsible for water development. Twenty-eight years later, in 1878, the California government created the office of the State Engineer, which became responsible for state water planning. With a $100,000 budget, the first state engineer, William Hammond Hall, conducted a comprehensive study of California's water problems. The resourceful Hall, who planned to secure additional funds for a more detailed study, found himself stymied by the legislature who, for unspecified reasons, in 1889 temporarily abolished the State Engineer position.

Other problems surfaced. Because the thousands of miners in the Sacramento area had to eat, agriculture had to expand to meet the demand. Many miners who failed in the diggings became farmers, and the areas under cultivation slowly grew. But the mining debris severely affected regional agriculture. When rivers and streams overflowed, the silt and debris would cover fertile agricultural lands, rendering them useless. By 1880, over 43,000 acres of fertile agricultural lands had been lost to the effects of hydraulic mining, whose toxic muck eventually reached and destroyed San Francisco bay's oyster beds. Antagonism between miners and farmers grew and suits were filed that, at first, attempted to collect damages from the mining companies and then later sought to ban hydraulic mining altogether. In 1884, the Sawyer Decision (*Woodruff v. North Bloomfield et. al.*), issued by the Federal Circuit Court, prohibited the discharge of mining debris into streams and rivers, terminating the era of hydraulic mining.

Three years later, in 1887, the California Legislature passed the Wright Act, which formed irrigation districts. While some officials viewed the Wright Act as a model for irrigation legislation in the West, others claimed it was a good idea badly implemented. The districts encountered major problems in selling their bonds, filling their reservoirs, and allocating water on a fair and impartial basis. In 1897, ten years after it initially passed, the legislature amended the Wright Act, immediately ceasing the establishment of irrigation districts until the formation of the Irrigation Districts Bond Certification Commission.

It was not until the late nineteenth century when the Federal government became interested in California's water. In 1873, a commission headed by senior USACE west coast engineer Colonel Barton Stone Alexander studied the Sacramento and San Joaquin River valleys. In his report to President Ulysses Grant, Alexander envisioned a series of canals and other diversions to help facilitate and complete an exchange of water from the wetter Sacramento Valley to the drier San Joaquin Valley. Alexander's report, which drew on the failure of private irrigation interests in other parts of the world like Egypt, Spain, and India, also noted that individual farmers, local communities, and even large corporations were ineffective in obtaining adequate capital, mastering technological and engineering problems, and building large-scale water storage and irrigation works. Only the Federal government, working with states and local farmers, could provide the investment and engineering expertise needed to finance and construct such works.

The need to check the devastating historic flood cycles in all Central Valley drainages also provided impetus for a comprehensive water plan. In its natural condition, about one-fourth of the valley's floor was subject to annual or periodic overflow, with the Sacramento River Valley the most prone to flooding. Floodwaters that originated in the surrounding mountains flowed out of the deep river canyons and spread laterally over the relatively flat valley floor, inundating extensive areas. The lands bordering this vast flood plain were among the first areas to be cultivated, but soon farmers began to risk the danger of flooding in order to utilize the rich agricultural lands in the overflow areas.

The first flood control projects were low levees which the farmers themselves built to protect their lands from inundation. As agriculture continued to develop, levees were extended farther and farther into areas subject to natural flooding. Such extensive levee building in some localities greatly restricted the natural floodways to the ocean, resulting in the increased frequency of levee breaches and the construction of higher levees. Among the most damaging are the heavy foothill winter rain floods—short yet very intense rainstorms—whose runoff is sometimes enhanced by melting snow pack from the higher mountains. USACE data compiled in the first four decades of the twentieth century identified 42 damaging winter rain floods in the Sacramento Valley, 15 in the lower San Joaquin Valley, and 13 in the Tulare Lake Basin.

Although Central Valley urban centers have better protection than rural areas, in general they are still liable to floods larger than those on record. Sacramento is the best such example. As with other major cities in the American West like Denver, the city's founders placed the new town next to a river confluence, and laid out streets parallel to both rivers' courses. Located adjacent to the Sacramento and American Rivers, Sacramento has a long history of devastating floods, because it was built in the middle of an inland sea. Local Indian tribes warned settlers about flooding from the two rivers.

Settlers in the American West, however, rarely heeded dire native warnings. On 7 January 1850, the first major flood devastated the newly-settled Sacramento. Residents learned a painful lesson that not only was the Sacramento River a means of transportation and a good source of water; it could also threaten life and destroy property. No levees protected the new town and within hours the entire area stretching one mile back from the river was inundated. And the rains continued, with the winter of 1861-62 as one of the wettest on record. Over 30 inches of rain fell in less than three months, and the American and Sacramento Rivers quickly rose to flood levels. On 9 December 1861, one of the levees protecting Sacramento failed and a torrent of water flowed through the town. Ironically, the same levees that had been built to keep the water out now kept the water in, and had to be breached to allow the water to flow out of the inundated area.

The rains continued through the winter, and in early March 1862, the events of December 9 were played over again. The situation became so dire that the California state government temporarily abandoned Sacramento and moved to San Francisco. Despite the construction of small levees and the rechannelization of the American River to redirect its meeting point with the

Sacramento, more destructive floods struck the town over the next 60 years. Due in part to the 1861-1862 floods, I, J, and K Streets to 12th Street were raised by as much as 15 feet east of the Sacramento River by 1873.

In response to a devastating flood in 1878, State Engineer William Hammond Hall devised the first comprehensive flood control plan for the Sacramento Valley in 1880. One point emphasized by the resourceful and thorough Hall looked at the impacts of gravel mining and debris buildup on the Sacramento's smaller tributaries—especially the Yuba and Feather Rivers—and how this buildup affected the drainage of larger downstream rivers. Over the next 40 years, fueled by more floods not only in Sacramento but also along the river's course north to Red Bluff, the USACE and state engineers examined how the mining debris buildup affected rivers in flood stages, and what they could do to check this troublesome problem.

As yet another example of the Progressive emphasis on centralized planning and conservation, after 1911 the state legislature created a Reclamation Board and appointed it authority over all flood-protective works in the Sacramento Valley. The board then joined with the USACE's Sacramento District office to draw up the Sacramento Valley Flood Control Project, a system of carefully-designed levees and bypasses to prevent floodwaters from inundating the valley floor. In 1917, Congress, drawing upon Hall's massive study, the California Debris Commission, and recommendations from the USACE and the state Reclamation Board, authorized the Sacramento Flood Control Project as the nation's first comprehensive Federal Flood Control Act. Although this was a significant step, all concerned parties still sought the protection from flooding that only massive storage reservoirs and dams could provide.

As the twentieth century dawned in California, it became increasingly apparent that the state needed some kind of comprehensive water plan. In addition to the exponential increase of California's population in general, growers both large and small desired a program that could capture water in the two major drainages for agricultural and flood control purposes, and prevent it from going to sea (then known as the concept of waste), one that government intervention could accomplish. Initially, there were concerns among growers about restrictions that officials in Sacramento or Washington, D.C. might impose, but this seemed less troublesome than the serious issues of depleted water tables, frequent destructive floods, and mounting operation costs. It got so bad that many small farmers fell into tenancy or migrated to the state's burgeoning cities to take advantage of increased job opportunities. The time was ripe for a daring proposal.

CVP AUTHORIZATIONS I, 1920-1940: SHASTA, DELTA, FRIANT DIVISIONS [§]

Although larger landowners advanced their agricultural quotas in the early years of the twentieth century, mostly through the incorporation of inexpensive immigrant labor for harvest, the state water situation remained shaky. To compound the situation, groundwater levels in many drier areas of the Central Valley, like the Tulare Basin, were dropping precipitously. It was not until 1919 when highly respected former USGS official Robert B. Marshall suggested the first substantial proposal, one based on his years surveying California's complex topography. He drew on this knowledge to propose what became known as the "Marshall Plan," one that called for a large dam and reservoir on the Sacramento River's northern reaches, along with two long peripheral canals to help reclaim drier areas along both sides of the entire Central Valley. The plan also called for providing more municipal water to growing cities like San Francisco, increasing flood control and navigability on the Sacramento River, and preventing salt water intrusion into the Delta. The Marshall Plan also looked at diverting water to southern California

[§] U.S. Congress, House of Representatives, *Central Valley Project Documents, Part One, Authorizing Documents.* 84th Congress, 2nd Session, House Document 416. (Washington, D.C.: GPO, 1956); U.S. Department of Agriculture, Bureau of Agricultural Economics, *History of Legislation and Policy Formation of the Central Valley Project,* (Berkeley: USDA-BAE, 1946); *Central Valley Project,* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); Norris Hundley, Jr., *The Great Thirst, Californians and Water, 1770s-1990s,* (Berkeley: Univ. of California Press, 1992).

from the Kern River near Bakersfield via a tunnel under the Tehachapi Mountains. Revenue for this ambitious scheme would be generated through sales of water and electricity generated at state power plants throughout the system.

Problems, however, existed. Marshall's proposal failed to gain approval in the state legislature or in three modified versions submitted to—and rejected by—voters over the next decade. One reason was the huge costs, estimated at $800 million. Professional engineers also questioned the adequacy of Marshall's collection of data on potential storage sites. Opposition also formed from private utility concerns like Pacific Gas and Electric and Southern California Edison, who rejected Marshall's provision of revenue generation through state-operated powerplants as a socialist conspiracy (concerns partly fueled by the "Red Scare," an ominous national issue in the 1920s). Shifting political currents of the times further complicated matters. When Marshall unveiled his plan after World War I, supportive Progressive Republicans retained substantial influence in state politics. But as the 1920s unfolded, they were displaced by conservative Republicans who eventually dominated the legislature. These fiscal conservatives repeatedly rejected Marshall's plan as too pricey.

Perhaps with the Marshall Plan as impetus, California became more interested in formulating some kind of comprehensive state water plan during the 1920s and directed the state engineer to come up with such a plan. Much like Marshall's plan, flood control, conservation, navigability, salinity repulsion, storage, and distribution would finally be accomplished if the state took charge. Between 1920 and 1932, approximately 14 reports detailed the state's water flow, drought conditions, flood control, and irrigation issues. California State Engineer Edward Hyatt used these reports to create the California State Water Plan.

Salinity control in the Sacramento-San Joaquin River Delta became a top concern for northern California water users, and a major component of the state water plan. Salinity intrusion plagued the Delta, causing problems for cities like Antioch and Pittsburg. Unless water flowed west past Antioch at a minimum of 3,300 feet per second, salt water from San Francisco Bay moved east into Suisun Bay and the Delta during high tide, rendering the water unusable for crops and industry. Other problems complicated matters. Between 1919 and 1924, salt water intrusion into Suisun Bay allowed teredo, a wood boring saltwater worm, to destroy $25 million of the bay's wharves and pilings. By 1926, saltwater intrusion had become so widespread that Antioch and Pittsburg stopped using Suisun Bay water for crops and industry, something both cities had relied upon since the mid-nineteenth century.

To nullify this salinity intrusion issue, in 1930 the state water plan proposed the construction of a 420 foot high foot high dam at Kennett (a.k.a. Shasta) to maintain regular water flows to Antioch and Pittsburg, and to keep saltwater out of Suisun Bay. Three years later, in 1933, the California Legislature authorized the (future) CVP as a state project; the act also authorized the sale of revenue bonds for construction not to exceed $170 million. But even with authorized revenue bonds, the state found itself unable to finance the project, a situation exacerbated by the general economic depression of the 1930s. Furthermore, California could not get the project approved for loans and grants under the National Recovery Act, a New Deal program initiated by President Franklin D. Roosevelt. Taking another route to Federal relief funding, California applied to the Federal Emergency Administration of Public Works (FEA) for grants and loans, and created the Water Project Authority. The House Committee on Rivers and Harbors recommended $12 million of Federal funds for Kennett Dam's construction, because of the national benefits to flood control and navigation on the Sacramento River. After reviewing the investigations, the California Joint Federal-State Water Resources Commission, the Senate Committee on Irrigation and Reclamation, the USACE, and Reclamation approved the plan.

On 30 August 1935, the Rivers and Harbors Act of 1935 authorized construction of initial CVP features by the USACE. Yet only eleven days later, on 10 September 1935, President Roosevelt issued an executive allocation of $20 million (reduced to $4.2 million) under the Emergency Relief Act (ERA) to the Department of the Interior for construction of Shasta and Friant Dams and other major CVP features, funds declared as "reimbursable in accordance with reclamation laws." Officials, however, jumped the gun under the assumption that the approval was valid under ERA provisions, for the Supreme Court Case *United States v. Arizona* (295 U.S. 174) threatened this assumption. Before 1935, the government sometimes started relief funded irrigation projects without conforming to the Reclamation Act. The court's decision said that the Secretary of the Interior and the Federal Administrator of Public Works did not have authority to construct Parker Dam on the Colorado River without Congressional consent. The Supreme Court ruled that such an approach violated Reclamation laws.

Additionally, the CVP's authorization could not take place at that time due to no executive branch findings nor feasibility approvals. These technical problems, however, did not stall the project's authorization. Active participation in Central Valley affairs by Reclamation started in September 1935 at meetings in Sacramento and Berkeley. Reclamation Commissioner Elwood Mead, Chief Engineer Raymond Walter, Construction Engineer Walker Young, and State Engineer Edward Hyatt attended the meetings. On 26 November 1935, Secretary of the Interior Harold Ickes sent the feasibility report to the President, and seven days later, on 2 December, Roosevelt approved the CVP, including Kennett (later Shasta), Friant, and Contra Costa (later Delta) Divisions. Passed by Congress in 1937, the Rivers and Harbors Act re-authorized the CVP with $12 million in initial construction funds for construction by the Secretary of the Interior, specifically Reclamation. The act also formally listed flood control, improvement of navigation, and river regulation (including salinity control) of the Sacramento and San Joaquin Rivers as CVP's top priorities. Reclamation's primary historic mission, that of supplying water for irrigation and municipal use, followed these priorities, with hydropower generation last.

Most significantly, it was the first time in Reclamation's brief history that facilities they would build would not be prioritized for irrigation and hydropower purposes. River navigation and flood control were historically the USACE's charge, not Reclamation's, and the Interior agency was treading uncharted waters.

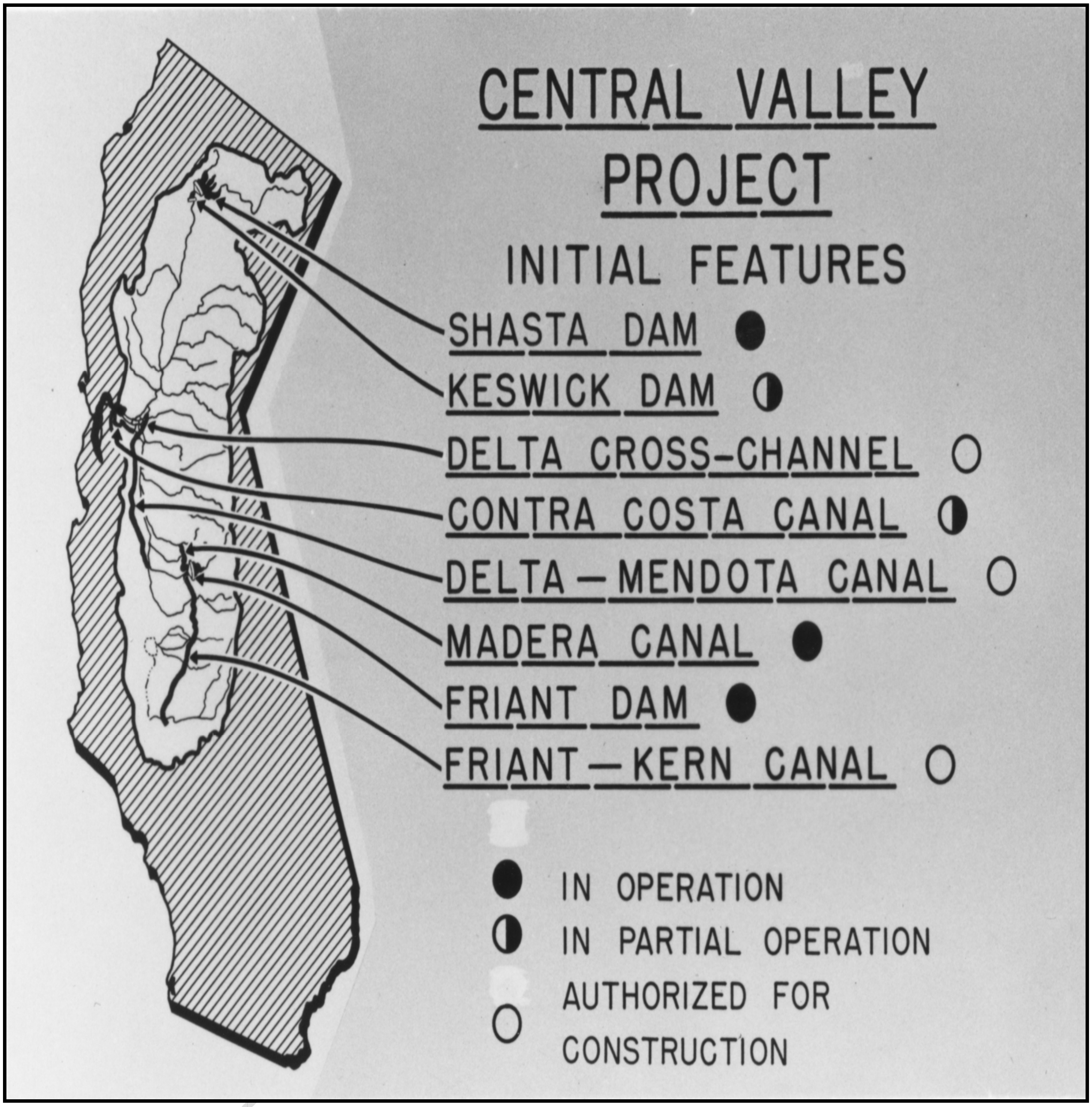
The aspect of flood control in valleys historically prone to flooding cannot be overemphasized in the CVP's purpose. According to the Reclamation Region 2 (Mid-Pacific) 1981 publication *Central Valley Project: Its Historical Background and Economic Impacts*, flood control is the CVP's "highest priority function":

> This is entirely appropriate because human lives often are involved. During flood emergencies, the Project is operated to optimize flood protection in accordance with criteria established by the U.S. Army Corps of Engineers…. No one knows the number of lives that have been saved by the flood protection operations of the Central Valley Project. Folsom Dam and Lake were credited with prevention of catastrophic floods in 1955 and 1964. These surely would have inundated large portions of Sacramento, and probably resulted in loss of life had these structures not been in place. Flood control operations at Folsom also protect highly urbanized areas along the American River…. Untold human suffering has been averted and unknown numbers of lives saved, as well as hundreds of millions of dollars in property values protected, as a result of Central Valley Project flood control operations. Shasta and Friant Dams routinely protect vast areas in the Sacramento and San Joaquin Valleys from devastating floods that occurred frequently in those watersheds before the dams were constructed (24-25).

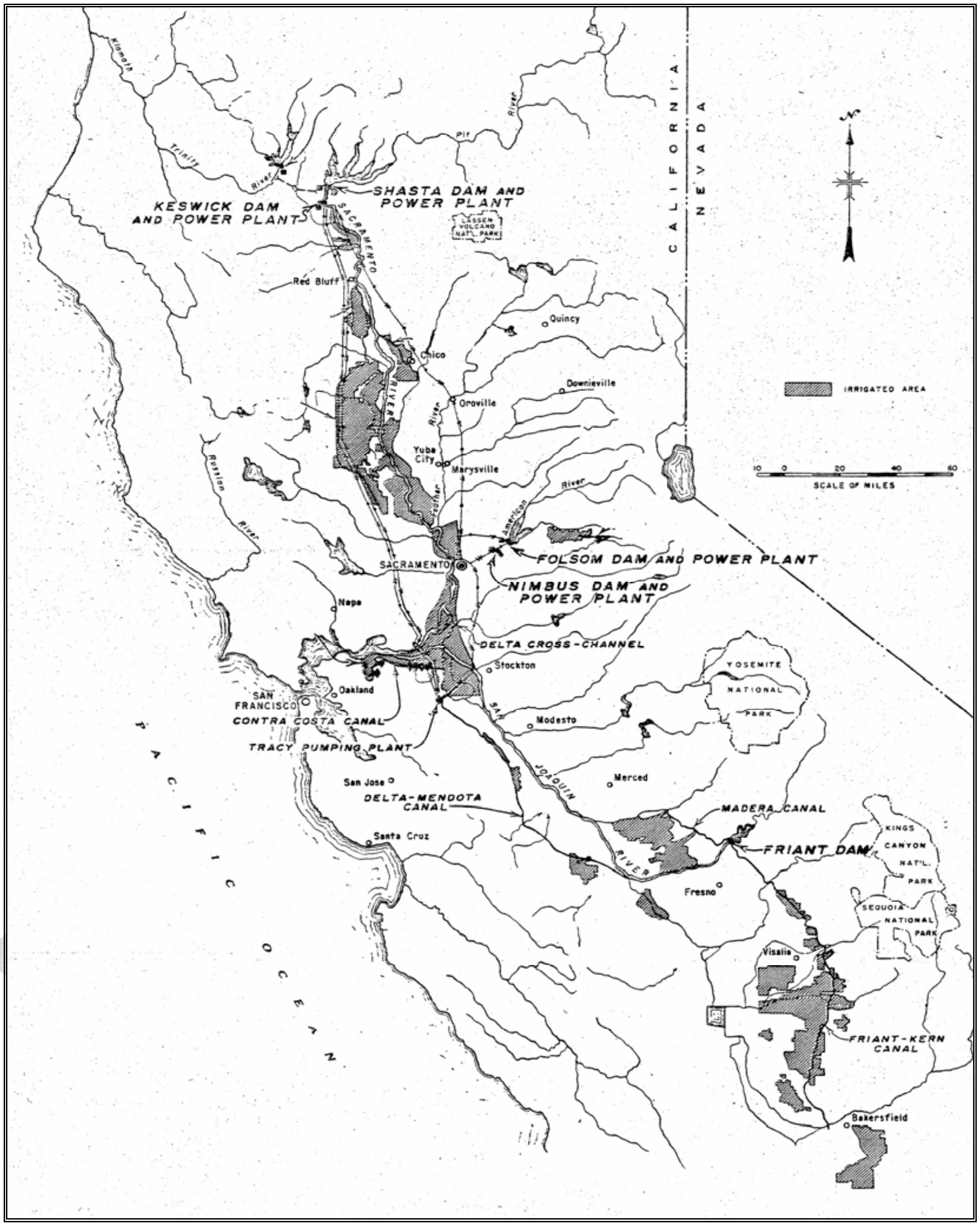
The authorized CVP differed in stature from ambitious early water transfer plans like Marshall's. Original north to south water transfer proposals envisioned a large dam where Shasta now stands as well as other dams at high elevations for storage of surplus water. High-line canals would have encircled the entire valley with gravity flows from the reservoirs delivering northern water to the arid southern lands. The storage part of this concept was used in later plans developed as part of the authorized CVP, albeit reduced in scope. The peripheral highline canal aspect, however, was changed significantly. Instead, water from a northern reservoir (Shasta) would flow south in natural watercourses to the Sacramento-San Joaquin Delta, where a short channel cut (Delta Cross Channel) would redirect Sacramento River water to a pumping plant (Tracy). This pumping plant would lift this water into the headworks of a highline canal (Delta-Mendota) in the western Coastal Range foothills for gravity transport to a connection point with the San Joaquin River 30 miles east of Fresno (Mendota Pool). Another canal (Contra Costa) fed by the northern transfer would provide irrigation and municipal water to Suisun Bay cities and farms.

(Courtesy Bureau of Reclamation)

Simultaneously—yet working independently—San Joaquin River water would be stored and diverted by an upstream dam in the Sierra Nevada foothills east of Fresno (Friant) into two highline canals (Madera, Friant-Kern) for gravity service to lands along the east side of the central and southern San Joaquin Valley. The northern water imported from Shasta Dam moved south through the Sacramento Valley to be exchanged for the San Joaquin River water diverted by Friant Dam. This exchange would partially offset the geographical imbalance of land and water resources between the northern and southern parts of the valley, and, with the exception of initial features on the American River, comprise the CVP's initial features as authorized in 1935.



(Courtesy Bureau of Reclamation, c.1944)



Map 2: Central Valley Project, c. 1956

CVP AUTHORIZATIONS II, 1940-1956: AMERICAN RIVER DIVISION [**]

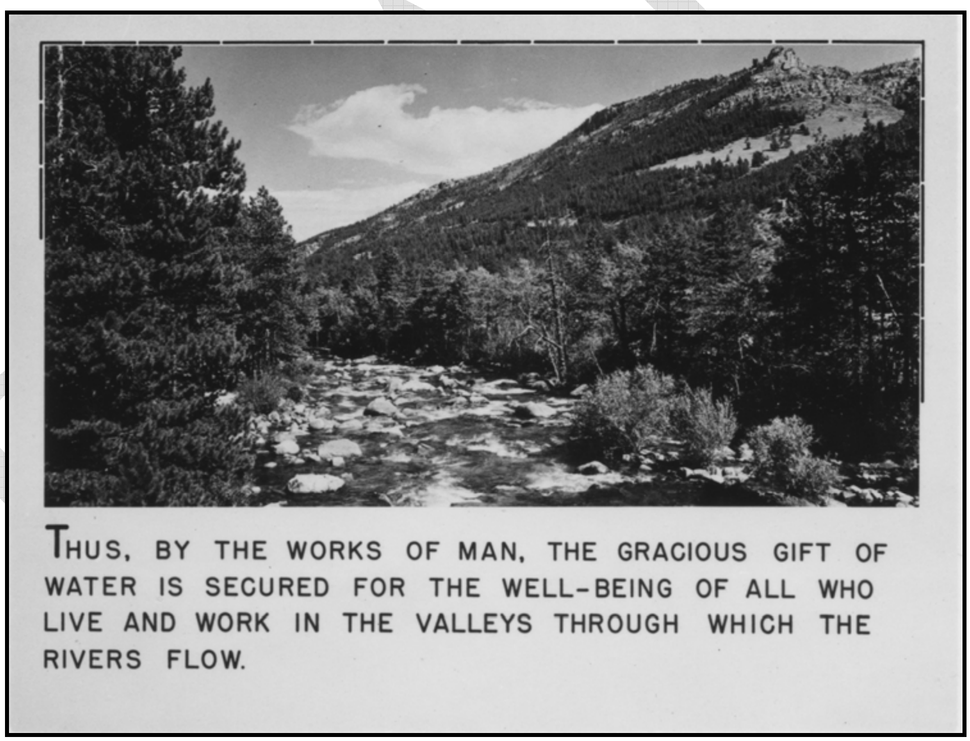
The early years of World War II and the immediate postwar era demonstrated the urgent need for much greater water and power supplies than the CVP's initial features could deliver. Population, industrial, and agricultural expansion overtook the project. To meet increased needs, Congress authorized the addition of new divisions to the CVP. Flood control on the American River east of Sacramento also remained a top priority. As a result, one aspect of the Flood Control Act of 1944 initially authorized (the future) Folsom Dam as a small, 355,000 acre-foot (or ac/ft, the amount of water needed to cover one acre one foot deep) flood control unit to be constructed by the USACE.

California's exponential municipal and industrial growth during this period, however, demanded more multipurpose water facilities. The 1949 enactment of California Representative Claire Engle's American River Bill converted a limited, single purpose authorization of a sole flood control facility (Folsom) into an enlarged, multiple purpose facility fully integrated into the CVP, thereby meeting perceived needed increases in power and irrigation resources. Bureaucrats and engineers also looked to the Flood Control Act of five years previous and examined Folsom's role as only a flood control facility. Further engineering and economic studies by Reclamation, concurred with by the USACE and endorsed by state officials and various local agencies, however, confirmed the proposed reservoir's capacity was inadequate under the multiple purpose concept for full economic integration and utilization of available water supplies.

Various Congressional bills, in addition to President Harry Truman's recommendations to

[**]U.S. Congress, House of Representatives, *Central Valley Project Documents, Part One, Authorizing Documents.* 84th Congress, 2nd Session, House Document 416. (Washington, D.C.: GPO, 1956); U.S. Department of Agriculture, Bureau of Agricultural Economics, History *of Legislation and Policy Formation of the Central Valley Project,* (Berkeley: USDA-BAE, 1946); Norris Hundley, Jr. *The Great Thirst,* (Berkeley: Univ. of California Press, 2001); Marc Reisner, *Cadillac Desert,* (New York: Penguin, 1993; *Central Valley Project,* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995).

Congress, initiated the legislative authorization for the change. President Truman also initiated the "Folsom formula" for the integration of multiple purpose developments of Central Valley water resources as integral CVP components. These Presidential recommendations were incorporated into the American River Act of 1949. As authorized, the CVP's American River Division included the (previously authorized) Folsom Dam and reservoir (now a 977,000 ac/ft multipurpose unit with power plant), Nimbus Dam, power plant, and reservoir as a regulation facility for Folsom, and the Sly Park unit for irrigation and municipal water supplies to the communities of Placerville and Camino. The Sly Park unit is no longer under Reclamation's jurisdiction and was previously been determined as ineligible for the National Register. The act's provisions also called for further studies regarding more multipurpose units to deliver water for further enhancement of irrigation and municipal uses within the Central Valley area.



Bureau of Reclamation Promotional Slide, 1945

Table 2: Chronology of Central Valley Project Authorizations*

(**Bold** indicates authorizations of historic facilities covered in this MPL)

Authorization Act	Date	Division or Unit	Major Features	Completed
Rivers and Harbors Act of 1937	**26 August 1937**	**Shasta Division Friant Division Delta Division**	**Shasta, Friant, and Keswick Dams, Tracy Pumping Plant, Delta-Mendota, Madera, Friant-Kern, and Contra Costa Canals and facilities; Delta Cross Channel; power facilities, fish hatchery**	**1951**
Rivers and Harbors Act of 1940	**17 October 1940**		**Reauthorized features listed above and added irrigation distribution system**	**1950s and 1960s**
American River Act	**14 October 1949**	**American River Division**	**Folsom and Nimbus Dams; dikes; power facilities;** Sly Park Dam and facilities; fish hatchery	**1956**
Sacramento Valley Irrigation Canals	25 September 1950	Sacramento Valley Canals	Red Bluff Diversion Dam; Corning Canal and Pumping Plant, Tehama-Colusa Canal and fish spawning facilities; irrigation distribution systems	1986
Grasslands Development	27 August 1954	Grasslands Waterfowl Management	Wells and drainage recovery facilities; revised CVP operations	1955
Trinity River Division	12 August 1955	Trinity River Division	Trinity, Claire Hill Whiskeytown, and Lewiston Dams; Clear Creek and Spring Creek Tunnels; 4 powerplants; transmission facilities; fish hatchery	1964
San Luis Unit	3 June 1960	San Luis Unit	San Luis Dam; pumping-generating plant; O'Neill Forebay and Pumping Plant; San Luis Canal; Pleasant Valley Canal and pumping plant; irrigation distribution systems	1984?
Rivers and Harbors Act of 1962	23 October 1962	New Melones, Hidden, and Buchanan Projects	New Melones, Hidden, and Buchanan Dams	1981
Auburn-Folsom South Unit	2 September 1965	Auburn-Folsom South Unit	Auburn Dam, Folsom South Canal; Sugar Pine Dam; Foresthill Conduit; County Line Reservoir; Folsom-Malby Conduit	Not Completed
San Felipe Division	27 August 1967	San Felipe Division	Pacheco Tunnel; Santa Clara and Hollister Conduits; pumping plants	1987
Black Butte Integration	23 October 1970	Black Butte Project	Black Butte Dam	1963
Reclamation Auth. Act of 1976	28 September 1976	Allen Camp unit	Allen Camp Dam, Diversion Dam; conduits; wildlife refuge	Not Completed

*Source: Raymond W. Gaines, Central *Valley Project Water Development: Historic Background, Economic Impacts, Future Outlook*, (Privately Published, 1986), 7.

THE ACREAGE LIMITATION ISSUE

President Roosevelt's 1935 approval of the CVP (and the Congress's subsequent action placing Reclamation in charge of the project) created unique legal issues regarding acreage limitations and project repayment. Since Reclamation was officially in charge of building the CVP and distributing the water, the undertaking was subject to Reclamation law. This mandated that no more than 160 acres could be watered by any individual farmer using Reclamation subsidized water, and that any excess irrigated acreage, as stated by a 1926 amendment to the Reclamation Act of 1902, must be sold within ten years at a price that reflected the land's worth before the arrival of project water. This amendment was designed to reinforce the original purpose of the 1902 act: to reclaim arid lands; to support the family farm; and to stop large landowners and speculators from profiting at the government's expense.

The primary problem with the Central Valley, unlike most other Reclamation arid lands projects, was that most of the CVP project lands had passed into private hands long before the bureau's arrival. And to complicate matters, most landholdings exceeded 160 acres, with many absentee owners. Unlike Washington State's Columbia Basin Project, which was authorized the same year as the CVP (and followed the entrenched Reclamation mantra of build the project first and the small family farms will follow), large landowners and farms preceded the CVP, and thus this project did not create many new farms. Undaunted, the government saw fit to enforce the 160 acre limitation. Backed by the president and Reclamation commissioner, in 1943 Interior Secretary Harold Ickes announced his intentions to enforce this law, based on the premise that it would prevent monopolies and land speculators from taking hold on Central Valley lands and using project water for financial gain.

This move angered growers and farmers across the valley, and they reacted swiftly. Powerful growers groups and irrigation districts lobbied for investigations into the possibility that the state could purchase the CVP, but this failed in the courts. One Tulare County farmer serving in the

U.S. House of Representatives in 1944 attached a rider to a Congressional bill that would have allowed Central Valley farmers full exemption from the 160 acre limitation, citing that the Federal Government had to be stopped from socializing agriculture and forcing "communism" upon the Central Valley. This bill was killed by Progressive New Deal democrats reeling from reports of violations of farmworkers' rights by corporate agriculture. Limitation opponents also lobbied Congress for the USACE to build dams proposed for the valley's east side (Folsom, Pine Flat, New Melones), because water delivered by that agency's projects were not subjected to acreage limitations. Limitation proponents always seemed to be one step ahead of opponents, however, and succeeded by including this restriction in all new USACE-built dams on the valley's east side.

Yet despite the rhetoric, Reclamation did little to enforce the limitation law, mostly because powerful Central Valley agribusinesses had considerable pull in Washington politics, and Reclamation did not want to jeopardize any chances of future water projects being killed by an unsympathetic Congress. Instead, in the late 1940s Reclamation Commissioner Michael Straus adopted a policy of "technical compliance," one that allowed large growers and agribusiness concerns to circumvent the law via legal loopholes. This took several forms, one of which was to allow corporate farms to go under stockholder ownership, and allow each stockholder to obtain 160 acres worth of Reclamation water. Other ways included landowners deeding, then leasing back, 160 acre parcels to employees; allowing growers to deed 160 acre parcels to assorted relatives; and to do what was called "accelerated payment," which allowed early lump sum payments by landowners of all construction costs for their irrigation systems, on the theory that if this was done in the ten year post-construction repayment grace period, any disposal of excess lands could be avoided. In other words, pay off the government early so it could not force landowners to dispose of their excess lands.

Much to the delight of Central Valley agriculturalists, Straus's "technical compliance" policy continued nearly unabated for four *decades* through the Eisenhower, Kennedy, Johnson, Nixon, Ford, and Carter administrations. Reform, however, seemed imminent. A compliance study conducted late in the Carter administration revealed that more than 90 percent of Reclamation acreage violations were in California and Arizona, two states with benign, two season climates that meshed well with the legally decreed 160 acre limitation. In 1982, however, Central Valley growers successfully lobbied Congress for the first wholesale change to the Reclamation Act's acreage limitation: the 160 acres now swelled to 960 acres and, to further lessen the burden upon large agribusinesses, leasing and residency restrictions were eliminated. In turn, agribusinesses had to pay full costs for any water delivered to all lands beyond the 960 acres. Yet in 1987, President Reagan's Interior Solicitor delivered an opinion allowing subsidized water to be sold in unlimited quantities to 960 acre "paper farms" owned by relatives and trusts in the same family. As water journalist Marc Reisner commented, this move reflected "the same fraud, on a much larger scale, that had gone on before the Reclamation Act was 'reformed'."

What proceeded only touched the surface of this complicated issue that lingered for decades under the guise of "technical compliance." And despite some modicum of reform in 1982, it is clear that the large Central Valley agribusinesses had great influence on the office of the President as well as the Congress. Yet the CVP is unique in Reclamation's history; never before did the agency have to address and fashion policy on how to deliver subsidized water to large farms and agribusinesses that had existed long before the agency's arrival. But the history of Reclamation and the CVP is one of firsts. Shasta Dam was the first Reclamation built and operated facility that did not prioritize irrigation and hydropower as its primary purposes; instead, with Shasta, Reclamation was treading waters allocated to the USACE—flood control, navigation, and salinity repulsion.

PLANNING AND CONSTRUCTION OF HISTORIC CVP FEATURES: 1937 to 1956

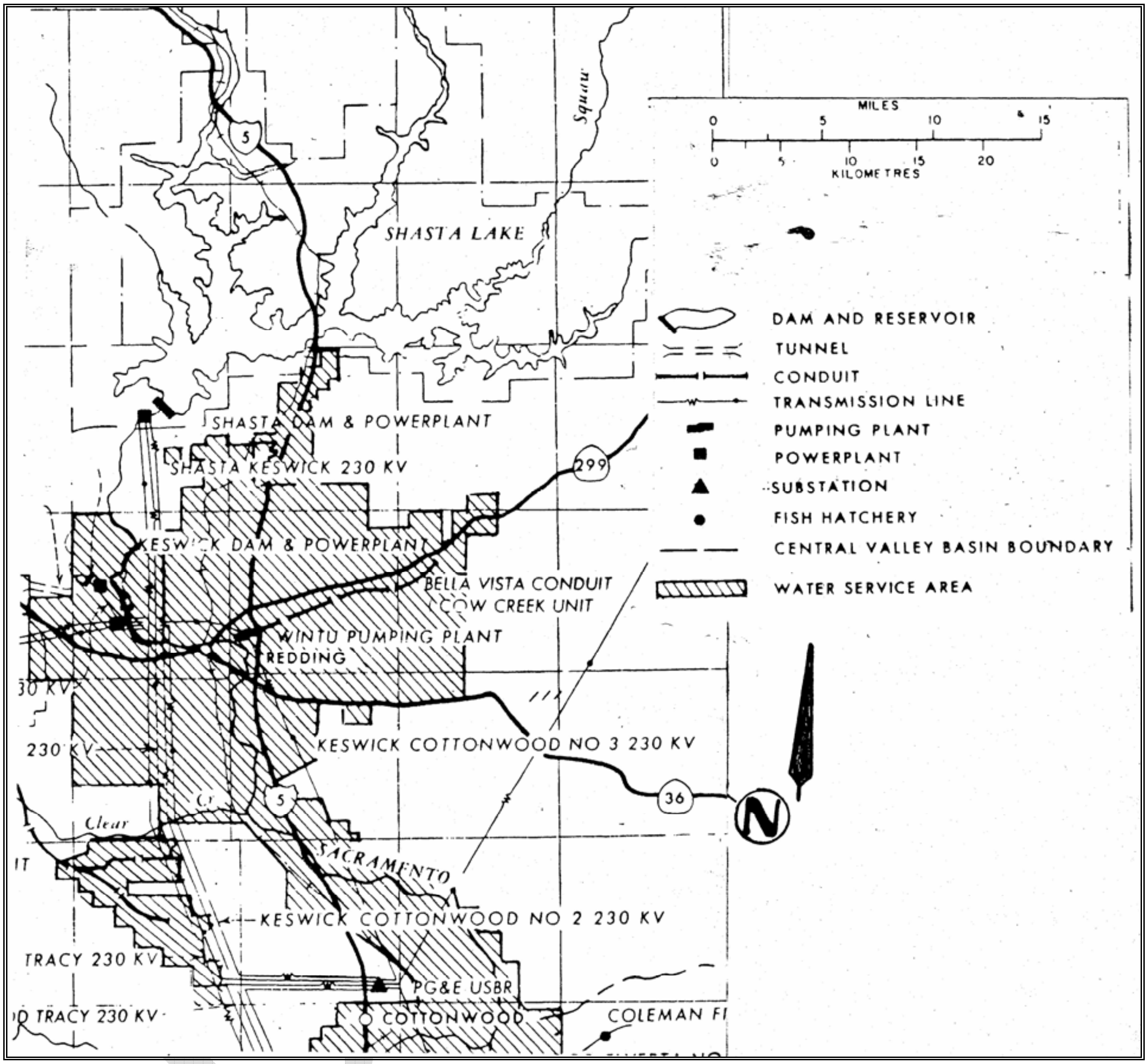
Historic Shasta Division [††]

As the first CVP northern division built, Shasta Division's operations are uncomplicated. Lake Shasta, Shasta Dam, and its downstream regulating facility Keswick Dam and reservoir help store and regulate Sacramento River water for flood control, navigation, and irrigation needs; while Shasta and Keswick Powerplants generate project and consumer hydroelectric power as needed, with much of this power going to Delta pumping facilities (see Map 3). Huge in geographic scope, the Shasta Division has a drainage area of 6,665 square miles, and a storage capacity of 4,552,000 ac/ft.

Shasta Dam and Powerhouse

In preparation for construction of the Shasta Division, Reclamation studied locations for three dams. For the future Shasta Dam, the agency recommended the Kennett site, located on the Sacramento River approximately 10 miles northwest of Redding. Reclamation soon discovered that this site required the relocation of approximately 30 miles of the Southern Pacific Railroad's line. In addition, Reclamation also investigated two sites for the proposed Baird Dam, and three for Table Mountain Dam, neither of which were built. In December 1935, Reclamation began initial exploration of the Kennett Dam site, first by clearing out and re-timbering several exploratory tunnels originally started by the state.

[††] Eric Stene, "The Shasta Division – Central Valley Project," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); Al Rocca, *Shasta Lake: Boomtowns and the Building of Shasta Dam* (Charleston, SC: Arcadia Press, 2002); Al Rocca, *America's Master Dam Builder: The Engineering Genius of Frank T. Crowe* (Latham, MD: Univ. Press of America, 2001); and *Design Summary: Shasta Temperature Control Device* (Denver: Bureau of Reclamation, 1997).



Map 3: Shasta Division

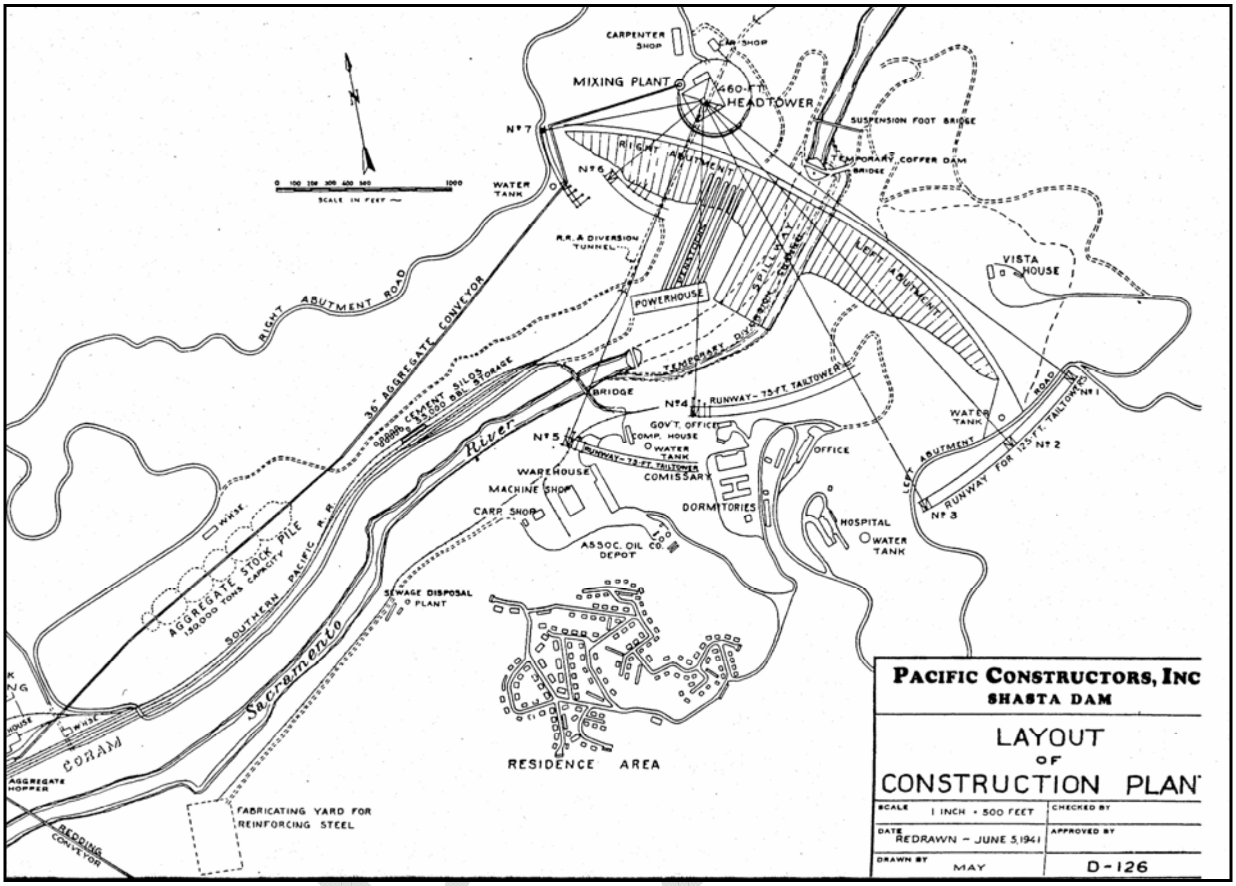
In 1937, work crews began experimental washing and grouting of foundation seams, and work started on the government construction camp Toyon, located a couple miles from the dam site. Three companies received contracts to construct the camp's buildings and water systems, and completed them in early 1938. At a ceremony a few months earlier, Reclamation Commissioner John C. Page officially named the future dam Shasta after Mount Shasta, citing the name's geographic and historic significance. Gone forever was the burg Kennett, a small copper mining town and railroad way station in the Sacramento Canyon upstream from the dam site. All of the town's buildings were bulldozed or burned.

Pacific Constructors Inc. (hereafter PCI) received the contract for Shasta Dam's construction. Possibly to avoid labor troubles afflicting other contractors, PCI fashioned a contract with the Building and Trades Department of the American Federation of Labor (AFL) and its affiliates. In the contract, PCI recognized the unions and agreed, with exceptions, to employ only union members. PCI also agreed to stick with the unions' prescribed wage scale for construction of Shasta Dam and Powerplant. One PCI contractor, Colonial Construction Company, excavated the diversion tunnel and temporarily relocated the Southern Pacific Railroad line at Shasta Dam site, while another contractor, United Concrete Pipe Corporation, relocated the rail line north of the dam site proper. Colonial soon discovered that the tunnel excavation material was not self supporting, and tried several methods of tunnel digging to advance their progress, finally proving successful. The company excavated a total of 958 feet from both headings, advancing 709 feet from the south portal alone. Before the end of 1938, Colonial had finished more than half the contract's requirements.

PCI commenced operations on Shasta Dam before actually receiving the notice to proceed dated 8 September 1938. During 1938 PCI finished most of the company camp, started excavation of both abutments, the switchyard road, and the left abutment corewall; stockpiled earthfill material for embankments, began placement of rolled fill and excavation of rock on the left abutment's embankment section, and nearly completed the Sacramento River's bypass channel along the left bank by year's end. Over the next year, PCI finished the construction camp, and continued raising their construction facilities. Excavation of the dam site was top priority during the work season, removing almost three million cubic yards of material. Colonial Construction finished the temporary Southern Pacific line relocation and the diversion tunnel by the end of 1939.

Concrete placement on relocated railroad structures, the Pit River Bridge, and Shasta Dam commenced in 1940, and continued throughout the year at various locations. Using an elaborate cableway system for pouring purposes, on 8 July 1940, PCI poured Shasta Dam's first concrete. Devised by project supervisory engineer Frank T. Crowe—whose previous accomplishment was the construction of Hoover Dam on the Colorado River—the system consisted of a 465 foot head tower and seven smaller, mobile tail towers mounted on rails, and used eight cubic yard buckets to haul concrete to placement locations. Workers used a system of hand signals to help guide operators as the concrete (and other construction materials) were placed. Using this efficient delivery method, PCI placed Shasta's concrete in separate, fifty-foot-wide sections or blocks. PCI also dissipated the heat generated by the curing concrete through circulating river water in pipes installed in the concrete. The curing process allowed for faster heat dissipation, because slower curing would further weaken the concrete. Notwithstanding frequent work site flooding, by 1941 PCI had poured nearly 500,000 cubic yards of concrete.

Another construction innovation devised by Crowe for Shasta project was the longest conveyor belt system ever built for any purpose—nearly ten miles. Manufactured by Goodyear Rubber and Tire Company, this 3-foot-wide belt hauled 3-to-6-inch diameter cobble harvested from the beds of the Sacramento River near Redding nine miles to a sorting facility at Coram downstream from the dam site. Once sorted and stored, the belt then hauled aggregate three-quarters of a mile uphill to the concrete mixing plant at the dam's right, or west abutment. Innovations never before used on any large scale dam construction site, the cableway and the conveyor belt systems allowed Crowe's workers to raise America's second largest concrete dam and its powerhouse in a relatively short period of time: six years and nine months.



Shasta Dam Cableway and Conveyor Belt System (Bureau of Reclamation)

Despite increased security at the dam site during 1941, work proceeded smoothly and rapidly; on 3 May 1941, PCI placed the one-millionth cubic yard of concrete in Shasta. Other world events, however, were creating problems with supplies, especially with steel; the war effort required a large amount of steel, postponing delivery of the seventeen bulkhead gates for the dam's draft tube outlets. And despite some concrete shortages—and heavy rainfalls—on 13 October PCI poured the two millionth yard of concrete in the dam. Yet there were problems. PCI found a badly fractured seam in the river channel, requiring more excavation than originally thought. The seam issue delayed concrete placement in the river channel for some time. Additionally, in 1941 Reclamation provided funds for Shasta Powerplant's fifth power unit, as well as the construction of Keswick Dam located six miles downstream.

World War II's early years also shifted priorities. The original construction program scheduled completion of Shasta Powerplant and first power generation by 1945. California's rapidly growing defense industry, however, demanded power availability by January 1944. To meet this demand, Shasta received top priority rating for continuing construction as early as 1941, with Reclamation under constant pressure from Congress to complete the dam in order to meet the increased wartime demand for industrial electricity. And in addition to material shortages, the war caused a high turnover rate on CVP construction, as workers left to join the military or take lucrative jobs in the defense industry. Because of this, contractors found it necessary to raise wages in order to keep workers, despite these wages being above the minimums specified in the contracts.

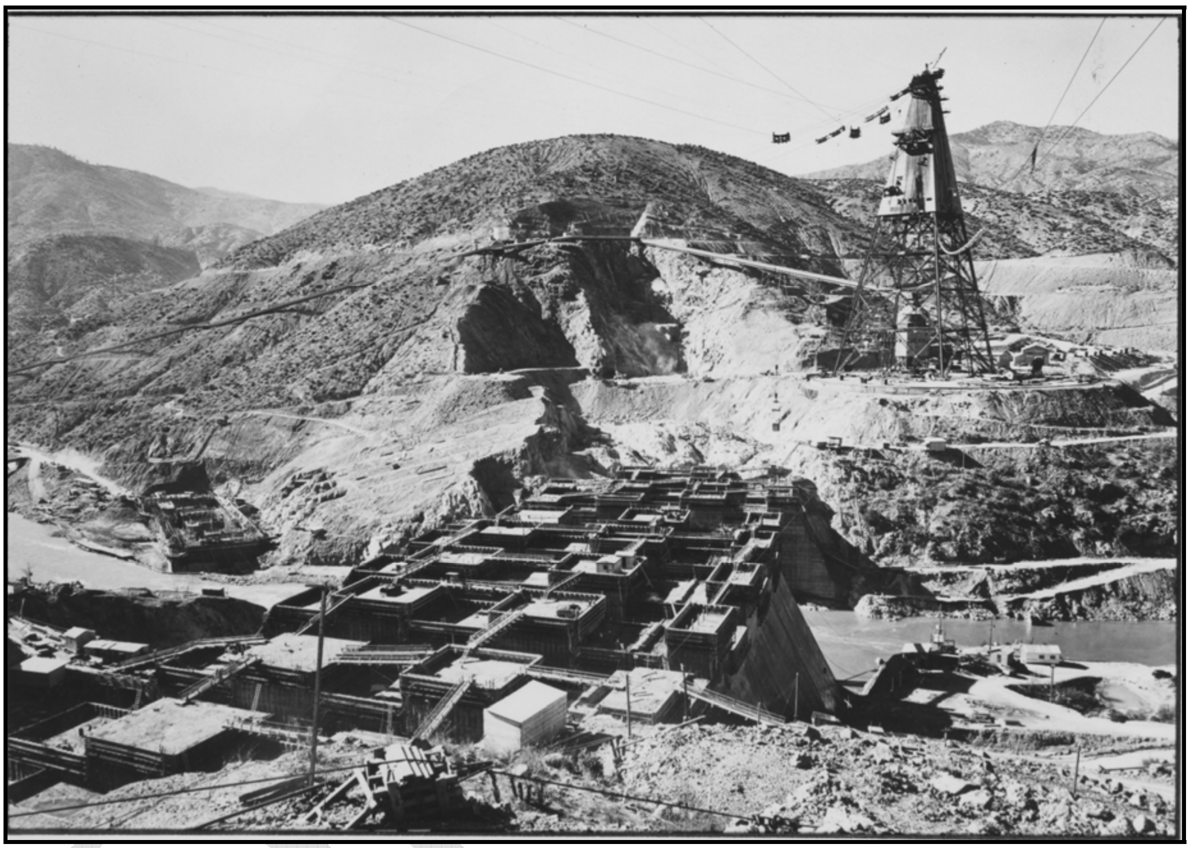
Heavy rains during early 1942 did not impede progress on the right abutment's excavation and the Southern Pacific line's relocation. The railroad began routing its trains over the relocated track in March, allowing for the excavation of the powerhouse and the penstock section to proceed. As operations continued, PCI switched to a smaller cableway system and four cubic yard buckets for Shasta concrete placement, a system that gave PCI more flexibility and latitude in laying concrete. Concrete operations started on the right abutment in May 1942, and continued on the left abutment and center spillway. Detailed form work and complex placement of reinforcement steel and other embedded materials made concrete placement on the spillway, fishtrap, powerhouse, and penstocks a complicated, labor intensive operation. As concrete operations continued throughout 1942, PCI removed both cofferdams used to block and divert water away from the construction site. On 28 March, PCI poured the three millionth cubic yard of concrete, with the four millionth cubic yard poured on 31 August.

The Pacific Northwest's escalating wartime industry also necessitated the shifting of important hydropower components from one project to another. In late 1942, the government ordered Reclamation to transfer two turbines and generators from Shasta to the new Grand Coulee Dam on the Columbia River Project in Washington. Estimates showed that Reclamation could start generating power at Grand Coulee in spring 1943, whereas Shasta could not begin operations until 1944 at the earliest. The heads of the two dams were similar, allowing the transfer to take place. However, this was an expensive operation; Reclamation transferred two generators from storage at Hoover Dam in Nevada, one turbine from Shasta, and the other turbine from Allis-Chalmers in Milwaukee, to help Grand Coulee's powerhouse generate cheap hydropower for Pacific Northwestern defense contractors like Boeing in Seattle.

During 1943, PCI continued to alternate diversions of the Sacramento River through different blocks of Shasta Dam, leaving two blocks open for diversion and a third to relieve flooding. PCI also continued excavating both abutments, the powerhouse tailrace, and the river channel, and finished the excavation for the spillway apron as well as the right and left training walls. And although a manpower shortage during 1943 slowed operations somewhat, they continued through the year; concrete placement on the dam proper totaled 6.2 million cubic yards. On 6 July 1943, concrete operations resumed on the diversion blocks, allowing PCI to route the river through the diversion tunnel. After the Sacramento River started flowing through the tunnel, the rate of concrete placement on the spillway sections increased. By the end of 1943, all concrete except for two blocks had been placed.

On 4 February 1944, PCI closed the diversion tunnel at Shasta and plugged it with concrete. During 1944, the company concluded excavation for the dam's final two blocks, ending all required excavation. Although the dam was essentially completed, PCI could not complete the gate chambers because the drum gates were not available. General Electric Company concluded the installation of two generator units on 1 June 1944, and PCI poured the last concrete on the dam three days before Christmas 1944. With most of the concrete poured, Reclamation accepted

PCI's Shasta Dam and Powerplant work on 20 June 1945, a scant two months before Japan's official surrender that marked World War II's end.



Shasta Dam under Construction, c.1939. (Bureau of Reclamation)

Over the next four years, Reclamation account workers (agency employees) and other contractors put the finishing touches on Shasta Dam and Powerhouse. 1946 witnessed the installation of valves, the river outlet works, and the spillway drum gate fixtures, along with the return of generator units two and five from Grand Coulee Dam (1946 also witnessed the death of Frank Crowe, who was buried in Redding.) 1947 saw even more progress, including the installation of the fourteen 96-inch outlet valves and the outlet control system, the permanent lighting system, stair handrails, and visitor's facilities. Work in 1948 included installation of the outlet pipes, and continued work on the spillway drum gates. General Electric also continued with installing and testing two of the powerplant's generating units. On 27 April 1949 the fifth unit commenced operations, five years after the first unit started. A little over two months later, on 2 July 1949, Reclamation started guided tours of the facility. John Gist Company completed placement of the drum gates on the dam's spillway in 1950, with Haas and Rothschild finishing the reservoir clearing work (started in 1939 by Civilian Conservation Corps workers.) 1950 also marked the completion of all Shasta Dam facilities, thirteen years after construction commenced. On 17 June 1950, Reclamation formally dedicated Shasta Dam.

As completed, Shasta Dam is the second largest concrete dam *in mass* in America (Grand Coulee Dam on the Columbia River is the largest.) As the CVP's "keystone" feature, the concrete, curved gravity dam stands 602 feet high, with a crest length of 3,460 feet. It is 543 feet thick at its base, and tapers to 30 feet thick at the crest. The 6.5 million cubic yards of concrete poured to create the dam totals 156 million tons. The central spillway is 487 feet long and 375 feet wide, and is the tallest man-made waterfall in the world. Three drum gates 110 feet wide, 28 feet tall, and weighing 500 tons each provide spill relief when the lake approaches its crest elevation of 1076.2 feet above mean sea level (amsl). The dam's crest is 1077.5 feet amsl. To provide additional spill relief, Shasta's spillway face contains 18 river outlets, each 8.5 feet in diameter, with a maximum capacity of 186,000 cubic feet of water per second.

At 96 feet wide and 450 feet long, the concrete, art-deco influenced Shasta Powerplant is one of California's largest, standing 156 feet tall (nearly fifteen stories) from ground level to roof parapet. Water from the dam is released through five, 15-foot in diameter external penstock pipes wide enough to drive a school bus through. This water delivered by the penstock pipes drive the turbines that operate the five main generator units and the two station service units. Eighty-five tons of water per second is required to drive each turbine at full generator load.

Power is generated at 13,800 volts and stepped up to 230,000 volts for transmission to California customers.

Shasta Lake is California's largest man-made reservoir, with a capacity of 4,552,000 ac/ft. With its drainage area of 6,665 square miles, there are 365 miles of shoreline, 35 miles at its longest point on the Pit River Arm. The lake provides recreational opportunities, including boating, fishing, water skiing, and camping.

Keswick Dam and Powerhouse

Named after Lord Keswick of London, President of Mountain Copper Company Limited, work on Keswick Dam started in October 1941, three years after construction commenced on Shasta Dam. Reclamation contracted with two companies for Keswick's construction, Guy F. Atkinson and Kier Construction Company (Atkinson-Kier). Atkinson-Kier placed the first concrete for Keswick on 14 November of the same year, and by December the contractor had completed excavation of the left abutment, just over half of the right abutment, and finished the foundation grouting for the spillway and the left abutment.

Much like Shasta Dam and Powerplant, the early years of World War II hampered progress on the Keswick facility. In 1942, Reclamation moved back Keswick's completion by Atkinson-Kier under the first War Powers Act of 1941, with Reclamation initiating the order for changes on 17 March 1942. On 26 December, the War Production Board (WPB) limited construction on Keswick facility, only permitting the completion of the fish trap and the section of the dam necessary for fish trap operation.

The year 1943 witnessed more war-fueled confusion on the Keswick facility. Atkinson-Kier completed all facility work authorized by the WPB on 24 April 1943, and started to dismantle equipment. Two days later, however, they received orders to resume construction, despite the fact most workers had been released. Once replacements were hired, Atkinson-Kier resumed construction. Orders for Changes Number Two, issued 12 July 1943 and pursuant to the War Powers Act of 1941, ordered the completion of Keswick Powerplant and adjacent structures, except second stage concrete and floor finishing. The Orders for Changes added embedded metal work and roof construction for the powerhouse superstructure, the elevator tower, and related downstream structures. The Orders also extended the Keswick facility's completion time to 30 April 1944. Concrete placement continued throughout 1943, with Atkinson-Kier pouring approximately 53,000 cubic yards.

Although 1944 was wrought with on-site labor disputes, work continued after a lengthy strike that halted operations for a little over a month. And for unknown reasons, Keswick rated very little attention from 1945 and 1946 CVP *Project Histories*. 1947, however, was a productive year; Atkinson-Kier installed the penstock frames, turbines, generators, and draft tube gates. The contractor also finished the powerhouse structure, and completed the right abutment access road and fish traps by year's end. Exhaustion of funds forced work to stop on 1 December 1947, although some limited work continued on one powerplant unit.

1948 witnessed the spillway's completion, and the repair of eroded spillway apron sections. In 1949, Wismer and Becker installed two generators at Keswick Powerplant, with Reclamation placing Units Two and Three into operation on 9 October and 21 December 1949, respectively. Contractors Elliot and Gist received the contract for Keswick Dam's finishing work the same year, and one year later placed the dam's fifty-by-fifty vertical spillway gates. Wismer and Becker installed the powerplant's final generating unit on 31 March 1950. This final act marked the completion of Keswick facility, and the completion of the Shasta Division of the CVP.

Keswick Dam and Powerhouse, c.1945 (Bureau of Reclamation)

As completed, Keswick Dam is a concrete gravity structure standing 157 feet high with a 1,046 foot long crest (crest elevation 595.5 feet amsl). The dam's base is 110.6 feet thick, tapering to 20 feet thick at the crest. 214,000 cubic yards of concrete went into the dam's construction. Bookended with embankment wing dams, the dam also has migratory fish trapping facilities that operate in conjunction with the Coleman Fish Hatchery located 25 miles downstream on Battle Creek. Salmon and other migratory fish are trapped when they reach the dam, then are transported to the U.S. Fish and Wildlife Service operated hatchery.

Keswick Powerplant has three generating units with a total capacity of 117,000 kilowatts (kW), and is dedicated first to meeting energy requirements of CVP facilities, with any remaining energy marketed to various preference customers in northern California. The 23,800 ac/ft afterbay known as Keswick Reservoir stabilizes the erratic water flow released through the Shasta and Spring Creek Powerplants. Keswick Reservoir also captures water diverted from Clair Hill Whiskeytown Reservoir through the Trinity Division's Spring Creek Tunnel.

Post-Construction History, Historic Shasta Division

As Shasta Lake rose behind the dam, it placed an obstacle in the path of people commuting near the reservoir. To relieve the problem, in 1945 Reclamation started a ferry operation on the lake for businesses and individuals that needed to traverse the new body of water. The operation used two 56-foot-long barges towed by 36-foot Higgins boats, with each barge capable of holding 55 tons of loaded ore trucks.

During the 1960s and 1970s, the American environmental movement hit full stride, and this impact was felt on the Shasta Division and the CVP in general. One major piece of legislation, the Endangered Species Act of 1973, created even more controversy surrounding the issue of how both Shasta Division dams affected the migratory routes of Steelhead trout and Chinook salmon. Shasta and Keswick Dams blocked a large number of Sacramento River tributaries and streams these fish used for spawning. Fish traps and hatcheries joined forces to move the migrating fish upstream or artificially breed them, but this approach could not keep pace with the general overall population decline. Shasta Dam not only blocked migration routes upstream, it blocked the flow of cool water downstream, keeping temperatures above the maximum 56 degrees Fahrenheit needed by spawning salmon.

Shasta Dam c.1945, Mt. Shasta in Background (Bureau of Reclamation Photo)

Starting in 1992, Reclamation began bypassing the turbines in Shasta Powerplant to release water directly into the Sacramento River to improve conditions for endangered, winter-run Chinook salmon. However, since power generation was crucial to Shasta's CVP role, another alternative was conceived and implemented. Five years later, in 1997, Reclamation installed a temperature control device (TCD) on the dam's upstream face. The TCD is designed to allow greater flexibility in the management of cold water reserves in Shasta Lake, while enabling hydroelectric power generation to occur and to improve salmon and trout habitat conditions on the upper Sacramento River.

Historic Friant Division [‡‡]

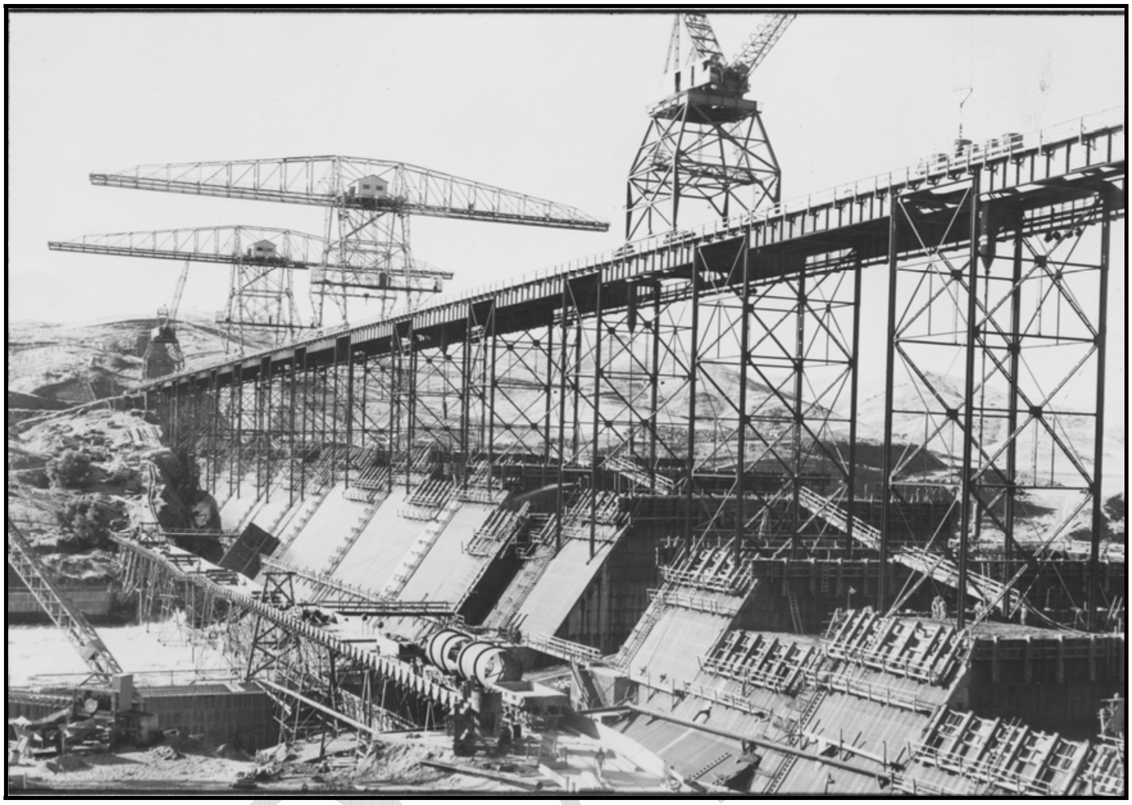
An anomaly in the CVP's complicated history, the Friant Division developed along lines similar to other western Reclamation projects; build the dam and the canals, then deliver water and hydropower to irrigators and municipal users. As one of three initial CVP segments (Shasta and Delta Divisions being the others) Friant Division is separate, yet simple in design. And its significance in the economic and agricultural history of California and America cannot be overstated. Of the top five agricultural producing counties in the United States, three—Fresno, Tulare, and Kern—are watered by Friant Division facilities.

Friant Dam

In October 1939, Reclamation awarded an $8.7 million dollar contract to Griffith Company and Bent Company, both located in California, to build Friant Dam, located 25 miles northeast of Fresno on the San Joaquin River. Under contract terms, the firms (hereafter Griffith-Bent) had 1,200 days from October 1939 to finish the job. Griffith-Bent would do all the work, as well as supply labor and equipment, while the government would furnish cement, steel, and other materials through the competitive bidding process. Reclamation also signed 28 contracts for clearing 3,552 acres of trees and brush for the future Millerton Lake.

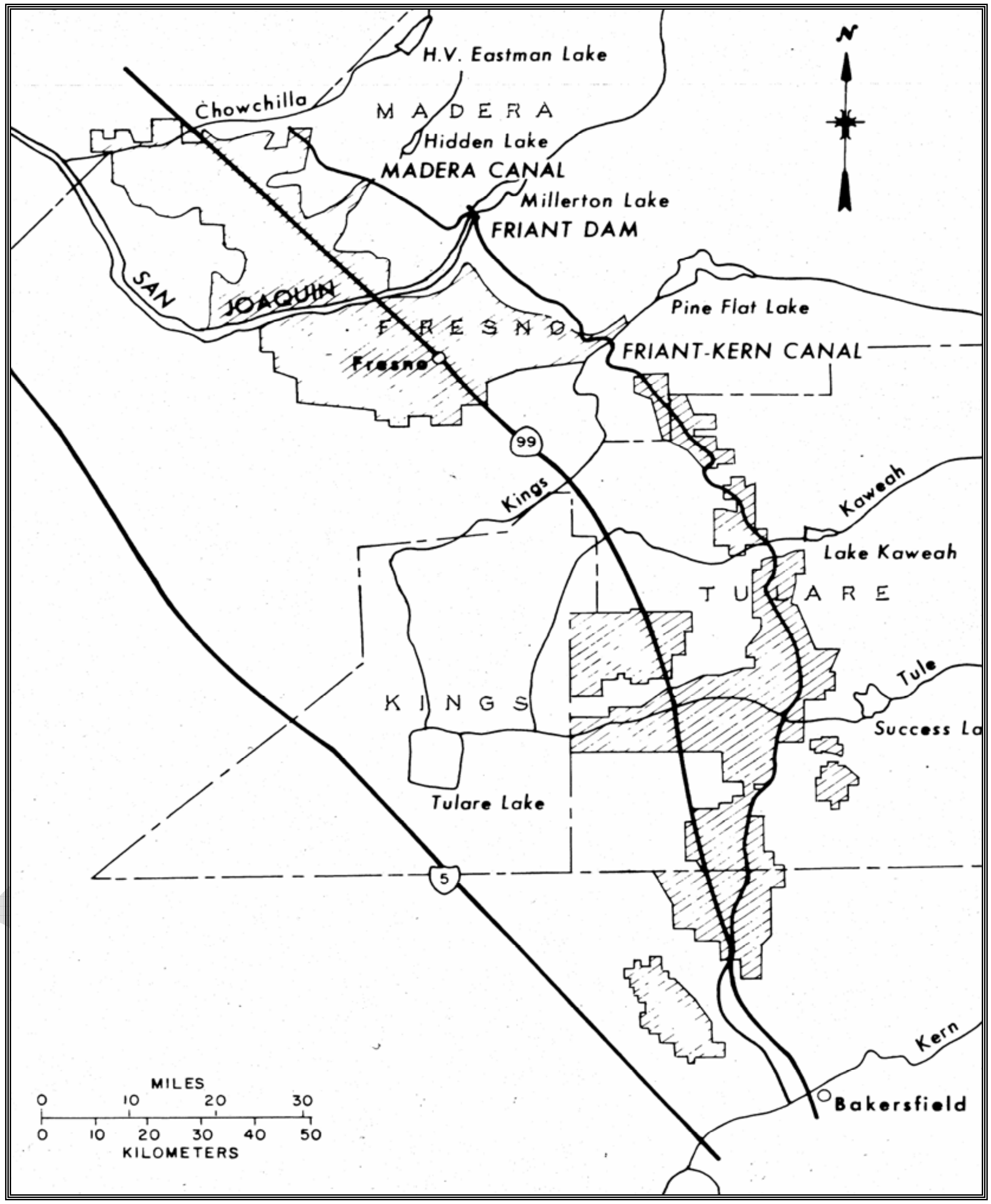
Overseeing Reclamation's activity as the Friant Division's construction engineer was former Assistant Commissioner of Reclamation Roy B. Williams, while H. Stanley Bent served as the contractor's project manager.

[‡‡] Robert Autobee, "The Friant Division," in *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); *Technical Record of Design and Construction, Friant-Kern Canal* (Denver: Bureau of Reclamation, 1958); and *Friant Unit of the Central Valley Project* (Lindsey, CA: Friant Water Users Authority, 1989.)



Friant Dam Under Construction, c.1940 (Bureau of Reclamation)

Barely 3 months earlier, a camp town of more than 50 houses, an office building, and two 48-man dormitories opened on a fifty acre parcel near the town of Friant. Landscaped yards, modern utilities, and paved streets distinguished this camp from many of the roughshod, ramshackle camps often found near other CVP and Reclamation construction sites. Still, the camp was not big enough. Many Friant workers lived in the nearby towns of Fresno, Clovis, and Friant, and commuted to the job site each day via automobile or bus. The Friant project needed laborers, and the prospect of any kind of job during the Depression created a manpower flood that the company camp could not accommodate. Additionally, the arrival of many desperate workers seeking jobs drove Reclamation, the police of two counties, and the Madera County Health Department to prohibit squatter's camps near the dam site.



Map 4: Friant Division

On 5 November 1939, with Interior Secretary Harold Ickes looking on, a thunderous dynamite blast signaled the official groundbreaking of Friant Dam. Over the next year, powerful blasts from small powder charges helped remove over 1.2 million cubic yards of loose material during foundation excavation. On two occasions in 1940 and 1941, Reclamation engineers diverted the San Joaquin River to place the dam's concrete. First, the river's course was channeled through a 36-foot timber flume in July 1940, so workers could excavate and pour concrete. The diversion, however, was delayed by the discovery of a 150-foot-wide fault seam in the left abutment. The seam dipped approximately 60 degrees downstream, but was too old geologically to menace the structure. To provide reinforcement, at select locations across the seam workers dug shafts 10 feet wide by 15 to 25 feet long and 50 to 100 feet deep, backfilling the gouges with concrete lifts to reach the foundation.

With foundation in place, in spring 1941 engineers moved the "river in a box" back to the spot to where the timber flume was first located, to continue concreting. Crews blasted an upstream cofferdam out of the riverbed, throwing an earth and rock barrier across the temporary channel leading to the flume. Shifts worked around the clock to avoid spring flooding. Early in the diversion process, however, flood waters dumped mounds of silt, destroying the forms; construction was temporarily delayed while workers cleaned up the mess. As the dam rose from the riverbed, all flow traveled through three diversion conduits at the structure's base.

Reclamation's first use of a powdery substance known as pumicite pozzolan admixture occurred at Friant site. Pumicite reduced cement content and heat generation, avoiding surface cracking. Obtained from a local deposit, pumicite was added to mass concrete in amounts equal to 20 percent of cement weight. All materials went to the concrete mixing plant which, at top speed, could produce 6,000 cubic yards of aggregate per hour. And in the course of gathering gravel for concrete, scattered through a thirty foot deep deposit on the river's left bank, the government and its contractors literally struck gold. Under a supplemental contract between Reclamation and the contractors, Griffith-Bent recovered the metal and divided the profits with the government. After a $24,000 deduction covering the expense of installing the recovery plant, the net proceeds from 5,428 ounces of reclaimed placer gold totaled $176,000.

The use of absorptive form lining was another Reclamation construction innovation started at Friant Dam. On most work sites, concrete hardened in place with the help of lumber forms. At Friant, the contractors used lightweight, highly absorbent fiberboard, commercially known as *Celotex*, which was similar in appearance to ordinary wallboard. The side placed against the concrete was lightly impregnated with sticky, bituminous paint. Requiring 24 hours to set, the fiber lining eliminated air bubbles and water holes, and gave the dam a rough face with a pattern of small indentations.

Summer heat at the damsite could reach 116 degrees, so both parties agreed not to place concrete in temperatures exceeding 70 degrees. Griffith-Bent installed ice making machines, nicknamed the "ice cream plant" by workers, which cooled the concrete during hot weather. Additionally, the pumicite/cement mixture decreased setting and reduced heat generation within the concrete. Engineers set a maximum goal of 170,000 cubic yards poured each month. To reach the target, all four mixers in service had to dump every four minutes, 24 hours a day, 30 days a month, allowing no time for breakdowns, repairs, or delays.

On 29 July 1940, block 17 near the south abutment received the first concrete. The huge amount of concrete necessary to complete the dam demanded a premium on economy in all stages of manufacture and placement. Thanks to an unusual method of placing and transporting concrete, soon after the first pour, the structure's crest was as long as eight city blocks. In order to form Shasta Dam, buckets of concrete swung by cable across the canyon. At Friant, the pace was quicker. Four small, diesel-electric cars ran on two tracks each transporting 4-cubic-yard buckets. The cars were lifted by two 30-ton gantry cranes and lowered onto the forms.

Steel trestles standing 210 feet high and 2,200 feet long supported the track system. The web of steel helped realize the goal of maximum concrete placed with a minimum of interference related to handling forms and clean-up. Along the trestle ran two huge hammerhead cranes with 300 foot arms, and a "whirly" crane with a 125 foot boom. Supplementing the hammerheads and revolving derricks was a pair of stiff-legged derricks with 180-foot booms. By March 1941, with the dam almost one-quarter complete, 5,500 cubic yards of concrete were placed each day.

Friant Dam Nearing Completion, 1942 (Bureau of Reclamation)

The contractor also switched brands of commercial cement from a high to low alkali content once the dam's completion was in sight; the change resulted in lighter colored sections and more visible cracking. In addition to helping place concrete, all the derricks assisted in handling steel, pipe, and other materials. In order to keep up the demanding pace and reduce lost time, the contractor installed eighteen flush toilets and cool drinking water for workers halfway up the 3,800 ton trestle.

Unfortunately, progress made throughout 1941 screeched to a halt in early 1942 by order of the War Production Board (WPB). Due to the stringency of critical materials, Friant and other CVP elements were classified as non-essential to the war effort. In spite of the suspension notice, however, the final cubic yard of Friant concrete was placed on 16 June 1942. Finished just six weeks short of two years after the first pour, 2,135,000 cubic yards of concrete makes Friant America's fourth largest concrete dam *in mass* after Grand Coulee, Shasta, and Hoover Dams. After completion of a few remaining components like spillway drums and control valves, in November 1942, Reclamation classified Friant Dam as ready for service.

Viewed by some as a smaller, non-curved version of Shasta Dam with its center spillway design, Friant Dam is a concrete gravity structure standing 319 feet tall, with a crest length of 3,488 feet. The dam's base is 267 feet thick, and tapers to 20 feet thick at the crest elevation of 581.25 feet amsl. Reclamation designed Friant's spillway to pass flood waters through Millerton Lake, Friant's 520,528 acre-foot, 15 mile long reservoir. The spillway's capacity is 83,020 cubic feet per second (cfs). Flow over the spillway is controlled by three 100-foot-wide by 18-foot-high buoyancy operated drum gates. The spillway gates rise by flotation when water enters each gate chamber, which are in the recess of the spillway, and form a portion of the crest when lowered.

On Friant Dam, there are two canal outlets, one for Friant-Kern Canal, and one for Madera Canal, and a separate river outlet. The river outlet works are four 110-inch-diameter steel pipes through the dam, controlled by four 96-inch diameter hollow jet valves at the outlet ends, and a corresponding chute and silting basin. The capacity of the four hollow jet valves is 16,400 cfs; however, the flow rarely exceeds 100 cfs. Smaller releases to the river flow through two 24-inch diameter steel pipes that branch from penstocks three and four, and releases are controlled by two 18-inch diameter needle valves located at the outlet ends.

Friant-Kern Canal

The Friant-Kern Canal outlet works are located on the spillway's left side, and consist of four 110-inch steel pipes through the dam controlled by four 96-inch hollow jet valves at the outlet ends, and a stilling basin. Traveling in a southerly direction over 151.8 miles, the canal carries water from Millerton Lake to the Kern River four miles west of Bakersfield. Peter Kiewit and Sons Company of Omaha submitted the low bid of $1.1 million, received the contract in July 1945, and started excavation a month later. Sprawled over three counties, as many as 292 people worked on Friant-Kern's construction. The gravity feed for the canal's initial diversion capacity is 5,000 cfs, which gradually decreases to 2,000 cfs at its Kern River terminus.

Because it was built through an already highly developed area (unlike its west valley twin the Delta-Mendota Canal) the Friant-Kern's construction disrupted numerous features of modern technology. More than 350 overhead and underground telephone, telegraph, power, oil, and gas lines were moved to higher ground and/or relocated. Heavy crawler tractors and bulldozers, equipped with attachments to cut roots below the surface, plowed their way through orchards and vineyards. Along a 113 mile stretch between Friant Dam and the White River, more than 500 different structures including overchutes, drainage inlets, irrigation crossings, and turnouts were built. During construction, placement of concrete lining was aided by the use of a traveling gantry; almost 85 percent of the canal is concrete lined. In those sections, the canal's maximum top width is 128 feet, decreasing to a bottom width of 24 feet, with water depths dropping from 19.9 to 11 feet. Canal bottom width ranges from 64 to 40 feet with varying water depths in the earth-lined sections. On 9 July 1949, 2,500 people witnessed a former Reclamation engineer and a citrus grower from the town of Lindsay usher in the first delivery of Friant-Kern Canal water. Costs for all aspects of the Friant-Kern Canal totaled $60.8 million. Although some sections in seismically active areas near Porterville are lined with compacted earth and not concrete, Friant-Kern is still the longest lined canal in the West.

Madera Canal, With Friant Dam in Background (Bureau of Reclamation)

Madera Canal

On a map, Friant-Kern's twin, the Madera Canal, looks like the division's short arm. With outlet works situated on Friant Dam's upstream right (north) side, Madera Canal is 36 miles long and terminates at the Chowchilla River. The canal's capacity is 1,275 cfs at the head, dwindling to 625 cfs at its terminus. The outlet works feature two 91-inch diameter steel pipes controlling releases through two 86-inch-diameter interior differential needle valves at the outlet ends. The needle valves discharge water into a stilling basin that marks Madera Canal's starting point. The canal bottom width varies from 10 to 8 feet with a water depth of 9 to 7 feet in the concrete lined sections. Canal bottom width varies from 24 to 20 feet with water depths from 9 to 7 feet in the earth-lined sections; approximately 79 percent of the canal is earth-lined. Water ran through the entire length of the Madera Canal for the first time on 10 June 1945, with first deliveries made one month later. The construction of smaller distribution canals and laterals still had to proceed in order for the canal to become fully operational. Before this, water did not come to individual farmers, but ran along six water courses in the area to raise water tables.

Post-Construction History, Historic Friant Division

Despite frequent drought cycles in central California over the last 60 years, water has spilled at Friant Dam in 1982, 1983, 1986, most years in the 1990s after drought cycles, and most recently in January 2005. On 4 January 1997 Millerton Lake reached record high water levels; heavy flooding upriver caused the lake's rising waters to come within four inches of breaching Friant and flooding the outskirts of Fresno. Compounding the emergency was the failure of emergency spillway gates to open; Reclamation workers adjusted the gates fast enough to ward off a potential disaster.

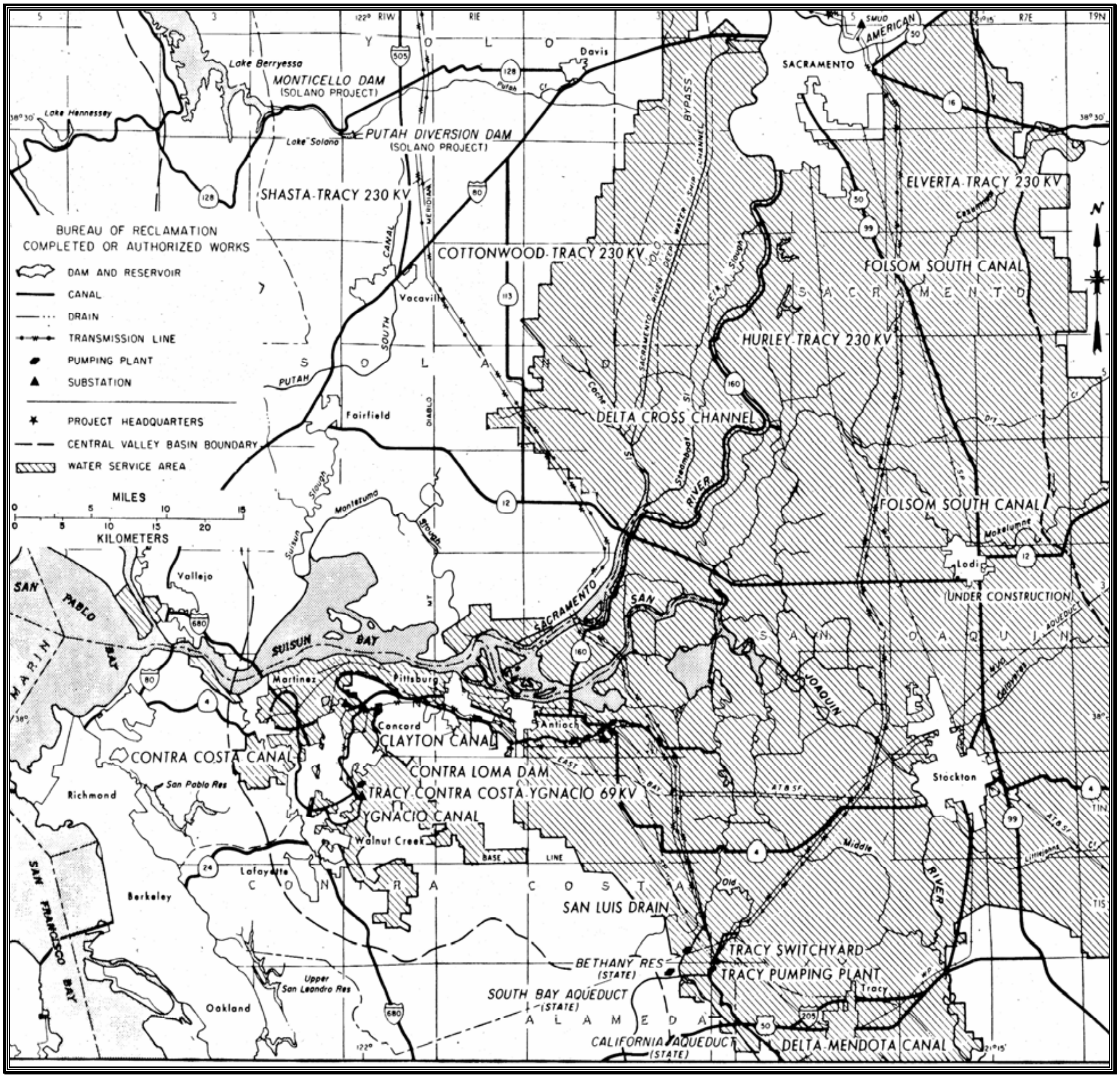
Other problems have plagued Friant Dam in recent years. The alkali carried by the San Joaquin River has left its mark on the dam's face. Parts of the crest and other supplementary fixtures, described as excellent looking in the late 1960s, have developed long, wide cracks. Areas most severely affected did not receive the aggregate and pumicite pozzolan mixture. Concrete expansion is visible along the top six feet of the crest, the chute surface, and the reinforced concrete portions of the structural framing around the outlets. In 1984, Reclamation predicted that deterioration and seepage had not yet jeopardized the dam's safe operation; however, it will eventually do so. An engineer's safety report recommended that after 44 years of service, a modification study to prevent the concrete's continuing decays was needed.

Historic Delta Division [§§]

In contrast to the relative operational simplicity of the CVP's Shasta and Friant Divisions, the Delta Division is more complex. The Delta Division (originally authorized as the Contra Costa Division in 1937, name changed the same year) acts as the hub around which the CVP wheel revolves. The Delta Division contains the facilities that transfer water from the Sacramento River to bolster irrigation supplies to thirsty lands previously dependent on the San Joaquin River. The Sacramento-San Joaquin Delta is a triangle-shaped patch of land that lies northeast and inland of the San Francisco Bay area. The Delta proper is about fifty miles long from north to south with a maximum width of approximately 25 miles. Over half of the once-marsh filled Delta lies at or below sea level.

[§§] Eric Stene, "The Delta Division – Central Valley Project," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); Tracy *Pumping Plant and Intake Channel and Discharge Lines, Technical Record of Design and Construction,* (Denver: Bureau of Reclamation, 1959).

Map 5: Delta Division



Contra Costa Canal

Reclamation awarded various contracts to many companies to build Contra Costa Canal in somewhat piecemeal fashion over a course of a decade. Much like the rest of the CVP's historic features constructed during this time, World War II caused much of the delay. On 19 March 1937, Reclamation awarded the first contract to two companies, Haas, Doughty, and Jones, and Marshall and Stacy (Haas-Marshall), for the canal's first section. Receiving the notice to proceed on 13 October the same year, work commenced six days later on the 19th—this is acknowledged as the inauguration of CVP construction. By year's end, Haas-Marshall completed the Marsh Creek Siphon and started on the Fox Slough Siphon, and completed their initial contract work on 5 August 1938.

Four months later, on 2 December 1938, Reclamation awarded two more contracts for Contra Costa Canal construction to Pearson, Minnis, Moody, Werner, and Webb (Pearson) on 30 June 1938, and to Haas-Marshall on 2 December 1938. Both companies finished their work in 1939. On 5 March 1939 Reclamation awarded yet another contract, one for $130,000, to George B. Henly Construction Company for construction of Contra Costa Pumping Plants One through Four. Henly received the notice to proceed on 25 March, but actually started work 10 days earlier. The contractor placed twenty-four inches of reinforced concrete for the plants' base slabs. Each plant contained six pumping units, with 9-foot-tall by 6-inch-wide intake bays formed by 18-inch-thick concrete walls. Less than one year later, on 7 March 1940, Henly completed all pumping plant contract work.

Reclamation started test pumping at Pumping Plant Number One during the summer of 1940, in preparation for using operational portions of the canal in the fall. Reclamation Engineer Walker Young threw the switch to start one of the pump units on 8 July 1940; the same day work crews placed the first bucket of concrete on Shasta Dam. Reclamation turned the first water into the sea level section of the canal on 9 August 1940. This proved to be a blessing for Pittsburg residents, who had watched the hardness of their well water increase exponentially. This decreasing water quality convinced Pittsburg residents to contract with Reclamation for water deliveries from the canal; in anticipation, the city in 1939 built a water treatment plant. Pittsburg received its first canal water on 18 August 1940. On that day, the canal stretched twenty miles—nearly half of its final length—and reached four miles past the city. With this water delivery, the Contra Costa Canal became the first operational CVP engineering feature.

Contra Costa Canal, c.1942 (Bureau of Reclamation)

Anticipating an extension of the canal to reach the city of Martinez, in 1941 city officials advertised the sale of $286,000 in bonds to finance a water treatment plant. Unsure if Reclamation would construct the extension, Martinez's mayor complained to Reclamation Commissioner John Page that the city could not afford construction of the treatment plant and the canal if Reclamation did not build the extension. The mayor also feared further financial encroachment by the California Water Service Company which, he claimed, already took 300 outside customers from Martinez. To complicate matters, canal construction lagged six months behind schedule due to a landslide four miles east of Martinez.

To continue with construction, on 18 October 1940 Reclamation awarded a $319,862 contract to Trewhitt-Shields and Fisher (Trewhitt-Shields.) The contractor started work on earthwork, canal lining, and structures on 21 March 1941, nearly completing the contract by year's end. Trewhitt-Shields completed their work on 17 May 1942, less than a week before operations of Contra Costa Canal halted because of World War II. And although more work subcontracted by Trewhitt-Shields recommenced soon afterward, Reclamation's failure to supply construction materials prevented any significant progress before the War Production Board (WPB) officially stopped work. To allow continued operations, on 26 February 1942 Reclamation applied for a preference rating for the canal under the War Food Program. The WPB refused, citing that the excessive quantity of critical materials was deemed greater than any benefits the canal could provide. Work on the canal came to a halt on 23 May; on 8 August Reclamation submitted an application to the WPB to resume construction, obtain priority assistance, and an allotment for controlled materials to complete the Contra Costa Canal system. Again, the WPB rejected Reclamation's application.

This request and reject cycle continued unabated. Several times from 1942 through 1945 Reclamation requested resuming canal construction, and the WPB rejected their request. Since no construction could happen, and Reclamation was fearful of sabotage, canal security during wartime became the agency's new priority. Reclamation hired armed guards to help protect the canal, and also armed their operations personnel to patrol the canal's reaches. Although the protection program ended in 1944, Reclamation persuaded many of the armed guards to stay on as maintenance personnel. Work continued after World War II on the canal's final ten miles, at a cost of $1.5 million.

Part of completing the Contra Costa Canal was to also build its terminus, Mountain View (later renamed Martinez) Dam. On 18 March 1946 Reclamation awarded a $568,974 contract to Parish Brothers Construction to build not only Martinez Dam, but to finish the canal's final section. Parish Brothers finished the dam's embankment placement on 12 November 1946, and completed the outlet control tower the same year. The contractor completed Martinez Dam in May 1947, and completed the final main section of the Contra Costa Canal four months later on 29 September 1947. Martinez Dam is a modified homogenous offstream earthfill dam 1,200 feet long at the crest and 62 feet high, and is operated by the Contra Costa Water District. Martinez Reservoir has a capacity of 268 ac/ft.

In March 1947, Parish Brothers received the contract originally awarded to Trewhitt-Shields for Contra Costa Canal's completion, but re-advertised by Reclamation after World War II. This contract included the construction of two small municipal offshoot canals that serve Concord and Walnut Creek, the Ygnacio and Clayton Canals. And while Parish Brothers started work, lack of funds delayed the completion of these two ancillary canals. Once resumed, Parish Brothers lined Clayton Canal with concrete, and lined 4.06 miles of Ygnacio Canal with a two inch layer of asphaltic concrete. Parish Brothers completed all work on the Contra Costa, Clayton, and Ygnacio Canals by November 8, 1948.

As completed, the Contra Costa Canal travels 47.7 miles from a location in the Delta east of Oakley to Martinez reservoir, with a capacity of 350 feet per second. Mostly exposed and lined, with some above and underground piped sections in urban areas near Martinez and Concord, Contra Costa Canal has a maximum bottom width of 24 feet. The now-abandoned Clayton Canal is 4.8 miles long, with a bottom width of four feet, while the still-active Ygnacio Canal travels 5.2 miles through the city of Concord with a bottom width of five feet.

Delta-Mendota Canal

Because Friant Dam diverted most of the San Joaquin River's flow out of its natural channel into the Madera and Friant-Kern canal systems, after World War II Reclamation built the 115-mile long Delta-Mendota Canal to replace this water. This transfer plan called for a pumping plant at Tracy to pull water from the Sacramento River (via the Delta Cross Channel), then lift it 197 feet into the Delta-Mendota Canal's headworks. This canal would gravity transport the water south to the Mendota Pool, a collection facility at the junction of the San Joaquin River and the North Fork of the King's River 30 miles west of Fresno.

The sheer length of the Delta-Mendota Canal required several contracts to excavate and complete construction of the earthwork, the concrete lining, and the structures. On 25 October 1946 Reclamation awarded the first contracts to Morrison-Knudsen Company and M.H. Hasler Construction (Morrison-Knudsen & Hasler). Other companies that received construction contracts for the canal included Hubert Everist Sr., Western Contracting Corporation, United Concrete Pipe Corporation/Vinnell Company, and A. Teichert and Sons Incorporated.

Delta-Mendota Canal contractors excavated the canal with motor-driven or tractor-towed scrapers, draglines, graders, and bulldozers. Morrison-Knudsen & Hasler operated the canal construction's largest dragline on a three-shift basis for 21 hours a day, 6 days a week, and trimmed the high spots with a bulldozer and a grader. Yet the western San Joaquin Valley's water tables and soils proved troublesome. Around Station 500, high ground water and sand forced de-watering of the area into a pilot ditch and sump. United Concrete and Pipe and Vinnell pumped the water into adjacent drains to allow further excavation. Some areas had unsuitable foundation materials classified as "adobe" soil, which the contractors removed before plowing, sprinkling, then compacting the materials with a roller. Control structures at Station 5476+35 and nearby lay below the canal's subgrade and thus, through the use of two sump pumps, required extensive dewatering before construction.

More excess moisture plagued canal contractors. Heavy rainfall in November 1950 created high water in Los Banos and San Luis Creeks. Excess water from these creeks breached the canal and caused extensive damage to it and some siphons. So much water came in that Los Banos Creek continued flowing south and north in the canal proper, with the northern flow emptying out of the San Luis wasteway turnout. San Luis Creek proved no less troublesome and even more damaging; the creek broke into a lined section of the canal, and rushed out of a wasteway. The rushing water washed away concrete forms and nearly filled the San Luis Creek Siphon with debris and gravel, and damaged some 24-inch welded steel pipes, reinforcing steel, and partially placed wood side panels on some of Morrison-Knudsen & Hasler's sections. All the flooding literally caused all work on the canal to halt until Reclamation assessed the damages.

The deluge continued and during the first weekend of December 1950, heavy rains caused water from Garzas Creek to undermine an overchute pier and float some of the canal's concrete lining. Labor problems exacerbated an already tenuous situation, including United Pipe/Vinnell workers undergoing a series of strikes the first two weeks of May 1951. Once weather cleared and workers returned, canal construction resumed at a rapid pace. Western Contracting Corporation's 9 April 1952 completion of the San Luis wasteway and holding reservoir dike signaled the end of the Delta-Mendota Canal's construction. The final contract cost of the canal totaled nearly $41 million, while Reclamation's estimates of the final costs, including repairing all flood damaged sections, totaled $48.7 million.

The Delta-Mendota Canal originates at its intake headworks on the bank of the Old River, a natural channel in the Delta a few miles north of the Tracy Pumping Plant. After flowing to Tracy via the intake channel, the plant then lifts the canal's water 197 feet to the headworks where gravity feed directs the water 116.6 miles south to Mendota Pool. The canal's first 95 miles are concrete lined, while the remaining is unlined. The canal has a bottom width of 100 feet and a capacity of 4,600 cfs to check 1, diminishes to 4,199 cfs at O'Neill Forebay, and continues to reduce all the way to its Mendota Pool terminus.

Tracy Pumping Plant (C.W. "Bill" Jones Pumping Plant)

Without the massive Tracy Pumping Plant, now known as the C.W. "Bill" Jones Pumping Plant, the CVP could not operate as designed. On 23 June 1947, Reclamation Commissioner Michael Straus awarded contracts totaling $5.8 million for the plant and its appurtenant facilities to SUHB Companies, a joint venture of Stolte, Inc., United Concrete and Pipe, Ralph A. Bell, and Duncan-Harrelson Company. More significantly, the contract to build the plant was the first ever awarded by a Reclamation Commissioner in excess of $500,000. Schedule one included the plant structure proper, the Delta-Mendota Intake Channel, the railroad and highway culvert, and the higher head discharge pipes. The second schedule specified the lower head discharge pipes and the outlet structure. SUHB Companies also received the contract for finishing work and installation of major equipment.

SUHB excavated the plant's site, using untreated forty-two to fifty-one foot Douglas fir pilings, and pumpcrete machines to transport the concrete from mixer to placement area. Constructed next to a major fault line and designed to withstand a series of massive earthquakes, the contractors placed a total of 29,410 cubic yards of concrete and 2,965 tons of reinforcement steel. Worthington Pump and Machinery Corporation of Harrison, New Jersey, supplied the plant's six eighty-four-inch pumps, with Allis-Chalmers Manufacturing Company of Milwaukee supplying the pump drive motors. SUHB installed all the pumps and related machinery. SUHB completed Tracy Pumping Plant and intake channel work on 30 December 1949 at an estimated cost of $16.2 million. The 362-foot-long by 99-foot- wide plant's six pumping units have a total capacity of 4,602 cubic feet per second. Upon its completion, Tracy Pumping Plant was the most massive concrete-reinforced building in America, an honor previously acknowledged to Fort Knox.

On top of the plant, and running its entire length, is a 100-ton outdoor, traveling-type, single trolley gantry crane with a 20 ton auxiliary hoist mounted on rails. This crane is used for maintenance and service for the pumps and motors, for transferring equipment from the plant to the machine shop, and for raising and lowering the pump intake block gates. This gantry crane has a span of 56 feet 6 inches, and a clearance of 29 feet above the pumping plant's roof. The crane structure is supported on four equalized trucks, consisting of two wheels each that are mounted on rails built into the pumping plant's roof. The crane travels at a maximum speed of 77 feet per minute. The plant's machine shop houses a smaller, 25-ton traveling crane used to move and transport smaller materials inside the plant.

Delta Cross Channel

On 12 January 1945, nine months before the end of World War II, Reclamation announced the final location for the Delta Cross Channel. Considered by one Reclamation official as the CVP's most import segment, the channel redirects Sacramento River water to the Tracy Pumping Plant for redistribution south via the Delta-Mendota Canal. The channel's route followed the plan chosen by California State Engineer Edward Hyatt. Reclamation believed the Delta Cross Channel and the training works in the San Joaquin River necessary to prevent the highly polluted low water flows of the San Joaquin from infiltrating the Tracy Pumping Plant. This intrusion could raise salinity in the adjoining waters above the standards set in the Water Exchange Contract for low flows. The channel also plays an essential role in supporting deliveries through the Tracy Pumping Plant by circulating Sacramento River water into the interior Delta, maintaining interior Delta water quality at acceptable levels for pumping.

And, in simulations to investigate possible alternative locations for the Delta Cross Channel, Reclamation engineers, for the first time, made use of an analog computer to solve an unsteady flow problem.

Reclamation awarded the earthwork contract for the Delta Cross Channel to George Pollock Company on 8 May 1950. Other contract awards issued the same month included Consolidated Western Steel Corporation for supplying the sixty by thirty radial gates, and Bethlehem Pacific Coast Steel Corporation for the radial gate hoists for the channel flood gate structure.

As the CVP's shortest directed water route, the Delta Cross Channel travels 1.2 miles from the Sacramento River in Walnut Grove directly to Snodgrass Slough in the Mokelumne River basin. Although the primary use is one of water transfer from north to south, the Delta Cross Channel also helps combat salt water intrusion in the Delta and dilutes local pollution. After entering

Snodgrass Slough, the Sacramento River water follows natural courses to Old River slough near the Delta-Mendota Canal's intake channel at Tracy Pumping Plant. The channel has a bottom width of 210 feet and a capacity 3,500 cubic feet per second. During high water, Reclamation closes the control gates to prevent flooding in the Delta's San Joaquin drainage section. After the flood danger passes, Reclamation then opens the gates to allow water through to the Tracy Pumping Plant.

Post-Construction History, Historic Delta Division

The Delta Division's powerful pumping plants had major, and often detrimental, effects on stream flow in the Delta and the San Joaquin River Basin. During periods of low water flow and high quantities of exports, the Delta pumps actually reversed the San Joaquin River's flow, sending it back upstream. Through the Delta's transport systems, water normally traveling to the west toward San Pablo Bay instead moves back to the east and south. These "reverse flows" disorient migratory fish (often luring them to pumps) and draw salty ocean water into the San Joaquin and other riverways.

In 1944, Reclamation officials realized the Delta salinity problem was worse than previously thought. Region 2 Director Charles E. Carey believed Shasta Dam could not entirely control the salinity problem. He announced possible alternatives to alleviate this problem: build a closed conduit through (or around) the Delta to carry Sacramento River water directly to the other side without letting it mix with Delta water; change the Water Exchange Contract to make the water quality requirement less extreme; control the Sacramento River tributaries to control salinity and assure water quality; or build Folsom Dam. The proposed closed conduit foreshadowed later plans for the Peripheral Canal.

In the course of Delta Division development, the Peripheral Canal, though not built, became one of the most controversial elements. Reclamation proposed the canal to the Interagency Delta Committee (IDC) in early 1963 as an alternative water transfer system. By early 1965, the proposed canal had gained almost universal acceptance in the Delta region. California wanted Reclamation to design and build the Peripheral Canal, then the state would assume control. Reclamation, however, did not want the state to have control of the canal, but did not have the authority to build it. California's Department of Water Resources (DWR), on the other hand, did have authority to construct the canal.

The IDC pointed out that much of the Peripheral Canal route would parallel Interstate 5, and materials excavated from the canal could be used as highway backfill. In January 1968, the California Departments of Water Resources and Public Works executed an agreement under which public works advanced $2 million to purchase rights of way in San Joaquin County for the canal. DWR agreed to repay the money when canal construction began or no later than 1 January 1976.

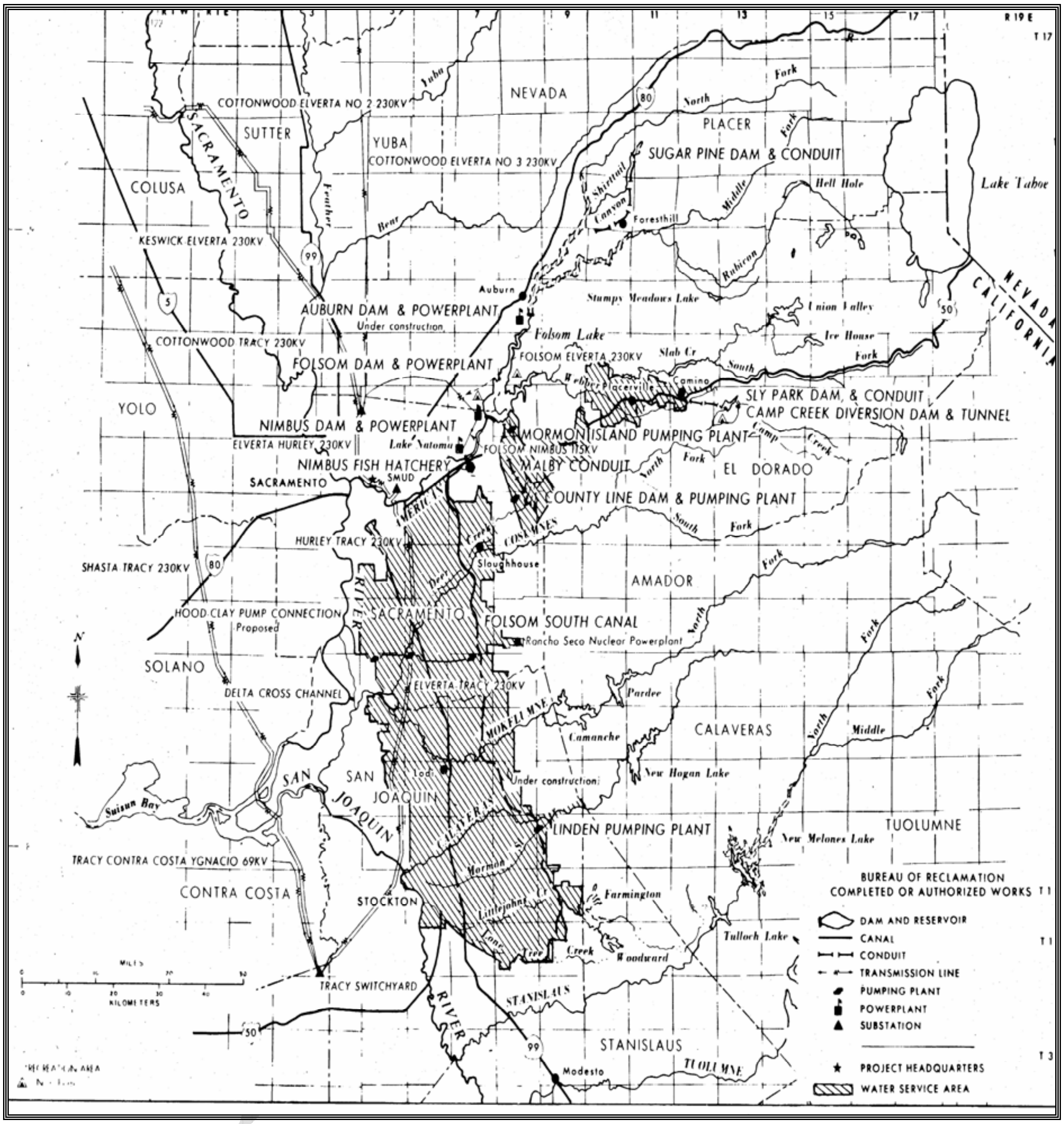
Changing attitudes in America towards the environment, along with a cornucopia of other issues, however, soon influenced public perceptions of the canal. Contra Costa County opposed the canal, because residents viewed it as yet another way to transport fresh water from their locale to southern California. Concurrently, questions arose about the possible environmental impact on fish populations the Peripheral Canal would have on Delta and Central Valley fish populations. Environmentalists believed the canal's outlets would draw in fish, and the nitrogen-rich water from agricultural drainage could foster algae growth, stagnating waters and suffocating fish.

In a 4 December 1969 speech to the Irrigation District's Association, DWR Director William Gianelli responded to the environmental arguments with his famous "Californians must not fall into the quagmire trap of Chicken Little emotionalists." The draft environmental impact report of 1974 received such a negative response that DWR decided to take some extra time to prepare an acceptable final report. Early in 1975, with construction of the Peripheral Canal slated to commence that summer, DWR Director John Teerink announced a one-year delay.

Two years later, in 1977, the DWR proposed a coalition of joint state and federal programs and facilities that included the 42-mile-long Peripheral Canal. DWR maintained that the canal would circumvent the Delta's channels, and carry Sacramento River water more efficiently to CVP and State Water Project pumping plants. The canal could release fresh water into the Delta at certain points along its reaches to support irrigation, to benefit fish and wildlife, and to repel saltwater intrusion. Supporters, including the Metropolitan Water District of Southern California and various agribusinesses, argued that the canal would help end the reverse flows caused by the south Delta pumps. Opponents continued arguing against the environmental impact of the canal and further water exports south. A referendum on the project went before California voters as Proposition 9 in 1982, and was soundly defeated mostly due to costs (an estimated $3.1 billion) and environmental concerns. Other alternatives surfaced after Proposition 9's defeat, but none advanced.

Environmental problems rose to the forefront in the CVP, and the Delta Division is only partially to blame for these problems. All CVP divisions and the State Water Project supply water to the Central Valley, and they all contribute to the problem. One high profile problem that grew out of the CVP was the declining population of Chinook salmon in the Sacramento River. Most attention focused on this fish, listed as threatened by the Federal government and endangered by the state. The estimated population of the winter-run Chinook in 1969 reached 117,000. In 1991, only 191 adults returned to the river to spawn.

Studies link the Chinook's decline to several factors, including predation by two non-native Delta species introduced in the Delta, the Striped Bass and the Colorado River Squawfish, the lack of water flows in the rivers because of upstream dams, and disorientation and destruction by the Delta Division's pumping plants. Another species facing precipitous declines and possible extinction is the Delta smelt. A three-inch-long fish found only in the Sacramento-San Joaquin Delta, the smelt faces destruction by the same forces as the Chinook salmon. The California Fish and Game Commission rejected the smelt for a state listing as a threatened or endangered species, but in March 1993 the U.S. Fish and Wildlife Service listed the smelt as threatened under the Endangered Species Act.



Map 6: American River Division (not all features are historic or owned by Reclamation)

Historic American River Division [***]

An effort overseen by two competing Federal water agencies, the USACE supervised Folsom Dam's construction, while Reclamation supervised construction of Folsom Powerplant, Nimbus Dam and Powerplant, and Nimbus Fish Hatchery. This division grew mostly out of a desire by state and federal governments in the early 1940s to provide better flood relief to the American River, which flows directly through the flood-prone capital of America's most populous state.

Folsom Dam and Powerplant

Originally authorized in 1944 for construction by the USACE as a 355,000 ac/ft flood control unit, in 1949 Folsom Dam, located on the American River east of Sacramento, was reauthorized as a 1,000,000 ac/ft multi-purpose facility. Folsom Dam consists of a concrete main section, flanked by two earthfill wing dams, a large, earthfill saddle dam (Mormon Island Auxiliary Dam), and eight smaller earthfill dikes. Work to be completed under the $29.5 million primary contract consisted of construction of the concrete section and wing dams, and three dikes. Initial excavation work on Folsom facility began in November 1948. In October 1951, the primary contractor, a joint venture between Savin Construction Corp. of East Hartford, Connecticut, and Merritt-Chapman & Scott, Inc., of New York, began work on the dam's main section, with the first concrete poured on 29 October 1952.

During work on the main section's foundation, workers discovered a fault that required extensive

[***] William Joe Simonds, "The American River Division," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995); *Basic Design Controls, Nimbus Dam and Power Plant* (Denver: Bureau of Reclamation, 1952); *Comprehensive Facility Review, Folsom Dam and Dikes* (Denver: Bureau of Reclamation, 2000).

excavation and grouting. The fault ran under a portion of the main section that had already been poured. To correct the problem, the contractor dug a tunnel that followed the fault line until they reached the end, then extended the tunnel 150 feet in each direction along the fault line and filled it with concrete. These additional foundation excavations required the removal of an additional 70,000 cubic yard (cu/yd) of material, and the placement of an additional 50,000 cu/yd of concrete.

The construction of Folsom Dam and Lake affected 142 parcels of land, with 51 structures that needed to be moved or torn down. Many forced to give up their lands were fifth generation occupants. In at least one case, the sadness over giving up the family homestead led to tragedy. Rancher Peter Dickinson had owned 400 acres at Folsom since 1918, and was deeply saddened about having to give up his land. Upset by her father's condition, Dickinson's daughter, Etta, shot her father, set fire to their house, then hanged herself.

While USACE contractors continued work on Folsom Dam, Reclamation contractors started on the Folsom Powerplant, located on the right abutment of the main concrete section. The first contract for Folsom Powerplant was awarded to the Guy F. Atkinson Company of San Francisco on 5 June 1951, with a bid of $1.4 million for excavation and earthwork on the powerhouse, warehouse, fabrication areas, tailrace channel, and access road. Work started on these facilities the same month.

On 10 April 1952 Reclamation awarded a $5.7 million contract for construction of Folsom Powerplant and appurtenant works to Guy F. Atkinson Company, with work commencing one month later on the excavation of the first of three power penstock tunnels. Each of the tunnels was driven 30 to 40 feet from the upstream side, then the work advanced from the downstream end to meet with the upstream headings. In late May, work started on the downstream headings, with the last of the three tunnels being excavated on 14 September 1953. By 9 October, the tunnels were cleaned and readied for placement of the penstock pipes. Concrete work at Folsom Powerplant started on 24 October 1952 with placement of concrete in the gravity training wall between the between the concrete and the spillway stilling basin. On 3 April 1953 workers placed the powerhouse's first concrete.

Installation of the three, 15-foot, 6-inch diameter penstock pipes that supply water to Folsom's turbines began on 5 October 1953. By the end of 1954, workers completed the installation of all three tubes. While the tubes were being finished, workers installed the powerhouse's turbines and generators beginning with the embedded parts. This included the turbine pit liners, the spiral cases, and draft tube liners. Westinghouse Electric supplied the three generators at a cost of a little over $3 million. All three units were sequentially placed into service from 12 May to 6 December 1955, and other than a few minor deficiencies corrected by Westinghouse, the units operated without problems.

By early 1955, work on Folsom Dam had reached a point where water storage was possible, and in February the first storage of water at Folsom was recorded. The final concrete pour on the dam's main section was on 17 May 1955, with all work under contract for construction of the main dam completed by May 1956. Even before its completion, Folsom Dam demonstrated its effectiveness as a flood control unit. In December 1955 and January 1956, heavy rains caused the American River to rise, filling Folsom Lake to its 1,000,000 ac/ft capacity. The dam's ability to contain the river's flows prevented an estimated $20 million in downstream damages. On 5 May 1956, Folsom Dam and Lake were officially dedicated, and nine days later the USACE transferred the dam's operation and maintenance to Reclamation.

Folsom Dam is a concrete gravity structure 340 feet high and 1,400 long at its crest. The main section is flanked by two earthfill wing dams, with the right wing dam at 6,700 feet long and 145 feet high, and the left at 2,100 feet long and 145 feet high. In addition to the main section and wing dams, one auxiliary dam and eight smaller earthfill dikes help contain Folsom Lake. The Mormon Island Auxiliary Dam is 4,820 feet long and 110 feet high, while the earthfill dikes range in height from 10 to 100 feet, and in length from 740 to 2,060 feet. The combined length of the main dam, its earthen wings dams, Mormon Island Auxiliary Dam, and the eight dikes total 26,730 feet, over five miles. The total volume of materials in all Folsom structures is 13,970,000 cu/yd, including 1,050,000 cu/yd of concrete in the main section. The spillway, which is located in the concrete main section, is divided into eight smaller sections each controlled by a 42-by-50- foot radial gate.

Folsom Lake has a capacity of 977,000 ac/ft, with a surface area of 11,540 acres. Folsom Powerplant has three generating units each rated at over 76,000 k/W, with a combined rating of 198,720 k/w. Water is supplied to the three, 74,000 horsepower (h/p) turbines that drive the generators through three, 560-foot-long, 15-foot 6-inch diameter penstocks that run through the right abutment of the main dam.

Nimbus Dam, Powerplant, Fish Hatchery

The primary contract for construction of Nimbus Dam and Powerplant was awarded on 18 June 1952 by Reclamation to a joint venture between the Winston Brothers Construction Company and the Al Johnson Construction Company, both of Monrovia, California. The winning bid of $6.1 million covered construction of the main dam, the powerplant, and all appurtenant features. In early July, the contractors excavated the inlet channel to provide access for their construction bridge. In August, excavations on Nimbus's right abutment and foundation commenced. By year's end, the concrete for Nimbus Powerhouse had been completed.
On 31 August 1953, work in preparation for the installation of the eighteen, 40-by-24-foot radial

gates started. This work consisted of installation of the embedded parts of the gate works. These parts, including the bearing pedestals, seal plates, and anchors, were supplied by Valley Iron Works of Yakima, Washington. The radial gate hoists, each with a lifting capacity of 75,000 pounds, were supplied by Willamette Iron and Steel of Portland, Oregon, and the gates themselves by Berkeley Steel of Berkeley, California. Workers placed the first gate in position on 28 September 1953, with the final gate placed on 2 November 1954.

Installation of Nimbus's turbines and generators began with placement of embedded parts on 23 September 1954 by Winston-Johnson Company, under terms of the primary contract. Supplied by the Elliot Company of Ridgeway, Pennsylvania, installation of the generators started on 15 December 1954. Operational tests commenced on 25 April 1955, and continued until early June. Turbine acceptance tests were successfully conducted in September, with the units placed online soon after.

All did not go smooth at either site; however, for flooding constantly plagued construction at Folsom affected the Nimbus site. The wet spring of 1953 was especially troublesome. On 9 January 1953, the coffer dam protecting work at Folsom failed, causing the coffer dam protecting work at Nimbus to also fail, flooding that site. In late April, high water again caused the Nimbus coffer dam to fail, again flooding the construction site. And history repeats itself; a month later the Folsom coffer dam failed yet again, flooding the Nimbus site. As a result of damages and time lost caused by the Folsom coffer dam failures, the primary contractor at Nimbus, Winston-Johnson, filed suit against Folsom's prime contractors, Merritt-Chapman & Scott and Savin Construction.

Despite the flooding, work progressed at a steady pace. All work on Nimbus Dam and

Powerplant was completed and accepted by the government in July 1955. Nimbus Dam is a concrete gravity structure 87 feet high and 1,093 feet long at its crest. Flows are controlled by eighteen, 40-foot by 24-foot radial gates. Nimbus Dam's backwater, Lake Natoma, has a capacity of 8,760 ac/ft, with a surface area of 540 acres. Nimbus Powerplant, located on the dam's right abutment, contains two 7,763 k/W generators with a combined output of 13,500 k/W. Water is supplied to the two 9,400 h/p turbines that drive the generating units through six, 45.5 foot long penstocks.

As with many other dams constructed in the West by Reclamation and the USACE, construction of Folsom and Nimbus blocked access to natural spawning grounds of salmon and steelhead trout. To compensate for the loss of these spawning areas, Reclamation constructed a fish hatchery a quarter-mile downstream from Nimbus Dam. On 14 August 1954, the contractor began work, and the facility was completed a little over a year later on 17 October 1955. The fish hatchery has a capacity of 30,000,000 eggs. Water is supplied through a 1,415-foot-long 42-inch diameter concrete pipe that runs from the left abutment of Nimbus Dam.

And much like the Keswick facility's role as an afterbay to control erratic releases from Shasta and Spring Creek powerplants, the Nimbus facility and Lake Natoma control erratic releases from Folsom's powerplant.

Post-Construction History, Historic American River Division

Since its completion, no other units in California have been more effective in providing flood control than the Folsom/Nimbus combination. Following the floods of 1955, when it prevented $20 million in damage, Folsom Dam, working in conjunction with Nimbus Dam, continued to prove its worth. In 1963 and 1964, Folsom and Nimbus restrained six day flows of 630,000 ac/ft and 990,000 ac/ft, respectively, preventing an estimated $90 million in damages.

But the toughest test came during the wet winter of 1986. During a six day period starting on 14 February, Folsom and Nimbus held in check inflows of greater than 1.14 million ac/ft, well above the design limit of 978,000 ac/ft for a six day flood. At the storm's height, inflows into Folsom Lake reached 170,000 square feet (s/f), with the maximum discharge at Nimbus reaching 130,000 s/f. The levee system protecting Sacramento was pushed beyond its design limit of 115,000 s/f, but through careful planning and operation of both dams, major damage was avoided. Water storage behind Folsom Dam reached 1,028,000 ac/ft, 18,000 ac/ft greater than its design capacity. The total amount of damage prevented by Folsom and Nimbus Dams in the 1986 floods exceeded $4.5 billion; by 1994, the Folsom/Nimbus duo had prevented an estimated total of $4.83 billion in flood damage.

In 1988, a study was conducted to reanalyze the performance of Folsom's main dam, auxiliary dam, and the dikes under the most current, worst-case seismic event model. The test showed that the main dam and earthfill dikes would perform satisfactorily should the design quake occur. Mormon Island Auxiliary Dam, however, had the potential to fail. To check this, in 1994 Reclamation performed safety modifications to shore up these deficiencies.

Prior to 1995, Folsom Dam had operated for four decades without any significant operational problems or modifications. However, on 17 July 1995, as Folsom Lake neared maximum capacity, operators attempted to raise spillway gate #3 to make a routine release of water. As the gate rose, one of its supporting arms buckled, allowing the gate to swing open. This released nearly 45,000 cfs into the American River through gate #3, necessitating the cessation of power generation and releases through the other gates. Flows through the damaged gate continued unabated for three weeks, until contractors were able to lower a 107-ton panel of steel beams into the gate in front of the opening. In order to prevent further damage to its downstream facility, Reclamation staff at Folsom acted quickly to open gates at Nimbus to allow passage of this release. No one was injured in the American River by this flow, partly because it occurred early in the morning hours ahead of typical recreational usage. During the three weeks of uncontrolled spill, nearly 360,000 ac/ft of water was lost—nearly one-third of Folsom Lake's capacity.

A 1992 Safety of Dams evaluation on Nimbus showed the facility to be in excellent condition, with no major problems or deficiencies. It was determined that the dam's design would operate without failure under both the maximum probable seismic event and maximum probable flood.

Since 9/11, both facilities have undergone security upgrades similar to other high-profile CVP facilities like Shasta and Friant Dams. Citing national security concerns, in 2003 Reclamation closed the road atop Folsom Dam, an important commuter route for locals driving from one side of the Delta River Canyon to the other. Although the City of Folsom offered over $2 million to Reclamation reopen the road, citing congestion and gridlock on other city streets as the primary reason, the agency refused. To alleviate the problem, plans are underway for the USACE to construct access roads and a bridge across the American River downstream from Folsom Dam; plans are also under consideration to raise the dam to provide more storage and flood relief.

CVP ENGINEERING FEATURES 1957-2000: AN OVERVIEW

In order to understand current CVP operations, it is necessary to briefly overview the project's (currently) non-historic engineering features and how they enhanced the capabilities of the historic features previously examined. Table 2 details the major legislation that created the new divisions after 1956. This MPL is designed to be amended in the future when these features become National Register eligible, as per the 50 year standard.

Trinity Division [†††]

As another scheme to divert more water to the Sacramento River basin, the Trinity River flows westerly from the Scott Mountains, where it joins the Klamath River approximately 41 miles from the Pacific Ocean. Authorized on 12 August 1955, the CVP's Trinity River Division consists of Trinity Dam and Claire Engle Lake (located about 55 miles northwest of Redding), Trinity Powerplant, Lewiston Dam and Lake, Lewiston Powerplant, Clear Creek Tunnel, Judge Francis Carr Powerhouse, Whiskeytown Dam and Lake, Spring Creek Tunnel and Powerplant, Spring Creek Debris Dam and Reservoir, and related pumping and distribution facilities.

Operations-wise, Trinity Dam stores Trinity River Water in Claire Engle Lake, and water is released through Trinity Powerplant. A few miles downstream, Lewiston Dam diverts Trinity River Water through the Lewiston Powerplant, where it is directed into Clear Creek Tunnel to begin the eleven-mile journey through the Trinity Mountains. Water then enters Whiskeytown Lake through Judge Francis Carr Powerplant.

[†††] Eric Stene, "The Trinity River Division- Central Valley Project," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995).

Some of this water diverts from the lake into the Clear Creek Unit South Main Aqueduct to irrigate lands in the Clear Creek Unit. The remainder flows through the Spring Creek Power Conduit and Powerplant into the Shasta Division's Keswick Reservoir. From there, the water goes through Keswick Powerplant, then south to the Sacramento River.

Trinity Dam, Powerplant, Claire Engle Lake

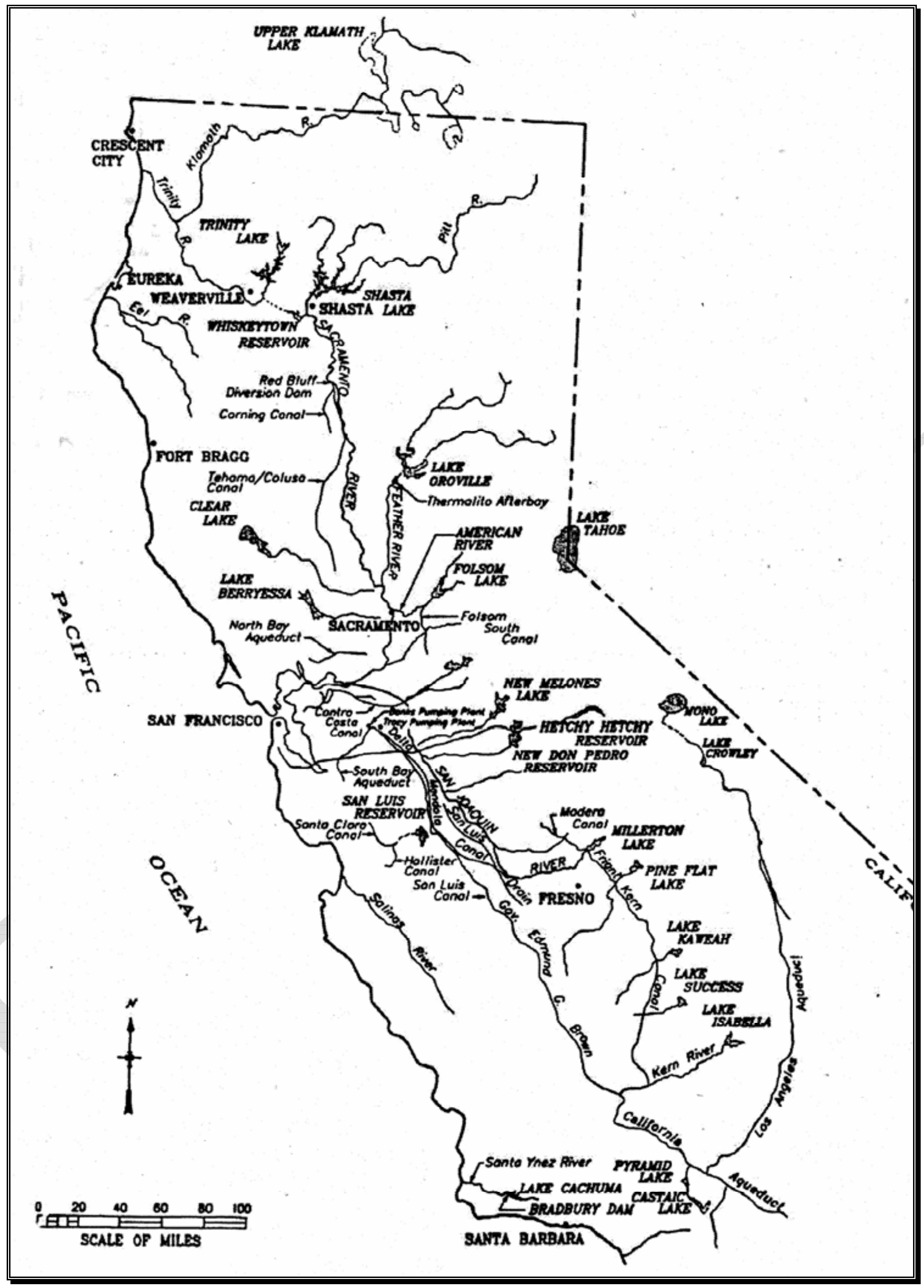
Trinity Dam regulates flows and stores surplus water for irrigation. Completed in 1962, Trinity is America's tallest earthfill dam at 538 feet high, with a crest length of 2,450 feet, and a volume of 29,000,000 cu/yd of material. Claire Engle Lake has a storage capacity of 2,448,000 ac/ft. The lake offers many recreational opportunities, including fishing, camping, boating, water skiing, and hunting. Trinity Powerplant is a peaking plant dedicated to meet the electrical needs of CVP facilities. The remaining energy is then marketed to various preference customers in northern California, with Trinity County getting top priority. Completed in 1964, the powerplant began operations with a capacity of 100,000 kW for its two generators. Using advancements in high voltage technology, Reclamation upgraded both generators by 20,000 kW for a total current capacity of 140,000 kW.

Lewiston Dam, Lake, Powerplant

Located seven miles downstream from Trinity Dam, Lewiston Dam creates an afterbay to Trinity Powerplant and diverts water to Whiskeytown Lake via the Clear Creek Tunnel and Judge Francis Carr Powerhouse. Completed in 1963, Lewiston Dam is a zoned earthfill structure 97 feet high with a crest of 754 feet. Lewiston Reservoir has a capacity of 14,660 ac/ft. Completed in 1964, Lewiston Powerplant is located at the base of Lewiston Dam. Lewiston Powerplant is a "run-of-the-river" plant which provides station service to Trinity Powerplant, as well as power to the Trinity River Fish Hatchery (operated by the California Department of Fish and Game.) With one station service unit rated 350 kW, any excess energy is sold to Pacific Gas and Electric.

Judge Francis Carr Powerhouse

Formerly known as Clear Creek Powerplant, Judge Francis Carr Powerhouse is located on Clear Creek at the outlet of the Clear Creek Tunnel on the northwestern end of Whiskeytown Lake. Completed and operational in 1963, it is structurally and architecturally identical to the Trinity and Spring Creek Powerplants. The power facilities consist of an intake structure located in Lewiston Reservoir, the tunnel, a powerplant bypass to Clear Creek, a surge tank and basin, penstocks and valve structure house, and two 13.8 kW generators each rated at 80,000 kilovolt amperes (kVA). Although the powerhouse generators' capacity was originally 143,680 kW, in 1984 Reclamation upgraded the generators to their current capacity of 154,400 kW. Like Trinity Powerplant, Judge Francis Carr Powerhouse is a peaking plant dedicated to first meeting CVP energy requirements, with the remaining energy marketed to various preference customers in northern California, with Trinity County getting top priority.



Map 7: Central Valley Project Major Components, including State Water Project

Clair A. Hill Whiskeytown Dam and Lake

Located on Clear Creek, Clair A. Hill Whiskeytown Dam and Lake regulates Trinity River flows discharged from Judge Francis Carr Powerhouse, and regulates the runoff from the Clear Creek drainage area. Completed in 1963, the dam is a zoned earthfill structure 282 feet high with a crest length of 4,000 feet. Its reservoir, Whiskeytown Lake, has a capacity of 241,100 ac/ft and provides assorted recreational opportunities similar to other CVP reservoirs and lakes.

Spring Creek Debris Dam, Reservoir, Tunnel

Completed in 1962, Spring Creek Debris Dam, located above the Spring Creek Powerplant tailrace, is an earthfill structure 196 feet high with a 1,110 foot-long crest. The 5,780 ac/ft capacity Spring Creek Reservoir controls debris which would otherwise enter the Spring Creek Powerplant's tailrace, and provides important fishery benefits by controlling contaminated runoff resulting from old mine tailings on Spring Creek. The 18.5 foot diameter, 2.4 mile long Spring Creek Tunnel diverts water from Whiskeytown Lake to the Spring Creek Powerplant.

Spring Creek Powerplant

Identical in design to the Trinity and Carr Powerplants, the Spring Creek Powerplant is located at the Spring Creek arm of Keswick Reservoir about one mile northwest of Keswick Dam. Situated at the foot of Spring Creek Debris Dam, water for power is received from Whiskeytown Lake through Spring Creek Tunnel and sent through the powerplant, which then discharges the water to Keswick Reservoir. Completed and operational in 1964, its generators are rated at 180,000 kW. Like the other Trinity Division powerplants, Spring Creek is a peaking plant dedicated to first meeting CVP energy requirements, with remaining energy marketed to various preference customers in northern California and Trinity County. Powerplant operations are tied to flow regimes aimed at minimizing the buildup of metal concentrations in the Spring Creek arm of Keswick Reservoir.

Distribution System

The Cow Creek and Clear Creek South Units were authorized as a part of the CVP's Trinity River Division. They consist of pumping plants and conveyance systems to transport irrigation water to approximately 6,800 acres of irrigable land east of Redding, and 4,600 acres of irrigable lands west of Anderson, respectively.

Sacramento River Division, Sacramento Canals Unit [‡‡‡]

The CVP's Sacramento Canals Unit was designed to provide irrigation water in the Sacramento River Valley, principally in Tehama, Glenn, and Colusa Counties. Authorized on 25 September 1950, the unit's major facilities include Red Bluff Diversion Dam, Corning Pumping Plant, the Tehama-Colusa Canal, and the Corning Canal. In 1963, the USACE finished building Black Butte Dam as a separate project. The Black Butte Integration Act of 23 October 1973 brought the dam and reservoir under the Sacramento River Division as the Black Butte Unit.

[‡‡‡] Eric Stene, "The Sacramento River Division – Central Valley Project," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995).

Red Bluff Diversion Dam

Completed in 1964, Red Bluff Diversion Dam is a gated weir concrete structure bookended with earthfill wings that stands 52 feet high and is 5,985 feet long at its crest. It is located on the Sacramento River about 2 miles south of Red Bluff, and diverts Sacramento River water into the Corning and Tehama-Colusa Canals for irrigation service to the south.

Corning Canal

The Corning Canal diverts water from the Tehama-Colusa Canal's settling basin about one-half mile downstream of Red Bluff Diversion Dam. The water is then lifted 56 feet at the Corning Pumping Plant and delivered to lands in Tehama County that have elevations too high to be served by the Tehama-Colusa Canal. Completed in 1957, Corning Canal is 21 miles long, terminating about 4 miles southwest of Corning. The initial diversion capacity is 500 cfs, gradually dwindling to 88 cfs at the terminus.

Tehama-Colusa Canal

Completed in 1980, the Tehama-Colusa Canal receives water from Red Bluff Diversion Dam's settling basin. Facilities consist of a drum screen complex to keep fish out of the dual-purpose canal, and a single purpose spawning channel that parallels the main canal for a short distance. The fish facilities provide 1.6 million square feet of special, gravel-bottomed canal as a salmon spawning area, the largest of their kind in the world.

The Tehama-Colusa Canal is 110.9 miles long, 11 miles shorter than originally intended. It travels south from Red Bluff Diversion Dam through Tehama, Glenn, and Colusa Counties, and into Yolo County, where it terminates about 2 miles south of Dunnigan. The canal's initial capacity is 2,530 feet per second, and gradually diminishes to 1,700 feet per second at its terminus. Funks Dam and reservoir is located along the canal; its primary purpose is to regulate canal flows.

Pumping Plants

Six pumping plants operate along the Sacramento Canals Unit. Five of these plants feed water to the Colusa County distribution system from the Tehama-Colusa Canal. Completed in November 1960, the Corning Pumping Plant diverts then lifts Sacramento River water from the Red Bluff Diversion Dam to the Corning Canal.

American River Division, Auburn-Folsom South Unit [§§§]

The CVP's Auburn-Folsom South Unit was designed to provide a new and supplemental water supply for irrigation and municipal and industrial needs, and to alleviate the badly depleted groundwater tables in the Folsom South service area. Authorized in 1965, the Auburn-Folsom South Unit originally consisted of Auburn Dam and Powerplant (the primary feature, to be located on the American River near Auburn), County Line Dam and Reservoir, Sugar Pine Dam and Reservoir, and the Folsom South Canal. However, only Sugar Pine and portions of the Folsom South Canal have been completed. Despite the construction of an automobile bridge and

[§§§] William Joe Simonds, "The American River Division," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995).

diversion tunnel at the site, Auburn Dam's construction has been placed on indefinite hold pending further detailed environmental and seismic studies. The same holds true for County Line Dam, to be located on Deer Creek about 10 miles south of Folsom Dam.

The Sugar Pine facility provides water for the Foresthill Divide area, while the Folsom South Canal provides municipal and industrial water for Sacramento and San Joaquin Counties. Although Sugar Pine Dam was built by Reclamation and completed in 1982, operation and maintenance responsibilities were transferred to the Foresthill Public Utility District in 1984.

Folsom South Canal

Reclamation planned the Folsom South Canal to be built in five reaches, totaling 68.8 miles. However, only the first two reaches totaling 26.7 miles have been built, with no current plans to build the remaining three stretches. The canal originates at Nimbus Dam on the American River, and extends southward. As originally planned, the Folsom South Canal would have terminated about 20 miles southeast of Stockton. This concrete lined canal has a capacity of 3,500 cfs for the first two reaches, with a bottom width of 34 feet and a maximum depth of 17.8 feet.

East Side Division, New Melones Unit [****]

The East Side Division and the construction of the New Melones Dam and Powerplant is one of the most controversial chapters in CVP history. Developing this division brought the need for water and flood control into direct conflict with concerns over damage to cultural resources and the environment. The battle over construction of New Melones Dam signaled that the era of large dam construction had come to an end. This controversy revolved around the loss of a

[****] William Joe Simonds, "The East Side Division, The New Melones Unit," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995).

popular stretch of recreational whitewater, inundation of archeological sites, and flooding of the West's deepest limestone canyon. Controversy over the project lasted more than a decade before approval to proceed and build the dam and powerplant.

The Flood Control Act of 1944 authorized construction of a 355-foot-high concrete arch dam (and use of the existing powerplant) to replace the original Melones Dam. The USACE was to build and operate this dam to help alleviate serious flooding along the Stanislaus and lower San Joaquin Rivers. However, the Flood Control Act of 1962 reauthorized and expanded the project into a multi-purpose (irrigation, flood control, power generation) unit to be built by the USACE and operated by the Secretary of the Interior as part of the CVP, thus creating the New Melones Unit. The 1962 act also changed the dam to a 625-foot-high earth and rockfill dam, and required the construction of a new powerplant.

New Melones Dam and Lake

Located on the Stanislaus River about 40 miles east of Stockton, New Melones Dam is about three-quarter of a mile downstream from the original Melones Dam. Built by the Oakdale and South San Joaquin Irrigation Districts in 1926, the original dam is now submerged under the reservoir. Completed in 1979, and primarily a CVP flood control facility, New Melones Dam is a earth and rockfill structure that stands 625 feet above streambed, has a crest length of 1,560 feet, and a volume of 15,700,000 cu/yd of materials. Its reservoir, New Melones Lake, has a capacity of 2.4 million ac/ft, a water surface area of 12,500 acres, and 100 miles of shoreline. Operations of the New Melones facility also depend on Tulloch Reservoir as an afterbay to control erratic releases.

New Melones Powerplant

Completed in 1979, New Melones Powerplant is located immediately downstream of the dam on the north bank. It contains two generators, each rated at 150,000 kW. The generating capacity is about 279 megawatts, producing about 455 million kW-hours of energy annually. This energy is equivalent to the annual electrical requirements of some 72,000 households. Water is supplied to the power units by two, 17-foot diameter, concrete lined tunnels that branch off from the main multi-purpose outlet tunnel.

San Felipe Division [††††]

This CVP division, located in the central coastal area of California, embraces the Santa Clara Valley in Santa Clara County, the northern portion of San Benito County, the southern portion of Santa Cruz County, and the northern edge of Monterey County. Division features include San Justo Dam and Reservoir, Pacheco Tunnel reaches one and two, 48.5 miles of closed conduits, two pumping plants, switchyards, and one small reservoir. Provisions for the future construction of about 25 miles of closed conduits to Santa Cruz and Monterey Counties are included in the division features.

Authorized in 1960, the division provides supplemental water to 63,500 acres of land, in addition to 132,400 ac/ft annually for municipal and industrial use. Water is conveyed from the Sacramento/San Joaquin Delta through the Delta-Mendota Canal to the O'Neill Forebay. The water is then pumped into San Luis Reservoir and diverted through the 1.8 miles of Pacheco Tunnel Reach One to the Pacheco Pumping Plant. The plant then lifts the water to the 5.3-mile-long high-level section of the Pacheco Tunnel Reach Two, and without additional pumping,

[††††] Wyndham Whynot and William Joe Simonds, "The Central Valley Project – The San Felipe Division," *Central Valley Project* (Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995.)

flows through the Pacheco Conduit to the bifurcation of the Santa Clara and Hollister Conduits. The water is then conveyed throughout the service areas for irrigation and municipal/industrial purposes.

San Justo Dam and Reservoir

Completed in January 1986, San Justo Dam is located about 3 miles southwest of Hollister. The dam's primary purpose is to serve as an offstream storage facility. Water from Hollister Conduit is stored in the reservoir and released in the winter months. San Justo Dam is a zoned earthfill and rock structure that stands 146 feet high, with a crest length of 1,105 feet. A zoned earthfill dike structure 66 feet high with a 918-foot-long crest is required as a supplemental feature. Together, these features form a reservoir with a 10,308 ac/ft capacity.

Hollister Conduit

Completed in May 1987, the underground, 17-mile-long Hollister Conduit has a capacity of 83 cfs, and extends from the Pacheco Conduit to San Justo Reservoir.

Santa Clara Tunnel and Conduit

Completed in May 1987, Santa Clara Tunnel and Conduit is 22.1 miles long, and has a capacity of 330 cfs. It conveys water from the Pacheco Conduit to the Coyote Pumping Plant, for distribution to Santa Clara County.

Pacheco Tunnels

Completed in October 1986, both Pacheco Tunnel reaches total 7.9 miles, are 9.5 feet in diameter, and have capacities of 480 cfs. The tunnels, along with the Pacheco Pumping Plant, convey water from San Luis Reservoir through the Diablo Mountain range.

Pacheco Conduit

Completed in September 1986, the 7.9 mile long Pacheco Conduit transports water from the Pacheco Tunnel Reach Two outlet to the bifurcation of the Santa Clara and Hollister Conduits.

Pumping Plants and Switchyards

Division facilities also include two pumping plants and switchyards. The Pacheco Pumping Plant is located at the end of Pacheco Tunnel Reach One, while the Coyote Pumping Plant is located at the end of the Santa Clara Conduit near Anderson Dam.

West San Joaquin Division, San Luis Unit [‡‡‡‡]

The San Luis Unit, a part of the Central Valley Project and also part of the State of California Water Plan, was authorized in 1960. Reclamation and the State of California constructed and operate this unit jointly. Some features are "joint-use facilities" of the Federal Government and the State. The principal purpose of the Federal portion of the facilities is to furnish approximately 1.25 million ac/ft of water as a supplemental irrigation supply to some 600,000 acres located in the western portion of Fresno, Kings, and Merced Counties.

[‡‡‡‡] Robert Autobee, "The West Side Division, The San Luis Unit," *Central Valley Project (*Denver: Bureau of Reclamation History Program, Unpublished Manuscript, 1995.)

The major portion of San Luis Unit is a combined effort of the Federal and State governments; 55 percent of the total cost is contributed by the State of California and the remaining 45 percent by the United States. The joint-use facilities are O'Neill Dam and Forebay, B.F. Sisk San Luis Dam, San Luis Reservoir, William R. Gianelli (San Luis) Pumping-Generating Plant, Dos Amigos Pumping Plant, Los Banos and Little Panoche Reservoirs, and San Luis Canal from O'Neill Forebay to Kettleman City, together with the necessary switchyard facilities.

The Federal-only portion of the San Luis Unit includes the O'Neill Pumping Plant and Intake Canal, Coalinga Canal, Pleasant Valley Pumping Plant, and the San Luis Drain.

B.F. Sisk Dam and Reservoir

These joint Federal/State facilities are located on San Luis Creek near Los Banos, California. Completed in 1967, B. F. Sisk Dam is a zoned earthfill structure 382 feet high with a crest length of 18,600 feet; it contains 77,656,000 cubic yards of material. The dam's crest is 30 feet thick; the maximum base width is 2,420 feet. In the United States, only the USACE’s Fort Peck and Oahe Dams along the Missouri River in the Dakotas carry greater mass for an earthfill structure.

The reservoir has a capacity of 2,041,000 ac/ft and is used to store surplus water of the Sacramento-San Joaquin Delta. Releases are made through the San Luis Pumping-Generating Plant, using its power generating capacity.

O'Neill Dam and Forebay

These joint Federal/State facilities are located on San Luis Creek, 2.5 miles downstream from San Luis Dam. O'Neill Dam, completed in 1967, is a zoned earthfill structure with a height of 87 feet and a crest length of 14,300 feet. The top 20,000 ac/ft acts as the re-regulator storage necessary to permit offpeak pumping and onpeak generation by the main San Luis Pumping-Generating Plant.

The O'Neill Forebay Inlet Channel extends 2,200 feet from the Delta-Mendota Canal to deliver water to the O'Neill Forebay. The forebay holds 56,000 ac/ft, part of which is used for regulator storage to permit off-peak pumping and on-peak generation. Six pumping units of the O'Neill Pumping-Generating Plant lift water 45 to 53 feet into the forebay. The forebay, with a capacity of 56,400 ac/ft, is used as a hydraulic junction point for Federal and State waters.

O´Neill Pumping Plant

This Federal facility consists of an intake channel leading off the Delta-Mendota Canal, 70 miles south of the Tracy Pumping Plant, and six pumping-generating units. The plant was completed in 1967. These units operate as pumps to lift water from 45 to 53 feet into the O'Neill Forebay. When water is occasionally released from the forebay to the Delta-Mendota Canal, these units operate as generators. When operating as pumps and motors, each unit can discharge 700 cfs and has a rating of 6,000 h/p. When operating as turbines and generators, each unit has a generating capacity of about 4,200 kW.

William R. Gianelli Pumping-Generating Plant

This joint Federal/State facility, located adjacent to San Luis Dam, lifts water by pump-turbines from the O'Neill Forebay into San Luis Reservoir. During the irrigation season, water is released from San Luis Reservoir back through the pump-turbines to the forebay, and energy is reclaimed.

Each of the eight pumping-generating units uses 63,000 h/p when pumping, or will develop 53,000 kW when generating. When completed in 1967, it became California's largest hydroelectric plant.

San Luis Canal

This joint Federal/State facility is a concrete-lined canal with a capacity ranging from 8,350 to 13,100 cfs. The San Luis Canal is the biggest earth-moving project in Reclamation history. It is the federally-built and operated section of the California Aqueduct and extends 102.5 miles from the O'Neill Forebay, near Los Banos, in a southeasterly direction to a point west of Kettleman City. The 138-foot-wide channel is 36 feet deep, 40 feet wide at the bottom, and lined with concrete.

Before computers were available, field surveyors spent a day converting a mile’s worth of raw field data into working cross-sections and engineering material. Keypunch cards and magnetic tape fed into a Reclamation computer in Denver cut the calculating time for designing San Luis canal by an estimated 26 man years.

The first release of water from the O'Neill Forebay to the initial reach of the canal was on April 13, 1967. Water was pumped from Dos Amigos Pumping Plant into the second reach in October of that year, and by December, water reached Kettleman City at the end of Reclamation’s canal. At that point, the conduit becomes the state's California Aqueduct.

Dos Amigos Pumping Plant

This joint Federal/State facility, 17 miles south of the Forebay, is a pumping plant in the San Luis Canal. The plant contains six pumping units, each capable of delivering 2,200 cfs to the canal at 125 feet of head.

Pleasant Valley Pumping Plant

Pleasant Valley Pumping Plant is a Reclamation facility which pumps water into the Coalinga Canal. Westlands Water District operates and maintains this pumping plant. This Federal facility lifts water 180 feet from an intake channel leading from the San Luis Canal at mile 74. Three 7,000-, three 3,500-, and three 1,250-h/p units are used to deliver 1,135 cfs of water to the Coalinga Canal and 50 cfs of water to a distribution lateral serving adjacent lands north of the pumping plant.

Coalinga Canal

This Federal facility, completed in 1973 and formerly called Pleasant Valley Canal, carries water from the turnout structure on the San Luis Canal to the Coalinga area, in Fresno County. The system includes a 1.6-mile intake channel to the Pleasant Valley Pumping Plant and 11.6 miles of canal. The initial capacity of the canal is 1,100 cfs, decreasing to 425 cfs at the terminus. Reaches 1 and 2 of the canal are operated by the Westlands Water District.

Los Banos and Little Panoche Detention Dams and Reservoirs

Los Banos and Little Panoche Detention Dams are southwest of the town of Los Banos on Los Banos and Little Panoche Creeks. These joint Federal/State facilities are required to protect the San Luis Canal by controlling flows of streams crossing the canal. Los Banos Reservoir has a capacity of 34,600 ac/ft. It protects the city of Los Banos and adjacent areas from damaging floods and provides recreation facilities for picnicking, camping, swimming, fishing, and boating. Little Panoche Reservoir contains floodwater collected over 81.3 square miles of mountainous drainage area and provides limited recreation facilities. Both are zoned earthfill detention dams. Los Banos Detention Dam, completed in 1965, is 167 feet high with a 1,370-foot-long crest. It provides 34,500 ac/ft of flood control capacity with a maximum controlled release of 1,000 cfs. Little Panoche Detention Dam, completed in 1966, contains a little more than a million yards of earthfill in its 151-foot-high embankment. The dam's crest is 1,440 feet long and 30 feet wide. The reservoir's capacity is 5,580 ac/ft.

San Luis Drain and Kesterson Reservoir

The San Luis Drain, a Federal facility, is designed to convey and dispose of subsurface irrigation return flows from the San Luis service area. Construction began in April 1968. The drain was designed to collect subsurface drainage from 8,000 acres in the San Luis service area, and transport the water for disposal in the west Delta. The design capacity was 300 cfs. Of the planned 188 miles of drains, 87 miles were completed; construction was halted in 1975 because of mounting costs and concerns about the quality of the agricultural drainage that would go into the Delta’s ecosystem.

Kesterson Reservoir is a collection of ponds outside the town of Gustine, in Merced County, where water was ponded, regulated, and allowed to evaporate pending approval and construction of an outlet for the San Luis Drain. The reservoir served in the conservation and management of wildlife and recreation and was designated as a national wildlife refuge.

Non—Historic Engineering Features of Historic CVP Divisions

Friant Division

John A. Franchi Diversion Dam

The only non-historic feature on the Friant Division is the John A. Franchi Diversion Dam. Completed in 1964, the dam was built by Reclamation and is operated by the Madera Irrigation District. It is an earth and sheet steel piling structure that stands 15 feet high and spans 263 feet across the Fresno River, and helps divert Fresno River water into the Madera Equalization Reservoir.

Delta Division

Contra Loma Dam

The only non-historic feature on the Delta Division is Contra Loma Dam, an offstream water storage site for the Contra Costa Canal. Completed in 1967, Contra Loma Dam is a zoned earthfill structure 107 feet high with a crest length of 1,050 feet. Contra Loma Reservoir has a capacity of 2,100 ac/ft. The dam and reservoir are situated at the southern end of Antioch, and are operated by the Contra Costa Water District.