LAYPERSON'S GUIDE TO

California Water

Prepared by the Water Education Foundation

Contents

Updated 2003

On the Cover:

Burney Creek in northern California provides the water for Burney Falls, a popular tourist destination as well as an integral part of the state's complex water system.

Inset: The California Water Map, a 24" by 36" poster published by the Water Education Foundation. Copies are $10.00 each and can be ordered from the Foundation.

The *Layperson's Guide to California Water* is prepared and distributed by the Water Education Foundation as a public information tool. It is part of a series of Layperson's Guides that explore pertinent water issues in an objective, easy-to-understand manner.

The mission of the Water Education Foundation, an impartial, nonprofit organization, is to create a better understanding of water issues and help resolve water resource problem through educational programs. For more information contact:

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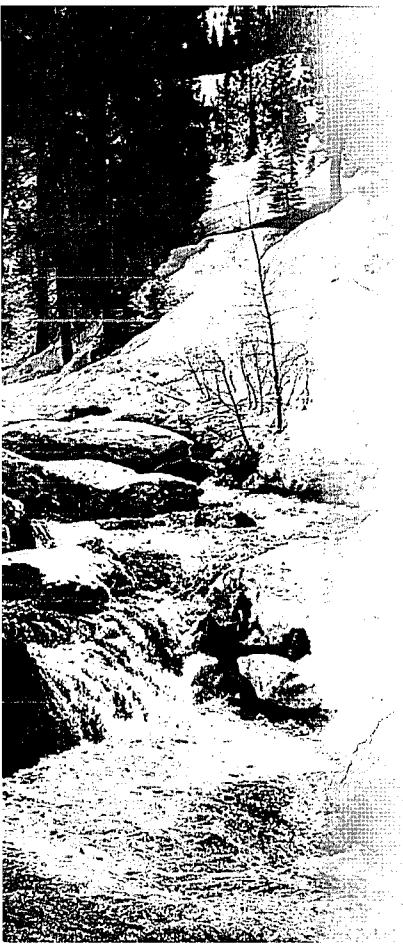
Introduction



The Sierra Nevada snowpack serves as a natural reservoir where winter precipitation is stored until it melts in the spring and summer. California's average annual runoff is about 71 million acre feet of water.

California and water. The two always have been, always will be, inextricably linked. No resource is as vital to California's urban centers, agriculture, industry, recreation, scenic beauty and environmental preservation as its "liquid gold."

And no resource is as steeped in controversy. Throughout California's history, battles have been waged over who gets how much of this precious resource. While the echoes of rifle shots and dynamite explosions are part of the state's distant past, the fight continues today in courtrooms throughout the state and on the floors of the state Legislature and the U.S. Congress.

The basic issues affecting California's water supply are distribution and sharing the resource. Distribution, over both distance and time, is coupled with conflicts between competing interests over the use of available supplies. Nearly 75 percent of the available water originates in the northern third of the state (north of Sacramento), while 80 percent of the demand occurs in the southern two-thirds of the state. The demand for water is highest during the dry summer months when there is little natural precipitation or snowmelt. California's capricious climate also leads to extended periods of drought followed by flooding.

These basic problems have been remedied, in large part, by building one of the most complex and sophisticated water storage and transport systems in the world. An integrated system of federal, state and locally owned dams, reservoirs, pumping plants and aqueducts transports large portions of the state's surface water hundreds of miles. California's rise to pre-eminence as the nation's most populous state, and the world's fifth largest economy, has depended largely on its ability to resolve many of these water supply problems.

But moving water over great distances has created intense regional rivalries. Water feuds historically have divided the state, pitting north against south, east against west and three major stakeholders (agriculture, urban and environment) against one another. Intense disagreements persist over the manner in which California's water resources are developed and managed.

Environmental groups and fish and wildlife biologists argued for years that the health of California's fish populations, riparian vegetation and wildlife have been sacrificed to ensure adequate water supplies for cities and farms. The environmental movement, backed by strong state and federal environmental legislation beginning in the 1970s, slowed the construction of most new dams and conveyance facilities for more than 30 years. Other water development projects have been stopped by high construction costs, concerns over seismic safety and a dearth of suitable locations.

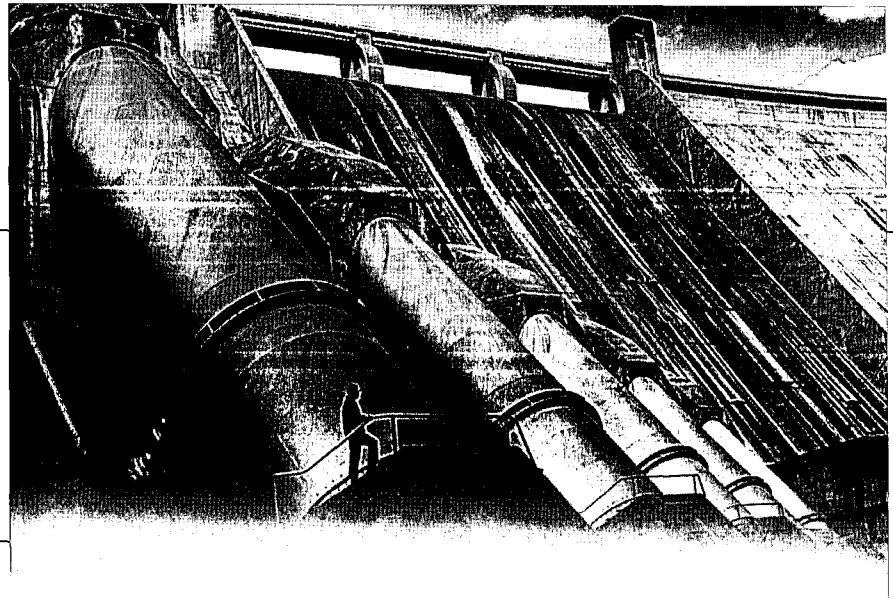
While the environmental movement appeared to signal an end to the dam-building era, California's relentless population growth has kept up pressure to find enough water to meet the state's needs. Census figures for 2001 put California's population at 34.5 million people, with forecasts that it will approach 50 million by 2025. The California Department of Water Resources (DWR) estimated in 1998 that urban water needs in average water years would grow from 8.8 million acre-feet in 1995 to 12 million acre-feet in 2020. Given those growth scenarios, water planners are looking at ways to augment surface water storage by raising dams or building new off-stream reservoirs.

New storage and conveyance facilities are being studied as part of the CALFED process, a collaboration of federal and state entities, along with stakeholder groups, that is working to resolve issues in the Sacramento-San Joaquin Delta – the source of water for about two-thirds of the state. A permanent California Bay-Delta Authority was authorized in 2002 to oversee an ambitious 30-year plan that addresses the major areas of ecosystem restoration, water supply, water quality and levee stability (see page 16).

Uncertainty about new surface water facilities has led water managers to focus on developing alternative ways to meet the growing demand such as water marketing and water transfers (exchanging, leasing or selling water from one water user to another), urban water conservation programs and increased reliance on groundwater supplies. California voters have recognized the need for new water infrastructure by approving Proposition 13, a $1.97 billion bond issue in 2000, and Proposition 50, a $3.44 billion bond issue in 2002, both of which provide funds to augment supplies and improve water quality.

Yet the age-old conflicts persist, most recently in negotiations to reduce California's use of Colorado River water. State, local and federal negotiators have been working on a complex plan to gradually cut California's use by about 20 percent, but agreement on a key agriculture-to-urban water transfer has been elusive, as has resolution of an environmental issue – the desire to protect the Salton Sea in any such transfer.

This Layperson's Guide, part of a continuing series published by the Water Education Foundation, is intended to give the reader basic background information on California's water resources. More in-depth information on many of the topics addressed in this guide can be found in other Layperson's Guides in the set.



A worker is dwarfed by the five huge penstocks and spillway of Shasta Dam on the upper Sacramento River.

THE RESOURCE

California's "Mediterranean" climate, characterized by warm, dry summers and mild winters, is considered one of its great attractions, but it also can be unpredictable with flooding followed by drought and few years of "normal" precipitation. Precipitation averages about 193 million acre-feet per year. (An acre-foot, the common measurement for water, equals 325,851 gallons, or enough water to cover a football field to a depth of one foot.) About two-thirds of that total (121 million acre-feet) evaporates, percolates into the ground or is absorbed by plants. This leaves about 71 million acre-feet in average annual runoff, much of which eventually flows into California's two great river systems: the Sacramento and San Joaquin rivers. Both these rivers flow through the Central Valley and meet in the Delta.

Runoff and precipitation in California can be quite variable. Of the 10 water years between 1993 and 2003, five were considered by DWR to be wet (above average), two were above average, two were listed as dry and one was listed as critically dry. The wide variability is illustrated dramatically by the 1987-1992 drought, when annual runoff was about half the average amount – about 35 million acre-feet – and 1995's flooding, when runoff was about 130 million acre-feet.

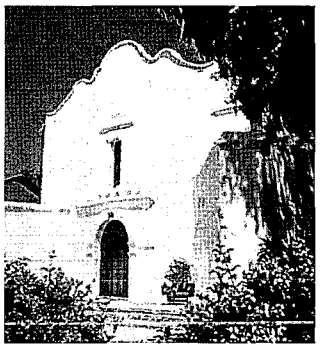
Precipitation also varies widely, sometimes reaching more than 100 inches per year on the north coast, yet less than 2 inches of rain annually in the inland deserts bordering Mexico. The state's mountain ranges also affect precipitation. The Coastal Range prevents moisture from reaching the dry Central Valley and the Sierra Nevada catches clouds before they reach Nevada. As clouds rise and cool they drop their moisture and feed the streams that flow down the mountains' western slope. The Sierra Nevada snowpack melts in the warmth of spring and runoff fills reservoirs where it is stored for use in the dry summer.

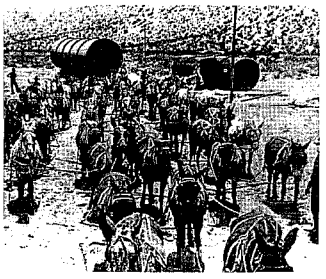
In addition to the state's runoff, California annually receives about 1.4 million acre-feet in runoff from Oregon and 4.4 million acre-feet from the Colorado River. In a normal precipitation year, about half of the state's available surface water – 35 million acre-feet – is collected in over 1,300 local, state and federal reservoirs. This water is called "developed water" because it is managed, stored, diverted from rivers or otherwise developed for human or environmental use.

Roughly one-third of the state's water supply in a normal year comes from groundwater. Its usage can increase to 40 percent or more during drought years. California leads the nation in groundwater withdrawals, pumping about 16.6 million acre-feet annually, according to DWR. The state has substantial groundwater reserves that lie beneath about 40 percent of its land area. This water doesn't exist in underground lakes but in the pores and spaces between alluvial materials (sand, gravel, silt or clay) in water-bearing formations called aquifers. Of an estimated 850 million acre-feet of water stored in California's underground aquifers, only about 250 million acre-feet can be economically used. However, this is six times the 44 million acre-feet capacity of the state's surface water reservoirs. Eighty percent of the state's pumped groundwater goes toward agricultural irrigation.

At the heart of California – and of most discussions about water – is the Sacramento-San Joaquin Delta. This 1,153-square-mile maze of islands and interconnected waterways is located where the Sacramento and San Joaquin rivers converge and flow into San Francisco Bay. About 42 percent of the state's annual runoff flows through the Delta. Two-thirds of Californians get all or part of their drinking water from the Delta by virtue of local, state or federal water projects that export water to the San Francisco Bay area and central and southern California. The Delta also is the largest estuary on the West Coast boasting hundreds of species of birds that travel along the Pacific Flyway and dozens of fish species, including salmon and steelhead that migrate through the Delta on their journey to and from the ocean.

Chronology





1769 First permanent Spanish settlements; water rights established.

1848 Gold discovered on the American River.
Treaty of Guadalupe signed, California ceded from Mexico, California republic established.

1850 California granted statehood.
Office of Surveyor General established and charged with planning water projects.

1860 Legislature authorizes the formation of levee and reclamation districts.

1880 First flood control plan for the Sacramento Valley developed by State Engineer William Hammond Hall.

1884 Federal Circuit Court decision in *Woodruff v. North Bloomfield*, requires termination of hydraulic mining debris discharges into California rivers.

1886 California Supreme Court decision in *Lux v. Haggin* reaffirms legal pre-eminence of riparian rights, upheld again 40 years later.

1892 Conservationist John Muir founds the Sierra Club.

1901 First California deliveries from the Colorado River made to farmland in the Imperial Valley.

1902 U.S. Bureau of Reclamation established by the Reclamation Act of 1902.

1905 First bond issue for the city of Los Angeles' Owens Valley project; second bond issue in 1907 approved for actual construction.
Colorado River flooding diverts the river into Imperial Valley, forming the Salton Sea.

1908 City of San Francisco's filings for Hetch Hetchy project approved.

1913 Los Angeles Aqueduct begins service.

1920 Col. Robert B. Marshall of the U.S. Geological Survey proposes a statewide plan for water conveyance and storage.

1922 Colorado River Compact of 1922 appropriates 7.5 million acre-feet per year to each of the river's two basins.

1923 Hetch Hetchy Valley flooded to produce water supply for San Francisco despite years of protest by John Muir and other conservationists.
East Bay Municipal Utility District formed.

1928 Congress passes Boulder Canyon Act, authorizing construction of Boulder (Hoover) Dam and other Colorado River facilities.
Federal government assumes most costs of the Sacramento Valley Flood Control System with passage of the Rivers and Harbors Act.
California Constitution amended to require that all water use be "reasonable and beneficial."
St. Francis Dam collapses, flooding the Santa Clara Valley, killing more than 450 people.
Worst drought of the 20th century begins in California and ends in 1934, establishing benchmark for storage and transfer capacity of all major water projects.

1931 State Water Plan published, outlining utilization of water resources on a statewide basis.
County of Origin Law passed, guaranteeing counties the right to reclaim water from an exporter if it is ever needed in the area of origin.

1933 Central Valley Project (CVP) Act passed.

1934 Construction starts on the All-American Canal in the Imperial Valley (first deliveries in 1941) and on Parker Dam on the Colorado River.

1937 Passage of the Rivers and Harbors Act of 1937 authorizes construction of initial features of the CVP by the U.S. Army Corps of Engineers.

1940 Metropolitan Water District of Southern California's Colorado River Aqueduct completed, first deliveries in 1941.

1944 Mexican-American Treaty guarantees Mexico 1.5 million acre-feet per year from Colorado River.

1945 State Water Resources Control Board (State Board) created.

1951 State authorizes the Feather River Project Act (later to become the State Water Project).
First deliveries from Shasta Dam to the San Joaquin Valley.

1955 Flood in the Sacramento Valley kills 38 people.

1957 California Water Plan published.

1959 Delta Protection Act enacted to resolve some issues of legal boundaries, salinity control and water export.

1960 Burns-Porter Act ratified by voters; $1.75 million bond issue to assist statewide water development.

1963 *Arizona v. California* lawsuit decided by the U.S. Supreme Court in Arizona's favor, allocating 2.8 million acre-feet of Colorado River water per year to Arizona.

1964 Partially completed Oroville Dam helps save Sacramento Valley from flooding.

1966 Construction begins on New Melones Dam on the Stanislaus River after 20 years of controversy over the reservoir's size and environmental impacts; completed in 1978.

1968 Congress authorizes Central Arizona Project (CAP) to deliver 1.5 million acre-feet of Colorado River water a year to central and southern Arizona.
Congress passes Wild and Scenic Rivers Act.

1970 Passage of the National Environmental Quality Act (NEPA), the California Environmental Quality Act (CEQA) and the California Endangered Species Act (CESA).

1972 California Legislature passes own Wild and Scenic Rivers Act to preserve the north

coast's remaining free-flowing rivers from development.
Federal Clean Water Act (CWA) passed to clean up the nation's polluted waters.

1973 First SWP deliveries to southern California.

1974 Congress passes the Safe Drinking Water Act.

1978 State Board issues Water Rights Decision 1485 setting Delta water quality standards.

1980 State-designated wild and scenic rivers placed under federal Wild and Scenic Rivers Act protection.

1982 Proposition 9 (SB 200), the Peripheral Canal package, overwhelmingly defeated in statewide vote.
Reclamation Reform Act raises from 160 acres to 960 acres the amount of land a farmer can own and still receive low-cost federal water.

1983 California Supreme Court in *National Audubon Society v. Superior Court* rules that the public trust doctrine applies to Los Angeles' diversion from tributary streams of Mono Lake.
Dead and deformed waterfowl discovered at Kesterson Reservoir, pointing to problems of selenium-tainted agricultural drainage water.

1986 Ruling by the state Court of Appeals (Racanelli Decision) directs the State Board to consider all beneficial uses, including instream needs, of Delta water when setting water quality standards.
Passage of Safe Drinking Water and Toxic Enforcement Act (Proposition 65) prohibiting discharge of toxic chemicals into state waters.
Coordinated Operation Agreement for CVP and SWP operations in the Delta signed.
Severe flooding nearly tops levees in Sacramento.

1987 State Board's Bay-Delta Proceedings begin to revise D-1485 water quality standards.

1989 In a separate challenge to Los Angeles' Mono Basin water rights, an appellate court holds that fish are a public trust resource in *California Trout v. State Water Resources Control Board.*
MWD and Imperial Irrigation District agree that MWD will pay for agricultural water conservation projects and receive the conserved water.

1991 MOU signed to implement urban water conservation programs.
Inyo County and the city of Los Angeles agree to jointly manage Owens Valley water, ending 19 years of litigation.
West Coast's first municipal sea water desalination plant opens on Catalina Island.

1992 Congress approves landmark CVP Improvement Act.

Lake Oroville on the Feather River – the State Water Project's largest storage reservoir – during drought conditions in February 1991.

1993 Federal court rules in *Natural Resources Defense Council v. Patterson* that the CVP must conform with state law requiring release of flows for fishery preservation below dams.
Arizona's CAP declared complete by the federal government.

1994 State Board amends Los Angeles' water rights licenses to Mono Lake.
Bay-Delta Accord sets interim Delta water quality standards.

1995 State Board adopts new water quality plan for the Delta and begins hearings on water rights.

1997 New Year's storms cause state's second most devastating flood of the century.
SWP's Santa Barbara Aqueduct completed.

1999 Splittail minnow and spring-run Chinook salmon added to federal endangered species list.

2000 CALFED Record of Decision signed by state and federal agencies giving go-ahead for 30-year plan to improve water quality, reliability and environment of the Delta.

2002 Voters approve Proposition 50, a $3.44 billion bond issue to fund improvements in water quality and reliability and pay for safe drinking water projects.

2003 Interior Secretary orders California's allocation of Colorado River water limited to 4.4 million acre-feet; negotiators revisit Quantification Settlement Agreement.
Environmental groups and DWR settle lawsuit over 1995 Monterey Agreement, which restructured SWP water-supply contracts; settlement will require more precise forecasts by DWR of water availability.

Developing the State's Water

Early Development

The American Indians who first inhabited the territory altered streambeds by driving in poles and erecting simple dams for catching salmon. The first significant development of California's water resources began in the late 1700s, when Spanish padres used ditches to irrigate mission fields from nearby streams. But the Gold Rush of 1849 was the impetus for extensive development. The discovery of gold at John Sutter's mill on the American River brought thousands of miners to California to comb the Sierra Nevada foothills for riches.

These fortune seekers built the state's first hydraulic works – reservoirs and more than 4,000 miles of ditches and flumes – to sluice out the elusive shining metal. Water was harnessed and blasted into hillsides to dislodge gold in a practice called "hydraulic mining." Debris resulting from these mining practices washed down from the mountains and choked rivers, inundated native salmon spawning grounds and caused serious problems with flooding for navigation and downstream water users.

As the gold began to diminish, California's new settlers sought their fortunes elsewhere – many in the fertile soils of the Central Valley and Delta. As farming grew, so did the need for a dependable water supply. While many areas experienced too little water, others had too much. In the maze of swamps, sloughs and marshlands that form the Delta, farmers began building levees around periodically submerged islands and pumped water from behind them to reclaim the land for agriculture. Between 1860 and 1930, most of the Delta's 350,000 acres of fresh water marsh were leveed, drained and planted.

Elsewhere, groundwater pumping enabled farms and cities to flourish despite the aridity of southern and central California. However, groundwater levels began to drop, which caused an increase in pumping costs. This pointed out the need for a more efficient distribution of the state's surface water supplies.

Groups of farmers banded together, and cooperatives and development companies formed to finance and construct water projects in the San Joaquin Valley and southern California. The inherent problems associated with placing control of such a vital, public resource in private hands brought a move toward increasing public control.

Numerous attempts were made to find a workable law under which public irrigation districts could be formed. It was not until a young Stanislaus County school teacher named C.C. Wright was elected to the state Legislature that those efforts came to fruition in the Wright Irrigation District Act of 1887. The first irrigation district formed under the new law, Turlock Irrigation District, was organized the same year and others quickly followed suit. The act evolved into the California Irrigation District Act of 1917, and paved the way for other types of water development and delivery districts, such as county water districts and special services districts.

The American Indians, who first inhabited the territory, altered streambeds by driving in poles and erecting simple dams for catching salmon.

As early as 1875, the U.S. Army Corps of Engineers (Corps) began work on the Sacramento and Feather rivers to improve navigation. In 1920, Col. Robert Bradford Marshall of the U.S. Geological Survey proposed a comprehensive, statewide plan for conveyance and storage of California's water supplies. This plan served as the framework for an eventual State Water Plan, which later formed the basis for the federal Central Valley Project (CVP).

However, the history of early water development in California also tells stories of tragedy. William Mulholland, Los Angeles' chief engineer at the turn of the century and moving force behind the Owens Valley aqueduct, also designed more than a dozen reservoirs. These included the St. Francis Dam built in the San Francisquito Canyon, which was filled with water from the Owens Aqueduct. After reaching full capacity for the first time on March 12, 1928, the dam began to leak. Just before midnight, the dam

collapsed sending a 100-foot wave down into the Santa Clara Valley (today's Santa Clarita Valley near the Magic Mountain area north of the San Fernando Valley). "The torrent swept clean 65 miles of rich, fertile valley...One-hundred-ton blocks of concrete rode the water like rubber ducks. Ranch houses were crushed like eggshells, their cement foundations pulverized. Steel bridges were smashed like tin cans, and acres of citrus and nut trees uprooted..." Sections of Ventura County lay under tons of debris and more than 400 people were dead, according to Margaret Leslie Davis, author of *Rivers in the Desert: William Mulholland and the Inventing of Los Angeles.*

Water Rights

As the state grew, a complex system of water rights evolved. Under earlier Mexican rule, the prevailing law was the pueblo right. Pueblos – primitive towns – had the right to use water to satisfy their inhabitants' needs, ranging from domestic uses to irrigation. After California became a state in 1850, the common law of England was adopted to include "riparian rights" – water rights laws based on ownership of land bordering a waterway. The riparian property owner possesses the right to use that water, a right that cannot be transferred apart from the land.

During the Gold Rush, miners developed a system of claiming rights to take and transport water. They "posted notice" at diversion points from which the right by priority of appropriation, or "first in time, first in right," developed. Mining communities recognized and protected the rights of "posted" appropriators. These appropriative rights are water use rights based on physical control and beneficial use of the water without regard to the relationship of land to water. These rights are entitlements to a specific amount of water with a definite date of priority and may be sold or transferred. In 1914, major changes in law established a permit and licensing process for establishing appropriative rights.

Conflicts developed between riparian water right holders and appropriative water right holders that continue today. Two important state Supreme Court decisions, *Lux v. Haggin* in 1886 and *Herminghaus v. Southern California Edison Company* 40 years later, reaffirmed the legal pre-eminence of riparian rights. During the years that intervened between the two cases, the number of cities, agricultural water users and other appropriative users increased. When *Herminghaus* was decided, riparian users were not required to make reasonable use of water to conserve it for appropriative users. However, reasonable use of water was required by appropriative users. Public consternation over the decision resulted in a constitutional amendment in 1928, which sets the standard for water use today.

Appropriative water rights were first established when miners claimed water by diverting it.

Article X, Section 2 of the California Constitution requires that all water use be both "reasonable and beneficial." Beneficial uses include irrigation, domestic, municipal and industrial, hydroelectric power, recreational use and protection and enhancement of fish and wildlife. Reasonable use, however, is more difficult to categorize. It is defined in part by what it is not; that is, waste or unreasonable use. According to the state Supreme Court, reasonableness is determined by the circumstances "but varies as the current situation changes."

Today, California operates under a dual system that recognizes both riparian and appropriative rights. In addition, with the dawn of the 21st century, the courts increasingly have recognized instream uses and expanded public trust values in determining how the state's water resources should be best used. Rooted in Roman law, the public trust doctrine recognizes the public right to many natural resources including "the air, running water, the sea and its shore." The public trust doctrine requires the sovereign, or state, to hold in trust designated resources for the benefit of the people. Public trust rights historically included navigation, commerce and fishing, but have been broadened to include the right to recreate, hunt and preserve scenic and ecological values.

The Projects

The development of California's surface water resources has been a diverse process performed by private companies and local, state and federal agencies, yielding a variety of benefits and problems. On the plus side, the state has greatly improved its navigable waterways and provided water for homes, farms, industry, recreation and wildlife areas. Flood control projects have prevented billions of dollars' worth of damage and countless lost lives. Hydropower, a relatively pollution-free source of electricity, has helped lessen our dependence on oil, gas and coal. The ability to deliver millions of gallons of fresh water to the semi-arid Central Valley and southern California has spurred great agricultural and industrial productivity.

The negative side of the development is that some of California's rivers and streams, marshlands and valleys, and the wildlife inhabiting these areas, have been significantly altered or destroyed. When the Tuolumne River was dammed in 1923 to provide water for the city of San Francisco, a valley rivaling nearby Yosemite Valley in beauty was lost. With stream channelization, 90 percent of the state's original wetlands have disappeared. Dams and agricultural diversion on the Sacramento and San Joaquin river systems have blocked salmon spawning migrations and reduced stream flow, eliminating salmon runs in some stretches and threatening the continued survival of others.

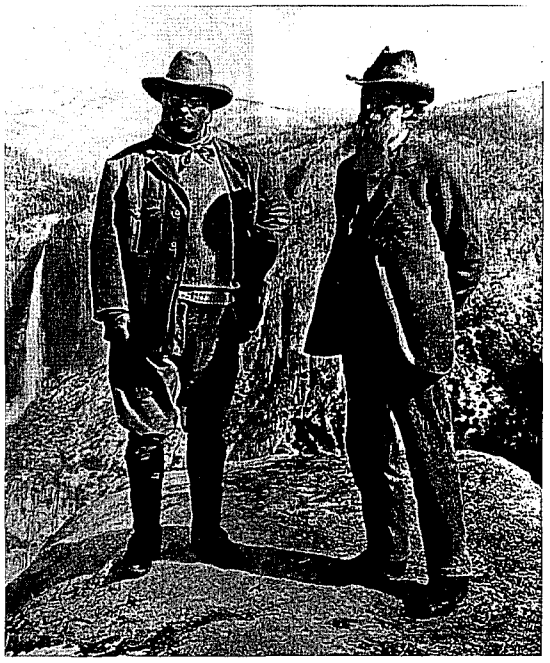
First Projects

Early on, California's two major population centers, the Los Angeles and San Francisco Bay areas, recognized the need to augment local water supplies and were the first to develop faraway sources.

In 1905, the city of Los Angeles filed for water rights on the Owens River in the eastern Sierra Nevada, 250 miles away. Under water chief Mulholland, municipal crews began work on a 233-mile aqueduct capable of delivering four times more water than the city then required. The Los Angeles Aqueduct was completed in 1913, and with the availability of this firm water supply the city grew. By 1920, Los Angeles was as populous as San Francisco. In order to protect its rights, Los Angeles began purchasing land and accompanying water rights in the Owens Valley and converting cropland to a less water-intensive use: cattle grazing. Irrigated acreage in the valley dropped from about 75,000 acres in 1920 to 23,625 acres in 1940. Area ranchers and businessmen feared for the valley's agricultural future and dynamited the aqueduct in a futile attempt to stop the water from flowing south.

With Los Angeles as landlord, the Owens Valley developed into a recreation area with leased rather than owner-occupied farms. Today Los Angeles controls nearly all the land on the valley floor. Until recent court decisions reduced the amount of exported water, valley water provided up to 75 percent of the city's annual supply. After years of legal battles, Inyo County and the city of Los Angeles came to an agreement in 1991 to jointly manage the valley's water resources and regulate the amount of exported water based on environmental effects. Particulates from the dried lake bed have raised health concerns for those in the region. In 1998, a basin re-watering plan was instituted to reduce particulates and improve air quality.

At the turn of the century, San Francisco was looking at available water resources. It chose as a supply the Tuolumne River that flows through the western slopes of the Sierra Nevada. The Hetch Hetchy Valley in Yosemite National Park was selected as a dam site. Controversy over developing this magnificent, pristine valley into a reservoir brewed for decades. John Muir, the great conservationist and founder of the Sierra Club, led the fight against development. Nevertheless, a series of bond measures was approved to build the system, and in 1913 Congress passed the Raker Act, authorizing the Hetch Hetchy project while attempting to placate conflicting interests. In 1923, with the completion of O'Shaughnessy Dam, the Hetch Hetchy Valley was flooded.



President Theodore Roosevelt (left) and John Muir pose together high above Yosemite Valley in 1903. Muir helped influence Roosevelt to preserve the valley as a park, but he could not halt the flooding of nearby Hetch Hetchy Valley.

Central Valley Project

The federal government has long played a major role in development of the West's water resources. With passage of the Reclamation Act of 1902 and the leadership of President Theodore Roosevelt, the U.S. Bureau of Reclamation (Bureau), a branch of the Department of the Interior, was created to reclaim Western lands, primarily for agricultural development.

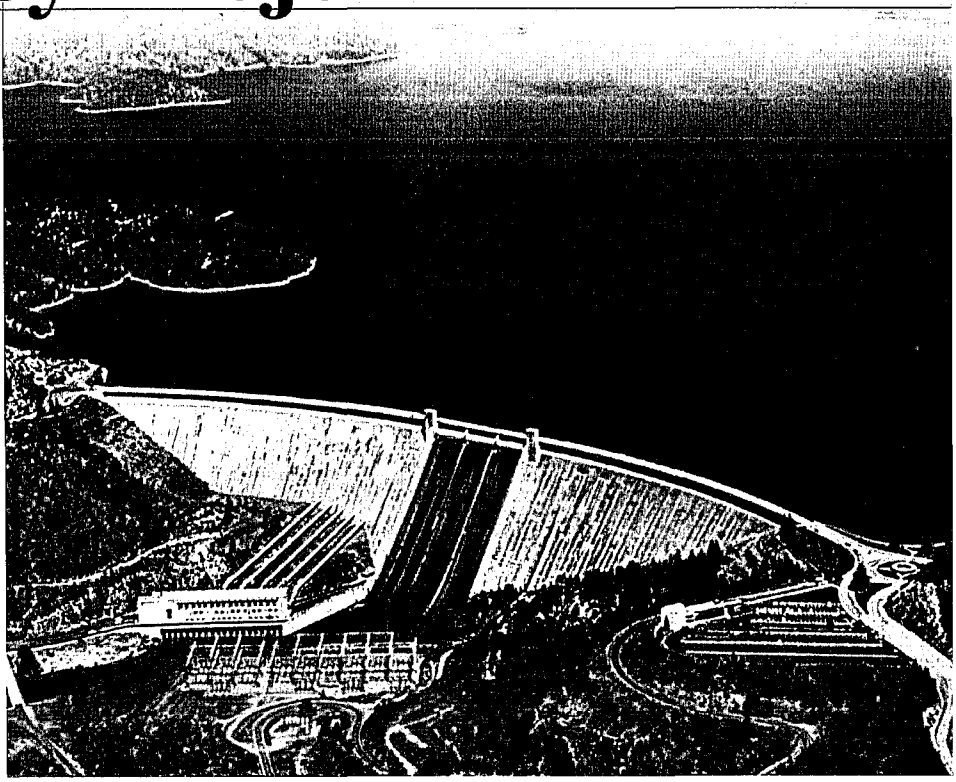
A massive project to benefit California's vast Central Valley was the focus of state and federal attention. Conceived in 1933 as a state project to control flooding, store water and produce electricity, the proposed state-funded Central Valley Project quickly ran into Depression-era financing difficulties. Attempts to obtain federal grants and loans failed and the state asked the federal government to take over. In 1937, passage of the Rivers and Harbors Act authorized construction of the initial features of the federal CVP, and by 1951, most were completed.

The CVP encompasses 18 dams and reservoirs with a combined storage capacity of 11 million acre-feet, 11 power plants and three fish hatcheries. The dams and reservoirs of the CVP were constructed primarily for river regulation, navigational improvement and flood control. In a normal year the CVP delivers about 7 million acre-feet of water, 95 percent for irrigation and 5 percent for urban use. It provides water to 3 million acres of farmland in the Central Valley – and water to about 2 million urban customers. The project also provides water for power generation and recreation.

Major features of the CVP include Shasta Dam and reservoir on the Sacramento River, Trinity Dam and Clair Engle Lake on the Trinity River, Folsom Dam and reservoir on the American River, Friant Dam and reservoir on the San Joaquin River, New Melones Dam and reservoir on the Stanislaus River and San Luis Reservoir, a joint federal-state storage facility.

One of the CVP's last features, the New Melones Dam on the Stanislaus River, helped galvanize the river-preservation movement in California. The struggle between environmentalists and water developers lasted from the early 1970s until the Stanislaus Canyon was flooded in 1982 and 1983 during a high runoff year.

The federal government financed nearly all construction costs on most CVP projects, with costs to be reimbursed by state and local agencies over a period of decades. CVP customers initially paid a flat rate for water, but in 1986 the Bureau approved a new irrigation rate-setting policy that increased prices for CVP water. The 1992 CVP Improvement Act (CVPIA) mandated replacement of fixed-price water supply contracts with a tiered pricing structure. As fixed-price contracts expire, they are being replaced by tiered pricing contracts.



Shasta Dam and reservoir on the upper Sacramento River is the CVP's largest storage facility, capable of holding 4.5 million acre-feet of water.

The CVP and other federal reclamation projects created a subsidy in the form of interest-free water and facilities for irrigation users, a feature designed to bring settlers to the West and bolster the economy and national security. The 1902 Reclamation Act included a provision limiting this low-cost water to farmers who owned 160 acres or fewer. The limitation was long opposed by farmers, and the Reclamation Reform Act of 1982 increased the allowable acreage to 960.

CVP facilities opened up new Central Valley lands to farming, especially on the west side of the San Joaquin Valley, but an unfinished part of the project caused some farm land to be taken out of service. CVP plans initially included a canal to collect irrigation drainage from west side farms, but the drain was never completed. Several farmers in Westlands Water District sued the Bureau for not providing the promised drainage. The suit was settled in 2003 with the Bureau agreeing to buy out the farmers and retire the land from production.

The question of state or federal ownership of the CVP has been an issue since the project's incep-

tion. Disagreement simmered over how the project would be administered and who would benefit. In 1945, the secretary of the Department of the Interior suggested a purchase price of $357 million – then considered an incredible cost – and eventually the state dropped the proposal. In 1992, the discussion was broached again, but stalled. CVP users launched an unsuccessful effort to buy the project in 1995, halted by disagreements over the purchase price, liability issues and concerns about the rate charged for water supply.

In 1962, President John F. Kennedy and California Gov. Pat Brown triggered the detonation of explosives to break ground on the joint federal-state San Luis Dam and Reservoir project near Los Banos.

The CVP's benefits touch the lives of every American who buys grapes, lettuce, canned tomatoes or a cotton shirt made from Central Valley crops. The major redistribution of water that it wrought, however, has not occurred without controversy. Conflicts have long festered over the project's public costs and private benefits. Critics contend that by encouraging agriculture on a grand scale, the CVP has contributed to the depletion of anadromous fish and the buildup of salt and selenium in San Joaquin Valley soils. More recently, urban water users and environmental advocates have coveted the CVP's hold on 20 percent of the state's developed water.

In 1992, the changing views and conflicting values coalesced in the form of landmark federal legislation, the CVPIA. The act brought fundamental change to CVP operations and water allocation, elevating fish and wildlife protection and restoration to a primary project purpose. CVPIA reallocated 800,000 acre-feet of CVP yield annually (600,000 acre feet in dry years) to restore valley fisheries and wildlife and established a $50 million environmental restoration fund. It also allowed CVP water rights holders to sell their water to outsiders. CVPIA pleased environmentalists and municipalities, but many CVP farmers say the act goes too far.

In 1997, farmers from the west side of the San Joaquin Valley and environmentalists filed suit against the Bureau over its plan to improve water quality for endangered fish using a portion of the CVPIA water. Both sides said the federal government had to include an accounting method for keeping track of how much water would be needed for the fish, and in 1999 a federal judge agreed. The Bureau developed a new plan in 1999 and a federal court ruling in March 2000 ended the three-year suit after deciding the federal plan legally used and accounted for the environmental CVPIA water.

The CVPIA also included provisions to help rebuild populations of anadromous fish whose migratory patterns are affected by CVP facilities. One such provision, the Anadromous Fish Restoration Plan, is intended to double the number of anadromous fish, including Chinook salmon. A draft plan issued in 1997 will not be finalized until a record of decision is issued on the programmatic EIS of the CVPIA.

Since the late 1980s, populations of Chinook salmon in the Sacramento, Klamath and San Joaquin river basins have declined, with many runs at or near record lows. While mitigation plans and facilities have been a part of the CVP since the early 1940s, fish protection efforts had little impact on project operations until 1989, when one of four Sacramento River Chinook salmon species – the winter-run – was listed under the state and federal Endangered Species Acts (ESA). In 1998, spring-run Chinook were listed as well.

The effort to save the winter-run, especially during the drought years, brought fundamental change to CVP facilities and operations. New, state-of-the-art fish screens were installed at Red Bluff Diversion Dam on the Sacramento River. The dam's gates are now raised for eight months a year to allow salmon free passage. In the Delta, gates at the Delta Cross Channel also are closed for several months to reduce fish entrainment at the export pumps. Spawning gravel was replaced along miles of river and a captive winter-run breeding program is underway.

Other fish-protection projects include an $80 million temperature control device installed at Shasta Dam in mid-1997 and modernization of the Coleman and Nimbus fish hatcheries. Funded by the CVPIA, the temperature control device allows dam operators to forego cold water releases from the outlets to improve spawning conditions for the endangered winter-run salmon. The hatchery improvements are intended to help sustain the commercial ocean catch, but hatcheries cannot replace the wild salmon stocks biologists consider essential for survival of a species.

The CVPIA is being used as the wedge to get water meters installed in some of the last unmetered Central Valley communities. The Bureau has told cities such as Fresno and Folsom to install meters or face a cutoff of CVP water. Legislation also was proposed in 2003 to require urban water suppliers to install meters by January 1, 2008.

Colorado River

The turbulent Colorado River is one of the most controversial and heavily regulated rivers in the world. From its beginning northwest of Denver, the 1,450-mile long river and its tributaries pass through parts of seven states: four in the Upper Basin – Colorado, New Mexico, Utah and Wyoming – and three in the Lower Basin – Arizona, California and Nevada. Its water also is shared by several American Indian tribes and the Republic of Mexico. The Colorado is the only reliable water source for much of the desert Southwest. Allocations of the river are based on an average annual supply of 15 million acre-feet.

The first Californians to tap the Colorado River were settlers in the Palo Verde and Imperial valleys. They built canals to deliver river water to farmlands. In 1905, the river broke through a series of dikes, flooding a salty basin in the Imperial Valley and forming the Salton Sea. Monumental effort was required to divert the river back into its customary channel, a feat accomplished in 1907. Continued problems with water supply prompted settlers to form the Imperial Irrigation District (IID) in 1911. Because the main canal and levees supplying river water were located in Mexico and offered little security, valley pioneers and the district lobbied for an "All-American" canal north of the border.

Dividing use of the Colorado River's waters has not been easy and has involved compromises, interstate compacts, a U.S. Supreme Court decree, a treaty with Mexico and federal and state legislation. The interstate 1922 Colorado River Compact divided the watershed into Upper and Lower basins and apportioned the right to use 7.5 million acre-feet per year to each basin. Subsequently, Congress approved the Boulder Canyon Project Act, subdividing the water among the three Lower Basin states and authorizing construction of Hoover and Imperial dams and the All-American Canal. Under this act, California agreed to limit itself to no more than 4.4 million acre-feet of water per year, plus half of any surplus.

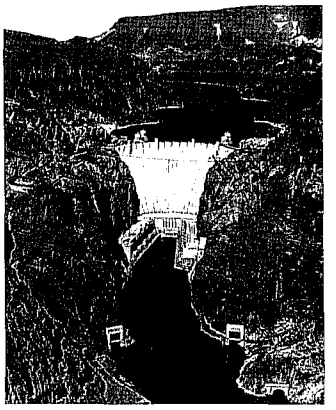
In 1924, Los Angeles applied to divert 1.1 million acre-feet annually from the Colorado. Los Angeles and other south coast cities promoted the formation of the Metropolitan Water District of Southern California (MWD) to build an aqueduct and serve as a water wholesaler. MWD was created by the Legislature and approved by public vote in 1928. A $220 million bond issue for a 242-mile long Colorado River Aqueduct was passed in 1931 and 10 years later it was completed. The aqueduct was later expanded to its current 1.2 million acre-feet capacity.

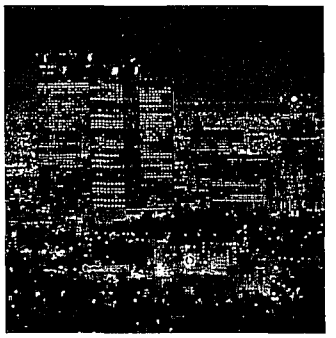
By 1952, disagreement erupted over the river's apportionment in the form of *Arizona v. California*. Arizona, with its growing population, wanted to ensure its share of the river under the 1922 Compact remained intact. Arizona appealed to the U.S. Supreme Court to confirm California's right to use only 4.4 million acre-feet of Colorado River water annually, plus half of any water determined surplus (including a state's apportioned but unused water) by Interior. The 1963 ruling confirmed this and entitled Arizona to receive 2.8 million acre-feet, not counting supply from tributary streams.

In recent years, southern California has used more than its 4.4 million acre-feet share of Colorado River water – up to 5.3 million acre-feet in some years. In December 1996, then-Interior Secretary Bruce Babbitt warned that because of growing demands in Arizona and Nevada, California should develop a conservation plan to avoid continually exceeding its allocation or else be subject to federally imposed water supply cuts.

Extensive negotiations led to California's Colorado River Water Use Plan, known colloquially as the "4.4 Plan." The plan is intended to gradually reduce California's use of the river by approximately 800,000 acre-feet annually by using a combination of water conservation, water transfers, dry-year fallowing agreements, lining sections of the All-American Canal to reduce seepage, groundwater banking, special surplus conditions and possibly desalination of drainage water. A linchpin of the deal was the Quantification Settlement Agreement, or QSA, which quantifies the water rights of southern California's big agricultural entities to Colorado River water.

A major part of the 4.4 Plan is a long-term water transfer of up to 200,000 acre-feet per year – the largest in California history – between IID and the San Diego County Water Authority (SDCWA). A related component is a recovery plan for the Salton Sea. The QSA appeared headed for approval in December 2002, when it suddenly unraveled. For several reasons, including concerns over proposed land fallowing in the Imperial Valley and potential liability for Salton Sea recovery, IID directors narrowly rejected the deal just before a December 31, 2002, deadline set by the Interior Department. When last-minute negotiations failed, Interior Secretary Gale Norton ordered California's allocation of Colorado River water cut to 4.4 million acre-feet beginning January 1, 2003. At IID's request, a federal judge in March 2003 nullified Interior's order as parties continued talks to revive the deal.



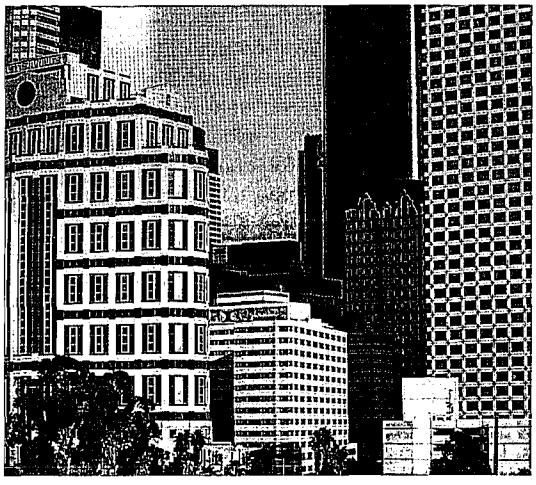


State Water Project

California's population doubled between 1940 and 1960. It appeared the state could not rely solely on federal or local sources to help meet future water needs. Water planners recognized the need for Delta improvements and for supplemental water to support growing southern California and prevent groundwater overdraft in the Central Valley. Additionally, the need for flood control on the Feather River was recognized, as was the San Joaquin Valley's need for an outlet for saline irrigation drainage from fields.

The first California Water Plan was published in 1957. It recommended immediate construction of a Feather River project, later to become the State Water Project (SWP), as the initial unit of the plan. After years of debate and study, the State Water Resources Development Act, known as the Burns-Porter Act, was ratified by voters in 1960. Gov. Edmund G. "Pat" Brown led the effort to resolve California's long-standing water conflicts. He recognized, as had his predecessor Gov. Goodwin Knight, that water was crucial to the state's future.

The works specified in the $1.75 billion bond issue included dams and reservoirs; several aqueducts, including a major conveyance system – the California Aqueduct – to carry water from the Delta to southern California, levee improvements and facilities to transfer water across the Delta, the joint-use (state and federal) San Luis project and drainage facilities for the San Joaquin Valley. Fish mitigation facilities include the Feather River Fish Hatchery downstream from Oroville Dam and the John E. Skinner Delta Fish Facility, where fish are diverted away from Delta pumps. To date, the initial features of this huge system have been completed though no drain has been built.



The California Aqueduct, above, as it meanders south along Interstate 5 near the Coast Range. The aqueduct delivers water 444 miles from the Delta to the city of Los Angeles, right.

Today's SWP consists of 22 dams and reservoirs. Water in the upper Feather River is provided from the project for water supply and recreation uses, where Oroville Dam forms the SWP's largest storage reservoir with a capacity of 3.5 million acre-feet. From there, water flows south to the Delta where the North and South Bay aqueducts serve communities in the San Francisco Bay area. The 444-mile long Edmund G. Brown California Aqueduct begins at the Delta Pumping Plant and parallels Interstate 5 south to the Tehachapi Mountains. To cross the Tehachapis into southern California, water is lifted at the A. D. Edmonston Pumping Plant some 2,000 feet – more water pumped higher than anywhere else in the world.

About 30 percent of SWP water is used for irrigation, mostly in the San Joaquin Valley. Approximately 70 percent is used for residential, municipal and industrial use, mainly in southern California. The SWP is operated and managed by DWR. Twenty-seven water agencies, of which MWD is the largest, contract with DWR for project water. These contracts call for ultimate delivery of 4.2 million acre-feet a year. Because the SWP as originally designed has not been completed, about 3 million acre-feet of "firm yield" is provided each year.

Under the terms of the SWP's $1.75 billion bond issue, users for the most part pay all costs of the project, including interest. SWP contractors also pay energy costs and a transmission charge based on the distance the water is transported. By contrast, the earlier constructed CVP only required repayment of the principal for its irrigation projects. Although SWP water is much more expensive than federal water, it is not subject to an acreage limit, as CVP water is.

Water delivery shortages during the 1987-92 drought triggered disputes over SWP service contracts, and a few SWP contractors threatened suit. After three months of negotiations, DWR and SWP contractors reached agreement on amendments to the SWP contracts in Monterey, Calif., in December 1994. The landmark Monterey Agreement signed by 26 of the then 29 SWP water contractors restructured SWP contracts to allocate water based on contractual entitlements instead of the amount of water actually

used in a year. In times of shortages, the SWP agricultural and urban contractors will be cut equally, whereas previously agricultural contractors' supplies were reduced first. SWP irrigators agreed to permanently retire 45,000 acre-feet of water entitlements and allow permanent sales of up to 130,000 acre-feet of water to urban contractors in exchange for transfer of the 20,000-acre Kern Fan Element of the Kern Water Bank.

As with so many other California water issues, the Monterey Agreement did not satisfy all parties. Environmental groups and a water agency in the Feather River watershed sued DWR in 1996 claiming the agreement did not receive adequate environmental review and the use of SWP water entitlement amounts encouraged growth without sufficient water supplies. The lawsuit was settled in 2003 with an agreement that DWR would prepare a new environmental impact report and give more accurate reports on the project's true water-delivery capabilities, which typically are lower than entitlement amounts.

To increase the firm yield of the SWP, DWR developed the Kern Water Bank, an underground storage project in Kern County. Water stored in an underground water aquifer – also known as water "banking" – is used to alleviate shortages in times of drought and increase SWP storage capacity without the construction of costly and environmentally troublesome surface reservoirs. Under the program, depleted groundwater aquifers are recharged with surface water delivered through the aqueduct in wet years. It also entails the recharge of ponds (shallow ponds where water is spread so that it percolates into the ground) and "in-lieu" programs. Under the latter, farmers are provided surface water in wet years to use in place of pumped groundwater. The Kern Water Bank was transferred from DWR to a new entity, the Kern Water Bank Authority, in 1996. By 2003, the bank had almost 2 million acre-feet of water stored underground.

After years of opposition fueled by no-growth advocates, Santa Barbara County voters in 1991 approved an aqueduct to serve the central coast. Construction on the $575 million pumping station and Coastal Aqueduct, which extends from Kern County to Lake Cachuma, began in 1994 and was completed in July 1997. In 2003, DWR planned to deliver 90 percent of the 70,486 acre-feet requested by the Santa Barbara and San Luis Obispo county water districts.

Local Districts

While the state and federal projects have played major roles in developing California's water resources, the role of local development should not be overlooked. Since the early 1900s, local water projects made possible the growth of Los Angeles and San Francisco, other southern California cities and agricultural areas throughout the state. Local districts also worked with private power utilities to construct projects that provide water and electricity.

Today hundreds of water utility districts supply Californians with water purchased by contract from the state or the Bureau, bought wholesale from another water agency or developed with local resources. It is estimated that there are more than 3,700 public and private agencies in California dealing with some aspect of water supply, use or treatment.

The largest of these is MWD. In 1995, MWD broke ground on a new 800,000 acre-feet reservoir in Riverside County. Completed in 2000, the $2-billion Diamond Valley Reservoir doubled surface water storage capacity for southern California; provides emergency storage in the event an earthquake disrupts other water sources, provides added drought insurance, assists in optimizing groundwater storage programs and helps improve water quality for the region.

Likewise, in northern California, Contra Costa Water District (CCWD) has created its own water supply by passing local bonds. Completed at the end of 1997, CCWD's $450-million Los Vaqueros Reservoir holds 100,000 acre-feet of water. Like MWD's Diamond Valley Reservoir, Los Vaqueros increased water supply reliability and water quality (through blending) for customers. Plans to expand it are under study.

Construction on Metropolitan Water District of Southern California's new 800,000 acre-feet Diamond Valley Reservoir was completed in 2000.

Flood Management

The rivers and streams that bring prosperity to California also can bring death and destruction when they burst from their banks.

The rivers and streams that are the lifeline of California also can be tremendously destructive forces when they burst from their banks. Before large-scale human settlement, California's rivers regularly ran wild over expansive floodplains, creating vast wetlands and marshy areas. Hydraulic mining practices during the Gold Rush era unwittingly made flooding worse by clogging rivers with sediment, which raised river beds and interfered with navigation and farming. In 1862, Sacramento was inundated by flood waters; in some areas the water was more than 20 feet deep. In response, landowners, merchants and farmers joined forces to protest the practice of hydraulic mining. In 1884, it was prohibited by the federal court.

The first plan to control seasonal flooding of the Sacramento Valley was formed by State Engineer William Hammond Hall in 1880. Once called the "Nile of the West," the Sacramento River yields about 35 percent of the state's water supply. In its natural state, the river periodically overflowed its banks during heavy winter rains and spring snowmelt. The need for flood control was highlighted by devastating flooding between 1902 and 1909. In 1917 a Sacramento Flood Control Project was authorized consisting of a system of levees, overflow weirs, pumping plants and bypass channels. In times of high flows, the bypasses carry many times the amount of water left in the Sacramento River. Relieved from the threat of floods, the area experienced an agricultural renaissance.

Today the Central Valley has a flood protection network that includes 23 reservoirs with flood detention space and more than 1,760 miles of federally designated levees, overflow weirs and channels. In addition, a series of dams were built on the western slope of the Sierra Nevada for both flood control and water supply. These include Shasta Dam on the Sacramento River, Oroville Dam on the Feather River and Folsom Dam on the American River.

The flood management system has been sorely tested over the years – most recently by the 1997 New Year's flood. The January deluge, which was the second most devastating flood of the 20th century, killed nine people, forced the evacuation of 120,000 people and caused nearly $2 billion in damage. The flood's destruction raised many questions – from technical to philosophical -- about the limitations of floodplain management and the hazards of floodplain development.

Three flood events between 1986 and 1997 prompted the Sacramento region to rethink its existing flood control system. Some have focused on the long-proposed Auburn Dam, on the American River above Folsom Dam, a controversial and unfinished feature of the CVP. Originally designed as a multipurpose project, some see a completed Auburn Dam as the solution to the Sacramento area's flood problems. But work on the dam was halted in 1977 after an earthquake raised questions about its safety and attempts to get the project completed have failed. Meanwhile, other solutions to Sacramento's periodic flooding problems have been offered, including raising the height of Folsom Dam and strengthening levees along the Sacramento and American rivers.

In the more arid southern California region, flash floods prompted formation of the state's first flood control district in 1915 in Los Angeles. To protect against flash flood dangers, one of the largest and most intricate flood control systems in the world was constructed. The network is operated by the Los Angeles County Department of Public Works in coordination with the Corps. It includes 15 flood control and water conservation dams, 450 miles of open flood control channels, and 2,500 miles of underground storm drains.

Flood control involves many different local, state and federal agencies, and their management philosophies change with the political and economic times. There is growing concern over the costs of providing disaster relief to property repeatedly damaged by floods. Traditional flood control strategies also have been affected by the massive 1993 Mississippi River flooding. The concept of floodplain management came to the forefront and interest was renewed following the 1997 New Year's flood. Floodplain management includes giving constricted rivers more breathing room by setting back levees, reducing floodplain development and giving equal weight to environmental and economic factors in making management decisions.

Complicating flood control practices and management are the often conflicting water supply practices and needs. Flood control managers must keep enough reservoir storage space available to manage floods during heavy precipitation, but water suppliers focus on storing enough water to protect against drought.

Groundwater

For more than a century, groundwater has supplied a major part of California's water needs – about one-third of the water supply in normal years and up to 40 percent in critically dry years. Although the state's surface and groundwater have been treated as separate resources, they are intimately connected. Precipitation seeps into the earth to become groundwater, later resurfacing in a spring, river or spring-fed lake. The use, transfer or contamination of one can directly affect the other.

The Golden State uses more groundwater than any other state – approximately 14.5 million acre-feet in normal years. Forty-three percent of Californians get their drinking water from groundwater, and it is the sole source of drinking water for many cities. Unlike most other Western states, however, California has no statewide management program or permit procedure to regulate groundwater appropriations. Appropriative procedures developed for surface water apply only to groundwater flowing through known and definite channels. But the bulk of California's vast groundwater resource – percolating groundwater – is not covered by these regulations.

Generally, Californians use more groundwater than is replaced naturally or artificially. It is estimated by DWR that annual statewide overdraft – the amount by which long-term extraction exceeds long-term supply – will decrease from 1.5 million acre-feet in 1995 to about 1.1 million acre-feet in 2020. Problems associated with overdrafted basins include lower water tables and increased energy costs for pumping, land subsidence, contamination from sea water intrusion and reduction in storage capacity of some basins.

Although there are no statewide regulations governing groundwater use, general parameters are provided by a number of judicial decisions. Until the early 1900s, California followed the English system that essentially allowed unregulated groundwater pumping. In 1903, the state Supreme Court in *Katz v. Walkinson* decided that given the state's arid climate, a rule of reasonable use should be applied to groundwater extractions. The *Katz* decision also held that property owners above a common aquifer have a shared right to the reasonable use of the groundwater below. Subsequently, courts established that groundwater may be appropriated by pumping and transported for use on land beyond the boundaries of the aquifer. A groundwater user's right is likely to go undisturbed unless challenged by a competing user in court or unless government intervenes in response to problems resulting from that use, such as land subsidence or contamination.

Today groundwater withdrawals are regulated only on a limited basis including where 1) a groundwater basin has been adjudicated; 2) the Legislature has granted a local water district power to monitor or regulate use or levy a "pump tax"; 3) groundwater management districts or counties have adopted relevant ordinances; 4) the water agencies in an area have agreed to self-regulation.

There are 19 adjudicated groundwater basins in California, most of them located in southern California. An adjudicated basin typically is overseen by a watermaster, an individual or committee charged with overall management of the groundwater basin. The watermaster monitors groundwater withdrawals to prevent overpumping and protects water quality of the basin. The activities of a watermaster are paid for by fees levied on groundwater pumpers within the adjudicated basin.

Attempts over the years to adopt statewide groundwater regulations have been vigorously opposed by overlying land owners, particularly agricultural interests and local water districts. At the local level there has been movement to control groundwater pumping. Under state legislation passed in 1992, local entities may voluntarily develop groundwater management plans in unregulated basins. In 1994, a state appellate court upheld the authority of cities and counties to regulate groundwater use.

Groundwater was once considered safe from pollution. It was believed that as surface water percolated into the ground, the soil would filter out contaminants. However, with continued use and disposal of toxic chemicals and the development of increasingly sophisticated detection equipment, traces of industrial solvents, pesticides and other chemicals have been discovered in groundwater supplies throughout California. The most recent contaminant of concern is perchlorate, a chemical used to make explosives and fireworks. Mainly a legacy of military ordnance manufacturing, perchlorate has been detected in more than 300 wells statewide. The California Department of Health Services is scheduled to issue a maximum contaminant level for perchlorate in drinking water by January 2004.

Concerns over groundwater quality led to enactment in 2001 of AB 599, a law that requires comprehensive monitoring and assessment of groundwater basins throughout California. The State Board issued a report in March 2003 outlining its plan for establishing such a program, which includes making monitoring and assessment information available to the public.

California uses more groundwater than any other state – on average 15 million acre-feet annually. Groundwater accounts for 30 percent of the state's supply in a normal water year and up to 40 percent in dry years.

Delta Issues

Aerial view of the Delta, a man-made collection of waterways and reclaimed islands that serves as a vital environment for fish and wildlife and the switching yard for the CVP and SWP pumps.

Probably the single most important aspect of California's complicated water picture is the Sacramento-San Joaquin Delta. The Delta is located southwest of Sacramento at the confluence of California's two greatest rivers, the Sacramento River flowing from the north and the San Joaquin River flowing from the south. Once an immense wetland, the Delta has been transformed since the Gold Rush into a complex maze of 57 major reclaimed islands intersected by a braided network of shallow channels and sloughs. It is the largest and most modified estuary on the west coast of North America.

About 42 percent of the state's annual runoff flows through the Delta and out to San Francisco Bay. The Bay-Delta Estuary is a mixing zone of fresh and salt water, and its unique environment supports diverse plant, fish and animal life. Construction of the CVP and SWP made the Delta a critical link in the state's complex water distribution system by using its channels to transport water from upstream reservoirs to the south Delta, where state and federal facilities (the Harvey O. Banks Delta Pumping Plant and the Tracy Pumping Plant) pump water into the California Aqueduct and CVP canals. Two-thirds of California's drinking water passes through the Delta.

The Delta is the state's most important fishery habitat. An estimated 25 percent of all warm water and anadromous sport fish and 80 percent of the state's commercial fishery live or migrate through the Delta. Several of these species – striped bass, Chinook salmon and Delta smelt – are in decline because of a combination of factors including water diversions, entrainment in water pumps, degraded water quality and the presence of non-native species that compete for food. Measures to protect the endangered winter-run Chinook salmon and the threatened 3-inch Delta smelt, which lives only in the Delta, have affected water exports – both the volume and timing of diversions. Some fishery stocks have shown signs of improvement in recent years, but biologists are uncertain if those trends will continue. Delta smelt numbers rebounded enough in the late 1990s that two Central Valley water agencies sought review in 2002 of the smelt's 1993 listing as a federal threatened species. They claim the listing caused reductions in water exports to farmers, but environmental groups and some fisheries biologists say the smelt's short lifespan (typically one year) means it is too early to consider changing the listing.

The Delta levee system, which turned what was once a marshland into productive farmland, is unstable and in constant need of repair. Numerous studies have shown that their repair and maintenance will cost hundreds of millions of dollars. Since 1980, 17 Delta islands have been partially or completely flooded. In addition, earthquakes pose a potential threat to levee stability. A sound, well-maintained levee system is essential both to the integrity of the islands and protection of the fresh water supply moving through the Delta. In some instances, local efforts to repair and maintain levees have come in conflict with state laws protecting riparian vegetation. To reduce levee failure and minimize the subsidence of highly eroded levees, DWR purchased land on two Delta islands and plans to convert them from agricultural use to wildlife habitat.

Over the years, numerous plans have been advanced to protect the Delta from salt water intrusion, periodic flooding, decreased stream runoff, and to preserve the region for fisheries, wildlife and recreation use. In the latter half of the 19th century and into the 20th century, the state studied physical barriers to prevent salt water intrusion that later were deemed uneconomical. Several times over the past 35 years (the first in 1964), proposals

have been made to build a so-called peripheral canal to move water around the Delta. In concept, doing so would improve water quality for southern California by eliminating the problem of salt intrusion from the Delta. However, concerns over increased water exports to central and southern California, along with concerns over the high price tag have kept the proposal from becoming reality.

In 2000 a consortium of federal and state agencies with management and regulatory responsibilities in the Bay-Delta, known as CALFED, signed a "record of decision," called the ROD, a 30-year plan to restore the Delta ecosystem and alleviate chronic water management problems. In 2002, legislation was approved to create the California Bay-Delta Authority to oversee the plan. Advised by a stakeholder group representing the agricultural, urban, environmental, fishing and business communities, the Authority proposes a variety of actions encompassing four main program components: ecosystem restoration, water quality improvement, water supply reliability and flood management. The program will be implemented in stages, the first of which is seven years long. The staging is intended to allow CALFED to monitor progress and tweak the various programs as needed.

Delta Water Quality Standards

The decades-long process of reaching agreement on water quality standards for the Delta illustrates the contentiousness of California water issues. The process has involved state and federal agencies, the courts and the three main water stakeholders – agriculture, urban water users and environmental interests.

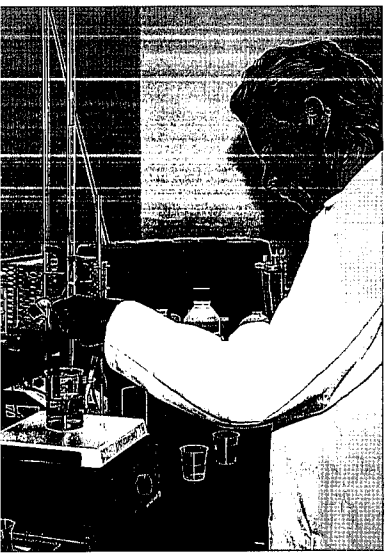
It began with a series of public hearings convened by the State Board in 1987 to re-evaluate the 1978 Bay-Delta water quality standards in accordance with the landmark 1986 case *U.S. v. State Water Resources Control Board*. That ruling, known as the Racanelli decision after its author, held that the State Board was required to consider both instream and consumptive uses when setting water quality standards, and that water rights are to be determined separately. The hearings yielded a draft water plan in late 1988 that included water quality and flow objectives, but it was undone by agriculture and urban water interests who feared supply cutbacks.

Interim water quality standards were prepared in 1992, but those standards, included in Decision 1630, were strongly opposed by agricultural water users yet supported by environmentalists and urban water suppliers. In March 1993, then-Gov. Wilson called on the State Board to drop the proposed interim standards. Enter the U.S. Environmental Protection Agency (EPA), which in December 1993 proposed an interim water quality plan under its Clean Water Act (CWA) authority. That plan incorporated the requirements of the CWA, ESA and CVPIA, but it was opposed by urban and agriculture water users because it proposed reductions in water exports and increases in fresh water flows to the Bay-Delta. Another year of intense negotiations between the federal and state agencies, urban water users, agricultural groups and environmental interests, finally produced the historic December 1994 Delta accord.

That interim agreement resolved, at least temporarily, the disputes over Delta water quality standards and laid the foundation for the CALFED process. It gave certainty to water suppliers by capping reductions of water exports at 400,000 acre-feet in normal years and 1.1 million acre-feet in dry years. Environmental interests got a promise to develop a comprehensive ecosystem management plan to protect the ailing estuary while long-term restoration plans are developed. Underlying the accord was an assumption that no additional water will be required to protect listed or potentially endangered or threatened species. In May 1995, the State Board approved a Bay-Delta Plan with interim water quality standards similar to those outlined in the December 1994 accord. EPA approved the State Board's plan and withdrew its standards. Since then, DWR and the Bureau have been working on a voluntary water rights settlement (known as Phase 8) to implement the flow-dependent water-quality objectives of the 1995 plan.

Trihalomethanes (THMs) remain a difficult problem for Delta water quality. THMs are suspected human carcinogens formed when Delta water high in dissolved organic carbon is disinfected with chlorine. To comply with declining maximum contaminant levels (MCLs) for THMs, some water utilities have switched from chlorine disinfection to chloramines or ozone treatment. Drinking water systems serving more than 10,000 people became subject to an 80 parts per billion MCL on January 1, 2002, and that level applies to all systems beginning January 1, 2004.

Water Quality



Because of natural and manmade toxics and pollutants, municipal water agencies invest in costly treatment equipment to provide safe water that meets state and federal guidelines.

For decades, Californians have taken for granted a high-quality water supply, but threats have emerged to water quality that are legacies of past practices or byproducts of modern life. Drinking water derived from clean Sierra snowmelt or groundwater meets strict federal and state standards, but surface water can be contaminated by salts and organic carbon on its journey through the Delta, and a number of groundwater sources have become contaminated by nitrates and industrial chemicals.

Water quality in California is regulated by several state agencies, including the State Board and its nine regional boards and the Department of Health Services. The former enforces clean water laws and administers the Clean Water Grant Program, which funds construction of waste treatment facilities. The latter administers the federal Safe Drinking Water Act (SDWA), which establishes enforceable MCLs for various contaminants. Passed in 1974, the SDWA regulates drinking water quality and authorizes EPA to set water quality standards. It was amended in 1996 to place more emphasis on protecting sources of drinking water and controlling microscopic diseases in water, including *Cryptosporidium*.

Water supplies have been contaminated by both manmade and natural substances, including industrial wastes, pesticides, urban runoff and microscopic organisms. Many consider the greatest threat to surface water to come from nonpoint sources of pollution, such as runoff from agricultural fields and abandoned mines and stormwater runoff. Stormwater usually is not treated before it is discharged, so it can contain contaminants such as pesticides, nitrates from fertilizers, pathogens from animal waste and automotive and industrial chemicals. In efforts to clean up stormwater discharged to rivers, bays and the ocean, the State Board has issued general permits for municipalities and construction sites that try to prevent contaminants from those sources from entering municipal storm sewers.

Numerous national and state laws have been enacted in an attempt to deal with the problems of toxic chemical contamination of groundwater, surface water and the surrounding environment. A cornerstone of these is the Clean Water Act (CWA), passed by Congress in 1972 and administered by EPA. The CWA established a national commitment to restoring and maintaining national waters in "fishable, swimmable" quality.

Under the CWA, Total Maximum Daily Loads (TMDLs) are becoming an integral part of federal and state regulation of pollutants in waterways. According to the EPA, TMDLs are "a calculation of the maximum amount of a pollutant a waterbody can receive and still meet water quality standards." In a precedent-setting move, a federal judge ruled in 2000 that the federal EPA can set limits on pollution of rivers caused by logging, agricultural runoff and other non-point source pollution. The nine Regional Water Quality Control Boards in California are developing TMDLs for a variety of pollutants, including sediment, pathogens and specific chemicals.

The ability to detect contaminants in water has steadily improved, presenting regulators with challenges and opportunities. On the one hand, contaminants can be detected far more accurately, but the increased sensitivity of testing methods also means more contaminants are being found. One such contaminant is perchlorate, an ingredient used in the manufacture of rocket fuel and explosives. Perchlorate left over from World War II and Cold War defense plants has contaminated more than 300 wells in California and has entered the Colorado River system via the Las Vegas Wash. An MCL for perchlorate is scheduled to be adopted by Jan. 1, 2004.

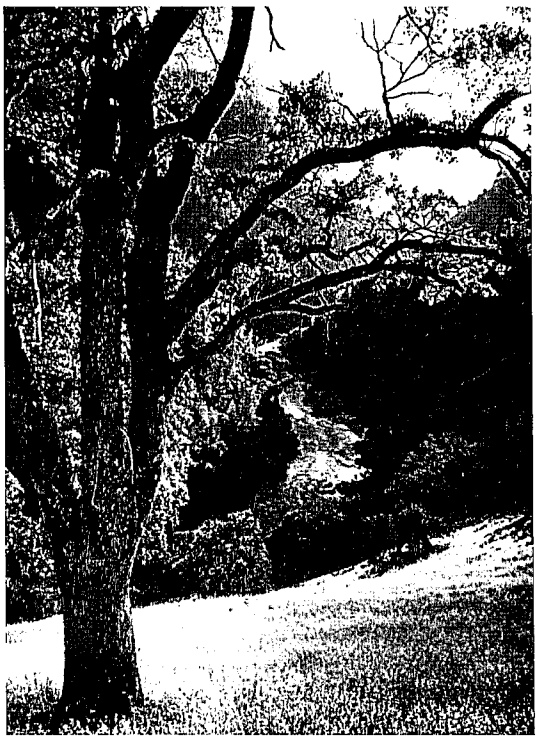
Arsenic is a naturally occurring contaminant described by DHS has "ubiquitous" in drinking water sources in California. Exposure to high levels of arsenic through drinking water is linked with cancer, heart disease and diabetes. U.S. EPA lowered the MCL for arsenic in drinking water to 10 ppb, effective in 2006, and California law calls for adoption of a new MCL for arsenic by June 30, 2004. Preliminary DHS data indicate that more than 300 drinking water systems in 42 California counties have detected arsenic at levels above 10 ppb.

Another major water quality problem facing the state is the buildup of salt and selenium in agricultural soil. For years, farmers in the San Joaquin Valley and in the Imperial and Coachella valleys to the south, kept crop damaging salt from building up in the soil and shallow groundwater by installing underground drainage facilities. However, the salty drainage water contains selenium, and when concentrated in an evaporation pond or other drainage facility, salt and selenium can reach levels toxic to the birds attracted to these ponds. In some areas the buildup of salts and selenium has led to retirement of land from farming. In 2003, the U.S. Department of Justice settled a lawsuit brought by farmers in the Westlands Water District by agreeing to pay the farmers $107 million to retire 33,000 acres of land from production. The farmers claimed their land became worthless because the Bureau never built facilities into which they could discharge irrigation drain water.

Environmental Issues

During the two decades following World War II, development of California's water was virtually unimpeded. But by the 1970s, environmental awareness had grown to an extent that environmental considerations came to be factored into the water supply equation. As a result of enactment of new laws, attention was focused on "instream uses" of water to benefit fish and wildlife, recreation, water quality and aesthetics – uses to which price tags cannot easily be attached. By 1990, these uses rivaled such traditional benefits as irrigation and navigation in importance. Such instream uses are recognized by the state constitution and Water Code as beneficial and must be considered in administrative decisions and in issuing water rights permits. Rising costs and the enactment of state and federal environmental legislation have resulted in few major water development projects being built since 1980.

Since the 1970s, California has pioneered some of the toughest state environmental legislation. The California Legislature was the first in the country to protect rare plants and animals through passage of the California Endangered Species Act in 1970, and Congress followed suit in 1973 by passing the federal



Eighty-three miles of the Tuolumne River upstream of New Don Pedro Dam are protected from further development by state and federal laws preserving wild and scenic rivers.

Mono Lake

The change in values over time is reflected in the case of Mono Lake, a strangely beautiful saline body of water located west of Yosemite National Park in the Sierra Nevada. In 1940, the city of Los Angeles was granted permits to divert water from four of the seven tributaries feeding Mono Lake. It was acknowledged that these diversions would lower the lake's level. However, at that time a higher value was placed on urban water supply than on environmental uses. Forty years later, the lake's level had dropped more than 40 feet. The decline in the lake level and simultaneous increase in salinity jeopardized the basin's unique shrimp and bird population. The lowered lake also uncovered stretches of the highly alkaline lake bed. When exposed to the wind, dust storms are created that are harmful to the respiratory system.

In 1979, the National Audubon Society joined with the Mono Lake Committee in a lawsuit against the Los Angeles Department of Water and Power (LADWP) charging that the state, as supervisor of the public trust, was obligated to protect navigable bodies of water against diversions causing environmental damage. In a 1983 landmark decision, the California Supreme Court held that the public trust doctrine applied to Los Angeles' rights to divert water from Mono Lake's feeder streams. It held that the state retains jurisdiction over these rights and may reconsider the impact on public trust, which in addition to commerce, navigation and fishing, includes wildlife habitat. The necessity of protecting the public trust was to be determined by balancing the value and cost of instream water needs against the benefits and costs of diversions.

In response, an injunction was issued in 1991 by a superior court halting LADWP's water exports. Concurrently, an appellate court in a 1989 ruling and follow-up decision held that LADWP's licenses must be modified to allow sufficient flow to re-establish fisheries. The litigation over Mono Lake continued until October 1994, when the State Board amended Los Angeles' water rights to protect and restore the lake and its tributary creeks. In 1998, the State Board adopted additional restoration plans for Mono Lake. Currently about 6,382 feet above sea-level, the lake is expected to meet the State Board mandated height of 6,392 feet above sea-level in about 10-15 years.

ESA. Also in 1970, the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) were passed, requiring lead public agencies to prepare and submit for public review environmental impact statements or reports (EIS and EIR) on major projects.

In 1972, the state Legislature moved to preserve the north coast's free-flowing rivers from development by passing the Wild and Scenic Rivers Act, preserving about a quarter of the state's undeveloped water in its natural state. The act prohibits construction of dams or diversion facilities, except to serve local needs, on portions or entire rivers around the state.

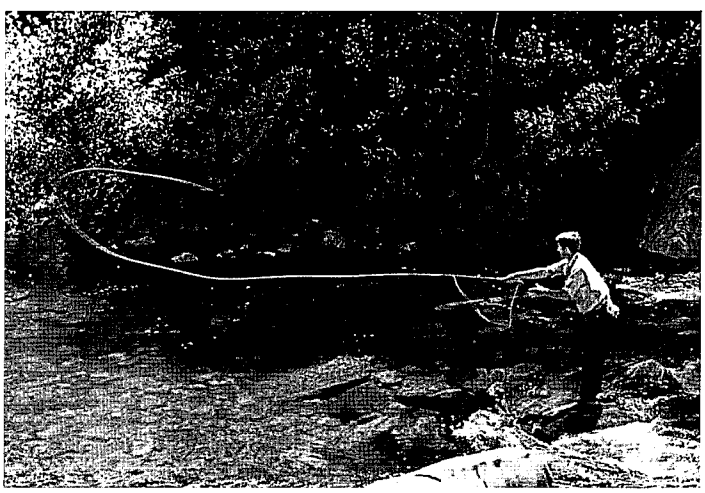
The 1972 CWA is one of the nation's most sweeping environment laws. At the time of its passage, polluted rivers caught fire and lakes were declared dead because of industrial and untreated discharges. In addition to water quality standards, the CWA section 404 regulates the filling or dredging of wetland areas. Early federal practices encouraged the reclamation of wetlands through draining and diking or filling, which eliminated the vast majority of wetlands. More than 90 percent of the Central Valley wetlands were destroyed. With passage of the CWA, other environmental laws and court decisions, the government began protecting wetlands, which filter pollutants, absorb flood waters, recharge groundwater and shelter fish and wildlife.

There has been some backlash against environmental laws by critics who claim the laws put environmental preservation above people. In two U.S. Supreme Court decisions, property-rights advocates have successfully limited the reach of environmental protection. In *Bennett v. Spear*, the court significantly expanded the class of individuals and entities who can sue under the federal ESA to include those claiming economic injuries arising from ESA-based actions. Prior to *Bennett*, only those seeking to protect an ESA-listed species could bring an ESA claim. Private property interests scored another victory in *Suitum v. Tahoe Regional Planning Agency*. Reversing two lower courts, the Supreme Court held that a Tahoe landowner who was prohibited from developing her property, which is a wetland, could go to trial and seek compensation for alleged economic loss caused by the land use restriction. Two lower courts had barred Suitum from litigating her land's worth until she tried to sell it. In lieu of development rights, Suitum was given transferable development rights by the regional land use agency.

In contrast, a widely used tool that allowed development of property that could affect a listed species was invalidated by a state appellate court. The Department of Fish and Game (DFG) issued what are known as "incidental take permits" for more than 160 public and private projects under the state ESA. The state court ruled, however, that DFG lacked the authority to allow the incidental "take" – the killing or harming – of those listed species.

Federal and state initiatives during the 1990s tried to reduce ESA conflicts by replacing the single-species protection approach with broader concepts of biodiversity planning and habitat management. On the federal side, Interior allowed landowners who have listed species on their property and agree to a habitat conservation plan to avoid additional ESA requirements to further protect a threatened or endangered species. In southern California, a state-initiated plan was developed to protect the gnatcatcher, a threatened songbird that lives in coastal sage scrub located in prime real estate. The state's Natural Communities Conservation Plan allows development of the coastal sage region on condition that parcels of sage, which provide critical habitat to the gnatcatcher, will be preserved.

Above, sorting salmon at a state fish hatchery. Chinook salmon numbers have declined in recent years. Right, an angler casts his line on the Smith River.



Stretching the Supply

The state's population is growing by approximately 750,000 people a year and by 2025 is expected to reach nearly 50 million. The sunny, arid southland will account for half this growth, and this area faces decreased entitlements to imported water from the Colorado River and the eastern Sierra. California now has a firm annual supply of about 35 million acre-feet of developed water. According to DWR's 1998 update of Bulletin 160, *The California Water Plan*, without additional facilities and improved water management, the average annual shortfall by 2020 could be from 2.4 million acre-feet in normal years to as much as 6.2 million acre-feet in critically dry years. Urban growth will make up the bulk of the expected gap between future supply and demand.

The dire predictions about the ever-growing demand for water and unpredictable and diminishing supply have forced water managers throughout the state to look at alternative water supply options. These include water marketing, water banking and conjunctive use, water conservation, sea water desalination and the retirement of agricultural lands with poor drainage.

Water Marketing

Water marketing is the transfer or sale of water or water rights from one user to another. The idea that water could be sold as a commodity emerged in the late 1970s. But water transfers did not come to the forefront until push came to shove during the 1987-1992 drought. Out of necessity individual water agencies in 1991 arranged many short-term water transfers – exchanges of water for one year or less. That same year, the state itself became a water broker when it created the Drought Water Bank. DWR bought mostly surface water from agricultural users and sold it to water-strapped urban, agriculture and environmental interests.

Legislation has been enacted both at the federal and state levels to remove some institutional and regulatory constraints on water transfers. The CVPIA allowed water rights holders to sell CVP water for a profit to other entities, including those outside the CVP service area.

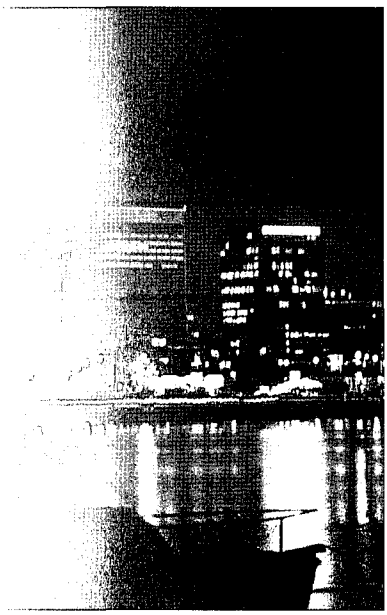
Reallocating the available water on a supply-and-demand basis is viewed by proponents as the best financial, political and environmental means of accommodating an increase in population. Water transfers can occur among farmers, who use the bulk of the developed water supply, and between agriculture and urban users. The latter is encouraged by high prices cities are willing to pay for water. The buying and transferring of water from the poorer rural areas to wealthier cities raises fear in some that other regions could meet the same fate as the Owens Valley. After the eastern Sierra region's surface and groundwater were bought up by Los Angeles to feed the booming population 250 miles away, Owens Valley's agricultural economy nearly dried up.

The first large-scale water transfer programs between agriculture and urban agencies involved the Colorado River and MWD, the state's largest urban water supplier. In 1988, MWD and IID – the largest user of Colorado River water – agreed that MWD would pay $233 million for conservation measures to improve IID's water distribution system. The primary conservation measure involves extensive lining of IID's irrigation canals to eliminate seepage. In turn, MWD is to receive the water conserved, which is more than 100,000 acre-feet of Colorado River water annually, for a minimum of 35 years following completion of the project. In 2003, MWD exercised options to buy 50,000 acre-feet of water for $5 million from Sacramento Valley rice farmers.

Illustrative of the complexities of some water transfers is the proposed long-term transfer of up to 200,000 acre-feet per year of conserved Colorado River water from IID to SDCWA. First proposed by SDCWA in 1996, the transfer became part of a larger plan to cap California's allocation from the Colorado River at 4.4 million acre-feet (see page 11). As of early 2003, neither the transfer nor the larger plan had received final approval from all parties. IID rejected the larger plan in December 2002 over concerns the transfer could lead to land fallowing in the district and that IID could be held liable for environmental damage to the Salton Sea.

Although water transfers have the potential to allocate water more efficiently, potential adverse impacts on third parties can occur. Fallowing of land and associated effects on farm workers are just two of the risks of water transfers. Some fear that long-term water transfers – more than one year – from farms to cities will hasten conversion of farmland for suburbs. Another problem can arise when farmers sell their surface water and continue to grow crops by substituting groundwater.

Because much of the water marketed would pass through the Delta – the heart of the water supply



Transferring water from agricultural to urban use may open up new supplies for growing cities. The proposed transfer of up 200,000 acre-feet of water from Imperial Irrigation District to the city of San Diego (above) could become the largest such transfer in the state's history.

system – its facilities need to be improved to facilitate transfers. Additional sticking points are the allocation of water for environmental needs and environmental effects of actual water transfers.

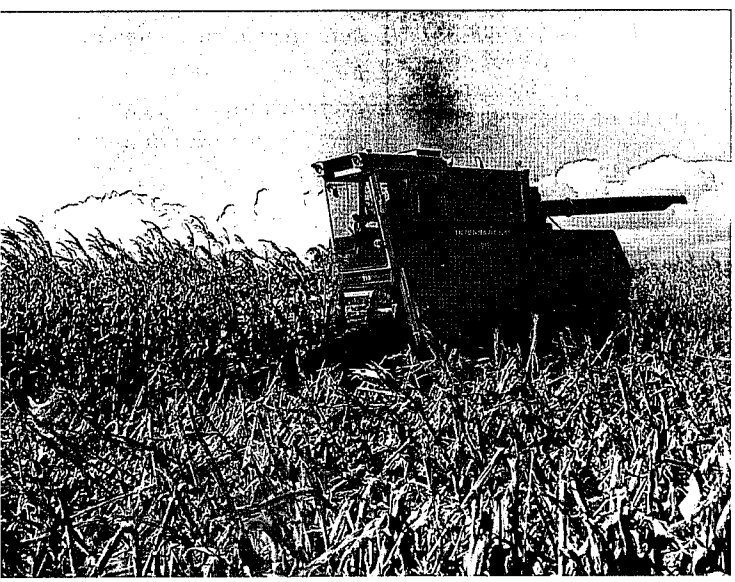
In recent years, private companies have tried to make an entrée into California's water market from a business standpoint. Investing in water as a commodity, companies like Cadiz Inc, Western Water Co., Vidler Water Co. and Azurix have purchased land and/or corresponding water rights in order to sell water to those willing to pay. In some instances, these companies provide storage for other parties to bank their unused water supplies until they are needed. Private companies have found California's water market a difficult one in which to make money, in part because of high prices charged by federal and state facilities to use CVP and SWP conveyance systems. State and federal interests counter that private interest use of facilities should not be subsidized and therefore require payment for the full cost of using the facilities.

Water Conservation

Water conservation is an essential tool to stretch the water supply – or more accurately, to use the existing supply more efficiently. Urban and agriculture conservation measures could reduce demand by about 1.2 million acre-feet, according to DWR. Conservation helped many communities pull through the 1987-1993 drought. In 1991, several urban water agencies achieved a 25 percent reduction in water use from 1987 levels.

Urban water suppliers have developed and implemented water conservation practices known as Best Management Practices (BMPs). As of 2003, about half of the state's 450 urban water suppliers had signed a Memorandum of Understanding – an agreement to implement BMPs to conserve and reuse water. These include the installation of water-saving plumbing fixtures and water meters on all new construction, public information programs, municipal landscape water conservation requirements and financial incentives to reduce water use. DWR estimates that following urban BMPs could reduce annual water demand by 900,000 acre-feet by 2020. Implementation of BMPs is getting a closer look from state officials, who have developed a certification program to measure to effectiveness of urban BMPs.

Agriculture is one of the largest water users in the state and efforts to promote water conservation among farmers have grown as water supplies become tighter.



DWR estimates that urban areas will be using 16 percent of the total water supply by 2020, up from 10 percent in 1990. Critics say there would be significant savings of water if farmers grew crops that required less water and/or if they managed water more carefully through use of drip irrigation or other water-saving systems. Agricultural interests counter that farming is a vital water-intensive business and that most of the applied water eventually returns to the rivers or seeps into the ground to recharge aquifers. They also point out that in drought years agriculture water is often the first to be cut. But, in late 1996, agricultural interests did sign a MOU promoting water conservation. Irrigation districts and water agencies agreed to carry out BMPs, known as Efficient Water Management Practices (EWMPs), which include construction and operation of tailwater reuse systems, automation of canal structures and installation of water meters to measure the amount of water delivered to water users.

Neither the urban or agricultural BMPs are universally endorsed.

CALFED has identified its Water Use Efficiency Program as one of the major program elements it plans to implement. According to CALFED, the program will conserve water through savings in the urban and agricultural sectors, as well as, via water reclamation projects. CALFED estimates it can recover up to 1.4 million acre-feet of water currently being lost in less time than it would take to gain similar benefits through surface storage and conveyance facility improvements, thus improving water quantity. Such water use efficiency also can improve water quality and improve the timing of instream flows, according to CALFED. Cost estimates for the voluntary program are between $1.5 and $2 billion during the first seven years of the program, with $500 million being invested by state-federal cost-sharing and $500 from matching local funds over the first four years.

Conjunctive Use

Another method of improving overall water supply reliability is joint or "conjunctive use" of groundwater and surface water. This includes the use of treated and recycled wastewater and imported water for artificial groundwater recharge, water conservation programs and underground water banking. Under a conjunctive use program, surface water is relied on for irrigation, urban use and to recharge groundwater basins during wet years. The excess surface water is "banked" or stored in underground aquifers so it is available when surface water supplies are low. Storing water underground has several advantages over surface water storage. It is far less damaging to the environment than the construction of reservoirs and dams and usually does not require an extensive distribution system. Water banked underground also has a much lower evaporation rate than surface reservoirs. Conjunctive use programs are being implemented by some local water districts such as the Kern Water Bank project.

Water Recycling

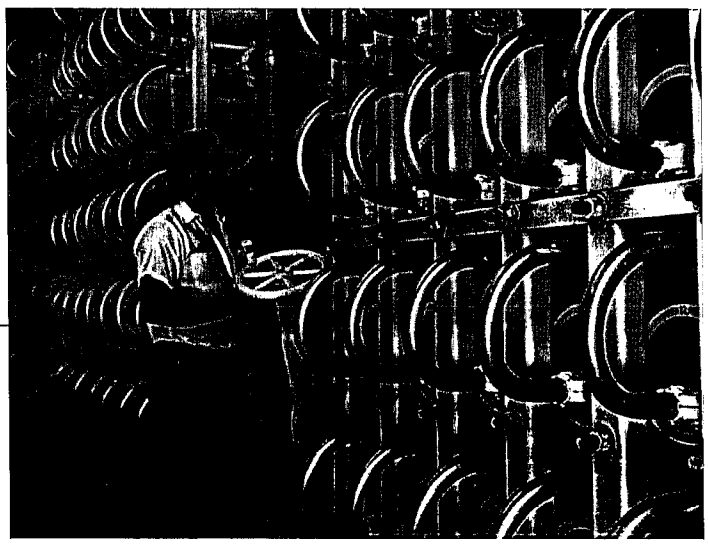
Recycling water so that it can be reused can extend water supplies, improve water quality, reduce the discharge and disposal costs of wastewater and save energy. Water recycling can be a basic or complex process depending on the end use of the water. Water treatment methods include the removal of sewage solids (primary effluent), oxidation and disinfection (secondary effluent), and coagulation, filtration and disinfection (tertiary effluent). Potable water also has been achieved in some regions of the state using advanced treated recycled water. Technologies such as microfiltration and reverse osmosis are used in instances where recycled water is used as drinking water.

Recycled water can be applied to agriculture and landscape irrigation, industrial recycling and recharging of groundwater. Such treatment and reuses of municipal wastewater increased during the 1980s, especially in southern California. Recycled water also can be used as a barrier to prevent sea water intrusion into groundwater basins, as is being done in Orange County. In some areas, like the San Gabriel Valley and the Bay Area, recycled water is used to supplement the areas' drinking water. There are, however, constraints on water recycling projects and in particular use of recycled water for consumption, the most significant being cost and public perception.

Recycled water is expected to play an increasingly important role in California. The state has a goal of using 1 million acre-feet of recycled water by 2010, and as of 2003 was using more than 500,000 acre-feet per year. CALFED has established water recycling as a key component of its Water Use Efficiency Program and estimates it can reclaim 225,000 to 310,000 acre-feet of water through water recycling during Stage 1 of the program. And Proposition 13, the $2 billion water bond passed in 2000, includes $40 million for loans to be used strictly for water recycling programs.

Sea Water Desalination

Recurrent droughts and uncertainties about future water supplies have led several California coastal cities to look to the ocean for supplemental supplies, but desalination projects have had mixed results. Two of three cities that built desalination plants in the 1990s later closed them for cost reasons, but falling costs since then led SDCWA to partner with a private company to develop a facility at Carlsbad to desalinate as much as 50 million gallons of sea water per day. Promoters of the Carlsbad project estimate the finished water will cost about $800 per acre-foot, still well above the price for water from other sources. Critics also caution that the reverse osmosis process used in desalination consumes large amounts of energy and creates brine waste, which must be disposed of.



This desalination plant uses the reverse osmosis process to remove salt from water.

Summary

Keeping California supplied with enough "liquid gold" to feed its growing population and economy and keep its environment healthy will continue to be a challenge for policy makers, the major water projects and water agencies. Besides finding enough supplies, they must cope with an aging water infrastructure, potential new contaminants and the prospect that climate change may alter the hydrology upon which California's water system is built.

Some encouraging steps have been taken toward resolving California's water problems. The 30-year CALFED program became a permanent fixture in 2003, and could deliver long-term solutions to knotty Delta problems. Voters approved multibillion-dollar bond issues in 2000 and 2002 to support a wide range of water projects and environmental enhancements. New legislation has linked future development to availability of adequate water supplies.

A range of new storage options is under consideration that could capture more surface runoff, but they will face stiffer environmental scrutiny than did similar projects a generation ago. Other ways to increase supply and efficiency, such as water marketing, desalination, conservation and water banking will play roles, but none by itself can make up the projected water deficit. And at the same time they need to invest in new ways to increase supply, water purveyors must replace and strengthen the aging canals, pipes and pumps that deliver water to end users.

Looming in the background is the issue of climate change. Climate change could reduce the northern Sierra snowpack, cause more spring flooding, trigger a rise in sea level and lengthen the dry season. Scientists continue to study how climate change might affect California's water system.

Policy makers faced similar challenges in the last century, which they met with the daring initiatives that created the CVP and SWP and enabled California to become the economic powerhouse it is today. Similar daring and imagination will be required to put together the policies to carry California through the 21st century.

Glossary

acre-foot – 325,851 gallons, or enough water to cover an acre of land 1 foot deep. An average California household uses between one-half and one acre-foot of water per year.

anadromous fish – fish species, such as salmon, that migrate from fresh water streams to the ocean and back to complete their life cycle.

appropriative rights – a water right based on physical control over water, or based on a permit or license for its beneficial use.

conjunctive use – the planned use and storage of surface and groundwater supplies to improve water supply reliability.

developed water – water that is controlled and managed (dammed, pumped, diverted, stored in reservoirs or channeled in aqueducts) for a variety of uses.

firm yield – the dependable annual water supply that could be available in all years, without exceeding specified shortages in agricultural deliveries during droughts.

groundwater – water that has seeped beneath the earth's surface and is stored in the pores and spaces between alluvial materials (sand, gravel or clay).

hydrologic cycle – movement of water as it evaporates from rivers, lakes or oceans, returns to earth as precipitation, flows into rivers to the ocean and evaporates again.

instream uses – the beneficial uses of water within a river or stream, such as providing habitat for aquatic life, sport fishing, river rafting or scenic beauty.

public trust doctrine – doctrine rooted in Roman law which holds that certain natural resources are the property of all, to be held in trust by the state.

Racanelli Decision – a 1986 ruling by the state Court of Appeals that the State Water Resources Control Board must consider all beneficial uses of Delta waters, including instream uses, when establishing water quality standards.

riparian rights – a water right based on the ownership of land bordering a river or waterway.

surface water – water that remains on the earth's surface, in rivers, streams, lakes, reservoirs or oceans.

water recycling – the treatment and reuse of wastewater to produce water of suitable quality for additional use.

Water Rights Decision 1485 – State Water Resources Control Board ruling issued in 1978 which established salinity standards for Bay-Delta waters.