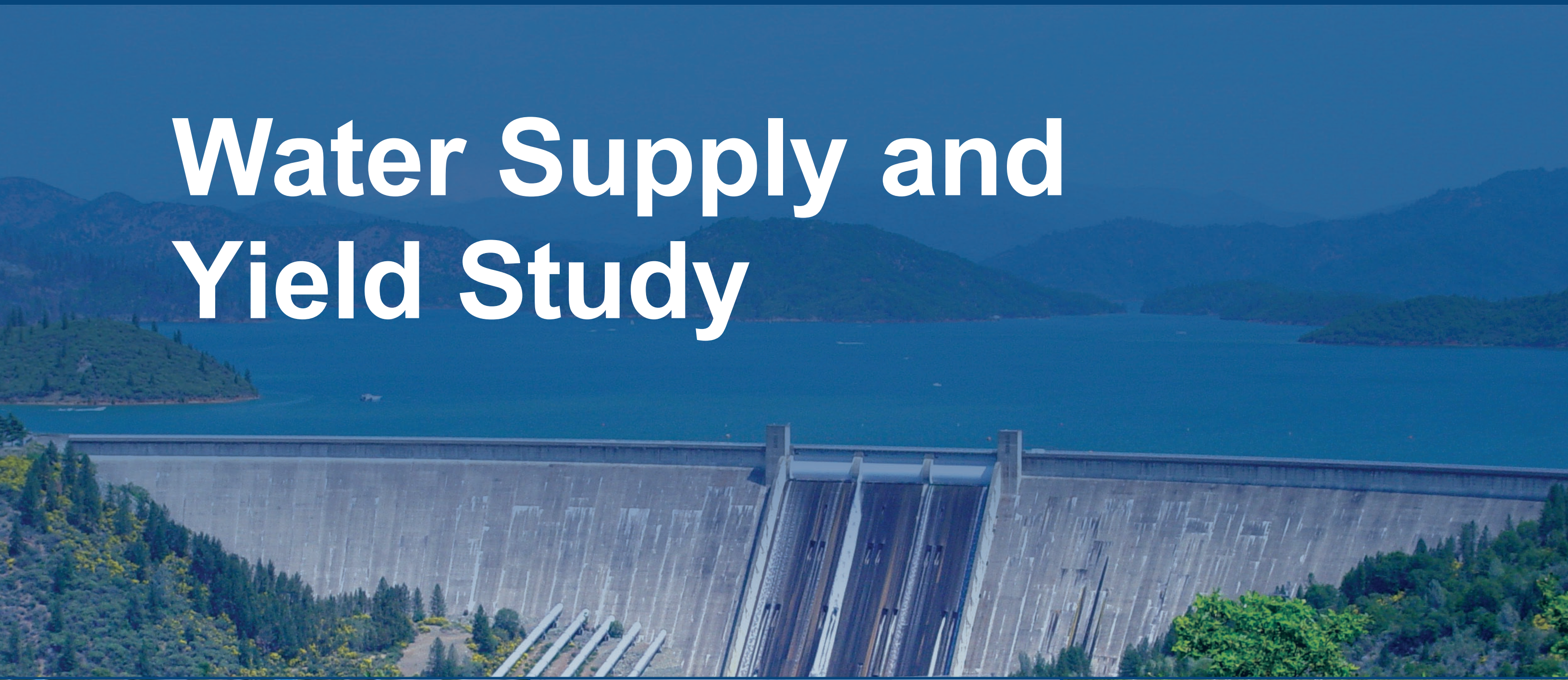
RECLAMATION

Managing Water in the West

Water Supply and Yield Study



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

March 2008

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Executive Summary

Background

Hydrologic conditions in California vary greatly from year to year, season to season, and place to place. Wet years bring the threat of floods, and drought years put pressure on available water supplies. The majority of the state's precipitation occurs in the northern third of the state during the winter, while much of the water is used in the central and southern portions of the state during the spring and summer. Because of this, meeting California's water demands is complicated by the logistics of moving water from its source to its place of use, which may be over hundreds of miles. The availability of storage and conveyance facilities may limit California's ability to deliver water to the right place at the right time.

To address the difference in the location and timing between water supplies and water demands, federal, state, and local water agencies constructed various water supply projects. The two main water storage and conveyance projects in California are the federal Central Valley Project (CVP) and the State of California's State Water Project (SWP), managed by the Department of Water Resources (DWR). Both the CVP and SWP use natural waterways and constructed facilities to convey water. To deliver this water to users in Central and Southern California, both projects convey water through the ecologically sensitive Sacramento–San Joaquin River Delta (Delta), which is upstream of San Francisco Bay.

Dramatic increases in statewide population, land use changes, and environmental and other regulatory requirements have put pressure on available water supplies and facilities to meet water demands on a regional basis and statewide. These pressures have presented challenges to reliably meeting year-to-year water demands. The availability of storage and conveyance facilities is another factor that currently limits California's ability to deliver water to the right place at the right time. The availability of storage and conveyance facilities will continue to be a limiting factor in the future.

Statewide water management systems include physical facilities like the California Aqueduct. (Source: DWR)

Authorization and Purpose

The CALFED Bay-Delta Authorization Act, Title 1 of Public Law 108-361 (the Water Supply, Reliability, and Environmental Improvement Act of 2004) directed the Secretary of the Interior (Secretary), acting through the Bureau of Reclamation (Reclamation), to conduct a study of available water supplies and existing and future needs for water in the State of California.

The Secretary is to prepare a report identifying possible projects and water management actions that could provide new firm yield and water supply improvements for the CVP. The Secretary is also required to incorporate and revise, as necessary, the results of the 1995 *Least-Cost CVP Yield Increase Plan* originally required by section 3408(j) of Central Valley Project Improvement Act (CVPIA) of 1992.

The purpose of this Water Supply and Yield (WSAY) Study is to identify the following:

1. Opportunities for new firm yield and water supply improvements for CVP water service contractors (entities with contracts for the delivery of CVP water)
2. Water management actions or projects that would improve firm yield for the CVP while balancing the available supplies with existing demands
3. The financial costs of the water management actions or projects
4. Beneficiaries and beneficiaries' willingness to pay for identified improvements

Study Area and Data Sources

As directed by Public Law 108-361, the study area addressed in this report includes the units of the CVP, the area served the CVP agricultural, municipal, and industrial water service contractors, and the CALFED Bay-Delta

> **Firm Yield Defined**
>
> Public Law 108-361 defines firm yield as "…a quantity of water from a project or program that is projected to be available on a reliable basis, given a specified level of risk, during a critically dry period."

Program (CALFED) Solution Area as shown in Figure ES-1.

Information for this study was primarily collected from the following sources:

- Reclamation planning studies, Title 16, Integrated Resource Management Plans, and other special studies
- CALFED *Programmatic Record of Decision* and Program Plans
- DWR's *California Water Plan Update 2005* (Update 2005) and various related studies

California's regional differences make it necessary to divide the study area into regions for the purpose of discussing water supplies and demands. For planning purposes, DWR divides the state into 10 hydrologic regions corresponding to the state's major drainage basins. Figure ES-2 shows these regions. For the purposes of some discussions, this report combines several hydrologic regions to delineate three geographic zones—North, Central, and South—to reflect geographic differences north and south of the Delta and within the Central Valley. These zones are shown in Figure ES-3.

Study Results

This WSAY Study provides the following information:

- Compares available water supplies and demands in wet, average, and dry years under current and future levels of development
- Identifies gaps between available water supplies and demands under current and future conditions
- Discusses indicators of existing water supply reliability and identifies factors that affect this reliability
- Describes projects and water management actions that may increase average deliveries and improve reliability during droughts
- Estimates the financial impacts and range of willingness to pay for additional storage and conveyance projects and for other water management actions

Supplies and Demands

Supplies

In an average water year, California receives close to 200 million acre-feet (MAF) of water from precipitation and imports or inflows from the Colorado River, Oregon, and Mexico. Of this *total supply*, about 50 to 60 percent is either consumed by natural processes (such as evaporation, evapotranspiration from native vegetation and forests, and groundwater percolation) or flows to Oregon, Nevada, the Pacific Ocean, and salt sinks like saline groundwater aquifers and the Salton Sea. The remaining 40 to 50 percent, called *dedicated supply*, is distributed among urban uses, agricultural uses, used to protect and restore the environment, or is stored in surface reservoirs and groundwater basins for later use.

CVP and SWP water deliveries vary considerably from year to year, and may be limited by available conveyance or storage facilities.

Water supply in California is provided to users by statewide water management projects, including the CVP and SWP and by local projects. Locally owned groundwater wells also contribute to supplies, especially during dry years. The availability of water supplies depends on the availability of water at the source, the ability of conveyance facilities to transfer water, and the quantity and pattern of water demand at its place of use.

The SWP and CVP manage, store, and deliver approximately 4 and 9 percent, respectively, of the state's water supplies. Local water projects and the Colorado River account for over 30 percent. However, deliveries vary considerably from year to year, and may be limited by available conveyance or storage facilities. The CVPIA and other environmental constraints have further restricted the CVP's ability to meet contract deliveries.

Current Demands and Supply-Demand Gap

Current water demands for representative wet (1998), average (2000), and dry (2001) years were developed using statewide water use data from Update 2005. The water use values from Update 2005 were adjusted to account for a variety of factors, including increased demands in average and dry years caused by these factors:

- Increased urban use resulting from population increases and drier conditions in 2001
- Reduced irrigated acreage resulting from insufficient supplies
- Reduced environmental flows resulting from insufficient supplies

Current statewide water demands were estimated to be 60.6 MAF in an average year (2000) and 57.2 MAF in a dry year (2001).

Supply-demand gaps were determined by totaling unmet urban, agricultural, and environmental demands, along with the annual estimated amount of groundwater overdraft, and comparing the result to currently available supplies. Supplies and demands were compared on a regional basis

FIGURE ES-1
Study Area

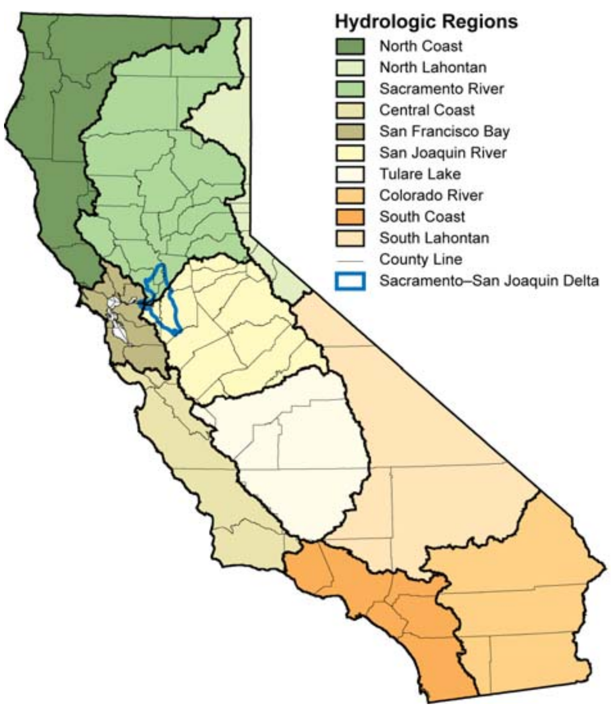

FIGURE ES-2
DWR's Hydrologic Regions

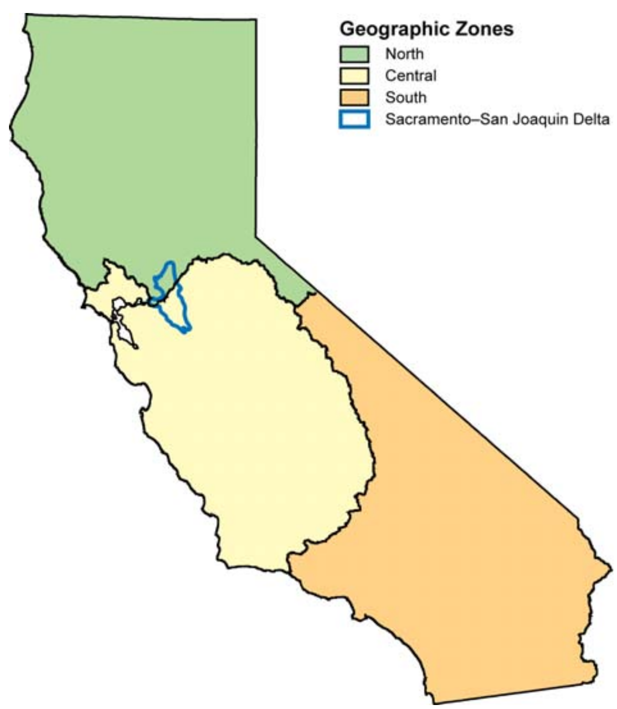

FIGURE ES-3
WSAY Study Geographic Zones

Current statewide water use requires exercise of reservoir carryover storage and overdraft of groundwater during average and dry years.

because comparing them on a statewide basis does not provide an accurate representation of supply-demand gaps at the regional level. If one region has surplus supply, it cannot be assumed that the surplus water can be conveyed to fill another region's supply-demand gap. Therefore, supplies and demands were compared by hydrologic region, and only gaps (not surpluses) were added to regional and statewide totals.

This analysis shows that the supply-demand gap for the state as a whole is approximately 2.3 MAF for 2000 (average year) and approximately 4.2 MAF in 2001 (dry year) (Figure ES-4). Regional supply-demand gaps reveal that shortages are greatest in the Central Geographic Zone.

Note that this analysis considered only a single dry year. The supply-demand gap in a drought year (preceded by one or more dry years) may be much greater.

Future (2030) Demands and Supply-Demand Gap

The projected future statewide water demands were estimated to be 60.8 MAF in an average year and 57.4 MAF in a dry year. Without future investment in water management actions or facilities, it is assumed that available water supplies in the future will remain about the same as under existing conditions. However, future supplies were adjusted slightly to reflect recent agreements regarding the reallocation of Colorado River water.

The projected gap between available water supplies and water demand in 2030 can be estimated by comparing future demands with existing supplies in average and dry years. Figure ES-5 shows that under projected future conditions, the supply-demand gap is approximately 4.9 MAF in average years and approximately 6.1 MAF in dry years. Regional supply-demand gaps reveal that shortages are greater in the South Geographic Zone under average and dry years

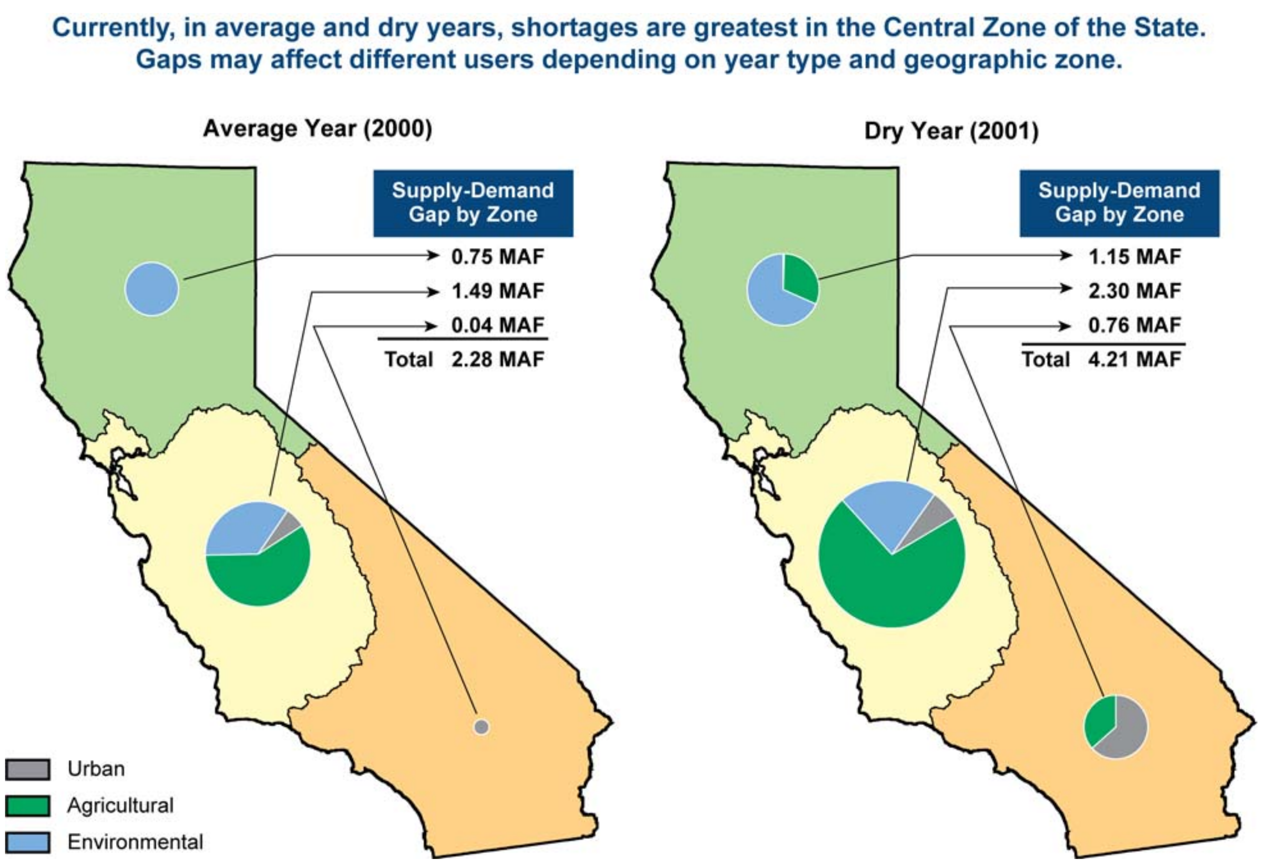

FIGURE ES-4
Existing Supply-Demand Gaps by Geographic Zone in an Average Year (2000) and Dry Year (2001)

Population growth, agricultural-to-urban land conversion, unknown future laws and regulations, and climate change add uncertainty to future demand estimates and may increase the risk that existing facilities and infrastructure will not meet demands during multiple-year droughts.

because of hydrologic conditions and facility (storage and conveyance) constraints.

Population growth, agricultural-to-urban land conversion, unknown future laws and regulations, and climate change add uncertainty to future demand estimates, and may increase the risk that during multiple-year droughts demands will not be met with existing facilities and infrastructure.

Projects and Water Management Actions

The gap between California's water supply and demand is substantial, and this need will not be met without significant investments in new infrastructure and water conservation actions. A variety of storage and conveyance projects and water management actions have the potential to help fill this gap.

Three categories of storage and conveyance projects were considered in this report. These three categories were based on the amount of available information, the level of development in the planning process, and the current understanding of the likelihood of those projects moving forward. The categories are described below and are not intended to signify implementation preference.

- **Level 1: CALFED-authorized storage and conveyance improvement studies**—These large-scale infrastructure improvements have been proposed as part of California's water resources management portfolio to provide more reliable water supplies and to meet competing needs for water. Reclamation and DWR have completed preliminary environmental studies and conceptual modeling, and will continue to formulate detailed alternatives for these improvement projects.
- **Level 2: Projects of recent public, agency, or political interest**—Projects categorized as Level 2 have undergone past

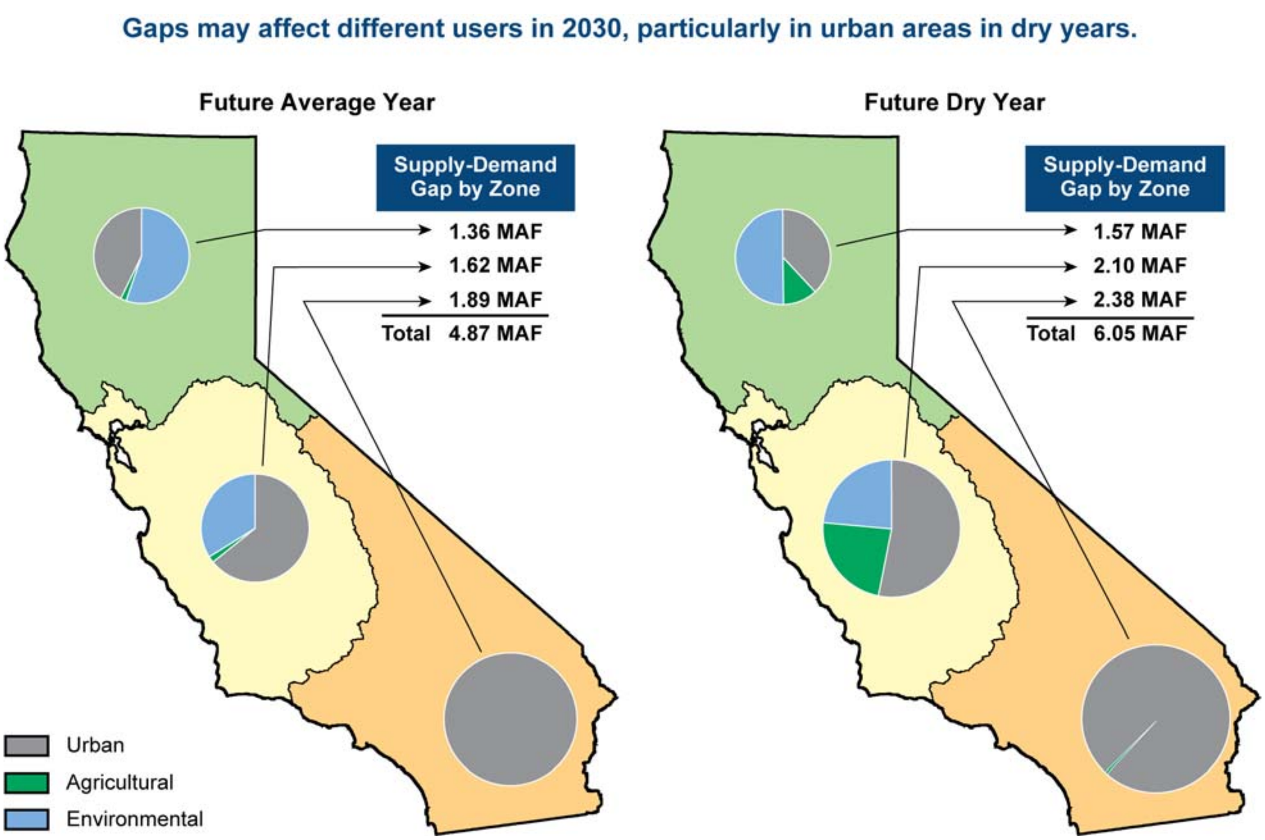

FIGURE ES-5
Projected 2030 Supply-Demand Gaps by Geographic Zone for Average and Dry Years

investigation that has been halted, delayed, or postponed because of changing strategies and priorities for water resources planning. As strategies and priorities continue to develop, and new challenges arise, Level 2 projects have the potential for further consideration.

- **Level 3: Regional opportunities**—Many other project possibilities for water supply improvement exist outside the major infrastructure projects characterized as Level 1 or Level 2.

Statewide water management actions consist of individual projects and programs that have potential to provide yield and water supply improvements for CVP agricultural and urban (municipal and industrial, or M&I) water service contractors. Two types of water management actions are described in this report:

- **Demand management actions** focus on reducing water demands and include agricultural and urban water use efficiency and land retirement.
- **Other actions** focus on increasing water supply, and include water transfers, water recycling, desalination, and conjunctive use.

Statewide, many of these actions are already being implemented as a result of market forces, naturally occurring conservation, work by Reclamation and DWR, ongoing initiatives by local water agencies and districts, CALFED initiatives, and initiatives by other entities.

The storage and conveyance projects and water management actions identified in this report formed the basis of a cursory-level analysis to identify which projects and actions could fill the existing and projected 2030 supply-demand gap. Figures ES-6 and ES-7, respectively, show the existing and projected 2030 average and dry year supply-demand gap along with the projects and water management actions that could be used to help fill the gap.

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years.

A diverse portfolio of projects and actions, consistent with the CALFED Record of Decision, are needed to fill the supply-demand gap.

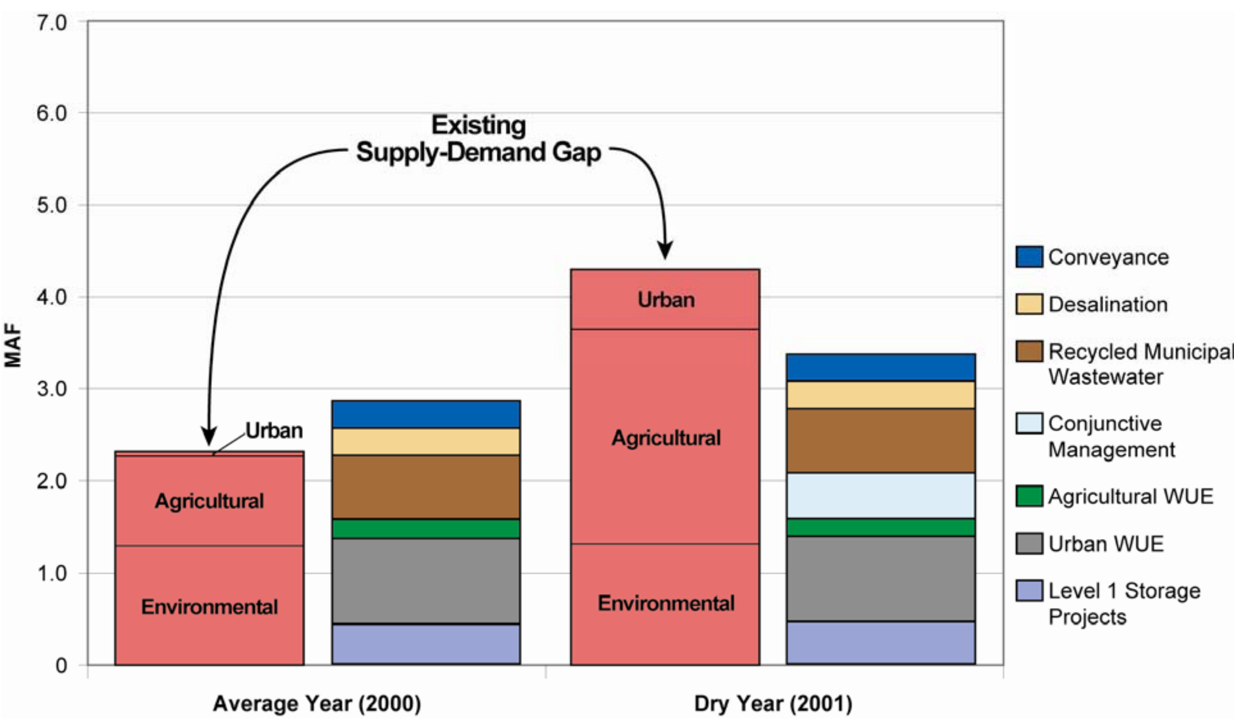

FIGURE ES-6
Projects and Water Management Actions to Help Fill the Existing Supply-Demand Gaps

Long-term water-supply reliability depends on being able to meet water demands in dry years, and additional measures, such as the Level 2 and Level 3 storage projects and more aggressive investments in water management actions, would be needed to fill the 2030 supply-demand gap. Similar to current conditions, it is likely that agricultural and environmental uses would continue to experience water supply shortages in future average and dry years, and drought year shortages could be even greater.

> If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the existing gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years.

Rate Impacts and Willingness to Pay

The economic aspects of the projects identified in this study are a key component in determining how to proceed with implementation. Determining what effect storage and conveyance projects will have on existing rates and what beneficiaries would be willing to pay are important components of a financial analysis. The financial impacts from implementing the projects and water management actions were evaluated by relating the associated water charges to water contractors' willingness to pay.

This analysis focused on the Level 1 storage and conveyance projects because these projects could be federally funded, and would be recovered through CVP contractor rate adjustments. Detailed yield and cost information is not available for the Level 2 and Level 3 projects. The water management actions would likely be funded through a mix of state, federal, and local agencies and organizations and do not influence the rates charged to CVP contractors. Therefore, these projects and water management actions were not included in this financial analysis.

The cost-of-service rate impact and willingness to pay analyses were undertaken to provide a basis for discussions of reimbursement policy changes that may be necessary for the construction of the Level 1 storage and conveyance projects. However, final determinations of financial feasibility will be made as part of subsequent feasibility studies for each individual project.

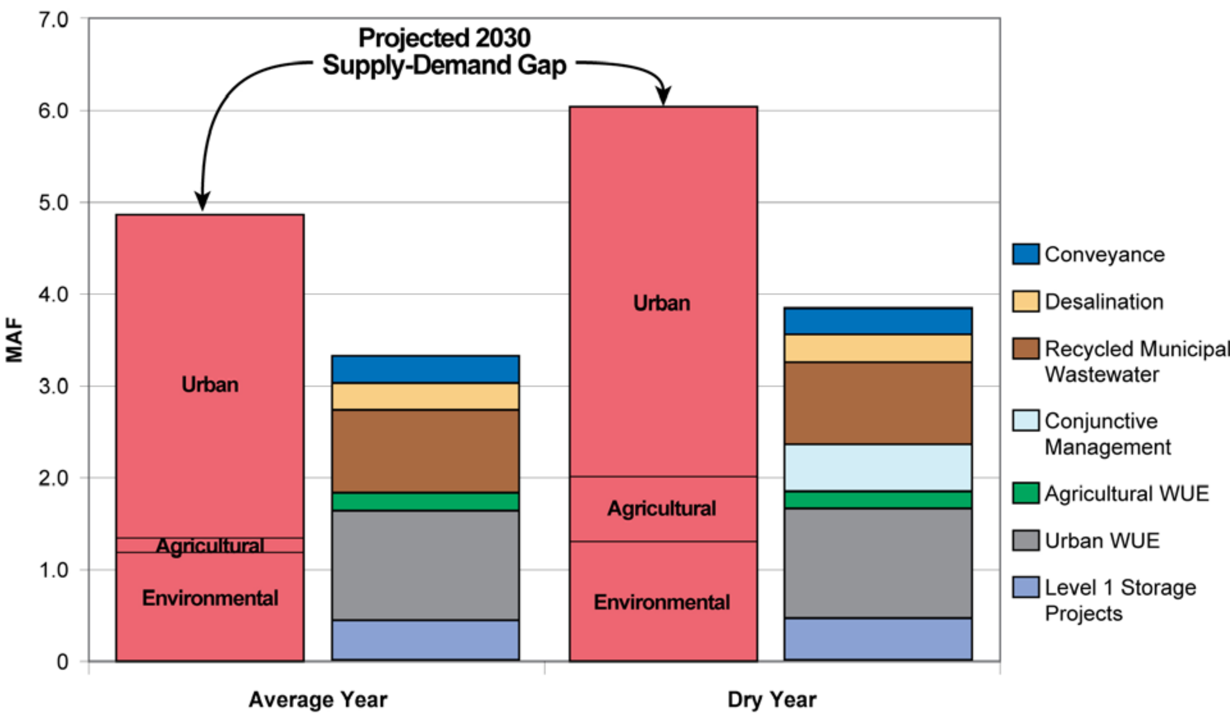

FIGURE ES-7
Projects and Water Management Actions to Help Fill the Projected 2030 Supply-Demand Gaps

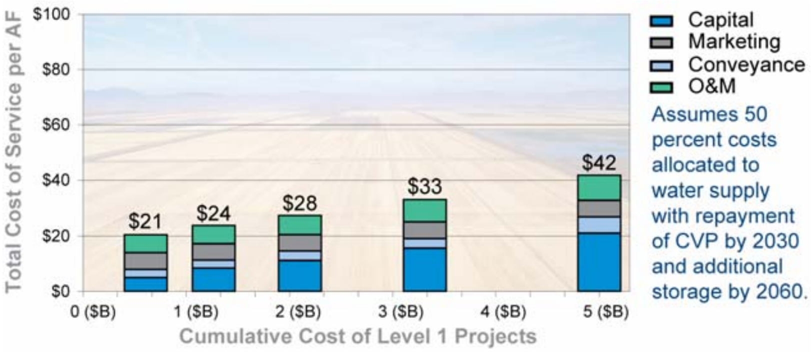

FIGURE ES-8
Irrigation Cost-of-Service Impact at 50 Percent Cost Allocation

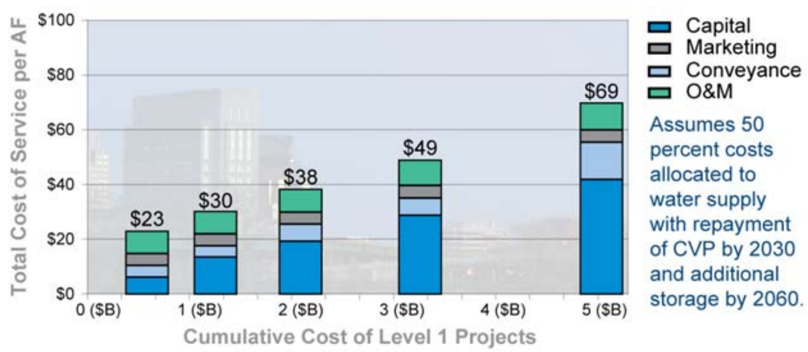

FIGURE ES-9
M&I Cost-of-Service Impact at 50 Percent Cost Allocation

Estimated Rate Impacts

A preliminary assessment was made of the cost-of-service rate impacts of implementing the Level 1 storage and conveyance projects. The cumulative per-acre-foot impact on CVP water charges from these projects, including capital and operations and maintenance costs allocated to water supply, is shown for irrigation contractors in Figure ES-8 and M&I contractors in Figure ES-9. Financing the existing CVP capital costs and all Level 1 storage and conveyance projects would result in a cost-of-service of about $40 per acre-foot for irrigation and $70 per acre-foot for M&I uses when allocating 50 percent of project costs to water supply. These rate estimates are for the period 2021 to 2030. After 2030, initial CVP capital costs will be repaid, and overall rates will fall to slightly lower levels.

Willingness to Pay

Historical water transfer prices, water management options, and contractor surveys all indicate a positive willingness to pay for additional water supplies. Based on reasonable and foreseeable actions to improve supply through water management actions and past transactions to increase permanent supply, contractors south of the Delta indicate an annualized willingness to pay for permanent supply of approximately $130 per acre-foot for irrigation users and $185 per acre-foot for M&I users. Recent transfer negotiations indicate that contractors may be willing to pay more than these amounts for new, permanent water supply.

However, it is important to note that not every contractor has the ability to pay the average willingness to pay amount. Some contractors will be unable to participate in the purchase of CVP water if the contract rates rise dramatically.

Next Steps

A variety of actions, programs, and projects are underway to improve statewide water supply reliability. Reclamation participates in some of these studies, such as the CALFED-authorized storage and conveyance improvement feasibility studies. The next steps toward meeting the needs for future water demand and reliability include the following:

- Continue to support the existing CALFED storage and conveyance projects.
- Support other surface storage and conveyance projects, as well as other statewide water management actions, such as WUE and conjunctive use, that could improve water supply and water supply reliability for CVP contractors.

The supply-demand gaps identified in this WSAY Study were developed by DWR hydrologic region and are based primarily on information from DWR's Update 2005. These supply-demand gaps are based on the best information available within the time requirements stated in the WSAY Study's authorization; however, additional data could be collected to develop CVP-specific supply-demand gaps. This would allow for the following analyses:

- Identification of supply-demand gaps by CVP division
- Identification of projects and water management actions to fill the supply-demand gap by CVP division

Major Technical Results

- Existing statewide water demand estimates:
  - Demands were developed for each hydrologic region and user (urban, agricultural, and environmental).
  - Demands were based primarily on information from Update 2005 and adjusted to reflect historical water demands rather than water use.
  - Existing statewide water demands were estimated as follows:
    - **60.6 MAF** in average water years (based on water use and unmet demands in 2000)
    - **57.2 MAF** in dry water years (based on water use and unmet demands in 2001)
- Amount by which current statewide water demands exceed available water supplies:
  - Supply-demand gaps were calculated by totaling unmet urban, agricultural, and environmental demands and annual estimated groundwater overdraft. The resulting total was compared to current supplies.
  - Supply-demand gaps were determined on a regional basis, and only unmet demands (not surpluses) were added to regional and statewide totals. If one region has surplus supply, it cannot be assumed that the surplus water can be conveyed to fill another region's supply-demand gap because of regulatory and infrastructure limitations on conveyance and basin-to-basin transfers.
  - Current statewide supply-demand gaps were estimated as follows:
    - **2.3 MAF** in an average water year (2000)
    - **4.2 MAF** in a dry water year (2001)
- The largest existing water supply-demand gap is in the Central Geographic Zone.
- Projected 2030 statewide water demand estimates:
  - As with existing demand estimates, projected 2030 water demands were also developed for each hydrologic region and user.
  - Overall projected 2030 water demands were estimated to increase for urban users, decrease for agricultural users, and remain the same for environmental users.
  - Projected 2030 statewide water demands were estimated as follows:
    - **60.9 MAF** in average water years
    - **57.4 MAF** in dry water years
- Estimated amount by which projected 2030 statewide water demand exceeds available water supplies:
  - Projected 2030 supply-demand gaps were calculated using the same methodology as the existing supply-demand gap calculation. Future supplies were assumed to be similar to existing supplies, except for Colorado River supplies, which were projected to decrease to the State's 4.4 MAF allocation.
  - Although the 2030 demands are similar to existing (2000) demands, projected increases in urban water demand throughout the state—especially in the central and southern portions of the state—result in an increased statewide water gap. Similar to the existing supply-demand gap calculation, surplus supplies in one region cannot be assumed to fill another region's supply-demand gap because of regulatory and infrastructure limitations on conveyance and basin-to-basin transfers.
  - Projected 2030 statewide supply-demand gaps were estimated as follows:
    - **4.9 MAF** in average water years
    - **6.1 MAF** in dry water years
- The largest projected 2030 water supply-demand gap is in the South Geographic Zone.
- If the Level 1 storage and conveyance projects were constructed and the investments in foreseeable water management actions were made, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years.
- When allocating 50 percent of project costs to water supply, the cost-of-service rate for financing the existing CVP capital costs and all Level 1 storage and conveyance projects is approximately $40 per acre-foot for irrigation users and $70 per acre-foot for M&I users.
- CVP contractor annualized willingness to pay for permanent water supply south of the Delta was determined to be approximately $130 per acre-foot for irrigation users and $185 per acre-foot for M&I users.

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Acronyms and Abbreviations

AF	acre-foot *or* acre-feet
CALFED	CALFED Bay-Delta Program
CALFED ROD	CALFED Programmatic Record of Decision
CALFED Finance Plan	CALFED Bay-Delta Program Finance Plan
CBDA	California Bay-Delta Authority
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento–San Joaquin River Delta
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
EWA	Environmental Water Account
Exchange Contractors	San Joaquin River Exchange Contractors
FY	fiscal year
M&I	municipal and industrial
MAF	million acre-feet
NEPA	National Environmental Policy Act
NOD	north-of-Delta
NODOS	North-of-Delta Offstream Storage
O&M	operations and maintenance
OCAP	Long-Term CVP Operations Criteria and Plan
PEIS	Programmatic Environmental Impact Statement
Reclamation	Bureau of Reclamation
ROD	Record of Decision
SBA	South Bay Aqueduct
Secretary	Secretary of the Interior
Settlement Contractors	Sacramento River Settlement Contractors
SOD	south-of-Delta

SWP	State Water Project
TAF	thousand acre-feet
Update 2005	*California Water Plan Update 2005, Bulletin 160-05*
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan
WAP	Water Acquisition Program
Westlands	Westlands Water District
WSAY	Water Supply and Yield
WUE	water use efficiency

1 Introduction

This section introduces the Water Supply and Yield (WSAY) Study's basis and purpose. To provide context for the study, background information on the geographical and historical perspective of water resources in California begins the discussion. Building on this foundation is an overview of the authorization and purpose of this WSAY Study, the study area, data sources, and a description of the related studies and programs.

Geographical and Historical Perspective

Contrast and diversity characterize California's geography and climate. Precipitation varies widely—from place to place, season to season, and year to year. Annual rainfall varies from more than 140 inches in the northwestern part of the state to less than 4 inches in the southeastern part. Most precipitation and runoff occur in the north and in the mountains, much of which falls as snow in the winter. As the snowpack melts in the spring, runoff fills major rivers and streams or percolates to aquifers.

Statewide water management systems include physical facilities like the California Aqueduct. (Source: DWR)

Historically, quickly melting snow would flood into the Central Valley, located in the central portion of the state, creating swamps and marshlands, or continue to the Pacific Ocean through the Sacramento–San Joaquin River Delta (Delta) upstream of the San Francisco Bay.

During the nineteenth century, farming increased in the Delta and Central Valley regions, which increased the need for a dependable water supply and flood control facilities. Farmers began draining land and building levees around the marshes and swamps to reclaim the land for agriculture. As agriculture expanded, the state's overall population and major cities, including San Francisco and Los Angeles, also grew. Although the agricultural lands and urban areas have grown significantly in the central and southern part of the state, the availability of water decreases from north to south. People in the central and southern portion of the state recognized the need to augment water supplies and develop remote sources.

To address the difference in the location and timing between water supplies and water demands, federal, state, and local water agencies constructed various water supply projects. The two main water storage and conveyance projects in California are the federal Central Valley Project (CVP) and the State of California's State Water Project (SWP). The major CVP and SWP storage and conveyance facilities are shown in Figure 1-1.

The Bureau of Reclamation (Reclamation) operates the CVP, one of the world's premier water supply projects. The CVP extends some 400 miles, from the Cascade Mountains near Redding in the north to the Tehachapi Mountains near Bakersfield in the South. It

Section Highlights

The WSAY Study's purpose is to identify the following:

- Opportunities for new firm yield and water supply improvements for CVP water service contractors
- Water management actions or projects that would improve CVP firm yield while balancing available supplies with existing demands
- The financial costs of the water management actions or projects
- The beneficiaries and beneficiaries' willingness to pay for identified improvements

The study area includes the CVP Service Area and the CALFED Solution Area.

Primary data sources include the following:

- Reclamation planning studies, Title 16, Integrated Resource Management Plans, and other special studies
- CALFED Record of Decision (ROD) and Program Plans
- The California Department of Water Resources' *California Water Plan Update 2005* and various related studies

This study uses and builds upon the results of the 1995 *Least-Cost CVP Yield Increase Plan.*

FIGURE 1-1
Major CVP and SWP Storage and Conveyance Facilities

Public Law 108–361, Section 103(d)(1)(C) Water Supply and Yield Study

(i) IN GENERAL.—The Secretary, acting through the Bureau of Reclamation and in coordination with the State, shall conduct a study of available water supplies and existing and future needs for water—

- (I) within the units of the Central Valley Project;
- (II) within the area served by Central Valley Project agricultural, municipal, and industrial water service contractors; and
- (III) within the CALFED Delta solution area.

(ii) RELATIONSHIP TO PRIOR STUDY.—In conducting the study, the Secretary shall incorporate and revise, as necessary, the results of the study required by section 3408(j) of the Central Valley Project Improvement Act of 1992 (Public Law 102–575; 106 Stat. 4730).

(iii) REPORT.—Not later than 1 year after the date of enactment of this Act, the Secretary shall submit to the appropriate authorizing and appropriating committees of the Senate and the House of Representatives a report describing the results of the study, including—

- (I) new firm yield and water supply improvements, if any, for Central Valley Project agricultural water service contractors and municipal and industrial water service contractors, including those identified in Bulletin 160;
- (II) all water management actions or projects, including those identified in Bulletin 160, that would—
  - (aa) improve firm yield or water supply; and (bb) if taken or constructed, balance available water supplies and existing demand with due recognition of water right priorities and environmental needs;
- (III) the financial costs of the actions and projects described under subclause (II); and
- (IV) the beneficiaries of those actions and projects and an assessment of the willingness of the beneficiaries to pay the capital costs and operation and maintenance costs of the actions and projects.

consists of 20 dams and reservoirs, 11 power plants, and 500 miles of major canals, as well as conduits, tunnels, and related facilities. The CVP manages some 9 million acre-feet (MAF) of water, annually delivering about 7 MAF of water for agricultural, urban, and wildlife use. Today, the CVP supplies water to approximately 3 million acres of irrigable agricultural land,[1] (approximately one-third of the total agricultural land in California), 2 million urban residents, and numerous wildlife refuges.

The California Department of Water Resources (DWR) operates the SWP, the largest state-built, multipurpose water project in the country. The SWP consists of a water storage and delivery system of reservoirs, aqueducts, power plants, pumping plants, and a conveyance system that extends for more than 600 miles, or two-thirds the length of California. Project functions also include recreation and support of fish and wildlife.

[1] Of the 3 million acres of irrigable agricultural lands within the CVP service area, approximately one-third is irrigated annually with CVP water. The balance is irrigated by other sources, or is fallowed, dryland farmed, or used for other purposes.

Seventy percent of the over 4 MAF in contracts for SWP water is for urban use.

Although the capacity to manage water in California is significantly developed, the state continues to be vulnerable to water shortages. Available water supply cannot meet existing water demands, and with California's population expected to grow by more than 10 million by 2030 (California Department of Finance, 2004), there is a vital need to improve existing supply facilities and improve water supply reliability. This report is intended to address the adequacy of available water supplies to meet current and future demands, discuss potential water management actions, and describe the economics of meeting future water demands.

Authorization

The CALFED Bay-Delta Authorization Act, Title 1 of Public Law 108-361 (the Water Supply, Reliability, and Environmental Improvement Act of 2004) directs the Secretary of the Interior (Secretary), acting through Reclamation and in coordination with the State of California, to conduct a study of available water supplies and existing and future needs for water. The findings of that study are to be presented by the Secretary to the appropriate authorizing and appropriating committees of the Senate and House of Representatives. This WSAY Study satisfies the requirements of Public Law 108-361, Section 103(d)(1)(C).

Purpose

Congress directed the Secretary to conduct a study of available water supplies and existing and future needs for water, and prepare a report identifying possible projects and water management actions that could provide new firm yield and water supply improvements for the CVP and help the state meet its current and future needs for water. The Secretary is also required to incorporate and revise, as necessary, the results of the 1995 *Least-Cost CVP Yield Increase Plan* originally required by section 3408(j) of the Central Valley Project Improvement Act (CVPIA) of 1992.

The purpose of this study is to identify the following:

1. Opportunities for new firm yield and water supply improvements for CVP water service contractors
2. Water management actions or projects that would improve firm yield for the CVP while balancing the available supplies with existing demands
3. The financial costs of the water management actions or projects
4. Beneficiaries and beneficiaries' willingness to pay for identified improvements

Public Law 108-361 defines *firm yield* as "…a quantity of water from a project or program that is projected to be available on a reliable basis, given a specified level of risk, during a critically dry period."

FIGURE 1-2
Study Area

Study Area and Data Sources

As directed by Public Law 108-361, the study area addressed in this report includes the units of the CVP, the area served by CVP agricultural, municipal, and industrial water service contractors, and the CALFED Bay-Delta Program (CALFED) Solution Area as shown in Figure 1-2. The CALFED Solution Area was defined in the CALFED ROD to include the Bay, Delta, and the areas in which diverted/exported water is used.

Information for this study was collected primarily from the following sources:

- Reclamation planning studies, Title 16, Integrated Resource Management Plans, and other special studies
- CALFED *Programmatic Record of Decision* (CALFED ROD) and Program Plans
- DWR's *California Water Plan Update 2005* (Update 2005) and various related studies

California's regional differences make it necessary to divide the study area into regions for the purpose of discussing water supplies and demands. For planning purposes, DWR divides the state into 10 hydrologic regions corresponding to the state's major drainage basins. Figure 1-3 shows these regions. A brief description of each hydrologic region is provided in Table 1-1.

For the purposes of some discussions, this report combines several hydrologic regions to delineate three geographic zones—North, Central, and South—to reflect geographic differences north and south of the Delta and within the Central Valley. These zones are shown in Figure 1-4.

Related Studies and Programs

The following studies and programs provide insight or otherwise affect the WSAY Study:

- CALFED Bay-Delta Program
- California Water Plan
- Central Valley Project Improvement Act
- Least-Cost CVP Yield Increase Plan

Descriptions of each study and program follow.

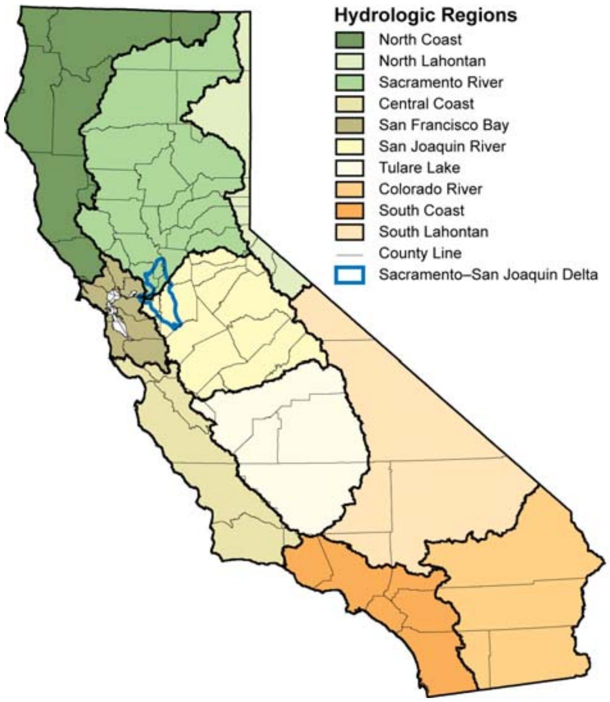


FIGURE 1-3
DWR's Hydrologic Regions

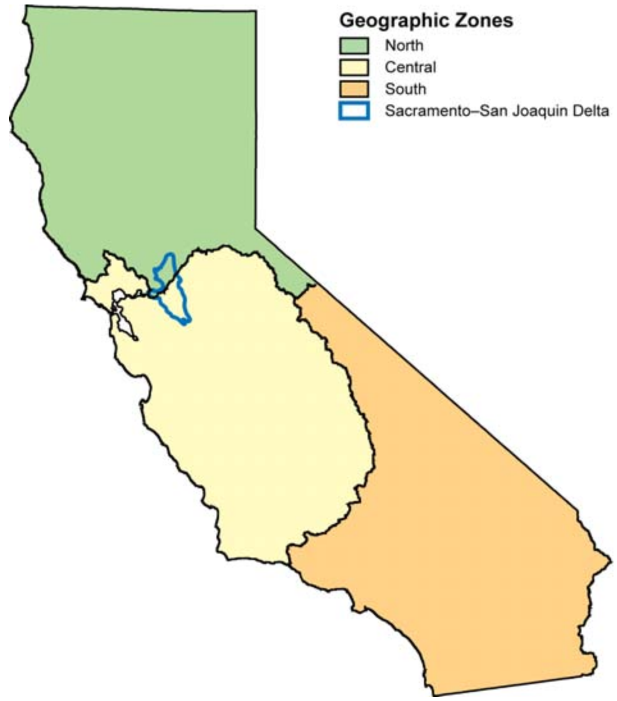


FIGURE 1-4
WSAY Study Geographic Zones

TABLE 1-1
California's Ten Hydrologic Regions and Corresponding Geographic Zones

Zone	Region	Description
North	North Coast	Klamath River and Lost River Basins, and all basins draining into the Pacific Ocean from Oregon south through the Russian River Basin
	North Lahontan	Basins east of the Sierra Nevada crest and west of the Nevada state line, from the Oregon border south to the southern boundary of the Walker River watershed
	Sacramento River	Basins draining into the Sacramento River system in the Central Valley (including the Pit River drainage), from the Oregon border south through the American River drainage basin
Central	Central Coast	Basins draining into the Pacific Ocean below the Pescadero Creek watershed to the southeastern boundary of Rincon Creek Basin in western Ventura County
	San Francisco Bay	Basins draining into San Francisco, San Pablo, and Suisun Bays, and into the Sacramento River downstream from Collinsville; western Contra Costa County; and basins directly tributary to the Pacific Ocean below the Russian River watershed to the southern boundary of the Pescadero Creek Basin
	San Joaquin River	Basins draining into the San Joaquin River system, from the Cosumnes River Basin on the north through the southern boundary of the San Joaquin River watershed
	Tulare Lake	The closed drainage basin at the south end of the San Joaquin Valley, south of the San Joaquin River watershed, encompassing basins draining to Kern Lakebed, Tulare Lakebed, and Buena Vista Lakebed
South	Colorado River	Basins south and east of the South Coast and South Lahontan regions; areas that drain into the Colorado River, Salton Sea, and other closed basins north of the border with Mexico
	South Coast	Basins draining into the Pacific Ocean from the southeastern boundary of Rincon Creek Basin to the international border with Mexico
	South Lahontan	The interior drainage basins east of the Sierra Nevada crest, south of the Walker River watershed, northeast of the Transverse Ranges, and north of the Colorado River Region. The main basins are the Owens and the Mojave River Basins

CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED) is a cooperative effort among federal and state agencies and California's environmental, urban, and agricultural communities. The Governor of California and the President of the United States initiated work on the program in 1995 to address environmental and water management problems associated with the Bay-Delta system. CALFED has taken a broad approach to addressing four problem areas:

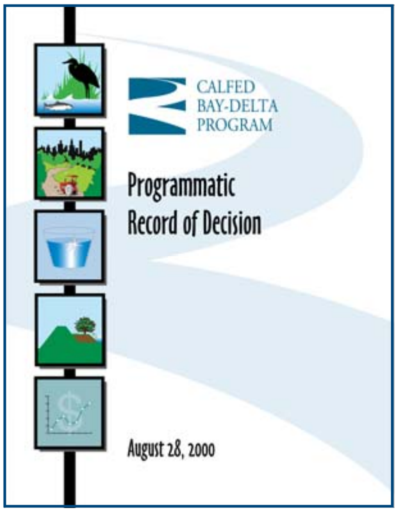
- Water quality
- Ecosystem quality
- Water supply reliability
- Levee system integrity

Implementation of the CALFED Program began after the circulation of the Final *CALFED Programmatic Environmental Impact Statement/Environmental Impact Report* and the signing of the CALFED ROD in August 2000. The Preferred Program Alternative described in the CALFED ROD consists of programmatic elements that set a long-term direction for CALFED consistent with the CALFED mission statement and objectives. The Preferred Program Alternative includes several interrelated programs and a series of actions to execute the programs.

Implementation of CALFED depends on authorization and funding by participating federal and state agencies. The Preferred Program Alternative is expected to require 25 to 30 years to complete. Implementation is divided into stages, with Stage 1 lasting through fiscal year 2007.

Relationship to WSAY Study

The CALFED ROD identified five potential surface storage reservoirs being investigated by DWR, Reclamation, and local water interests. These CALFED surface storage projects are being planned as multipurpose projects for water supply reliability, improved water quality, and ecosystem restoration.



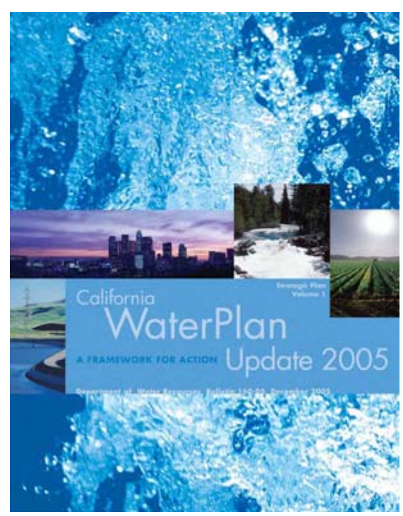
The five surface storage projects include raising Shasta Dam, constructing Sites Reservoir, constructing a reservoir in the Delta, expanding Los Vaqueros Reservoir, and constructing additional surface storage in the Upper San Joaquin River drainage. These five CALFED surface storage projects are described in Section 3 of this report and form the basis of the cost-of-service and willingness to pay assessments in Section 4.

California Water Plan

Updated approximately every 5 years, the *California Water Plan* is the state's strategic plan for managing and developing water resources statewide. Since its first *California Water Plan*, published as Bulletin No. 3 in 1957, DWR has prepared seven water plan updates, known as the Bulletin 160 series.

The most current version, referred to as Update 2005, describes the roles of state and federal government and the expanding role of regional and local agencies in California water management. The purpose of Update 2005 is to finalize statewide policy direction through broad public involvement. Update 2005 included a roadmap for completing the next version of the California Water Plan (2010) by identifying the analytical tools, studies, and data necessary to quantify and evaluate future water demand and supply.

Update 2005 used actual regional water use and supply data from three recent years—1998, 2000, and 2001—to show the variance of water supplies and uses in recent typical wet, average, and dry years, respectively. Statewide information was assembled from the 10 individual hydrologic regions. In some cases, numerical values in Update 2005 were developed by estimation techniques because measured data were not available on a statewide basis. Update 2005 also presents three future scenarios (Current Trends, Less Resource Intensive, and More Resource Intensive) for 2030. Each scenario describes a different base condition for 2030, to which the water community would need to respond by implementing various management strategies. The scenarios are created by various assumptions about important factors affecting water use and supplies (such as population growth, development patterns, crop markets, industrial productivity, and environmental regulations).



Relationship to WSAY Study

Update 2005 does not make project- or site-specific recommendations, but it does provide valuable insight on statewide water needs and describe how different resource management strategies play a role in helping to meet future water needs.

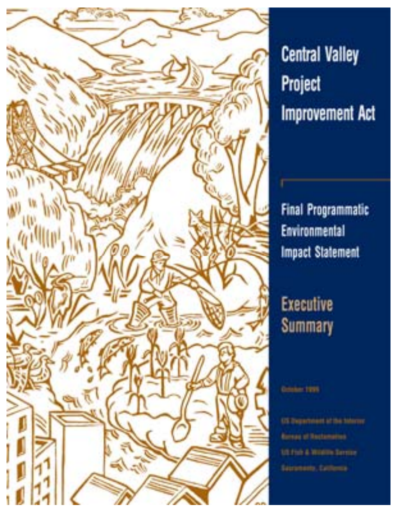
Recent statewide water use and supply data from Update 2005 were used as the basis of the current statewide water supply and demand projections in this study. The three future scenarios described in Update 2005 were used as the basis of the future statewide water supply and demands projections in this study. This information is presented in Section 2.

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA) of 1992 (Title 34 of Public Law 102-575) mandated changes in management of the CVP, particularly for the protection, restoration, and enhancement of fish and wildlife. The CVPIA dedicated a portion of the yield of the CVP to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River Basins, which resulted in the following provisions:

- Dedication of up to 0.8 MAF of supply per year to environmental needs, referred to as CVPIA 3406(b)(2) water
- Designation of additional water supplies to wildlife refuges
- Re-operation of the Trinity River Division to increase releases in the Trinity River to protect and restore the fishery

In 1999, Reclamation and the U.S. Fish and Wildlife Service (USFWS) completed the *CVPIA Programmatic Environmental Impact Statement* (PEIS) for the implementation of the CVPIA. The PEIS evaluated five alternatives that addressed a range of actions or programs to meet the CVPIA objectives, and analyzed the environmental and economic consequences of implementing the CVPIA. With regard to existing CVP water contractors, the PEIS projected reduced CVP contract deliveries, particularly for contractors located south of the Delta. The PEIS also projected that implementation of the CVPIA provisions would result in increased groundwater overdraft, agricultural land fallowing, loss of jobs, and loss of more than $150 million in annual agricultural revenues (Reclamation and USFWS, 1999).



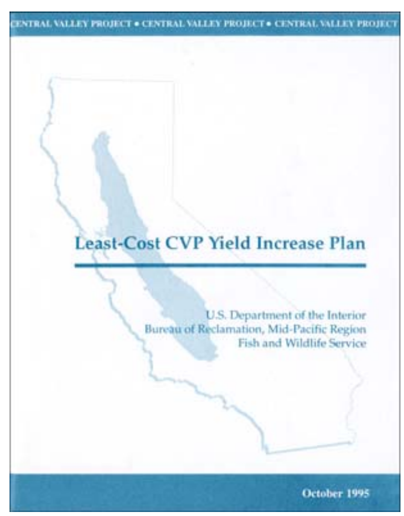
Relationship to WSAY Study

The CVPIA is one of the major components of the legal framework under which the CVP operates and the CVPIA provisions affect when, where, and for what purpose CVP water can be used. Implementation of the CVPIA has affected the distribution of available CVP supplies to CVP contractors and has reduced the overall supply available to agricultural and municipal and industrial CVP contracts. The water supply impact of implementing the CVPIA is addressed in Section 2 of this study.

Least-Cost CVP Yield Increase Plan

In 1995, Reclamation, on behalf of the Secretary and in conjunction with the USFWS, developed the *Least-Cost CVP Yield Increase Plan* and submitted it to Congress. The plan presented an appraisal-level evaluation of options that would need to be further refined as specific needs for yield increase became better known. Through a screening process, more than 100 yield increase options were narrowed to a subset of least-cost yield increase options with a potential yield of 3 MAF per year. The options included conjunctive use, land fallowing, conservation, reuse, surface storage, and conveyance. The plan determined that no option category would likely dominate a refined set of options. It foresaw a refined plan containing a combination of option categories that would minimize reliance on a single yield increase type and would minimize any particular kind of adverse impact.

Reclamation deferred subsequent efforts to improve the CVP water supply under the authority of section 3408(j) of the CVPIA because of a far-reaching and critical juncture in California water management that led to the development of the CALFED ROD and the release of the CVPIA PEIS.



Relationship to WSAY Study

A variety of changes have occurred since the publication of the October 1995 *Least-Cost CVP Yield Increase Plan*. For example, the estimated project costs and ideas about implementable projects have changed, and portions of the least-cost actions, such as conservation and conjunctive management, have been implemented. Additionally, the following two significant documents influencing CVP planning decisions have been published:

- The CVPIA PEIS, which documents the impacts of the CVPIA on CVP water service contractors
- The CALFED ROD, which presents CALFED's Preferred Program Alternative for long-term solutions to problems in the Delta

The WSAY Study uses the results of the *Least-Cost CVP Yield Increase Plan* and builds upon these results by incorporating information from the CVPIA PEIS and the CALFED ROD. This WSAY Study identifies new firm yield and water supply improvements that may serve to minimize the impact of the CVPIA on CVP water service contractors (see Section 2 for additional information on the impact of the CVPIA).

2 Supplies and Demands

Over the last 30 years, California's water demand has increased as irrigated agricultural lands, population, and environmental considerations have grown. However, California's water supplies and developed surface storage have remained relatively constant during those 30 years. This disparity has created a gap between available supplies and water demands in most years.

As California's population continues to grow, unmet water demands will create additional competition for available supplies among urban, agricultural, and environmental water users. Multiple-year droughts may have significant impacts to water deliveries as existing storage facilities are depleted of water. Many investment and management decisions must be made to secure a sustainable and reliable water supply for California through 2030 and beyond.

As California's population continues to grow, unmet water demands will create additional competition for available supplies among urban, agricultural, and environmental water users.

This section addresses four main points:

- Statewide variation in water supply and population distribution results in significant regional supply-demand gaps.
- Statewide water projects, local projects, and groundwater are managed to maximize water deliveries and reduce local supply-demand gaps. However, project deliveries are limited by available storage, conveyance facilities, and year-to-year variations in hydrologic conditions.
- Use of carryover storage and overdraft of groundwater basins are required to meet water demands during average and dry water years. Regional supply-demand gaps reveal that shortages are greatest in the Central Geographic Zone and South Geographic Zone.
- Supply-demand gaps are likely to grow in the future. Population growth, agricultural-to-urban land conversion, currently unknown future laws and regulations, and climate change add uncertainty to future demand estimates. These factors may increase the risk that existing facilities and infrastructure will not meet demands during multiple-year droughts.

California's Water Supply Variability

Hydrologic conditions in California vary greatly from year to year, season to season, and place to place.

Wet years bring the threat of floods, and drought years put pressure on available water supplies. The majority of the state's precipitation occurs in the northern third of the state during the winter, while much of the water is used in the central and southern portions of the state during the spring and summer. Because of this, meeting water demands within the state is complicated by the logistics of moving water from its source to its place of use, which may be over hundreds of miles. The availability of storage and conveyance facilities may limit California's ability to deliver water to the right place at the right time.

Section Highlights

Seasonal, geographic, and annual variability in precipitation poses significant challenges to meeting statewide water demands.

CVP and SWP deliveries vary considerably each year.

Current water use requires reservoir carryover storage use and groundwater overdraft in average and dry year types.

Current statewide demands exceed supplies by 2.3 MAF in average years and 4.2 MAF in dry years.

Future (2030) statewide demands exceed supplies by 4.9 MAF in average years and 6.1 MAF in dry years.

The needs for additional water supply are substantial, and will not be fully met without significant investment in new infrastructure and water conservation.

Multiple-year droughts may significantly impact water deliveries as existing storage facilities are depleted of supplies. Increased reliability is needed to protect water users during droughts.

Seasonal Variability

The majority of California's precipitation occurs in the northern third of the state during winter. During the summer, the presence of a cold ocean current along the western coast of California stabilizes the air, and the subsidence of a subtropical high pressure suppresses cloud development and precipitation. Figure 2-1 shows the fluctuation in precipitation over a typical year in Mt. Shasta City, Sacramento, Fresno, and the Imperial Valley.

This seasonal variability is important to water managers. Although most of the state's precipitation occurs in the winter and early spring, most water is used in the late spring and summer for agriculture and urban use, and for hydroelectric power generation. California must store water during the winter months to meet water demands throughout the summer.

Geographic Variability

California's climate is dominated by the Pacific storm track. Figure 2-1 shows how most precipitation occurs in the northern part of the state near Mt. Shasta City, while Fresno and the Imperial Valley in the central and southern part of the state receive much less rain.

California's numerous mountain ranges are another factor of variability; the mountains cause orographic lifting of clouds, producing precipitation mostly on the western slopes and creating a rain shadow on the eastern slopes.

Although most precipitation falls in the north and in the mountains, demand for water is concentrated in the Central Geographic Zone, where agriculture is prevalent, and in the South Geographic Zone, where population is dense along the coast and important agricultural areas are located inland. This geographic variability in precipitation and water demand led to the development of facilities to store and move water from north to south. To move south, this water must pass through the ecologically sensitive Delta region.

Geographic variability in precipitation and water demand led to the development of facilities to store and move water from north to south. To move south, this water must pass through the ecologically sensitive Delta region.

Annual Variability and Droughts

Significant variability in statewide precipitation from year to year affects annual water supplies. Figure 2-2 illustrates precipitation in California over the last century. The annual runoff from precipitation in the Sacramento Valley in Northern California is graphed over time and overlaid with year-type classifications developed by the State Water Resources Control Board. Critical drought periods are highlighted. Precipitation runoff conditions can range from drought to extreme flooding over just a few years. California's most recent dry period,

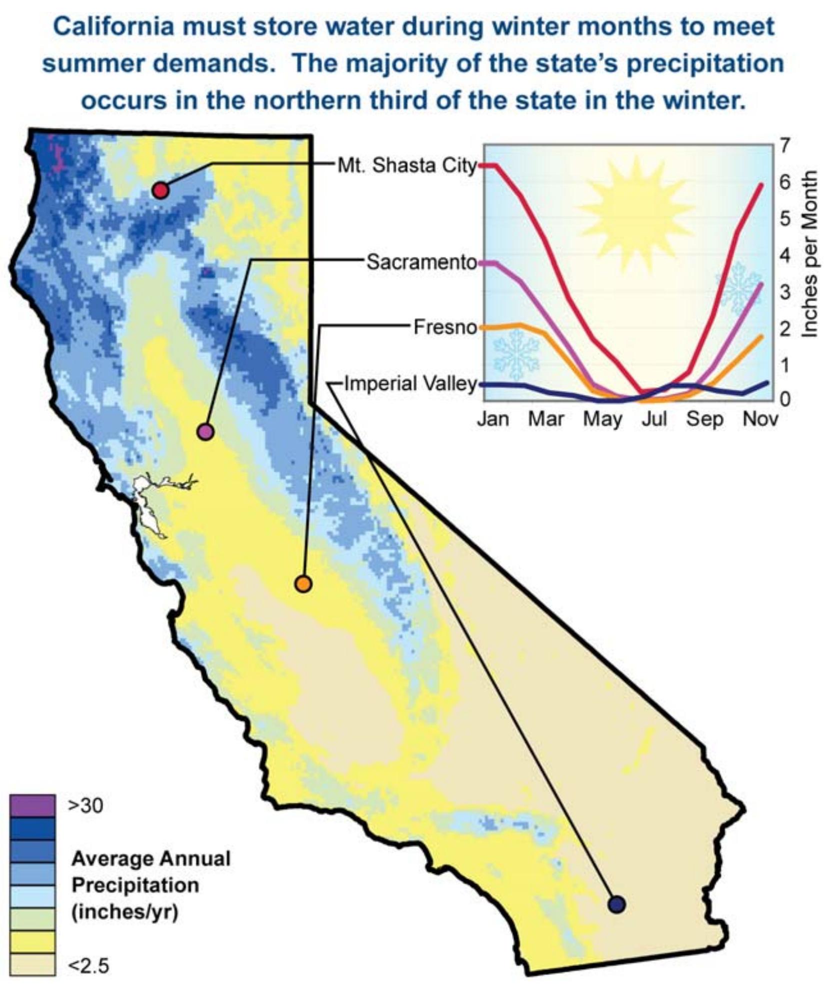


FIGURE 2-1
Average Monthly Precipitation in Mt. Shasta City, Sacramento, Fresno, and the Imperial Valley

a 6-year drought between 1987 and 1993, was followed by 5 years of above-normal precipitation from 1995 through 1999. In the wettest year on record, 1983, precipitation was over 200 percent of normal. The driest year on record was 1977, when precipitation was only about 20 percent of normal.

Climate variability has several effects on California's ability to deliver water. The availability of precipitation and runoff affects not only the water supply in the year it occurs, but also in subsequent years, because consecutive dry years reduce the ability of storage facilities to cushion drought impacts. The rate of evapotranspiration (the amount of water lost to both evaporation and transpiration) influences the demand for water, particularly by agriculture. The combination of such significant annual variability in precipitation and the growth of agriculture and population over the last century indicate that California must manage and store water during wetter years to meet demands during dry years.

Storage and Conveyance Limitations

Water is stored in California to alleviate the challenges of droughts and floods, and to help meet the seasonal and annual imbalance in water supplies and demands. Surface reservoirs may be used for seasonal operation (agricultural irrigation or urban supplies) or for carryover storage (storing water during wet years for use during dry years). During wet winter storms and in spring, when snow in the mountains is melting rapidly, surface reservoirs retain runoff near its source to prevent excessive flooding in communities downstream and to save water for later beneficial use. During summer months and throughout drought years, this stored water is available for downstream uses.

In an average year, net water supply storage decreases by nearly 6 percent, and in a single dry year, by as much as 14 percent or more.

When the demand for water is greater than the water stored in a single year, carryover storage is used to meet demands. Californians depend on carryover storage to meet demands in most years. Only during wet and above-normal years does net water storage in the state

Annual variability in precipitation and the threat of multi-year droughts indicate that California must manage and store water during wetter years to meet demands during dry years.

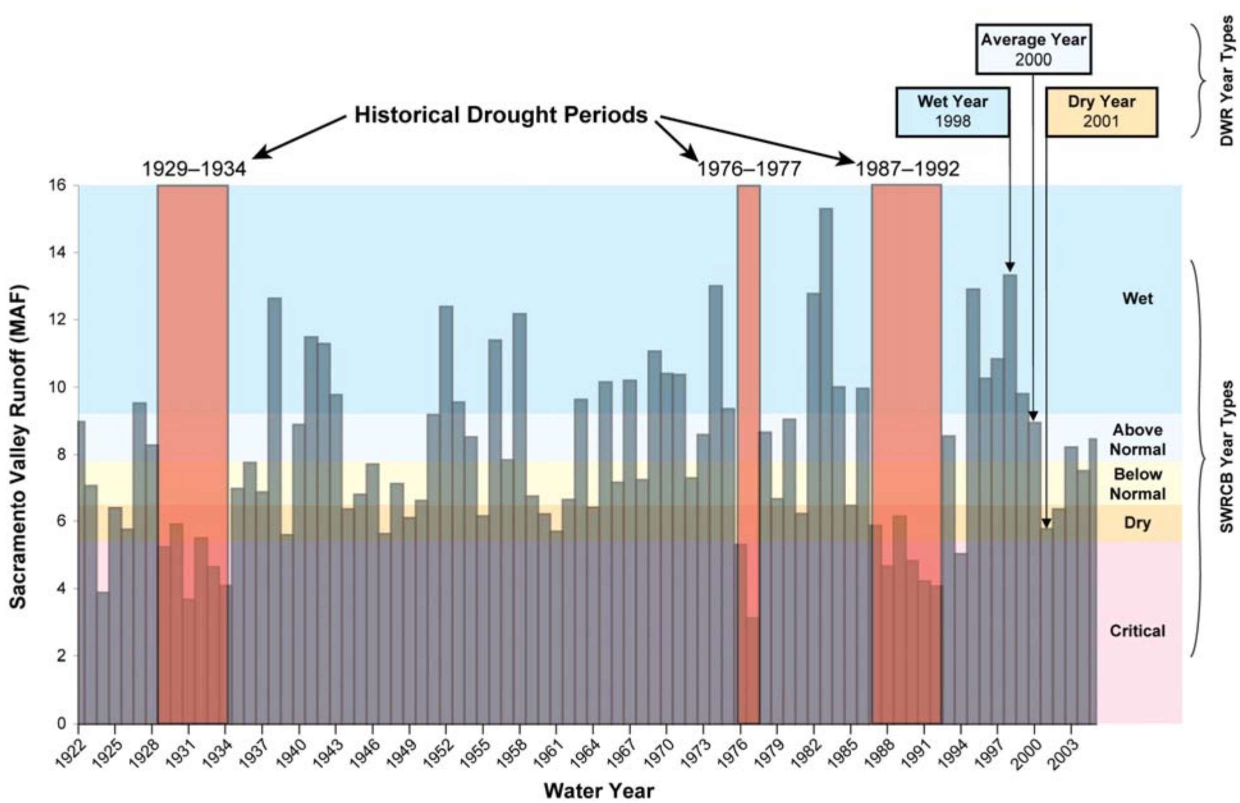


FIGURE 2-2
Variation in California Precipitation and Historical Drought Periods

increase. During an average year, net water supply storage decreases by nearly 6 percent. During a single dry water year, storage may decrease by a total of 14 percent or more, which affects the state's ability to meet water supplies the following year.

Consecutive dry years present additional challenges to storage. At the beginning of an extended dry period, the drought's duration is unknown. To manage potential shortages (or deficiencies during droughts), water may be released from storage based on a predetermined risk analysis procedure. As the drought continues, the procedure may impose progressively larger deficiencies (DWR, 1998).

Drought-year shortages produce significant social, economic, and environmental hardships.

Carryover storage was used in this way to supplement deliveries during the low-runoff years of the 1987–1992 drought. Figure 2-3 shows how project deliveries changed during this multiple-year drought, and Figure 2-4 illustrates the change in reservoir storage during that time. Although the drought lasted several years, neither the state or federal water project imposed significant delivery deficiencies during the first 3 years of the drought. When carryover storage was diminished by several consecutive dry years without replenishment, deliveries were sharply curtailed to manage the risk for meeting basic needs the following year.

As Californians experienced in 1991 and 1992, drought-year shortages produce significant social, economic, and environmental hardships. Urban water users face cutbacks in supply and mandatory rationing. Agricultural lands are

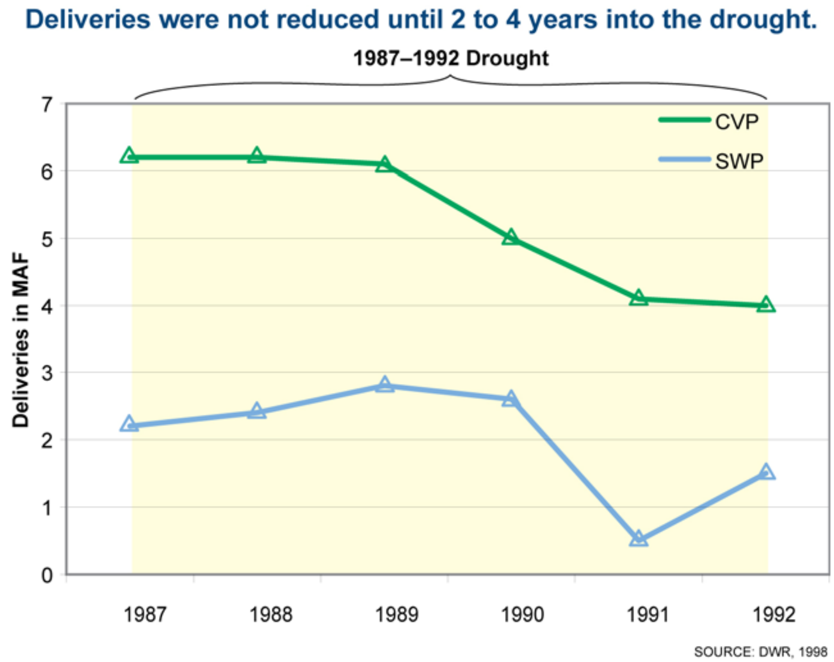


FIGURE 2-3
CVP and SWP Deliveries During the 1987–1992 Drought

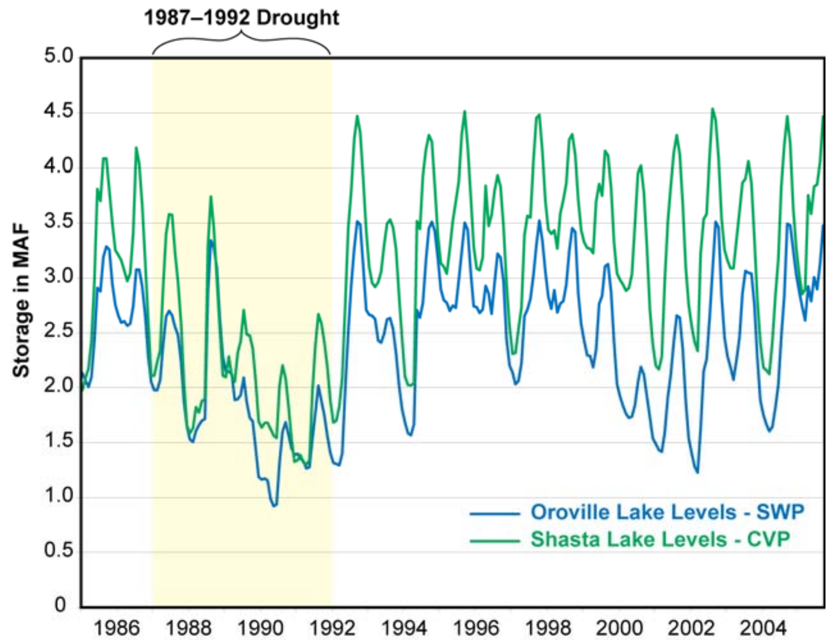


FIGURE 2-4
Change in Storage Levels in Shasta and Oroville Reservoirs During the 1987–1992 Drought

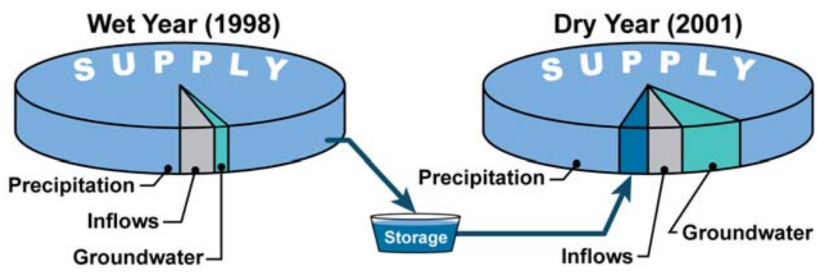


FIGURE 2-5
Components of California's Dedicated Water Supplies in Wet and Dry Years

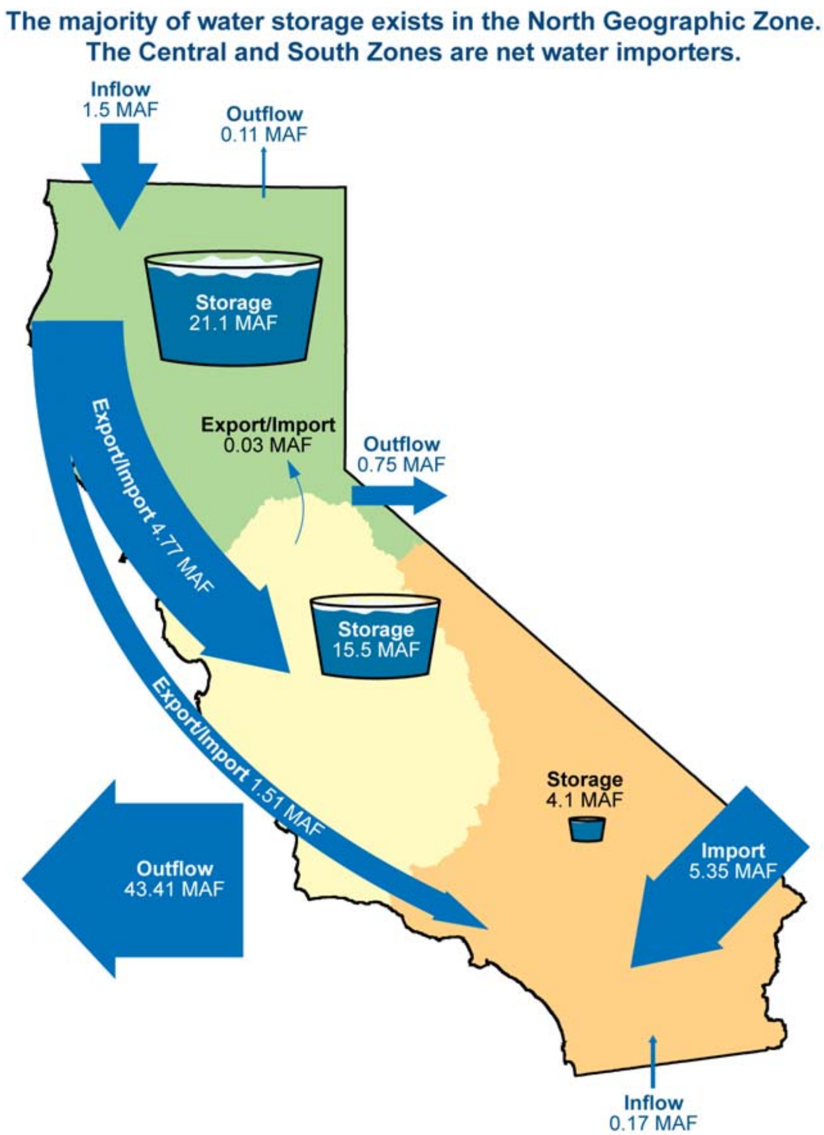


FIGURE 2-6
Developed Surface Storage, Average Imports and Inflows, and Average Exports and Outflows by Geographic Zone

fallowed, jeopardizing the state economy. Environmental water supplies are reduced, putting sensitive and endangered species at increased risk because of low flows or degraded water quality. The increasing pressure on available supplies makes meeting water demands even more difficult with each consecutive dry year. Increasing California's ability to capture and store water would improve water supply reliability during future droughts.

Water Management and Reliability

In an average water year, California receives close to 200 MAF of water from precipitation and inflows from the Colorado River, Oregon, and Mexico. Of this *total supply*, about 50 to 60 percent is either consumed by natural processes (such as evaporation, evapotranspiration from native vegetation and forests, and groundwater percolation) or flows to Oregon, Nevada, the Pacific Ocean, and salt sinks like saline groundwater aquifers and the Salton Sea. The remaining 40 to 50 percent, called *dedicated supply*, is distributed among urban and agricultural uses, used to protect and restore the environment, or stored in surface reservoirs and groundwater basins for later use. Figure 2-5 shows how the contributions of precipitation, stored water, and groundwater to dedicated water supplies vary between a wet and dry year.

In most years, more water is withdrawn from storage than is replenished. For example, in 2000, a recent average year, 82.5 MAF of supply was delivered to urban, agricultural, and environmental users, including Wild and Scenic Rivers. Of this total supply, carryover storage and groundwater overdraft accounted for about 6.7 MAF. Therefore, even in an average year, 6.7 MAF more water

Water Year Types Defined

Several water year type indices are used to characterize water availability depending on the amount of precipitation occurring in a single year or during several years. Essentially, more rain falls in some years (wet years), and less rain falls in others (dry years). Various agencies conducting studies for specific purposes have defined and used such terms to describe this phenomenon based on analytical need. This WSAY Study draws upon water year type information from several current and previous studies to assess water delivery reliability and demand.

	Year Type Indices	Multiyear Periods	Single Representative Years
Definitions	**Wet Year** **Above Normal Year** **Below Normal Year** **Dry Year** **Critical Year** Year-type classifications based on index ranges that incorporate weighted averages of the current year's runoff and previous year's indices. Refer to Figure 2-3 for an illustration.	**All Years** Average of the entire 73 years of historical hydrology: 1922–1994 **Driest Years** Average of three historical drought periods: May 1928–Oct. 1934 Oct. 1975–Sep. 1977 June 1986–Sep. 1992	**Wet Year** 1998 hydrologic conditions—falls within the SWRCB's wet year classification **Average Year** 2000 hydrologic conditions—falls within the SWRCB's above-normal year classification **Dry Year** 2001 hydrologic conditions—falls within the SWRCB's dry year classification
Use in this WSAY Study	To illustrate the fluctuating nature of water availability in California.	To assess CVP and SWP delivery capability and the impact of CVPIA on water deliveries.	To assess supplies, demands, and supply-demand gaps. The considerable amount of data available for every hydrologic region makes statewide assessment possible.
Source	SWRCB	Reclamation	DWR
Original purpose	The Sacramento Valley 40-30-30 Index and the San Joaquin Valley 60-20-20 Index were developed in 1995 to assess the water originating from the two primary water supply basins in the state.	The terms define periods to which results are presented for the CALSIM II water system operations model, which simulates the CVP and SWP over a 73-year period of record (1922–1994).	The 2005 Update reported on statewide hydrologic conditions and water use based on actual data from three recent year's representative of three different water year types.

was withdrawn from storage than was replenished.

The availability of dedicated water supplies depends on the availability of water at the source, the ability of conveyance facilities to transfer water, and the quantity and pattern of water demand at its place of use. Figure 2-6 shows developed surface storage, water exports, and imports among the North, Central, and South Geographic Zones. As the figure illustrates, the North Geographic Zone exports water, while the Central and South Geographic Zones are net importers. The SWP and CVP manage, store, and deliver approximately 4 and 9 percent, respectively, of the dedicated supplies. Local water projects and the Colorado River account for over 30 percent of the dedicated supply. Locally owned groundwater wells also contribute to supplies, especially during dry years.

CVP Supplies

The federal CVP is a multipurpose water reclamation project constructed and operated to regulate Sacramento River Basin and San Joaquin River Basin runoff to meet agricultural and urban needs in the Sacramento Valley, the San Francisco Bay Area, the San Joaquin Valley, and the Tulare Lake Basin. It is also the primary source of water for much of California's wetlands and provides flood protection, navigation, recreation, and water quality benefits. The CVP plays a key role in California's powerful economy, providing water for 6 of the top 10 agricultural counties in the nation's leading farm state.

Project Deliveries

The CVP delivers water to many users, including the Sacramento River Settlement Contractors (Settlement Contractors), the San Joaquin River Exchange Contractors (Exchange Contractors), municipal and industrial (M&I) contractors (urban users), agricultural contractors in the San Joaquin and Tulare Basins, and wildlife refuges. Each CVP contract type has a different priority for water delivery.

The Settlement Contractors and Exchange Contractors have the highest priority based on senior California water rights. The construction and operation of the CVP are facilitated largely due to negotiated contracts with these users; as such, CVP water deliveries to the Settlement Contractors and Exchange Contractors are the last to be reduced when drought conditions exist.

The next highest priority for deliveries belongs to CVP M&I contractors. During drought conditions, CVP agricultural contractors, who have the lowest priority, bear the greatest reductions during drought.

The priority of refuge water supplies varies compared to other project deliveries. Level 2 water, the amount required to meet existing refuge management needs, has a priority similar to that held by the Settlement Contractors and Exchange Contractors, and may not be cut by more than 25 percent in any year. Incremental Level 4 water, the amount needed for full habitat development, is purchased annually from willing sellers and takes on the priority of its prepurchase source, as specified by CVPIA, Section 3406(d)(4).

The CVP has water service contracts to deliver about 6.275 MAF per year. However, historical CVP deliveries have varied greatly from year to year depending on water year type and available water supply, pumping restrictions, and environmental demands.

To express the long-term variation of CVP deliveries, CALSIM II, a water system operations model, was used to simulate the operation of CVP and SWP under conditions represented in 73 years (1922–1994) of historical hydrologic data. These simulations were conducted in preparation of *The Delivery Impact of CVPIA*, commonly referred to as the "Delivery Impact Report" (Reclamation, 2005). The results of the simulations were used to estimate the delivery gap, or the average difference between CVP contract amounts and deliveries in all years and in driest years.

Under existing regulatory conditions (with the CVPIA), CALSIM II simulations show that the CVP delivers an average of 4.7 MAF per year in all years and 3.7 MAF per year in driest years. The overall average delivery gap is therefore approximately one-quarter of the maximum contract amount in all years, and over 40 percent in driest years. This concept is illustrated in Figure 2-7.

The delivery gap varies by contractor group type, however, as shown by Figure 2-8. Agricultural contractors have the largest delivery gap in all years and in driest years, at approximately 64 percent and 77 percent of their maximum contract amount, respectively. These gaps have grown to these levels with the passage of CVPIA, which has impacted CVP agricultural and urban (M&I) water supply.

Delivery Impact of the CVPIA

The implementation of the CVPIA in 1993 dedicated a portion of the yield of the CVP to protect, restore, and enhance fish and wildlife habitats in the Central Valley and

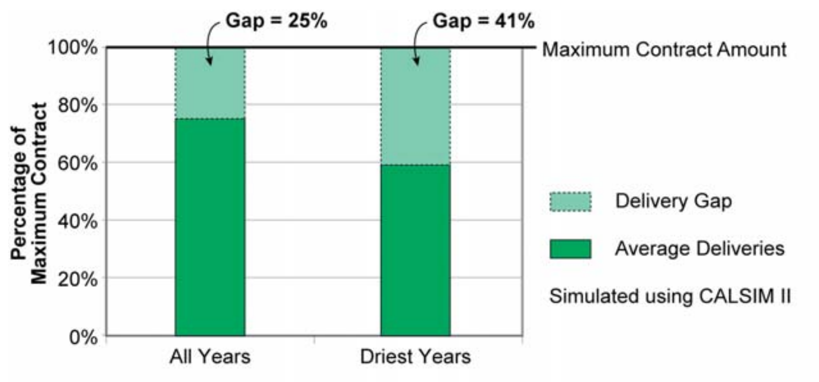


FIGURE 2-7
CVP Delivery Gap by Year Type

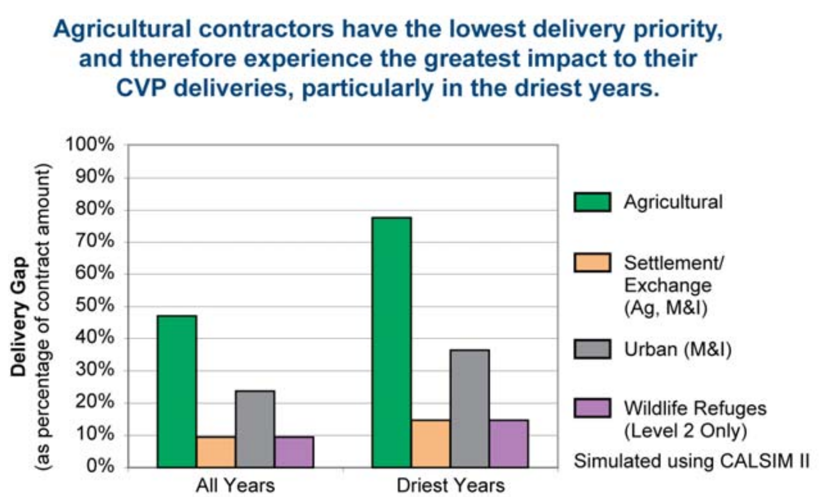


FIGURE 2-8
Gap between CVP Water Supply Contracts and Deliveries by Year Type

TABLE 2-1
Impact of CVPIA on CVP Deliveries in All Years and Driest Years

	All Years			Driest Years		
CVP Contract Deliveries	Pre-CVPIA (TAF)	Post-CVPIA (TAF)	Percent Change	Pre-CVPIA (TAF)	Post-CVPIA (TAF)	Percent Change
NOD agricultural	279	234	-16%	169	84	-50%
NOD M&I (urban)[a]	176	167	-5%	166	145	-13%
SOD agricultural[b]	1,588	1,137	-28%	931	471	-49%
SOD M&I (urban)	134	122	-9%	114	96	-16%
Total	**2,176**	**1,660**	**-24%**	**1,381**	**796**	**-42%**

Source: Reclamation, 2005
Note: Simulated using CALSIM II
[a] For simplification, NOD M&I (urban) deliveries include American River CVP contract water and Contra Costa Water District deliveries.
[b] For simplification, SOD agricultural deliveries include Cross Valley Canal agricultural deliveries.

Trinity River Basins. The CVPIA increased demands on the CVP by allocating a portion of yield to environmental uses instead of delivering this water to agricultural and urban uses, thereby impacting available water supplies and project deliveries.

Several key CVPIA provisions directly affect the availability of CVP water supplies to agricultural, urban, and environmental water users:

- Up to 0.8 MAF per year of supply is dedicated to environmental needs as CVPIA 3406(b)(2) water.
- Additional reliable water supplies are designated for use by wildlife refuges.
- The reoperation of the Trinity River Division increases releases in the Trinity River to protect and restore the fishery.

The Delivery Impact Report estimated the CVPIA's effect on the CVP's ability to deliver water to project contractors. This analysis quantified changes in the CVP's water supply delivery performance resulting from implementation of the CVPIA. The impact analysis was conducted by performing two CALSIM II simulations: one representing pre-CVPIA conditions and the other representing post-CVPIA conditions.

The Delivery Impact Report concluded that the CVPIA reduces water supply to CVP agricultural and M&I (urban) contractors by an average of 516 TAF per year (24 percent) in all years and by 586 TAF per year (42 percent) in driest years. Table 2-1 compares CVP deliveries to north-of-Delta (NOD) and south-of-Delta (SOD) contractors under pre- and post-CVPIA conditions. The table shows that the greatest impact from the CVPIA is seen in deliveries to SOD contractors. In particular, SOD agricultural deliveries are reduced by 28 percent on average (in all years) and by 49 percent in driest years.

The results from the Delivery Impact Report show that increased demands on the CVP affect water deliveries to agricultural and M&I (urban) contractors because more of the available supply is allocated to environmental uses.

These delivery gaps demonstrate that increasing demands on the CVP are creating a need for reliable water supplies, particularly during driest years in the southern half of the state.

State and Federal Refuges with CVP Supplies

Section 3406 of CVPIA required Interior, through Reclamation and the USFWS, to provide firm water supplies of suitable quality to maintain and improve wetland habitat areas on the Central Valley refuges that receive CVP water supplies. To comply with the CVPIA, a Water Acquisition Program was developed as a joint effort by Reclamation and the USFWS. The Water Acquisition Program has annually purchased incremental Level 4 water supplies from willing sellers to fulfill CVPIA obligations and meet refuge contract quantities.

SWP Supplies

The SWP is a large water supply, storage, and distribution system authorized by an act of the California State Legislature in 1959. The SWP is operated by DWR, and makes deliveries to approximately two-thirds of California's population. Of the contracted water supply, approximately 70 percent goes to urban users, and 30 percent goes to agricultural users. The SWP service area includes primarily agricultural users in the Tulare Basin and urban users in the San Francisco Bay Area, Central Coast,

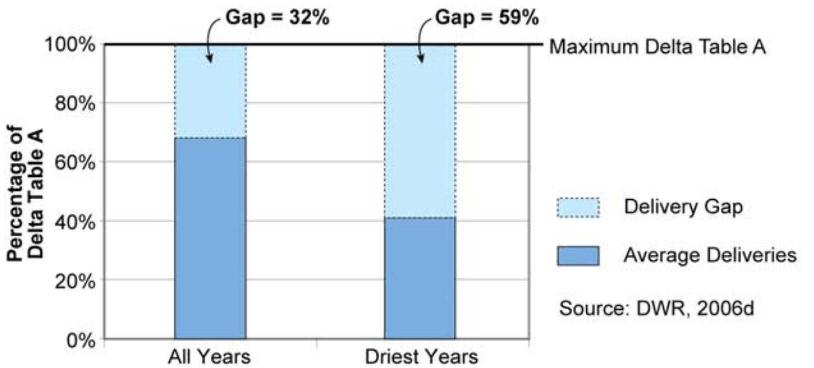


FIGURE 2-9
SWP Delivery Gap by Year Type

and Southern California Hydrologic Regions.

Project Deliveries

The SWP delivers water to two primary contractor groups: agricultural and M&I (urban). Each SWP contract has a *Table A amount*, which is a term used to represent the annual maximum amount of water to which each contractor has a contract right to request delivery. Previously referred to as *entitlement*, this amount is specified in Table A of each SWP contractor's water supply contract.

The total of all contractors' Table A amounts is currently 4.173 MAF per year (DWR, 2006d). Nearly all SWP deliveries are made south of the Delta for a total Delta Table A amount of 4.133 MAF per year. However, similar to the CVP, SWP supplies can vary greatly from year to year depending on water year type and available water supply, pumping restrictions, and environmental demands.

DWR's *Delivery Reliability Report 2005* assessed the delivery ability of the SWP using several different CALSIM II runs covering a 73-year period of record (DWR, 2006d). The CALSIM II studies developed for this report indicate that, from the Delta, the SWP delivers an average of 2.8 MAF per year in all years and 1.7 MAF per year in driest years[1] compared with the SWP Delta Table A of 4.133 MAF per year. The overall average SWP delivery gap is therefore approximately 32 percent of the maximum Delta Table A amount in all years and 59 percent in driest years. This is illustrated in Figure 2-9. Originally, M&I (urban) contractors had a higher priority than agricultural contractors, but since the 1995 Monterey Amendment, shortages are shared proportionally between agricultural and M&I contractors.

These delivery gaps demonstrate the need for reliable water supplies, particularly during driest years to SWP contractors south of the Delta.

Groundwater

Groundwater provides an estimated 30 percent of the state's total water supply in an average year (DWR, 2005). In some regions, groundwater provides 60 percent or more of the supply during dry years. Between 40 and 50 percent of the state's population relies on groundwater for part of its drinking water supply. Many small- to moderate-sized communities are entirely dependent on groundwater for drinking water supplies. In 1995, it was estimated that 14.5 MAF of groundwater was extracted in California, which represented 20 percent of all groundwater extracted in the United States (DWR, 2005).

[1] Summarized from the data provided in the *Delivery Reliability Report* for the WSAY Study. Model Table A delivery for Study 4 (DWR, 2006d). Does not include Model Article 21 water.

Groundwater in California is generally being withdrawn at a faster rate than it is being replenished, resulting in overdraft conditions. Figure 2-10 shows an example of dramatic overdraft-induced land subsidence in the Central Valley, one of several negative effects caused by overdraft.

Groundwater overdraft is not a sustainable water supply management action.

In Bulletin 118, DWR estimated statewide groundwater overdraft at between 1 and 2 MAF per year (DWR, 2003). It further identified 11 groundwater basins in a state of critical overdraft, eight of which are in the Central Valley. This amount

FIGURE 2-10
Land Subsidence Recorded on a Telephone Pole in the Central Valley (Source: USGS)

is compounded annually and has resulted in significant groundwater depletion over time.

Update 2005, which used a different analytical approach, estimated that more groundwater was withdrawn than replenished in the three year types (wet, average, and dry) used in that report (DWR, 2005). Although modern computers allow rapid manipulation of groundwater data to determine basin conditions such as groundwater storage changes or groundwater extraction, a lack of essential data in some groundwater basins limits the ability to make precise calculations.

Management approaches such as conjunctive use allow surface water supplies and groundwater supplies to be managed collectively. In some regions, groundwater is banked when surface water supplies are most plentiful, and then extracted and used as an important source of supply during droughts. However, groundwater overdraft can lead to a variety of economic and permanent environmental impacts, such as increased extraction costs, land subsidence, water quality degradation, and saltwater intrusion (DWR, 2003). Therefore, groundwater overdraft is not a sustainable water supply management action.

Current Water Use and Demands

To evaluate the adequacy of California's water supplies to meet existing and future water demands, this WSAY Study estimated and compared available water supply, typical water use, and overall water demand in different year types.

Each year, runoff from precipitation and water imported from adjacent states is dedicated to urban, agricultural, and environmental uses. Figure 2-11 shows the typical distribution of statewide water uses in an average year (2000).

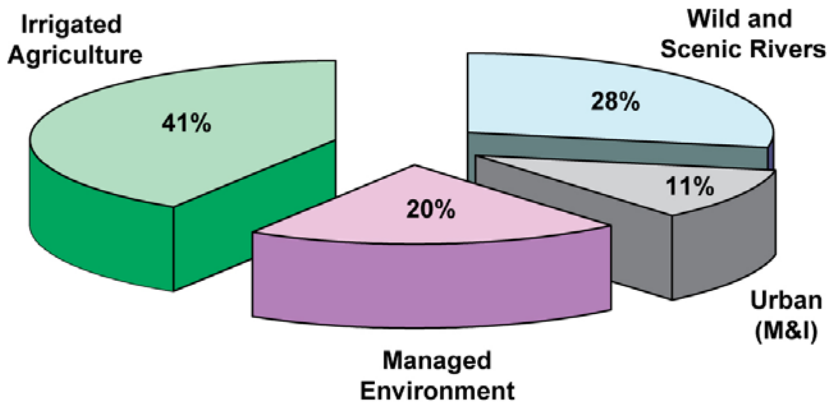


FIGURE 2-11
Distribution of Statewide Water Uses in an Average Year (2000)

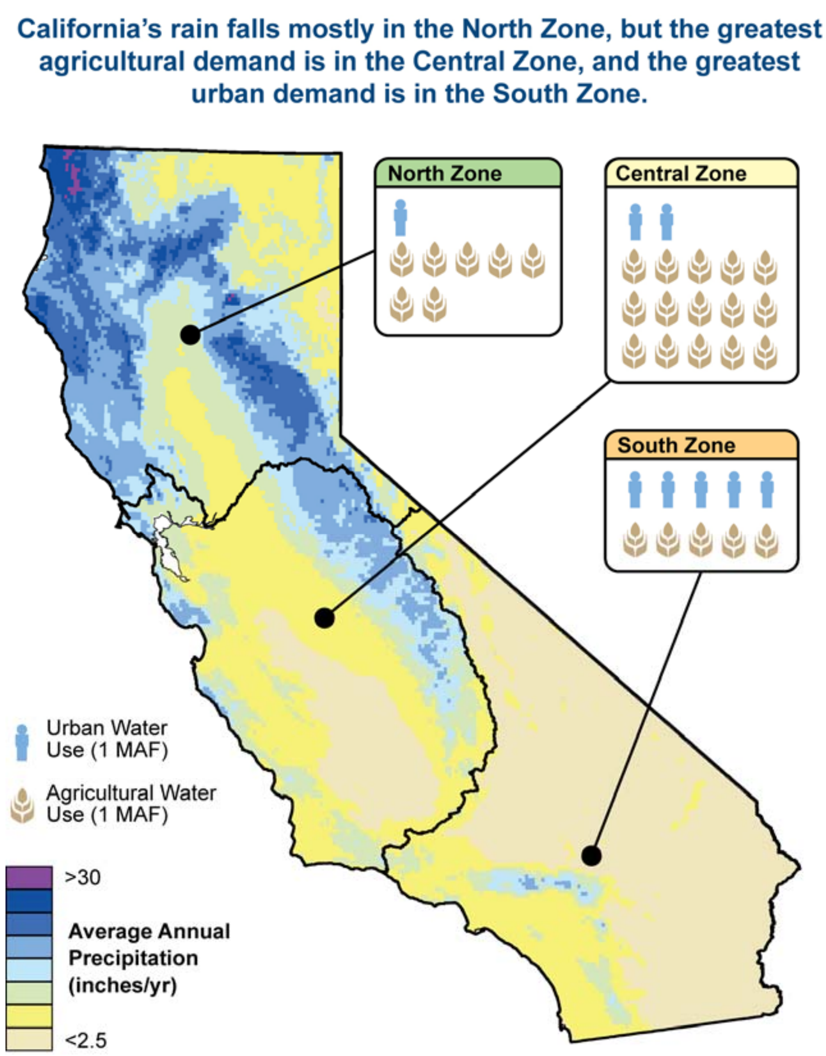


FIGURE 2-12
Distribution of Applied Water Uses by Geographic Zone

TABLE 2-2
Applied Statewide Water Use and Dedicated Supplies in Wet, Average, and Dry Years

Use	Wet Year 1998 (MAF)	Average Year 2000 (MAF)	Dry Year 2001 (MAF)
Urban use	7.8	8.8	8.4
Agricultural use	27.3	33.3	32.0
Environmental use	17.8	16.3	12.6
Total statewide use	**52.9**	**58.4**	**53.0**
Dedicated statewide supplies	**58.4**	**58.4**	**53.0**

Note: Environmental use and dedicated supplies do not include Wild and Scenic River flows. Dedicated supplies exclude water made available from groundwater overdraft in order to reflect the typical, sustainable supply for each year type.

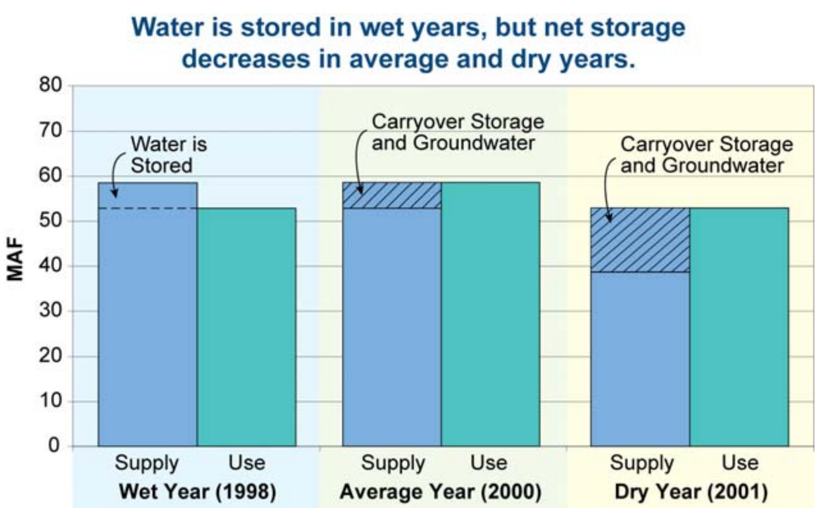


FIGURE 2-13
Statewide Dedicated Water Supplies and Uses by Year Type

Wild and Scenic River flows are classified separately in Figure 2-11. Wild and Scenic Rivers are designated by the state and federal government for their extraordinary scenic, recreation, fishery, or wildlife values. These rivers or river segments are considered fully appropriated (or fully "used" by the environment); therefore, including the flow of these rivers as dedicated environmental water uses would be misleading, because Wild and Scenic River uses simply represent what is available from unimpaired runoff. For this reason, such flows were excluded from this supply and demand analysis.

Uses vary significantly by geographic zone and hydrologic region. The distribution of applied water uses by geographic zone is shown in Figure 2-12. The North and Central Geographic Zones support the bulk of agricultural use in the state, while the majority of urban uses are in the South Geographic Zone. During an average year, most environmental flows and all Delta outflow requirements are met using water originating in the North Geographic Zone. Managed Delta outflows make up the largest environmental water use in the state, aside from Wild and Scenic River flows.

Water Use Estimates

Update 2005 estimated existing regional and statewide water use by compiling actual water use data from three recent years—1998, 2000, and 2001—to show the variation of water supplies and uses in a typical recent wet, average, and dry year, respectively. Water supply and use data was assembled from the state's 10 individual hydrologic regions, and no statistical adjustments were made to the data.

The total statewide applied water uses and supplies are listed in Table 2-2.

To meet some demands in average and dry years, more water is withdrawn from storage than replenished.

The Update 2005 estimate shows how water supplies and uses vary by year type. Figure 2-13 illustrates the differences between statewide supplies and uses in recent wet, average, and dry years. In a wet year, dedicated supplies are higher than the amount of water used, and the excess water is stored. In average and dry years, dedicated supplies and uses were equal. The carryover storage and groundwater indicated by the shaded area within the average and dry year supply boxes represents the net depletion in surface and groundwater storage in a given year type. Therefore, to meet some demands in average and dry years, more water is withdrawn from storage than replenished.

Figure 2-13 also shows that statewide water uses in an average year exceed water uses in a wet or dry year. During a wet year, the demand for water is lower because more water is available from precipitation. This corresponds to the lower water use in a wet year. During dry years, when less water is available from precipitation, a higher urban and agricultural demand is expected because of increased need for landscape watering and crop irrigation. The dedicated supply in a dry year may be insufficient to meet those increased needs. Therefore, during a dry year, it is likely that supply curtailments—rather than decreased demand—lead to the lower water use. Even in average water years, some growers forego planting and other agricultural operations because they lack a reliable water supply (DWR, 2005).

> During a dry year, it is likely that supply curtailments—rather than decreased demand—lead to lower water use.

Note that although 2001 was a dry year, it was not considered a drought year or critically dry year. The year 2001 followed six consecutive years designated as either above normal or wet. Reservoirs were filled prior to 2001, attenuating the impacts of a dry 2001. Although 2001 does illustrate how uses change based on hydrology, this single year does not reflect consecutive dry years' impact water supply reliability.

The water uses developed in Update 2005 account for physical and economic considerations that may affect the amount of water delivered to users. Water demand, as defined in this WSAY Study, is the amount of water a user desires to apply to a particular use, regardless of these factors.

To assess the actual water demand during average and dry years, unmet water needs must be accounted for. Forecasting future water demand must also include needs currently being unmet even in an average water year. The following discussion quantifies the existing gaps between water use and water demand in order to establish existing demands and forecast future water needs.

Use and Demand Defined

Water use is the amount of water *delivered to and used by a user*, which is dependent on water supply and *is influenced* by factors such as price, availability, and physical constraints. Update 2005 determined water use.

Water demand is an amount of water a *user desires to apply to a particular use*, such as crop irrigation, industrial processes, ecosystem needs, or residential supply, *regardless* of influencing factors such as price, available supply, or physical constraints. The WSAY Study determined water demand.

Water Demand in Average and Dry Years

The demand for water can be estimated by adjusting water use estimates to account for unmet demands and groundwater overdraft. Demands were determined for each hydrologic region using the following methodology.

Urban (M&I) Demand

A typical level of urban demand can be estimated by the level of water use during an average year. Urban demand in 2001, a dry year, likely increased as a result of increased need for landscape irrigation and an increase in population from the previous year. Incorporating the per capita increase in typical water use resulting from the increase in population from 2000 to 2001, statewide urban demand for water was estimated to be about 500 TAF greater in 2001 than in 2000, an average year.

Agricultural Demand

Agricultural water use decreased by 19 percent from 2000 to 2001, primarily as a result of fewer acres being irrigated, likely because of delivery reductions under dry year conditions. Since the number of irrigated acres in 1998 and 2000 were similar, it could be assumed that irrigated acreage would have been roughly the same in 2001 if there had been no delivery curtailments (shortages). Therefore, the agricultural water demand in 2001 would have been at least as much as the demand in 2000.

Environmental Demand

Statewide, numerous environmental flow objectives have not been met, even in wet years. For Update 2005, Environmental Defense conducted an analysis of unmet environmental flows using actual flow data for water years 1998, 2000, and 2001 (Environmental Defense, 2004). That analysis included a regional assessment of unmet environmental objectives and considered the following factors:

- Trinity River flows consistent with Trinity River Mainstem Restoration Plan ROD
- Additional water required to meet flow objectives in the Final Restoration Plan for the Anadromous Fish Restoration Program
- A level of protection in the Delta equivalent to that specified in the CALFED ROD and required for long-term Endangered Species Act assurances
- San Joaquin River flows needed to comply with the federal court order to restore the salmon fishery below Friant Dam
- All Level 4 refuge supplies
- The Ecosystem Restoration Program purchases identified in the CALFED ROD for Stage One implementation
- San Joaquin River flows at Vernalis consistent with levels specified in the 1995 Water Quality Control Plan

These unmet environmental flows did not include water needed for privately owned wetlands. In the update of the *Central Valley Wetlands Water Supply Investigations Report*, the Central Valley Habitat Joint Venture has preliminarily concluded that there is a supply shortfall of full deliveries to existing private wetlands in an average year. The update also concluded that there is a shortfall in reliable water supplies to meet supplemental wetland habitat goals originally established by the *Central Valley Wetlands Water Supply Investigations Report* (Ostroff, 2006). These additional supply gaps increase the statewide unmet refuge water demand calculated by Environmental Defense.

The unmet environmental demands developed by Environmental Defense and the Central Valley Habitat Joint Venture range from 1.11 MAF in a representative wet year (1998) to approximately 1.28 MAF in a representative dry year (2001). Unmet environmental flow objectives were also distributed to each applicable hydrologic region. To estimate the total environmental demand in both years, these unmet environmental flows were added to the overall environmental water demand in each year type.

Total Water Demand

Urban, agricultural, and environmental water demands were developed for each hydrologic region, primarily from Update 2005 data.

The water demand for each user was added to determine a total water demand. Total statewide water demands are listed in Table 2-3. Demands vary from about 54 MAF in wet years to about 61 MAF in average years. Demand is lowest in wet years, when more water is provided by precipitation and runoff, and higher in average

TABLE 2-3
Projected Statewide Demand by User in Representative Wet, Average, and Dry Years

User	Wet Year 1998 (MAF)	Average Year 2000 (MAF)	Dry Year 2001 (MAF)
Urban	7.8	8.9	9.0
Agricultural	27.3	34.2	34.2
Environmental*	18.5	17.5	14.0
Total statewide demand	**53.6**	**60.6**	**57.2**

* Does not include Wild and Scenic River flows

Statewide Demand Simulation and CALSIM II

Congress directed the Secretary to conduct a study of available water supplies and existing and future water needs by passing Public Law 108-361 (described in Section 1 of this report). This WSAY Study fulfills that need by identifying possible projects and water management actions that could provide new firm yield and water supply improvements for the CVP and help the state meet current and future water needs.

Generally, planning studies prepared by Reclamation address water supplies and needs in the integrated CVP and SWP service areas. However, the WSAY Study's authorization includes the CALFED Solution Area and statewide water needs, and therefore broadens the scope of this WSAY Study beyond the CVP and SWP service areas.

In many planning studies, Reclamation and DWR use a number of computer models to analyze water supply reliability, reservoir storage, and Delta water exports. CALSIM II, a monthly time-step planning and analysis model, is one such model used by both agencies to simulate operations of the CVP and SWP. CALSIM II is typically used to simulate how the CVP and SWP water supply systems respond to a future action, such as the addition of a new facility or implementation of a certain policy. CALSIM II simulates these responses over several years of historical hydrology, which is adjusted to reflect current or simulated future water demands, facilities, and operational constraints.

Although CALSIM II may seem appropriate to simulate future statewide water shortages, it does have limitations:

- Model output from different scenarios is intended to be analyzed comparatively in reference to a base simulated condition. CALSIM II is not designed to predict discrete river flows, daily water quality conditions, or drought shortages, but instead provide relative magnitudes of the long-term effects of alternative planning decisions.
- CALSIM II simulates the operations of the CVP and SWP systems and includes demands for CVP and SWP contractors. However, the CALSIM II model does not account for demands in areas outside of the CVP and SWP system, such as areas of the CALFED Solution Area and the North Coast and Central Coast.
- Operations and calculations in CALSIM II are based on generalized monthly operational rules to reveal trends reflected as the long-term average and critical and dry year average deliveries. Actual operations will likely be different than those simulated, resulting in differences between modeled and actual conditions in a given month or year. This means that CALSIM II is not intended to exactly replicate recent or historical operational conditions.

CALSIM II's intended use and its inherent limitations prevent it from being used to provide the data necessary to fulfill the requirements of the WSAY Study. Therefore, this report uses the hydrologic and water use data collected by DWR for Update 2005 to provide a better representation of existing and anticipated future statewide conditions.

and dry years, when less precipitation is available and more water is lost to evaporation. Environmental demands seem to decrease significantly during dry years because less runoff is available for instream flows. Consequently, unmet environmental demands are greatest during dry years.

TABLE 2-4
Existing Supply and Demand Gap for Average and Dry Years by Geographic Zone

Geographic Zone	Average Year 2000 (MAF)	Dry Year 2001 (MAF)
North	0.8	1.1
Central	1.5	2.3
South	<0.1	0.8
Total statewide gap	**2.3**	**4.2**

Current Supply-Demand Gaps

Supply-demand gaps were determined by totaling unmet urban, agricultural, and environmental demands, as well as the annual estimated amount of groundwater overdraft[2] and comparing the result to currently available supplies. Supplies and demands were compared on a regional basis because comparing supplies and total demands on a statewide basis does not provide an accurate representation of supply-demand gaps at the regional level. If one region has surplus supply, it cannot be assumed that the surplus water can be conveyed to fill another region's supply-demand gap. Therefore, supplies and demands were compared by hydrologic region, and only gaps (not surpluses) were added to regional and statewide totals.

Supply-demand gaps exist for all geographic zones in average and dry years.

This analysis shows that supply-demand gaps exist for all geographic zones in average and dry years. Table 2-4 lists the supply-demand gaps by geographic zones and for the state as a whole for 2000 (average year) and 2001 (dry year).

Regional supply-demand gaps reveal that shortages are greatest in the Central Geographic Zone. Detailed information on existing supplies, demands, and gaps by hydrologic region is provided in the appendix.

The source of each gap varies by year type and geographic zone, as shown in Figure 2-14. The gap in average years is primarily the result of unmet environmental demands, whereas the gap in dry years results from unmet urban, agricultural, and environmental demands.

Regionally, in the North Geographic Zone, unmet environmental demands account for 70 to 90 percent of the gap, whereas agricultural and urban demands account for the entire gap in the South Geographic Zone. Gaps exist in the central and southern parts of the state primarily because of hydrologic conditions and facility (storage and conveyance) constraints. Groundwater overdraft is greatest in the Central and South Geographic Zones, which is also reflected in the urban and agricultural gap for those areas.

Significant fluctuations in state precipitation from year to year and the high demands placed on available water result in supply-demand gaps in average and dry years. Additional storage and conveyance infrastructure and facility improvements are some of the options available to ensure that enough water supplies are available to meet demand during average and dry years.

During dry years in particular, water managers must balance a complicated set of considerations when deciding which demands can be met and how much water should be banked to protect against future droughts. Each year of a multiple-year drought presents a greater challenge to meeting the next year's water demands, because storage is further depleted with each successive dry year. The dry year supply-demand gaps calculated for this study only begin to describe the challenges faced by California during a multiple-year drought. As population and other demands on California's water supply increase in the future, it will become more difficult to ensure that water is available and reliable without investment in additional conveyance and storage facilities and demand-reduction options.

Future Challenges

Demand for water in the future will depend on several driving factors, including population growth and density, land use changes (such as conversion of agricultural areas to urban areas), unknown future laws and regulations, and the effects of climate change. These factors add uncertainty to future available supplies, and may increase the risk that existing facilities and infrastructure will be inadequate to meet demands during multiple-year

[2] Bulletin 118's estimate of groundwater overdraft was distributed to hydrologic regions that have areas reported to be in overdraft, including the Central Coast, South Coast, San Joaquin River, and Tulare Lake regions. Because overdraft is not a sustainable source of supply, 2 MAF was subtracted from statewide supplies in dry years and 1 MAF was subtracted in average years.

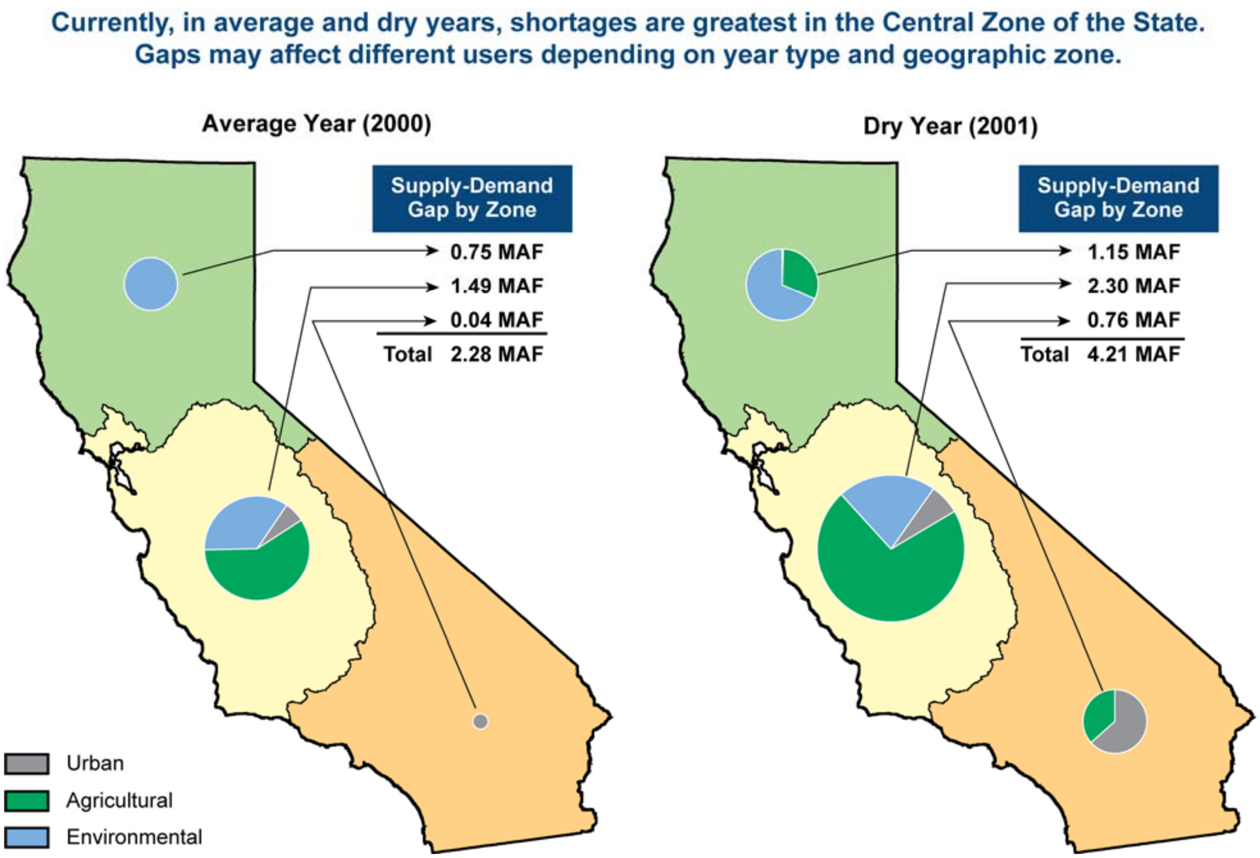


FIGURE 2-14
Existing Supply-Demand Gaps by Geographic Zone in an Average Year (2000) and Dry Year (2001)

droughts. The following discussion explains these driving factors, estimates water demand in 2030, and describes future supply-demand gaps regionally and statewide.

Factors Driving Future Water Demand

Future water demand can be gauged by studying historical trends in water use on a regional and statewide basis. Factors that may drive these trends into the future include population growth, conversion of agricultural land, environmental regulations, and climate change.

Population and Urban Growth

It is estimated that California's population will grow from 36 to 48.1 million people by 2030 (California Department of Finance, 2004) (Figure 2-15). Current trends point to nearly a 50 percent increase in single-family residences and a 35 percent increase in multifamily houses by 2030, resulting in increased urban water demand and potential conversion of agricultural land.

Regional growth is of vital concern to water supply and conveyance. Population is expected to increase most in the state's inland and southern areas by nearly 45 percent according to current trends. This could present a challenge to convey enough water from its source in the northern regions of the state to the growing demand in the south. Over the last 30 years, urban water use has nearly doubled in the South Coast Hydrologic Region. In contrast, urban water use in the North Coast Hydrologic Region has decreased by about 17 percent since 1980.

Conversion of Agricultural Land

California has approximately 27.6 million acres of farmland, about 9 million acres of which is irrigated. Agricultural land has been gradually shifting to urban or other nonagricultural uses; from 1990 to 2000, about 500,000 acres were converted from agricultural use to urban or other nonagricultural uses. The rate at which this land conversion will continue is uncertain, but based on current trends, approximately 700,000 acres of additional California farmland will be converted to urban use each decade. However, as a result of technological advances, multicropping, increased water efficiency, and production of higher-value crops per acre, yield per acre of agricultural land may continue to increase.

Environmental and Flow Regulations

Prior to the late twentieth century, flows for environmental uses were rarely regulated. Trends over the last few decades point to more flows being contributed to Delta outflows, restoration efforts, Wild and Scenic Rivers, wildlife refuges, and the Environmental Water Account (EWA). However, future environmental water demands could vary depending on future land use changes and the effectiveness of current and planned ecosystem restoration efforts.

These recent developments point to an increasing trend in dedicated environmental flows:

- State Water Resources Control Board Water Right Decision 1485 (D-1485), issued in 1978, set flow and water quality standards for the protection of beneficial uses in and from the Delta, and required the SWP and CVP to meet those standards as conditions of the water right permits for the projects. The Coordinated Operations Agreement of 1986 specified how the CVP and SWP would share the responsibility of meeting these Delta water quality standards.
- The Water Quality Control Plan, adopted in 1995 by the State Water Resources Control Board, required greater amounts of CVP water to meet water quality standards.
- Water Right Decision 1641 (D-1641), issued in 1999, assigned interim responsibility to the CVP and SWP to meet the flow and water quality objectives in the 1995 Water Quality Control Plan, and addressed the responsibility of certain other water right holders for meeting those objectives.
- The EWA, established in 2000, implemented pumping reductions at the Delta CVP and SWP export pumping plants to protect at-risk fish species, and used other assets to repay CVP and SWP users for water not pumped during the pumping restrictions. Pumping reductions may reduce water supply reliability for the CVP and SWP users south of the Delta.
- Compliance with the Endangered Species Act has altered CVP and SWP operations. Structural and operational changes have been required to maintain flows and reduce water temperatures below Shasta Dam for the endangered winter-run chinook salmon, resulting in less water being available for agricultural and urban (M&I) users. Additionally, CVP and SWP diversions from the Delta have been reduced to limit losses of special-status species, especially Delta smelt and winter-run chinook salmon.

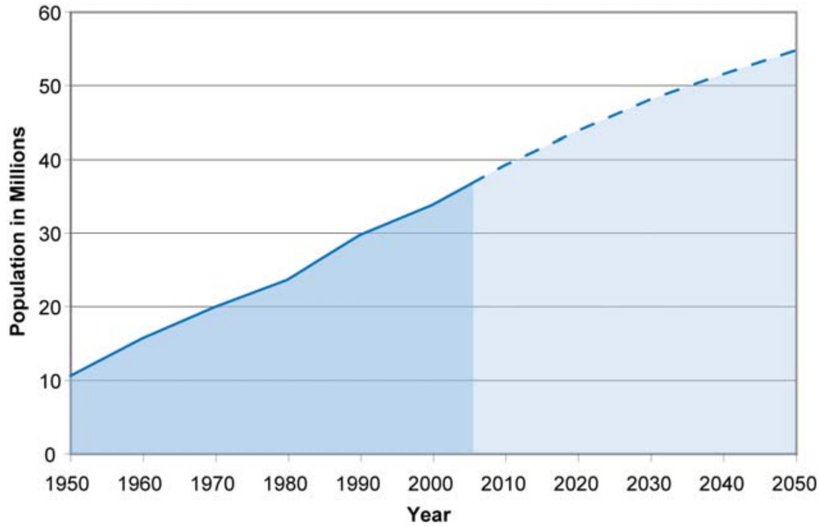


FIGURE 2-15
California Population Growth Trend

Environmental Water Account

The CALFED ROD established the Environmental Water Account (commonly referred to as EWA) to provide water for the protection and recovery of fish beyond that which would be available through existing regulatory protections related to CVP and SWP operations. The EWA program consists of two primary elements: implementing fish actions that protect at-risk native fish species, and maintaining water supply reliability by acquiring and managing assets to compensate for the supply effects of fish protection actions. Actions that protect fish species consist primarily of seasonal and annual pumping reductions at the CVP and SWP Delta pumping plants to protect fish at times when they are near the pumps or moving through the Delta. These pumping reductions can reduce water supply reliability for CVP and SWP contractors, so the EWA assets are used to repay CVP and SWP users for water not pumped during pump reductions (CALFED, 2000c; Rust, 2006). The EWA will be implemented through December 31, 2007.

Climate Change

For over a decade, scientists have been publishing formal, peer-reviewed articles on the potential causes and effects of global climate change. Although the debate continues within the scientific and political communities regarding the extent of climate change impacts on California, programs have been established to develop and implement a climate change research plan in order to improve the understanding of physical and economic impacts

Wild and Scenic Rivers

Passed in 1968, the National Wild and Scenic Rivers Act (Public Law 90-542 as amended; 16 U.S.C. 1271-1287), provides for the protection of "certain selected rivers of the Nation…with their immediate environments…be preserved in free-flowing condition." Patterned after the federal act, the California Wild and Scenic Rivers Act (Public Resources Code Sec. 5093.50 et seq.) was passed in 1972 to preserve designated rivers possessing extraordinary scenic, recreation, fishery, or wildlife values. These designated rivers or river segments are considered fully appropriated, although flows downstream of a designated river segment may be diverted for other beneficial purposes.

From a water supply perspective, flows in Wild and Scenic Rivers fall into two general categories:

- *Encumbered supplies*, including protected rivers flowing directly to the Pacific Ocean that do not have impoundments, diversion, and other modifications at a significant level (such as the Smith and Van Duzen rivers). These protected "free-flowing" rivers are fully appropriated and unimpaired, and thus unavailable for other beneficial use.

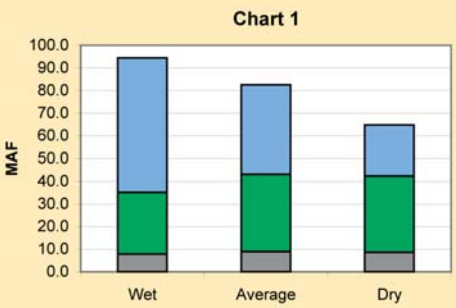
- *Available supplies* that include flows downstream of protected rivers or protected reaches (such as the American, Merced, and Tuolumne rivers). Flows downstream of protected rivers or reaches may be diverted for other beneficial use, and this diverted portion may be counted as a benefit to a water resource project.

The state's Update 2005 includes the unimpaired flows of Wild and Scenic Rivers as part of the state's dedicated supply allocated to environmental uses. Both flow categories (encumbered and available) are included in the environmental supplies and uses.

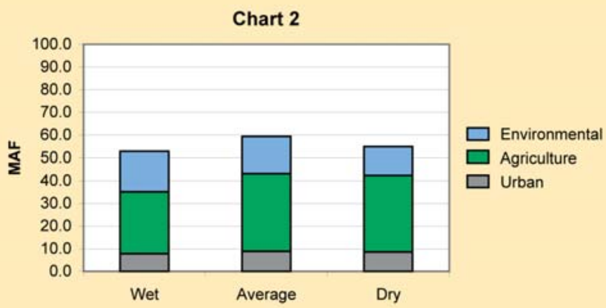
Excluding Wild and Scenic River flows from the supply-demand gap analysis helps water managers understand the environmental demands met through water management actions.

The WSAY analysis does not include Wild and Scenic River flows in its supply-demand gap analysis for two reasons. First, since required flows in Wild and Scenic Rivers and river segments are represented by what is available from unimpaired runoff, the demand in these segments is always met by the available supply—by definition, there is never a supply-demand gap. Second, including Wild and Scenic Rivers makes it possible to overstate the proportion of environmental demand that can be met through management, as the charts illustrate. Chart 1 shows water demands in three year types *including* Wild and Scenic Rivers, and Chart 2 shows demands *excluding* Wild and Scenic Rivers. Comparing these figures reveals that a significant portion of environmental demands in wet and average years is from unmanaged Wild and Scenic Rivers, and a relatively small fraction of environmental demands are met through management. Therefore, excluding Wild and Scenic River flows helps water managers better understand the environmental demands met through water management actions, such as timed reservoir releases.

Although the WSAY Study excludes Wild and Scenic River flows and uses, flows downstream of these segments diverted for urban or agricultural uses (the second flow category, available supplies) are included in the analysis; this is achieved by using an "applied" water balance methodology to calculate the supply-demand gaps.



Total Statewide Water Use *Including* Wild and Scenic River Flows



Total Statewide Water Use *Excluding* Wild and Scenic River Flows of climate change and to develop policy recommendations. The following discussion draws from Update 2005 and from the conclusions of two studies regarding the impacts of climate change on California's water resources and associated infrastructure: "Climate Change and California Water Resources: A Survey and Summary of the Literature" (Kiparsky and Gleick, 2003), and "Accounting for Climate Change" (Roos, 2005).

Climate change may affect not only the availability of precipitation, but also the demand for water for agricultural uses, the demand for hydropower to provide electricity for air conditioning and refrigeration, and the ability to store and convey water and control flooding. Much depends on the degree of warming and the magnitude of future changes. Some of the potential impacts include altered snowpack accumulation and melting patterns, altered runoff patterns, changes in water supply reliability, floods and droughts, increased water demands, and higher water temperature.

Climate change could influence where precipitation falls. Warming might push the winter storm track on the West Coast farther north, leading to a drier California. In contrast, some models show that warming may cause precipitation to increase, but snowpack to decrease. In any case, less snowfall would lead to less spring snowmelt. Consequently, reservoirs would be more difficult to refill during late spring and early summer of many years, potentially reducing the amount of surface water available during the dry season. Spring runoff in California's major rivers currently yields 40 percent of the estimated state net demand for agricultural and urban water use. Replacing that yield would require increased reservoir storage capacity, increased conveyance facilities, and other measures.

A second potential impact of climate change is sea level rise, which would result in two significant problems in the Delta: increased saltwater intrusion from the ocean, and increased pressure on levees protecting the low-lying land, much of which is already below sea level. Saltwater intrusion could degrade fresh water supplies pumped at the southern edge of the Delta or require more fresh water releases from upstream reservoirs to repel ocean water. Pressure on levees could ultimately result in a levee failure, potentially drawing saltwater into the Delta region and affecting overall Delta water quality.

A breach of one or more of the central Delta levees could result in the temporary or long-term disruption of the water supply for about two-thirds of the state's residents and for about half of the state's irrigated agriculture.

Many of the central Delta levees are built on unstable peat soil and are vulnerable to high water levels. Already subject to considerable pressure from tidal action, sea level rise could magnify the problem. A small rise can likely be tolerated by the levee system; a major rise of 1 foot or more could cause significant problems. A breach of one or more of the central Delta levees could result in the temporary or long-term disruption of the water supply for about two-thirds of the state's residents and for about half of the state's irrigated agriculture. Levee failure can cause large amounts of saline ocean water to be drawn into the Delta. Water supply pumping operations in the Delta for the SWP, CVP, and other supply systems would be compromised because of poor export water quality and because of environmental and regulatory obligations.

Projected Future Water Demands

Understanding the potential effects of the factors described in the preceding discussion and studying existing water use trends makes it possible to predict future water demands and determine how California can prepare to meet those demands.

Update 2005 projected water use in 2030 by developing three future scenarios—Current Trends, Less Resource Intensive, and More Resource Intensive—for each type of user (urban, agricultural, and environmental) to estimate a range of future water uses that could occur without additional management intervention. The scenarios varied plausible water use assumptions related to population growth, land use, and naturally occurring conservation, and highlighted important categories of uncertainties. To estimate a total future water use under each scenario, the projections for each user were totaled by scenario type. For example, the More Resource Intensive scenario projections for urban, agricultural, and environmental users were added to determine the total future water use under the More Resource Intensive scenario.

To enhance this approach, this WSAY Study evaluated the Update 2005 scenario assumptions for urban, agricultural, and environmental water use in an average year to ensure that full future water *demands* were reflected. In some cases, it was determined that the assumptions considered for one scenario better reflected current trends and unmet demands for one user than for a different user. For example, for urban users, only the Current Trends scenario assumes a population projection consistent with the established Department of Finance estimates. However, the same Current Trends scenario does not account for unmet environmental user demands; only the Less Resource Intensive scenario accounts for full unmet environmental demands.

To project total water demands in 2030 that are consistent with existing trends (population, land use, regulatory, and climate) and account for the unmet demands, this WSAY Study applied the Update 2005 scenarios to each type of user in the following manner:

- For urban water use, the Current Trends scenario assumes a population projection consistent with California Department of Finance estimates.
- For agricultural water use, the Less Resource Intensive scenario provides for some decrease in irrigated acreage consistent with current forecasts while accounting for an average increase in water use efficiency over the next 25 years.
- For environmental water use, the Less Resource Intensive scenario is the only scenario that assumes that full environmental demands (as defined by existing legislation) are met. Additional demand is added for private wetlands evaluated by the Central Valley Habitat Joint Venture, which was not included in Update 2005.

Adding all user demands by hydrologic region, the statewide water demand under a 2030 level of development is estimated to be 60.8 MAF in an average water year (excluding Wild and Scenic River flows). Future dry year demands were estimated by assuming there would be the same proportional differences between average and dry year demands as in current conditions. Using this assumption, the future statewide water demand in a dry year is estimated to be about 57.4 MAF. Table 2-5 summarizes total estimated 2030 statewide demands and provides existing demands for comparison.

TABLE 2-5
Projected Statewide Demand by User in Existing and Future (2030) Conditions for Average and Dry Years

	Average Year (MAF)		Dry Year (MAF)	
User	Existing	Future	Existing	Future
Urban	8.9	11.9	9.0	12.0
Agricultural	34.2	31.4	34.2	31.4
Environmental*	17.5	17.5	14.0	14.0
Total statewide demand	**60.6**	**60.8**	**57.2**	**57.4**

* Does not include Wild and Scenic River flows

Trends show a general increase in statewide water use, with growth particularly in dedicated environmental flows and urban use. Agricultural water use is projected to decline from 2000 to 2030.

These results follow existing statewide and regional trends. Figure 2-16 shows the trend in water use and demand from 1972 to 2030 statewide and for each geographic zone. The trends show a general increase in statewide water use, with growth particularly in dedicated environmental flows and urban use. Agricultural water use is projected to decline from 2000 to 2030.

Future water demand in California will vary significantly across regions and water users. Although a decrease in agricultural water demand outweighs an increase in urban and environmental water demand statewide, the majority of regions show an increase in water demand, particularly urban demands in the south. Regional demand changes by geographic zone are shown in Figure 2-17.

Demand projections generally show substantially increasing urban demands, particularly in southern coastal areas. In contrast, the Central Geographic Zone, especially the Tulare Lake Hydrologic Region, is likely to experience a decrease in agricultural water demand. From a statewide perspective, these changes in demand seem to be complementary to meeting future water supplies. However, increases in water demand must be addressed at the regional and local levels, because supplies made available in one part of the state as a result of reduced demand cannot necessarily be used to meet increasing demands in another part. The ability to transfer water from the Central Geographic Zone to meet Southern California's growing demands could be constrained by available conveyance facilities, area-of-origin issues, environmental impacts, and other third-party effects.

These trends in water demand indicate the need for an intensive focus on integrated water management efforts, storage projects, and improved conveyance facilities to move water from the Central Valley to other parts of the state.

Trends in water demand indicate the need for an intensive focus on integrated water management efforts, storage projects, and improved conveyance facilities.

Future Supply-Demand Gaps

Without future investment in water management actions or facilities, it is assumed that available water supplies in the future will remain about the same as they are under existing conditions.

One difference in future supplies will result from recent agreements regarding the reallocation of Colorado River water. The Quantification Settlement Agreement established mechanisms to reduce California’s dependence on the Colorado River through conservation and transfers (CVWD et al., 2002). These mechanisms will effectively result in a decrease in agricultural supplies in the Colorado River Hydrologic Region and a decrease in urban supplies in the South Coast Hydrologic Region. Although other changes in supplies may be possible in the future, these foreseen differences resulting from the Quantification Settlement Agreement have been integrated into the assumed 2030 supplies. These future statewide supplies, without further investment in water management actions or facilities, are listed for average and dry years in Table 2-6. Supply-demand gaps in a prolonged drought would likely be much greater than those listed for a single dry year.

The projected gap between available water supplies and water demand in 2030 can be estimated by comparing future demands with the anticipated future supplies listed in Table 2-6.

Table 2-7 shows the projected supply-demand gaps by geographic zone and statewide. Existing gaps are shown for comparison. Detailed information on future supplies, demands, and gaps by hydrologic region is provided in the appendix.

Table 2-7 also shows how future statewide demands exceed supplies in average and dry years. In dry years, the statewide future gap exceeds the existing gap. At the regional level, the future gap in the South Geographic Zone is nearly three times as large as the existing gap. In contrast, the future gap in the Central Geographic Zone slightly decreases.

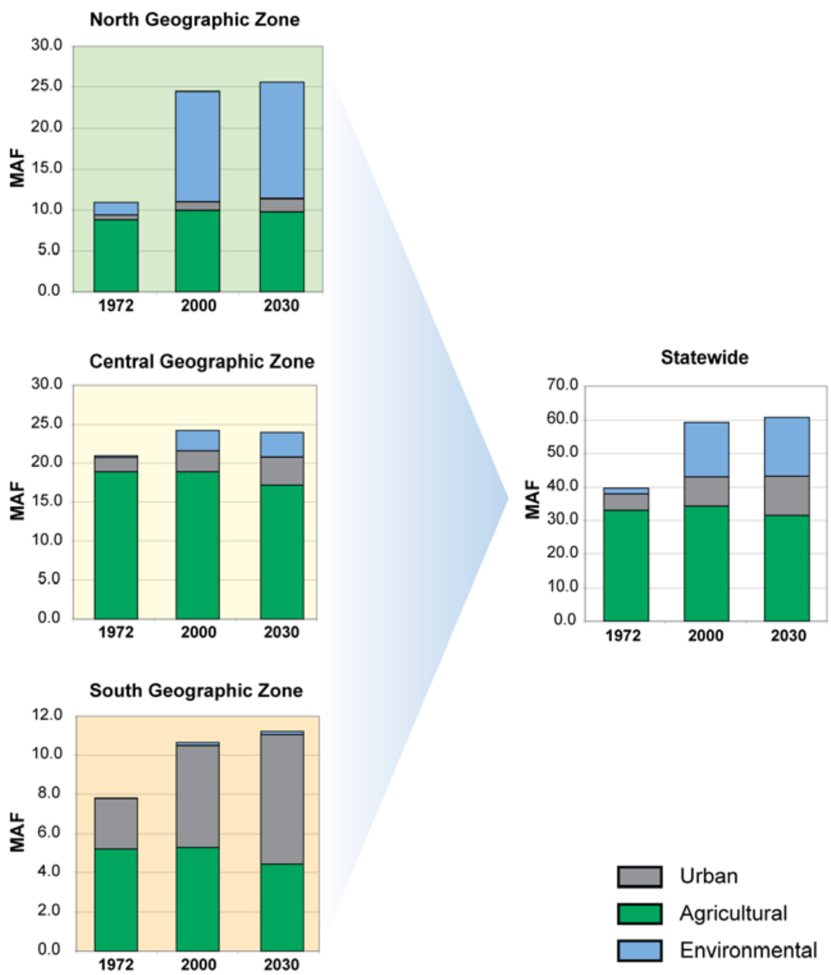


FIGURE 2-16
Geographic and Statewide Water Demand Trends from 1972 to 2030

TABLE 2-6
Assumed Statewide Future (2030) Dedicated Supplies in Average and Dry Years

Supply	Average Year (MAF)	Dry Year (MAF)
Urban supply	8.4	8.0
Agricultural supply	32.8	31.5
Environmental supply*	16.3	12.6
Total dedicated statewide supplies	**57.5**	**52.1**

* Does not include Wild and Scenic River flows

Future statewide demands exceed supplies in average and dry years.

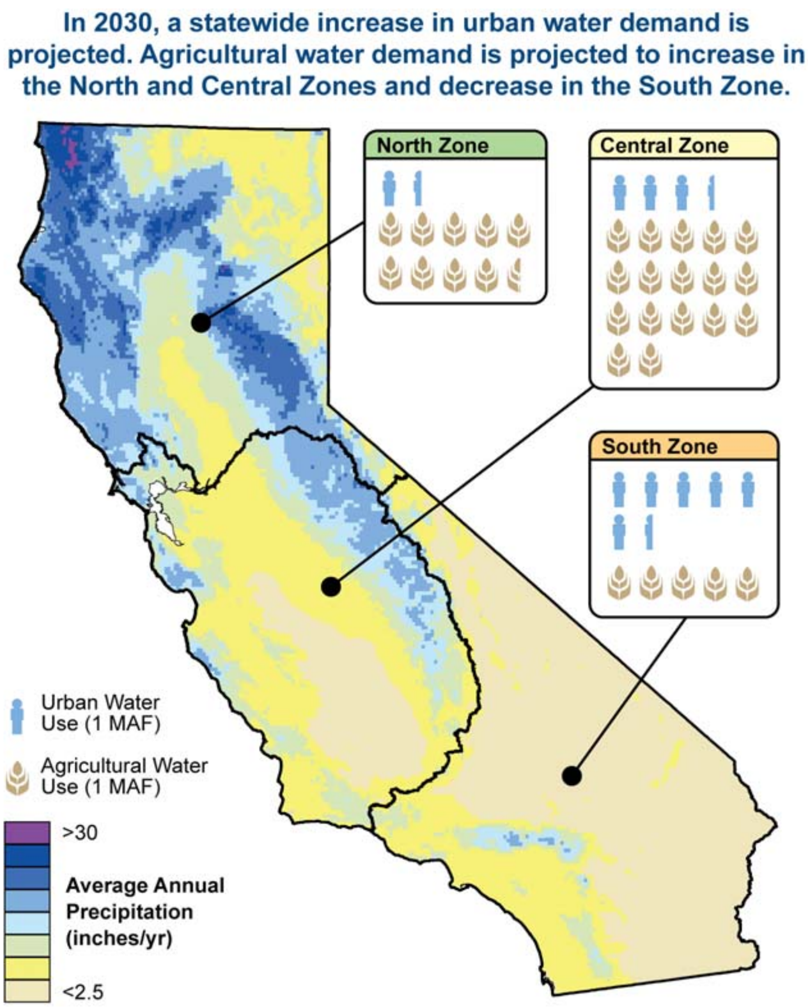


FIGURE 2-17
Distribution of Applied Water Demands in 2030 by Geographic Zone

TABLE 2-7
Supply-Demand Gaps in Existing and Future (2030) Conditions for Average and Dry Years by Geographic Zone

	Average Year (MAF)		Dry Year (MAF)	
Geographic Zone	**Existing**	**Future**	**Existing**	**Future**
North	0.8	1.4	1.1	1.6
Central	1.5	1.6	2.3	2.1
South	<0.1	1.9	0.8	2.4
Total statewide gap	**2.3**	**4.9**	**4.2**	**6.1**

Figure 2-18 displays the distribution of gaps by region and by use for a future average and dry year. The significant increase in the supply-demand gap in the South Geographic Zone results primarily from growth in urban demands. The Central Geographic Zone shows a decrease in agricultural water demand compared to current conditions. This follows existing regional trends, as discussed previously.

Need for Additional Water Supply Management and Infrastructure

Several factors indicate that the state's existing water supplies are not sufficient to meet demands, and that additional water supply management activities and projects are necessary to augment water supplies and delivery reliability in the future:

- Annual variability in precipitation and the threat of multiyear droughts indicate the need to manage and store water during wet years to meet demands during dry years. Seasonal variability in precipitation indicates the need to store water during wet winter months to meet water demands throughout dry summers. Geographic variability in precipitation and population indicates the need for adequate conveyance facilities to move water from the wetter north to the more densely populated south.
- CVP and SWP water deliveries vary considerably from year to year. Project deliveries may be limited by available conveyance or storage facilities. Passage of the CVPIA and other environmental constraints has reduced the ability of the CVP to meet contract deliveries. Future institutional constraints could further impact this ability.
- Current statewide water use requires exercise of reservoir carryover storage and overdraft of groundwater during average and dry years. Banked groundwater is an important source of supply during droughts, but groundwater overdraft is not a sustainable source of supply.

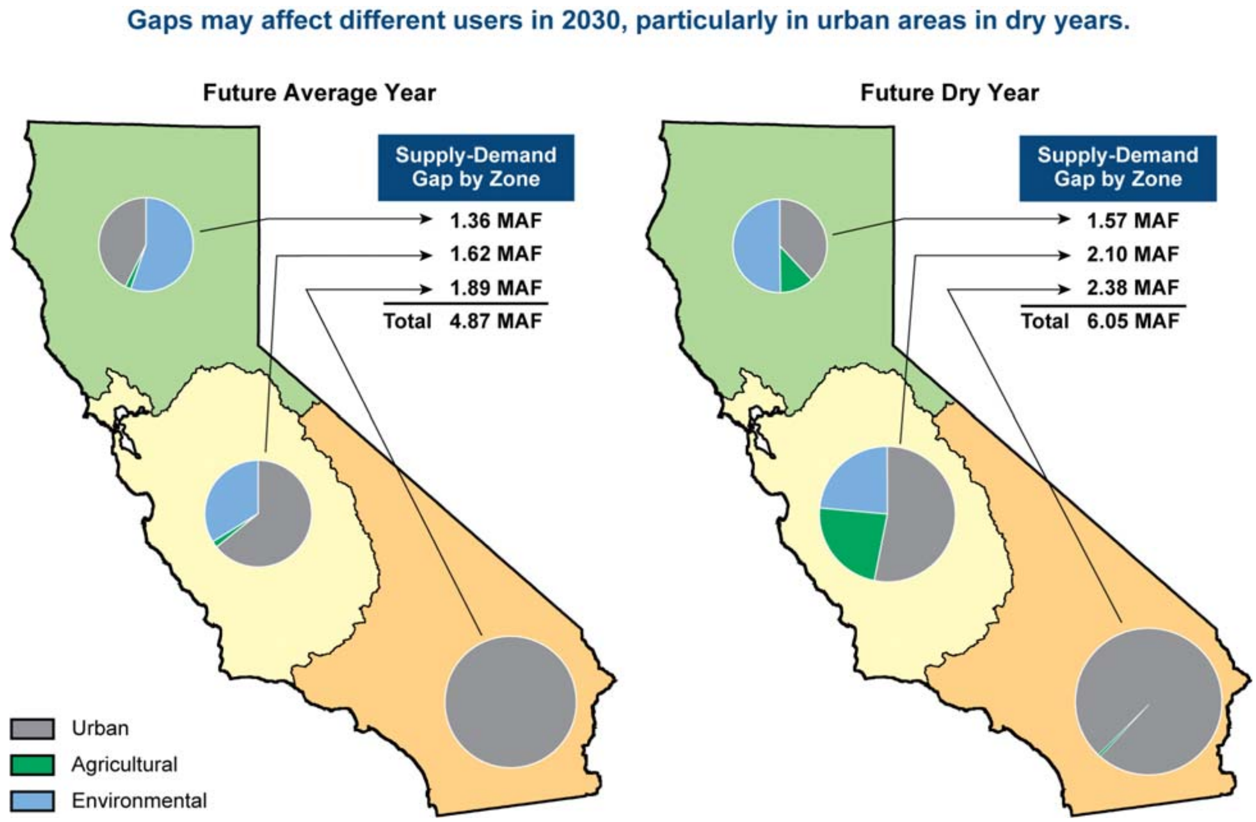


FIGURE 2-18
Projected 2030 Supply-Demand Gaps by Geographic Zone for Average and Dry Years

- Water demands exceed sustainable supplies in average and dry years. Regional supply-demand gaps reveal that shortages are greatest in the Central and South Geographic Zones. The South Coast and Tulare Lake Hydrologic Regions have the largest regional gaps. Demand gaps are larger in the central and southern parts of the state because of hydrologic conditions and facility (storage and conveyance) constraints.
- Future statewide demands exceed supplies in average and dry years. The future gap is greater than the existing gap. Regional supply-demand gaps reveal that shortages will be greatest in the South Geographic Zone. Gaps will increase by the highest percentage in the South Coast and San Francisco Bay Hydrologic Regions. Increasing urban demands, particularly in coastal areas, will impact the ability of existing facilities to meet future water needs.
- Population growth, agricultural-to-urban land conversion, unknown future laws and regulations, and climate change add uncertainty to future demand estimates and may increase the risk that demands will not be met during multiyear droughts with existing facilities and infrastructure.

3 Projects and Water Management Actions

The need for additional water supply is illustrated in Section 2 of this report. This section identifies the projects and water management actions that have the potential to improve firm yield or water supply within the CALFED Bay-Delta Solution Area, and assist the state in meeting its current and future needs for water.

Projects

Storage and conveyance projects have the potential to increase water supply by increasing average deliveries to water service contractors during critically dry periods or multiyear drought. The projects presented are categorized into three levels based on the amount of available information, the level of development in the planning process, and the current understanding of the likelihood of those projects moving forward. The three categories and the projects and actions considered in each are as follows:

- Level 1: CALFED-authorized storage and conveyance improvement studies
- Level 2: Projects of recent public, agency, or political interest
- Level 3: Regional opportunities

Descriptions of projects under each level category follow.

Level 1: CALFED-Authorized Storage and Conveyance Improvement Studies

The Level 1 projects are large-scale infrastructure improvements that have been proposed as part of California's water resources management portfolio to provide more reliable water supplies and to meet competing needs for water. Reclamation and DWR have completed preliminary environmental impact studies and conceptual modeling, and will continue efforts to formulate detailed alternatives that can be used in decision making for storage and conveyance improvements.

Storage Improvements

Surface storage reservoirs are widely used in California as a means of balancing the timing of the natural runoff pattern and the state's water needs. In 2000, the CALFED ROD identified five potential surface storage reservoirs for investigation by DWR, Reclamation, and local water interests:

- Shasta Lake Water Resources Investigation
- Sites Reservoir Investigation
- In-Delta Storage
- Los Vaqueros Reservoir Expansion
- Upper San Joaquin River Basin Storage Investigation

CALFED's surface storage projects are being planned as multipurpose projects for water supply reliability, improved water quality, and ecosystem restoration. These projects can provide regional benefits and broad public benefits to California; Figure 3-1 shows the general location of the project sites and identifies which potential benefits are associated with the storage projects described.

The following descriptions of the five potential storage projects identified in the CALFED ROD are based on information in the California Bay-Delta Authority's (CBDA) *CALFED Bay-Delta Surface Storage Investigation Progress Report* (CBDA, 2006).

Section Highlights

Projects and water management actions are needed to help fill the projected 2030 water supply demand gap.

Storage and conveyance projects would increase average deliveries to water service contractors during critical times.

Conveyance improvements play a critical role in the ability to utilize additional storage.

CALFED has authorized the study of storage and conveyance improvements.

Continued investment in water management actions is key to providing a reliable water supply in the future.

A wide range of estimates for additional water supply benefits and cost for both projects and water management actions is available.

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF gap in dry years.

Long-term water supply reliability depends on being able to meet water demands during dry years, and additional measures will be required to fill the dry year gap.

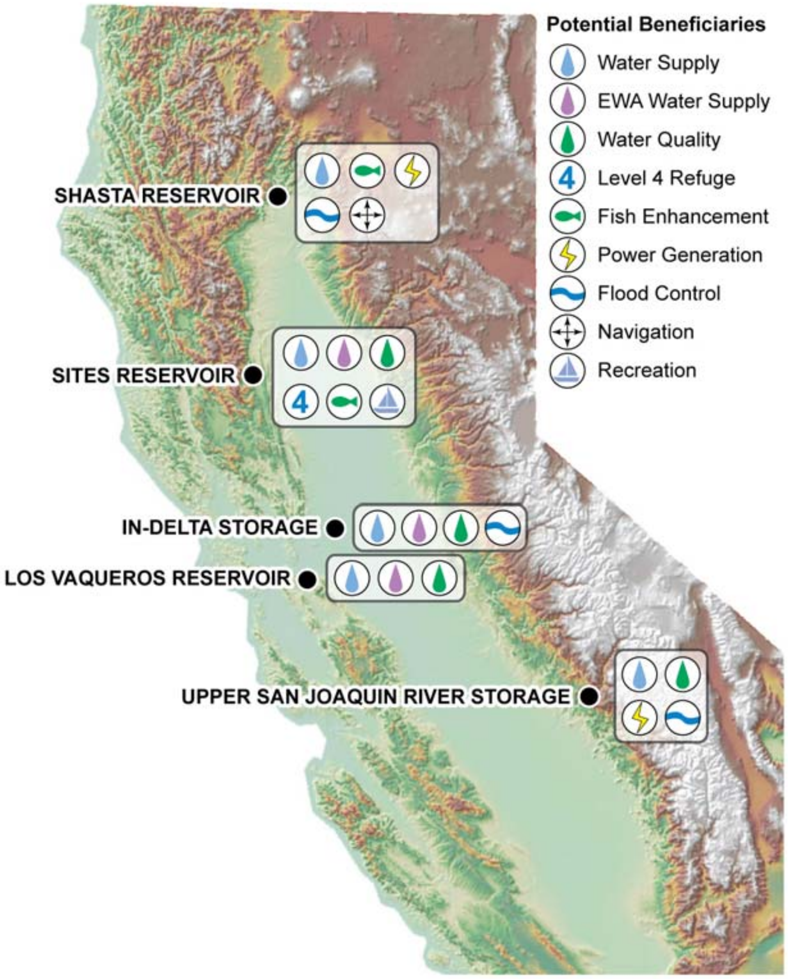


FIGURE 3-1
Level 1 Storage Project Sites and Potential Benefits

Shasta Dam Authority

Authorization

Rivers and Harbors Act of 1935, Rivers and Harbors Act of 1937 (re-authorized)

Purpose

Navigation, regulation, and flood control primary purposes with irrigation and domestic uses secondary

Federal Study Authorization

Public Law 96-375 of 1980 authorized the Shasta Lake Water Resources Investigation for the purpose of:

Engaging in feasibility studies relating to:

(1) Enlarging Shasta Dam and Reservoir, or constructing a replacement dam on the Sacramento River, and

(2) The use of the Sacramento River for conveying water from such enlarged dam.

Shasta Lake Water Resources Investigation

Shasta Dam is located on the Sacramento River in Shasta County, 9 miles northwest of Redding. The existing Shasta Reservoir has a storage capacity of 4.5 MAF and a dam height of 602 feet. The reservoir's volume could be increased by 300 TAF if the dam were raised above its current height by 6.5 feet, or increased by 635 TAF if the dam were raised 18.5 feet.

The primary purpose of increasing storage in Shasta Reservoir is twofold: to increase the available cold water pool for environmental needs, and to increase water supply capability. The increased cold water pool would help maintain the cooler water temperatures needed by anadromous fish (migrating salmon and steelhead trout) in the Sacramento River, helping to increase their survival rate. Increased water supply capability will help meet future agricultural, urban (M&I), and environmental water demands by increasing California's water supply capacity and supply reliability. Other project objectives include the following:

- Preserving and restoring ecosystem resources in the Shasta Reservoir area and along the Upper Sacramento River
- Reducing flood risk along the Sacramento River
- Developing additional hydropower capabilities at Shasta Dam

A preliminary study of three possible dam modification scenarios showed that if the dam were increased in height by 6.5 feet, the enlarged Shasta Reservoir could provide an additional long-term average water supply benefit of 40 TAF per year, and 60 TAF per year during the driest periods. If the dam were increased in height by 18.5 feet, the reservoir could supply an additional long-term average water supply benefit of 69 TAF per year, and 127 TAF per year during the driest periods. The third scenario would increase the dam height by 18.5 feet and construct anadromous fish habitat. Anadromous fish survival could increase by up to 9 percent under this scenario, and provide an additional long-term average water supply of 85 TAF per year, and 160 TAF per year during the driest periods. The long-term net energy production could increase by up to 40 gigawatt hours per year for a dam height increase of 18.5 feet.

Preliminary capital cost estimates for enlarging Shasta Dam ranged from $280 million to $480 million for different configurations.

Sites Reservoir Investigation

The Sites Reservoir Investigation, also known as the North-of-Delta Offstream Storage (NODOS) Investigation, is evaluating an offstream storage reservoir up to 1.8 MAF at the proposed Sites Reservoir and other locations in the Sacramento Valley. The project is in the feasibility study process which has three milestones: Initial Alternatives Information Report, Plan Formulation Report, and Feasibility Report with National Environmental Policy Act/ California Environmental Quality Act (NEPA/CEQA) compliance.

Sites Reservoir Study Authority

Federal Study Authorization

Public Law 108-7, Division D, Title II, Section 215, the Omnibus Appropriations Bill for Fiscal Year 2003 authorized the Sites Reservoir feasibility study to be pursued along with ongoing environmental projects in a balanced manner.

The proposed project will meet the following goals:

- Enhance water management flexibility in the Sacramento Valley while reducing water diversions from the Sacramento River during critical fish migration periods
- Increase supply reliability for a significant portion of the Sacramento Valley
- Provide storage and operational benefits for other CALFED programs, including Delta water quality and the EWA or similar program

The formulation of alternative plans is underway, but additional work is necessary before the alternative plans are fully developed and evaluated. Four conceptual scenarios for the NODOS project were developed to provide a preliminary estimate of project benefits. These four scenarios focused on a project that could increase water supply reliability for Sacramento Valley water users as well as the CVP and SWP contractors; improve Delta water quality; improve environmental health by providing water for ecosystem restoration purposes; and provide water supply and storage for the EWA or similar program.

Modeling output showed that a NODOS project could provide average annual water supply benefit to the CVP and SWP of 81 TAF to 259 TAF per year in the long term, and 315 TAF to 440 TAF per year during the driest periods. An average annual water supply benefit of up to 124 TAF per year in the long term and 147 TAF during the driest periods can be provided for the EWA or similar program. The quantity of water supply provided for the EWA is limited by the EWA's north-of-Delta (NOD) purchase goals. With operational flexibility created by NODOS, diversions from the Sacramento River at Glenn-Colusa Irrigation District and Tehama-Colusa Canal intakes could be reduced to protect fish migration during April through August by 170 TAF to 230 TAF per year in the long term, and 115 TAF to 235 TAF per year during the driest periods. However, additional analysis and refinement of water supply benefits are necessary once alternative plans are formulated during the Sites Reservoir Investigation Plan Formulation Study.

The preliminary capital cost study estimated the cost of constructing the reservoir and conveyance facilities associated with the Sites Reservoir Investigation to be between $1.3 billion and $2.3 billion, depending on the configuration chosen.

In-Delta Storage Project

The proposed In-Delta Storage Project consists of converting two islands (Webb Tract and Bacon Island) in the central Delta into new storage islands, and two other islands (Holland Tract and Bouldin Island) into habitat islands. The state completed a feasibility study evaluating in-Delta storage. Congressional authorization and appropriations would be required before a federal feasibility study could be conducted.

The storage islands would provide approximately 217 TAF of water capacity. The habitat islands would provide 9,000 acres of new managed habitat in the Delta. Together, the project could provide water supply reliability, operational flexibility, conjunctive management opportunities, water quality improvements, wildlife and habitat improvements, and improved stability of Delta levees.

Preliminary model results demonstrated that the average annual water supply benefits for the SWP and CVP for the four operational scenarios being considered vary from 52 to 77 TAF per year for the long term, and from 51 to 64 TAF per year during the driest periods. An average long-term annual water supply of 14 to 28 TAF per year can be provided for the EWA or similar program.

Preliminary total capital cost estimates for implementing the In-Delta Storage Project ranged from $700 million to $800 million, depending on the configuration.

Los Vaqueros Reservoir Expansion

The existing Los Vaqueros Reservoir, located in Contra Costa County in the San Francisco Bay Area, was completed in 1997 to provide 100 TAF of offstream water storage for the purpose of improving water quality and providing emergency supply for customers of the Contra Costa Water District (CCWD).

Los Vaqueros Reservoir Authority

Authorization

Los Vaqueros Reservoir is a locally owned facility authorized in 1988 by the voters of the Contra Costa Water District.

Purposes

Water quality, emergency supply storage, recreation, and flood control.

Federal Study Authorization

Public Law 108-7, Division D, Title II, Section 215, the Omnibus Appropriations Bill for Fiscal Year 2003 authorized the Los Vaqueros Reservoir Enlargement feasibility study to be pursued along with ongoing environmental and other projects in a balanced manner.

An expanded Los Vaqueros Reservoir could provide as much as 400 TAF per year of offstream storage to CCWD and other Bay Area water agencies. The purposes of the reservoir expansion project are the following:

1. Water supply reliability for Bay Area urban (M&I) water users
2. Less-costly replacement for the long-term EWA or similar program
3. Without limiting purposes 1 and 2, improve quality of water delivered to Bay Area urban (M&I) water users

As presently formulated, water supply benefits to other areas, including Southern California, are excluded from the project objectives. The studies indicate that the average annual water supply benefits for the CVP and SWP for the different configurations being considered vary from 0 to 13 TAF per year for the long term, and from 0 to 25 TAF per year during the driest periods. The average annual water supply of 117 TAF to 143 TAF per year in the long term, and 42 TAF to 65 TAF during the driest periods can be provided to the EWA or similar program.

Preliminary capital cost estimates for the Los Vaqueros Reservoir Expansion ranged from $870 million to $1.5 billion, depending on the configuration.

Upper San Joaquin River Basin Storage Investigation

The existing Millerton Lake, formed by Friant Dam, has a storage capacity of 520 TAF. The reservoir is operated to provide water supply to agricultural and urban areas within the Friant Division of the CVP, and to provide recreation and flood control along the San Joaquin River.

The CALFED ROD recommends evaluating the effects of increasing water storage in the Upper San Joaquin River Basin at Millerton Lake by raising Friant Dam or developing a functionally equivalent storage program.

Developing 130 to 1,310 TAF of additional storage throughout the Upper San Joaquin River watershed could contribute to the river’s restoration and improve its water quality. This increased storage would also facilitate additional conjunctive management and exchanges that would improve the reliability of water deliveries to urban areas. Other benefits could include hydropower production and flood control.

Unlike the other four storage projects, the studies for the Upper San Joaquin River Basin Storage

Friant Dam Authority

Authorization

Rivers and Harbors Act of 1935, Rivers and Harbors Act of 1937 (re-authorized)

Purpose

Regulate rivers and improve flood control and navigation, provide water for irrigation and domestic use, and power generation.

Additional purpose of providing water for fish and wildlife protection, restoration, and mitigation was authorized by the CVPIA.

Federal Study Authorization: Upper San Joaquin River Basin Storage Investigation

Public Law 108-7, Division D, Title II, Section 215, the Omnibus Appropriations Bill for Fiscal Year 2003 authorized the Upper San Joaquin Storage projects feasibility study to be pursued along with ongoing environmental and other projects in a balanced manner.

Investigation have not yet considered the effect of Upper San Joaquin Storage operations on CVP and SWP operations in the Delta. Previous study estimates described additional water storage benefits of 24 to 183 TAF per year, depending on the storage scenario.

Preliminary capital cost estimates for the Upper San Joaquin River Basin Storage Investigation ranged from $200 million to $1 billion, depending on the configuration.

Summary of Level 1 Storage Projects

Table 3-1, provided on the following page, is a summary of the preliminary estimated supply and cost for each of the five Level 1 storage projects described.

Conveyance Improvements

Presently, the CVP and SWP systems' ability to move water released by upstream reservoirs is limited by conveyance capacity through the Delta and the Delta-Mendota Canal (DMC) delivery system. The following specific conveyance constraints exist in the Delta:

- Inadequate conveyance capacity of canals and sloughs leading to Clifton Court Forebay (SWP) and the Tracy Pumping Plant (CVP) pumping facilities
- Delivery restrictions arising from endangered species movement through Delta channels
- Delivery restrictions due to excessive vegetation interfering with conveyance facility operation
- Endangered Species Act take limits
- DMC conveyance capacity lower than the authorized Tracy Pumping Plant capacity
- Decision 1641—water quality and Delta outflow requirements[1]
- Water quality and water levels for local south Delta water users downstream of the head of Old River
- Delta Cross Channel operations affecting ability to meet water quality objectives

Conveyance improvements alone, particularly those that increase the capacity of delivering water south of the Delta, may increase water supply by delivering water that would otherwise flow out of the Delta to San Francisco Bay. Conveyance improvements would significantly improve the yield of new storage facilities and the flexibility of the CVP and SWP. These potential conveyance projects are described in the following discussions:

- Banks 8,500 cubic feet per second (cfs) Capacity and Permanent Operable Gates
- DMC and California Aqueduct Intertie
- Enlarged Tracy Pumping Plant and DMC Intertie

Banks 8,500 cfs Capacity and Permanent Operable Gates

The SWP exports water from the Delta through operation of the Banks Pumping Plant, which has a maximum permitted capacity of 6,680 cfs. Water flows from the Delta channels into Clifton Court Forebay and then through the Skinner Fish Facility, where the majority of the fish are screened from the water.

The proposed action, generally referred to as the South Delta Improvement Program, seeks to increase the maximum allowable diversion rate at Clifton Court Forebay to 8,500 cfs. However, it is necessary to install permanent operable gates at several locations within the south Delta before the pumping capacity can be increased.

Banks Pumping Plant

Failure to achieve the 8,500 cfs Banks pumping capacity would limit the value of new north-of-Delta storage and other actions that make water available north of the Delta.

These gates are designed to fulfill two purposes: protect water quality and water levels for agricultural water users in the Delta, and protect salmon fisheries of the San Joaquin River, while still allowing for

Clifton Court Forebay and Skinner Fish Facility

[1] The State Water Resources Control Board adopted Water Right Decision 1641 on December 29, 1999. The Decision implements flow-related water quality objectives for the Bay-Delta Estuary, approves a petition to change points of diversion of the CVP and SWP in the southern Delta, and approves a petition to change places of use and purposes of use of the CVP. Refer to http://www.waterrights.ca.gov/baydelta/d1641.htm for additional information.

TABLE 3-1
Summary of Level 1 Storage Projects—Preliminary Cost and Supply

Storage Project Name and Scenario	Capital Cost ($ M)	Project Yield (TAF/year)	
		Long-term Average[a]	Driest Periods Average[b]
Shasta Lake Water Resources Investigation	280–480		
6.5-foot rise: water supply		40	60
18.5-foot rise: water supply		69	127
18.5-foot rise: water supply and anadromous fish		85	160
Sites Reservoir Investigation (NODOS)	1,300–2,300		
Scenario 1: water supply		259	392
Scenario 2: water quality		177	294
Scenario 3: environmental		220	314
Scenario 4: environmental and the Environmental Water Account		87	203
In-Delta Storage	700–800		
Scenario 1: water supply		77	64
Scenario 2: water quality and the Environmental Water Account		73	61
Scenario 3: water supply, the Environmental Water Account, and Ecosystem Restoration Program (CALFED)		52	51
Scenario 4: water supply, the Environmental Water Account, and water quality		63	49
Los Vaqueros Reservoir Expansion[c]	870–1,500		
Scenario 2: Environmental Water/SBA Water Quality		0	0
Scenario 3: SBA water supply reliability, Environmental Water Account, SBA water quality		8	17
Scenario 4: SBA & CCWD water supply reliability, Environmental Water Account, SBA water quality		13	25
Upper San Joaquin River Basin Storage Investigation[d]	220–1,000		
Raise Friant Dam 25 feet		24–29[e]	NA
Fine Gold Reservoir		65–136[e]	NA
Temperance Flat River Mile 274		165–183[e]	NA
Temperance Flat River Mile 279		86–146[e]	NA

Source: CBDA, 2006

[a] Long-term average is the average quantity for the period of Oct. 1922–Sep. 1994.

[b] Driest periods average is the average quantity for the combination of periods of May 1928–Oct. 1934, Oct. 1975–Sep. 1977, and June 1986–Sep. 1992.

[c] Scenario 1 is a future no-action base condition, so it provides no additional supply.

[d] Unlike the other four storage projects, the Upper San Joaquin River Basin Storage Investigation has not yet modeled scenarios considering the effect on operations on the CVP-SWP operations in the Delta. Therefore, the yield and cost information shown have a different basis than the values shown for the other four storage projects.

[e] Long-term average is the average quantity for the period of Oct. 1922–Sep. 1999.

NA: not available
SBA: South Bay Aqueduct

recreational navigational usage of the Delta channels. Currently, temporary rock barriers are installed on an annual basis. The installation of permanent gates will eliminate the need for annual installation of rock barriers, thus reducing costs for water users. In addition, the permanent gates will have greater operational flexibility, which would improve the management of the Delta's salmon fisheries.

Initial engineering studies indicate that the project, under certain conditions, would produce increased delivery by 90 TAF per year on average for the SWP, and 100 TAF per year on average for the CVP. The South Delta Improvement Program has recently been revised to defer the decision on 8,500 cfs capacity at Banks Pumping Plant until fishery issues can be resolved. Failure to achieve the 8,500 cfs Banks pumping capacity would limit the value of new NOD storage and other actions that make water available north of the Delta.

DMC and California Aqueduct Intertie

The CVP Tracy Pumping Plant has an authorized capacity of 4,600 cfs to pump water into the DMC. The capacity of the DMC was designed to closely match the amount of peak water demand expected along the canal. The amount, timing, and location of water deliveries from the DMC, along with the apparent canal subsidence, siltation, facility design, and other factors, have resulted in a mismatch between the authorized Tracy Pumping Plant capacity and the DMC conveyance capacity. These factors restrict the full use of the Tracy Pumping Plant.

This project would provide an intertie from the DMC to the California Aqueduct so that the full authorized capacity of the Tracy pumps could be used. The intertie would be located at milepost 7.2 of the DMC and connect with milepost 9.1 on the California Aqueduct. At this location, the

Delta-Mendota Canal and the California Aqueduct

DMC and California Aqueduct are about 400 feet apart horizontally and 50 feet apart vertically. The intertie would allow the Tracy Pumping Plant to operate at 4,600 cfs by moving approximately 400 cfs from the DMC to the California Aqueduct. On infrequent occasions, water may be moved from the California Aqueduct to the DMC.

> Water deliveries and engineering factors have resulted in a mismatch between the authorized Tracy Pumping Plant capacity and the DMC conveyance capacity.

Environmental compliance (NEPA and CEQA) analyses are currently underway for this project. Through construction, the project will cost about $30 million. Modeling studies indicate that approximately 35 TAF per year of yield would be restored for the CVP.

Enlarged Tracy Pumping Plant and DMC Intertie

Included in the CALFED Bay-Delta Authorization Act is the authorization to undertake a feasibility study for an enlarged intertie. The new feasibility study is investigating increasing the proposed intertie from 400 to 900 cfs capacity and increasing the capacity at the Tracy Pumping Plant. The additional 500 cfs would use increased Tracy Pumping Plant capacity for export south of the Delta and add operational flexibility. An increased authorized capacity at the Tracy Pumping Plant would be needed. This option would also require improvements to the DMC between the pumping plant and the intertie location to provide conveyance up to 5,100 cfs. No yield or cost estimates are currently available.

Level 2: Projects of Recent Public, Agency, or Political Interest

These projects, characterized as Level 2, have undergone past investigation that has been halted, delayed, or postponed because of changing strategies and priorities for water resources planning:

- Delta Isolated Facility/Dual Delta Conveyance
- Auburn Dam/Folsom South Canal

As strategies and priorities continue to develop, and new challenges arise, Level 2 projects have the potential for further consideration.

Delta Isolated Facility/Dual Delta Conveyance

Three alternative conveyance capacities (5,000, 10,000, and 15,000 cfs) for the Delta Isolated Facility are presented in the *CALFED Storage and Conveyance Components: Facility Descriptions and Cost Estimates* (CALFED, 1997). The alternative conveyance capacities described are intended to be combined with other Delta improvements to form various Dual Delta Conveyance configurations. These configurations would transfer a portion of the south Delta export demand through a Delta Isolated Facility and a portion through Delta channels.

The Delta Isolated Facility concept consists of an unlined canal, hydraulically isolated from the existing Delta channels, to convey Sacramento River water around the eastern edge of the Delta to the federal and state pumping plants in the south Delta. As proposed, the Delta Isolated Facility would help alleviate fish and water quality concerns in the Delta. Also, water quality degradation of export water caused by seawater intrusion and return flows from irrigation in the Delta and San Joaquin Valley would be eliminated. The Delta Isolated Facility would be combined with other Delta improvements to form a Dual Delta Conveyance system.

The principal facilities for each conveyance-level alternative include an intake channel with associated works; a pumping plant; 44 miles of unlined canal; 11 inverted siphons for river and slough crossings; and 17 bridges for county road, state highway, and railroad crossings.

Cost estimates (in 1997 dollars) prepared for the 5,000 cfs, 10,000 cfs, and 15,000 cfs alternatives are $850 million, $1.1 billion, and $1.3 billion, respectively (CALFED, 1997).

Auburn Dam and Reservoir, and Folsom South Canal

In conjunction with other facilities of the CVP, Auburn Reservoir would control the varying flows of the north and middle forks of the American River. Releases from the reservoir would operate Auburn Power Plant and supply the Folsom South Canal. The dam site is on the North Fork of the American River, adjacent to the city of Auburn, California.

Construction of Auburn Dam, Reservoir, and Power Plant was well underway when construction was halted because of concerns about the ability of the dam to withstand a major earthquake. Construction of the dam has been delayed due to environmental and safety concerns.

In December 2006, Reclamation completed a Special Report to update the analysis of costs and associated benefits of the Auburn-Folsom South Unit, Central Valley Project, California, authorized under federal Reclamation laws and the Act of September 2, 1965, Public Law 89-161, 79 Stat. 615 (Reclamation, 2006d).

The proposed reservoir would have a capacity of 2,326 TAF, and the power plant would contain four units with a total generation capacity of 800 megawatts. Cost figures in the Special Report represent an appraisal-level cost estimate for those features. Depending on assumptions, total project costs range from $6 to $10 billion.

The Folsom South Canal was planned to be constructed in five reaches for a total length of 68.8 miles. Only the first two reaches have been built, a total length of 26.7 miles, and there are no current plans to construct the remaining three reaches, about 42 miles, which are delayed pending reauthorization.

Level 3: Regional Opportunities

Many other project possibilities for water supply improvement exist outside the major infrastructure projects characterized as Level 1 or Level 2.

The CALFED's *Initial Surface Water Storage Screening* report began with a list of over 50 potential reservoir sites, which were screened down to sites for further consideration (CALFED, 2000b). The current CALFED storage projects under investigation (refer to the previously described Level 1 projects) were chosen from the screened list as the best projects for continued investigation.

The following regional descriptions provide an overview of areas where projects were considered:

- West Side Sacramento Valley
- East Side Sacramento Valley
- West Side/Off-Aqueduct San Joaquin Valley
- In- or Near-Delta
- CVP Pumping at Banks Pumping Plant

Sites not retained for additional CALFED consideration may still be candidates for development by others for other purposes, and further opportunities in these regions should not be overlooked.

West Side Sacramento Valley

Runoff from upstream tributaries to the Delta usually occurs in large volumes during short periods in winter and spring. New storage upstream of the Delta could store a portion of these flows in excess of instream flow requirements and water supply needs. While detaining water in storage, care must be taken to maintain periodic peak flow events in the rivers; these peak flows provide for natural fluvial geomorphic processes, including the moving and cleansing of gravels that are important to aquatic ecosystems. This is a more vital consideration associated with enlarged onstream storage compared to offstream storage; large amounts of water can be detained quickly in onstream storage, whereas conveyance capacity constraints allow only a minor percentage of large peak river flows to be diverted to offstream storage.

New storage upstream of the Delta could store a portion of upstream tributary runoff flows in excess of instream flow requirements and water supply needs.

To supplement instream flows and water supply, water could be released from upstream surface storage when needed to meet direct needs or to provide additional benefits through exchanges. In the Sacramento River Basin, for example, water could be released from offstream storage directly to local water users, reducing existing diversions from the Sacramento River during periods critical to fisheries. Water released for environmental purposes could include pulse flows to help transport fish through the Delta. During drier years, water could also be released to provide sustained flows for riverine and shallow water habitats, and to improve water quality in the Delta.

East Side Sacramento Valley

Upstream of the Delta, this storage could provide benefits similar to storage for the West Side Sacramento Valley. Runoff from upstream tributaries to the Delta usually occurs in large volumes during short periods in winter and spring. New storage upstream of the Delta could store a portion of these flows in excess of instream flow requirements and water supply needs. To supplement instream flows and water supply, water could be released from upstream surface storage when needed to meet direct needs or to provide additional benefits through exchanges. Water released for environmental purposes could include pulse flows to help transport fish through the Delta. During drier years, water could also be released to provide sustained flows for riverine and shallow water habitats, and to improve water quality in the Delta.

West Side/Off-Aqueduct San Joaquin Valley

A version of offstream storage, SOD off-aqueduct storage could be filled by diversions through the DMC or the California Aqueduct. Examples of existing off-aqueduct storage include San Luis Reservoir and Castaic Lake. New off-aqueduct storage would be filled by increasing Delta exports during periods of high flows and least potential harm to Delta fisheries. Water stored in new off-aqueduct storage could be released to meet export needs while export pumping from the Delta is curtailed during times of heightened environmental sensitivity in the Delta. Filling of off-aqueduct storage is of great value to export water users because this water can be delivered directly for use without Delta operational constraints. Off-aqueduct storage can significantly improve system operational flexibility.

Water stored in new off-aqueduct storage could be released to meet export needs during times of heightened environmental sensitivity in the Delta.

In- or Near-Delta

A major concern in the south Delta is the effect of continuing exports—specifically, entrainment and salvage of important fish species. To address this concern, CALFED is evaluating the concept of flexible operations. Flexible operations would allow reduced export pumping at times critical to fish, and increased export pumping at other times. For example, the SWP and CVP could reduce pumping when Delta inflow is low or when fish are present in large numbers, and increase pumping when Delta inflow is high and few fish are present. New in-Delta or near-Delta storage could significantly facilitate flexible operations, because during times that are problematic for fish species, it would allow pumping from storage rather than reduced-capacity pumping.

Flexible operations would allow reduced export pumping at times critical to fish, and increased export pumping at other times.

CVP Pumping at Banks Pumping Plant

Water deliveries to CVP contractors south of the Delta are pumped from the Delta through Reclamation’s Tracy Pumping Plant and SWP’s Banks Pumping Plant. Generally, CVP water is pumped through the Tracy Pumping Plant up to its capacity, and additional water is pumped through the Banks Pumping Plant. Pumping CVP water in the Banks Pumping Plant has a lower priority than pumping SWP project water or transfers by SWP contractors. After SWP use of the pumping plant, any remaining capacity in the Banks Pumping Plant is split equally between the CVP and the EWA. There are opportunities for the CVP to utilize more than the 50 percent remaining capacity if it is not used by the EWA.

Additional capacity is available at the SWP’s Banks Pumping Plant in some months. The CVP could utilize this space to increase exports to south-of-Delta contractors.

Although the CVP currently operates the Tracy Pumping Plant to meet its water allocation targets, additional capacity is available in the Banks Pumping Plant in some months. The CVP could utilize this space to increase exports to SOD contractors. Potential sources of water for this increased pumping include excess Delta outflow, additional releases from Shasta Lake or Folsom Lake, or the additional yield that would result from the development of new surface storage north of the Delta.

Water Management Actions

Statewide water management actions consist of individual projects and programs that have potential to provide yield and water supply improvements for CVP agricultural and M&I (urban) water service contractors. Water management actions have been categorized as either *demand management actions* or *other actions*. Demand management actions focus on reducing water demand, and include agricultural water use efficiency (WUE), urban WUE, and land retirement. Other actions focus on increasing water supply, and include water transfers, water recycling, and desalination.

Statewide, many of these actions are already being implemented as a result of market forces, naturally occurring conservation, work by Reclamation and DWR, ongoing initiatives by local water agencies and districts, CALFED initiatives, and initiatives by other entities. The last several years have witnessed continual improvement in agricultural WUE, urban WUE, and water recycling.

California Water Plan Update 2005 Potential Additional Annual Water Supply

DWR describes 25 "resource management strategies" in Update 2005. Several strategies focus on increasing water supply benefits by either generating new supplies or reducing water demand. Data from Update 2005, presented in Figure 3-2, illustrate the potential range of additional statewide water supply benefits from these strategies. The low end of the range represents the level of implementation likely to occur given current trends. The high end of the range is an upper boundary that represents what is technically possible but not necessarily cost effective in today's market.

Common Assumptions Model Version 7

A joint effort by DWR, Reclamation, and the CBDA, Common Assumptions is a process to develop consistency and improve efficiency among the CALFED surface storage investigations.

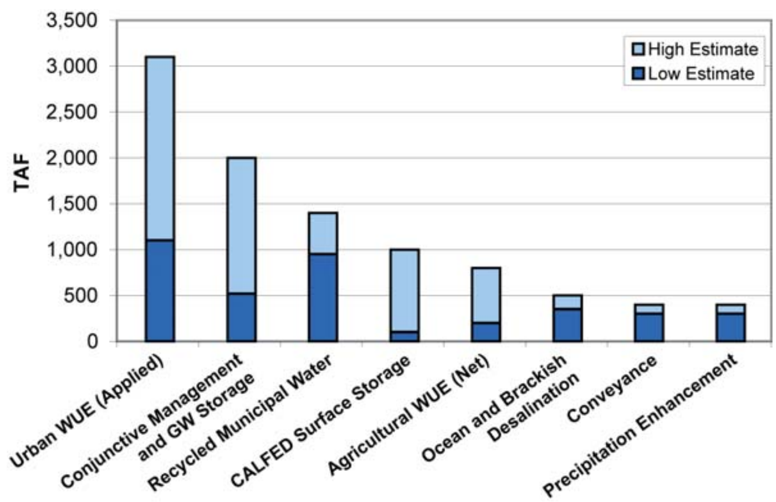


FIGURE 3-2
Potential Statewide Additional Annual Water Supply (DWR, 2005)

As part of the Common Assumptions modeling efforts, the characterization and quantification of water management actions in some of the hydrologic regions were documented in support of ongoing surface storage investigations. This included future baseline conditions that meet the criteria of being reasonably foreseeable. The conclusions drawn serve as an estimate of water supply produced from projects through 2030.

Water conservation has become a viable long-term supply option.

Demand Management Actions

Californians are already leaders in WUE measures such as conservation and recycling, and must continue to use water efficiently to get maximum utility from limited supplies. Water conservation has become a viable long-term supply option because it saves considerable capital and operating costs for utilities and consumers, avoids environmental degradation, and creates multiple benefits. Demand management and WUE actions should continue to be an integral part of water supply planning.

Strategies categorized as demand management actions focus on reducing water demand and include the following:

- Agricultural WUE
- Urban WUE
- Land retirement

Agriculture Water Use Efficiency

Agricultural WUE consists of improvements in technology, hardware, and water management to conserve water and improve water quality and environmental benefits. Effective agricultural WUE results in increased crop production without increasing the amount of water used.

Some conservation may reduce the amount of water applied to a field but does not produce real water savings. Real water savings are produced when *irrecoverable flows* (those that go to a salt sink, such as a saline aquifer, or are lost to evaporation) are conserved. By contrast, *recoverable flow* is water that, without the conservation measure, would have returned to groundwater or surface streams and become water supply for other users. In Figure 3-2, agricultural WUE (net) refers to irrecoverable flows.

Effective agricultural WUE results in increased crop production without increasing the amount of water used.

Recently, the CBDA completed a study that estimated the costs and benefits of water use as a part of the *Year-4 Comprehensive Evaluation of the CALFED Water Use Efficiency Element* final report (referred to as Year-4 Report) (CBDA, 2005b). The agricultural WUE annual savings from the study of irrecoverable losses range from 34 to 621 TAF, depending on investment level. The savings would come from onfarm improvements (how the water is applied on the field) and water-supplier improvements (how the water is conveyed and managed before it is delivered to the farmer). The costs of the agricultural water savings are estimated at $3 million to $150 million per year for 34 to 621 TAF, respectively.

The CALFED Water Use Efficiency Technical Appendix of the CALFED ROD also investigated the benefits of agricultural WUE. The CALFED ROD estimated that the benefit for irrecoverable loss reduction through agricultural WUE ranges between 120 and 563 TAF annually. The total cost of achieving a 563 TAF annual water savings by year 2030 is estimated at $0.3 billion to $2.7 billion.

The CALFED ROD and the Year-4 Report used different approaches and assumptions. The CALFED ROD's potential costs and benefits are based on assumed onfarm efficiency improvements of 85 percent within each hydrologic region and consider total irrigated crop area, crop water use, applied water, and depletions. The Year-4 Report estimates are based on crop water use, irrigated crop area, irrigation system type, and applied water within each Update 2005 planning area. It uses cost and performance information for onfarm and water-supplier improvements to estimate costs, consider various levels of funding and local implementation, and account for quantifiable objectives developed in CALFED's Water Use Efficiency Element. In addition, it includes an estimate of potential water use reduction from implementing a moderate level of regulated deficit irrigation.

The Update 2005 data in Figure 3-2 show a range of 200 to 800 TAF of potential additional annual water from net agricultural WUE. The technical documentation for Update 2005 indicates that the 200 TAF low estimate is the sum of the irrecoverable and recoverable flows (185 TAF rounded to 200 TAF). The technical documentation indicates that the 800 TAF high estimate comes from the 621 TAF estimated in the Year-4 Report plus an additional 94 TAF for lining the All-American and Coachella canals for a total of 715 TAF, rounded upward to 800 TAF to include the general assumption that some additional water supply benefits would be obtained from the Klamath Basin areas, for which data are not available.

The Common Assumptions investigation established a reasonably foreseeable conservation level of 74 TAF per year of irrecoverable flows including water management actions and programs that are either locally cost effective or are permitted and/or funded as of June 30, 2004, and are expected to continue being funded at the same rate through 2030.

Vineyard Using Drip Irrigation

The Common Assumptions investigation included the hydrologic regions of the Sacramento River, San Joaquin River, Tulare Lake, and South Coast. The San Francisco Bay region was not included in the agricultural WUE investigation because of its low concentration of agricultural uses. The boundaries of these hydrologic regions are shown in Figure 1-3.

The regions investigated represent approximately 80 percent of the irrigated agricultural acreage in the state. Assuming that agricultural WUE potential is proportional to irrigated agriculture acreage, the reasonably foreseeable conservation level for the state would be approximately 95 TAF annually. This value is shown in Figure 3-3 along with the Update 2005 low estimate.

Urban WUE focuses on reducing short- and long-term per capita urban water demand.

Urban Water Use Efficiency

Urban WUE focuses on reducing short- and long-term per capita urban water demand. It results from behavioral changes and changes to the hardware used in urban areas. Behavioral changes include educating the public about how to use less water. Examples of hardware changes include low-flush toilets, flow restrictors, and efficient washing machines. Urban WUE can improve water supply by freeing up water to be used for other purposes. Conserved water can be stored in reservoirs or groundwater basins to be used later. Other benefits of urban WUE include decreased energy use and lower capital operations and maintenance (O&M) costs for water distribution and treatment systems.

The CBDA sponsored a study of urban water conservation potential as part of the Year-4 Report. This study estimated an applied (combined recoverable and irrecoverable flows) water savings ranging from 1,153 to 2,075 TAF annually. An additional estimate of annual water savings of 3,096 TAF was provided as a reference; this level of savings represents the water savings potential using the assumptions of existing conservation technologies and 100 percent adoption of the evaluated conservation measures.

The range of water savings is based on varying assumptions about local water agency implementation of conservation measures and funding levels for CBDA grant programs. The low end of the range, 1,153 TAF annually, assumes historical levels of conservation and that grant program funding would consist only of remaining Proposition 50 funds available for urban conservation implementation. The higher end of the range, 2,075 TAF annually, assumes that all locally cost-effective measures are implemented, and that remaining Proposition 50 funds plus an additional $40 million per year of funding for the period of 2005–2014 and $10 million per year for the period of 2015–2030 would be available. Costs range from $223 per acre-foot to $522 per acre-foot, and would require an annual investment of between $99 million and $236 million.

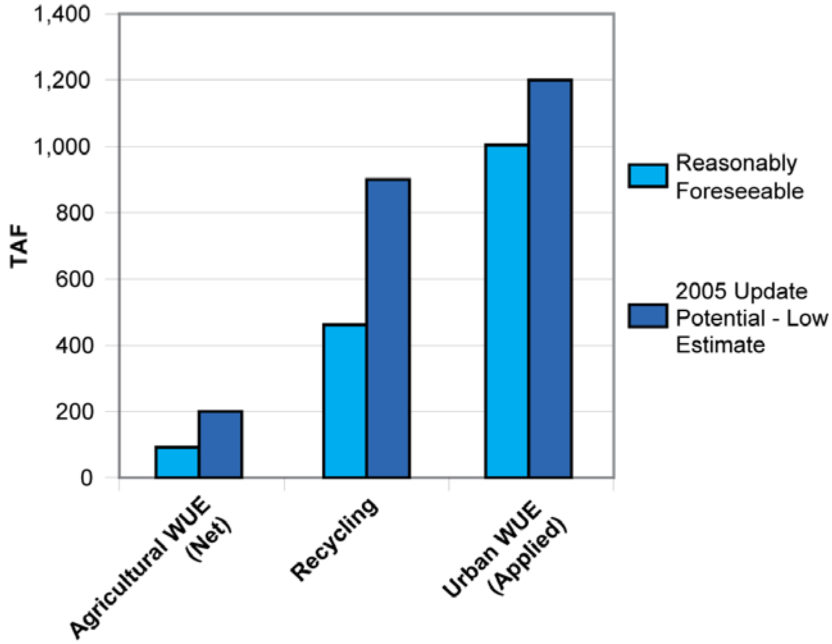


FIGURE 3-3
Statewide Conservation Level Estimates

The Update 2005 values provided in Figure 3-2 show a range of 1,200 to 3,100 TAF of potential additional annual water from applied urban WUE. The CALFED ROD estimated that the applied water savings of existing urban WUE programs ranges from 800 to 1,000 TAF annually at a cost of $150 to $450 per acre-foot.

The investigation for the Common Assumptions model included the hydrologic regions of the South Coast and the San Francisco Bay Region–South. It established a reasonably foreseeable maximum applied annual water savings in the year 2030 of 683 TAF that results from regulatory codes; implementing best management practices at historical rates; and investment of Proposition 50, Chapter 7 funds. The regions investigated represent approximately 68 percent of the population in the state. Assuming that urban WUE potential is proportional to population, the

Urban Water Use Efficiency Devices

reasonably foreseeable conservation level for the state would be approximately 1,000 TAF annually. This value is shown in Figure 3-3 along with the Update 2005 low estimate.

Irrigated Lands Retirement

Irrigated land retirement is the removal of farmland from irrigated agriculture. Retirement is practiced in one of two ways. Permanent land retirement is the perpetual cessation of land irrigation for agriculture, which is done for permanent water transfer or for solving drainage-related water quality problems. Crop idling or land fallowing, the temporary cessation of land irrigation for agriculture, can be employed to make water available in dry years. The water supply made available to other users as a result of these practices is discussed in the Water Purchases and Transfers section.

Irrigated lands retirement may make water supply available to other users.

Permanent land retirement in problem drainage areas would improve water quality and supply reliability. It would reduce the leaching of salts from soils and minimize the risk of selenium exposure to fish and wildlife in some areas. The total water made available by irrigated land retirement is potentially 2 to 3.5 acre-feet annually for each retired acre, assuming the lands are receiving their water allocation. This resulting available water from reduced demand can enhance water supply reliability.

Land retirement creates an opportunity to establish upland or other habitat for wildlife, but results in loss of lands available for agricultural production, which results in accompanying economic losses for the region and nation.

In 1992, The CVPIA Land Retirement Program authorized the purchase (from willing sellers) of agricultural land and associated water rights and other property interests that receive CVP water. The program is expected to retire about 100,000 acres of irrigated farmland. The program applies to lands that would improve water conservation or improve the quality of an irrigation district's agricultural drainage water, or that are no longer suitable for sustained agricultural production because of permanent damage resulting from severe agricultural drainage water management problems, groundwater withdrawals, or other causes.

Reclamation initiated a Land Retirement Demonstration Project to provide site-specific scientific data to guide the implementation of the Land Retirement Program. So far, this program has retired about 8,300 acres of land in the Westlands Water District (Westlands) and the Tulare Lake Basin. About 3,000 acres of drainage problem lands in Westlands have been retired as a part of *Britz v. U.S. Bureau of Reclamation* settlement agreements. An additional 33,000 acres in Westlands are planned to be retired over a 3-year period as a result of *Sumner-Peck vs. U.S. Bureau of Reclamation*. These retirements would be permanent land retirements, and the associated water allocation will be given to Westlands under a settlement agreement with Reclamation.

Other Actions

A diverse portfolio of water management strategies is essential to providing the flexibility needed to cope with changing and uncertain future conditions. The following water management actions are additional tools that can be incorporated as part of a water supply plan to meet current and future water needs:

- Water purchases and transfers
- Water recycling
- Desalination

Water Purchases and Transfers

Although purchase and transfer water for the CVP does not generate new water for the state, it could provide additional yield for the CVP. A transfer involves a willing seller who will forego a water use for some time, and a willing buyer who can make use of additional water. Purchase of water from water users outside the CVP must compete with several other programs and agencies planning to purchase the same water or use the same facilities for conveyance.

Although purchase and transfer water for the CVP does not generate new water for the state, it could provide additional yield for the CVP.

The California Water Code defines water transfers as a temporary or long-term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights. Temporary water transfers have a duration of 1 year or less [Section 1728]. Long-term water transfers have a duration in excess of 1 year [Section 1735].)

Many transfers among contractors of the CVP or the SWP are generally a redistribution of water, not strictly transfers. Water transfers can occur locally, between districts, or across the state if the water can be conveyed. Water transfers may be a temporary or permanent sale of a water right by the water right holder, a lease of the right to use water from the water right holder, a sale or lease of a contractual right to water supply, or a long-term contract for the purpose of improving long-term supply reliability.

Temporary and long-term transfers between water districts increased from 80 TAF in 1985 to more than 1,250 TAF in 2001. About 80 percent of these transfers are short term and 20 percent are considered long term. Since 1998, several permanent transfers have occurred between the CVP and SWP for up to 175 TAF annually.

Canal System

Economic studies conducted for the Environmental Water Account Final Environmental Impact Statement/ Environmental Impact Report indicate that annually, approximately 300 TAF in the Sacramento Valley and 400 TAF in the San Joaquin Valley could be made available through crop idling without unreasonably affecting the overall economy of the county that would lose the water (DWR, 2005). Statistics on water transfers should only be considered a snapshot in time, because new transfers are continually being negotiated.

The investigation for the Common Assumptions included the entire state for long-term temporary transfers. For temporary single-year transfers, available transfer supplies were estimated for the following hydrologic regions: San Joaquin River, Tulare Lake, and Sacramento River, which includes the Sacramento, Yuba, and Feather River subregions. Demands for single-year transfers were determined for the San Francisco Bay Region–South, and the South Coast Region. It established a reasonably foreseeable maximum potential of water transfer supplies by 2030 of 645 to 890 TAF per year depending on water year type.

Water Recycling

Water recycling is a program to reclaim and reuse municipal, industrial, domestic, and agricultural wastewater. It can also include reclaiming impaired groundwater and surface water. The recycled and reclaimed water can be used for a variety of purposes, such as ecosystem restoration, fish and wildlife habitat, groundwater recharge, urban water supply, agricultural water supply, power generation, and recreation. Water reclamation can produce flows that are useful to downstream areas. The terms *recycled water* and *reclaimed water* are used interchangeably.

Today, California's water agencies recycle about 500 TAF annually of wastewater. Figure 3-2 shows a range of 900 to 1,400 TAF of potential additional annual water from recycled municipal water by the year 2030, as reported by Update 2005. In the scheme of California's overall water supply, recycling provides new water for the state only in areas where wastewater is discharged to the ocean or to a salt sink. Recycling in other areas may provide new water for the water agency, but does not necessarily add to the state's water supplies. In these locations, discharged wastewater in interior California mixes with other water and becomes source water for downstream water users.

> Recycling provides new water for the state only in areas where wastewater is discharged to the ocean or to a salt sink.

The estimated capital cost for the range of potential recycling by 2030 is about $6 billion to $9 billion. Actual costs will vary based on the quality of the wastewater, the treatment level needed, and the availability of a distribution system. The majority of applications would cost between $300 and $1,300 per acre-foot of recycled water.

Water Recycling Facility

The investigation for Common Assumptions included the hydrologic regions of South Coast and San Francisco Bay. It established a reasonably foreseeable additional annual yield of approximately 331 TAF.

The regions investigated for Common Assumptions represent approximately 71 percent of the population in the state. Assuming that recycling potential is proportional to population, the reasonably foreseeable conservation level for the state is estimated to be approximately 466 TAF annually. This value is shown in Figure 3-3 along with the Update 2005 low estimate.

Desalination

Desalination is a water treatment process whereby salt is removed from seawater, brackish groundwater, or wastewater so that the water may be available for beneficial use. This is accomplished either by thermal distillation or membrane filtration. One type of membrane filtration is reverse osmosis, which is the treatment method most commonly used in California.

Wastewater recycling projects may require desalination treatment in order to meet water quality standards; similarly, groundwater projects that result in the extraction of brackish groundwater must often treat such water for salt. Additionally, desalination facilities may be operated exclusively for purposes other than producing new yield, such as wastewater desalted and injected into an aquifer to maintain a saltwater intrusion barrier.

Desalination is accomplished either by thermal distillation or membrane filtration.

Desalination facilities currently operate in California to provide water for municipal purposes. The following descriptions of these facilities are based on information in Update 2005.

Seven new desalination facilities, with a combined annual capacity of about 30 TAF annually, are in the design and construction phase. By 2030, it is estimated that 19 additional desalination facilities will be operational in California, resulting in a total additional supply of approximately 507 TAF per year. Of those 26 new facilities, it is estimated that 12 will be brackish groundwater desalting facilities with a capacity of approximately 91.2 TAF annually, and 14 will be seawater desalination plants with a capacity of approximately 415.4 TAF annually. The Metropolitan Water District of Southern California alone is targeting 150 TAF annually in sustained production. Additionally, 150 TAF annually in reclaimed municipal wastewater will be treated for salt statewide.

Reverse-osmosis Equipment in a Desalination Facility

Figure 3-2 shows a range of 300 to 500 TAF of potential additional annual water from ocean and brackish desalination water by the year 2030, as reported in Update 2005. The technical documentation for Update 2005 indicates that the low estimate of 300 TAF per year is based on the assumption that desalination facilities in the design, construction, or planning stages will be constructed. Any desalination facilities that had reconnaissance or feasibility-level planning studies prepared or in preparation at the time of Update 2005's publication were considered planned. The documentation indicates the high estimate of 500 TAF, which is the sum of 29.8 TAF under design or construction and 476.8 TAF for planned and projected. The resulting value of 506.6 TAF per year was rounded to obtain 500 TAF per year.

The investigation for Common Assumptions included the South Coast and San Francisco Bay Hydrologic Regions. It established a reasonably foreseeable maximum potential water supply by 2030 of 53.8 TAF per year that results from one seawater desalination project, two brackish groundwater desalting facilities, and Proposition 50 funds. In this analysis, any projects currently operational or that have received 25 percent of their total project cost from state and federal funds were deemed to be reasonably foreseeable. For projects with some level of funding, current (or future) levels of state and federal funds were applied to achieve financing of 25 percent of the total project cost. It is assumed that local funds will finance the remaining 75 percent. State and federal funds in excess of those spent to achieve 25 percent financing were applied to develop additional yield based on an average cost per acre-foot of developed capacity. This process accounts for a representative yield resulting from desalination that will be developed by the year 2030.

Conjunctive Water Management

Coordinated management of groundwater and surface water resources is called *conjunctive water management*. Groundwater is typically withdrawn during dry periods and replaced, or *recharged*, in wet periods, but many operational changes are possible depending on local conditions. By coordinating use of surface water and groundwater, both supply sources may be managed more efficiently. This, in turn, leads to greater yield and a more reliable water supply. Conjunctive management may also have the beneficial effects of reducing groundwater overdraft and land subsidence, and improving environmental conditions by leaving fish flows instream or creating wildlife habitat in percolation ponds or recharge basins.

Coordinating use of surface water and groundwater allows supply sources to be managed more efficiently.

Supplies for groundwater storage may be obtained by diverting portions of storm flows in local rivers, transferring water from out-of-basin sources, or by using reclaimed wastewater or desalinated water. Supplies enter groundwater storage either by percolation or by direct recharge through basins or injection wells.

The CALFED ROD set a target for 500 to 1,000 TAF of additional groundwater storage. To help meet this target, the DWR Conjunctive Water Management Program provided funds to support local initiatives in the total amount of $240 million, accounting for roughly 25 percent of project costs. The remaining 75 percent of costs were paid by the project proponents. Between fiscal years 2000 and 2004, 146 grants and loans were awarded. It is important to note that grant funding requests far exceeded available funding. In the case of Water Bond 2000 (Proposition 13), requests outstripped available funds by more than three-to-one. This program produced an estimated additional yield of 300 TAF/year that could be obtained at a total cost of approximately $1 billion.

Groundwater Pump

Figure 3-2 shows a range of 500 TAF to 2 MAF, as reported in Update 2005. Conservative estimates of additional implementation of conjunctive management indicate the potential to increase average annual water deliveries throughout the state by 500 TAF with 9 MAF of “new” groundwater storage. More aggressive estimates from screening-level studies indicate the potential to increase average annual water deliveries by 2 MAF with about 20 MAF of new storage. The more aggressive estimates are based on assumptions that require major reoperation of existing surface water reservoirs and require groundwater storage to achieve the benefits, but do not fully consider the conveyance capacity constraints for exports from the Delta and other conveyance facilities.

Unit costs range from $10 to $600 per acre-foot of additional annual yield, with an average of about $110 per acre-foot. Estimates from other recent grant proposals indicate that costs are rising, primarily because construction costs have increased. General information from several of the most recent proposals (fiscal year 2003–2004) for funding from Water Bond 2000 indicates the scale and range of conjunctive management projects currently being carried out throughout California.

Filling the Supply-Demand Gap

The existing and future gap between California’s water supply and demand is substantial, and a variety of projects and water management actions could be used to fill this supply-demand gap. A cursory-level analysis was conducted to determine whether these projects and water management actions could fill the existing and projected 2030 supply-demand gap. The results of this analysis are summarized here.

Figure 3-4 shows the existing average and dry year supply-demand gap along with the projects and water management actions that could be used to fill all or a portion of the gap if these projects were in place and the actions were fully implemented today. The values assumed for filling the existing water supply-demand gap are summarized in Table 3-2. If the Level 1 storage and conveyance projects were constructed and investments in water management actions were in place today, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years.

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were in place today, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years.

As shown in Figure 3-4, agricultural and environmental uses compose the majority of the supply-demand gap. These uses generally experience water supply shortages in average and dry years, resulting in reduced irrigated agricultural land and agricultural output, and increased pressures on environmental demands. Even if the projects and water management actions shown in Figure 3-4 could be implemented in the near term, agricultural and environmental uses are likely to continue to experience water supply shortages and associated negative effects of these shortages in dry years.

Figure 3-5 compares the projected 2030 supply-demand gap along with the projects and water management actions that could be used to fill a portion of the gap. The values assumed for filling the supply-demand gap are summarized in Table 3-2. If the Level 1 storage and conveyance projects were

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years.

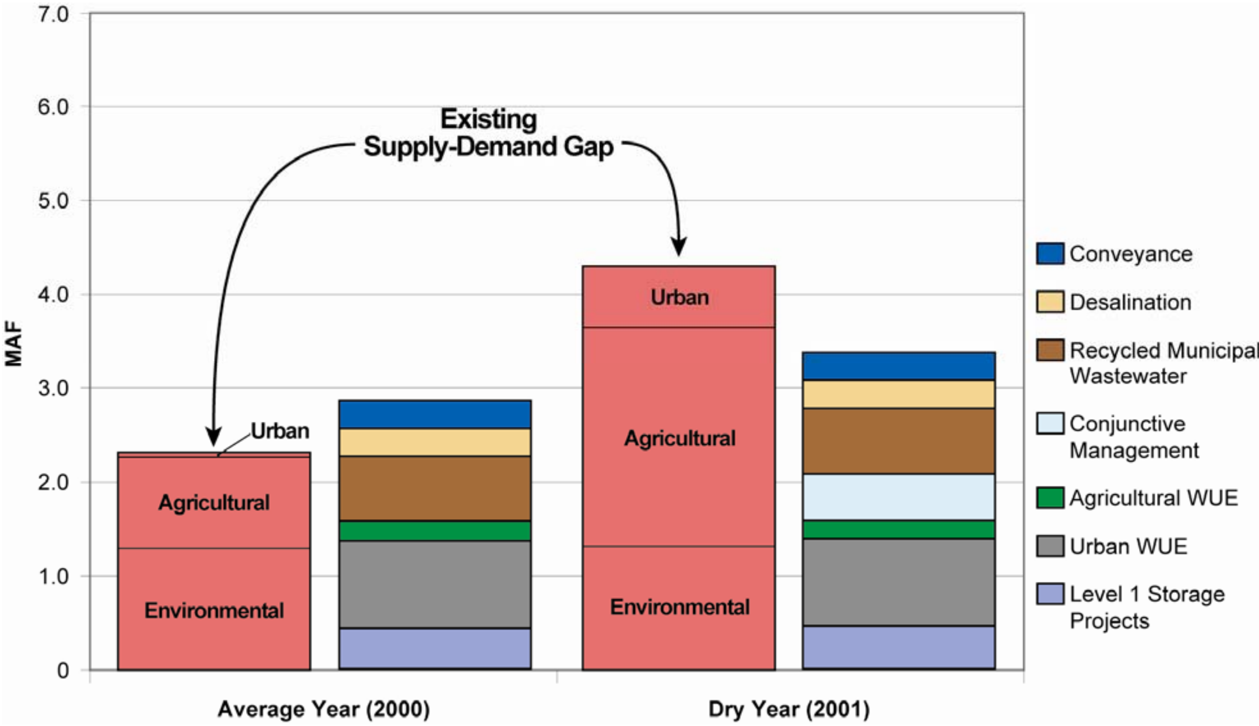


FIGURE 3-4
Projects and Water Management Actions to Help Fill the Existing Supply-Demand Gaps

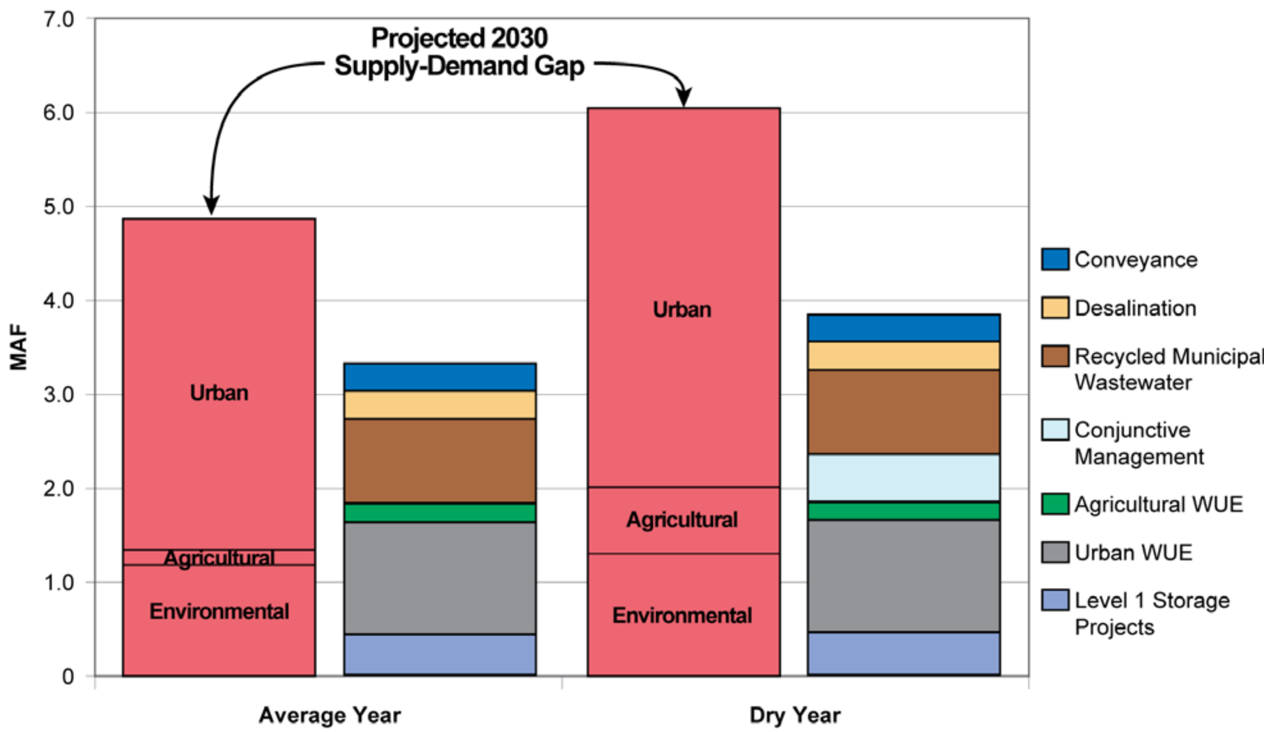


FIGURE 3-5
Projects and Water Management Actions to Help Fill the Projected 2030 Supply-Demand Gaps

TABLE 3-2
Projects and Water Management Actions to Help Fill the Existing and Projected 2030 Supply-Demand Gaps

	Existing		Projected 2030	
	Average Year (TAF)	Dry Year (TAF)	Average Year (TAF)	Dry Year (TAF)
Conveyance[a]	300	300	300	300
Desalination[a]	300	300	300	300
Recycled municipal wastewater[a,b]	690	690	900	900
Conjunctive management[c]	0	500	0	500
Agricultural WUE[a,d]	210	200	200	150
Urban WUE[a,b]	920	920	1,200	1,200
Level 1 storage projects[e]	430	450	430	450
Total	**2,850**	**3,360**	**3,330**	**3,800**

[a] The potential water supply from conveyance, desalination, recycled municipal wastewater, agricultural WUE, and urban WUE are based on the 2005 Update low estimate provided in Figure 3-2.
[b] Values were adjusted proportionally to account for differences in existing and projected 2030 population.
[c] Assumed to contribute to water supply during dry years and not average years. Participation in conjunctive use programs occurs in all years. However, net groundwater withdrawals are assumed to occur only in dry years.
[d] Values were adjusted proportionally to account for differences in the amount of existing and projected agricultural lands. Agricultural WUE also decreased slightly in dry years as a result of reduced deliveries to agricultural users. Although more water may be conserved per acre of irrigated land in a dry year, fewer acres may be irrigated in a dry year because of reduced deliveries. As a result, the total water conserved would actually be less in a dry year.
[e] The potential water supply from the Level 1 storage projects shown is the average of the storage projects alternatives listed in Table 3-1. The long-term average project yield in Table 3-1 was averaged across the different scenarios for each storage project and summed to obtain the average year value. A similar analysis was conducted using the driest period average in Table 3-1 to obtain the dry year value.

constructed and investments in water management actions were made, the projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years. Long-term water supply reliability depends on being able to meet water demands during dry years, and additional measures would be needed to fill this projected supply-demand gap.

Under the projected 2030 conditions, the urban gap is substantially larger than under existing conditions and accounts for the majority of the supply-demand gap. Urban uses generally take priority over agricultural and some environmental uses; therefore, it is likely that agricultural and environmental uses would continue to experience water supply shortages in future average and dry years.

As shown in Figures 3-4 and 3-5, both the Level 1 storage and conveyance projects and investments in water management actions are needed to fill the existing and future water supply-demand gap. Implementation of the Level 2 and 3 storage projects and more aggressive investments in water management actions would be needed to fill the 2030 supply-demand gap.

It is important to note that this analysis provides a statewide perspective of supply-demand gaps. Conveyance limitations and limited opportunities for projects and/or water management actions on a regional basis may exacerbate regional water supply-demand gaps.

4 Rate Impacts and Willingness to Pay

The economic aspects of the projects identified in this study are a key component in determining how to proceed with implementation. This section provides insight to possible financial and economic impacts through the following evaluations:

- Identification of the financial impacts from implementing the projects and water management actions identified in Section 3
- Estimation of beneficiaries' willingness to pay for additional water deliveries
- Development of an initial conclusion concerning the financial feasibility of the Level 1 storage and conveyance projects

Public Law 108-361, the authorizing legislation for this WSAY Study, requires an assessment of the beneficiaries' willingness to pay the capital and O&M costs of the actions and projects.

Determining what effect storage and conveyance projects will have on existing rates and what beneficiaries would be willing to pay are important components of a financial analysis. A project is considered financially feasible if sufficient revenue can be raised to pay the financial costs. A project can be economically feasible but not financially feasible if the beneficiaries are not willing or able to pay the associated water charges or fees.

Overview

The projects and water management actions identified in Section 3 are financed through various sources. Some projects are federally funded by Reclamation through the CVP and require repayment through rate adjustments to CVP contractors. The majority of water management actions are funded through state, federal, or local agencies and organizations and do not influence the rates charged to CVP contractors.

The Level 1 storage and conveyance projects identified in Section 3 could be federally funded, and would be recovered through CVP contractor rate adjustments. The impact these projects would have on the CVP rates is detailed later in this section. The Level 2 projects discussed in Section 3 do not have detailed yield and cost information associated with their construction and operation. However, these facilities would impact CVP rates to contractors through the same process as Level 1 projects.

The water management actions covered in Section 3 occur on a local level and do not have systemwide impacts to CVP rates. These water management actions are funded through a mix of state, federal, and local agencies and organizations. Statewide, many of these water management actions are already being implemented as a result of market forces, naturally occurring conservation, work by Reclamation and DWR, ongoing initiatives by local water agencies and districts, CALFED initiatives, and other entities. The following actions identified in Section 3 are included in the CALFED Bay-Delta Program Finance Plan (CALFED Financial Plan) (CBDA, 2005a):

- Agriculture WUE
- Urban WUE
- Water recycling
- Desalination

Federal, state, and local funding for water use efficiency, including urban and agricultural water conservation, recycling, and desalination, is $3.15 billion over

Section Highlights

Estimated cost-of-service for existing and all Level 1 projects:

- $40 per acre-foot for irrigation and $70 per acre-foot for M&I when allocating 50 percent of project costs to water supply
- $55 per acre-foot for irrigation and $95 per acre-foot for M&I when allocating 75 percent of project costs to water supply

CVP contractors' annualized willingness to pay for permanent water supply south of the Delta is approximately $130 per acre-foot for irrigation and $185 per acre-foot for M&I.

Recent transfer negotiations indicate that contractors may be willing to pay more than these amounts for new, permanent water supply.

Not every contractor has the ability to pay the average willingness to pay amount. Some contractors will be unable to participate in the purchase of CVP water if the contract rates rise dramatically.

Terminology

For the purpose of discussing CVP rate impacts in this section, the terms *M&I* and *irrigation* are used in place of urban and agriculture, respectively, to be consistent with contractual language. This is based on the language used in Reclamation's CVP Annual Ratebook.

the next 10 years. The objective is to meet 65 percent of this total from local water agencies and organizations and the remaining 35 percent from federal and state sources.

Agricultural WUE

Agricultural WUE consists of improvements in technology, hardware, and water management to conserve water and improve water quality and environmental benefits. The CALFED Finance Plan estimates that agricultural WUE over the next 10 years will be met by approximately 40 percent state and federal funding and 60 percent local agency and organization funding (CBDA, 2005a). California Propositions 50 and 84 are examples of state funding targeted for agricultural WUE.

Canal Lining to Prevent Seepage Losses

Urban WUE

Urban WUE focuses on reducing short- and long-term per capita urban water demand. It results from behavioral changes and changes to the hardware used in urban areas. The CALFED Finance Plan estimates that urban WUE over the next 10 years will be met by approximately 60 percent state and federal funding and 40 percent local agency and organization funding (CBDA, 2005a). California Propositions 50 and 84 are examples of state funding targeted for urban WUE.

Recycling

Water recycling is a program to reclaim and reuse municipal, industrial, domestic, and agricultural wastewater. It can also include reclaiming impaired groundwater and surface water. The CALFED Finance Plan estimates that recycling targets over the next 10 years will be met by approximately 25 percent state and federal funding and 75 percent local agency and organization funding (CBDA, 2005a). Title 16 and California Proposition 84 are examples of funding available for recycling.

Desalination

Desalination is a water treatment process whereby salt is removed from seawater, brackish groundwater, or wastewater so that the water may be available for beneficial use. The CALFED Financial Plan estimates that desalination targets over the next 10 years will be met by approximately 25 percent state and federal funding and 75 percent local agency and organization funding (CBDA, 2005a). California Propositions 50 and 84 are examples of funding available for desalination.

Desalination Plant

CVP Rate Impacts

The purpose of the rate impact analysis is to illustrate the relationship between anticipated increases in CVP project costs and future water charges. The CVP cost allocation repayment responsibilities for plant-in-service (capital costs) as of September 30, 2004, are provided in Figure 4-1. Each entity is allocated a portion of the approximately $3.4 billion in total CVP capital costs. Repayment methods vary by entity. For example, M&I and irrigation water users repay their share of costs through water rates, commercial power customers repay costs through power revenue, and state and federal costs are repaid using direct payments and federal taxes, respectively.

The total preliminary capital cost estimates for the Level 1 storage and conveyance projects range from $3.9 billion to $6.8 billion, and could result in an anticipated average annual yield of approximately 200 to 600 TAF.[1] As these and other water management actions are implemented to meet current and future needs, their costs will have a noticeable influence on CVP repayment responsibilities and contract water rates.

The basic steps in the ratesetting process for capital (new plant-in-service) additions to the CVP are the following:

1. **Cost Allocation.** Identify and allocate the costs of a multipurpose facility among the various authorized project purposes, which includes sub-allocating costs allocated to water supply among irrigation, M&I, and wildlife refuges.
2. **Reimbursement.** Identify the repayment responsibility for the cost of each facility and budgeted O&M costs, O&M deficits/surplus, and projected water deliveries.

[1] A high-end water supply estimate of 600 TAF annually is used to demonstrate the relationship between capital costs and rate impacts under a best-case scenario. This yield estimate is based on the aggregate water supply objective from each of the Level 1 storage and conveyance projects.

3. **Ratesetting.** Calculate contract water rates using information provided in the cost allocation and reimbursement steps.

These basic steps are described in greater detail in the following discussion.

Federal Cost Allocation Practices

Cost allocation is the process of identifying and allocating the costs of a multipurpose project among the authorized project purposes. The purposes authorized by law for the CVP are typically water supply, water quality, flood control, recreation, navigation, hydropower, and fish and wildlife.

For the CVP, the cost allocation identifies costs to be repaid to the federal government by water and power users, as well as the repayment obligations of non-federal public entities, such as the State of California and counties. The allocation also identifies nonreimbursable costs, borne by federal taxpayers (Reclamation, 2001). Reclamation annually updates the CVP cost allocations as changes occur in the uses of project-supplied water and power, and as new investments in facilities are completed. These updates are needed to provide input to the CVP water ratesetting process, which is performed by Reclamation. Cost allocations are also used to establish bases for financial feasibility studies when proposals are made for new additions to the project.

Federal Reimbursement Practices

Cost reimbursement refers to the collection of revenues to repay assigned costs. Funds for financing the initial construction of federal projects are appropriated from the general budget. The portion of the costs that must be repaid by beneficiaries varies by project purpose.

The reimbursement requirements for costs allocated to irrigation differ from those for other purposes. Irrigation water users are required to pay their share of O&M costs. However, interest costs are not reimbursable for irrigation, and the users' obligation to pay their allocated share of construction costs and restoration fund payments can be limited by a determination of their ability to pay, as defined by Reclamation law.

M&I water users and hydropower users must pay their share of O&M and construction costs, plus interest during construction and during the repayment period. Depending on legislation enacting repayment, recreation and fish-and-wildlife mitigation reimbursement may also be required. However, the federal share of costs allocated to most recreation, fish-and-wildlife enhancement, navigation, flood control, and water quality are nonreimbursable.

The water supply actions described in this report have been proposed by CALFED to be developed cooperatively with the State of California and local interests. Therefore, the financial analysis for each CALFED project cannot proceed using federal standards alone. Rather, the financial analysis should consider CALFED precedents, and state and local standards. However, CALFED precedents do not take precedent over state or federal laws.

Ratesetting

In general, the authorized CVP repayment period is fiscal year (FY) 1981 to the end of FY 2030. New repayment periods are established for the capital costs of major rehabilitation and new facilities added to the CVP, such as the San Felipe Division out-of-basin facilities, which have a repayment period of FY 1987 to the end of FY 2036. However, the construction costs for smaller additions or modifications fall within the initial 50-year repayment period. Capital additions (such as a new plant-in-service) are recorded in the Reclamation accounting system and reflected in contract water rates to the extent that they are allocated to irrigation and M&I water supply.

Table 4-1 summarizes, by selected facility, the 2006 CVP contract water rates for irrigation and M&I water. Contract rates may vary significantly among facilities depending on the cost of capital (for example, capital costs may include capital and conveyance, pumping, and so on), O&M for the capital costs, and deficit payments. Table 4-1 shows that contract rates range from $2 to $57 per acre-foot.

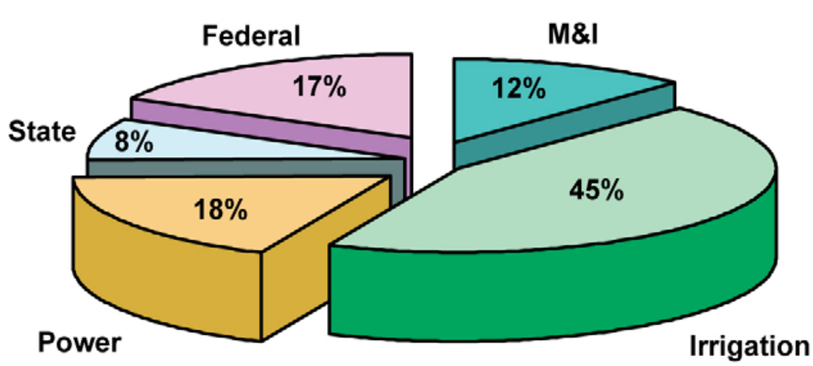


FIGURE 4-1
Existing Cost Allocation Repayment Responsibilities

TABLE 4-1
Summary of CVP Wholesale Water Charges by Selected Facility

Facility	2006 Water Contract Rate ($/AF)	
	Irrigation	M&I
Sacramento River	2–53	15
Corning Canal	15–18	NA
Tehama-Colusa Canal	14–22	23–35
San Felipe Unit	31–32	43
Delta-Mendota Canal	24–54	15–43
San Luis Canal	8–34	19–48
Friant-Kern Canal	23–30	15–57

Source: Reclamation, 2006a
NA: not applicable

Estimated Rate Impacts

The data necessary for conducting a specific rate impact analysis are not yet available for the storage and conveyance facilities described in Section 3 of this report. However, some information is available for Level 1 projects, and approximations can be made on the basis of the limited information available. A simplified example of this approximation is illustrated in Figure 4-2.

Because contract water rates are critical in determining the financial feasibility of any CVP improvements, a preliminary assessment was made of the cost-of-service rate impacts of implementing the Level 1 storage and conveyance projects. Both reimbursable and nonreimbursable purposes are served by the Level 1 storage and conveyance projects, and these projects tend to enhance the reliability of water supply to all water users. Therefore, the allocated costs are spread to the entire rate base in this ratesetting exercise.

The cumulative per-acre-foot impact on CVP water charges from adding storage, conveyance, marketing, and O&M costs allocated to water supply is shown for irrigation in Figure 4-3 and for M&I in Figure 4-4. In this analysis, costs are allocated to irrigation and M&I based on historical contract allocations. Along the x-axis, the costs of the additional Level 1 storage and conveyance projects are added, with the least expensive actions tallied first. The y-axis identifies the cost-of-service for capital, conveyance, marketing, and O&M associated with the capital, based on the cost and projected water supply yield from each storage and conveyance action.

The cost-of-service estimates were derived using a capital rate (total capital costs/total storage yield), conveyance rate (total conveyance costs/conveyance yield), and estimated marketing and O&M rates. Storage and conveyance capital cost, along with water yield from the projects, are added to current CVP capital and yield estimates to derive a total capital cost and projected water supply. Capital cost from all storage and conveyance projects is estimated at over $6 billion, and the total yield allocated to water supply is over 600 TAF.[2]

The cost-of-service rates are for storage and conveyance only; no pumping (conveyance or direct) or other costs (such as deficit costs) are included in this analysis. O&M and marketing costs are estimated for storage only and are extrapolated from existing facilities. It is anticipated that more-refined and accurate estimates of the cost-of-service rate impacts will be provided in future analysis, when additional cost allocation information becomes available.

On the basis of limited project-specific benefits and costs, it was assumed that 50 percent of the total storage project costs (along the x-axis) would be allocated to irrigation and M&I. The remaining 50 percent would be allocated to other purposes, such as environmental water supply.

The rate impact figures highlight a few important points:

- Cost-of-service rates are estimated to be about $40 per acre-foot for irrigation and $70 per acre-foot for M&I when including all of the Level 1 projects.
- The Level 1 projects are assumed to be constructed and operational by 2021, so the cost-of-service rate estimates are for the period

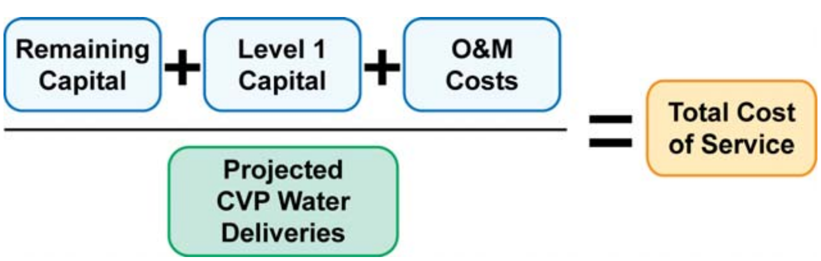


FIGURE 4-2
Approximation of Total Cost of Service

[2] A high-end water supply estimate of 600 TAF annually is used to demonstrate the relationship between capital costs and rate impacts under a best-case scenario. This yield estimate is based on the aggregate water supply objective from each of the Level 1 storage and conveyance projects.

2021 to 2030. After 2030, initial CVP capital costs will be repaid (with the exception of the San Felipe Division, which will be repaid in 2037), and overall rates will fall to slightly lower levels.

- The large increase in irrigation and M&I rates results from current total CVP capital costs increasing by approximately 150 percent as a consequence of implementing Level 1 projects, while the increase in CVP contract water supply is 10 percent.

Changing the proportion of cost allocated to irrigation and M&I causes a noticeable change in the cost-of-service rates. For illustrative purposes, changing the allocation of capital cost to irrigation and M&I to 75 percent increases the cost-of-service rates by 20 to 30 percent (Figures 4-5 and 4-6).

Willingness to Pay

Willingness to pay can be used for two separate purposes in water resources planning and management. The first is as a method of measuring economic benefits in benefit-cost analysis or cost-effectiveness analysis. The second use is in the financial analysis as a measure of the project participants' (for example, water contractors) willingness to repay the debt (such as water rates) incurred to finance the capital cost and to meet the O&M costs of the actions and projects.

Several methods can be used to estimate the willingness to pay for additional water supplies:

- Observation of water market transactions
- Surveys of water users
- Estimates of the value water has in production settings (irrigation or industrial)

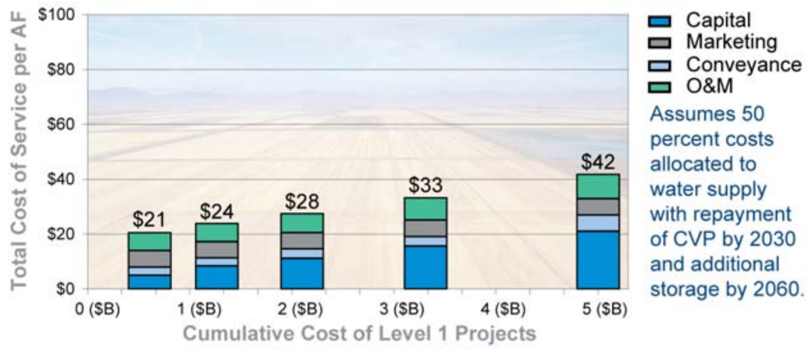


FIGURE 4-3
Irrigation Cost-of-Service Impact at 50 Percent Cost Allocation

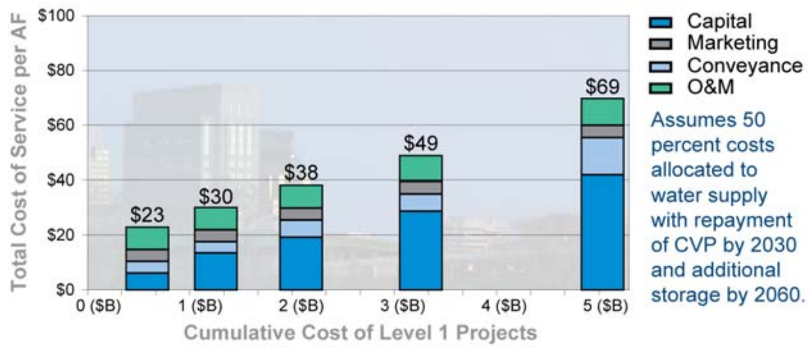


FIGURE 4-4
M&I Cost-of-Service Impact at 50 Percent Cost Allocation

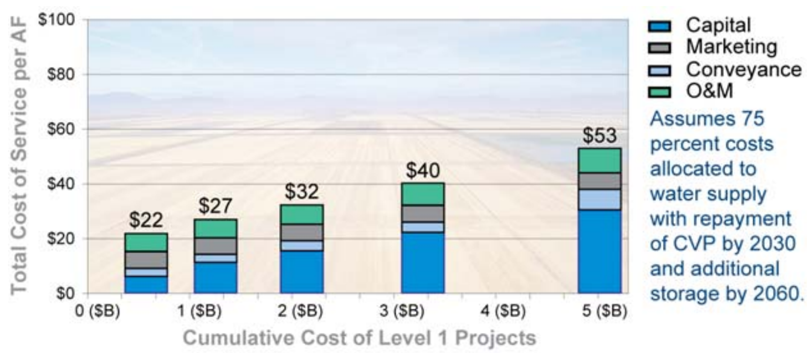


FIGURE 4-5
Irrigation Cost-of-Service Impact at 75 Percent Cost Allocation

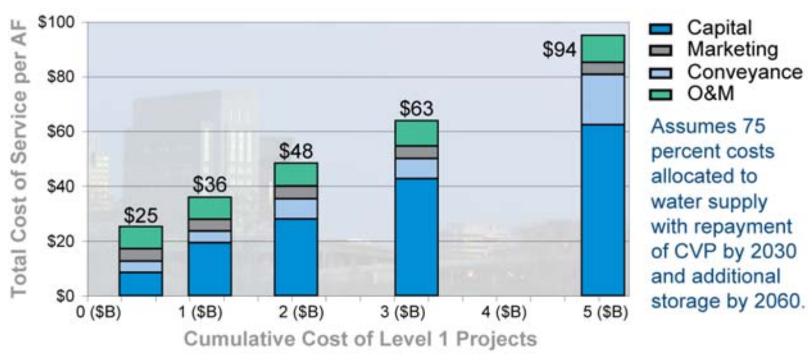


FIGURE 4-6
M&I Cost-of-Service Impact at 75 Percent Cost Allocation

- Identification of the cost to implement a least-cost alternative (such as the cost of groundwater pumping to augment supply)

When determining the willingness to pay for additional water supplies, baseline conditions are an important aspect to consider. Willingness to pay is dependent on considerations such as baseline deliveries, delivery timing, and water year type. Baseline conditions are implicit in historical transfer prices; however, when estimating future prices, these conditions may need adjustment to account for changing demand and supply for water.

Willingness to Pay Estimates

To estimate a range of willingness to pay for additional water supplies, three techniques were used:

- **Observation of transferred water prices.** Historical transfer prices are a good indication of the willingness to pay for additional water supplies. Transfers take place in a variety of situations (such as spot market, long-term, and permanent contract sales), north and south of the Delta.
- **Survey.** SWP and CVP contractors were surveyed to identify a need for water in the future and their willingness to pay for additional water.
- **Estimating the cost of water management options.** Each SWP and CVP contractor has different opportunities to secure additional water supplies. These opportunities might include desalination, recycling, and conservation. The costs of these alternatives are estimated to provide upper limits on the maximum willingness to pay for future water supplies.

Information obtained from these three methods was used to estimate willingness to pay for short-term, long-term, and permanent water supply north and south of the Delta. The following discussion describes the three methods in greater detail.

Historical Transfers

An indication of some water districts' willingness to pay for water is provided by the prices they have paid in recent years for water transfers. The CVPIA, the Drought Water Bank Dry Year Purchase Program, and the EWA have spawned a large number of transfer transactions in recent years. In addition, several long-term transfers are pending or have been approved (DWR, 2005).

Canal System

Most transactions are for the transfer of irrigation water from one district to another, but many transactions are for the transfer of irrigation water to environmental and M&I uses. In the case of CVP supplies, the total price paid per acre-foot includes the contract rate plus additional charges as applicable. Prices paid to the seller for irrigation use generally range from about $25 to more than $50 per acre-foot.

The broad spectrum of irrigation districts purchasing water at these prices indicates that many are willing to purchase additional water supplies at the rates being paid by the selling district. The prices paid for transferred water described in the following discussion represent only the amount paid for the acquisition of the transferred water; they do not include additional rates paid, costs for conveyance, storage, treatment, or seepage losses between the point of sale and point of water use.

Transferred water is priced depending on the volume of water transferred, reliability of the transferred water, and duration of the transfer. Another factor that determines willingness to pay for transfers is water year type.

Historical water transfers are categorized in the following manner:

- Spot market
- Long-term water purchase
- Water contract sales

Water market transfer prices historically paid for each type of transfer are detailed here. Reported prices do not include conveyance costs.

Spot Market Transfers

Spot market transfers are single-year transfers arranged between buyers and sellers in the year of transfer. These short-term arrangements provide willingness to pay information for actions by the following programs and agencies to augment single-year supplies:

- EWA
- Reclamation
- Westlands Water District

Environmental Water Account

In operation since 2001, the EWA water acquisition program has paid $75 to $100 per acre-foot for water from north-of-Delta (NOD) sources, and from $130 to approximately $460 per acre-foot from SOD sources. The prices vary

Chinook Salmon

by water year type. In dry and critically dry years, which have not yet occurred since the EWA's inception, the price of water is expected to rise beyond historical prices paid by the EWA for transfers.

The EWA water acquisition program separates acquisitions by region (NOD and SOD) and by water agency. Table 4-2 shows the EWA water acquisitions and the calculated average price per acre-foot for each of the 5 years. The FY 2000–2001 prices were higher than in any of the following 3 years because 2000–2001 was a drier-than-average year.

TABLE 4-2
EWA Acquisitions through 2005

Source	Year	Total EWA Water Acquired (TAF)	Average Price Paid ($/AF)*
NOD	2005	46	43
	2004	120	87
	2003	70	84
	2002	142	75
	2001	105	87
SOD	2005	90	177
	2004	35	190
	2003	145	169
	2002	97	181
	2001	231	221

Source: DWR, 2006a
* Does not include conveyance costs

Reclamation

Under its Water Acquisition Program (WAP), Reclamation acquires water for Level 4 refuge water supply, for Vernalis Adaptive Management Plan (VAMP) pulse flows, and to meet the terms of the San Joaquin River Agreement. Water acquisitions have been completed every year since 1994. Table 4-3 summarizes prices paid in recent years.

TABLE 4-3
Prices Paid by Reclamation's WAP ($ per acre-foot)

Source	2001–2002	2002–2003	2003–2004	2004–2005
NOD	NA	30	NA	NA
SOD	60–150	63–120	60–130	65–120

Source: Reclamation, 2006b; Reclamation, 2006c
Note: Does not include conveyance costs
NA: not applicable

Prices paid were generally in the range of $60 to $150 per acre-foot. All purchases were from SOD water users, excluding 2002–2003. NOD prices in 2002–2003 may be lower than typical for the region because of the particular districts involved, and because the transfers are part of a water rights settlement.

Westlands Water District

Data on costs of water transfers were provided by Westlands Water District, a water purveyor that serves the primary agricultural area on the west side of the San Joaquin Valley. Table 4-4 shows costs of water acquired in 2000–2004. A large share of these transfers might qualify as within-CVP transfers facilitated by CVPIA provisions.

Long-term Water Purchases

Long-term water purchases provide the buyer with a period of water transfers lasting longer than a single year. They also provide the buyer with the right to use the water for a specified term, but do not constitute the sale of water right or contract. The higher willingness to pay for long-term water transfers (higher than the spot market) is reflected in the more permanent nature of the arrangement. However, long-term transfer price is still dictated by the reliability, volume, and duration of the transfer. Table 4-5 provides information on some of the recent NOD and SOD long-term transfers.

Water Contract Sales

Transfers that are considered contract sales are a permanent transfer of water right or contract right. The price represents the cost of obtaining the right or contract, but not future payment for the use of water under the right or contract. This prevents direct comparison of water contract sales and short- and long-term transfers. However, annualizing the contract sale price provides an approximation of the annual price paid for capital outlay. Selected recent contract sales are summarized in Table 4-6.

Future Water Transfers

Urban demands are expected to increase as population increases, and agricultural demands are expected to decline and harden because of declining land in production, and increasing conservation efforts and percentage of permanent crops (DWR, 2005). The willingness to pay for transfers in the future depends on these changes in demand and also on the statewide hydrology, which may be altered as a result of climate change. These uncertainties complicate future willingness to pay estimation.

TABLE 4-4
Water Transfers to Westlands Water District, 2000–2004

Year	Transfers Purchased by Users (AF)	Transfers Purchased by District (AF)	Total Purchased (AF)	Water Cost ($/AF)*
2004	95,855	24,905	120,760	147
2003	106,141	27,641	133,782	108
2002	124,491	18,210	142,701	127
2001	106,761	132,894	239,655	138
2000	222,461	109,545	332,006	120

Source: DWR, 2006b
* Does not include conveyance costs

TABLE 4-5
Recent Long-term Transfers

Source	Year	Buyer	Seller	Duration (years)	Quantity (TAF)	Reported Price ($/AF)*
NOD	2005	DWR and CVP	Yuba County WA	9	63–188	25–125
	2003	City of Lodi	Woodridge WD	40	6	200
	2000	Contra Costa WD	East Contra Costa ID	Permanent	8.2	27
	2000	Northridge WD	Placer County WA	15	12	35
SOD	2003	Cities of Tracy, Lathrop, Manteca, and Escalon	South San Joaquin ID	30	44	191
	2003	Newhall Land and Farming Co.	Nickel Family	30	1.6	475
	1999	Reclamation	San Joaquin River Group Authority	10	11–110	27–60
	1997	Metropolitan	Arvin Edison WSD	25	50	165

Source: Adapted from Reclamation, 2006c
* Does not include conveyance costs

ID: irrigation district
WA: water agency
WD: water district
WSD: water storage district

TABLE 4-6
Water Contract Sales 2002–2004

Source	Year	Buyer	Seller	Quantity (AF)	Price ($/AF)	Annualized Price ($/AF)*
NOD	2002	Zone 7	Tulare Lake Basin WSD	400	1,600	96
	2002	Zone 7	Belridge WSD	2,219	1,500	90
SOD	2004	Westlands WD	Widren WD	2,900	1,500	90
	2004	Westlands WD	Centinella WD	2,500	1,400	84
	2002	City of Tracy	Banta Carbona ID	2,500	1,000	60
	2002	City of Tracy	West Side ID	5,000	1,000	60
	2003	Coachella Valley WD	Tulare Lake Basin WSD	9,900	2,150	129
	2003	Lemoore Naval Base	Tulare Lake Basin WSD	5,000	2,150	129
	2003	West Kern WD	Berrenda Mesa WD	6,000	1,000	60

Source: Adapted from Reclamation, 2006c
* Annualized values assume a 6 percent rate over a 20-year period. Does not include conveyance costs.

ID: irrigation district
WD: water district
WSD: water storage district

Over the last few years, the price paid for water contract sales has increased. Although this is not a sufficient sample of contract sales to estimate a trend, it does indicate that agencies are willing to pay upwards of $2,100 per acre-foot (plus the annual, or "use," payment for the contract) for the one-time purchase of a permanent transfer of water. However, this willingness to pay for contract sales is dependent on the availability and price of spot market transfers. If supply and demand trends push the price of short- and long-term transfers higher, contract sales for permanent water rights will also increase.

CVP and SWP Contractor Survey

Another approach for estimating willingness to pay for additional water deliveries is through contractor survey. A survey conducted for the WSAY Study in June 2006 obtained current information from CVP and SWP contractors. Table 4-7 summarizes the survey results. Contractors were first asked if they anticipated a need for additional supplies in the future (2025 or 2030). They were then asked to estimate the following:

- What they would be willing to pay for additional supplies
- What type of alternatives they may have (such as groundwater or transfers) to acquire additional water in the future

Most contractors surveyed were reluctant to provide their willingness to pay for additional water because they indicated that changing demand and supply conditions make it hard to estimate future willingness to pay, and current and future water transfer negotiations would be compromised if they stated their willingness to pay. Based on this response, the contractors were also asked to identify their "least-cost future supply options."

TABLE 4-7
Summary of SWP and CVP Contractor Survey

Project	Location	Question	Response
SWP	NOD	Need for additional supplies	Contractors indicated that dry year supplies are needed now and in the future. Reliability is the biggest issue.
		Willingness to pay for additional supplies	Contactors willing to pay up to $1,500 per acre-foot during dry years for additional SWP Table A amounts. No interest in wet year supplies was indicated. In the future, groundwater is a possible source for additional supply during dry years.
	SOD	Need for additional supplies	There is a need for additional water in dry years. Surface and groundwater supplement shortages when contract deliveries are reduced. Overdraft is a problem during dry years. Many contractors are interested in additional SWP supplies, and some are actively investigating storage opportunities (such as groundwater banking) to take advantage of additional supplies in wet years.
		Willingness to pay for additional supplies	To ensure willingness to pay, additional supplies would have to cost less than groundwater pumping. Local conservation, water transfers, and non-SWP water will provide for M&I growth, and willingness to pay for additional contract supplies would not exceed the cost of these alternatives. Contractors are looking for additional supplies from other water districts.
CVP	NOD	Need for additional supplies	Shortages occur in dry years now for some contractors and in the future for others. Reliability is the most significant issue.
		Willingness to pay for additional supplies	Willingness to pay would be no more than the cost of transferred water and groundwater from other districts, or the cost per acre-foot acquired from lining of canals.
	SOD	Need for additional supplies	Reliability is the most important issue. Additional water is needed in dry years. This is true for some contractors now, and will be more important in the future.
		Willingness to pay for additional supplies	Transfers, groundwater, and local supplies are used in dry years. Willingness to pay for additional contract water supplies over the cost to acquire these sources is unlikely. Willingness to pay for additional water supply is related to the level of certainty for delivery of additional contract supply.

When additional water is needed in average or dry years, the most likely determinant of willingness to pay for additional water will be the contractors' least-cost alternative for additional supplies. For example, in dry years many contractors have access to groundwater. If additional CVP supplies in dry years are cheaper than the cost to pump groundwater, those contractors will likely be willing to pay for the water.

Each SWP and CVP contractor surveyed was operating under different conditions. Some contractors could use water in all year types, while others primarily needed additional supplies in dry years to increase reliability. Contractors have varying access to additional water. Some pump groundwater in dry years, while others rely on transfers, conservation, and local actions to secure additional supplies.

Most contractors desire increased reliability in dry years. Many water district general managers said that reliability meant receiving their full contract allocations. Recent environmental regulations have most noticeably affected contract allocations to districts in dry years.

Agricultural Production

Although contractors express a strong interest in reliability of dry year supply, the availability of additional water in all year types might reveal a demand for additional water in all year types. For example, some contractors (such as CCWD and Santa Clara Valley Water District) do not identify an additional need for water, but when additional supplies are made available, the contractors purchase them (Mann, 2006).

Survey results indicate that each contractor is faced with different demand and supply conditions. Most have available alternatives for short-term supply, such as groundwater pumping. Based on water management options available to the contractors and stated willingness to pay, the willingness to pay for additional water ranges from $30 to $80 per acre-foot for irrigation contractors (for which groundwater pumping sets the maximum willingness to pay) to $200 per acre-foot for M&I uses. However, these are changes in temporary water supply, and water contract sales for permanent water rights that help improve long-term reliability have been priced over $2,100 per acre-foot.

Water Management Options

The third approach used to estimate willingness to pay for additional water deliveries identified least-cost alternatives available to contractors. Contractors can secure future water supply from several possible sources, such as groundwater pumping, desalination, recycling, and conservation. The costs for additional water supplies from these sources provide information on the upper limit of willingness to pay.

Urban areas, such as the southern San Francisco Bay Area and the South Coast, have recycling, desalination, and conservation options to provide additional supplies. Data on the amount of water available in 2030 from these options and the costs to implement them were collected as part of the Common Assumptions effort of the CALFED Bay-Delta Program Surface Storage Investigations (DWR, 2006c). These cost estimates indicate an upper limit on willingness to pay for additional supplies in the year 2030 (Table 4-8).

The cost of groundwater pumping is a better willingness to pay indicator for irrigation. Although willingness to pay may change depending on reliability, groundwater pumping to supply water in dry years can cost $30 to $80 per acre-foot. The more groundwater pumped, the higher the cost.

The costs of groundwater pumping change depending on the district and the geology of the region. It costs less for districts in the Central Valley Basin to access groundwater resources. Districts closer to the Sierra Nevada foothills deal with greater lift issues and other geological impediments that make groundwater pumping more costly.

TABLE 4-8
2030 Water Supply Options: Southern San Francisco Bay Area and South Coast

Option	Potential Yield (TAF)	Average Cost ($/AF)*
Southern San Francisco Bay Area		
Recycling	72	1,561
Desalination	134	1,294
Conservation	338	916
South Coast		
Recycling	383	801
Desalination	219	1,434
Conservation	128	513

Source: DWR, 2006c
* 2005 dollars

TABLE 4-9
Estimated Range of Willingness to Pay per Acre-Foot[a]

Contractor	NOD ($/AF)	SOD ($/AF)
Irrigation		
Short-term[b]	30–80[c]	30–80[c]
Long-term[d]	25–125	30–500
Permanent[e] (annualized)	NA	65–130
M&I		
Short term[b]	30–180	60–240
Long term[d]	30–210	195–200
Permanent[e] (annualized)	55–105	30–185

[a] Estimates are in 2005 dollars and rounded to the nearest $5 increment.
[b] Short-term market transfers are single-year transfers arranged between buyers and sellers in the year of transfer.
[c] Short-term willingness to pay in irrigation is limited by pumping costs (approximately $30–$80 per acre-foot)
[d] Long-term market transfers provide the buyer with a period of water transfers lasting longer than a single year. However, long-term transfers are not a sale of water rights.
[e] Permanent transfers are considered a permanent transfer in water right.
NA: not applicable

Willingness to Pay Results

The historical water transfer prices, water management options, and contractor surveys all indicate a positive willingness to pay for additional water supplies. Based on this information, an estimated range of willingness to pay for irrigation and M&I was developed. Willingness to pay was divided by region and duration (Table 4-9). The permanent willingness to pay estimates are reported as annualized values of capital outlay, so they are more representative of the annual fee a contractor may pay for increased supply. In this situation, contractors receive annual water supply for a single upfront payment. However, this single payment does not include possible future payment for contract supplies beyond the initial outlay.

Although short-term willingness to pay for additional water (transfers and groundwater) is a good estimate of how contractors will react to dry year shortages under current allocations, the willingness to pay for permanent water supply is a more likely estimate of the value of increased storage and conveyance projects. Contractors were apprehensive about stating their willingness to pay for securing additional supplies. However, based on reasonable and foreseeable actions to improve supply through water management actions, and past transactions to increase permanent supply, contractors indicate an annualized willingness to pay for capital outlay of approximately $185 per acre-foot for M&I and $130 per acre-foot for irrigation. However, recent transfer negotiations within the state indicate that contractors may be willing to pay even more per acre-foot of water than reported here.

Ability to Pay

It is important to note that not every contractor has the ability to pay the amounts indicated by the estimated willingness to pay range. Some contractors will be unable to participate in the purchase of CVP water if the contract rates rise dramatically. This analysis assumes that all contractors will have the ability to pay the estimated willingness to pay. Contractors' ability to pay should be addressed in additional analysis.

Conclusions

The intent of this section is to identify the financial impacts from implementing the projects and water management actions identified in Section 3, estimate the willingness to pay of beneficiaries for additional water deliveries, and use the information to develop an initial conclusion concerning the financial feasibility of the Level 1 storage and conveyance projects.

Water management actions identified in Section 3 of this report would not have systemwide impacts on the CVP rates charged to contractors. However, the rate impact of implementing all the Level 1 storage and conveyance projects is significant. When 50 percent of the project costs for the Level 1 storage and conveyance projects are allocated to water supply, cost-of-service rates are estimated to increase from the existing rates of about $19 per acre-foot to $42 per acre-foot for irrigation, and from $19 per acre-foot to $69 per acre-foot for M&I. The significant increase results from an approximate 150 percent increase in the CVP capital costs and only a 10 percent increase in CVP yield.

When 75 percent of the project costs for the Level 1 storage and conveyance projects are allocated to water supply, cost-of-service rates are estimated to increase to $53 per acre-foot for irrigation and $94 per acre-foot for M&I. However, with the importance of nonreimbursable fish-and-wildlife enhancement and water quality improvement in the ongoing plan formulation studies, a cost allocation of 75 percent to water supply is unlikely.

The beneficiaries' willingness to pay for additional water ranges from $30 per acre-foot for NOD spot market transfers to over $500 per acre-foot for SOD long-term transfers. Contractors' willingness to pay is dependent on circumstances surrounding available groundwater, transfers, and other water management options. However, there is a demand for additional water, as detailed in Section 2, and contractors have been historically willing to pay for additional water to meet this demand.

Based on the survey of CVP and SWP contractors, their most pressing issue is water supply reliability. Adding Level 1 storage and conveyance projects would increase the reliability of contract deliveries, similar to the purchase of water contracts. Because of this, water contract transactions are a reliable estimate of a contractor's willingness to pay for additional water deliveries from storage. Recent transactions indicate that SOD contractors are willing to pay an annualized capital outlay value of $130 per acre-foot for irrigation and $185 per acre-foot for M&I. NOD contractors have paid an annualized capital outlay value of $105 per acre-foot for M&I. However, the total willingness to pay for permanent water supply is likely higher if payments for future contract deliveries and conveyance charges were included.

Rate impacts from the Level 1 storage and conveyance projects are below the observed annualized capital outlay for recent water contract sales. This is a good indication that contractors are willing to pay for a portion of the capital cost associated with the Level 1 storage and conveyance projects. Additional analysis of rate impacts will be possible when specific cost allocation information for the individual storage projects becomes available.

5 Results and Next Steps

Over the past decade, continual improvement in agricultural WUE, urban WUE and water recycling, construction of facilities for new groundwater or conjunctive management projects, and local storage projects have all contributed to improved water delivery. However, an imbalance between supply and demand still exists.

The following discussion summarizes this WSAY Study's key results and provides a list of recommended next steps toward improved statewide water supply reliability.

Results

This WSAY Study's major results are summarized here according to the order in which this report has addressed the needs of the study's purpose:

- Supply and demand
- Projects and water management actions
- Rate impacts and willingness to pay

Table 5-1, provided on the following page, summarizes how these results comply with each requirement stated in the WSAY Study's authorization in Public Law 108-361.

Supply and Demand

Several factors indicate that the state's existing water supplies are not sufficient to meet demands, and that additional water supply management activities and projects are necessary to augment water supplies and delivery reliability in the future:

- Annual and seasonal precipitation variability require that water be managed and stored in wet years and wet winter months to meet demands during dry years and dry summers.
- Geographic variability in precipitation and population require adequate conveyance facilities to move water from the wetter north to the more densely populated south.
- CVP and SWP water deliveries vary considerably from year to year, and may be limited by available conveyance or storage facilities.
- CVPIA and other environmental constraints have reduced the ability of the CVP to meet contract deliveries.
- Current statewide water use requires the use of carryover storage and groundwater overdraft in average and dry years. During droughts, banked groundwater is an important supply, but overdraft is not a sustainable source.
- Water demands exceed sustainable supplies in average and dry years, and supply-demand gaps are greatest in the Central and South Geographic Zones. The South Coast and Tulare Lake Hydrologic Regions experience the greatest shortages.
- Demand gaps are larger in the central and southern parts of the state because of hydrologic conditions and facility constraints.
- Future statewide demands exceed supplies in average and dry years to a greater degree than the existing gap.
- Future shortages will be greatest in the South Geographic Zone. Gaps will increase by the highest percentage in the South Coast and San Francisco Bay Hydrologic Regions. Increasing urban demands, particularly

Section Highlights

Current statewide water demand estimates:

- ♦ 60.6 MAF in average years
- ♦ 57.2 MAF in dry years

Current statewide water demands exceed available water supplies by:

- ♦ 2.3 MAF in average years
- ♦ 4.2 MAF in dry years

Future (2030) statewide water demand estimates:

- ♦ 60.8 MAF in average years
- ♦ 57.4 MAF in dry years

Amount by which future (2030) statewide water demands exceed water supplies:

- ♦ 4.9 MAF in average years
- ♦ 6.1 MAF in dry years

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF gap in dry years.

Estimated cost-of-service for existing and all Level 1 projects:

- ♦ $40 per acre-foot for irrigation and $70 per acre-foot for M&I when allocating 50 percent of project costs to water supply
- ♦ $55 per acre-foot for irrigation and $95 per acre-foot for M&I when allocating 75 percent of project costs to water supply

CVP contractors' annualized willingness to pay for permanent water supply south of the Delta is approximately $130 per acre-foot for irrigation and $185 per acre-foot for M&I.

TABLE 5-1
WSAY Study Authorization and Compliance

Requirement in Authorization	How the Study Complies
Describe new firm yield and water supply improvements, if any, for CVP agricultural water service contractors and M&I water service contractors, including those identified in Bulletin 160.*	Description included in Section 3, Projects and Water Management Actions. These new water supply and water supply improvements include new storage and conveyance projects and other water management actions, such as agriculture and urban WUE, irrigated lands retirement, conjunctive use, water purchases and transfers, water recycling, and desalination. Projects identified in Update 2005 were also included in this report to the extent that they would provide water supply and water supply improvements within the study area (the CVP service area or CALFED Solution Area).
Describe all water management actions or projects, including those identified in Bulletin 160,* that would have the following effects: • Improve firm yield or water supply • If taken or constructed, balance available water supplies and existing demand with due recognition of water right priorities and environmental needs	New water supply and water supply improvements, including those identified in Update 2005, are discussed in Section 3. Many of the projects described attempt to balance the overall available water supplies and existing demand with due recognition of water right priorities and environmental needs. As described in Section 2, Supplies and Demands, current statewide demands exceed supplies by 2.3 MAF in average years and 4.2 MAF in dry years, and future (2030) statewide demands exceed supplies by 4.9 MAF in average years and 6.1 MAF in dry years. An analysis was conducted to determine if the water management action and projects identified in Section 3 of this WSAY Study could fill the existing and future (2030) water supply-demand gap. Based on this analysis, if the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The future (2030) supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF gap in dry years.
Describe the financial costs of the actions and projects identified in the report.	Where information is available, costs for projects and actions identified in this report are provided in Section 3 under the respective project descriptions. The impacts on CVP rates from constructing new storage and conveyance projects were evaluated in Section 4, Rate Impacts and Willingness to Pay. As described in Section 4, the cost-of-service analysis focused on the Level 1 storage and conveyance projects. Based on the analysis, financing the existing CVP capital costs and all of the Level 1 storage and conveyance projects would result in the following estimated cost-of-service rates: • $40 per acre-foot for irrigation and $70 per acre-foot for M&I when allocating 50 percent of project costs to water supply • $55 per acre-foot for irrigation and $95 per acre-foot for M&I when allocating 75 percent of project costs to water supply
Describe the beneficiaries of those actions and projects, and an assessment of the willingness of the beneficiaries to pay the capital costs and O&M costs of the actions and projects.	The potential beneficiaries of the Level 1 storage and conveyance projects are described in Section 3. Because of uncertainty concerning the other new storage and conveyance projects (the Level 2 and Level 3 projects), potential beneficiaries were not identified for these projects. In the event that these projects proceed, beneficiaries would be identified in future project-specific analysis. The water management actions described in this study would result in both direct and indirect benefits to local, regional, and statewide water users and to the environment. However, these actions generally result in indirect benefits, making the identification of beneficiaries difficult at the current level of analysis. The willingness to pay the costs of new Level 1 storage and conveyance projects was evaluated in Section 4. CVP contractors' annualized willingness to pay for permanent water supply south of the Delta is approximately $130 per acre-foot for irrigation and $185 per acre-foot for M&I. Because the other new storage and conveyance projects (the Level 2 and Level 3 projects) and the water management actions are likely to be financed through a variety of sources, including local funds, grants, state proposition funds, and water users, the willingness to pay for the Level 2 and Level 3 projects has not been identified at this time.

* Bulletin 160 is referred to as Update 2005 in this WSAY Study.

in coastal areas, will impact the ability of existing facilities to meet future needs.

- Population growth, agricultural-to-urban land conversion, unknown future laws and regulations, and climate change add uncertainty to future demand estimates and may increase the risk that existing facilities and infrastructure will not meet demands during multiple-year droughts.

Projects and Water Management Actions

Preliminary studies indicate that new storage projects would provide new water supply and improvements in water supply reliability. Water management actions such as agriculture and urban WUE, irrigated lands retirement, conjunctive use, water purchases and transfers, water recycling, and desalination also have the potential to provide water supply improvements.

If the Level 1 storage and conveyance projects were constructed and investments in water management actions were made, the existing supply-demand gap could be met in average years, but a gap of over 0.8 MAF would remain in dry years. The projected 2030 supply-demand gap would remain at over 1.5 MAF in average years and over 2.2 MAF in dry years.

Long-term water supply reliability depends on being able to meet water demands during dry years, and additional measures will be required to fill the dry year gap. A diverse portfolio of projects and actions consistent with the CALFED ROD is needed to fill the supply-demand gap. Projects and actions include the Level 1 storage and conveyance projects and the water management actions identified in Section 3 of this WSAY Study. Additionally, implementation of the Level 2 and Level 3 storage projects and more aggressive investments in water management actions would be needed to fill the 2030 supply-demand gap. Similar to current conditions, it is likely that agricultural and environmental uses would continue to experience water supply shortages in future average and dry years.

Rate Impacts and Willingness to Pay

The impacts on CVP rates from constructing new storage and conveyance projects were evaluated by relating the associated water charges to water contractors' willingness to pay. Financing the existing CVP capital costs and all Level 1 storage and conveyance projects would result in these estimated cost-of-service rates:

- $40 per acre-foot for irrigation and $70 per acre-foot for M&I when allocating 50 percent of project costs to water supply
- $55 per acre-foot for irrigation and $95 per acre-foot for M&I when allocating 75 percent of project costs to water supply

These rate estimates are for the period 2021 to 2030. After 2030, initial CVP capital costs will be repaid, and overall rates will fall to slightly lower levels.

Based on reasonable and foreseeable actions to improve supply through water management actions and past transactions to increase permanent supply, contractors indicate a willingness to pay for permanent water supply south of the Delta of approximately $130 per acre-foot for irrigation and $185 per acre-foot for M&I. Recent transfer negotiations indicate that contractors may be willing to pay more than these amounts for new, permanent water supply. However, not every contractor has the ability to pay the average willingness to pay amount. Some contractors will be unable to participate in the purchase of CVP water if the contract rates rise dramatically.

Next Steps

A variety of actions, programs, and projects are underway to improve statewide water supply reliability. Reclamation participates in some of these studies, such as the CALFED-authorized storage and conveyance improvement feasibility studies. The next steps toward meeting the needs for future water demand and reliability include the following:

- Continue to support the existing CALFED storage and conveyance projects.
- Support other surface storage and conveyance projects, as well as other statewide water management actions, such as WUE and conjunctive use, that could improve water supply and water supply reliability for CVP contractors.

The supply-demand gaps identified in this WSAY Study were developed by DWR hydrologic region and are based primarily on information from DWR's Update 2005. These supply-demand gaps are based on the best information available within the time requirements stated in the WSAY Study's authorization; however, additional data could be collected to develop CVP-specific supply-demand gaps. This would allow for the following analyses:

- Identification of supply-demand gaps by CVP division
- Identification of projects and water management actions to fill the supply-demand gap by CVP division.

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Glossary

Glossary

acre-foot. A term used in measuring the volume or amount of water needed to cover 1 acre (43,560 square feet) 1 foot deep (325,851 gallons or 1,233.5 cubic meters). It is considered to be roughly the amount of water used annually by a family household of four.

agricultural water use efficiency. Agricultural WUE consists of improvements in technology, hardware, and water management to conserve water and improve water quality and environmental benefits.

applied water. The amount of water from any source needed to meet the demand for beneficial use by the user. It includes consumptive use, reuse, and outflows. It does not include precipitation or distribution losses.

aquifer. A natural underground layer of porous, water-bearing materials (such as sand and gravel) usually capable of yielding a large amount or supply of water.

beneficial use. Water used for the betterment of society, such as irrigation, municipal, or environmental use. California's State Water Resources Control Board identifies 24 categories of beneficial use.

carryover storage. Water stored in surface reservoirs or in an aquifer (groundwater storage) during wet years for use during dry years.

conjunctive management (or conjunctive use). Coordinated operation of surface water storage and use, groundwater storage and use, and conveyance facilities to maximize the efficient use of the resource.

conveyance. Movement of water through natural or constructed facilities such as rivers, channels, pipelines, canals, pumps, diversions, and distribution systems.

cost allocation. The process of distributing project costs among authorized project purposes to determine repayment requirements. The purposes authorized by law for the CVP are typically water supply, water quality, flood control, recreation, navigation, hydropower, and fish and wildlife.

cost reimbursement. Refers to the collection of revenues to repay the costs of a project. Funds for financing the initial construction of federal projects are appropriated from the general budget. The portion of the costs that must be repaid by beneficiaries varies by project purpose.

dedicated supply. The portion of the total supply distributed among urban and agricultural uses, dedicated to protect and restore the environment, or stored in surface and groundwater reservoirs for later use.

desalination. The process of removing salt from seawater or brackish water, including groundwater or wastewater, either by natural means or by specific water treatment processes.

drainage basin. The area of land that drains its water into a river.

drip irrigation. An irrigation method in which water is delivered to or near each plant in small-diameter plastic tubing. The water is then discharged through pores or small emitters on the tubing.

drought. Climatic condition during a defined prolonged period, greater than 1 dry year, when precipitation and runoff are below average.

evapotranspiration. The amount of water transpired by plants or evaporated from adjacent soil surfaces in a specific time period.

firm yield. As defined by Public Law 108-361: a quantity of water from a project or program that is projected to be available on a reliable basis, given a specified level of risk, during a critically dry period. This definition differs from current Reclamation policy, which defines firm yield as the maximum quantity of water that can be guaranteed with some specified degree of confidence during a specific critical period. The critical period is that period in a sequential record that requires the largest volume from storage to provide a specified yield.

geographic zone. Geographic zones were delineated for the propose of discussion and analysis in the WSAY Study. Each of the three geographic zones (North, Central, and South) comprises several hydrologic regions.

groundwater. Water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated, such as in an aquifer.

hydrologic region. For planning purposes, the California Department of Water Resources divides the state into 10 hydrologic regions corresponding to the state's major drainage basins.

recycled water. Municipal, industrial, or agricultural wastewater treated so that it can be reused.

runoff. Precipitation, snowmelt, or irrigation in excess of what can infiltrate the soil surface.

service area. The geographic area served by a water agency or district.

spot market transfers. Single-year water transfers arranged between buyers and sellers within the year of transfer. These short-term arrangements may be used by agencies to augment single-year supplies.

total supply. The sum of all water entering the state, which includes precipitation and inflows from the Colorado River, Oregon, and Mexico.

urban water use efficiency. Urban WUE consists of improvements in methods, technology, hardware, or behavioral changes that result in the same beneficial residential, commercial, industrial, and institutional uses with less water or increased beneficial uses from existing water quantities.

water demand. An amount of water that a user desires to apply to a particular use, such as crop irrigation, industrial processes, ecosystem needs, or residential supply, regardless of influencing factors such as price or available supply.

water management action. A project or program that has potential to provide yield and water supply improvements. Water management actions are categorized as either *demand management actions* or *other actions*. Demand management actions focus on reducing water demand; these include agricultural water use efficiency (WUE), urban WUE, and land retirement. Other actions focus on increasing water supply; these include water transfers, water recycling, and desalination.

water recycling. A program to reclaim and reuse municipal, industrial, domestic, and agricultural wastewater. It can also include reclaiming impaired groundwater and surface water.

water transfers. Selling or exchanging water or water rights among individuals or agencies.

water use. The amount of water delivered to and used by a user, which is dependent upon water supply and is influenced by factors such as price and availability.

water year type. For the purposes of water management planning, a classification system used to compare variation in annual precipitation and runoff. For example, water year types may include wet, above normal, average, below normal, dry, critical.

water year. A calendar year used for water calculations. Different agencies may use different calendar periods for their water years.

willingness to pay. Method of estimating the value of activities, services, or other goods, where value is defined as the maximum amount a consumer would be willing to pay for the opportunity rather than do without. The total willingness to pay, minus the user's costs of participating in the opportunity, defines the consumer surplus and benefits.

APPENDIX

Supply-Demand Gap Tables

APPENDIX

Supply-Demand Gap Tables

This appendix provides details of the statewide supply-demand gaps broken down by hydrologic region and users in the following tables:

Table A-1: Dry Year (2001) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Table A-2: Average Year (2000) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Table A-3: Wet Year (1998) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Table A-4: Future Dry Year Supplies, Demands, and Gaps by Hydrologic Region and Statewide (2030 Conditions)

Table A-5: Future Average Year Supplies, Demands, and Gaps by Hydrologic Region and Statewide (2030 Conditions)

TABLE A-1
Dry Year (2001) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Hydrologic Region	User	Supply (TAF)	Demand (TAF)	Gap (TAF)	Total Regional Gap (TAF)[a]
North Coast	Urban	150	150	0	280
	Agricultural	630	810	180	
	Environmental	1,730	1,830	100	
San Francisco Bay	Urban	1,110	1,080	0	0
	Agricultural	120	110	0	
	Environmental	30	30	0	
Central Coast	Urban	140	300	160	420
	Agricultural	760	1,020	260	
	Environmental	10	10	0	
South Coast	Urban	3,920	4,270	350	500
	Agricultural	760	910	150	
	Environmental	40	40	0	
Sacramento River	Urban	880	880	0	830
	Agricultural	8,570	8,710	140	
	Environmental	8,700	9,390	690	
San Joaquin River	Urban	620	620	0	500
	Agricultural	7,040	7,020	0	
	Environmental	1,840	2,340	500	
Tulare Lake	Urban	670	670	0	1,380
	Agricultural	9,420	10,800	1,380	
	Environmental	80	80	0	
North Lahontan	Urban	40	40	0	40
	Agricultural	430	470	40	
	Environmental	110	110	0	
South Lahontan	Urban	240	280	40	60
	Agricultural	340	360	20	
	Environmental	80	80	0	
Colorado River	Urban	610	700	90	200
	Agricultural	3,900	4,010	110	
	Environmental	30	30	0	
Statewide[b]	Urban	8,380	8,990	640	
	Agricultural	31,970	34,220	2,280	
	Environmental	12,650	13,940	1,290	
Total[c]		**53,000[d]**	**57,150**	**4,210**	

[a] Each total regional gap is the sum of all user gaps (urban, agricultural, and environmental) for a particular hydrologic region.

[b] Statewide supplies, demands, and gaps are the sum of the supplies, demands, and gaps for each hydrologic region, respectively.

[c] Total supplies, demands, and gaps are the sum of statewide supplies, demands, and gaps for each user type, respectively.

[d] Statewide supplies are reduced by 2 MAF in a dry year to account for Bulletin 118's maximum estimate of groundwater overdraft. It is assumed that overdraft is not a sustainable source of supply. The 2 MAF is distributed over the supplies of applicable hydrologic basins that have reported subbasins in overdraft.

TABLE A-2
Average Year (2000) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Hydrologic Region	User	Supply (TAF)	Demand (TAF)	Gap (TAF)	Total Regional Gap (TAF)[a]
North Coast	Urban	150	150	0	340
	Agricultural	810	810	0	
	Environmental	1,870	2,210	340	
San Francisco Bay	Urban	1,070	1,070	0	0
	Agricultural	110	110	0	
	Environmental	30	30	0	
Central Coast	Urban	300	300	0	280
	Agricultural	740	1,020	280	
	Environmental	20	20	0	
South Coast	Urban	4,210	4,250	40	40
	Agricultural	910	910	0	
	Environmental	40	40	0	
Sacramento River	Urban	860	860	0	410
	Agricultural	8,710	8,710	0	
	Environmental	11,460	11,870	410	
San Joaquin River	Urban	600	600	0	630
	Agricultural	6,910	7,020	110	
	Environmental	2,540	3,060	520	
Tulare Lake	Urban	650	650	0	580
	Agricultural	10,220	10,800	580	
	Environmental	70	70	0	
North Lahontan	Urban	40	40	0	0
	Agricultural	470	470	0	
	Environmental	110	110	0	
South Lahontan	Urban	270	270	0	0
	Agricultural	360	360	0	
	Environmental	90	90	0	
Colorado River	Urban	680	680	0	0
	Agricultural	4,010	4,010	0	
	Environmental	30	30	0	
Statewide[b]	Urban	8,830	8,870	40	
	Agricultural	33,250	34,220	970	
	Environmental	16,260	17,530	1,270	
Total[c]		**58,340**[d]	**60,620**	**2,280**	

[a] Each total regional gap is the sum of all user gaps (urban, agricultural, and environmental) for a particular hydrologic region.

[b] Statewide supplies, demands, and gaps are the sum of the supplies, demands, and gaps for each hydrologic region, respectively.

[c] Total supplies, demands, and gaps are the sum of statewide supplies, demands, and gaps for each user type, respectively.

[d] Statewide supplies are reduced by 1 MAF in an average year to account for Bulletin 118's minimum estimate of groundwater overdraft. It is assumed that overdraft is not a sustainable source of supply. The 1 MAF is distributed over the supplies of applicable hydrologic basins that have reported subbasins in overdraft.

TABLE A-3
Wet Year (1998) Supplies, Demands, and Gaps by Hydrologic Region and Statewide (Current Conditions)

Hydrologic Region	User	Supply (TAF)	Demand (TAF)	Gap (TAF)	Total Regional Gap (TAF)[a]
North Coast	Urban	140	140	0	160
	Agricultural	660	660	0	
	Environmental	1,840	2,000	160	
San Francisco Bay	Urban	990	990	0	0
	Agricultural	90	90	0	
	Environmental	30	30	0	
Central Coast	Urban	260	260	0	0
	Agricultural	830	830	0	
	Environmental	20	20	0	
South Coast	Urban	3,620	3,620	0	0
	Agricultural	690	690	0	
	Environmental	30	30	0	
Sacramento River	Urban	730	730	0	310
	Agricultural	6,460	6,460	0	
	Environmental	13,640	13,950	310	
San Joaquin River	Urban	560	560	0	230
	Agricultural	5,460	5,460	0	
	Environmental	1,940	2,170	230	
Tulare Lake	Urban	550	550	0	0
	Agricultural	8,570	8,570	0	
	Environmental	60	60	0	
North Lahontan	Urban	40	40	0	0
	Agricultural	400	400	0	
	Environmental	100	100	0	
South Lahontan	Urban	210	210	0	0
	Agricultural	280	280	0	
	Environmental	100	100	0	
Colorado River	Urban	700	700	0	0
	Agricultural	3,870	3,870	0	
	Environmental	30	30	0	
Statewide[b]	Urban	7,800	7,800	0	
	Agricultural	27,310	27,310	0	
	Environmental	17,790	18,490	700	
Total[c]		**52,900**	**53,600**	**700**	

[a] Each total regional gap is the sum of all user gaps (urban, agricultural, and environmental) for a particular hydrologic region.

[b] Statewide supplies, demands, and gaps are the sum of the supplies, demands, and gaps for each hydrologic region, respectively.

[c] Total supplies, demands, and gaps are the sum of statewide supplies, demands, and gaps for each user type, respectively.

TABLE A-4
Future Dry Year Supplies, Demands, and Gaps by Hydrologic Region and Statewide (2030 Conditions)

Hydrologic Region	User	Supply (TAF)	Demand (TAF)	Gap (TAF)	Total Regional Gap (TAF)[a]
North Coast	Urban	150	190	40	260
	Agricultural	630	750	120	
	Environmental	1,730	1,830	100	
San Francisco Bay	Urban	1,110	1,280	170	170
	Agricultural	120	110	0	
	Environmental	30	30	0	
Central Coast	Urban	140	350	210	310
	Agricultural	760	860	100	
	Environmental	10	10	0	
South Coast	Urban	3,500	5,140	1,640	1,640
	Agricultural	760	640	0	
	Environmental	40	40	0	
Sacramento River	Urban	880	1,420	540	1,230
	Agricultural	8,570	8,540	0	
	Environmental	8,700	9,390	690	
San Joaquin River	Urban	620	1,040	420	920
	Agricultural	7,040	6,420	0	
	Environmental	1,840	2,340	500	
Tulare Lake	Urban	670	990	320	700
	Agricultural	9,420	9,800	380	
	Environmental	80	80	0	
North Lahontan	Urban	40	50	10	80
	Agricultural	430	500	70	
	Environmental	110	110	0	
South Lahontan	Urban	240	440	200	200
	Agricultural	340	310	0	
	Environmental	80	80	0	
Colorado River	Urban	610	1,110	500	540
	Agricultural	3,440	3,480	40	
	Environmental	30	30	0	
Statewide[b]	Urban	7,960	12,010	4,050	
	Agricultural	31,510	31,410	710	
	Environmental	12,650	13,940	1,290	
Total[c]		**52,120[d]**	**57,360**	**6,050**	

[a] Each total regional gap is the sum of all user gaps (urban, agricultural, and environmental) for a particular hydrologic region.

[b] Statewide supplies, demands, and gaps are the sum of the supplies, demands, and gaps for each hydrologic region, respectively.

[c] Total supplies, demands, and gaps are the sum of statewide supplies, demands, and gaps for each user type, respectively.

[d] Statewide supplies are reduced by 2 MAF in a dry year to account for Bulletin 118's maximum estimate of groundwater overdraft. It is assumed that overdraft is not a sustainable source of supply. The 2 MAF is distributed over the supplies of applicable hydrologic basins that have reported subbasins in overdraft.

TABLE A-5
Future Average Year Supplies, Demands, and Gaps by Hydrologic Region and Statewide (2030 Conditions)

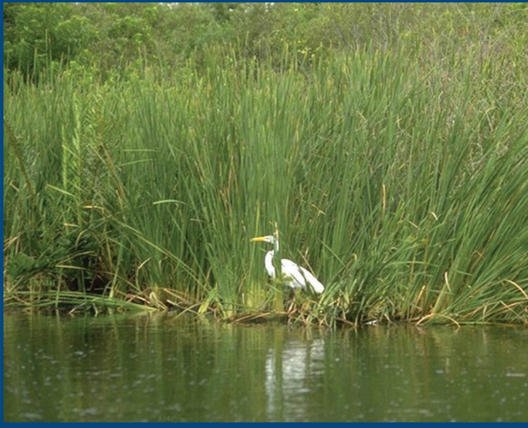
Hydrologic Region	User	Supply (TAF)	Demand (TAF)	Gap (TAF)	Total Regional Gap (TAF)[a]
North Coast	Urban	150	190	40	380
	Agricultural	810	750	0	
	Environmental	1,870	2,210	340	
San Francisco Bay	Urban	1,070	1,270	200	200
	Agricultural	110	110	0	
	Environmental	30	30	0	
Central Coast	Urban	300	350	50	170
	Agricultural	740	860	120	
	Environmental	20	20	0	
South Coast	Urban	3,790	5,120	1,330	1,330
	Agricultural	910	640	0	
	Environmental	40	40	0	
Sacramento River	Urban	860	1,390	530	940
	Agricultural	8,710	8,540	0	
	Environmental	11,460	11,870	410	
San Joaquin River	Urban	600	1,010	410	930
	Agricultural	6,910	6,420	0	
	Environmental	2,540	3,060	520	
Tulare Lake	Urban	650	970	320	320
	Agricultural	10,220	9,800	0	
	Environmental	70	70	0	
North Lahontan	Urban	40	50	10	40
	Agricultural	470	500	30	
	Environmental	110	110	0	
South Lahontan	Urban	270	430	160	160
	Agricultural	360	310	0	
	Environmental	90	90	0	
Colorado River	Urban	680	1,080	400	400
	Agricultural	3,550	3,480	0	
	Environmental	30	30	0	
Statewide[b]	Urban	8,410	11,860	3,450	
	Agricultural	32,790	31,410	150	
	Environmental	16,260	17,530	1,270	
Total[c]		**57,460**[d]	**60,800**	**4,870**	

[a] Each total regional gap is the sum of all user gaps (urban, agricultural, and environmental) for a particular hydrologic region.

[b] Statewide supplies, demands, and gaps are the sum of the supplies, demands, and gaps for each hydrologic region, respectively.

[c] Total supplies, demands, and gaps are the sum of statewide supplies, demands, and gaps for each user type, respectively.

[d] Statewide supplies are reduced by 1 MAF in an average year to account for Bulletin 118's minimum estimate of groundwater overdraft. It is assumed that overdraft is not a sustainable source of supply. The 1 MAF is distributed over the supplies of applicable hydrologic basins that have reported subbasins in overdraft.



Water Supply and Yield Study

March 2008

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