6

Evaluating Options From a Statewide Perspective

A main objective of this *California Water Plan* update is evaluating, at an appraisal level of detail, how California's water supply reliability needs could be met through 2020. This chapter outlines the process used to put together the conceptual evaluation and evaluates water management options that are statewide in scope. A brief discussion of methods available to local agencies for financing water management options is also provided.

The planning process includes developing regional water management evaluations for each of the State's ten major hydrologic regions, and integrating those results with statewide water management options to form a summary for the entire State. Development of regional water management evaluations is covered in Chapters 7-9.

Statewide water management options include demand reduction measures that many water agencies are expected to implement, and large-scale water supply augmentation measures that would provide supply to multiple beneficiaries in more than one hydrologic region. For example, a large offstream storage reservoir studied under CALFED's Bay-Delta program is considered a statewide option. A small reservoir project being studied by a local agency to provide benefits only to its service area is not a statewide option. Such local projects are covered in Chapters 7-9. This chapter opens by presenting a balance between California's water supplies and its water use, illustrating the shortages that would occur if no new water management facilities or programs were developed.

Sources of water supply must be identified to meet the needs of California's growing population. Chapters 6-9 discuss potential future water management options.

TABLE 6-1
California Water Budget with Existing Facilities and Programs (maf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	8.8	9.0	12.0	12.4
Agricultural	33.8	34.5	31.5	32.3
Environmental	36.9	21.2	37.0	21.3
Total	**79.5**	**64.7**	**80.5**	**66.0**
Supplies				
Surface Water	65.1	43.5	65.0	43.4
Groundwater	12.5	15.8	12.7	16.0
Recycled & Desalted	0.3	0.3	0.4	0.4
Total	**77.9**	**59.6**	**78.1**	**59.8**
Shortage	**1.6**	**5.1**	**2.4**	**6.2**

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Statewide Water Budget

The water supply and water use information discussed in Chapters 3 and 4 and summarized in Tables 3-3, 4-26, and 4-27 is combined into the statewide applied water budget with existing facilities and programs shown in Table 6-1. Regional water budgets with existing facilities and programs are shown in Appendix 6A. The shortages shown in Table 6-1 reflect the Bulletin's assumption that groundwater overdraft is not available as a supply.

The average water year shortages at 1995 and 2020 levels illustrate the need to develop new facilities and programs to improve California's water supply reliability. Californians are facing water shortages now, and will face them in the future. As Californians experienced in 1991 and 1992, drought year shortages are large. Urban water users faced cutbacks in supply and mandatory rationing, some small rural communities saw their wells go dry, agricultural lands were fallowed, and environmental water supplies were reduced. By 2020, without additional facilities and programs, these conditions will worsen, reflecting California's forecasted population increase. Appendix 6B shows forecasted shortages by hydrologic region, assuming that no new facilities or programs were implemented.

The following section describes the planning process used in Bulletin 160-98 to evaluate actions that would reduce the State's future water shortages.

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The Bulletin 160-98 Planning Process

The process used to evaluate ways to meet California's future water needs drew upon, at an appraisal level of detail, techniques of integrated resources planning. IRP evaluates water management options—both demand reduction options and supply augmentation options—against a fixed set of criteria and ranks the options based on costs and other factors. Although the IRP process includes economic evaluations, it also incorporates environmental, institutional, and social considerations which cannot be expressed easily in monetary terms.

The development of likely regional water management options used information prepared by local agencies. The regional water management options evaluations are not intended to replace local planning efforts, but to complement them, by showing the relationships among regional water supplies and water needs and the statewide perspective. Local water management options form the basis of the regional summaries which are combined into the statewide options evaluation. Figure 6-1 is an index map showing how the regional summaries are organized in Chapters 7-9.

FIGURE 6-1

Index to Regional Chapters

Initial Screening Criteria

The criteria used for initial screening of water management options were:

- ***Engineering***—an option was deferred from further evaluation if it was heavily dependent on the development of technologies not currently in use, it used inappropriate technologies given the regional characteristics (desalting in the North Lahontan Region), or it did not provide new water (water recycling in the Central Valley).
- ***Economic***—an option was deferred from further evaluation if its cost estimates (including environmental mitigation costs) were extraordinarily high given the region's characteristics.
- ***Environmental***—an option was deferred from further evaluation if it had potentially significant unmitigable environmental impacts or involved use of waterways designated as wild and scenic.
- ***Institutional/Legal***—an option was deferred from further evaluation if it had potentially unresolvable water rights conflicts or conflicts with existing statutes.
- ***Social/Third Party***—an option was deferred from further evaluation if it had extraordinary socioeconomic impacts, either in the water source or water use areas.
- ***Health***—an option was deferred from further evaluation if it would violate current health regulations or would pose significant health threats.

Major Steps in Planning Process

Major steps involved in the Bulletin 160-98 water management options evaluation process included:

- Identify water demands and existing water supplies on a regional basis.
- Compile lists of regional and statewide water management options.
- Use initial evaluation criteria to either retain or defer options from further evaluation. For options retained for further evaluation, group some by categories and evaluate others individually.
- Identify characteristics of options or option categories, including costs, potential demand reduction or supply augmentation, environmental considerations, and significant institutional issues.
- Evaluate each regional option or category of options in light of identified regional characteristics using criteria established for this Bulletin. If local agencies have performed their own evaluation, review and compare their evaluation criteria with those used for the Bulletin.
- Evaluate statewide water management options.
- Develop tabulation of likely regional water management options.
- Develop a statewide options evaluation by integrating the regional results.

The first step in evaluating regional water management options was to prepare applied water budgets for the study areas to identify the magnitude of potential water shortages for average and drought year conditions. In addition to identifying shortages, other water supply reliability issues in the region were reviewed. Once the shortages were identified, a list of local water management options was prepared. Where possible, basic characteristics of these options (yields, costs, significant environmental or institutional concerns) were identified.

After identifying options, they were compared with the initial screening criteria shown in the sidebar. For options deferred from further evaluation, the major reasons for deferral were given. Options retained for further evaluation were placed into the following categories:

- Conservation (urban and agricultural)
- Modifications to existing reservoirs/operations
- New reservoirs/conveyance facilities
- Groundwater/conjunctive use
- Water marketing
- Water recycling
- Desalting (brackish groundwater and seawater)
- Other local options
- Statewide options

Because each of these categories may contain many individual options, some options within each category were further combined into groups based upon their estimated costs. For example, water recycling projects costing less than $500/af were grouped into one category. Options were evaluated and scored against the set of fixed criteria shown in the sidebar.

The Bulletin 160-98 options evaluation process relied heavily upon locally developed information. Methods used to develop this information vary from one local agency to the next, making direct comparisons between cost estimates difficult. To make cost information comparable, a common approach for estimating unit cost was developed (Appendix 6C). However, due to lack of detailed information, not all

Options Category Evaluation

Evaluation Criteria	*What is Measured?*	*How is it Measured?*	*Score*
Engineering	Engineering feasibility	Increase score for greater reliance upon current technologies	
	Operational flexibility	Increase score for operational flexibility with existing facilities and/or other options	
	Drought year supply	Increase score for greater drought year yield/ reliability	
	Implementation date	Increase score for earlier implementation date	
	Water quality limitations	Increase score for fewer water quality constraints	
Engineering Score			**0 - 4**
Economics	Project financial feasibility	Increase score for lower overall costs and the ability to finance	
	Project unit cost	Increase score for lower overall unit cost (including mitigation costs)	
Economics Score			**0 - 4**
Environmental	Environmental risk	Increase score for least amount of environmental risk	
	Irreversible commitment of resources	Increase score for least amount of irreversible commitment of resources	
	Collective impacts	Increase score for least amount of collective impacts	
	Proximity to environmentally sensitive resources	Increase score for little or no proximity to sensitive resources	
Environmental Score			**0 - 4**
Institutional/Legal	Permitting requirements	Increase score for least amount of permitting requirements	
	Adverse institutional/legal effects upon water source areas	Increase score for least amount of adverse institutional/legal effects	
	Adverse institutional/legal effects upon water use areas	Increase score for least amount of adverse institutional/legal effects	
	Stakeholder consensus	Increase score for greater amount of stakeholder consensus	
Institutional/Legal Score			**0 - 4**
Social/Third Party	Adverse third party effects upon water source areas	Increase score for least amount of adverse third party effects	
	Adverse third party effects upon water use areas	Increase score for least amount of adverse third party effects	
	Adverse social and community effects	Increase score for least amount of adverse social and community effects	
Social/Third Party Score			**0 - 4**
Other Benefits	Ability to provide benefits in addition to water supply	Increase score for environmental benefits	
		Increase score for flood control benefits	
		Increase score for recreation benefits	
		Increase score for energy benefits	
		Increase score for additional benefits	
		Increase score for improved compliance with health and safety regulations	
Other Benefits Score			**0 - 4**
Total Score			**0 - 24**

option costs could be made comparable. Unit cost estimates took into account capital costs associated with construction and implementation (including any needed conveyance facilities), annual operations costs, and option yield.

Water management options can serve purposes other than water supply; they can also provide flood control, hydroelectric power generation, environmental enhancement, water quality enhancement, and recreation. In recognition of the multipurpose benefits provided by some water management options, the options evaluation scoring process assigned a higher value to multipurpose options, as shown in the sidebar. However, since the focus of the Bulletin 160 series is water supply, cost estimates were based solely on the costs associated with water supply.

Once options were evaluated and scored, they were ranked according to their scores. This ranking was used to prepare a tabulation of likely regional water management options, taking into account options that may be mutually exclusive or could be optimized if implemented in conjunction with other options. Depending on a region's characteristics, its potential options, and its ability to pay for new options, the tabulation of likely options may not meet all of a region's water shortages (especially in drought years).

This appraisal-level evaluation of options at a statewide level of detail is based on presently available information. The ultimate implementability of any water management option is dependent on factors such as the sponsoring entity's ability to complete the appropriate environmental documentation, obtain the necessary permits, and finance the proposed action.

Shortage Management

Water agencies may choose to accept less than 100 percent water supply reliability, especially under drought conditions, depending on the characteristics of their service areas. Shortage contingency measures such as restrictions on residential outdoor watering or deficit irrigation for agricultural crops can be used to meet temporary shortages. Demand hardening is an important consideration in evaluating shortage contingency measures. Implementing water conservation measures such as plumbing retrofits and low water use landscaping reduces the ability of water users to achieve future drought year water savings through shortage contingency measures.

Supply augmentation actions (purchasing water from the DWB) and demand reduction actions (urban rationing and agricultural land fallowing) are available to water agencies for coping with shortages that exceed planned levels of reliability. Table 6-2 summarizes actions taken by some of California's larger urban water suppliers to respond to water shortages in 1991, the driest year of the recent 1987-92 drought. Measures taken by agricultural water agencies and water users included increased pumping of groundwater, land fallowing, and intra- and interdistrict water transfers. The WaterLink system established by Westlands Water District (described in Chapter 8) is an example of an action that could be used by agricultural water suppliers to facilitate intradistrict water transfers as part of managing shortages.

The impacts of allowing planned shortages to occur in water agency service areas are necessarily site-specific and must be evaluated by each agency on an individual basis. In urban areas where conservation measures have already been put into place to reduce landscape water use, imposing rationing or other restrictions on landscape water use can create significant impacts to homeowners, landscaping businesses, and entities that manage large turf areas such as parks and golf courses. Drought year cutbacks in the agricultural sector create economic impacts not only to individual growers and their employees, but also to local businesses that provide goods and services to the growers.

Using Applied Water Budgets to Calculate New Water Needs

As discussed in Chapter 3, some municipal wastewater discharges, agricultural return flows, and required environmental instream flows are reapplied several times before finally being depleted from the State's hydrologic system. An applied water budget explicitly accounts for this unplanned reuse of water. Because reapplication has the potential to account for a substantial portion of a region's water supply, applied water budgets may overstate the supply of water actually needed to meet future water demands. Shortages calculated from an applied water budget must be interpreted with caution to determine new water needs for a region.

The amount of new water required to meet a region's future needs depends on several factors, including the region's applied water shortage, opportunities to reapply water in the region, and the types of water management options that are implemented

TABLE 6-2

1991 Urban Water Shortage Management

Water Agency[a]	*Reduction Goal*[b]	*Contingency Measures* A	B	C	D	E	F	G	H	I	J	K
Alameda County WD	18%		✔		✔		✔	✔	✔			✔
Contra Costa WD	26%	✔		✔	✔		✔	✔	✔		✔	✔
East Bay MUD	15%	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
LA Dept. of Water and Power	15%	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔
MWD of Southern California	31%	✔	✔	✔	✔	✔		✔			✔	✔
MWD of Orange County	20%		✔	✔	✔	✔	✔	✔	✔	✔		✔
Orange County WD	20%			✔		✔		✔	✔			✔
San Diego Co. Water Authority	20%	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
City of San Diego	20%			✔			✔	✔	✔	✔		✔
San Francisco PUC	25%	✔	✔		✔		✔	✔	✔		✔	✔
Santa Clara Valley WD	25%	✔	✔		✔			✔	✔	✔	✔	✔

A = Rationing
B = Mandatory Conservation
C = Extraordinary Voluntary Conservation
D = Increasing Rate or Surcharges
E = Economic Incentives
F = Device Distribution
G = Broadcast Public Information
H = Mailed Public Information
I = Water Patrols and Citations
J = Fines and Penalties
K = Water Transfer

[a] Agencies listed include both wholesale and retail water agencies and, as a result, the shortage contingency measures available to them are different.

[b] The actual performance of an agency's drought management may have exceeded the adopted goal. Several of the retail agencies are located within wholesalers' boundaries. Contingency measures shown can include both retail and wholesale measures.

in the region. If no water reapplication opportunities exist, then the region's new water need is equivalent to its applied water shortage. In this case, the new water need would be independent of the types of water management options that are implemented. However, if opportunities are available to reapply water in a region, then the region's new water need is less than its applied water shortage. In this case, the new water need depends on the types of water management options that are implemented.

Not all water management options are created equal in their ability to meet new water needs. Because supply augmentation options provide new water to a region, the opportunity exists for the options' effectiveness to be multiplied through reapplication. For example, a supply augmentation option may provide 100 taf of new water to a region. But through reapplication within the region, the option effectively meets applied water demands in excess of 100 taf. Demand reduction options, on the other hand, do not provide new water to a region. Hence, the opportunity does not exist to multiply the options' effectiveness through reapplication. To satisfy an applied water shortage of 100 taf, a demand reduction option must conserve 100 taf of water.

Calculation of regional and statewide new water needs is more complex than computing regional and statewide applied water shortages—new water needs also depend on reapplication and implemented water management options. An applied water shortage provides an upper bound on the new water need. A lower bound on the new water need can be estimated for each region by assuming that new water supplies are reapplied in the same proportion that existing supplies are reapplied. Minimum new water needs are computed for each region in Appendix 6D.

The tabulations of likely regional water management options in Chapters 7-9 use minimum new water needs as target values for selecting the appropriate number of regional options. If a region is unable to meet minimum new water needs as a result of regional characteristics, lack of potential options, or inability to pay for potential options, specifying minimum new water needs rather than applied water shortages as regional target values has no impact on options selection. On the other hand, if a region is able to meet its minimum new water needs, this does not necessarily guarantee that all applied water shortages would be met. The remaining applied water shortages would depend on the selected option mix—the more water conservation selected, the greater the remaining applied water shortages would be (as water conservation options do not provide reapplication opportunities.) This approach is consistent with the treatment of shortages in prior water plan updates, which used net water budgets. Because data in net water budgets factor out reapplied water, net water shortages are essentially the same as minimum new water needs. Appendix 6E provides a compilation of Bulletin 160-98 net water budgets, statewide and by region.

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Demand Reduction Options

Demand reduction has taken on a key role in the planning and management of water resources. By making wise use of water through water conservation, the need for new sources of supply can be minimized. Many agencies have implemented programs to achieve a high level of water use efficiency.

For nearly three decades, Californians have recognized the importance of water conservation. Since the 1976-77 drought, attention has focused on plans, programs, and measures to encourage efficient use of water. The water conservation options evaluated in this Bulletin are limited to actions that would have the effect of creating new water supply through reductions in existing consumptive use or water depletions. (The potential for depletion reductions exists where applied water would be lost to evapotranspiration, or to a saline water body, and could not be beneficially reapplied.) The options evaluated in this Bulletin would yield depletion reductions above the 2020-level demand reduction of 2.3 maf assumed to result from statewide implementation of existing BMPs and EWMPs. (Existing BMPs and EWMPs are discussed in Chapter 4.) Quantifying depletion reductions allows the comparison of water conservation options with water supply augmentation options such as water storage or recycling facilities.

The options presented are for planning purposes only and are not mandated targets. They represent an attempt to quantify potential water savings that may be achieved by implementing measures beyond current BMPs and EWMPs. Local water agencies can evaluate these options against other available options to assess appropriate actions for their service areas.

Since the purpose of the Department's Bulletin 160 series is to assess water supply benefits, it is that aspect of water conservation that the Bulletin addresses. Water conservation projects may provide additional benefits, such as reduction in water treatment costs, reduction in fish entrainment at water supply diversion structures, or reduction in nonpoint source runoff. These other benefits are recognized in the Bulletin's options evaluation process, as described earlier. As discussed in Chapter 3, the Bulletin treats demand reduction actions on an equal footing with water supply actions. Each action must create water that is new to the State's hydrologic region.

Data on Urban Landscaping

As plumbing code changes designed to reduce interior urban water use are implemented, a main potential for future urban water conservation lies in reducing exterior urban water use—specifically landscape water use. Estimating water use reductions from landscape irrigation changes is made difficult by the lack of data on irrigated urban landscaping. Only a handful of water districts in California have actual data on the extent of irrigated acreage (residential lots plus large turf areas, such as parks, cemeteries, and golf courses) in their service areas, and data are nonexistent at a statewide level. For planning purposes, California's irrigated urban acreage has historically been estimated at about one million acres at a 1980s/1990s level of development, based on estimated ratios of landscape acreage to total urban acreage from land use surveys. Such ratios vary widely by county (the Department's, for example, vary from percentages in the low teens to almost 40 percent), and are inherently subject to uncertainty. Water agencies are beginning to evaluate ways to quantify existing irrigated urban acreage—aerial photography or satellite imagery, estimated ratios from parcel maps, surveys, or questionnaires. Estimates of future irrigated landscape acreage are generally made by increasing an assumed base acreage by ratios of forecasted population growth—which implicitly assumes no major changes in housing density or single to multifamily housing ratios.

These uncertainties illustrate the present difficulty of quantifying landscape conservation savings, and lack of hard data to support planning estimates. Better estimates of urban landscape acreage would greatly improve future conservation planning.

TABLE 6-3

Urban Depletion Reduction Potential Due to Water Conservation Options Beyond BMPs[a] (taf)

Region	*Opt 1*	*Opt 2*	*Opt 3*	*Opt 4*	*Opt 5*	*Opt 6*	*Opt 7*	*Opt 8*
	New	*New & Existing*	*60 gpcd*	*55 gpcd*	*3%*	*5%*	*7%*	*5%*
	0.8 ET_0 Outdoor Water Use		*Indoor Water Use*		*CII Water Use Reduction*		*Distribution System Losses*	
North Coast	1	6	3	6	1	2	6	9
San Francisco Bay	2	52	38	77	11	18	D	13
Central Coast	4	13	8	17	2	3	3	8
South Coast	67	246	110	220	30	49	D	84
Sacramento River	D	D	D	D	D	D	D	D
San Joaquin River	D	D	D	D	D	D	D	D
Tulare Lake	D	D	D	D	D	D	D	D
North Lahontan	D	1	D	1	D	D	D	D
South Lahontan	20	31	7	15	2	4	4	12
Colorado River	9	18	2	3	1	2	9	13
Total (rounded)	**100**	**370**	**170**	**340**	**50**	**80**	**20**	**140**

[a] In some regions, these levels of conservation are already being achieved. Urban water conservation options beyond BMPs would not result in significant, cost-effective additional reductions in depletion in interior regions and are deferred (D). Only depletion reductions greater than 1 taf are considered in this table.

Although water conservation options will be carried out at the local level, they are discussed in this chapter conceptually as statewide demand reduction options for simplicity of presentation. Analyses of water conservation options for each hydrologic region are discussed in Chapters 7-9.

Urban Water Conservation Options

As discussed in Chapter 4, urban water use forecasts were calculated from estimates of population, urban per capita water use, and conservation savings from urban BMPs. The Bulletin assumes that urban BMPs are put into effect by 2020, resulting in an estimated 1.5 maf of demand reduction statewide.

The urban water conservation options described below assume a more intensive application of current BMPs and potential evolution of additional BMPs. If all of the options described below were implemented, nearly 1 maf/yr of depletion reduction could theoretically be attained. The level of water conserved from these options would vary for each region depending on current urban water use and the region's hydrology. Since little or no depletion reductions would be achieved in the Central Valley, urban water conservation options beyond BMPs are deferred for valley regions. Table 6-3 summarizes statewide urban water conservation options and the potential depletion reductions associated with each option. These options are evaluated for each region in Chapters 7-9.

Outdoor Water Use

Ideally, landscape water use could be derived by the method used for estimating agricultural water use—multiplying water use requirements for different landscape types by their corresponding statewide acre-

Courtesy of Barbara Cross

The greatest potential reductions in urban water use would come from reducing outdoor water use for landscaping. Data for accurately quantifying present acreage of urban landscaping (or for forecasting future acreage) are virtually non-existent today.

age, and summing the results to obtain a total for irrigated landscapes in the State. As discussed in the sidebar, no firm numbers are available for statewide irrigated urban landscape acreage. For this Bulletin, based on water budget data and projected increases in population, landscape water use in California is estimated to increase from about 2.4 maf in 1995 to 3.6 maf in 2020.

The Department estimates that landscape in California will be irrigated on average at 1.0 ET_0 by 2020. Options to reduce outdoor water use assume that statewide landscape irrigation could be reduced on average to 0.8 ET_0 either in new development, or in all development. These reductions would be realized through landscape water audits and incentive programs by retailers. So that the cost of implementing these options can be equitably compared with other supply augmentation options, the economic evaluations in Chapters 7–9 assume that implementation costs are funded by water purveyors and not by homeowners. This assumption implies that water purveyors could choose to carry out landscape water management programs in much the same manner as some urban purveyors have implemented ultra low flush toilet retrofit programs.

Option 1: Outdoor Water Use in New Development to 0.8 ET_0. The Model Landscape Ordinance indicates that a landscape plant factor of 0.8 ET_0 could be attainable through measures such as proper landscape and irrigation system design, more intensive landscape water audit programs, installing automatic rain sensors, better irrigation scheduling, and incentive programs tied to an ET-based billing structure. Statewide, about 100 taf/yr of depletion reductions could be achieved by reducing outdoor water use to 0.8 ET_0 at a cost of about $750/af. The ordinance is directly applicable to new construction; existing landscaping would require retrofitting.

Option 2: Outdoor Water Use in New and Existing Development to 0.8 ET_0. This option extends the provisions of Option 1 to include existing development. Statewide, about 370 taf/yr of depletion reduction could be achieved by reducing outdoor water use in new and existing development to 0.8 ET_0. The cost of this option is difficult to quantify and is greatly affected by site-specific factors. It is expected to be high due to the cost involved in retrofitting existing landscape.

Residential Indoor Water Use

Options to reduce indoor residential water use assume that by 2020, indoor water use in the State would average 65 gallons per capita daily. Options 3 and 4 would reduce this average to 60 gpcd and 55 gpcd, respectively. These reduced levels of indoor water use could be achieved statewide if strong incentive programs, such as financial incentives for retrofits, were provided. More aggressive indoor water audits would be needed. Conversion to horizontal axis washing machines is assumed to occur in 25 percent of all residences under Option 3 and 75 percent under Option 4.

Option 3: Reduce Residential Indoor Water Use to 60 gpcd. This option is based on the potential for a 3 gpcd reduction in leaks, a 1 gpcd reduction in shower usage, and a 1 gpcd reduction in laundry use. These savings result in an 8 percent reduction of applied water beyond current BMPs at the retail level. This option could achieve about 170 taf/yr in depletion reductions at a cost of about $400/af.

Option 4: Reduce Residential Indoor Water Use to 55 gpcd. This option is based on the potential for a 5 gpcd reduction in leaks, a 2 gpcd reduction in shower usage, and a 3 gpcd reduction in laundry use. These savings result in a 15 percent reduction of applied water beyond current BMPs at the retail level. This option could achieve about 340 taf/yr in depletion reductions at a cost of $600/af.

Interior CII Water Use

Urban BMPs account for 12 to 15 percent reduction in commercial, industrial, and institutional water use by 2020. Options 5 and 6 assume that CII water use could be reduced beyond BMPs with aggressive audits and information programs by the retailer. These options could reduce CII water use by an additional 3 percent and 5 percent. The reduction levels are based on measures with varying payback schedules, and also on a national study funded by EPA which identifies potential savings beyond BMPs attainable for various enterprises.

Option 5: Interior CII Water Use by 3 percent. This option is based on measures requiring a five-year start up time with payback in two years. The additional 3 percent CII reduction would require increased water audits and compliance with existing standards and regulations. This option could achieve about 50 taf/yr in depletion reductions, primarily in coastal regions, at a cost of about $500/af.

Option 6: Interior CII Water Use by 5 percent. This option is based on measures requiring an additional five-year start up period with a payback within two to five years. The additional 5 percent reduction would accrue through increased audits and compliance with

CALFED Water Conservation Planning

A technical appendix published with CALFED's March 1998 draft PEIR/PEIS outlined a proposed water conservation approach for urban and agricultural agencies wishing to participate in CALFED program benefits. CALFED's conservation levels differ from those used in Bulletin 160-98. CALFED's assumptions represent its vision of future conservation goals. Bulletin 160-98 uses the approach of forecasting the future based on present conditions. For example, CALFED assumes that new sources of financial assistance and other incentives would be provided to water agencies to encourage high levels of conservation. Bulletin 160-98 assumes that demand reduction options beyond BMPs and EWMPs must be cost-competitive with supply augmentation options, and that no new subsidies or financial assistance programs are provided.

Demand reductions estimated to occur from implementation of CALFED conservation measures were not included in CALFED's quantification of new water supplies potentially generated by the program. Thus, they are also not included in the Bulletin 160-98 quantification of potential new supplies from CALFED.

existing standards, and new efficiency standards. About 80 taf/yr of depletion reduction could be achieved, primarily in the coastal regions, at a cost of $750/af.

Distribution System Losses

The Department estimates that the average unaccounted water in the State's hydrologic regions ranges between 6 and 15 percent. Two percent is attributed to unmetered water use (including water used for construction, fire fighting, and for flushing drains and hydrants) and meter errors; therefore, distribution system losses range between 4 percent and 13 percent. Options to reduce distribution system losses assume that they could be reduced to 7 and 5 percent statewide with more aggressive leak detection and repair programs by the retailer.

Option 7: Distribution System Losses to 7 percent. This option assumes that water system audits would be carried out every three years, leak detection surveys would be conducted from the audits, and repairs would be made. The cost of this option is estimated to be about $200/af. This option would achieve about 20 taf/yr of depletion reductions.

Option 8: Distribution System Losses to 5 percent. This option assumes full metering of all water sources and points of use, annual water audits, leak detection of newly constructed pipelines, and systematic leak detection and repair programs linked to water audits. Implementation of this option would achieve about 140 taf/yr of depletion reduction at a cost of $300/af.

Agricultural Water Conservation Options

Agricultural water use in the Bulletin's 2020 forecast is calculated from estimates of crop acreage, unit applied water, unit ETAW and SAEs. Irrigated crop acreage was 9.5 million acres in 1995 and is expected to decline to 9.2 million acres by 2020 because of urbanization (mostly in the South Coast Region and San Joaquin Valley), westside San Joaquin Valley drainage problems, and changes in CVP water supply in the Central Valley.

Bulletin 160-98 assumes that water purveyors statewide will implement EWMPs by 2020, as described in Chapter 4. The resultant demand reduction is included in the Bulletin's 2020 agricultural water use forecast. Statewide implementation of EWMPs results in about 800 taf/yr of applied water reductions by 2020, largely from canal lining or piping and other measures increasing average on-farm SAE to 73 percent. Recent Department studies have shown that average SAEs might be increased to 80 percent through improved irrigation equipment and irrigation management practices.

The agricultural water conservation options described below were based on attaining SAEs greater than 73 percent, on average, through implementation of conservation measures in excess of present EWMPs. Average efficiencies of 76, 78, and 80 percent were used for the water management options. The Department's mobile laboratory data have shown these efficiencies can be achieved in certain locations and with some crops and irrigation methods.

Stressing orchards to reduce ET (also referred to as regulated deficit irrigation) was not evaluated as an option. The RDI method was used successfully during the drought, but may impact crop yields and needs further testing as a long-term management strategy. RDI and other irrigation techniques are discussed in Chapter 5.

Agricultural demand reduction options are evaluated for each hydrologic region and summarized in Table 6-4. The water conserved from these options varies for each region according to prevailing irrigation practices and the regional soil types and hydrology. As with urban conservation options, the purpose of implementing these agricultural conservation options is to generate new water supply by reducing depletions. Reducing consumptive use results in additional water supply only where water would otherwise be lost to evapotranspiration or to a saline water body such as the Pacific Ocean. In California agriculture, this condition exists primarily in the Colorado River Region (which drains to the Salton Sea), parts of the coastal regions, and the westside of the San Joaquin Valley. In the Sacramento River and the San Joaquin River Regions, almost all excess applied irrigation water is reused, ultimately percolating to usable groundwater or draining back into rivers that flow toward the Delta.

If all of the options discussed below were implemented, about 230 taf of depletion reduction could theoretically be achieved. In areas where no depletion reductions would be achieved by conservation beyond EWMPs (such as the Sacramento and San Joaquin River Regions), this additional conservation was deferred as a water supply option. Most of the potential for achieving depletion reductions through additional agricultural conservation occurs in the Colorado River Region. The environmental impacts of such conservation on the Salton Sea must be carefully evaluated. The Salton Sea provides valuable habitat for migratory waterfowl, and alternatives for stabilizing its increasing salinity are now being studied. Since agricultural drainage provides the bulk of fresh water inflow to the sea, actions reducing the freshwater inflow may not be implementable on a large scale.

Irrigation Management (Options 1, 2, and 3)

By 2020, the Department assumes that on-farm SAEs will average 73 percent statewide. Based on mobile laboratory studies, average SAE could reach 80 percent through programs that include irrigation system evaluations, better system design, and improved irrigation systems and management practices. Options 1, 2, and 3 represent the depletion reductions that would be obtained with improved average SAE at 76, 78, and 80 percent, respectively. Increasing average SAE from 73 to 76 percent would yield a depletion reduction of about 40 taf/yr statewide at about $100/af. Improving SAE from 73 to 78 percent would increase depletion reductions to 60 taf/yr statewide at a cost of $250/af. Improving irrigation management from 73 to 80 percent SAE would result in statewide depletion reductions of about 80 taf/yr at a cost of $450/af.

TABLE 6-4

Agricultural Depletion Reduction Potential Due to Water Conservation Options[a] Beyond EWMPs (taf)

Region	Opt 1	Opt 2	Opt 3	Option 4	Option 5	Option 6
	76%	78%	80%			
	Seasonal Application Efficiency			Flexible Water Delivery	Canal Lining and Piping[b]	Tailwater Recovery
North Coast	D	D	D	D	D	D
San Francisco Bay	D	D	D	D	D	D
Central Coast	D	D	D	D	D	D
South Coast	4	7	10	D	D	D
Sacramento River	D	D	D	D	D	D
San Joaquin River	D	D	D	2	2	2
Tulare Lake	7	12	17	D	D	D
North Lahontan	D	D	D	D	D	D
South Lahontan	2	3	5	D	D	D
Colorado River[c]	22	36	50	30	45	65
Total (rounded)	**40**	**60**	**80**	**30**	**50**	**70**

[a] Implementing options in certain regions would not result in any depletion reduction. These options are deferred (D). Only depletion reductions greater than 1 taf are presented in this table.

[b] Excludes lining of major conveyance facilities (eg., All American Canal, Coachella Canal), which are treated as individual options in the regional water management chapters.

[c] These options are subject to environmental review to ensure that reduced depletions will not have significant impacts to the Salton Sea.

Land Retirement in Drainage-Impaired Areas

Land retirement has been considered for purposes that include drainage management and creation of wildlife habitat, as well as for potential water supply gains. Currently, two programs have authority to fund land retirement—the CVPIA land retirement program and the San Joaquin Valley Drainage Relief Program created by State legislation in 1992. USBR's CVPIA program has significant funding for land retirement, as described in Chapters 2 and 4. Retiring drainage-impaired land on the westside of the San Joaquin Valley would result in reduction of applied water and depletions associated with the current agricultural land use. The use of this associated water—whether for agricultural, urban, or environmental purposes—would depend on the authority and purpose of the program implementing the retirement.

For illustrative purposes, Bulletin 160-98 quantified demand reductions associated with two land retirement scenarios on the westside of the San Joaquin Valley, where some agricultural lands face serious drainage problems and where the existing land retirement programs are authorized to make acquisitions. This analysis is presented to show the demand reduction amounts and potential associated socioeconomic impacts for these drainage management options. Since the scope of Bulletin 160-98 is limited to water supply/demand planning, the Bulletin does not include land retirement for drainage purposes as a water management option. The results of the land retirement analysis are shown in Appendix 6F.

Water Delivery Flexibility (Option 4)

The manner of water delivery to the farm affects water use and efficiency of use. Flexible water delivery allows a farmer to turn water on and off at will. This is currently impractical for many gravity flow agricultural water delivery systems because of the large volumes of water that must be delivered. However, some agricultural water agencies have been able to allow farmers to give shorter notice to the district before receiving water and to allow farmers to adjust flow rates and the duration of the irrigation. Flexible water delivery beyond that achieved through implementation of existing EWMPs would yield about 30 taf/yr at a cost of about $1,000/af.

Canal Lining and Piping (Option 5)

Increased water use efficiency could be achieved by improving on-farm distribution systems beyond the level of effort provided in existing EWMPs. Distribution system losses can be reduced by lining open canal systems or using pipelines. Pipelines would reduce depletions from evaporation and from seepage of applied water to unusable groundwater. (This option applies only to canal lining and piping of on-farm delivery systems. Lining of major conveyance facilities such as the All American Canal and lining of water agency-owned canals are treated as individual options in Chapters 7-9.)

Lining irrigation canal systems in the San Joaquin River Region could reduce depletions by about 2 taf/yr in areas that drain into unusable shallow groundwater. Less than 1 taf in annual depletion reduction would accrue in the Tulare Lake Region because many irrigation systems on the westside of the valley where there is unusable shallow groundwater are already lined or piped. This option could reduce depletions by 45 taf/yr in the Colorado River Region. It is estimated that this option would cost about $1,200/af.

Tailwater and Spill Recovery Systems (Option 6)

This option would improve irrigation efficiency by the construction of additional tailwater and spill recovery systems. The tailwater recovery option is only applicable to areas with furrow or border irrigation systems. Spill recovery systems would lessen the amount of water reaching unusable groundwater and surface water by reducing losses from operational spills in irrigation district delivery canals. About 70 taf/yr of depletion reductions could be achieved with this option, primarily in the Colorado River Region, at a cost of about $150/af.

Environmental Water Conservation Options

Unlike the urban and agricultural efforts discussed above, little formal planning for environmental water conservation has occurred. Development of a formal program to evaluate efficient water use on wetlands is currently the only active program. DFG, USBR, and USFWS are working with the Grasslands Resource Conservation District to develop an interagency program for water use planning for Central Valley wildlife refuges covered by the CVPIA. The program will include best management practices for efficient water use. Draft work products are expected in 1998. The Bulletin does not quantify options for wetlands water conservation.

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Water Supply Augmentation Options

Presently, most active planning for statewide water supply options is being done either for the CALFED Bay-Delta program or for SWP future supply. In accordance with CVPIA requirements, an appraisal level water supply augmentation report (for replacing the project water dedicated to environmental use) was recently prepared for the CVP. There has not been action to implement potential CVP supply options described in that report, apart from initiation of a conjunctive use study described later in this chapter. Statewide-level supply augmentation options are described in the following text, and a summary table of their potential yield is provided at the end of this section.

Conveyance Facilities

Two programs, the SWP Interim South Delta Program and the CALFED program, are studying conveyance actions in and around the Delta. Past studies have evaluated a potential Mid-Valley Canal, a major conveyance facility to supplement water supplies to the eastern San Joaquin Valley.

SWP Interim South Delta Program

The Department's Interim South Delta Program proposes to improve water levels and circulation in south Delta channels for local agricultural diversions, and to enhance existing delivery capability of the SWP by improving south Delta hydraulic conditions, allowing increased diversions into Clifton Court Forebay. This would allow for more frequent use of full pumping capacity (10,300 cfs) at the Banks Pumping Plant during high flows in the Delta, and more operational flexibility for reducing fishery impacts.

The ISDP partly responds to the proposed settlement of a lawsuit brought by the South Delta Water Agency against the Department and USBR. In the proposed settlement agreement, the three parties committed to develop mutually acceptable long-term solutions to the water supply problems of water users within SDWA. The Department has taken the lead responsibility for planning and constructing the project, with cost-sharing provided by USBR.

The ISDP preferred alternative would cost an estimated $60 million to construct and includes five components:

(1) Construction and operation of a new intake structure at the northeastern corner of Clifton Court Forebay, as part of providing greater operational flexibility in export pumping.
(2) Channel dredging along 4.9 miles of Old River just north of Clifton Court Forebay.
(3) Construction and seasonal operation of a barrier at the head of Old River in spring and fall to improve fishery conditions for salmon migrating in the San Joaquin River. (Construction of an Old River fishery barrier is included in CVPIA's list of mandated federal environmental restoration actions.)
(4) Construction and operation of three flow control structures at Old River, Middle River, and Grant Line Canal to improve existing water level and circulation patterns for agricultural users in the south Delta.
(5) Increased diversions into Clifton Court Forebay up to a maximum of 20,430 af daily on a monthly average basis, resulting in the ability to pump an average of 10,300 cfs at Banks Pumping Plant.

ISDP could augment SWP supplies by 125 taf/yr in average years and 100 taf/yr in drought years at a 2020 level of demand, based on present studies. This figure does not take into account any new operational restrictions that may be imposed on the project as a result of the environmental review and permitting process which it is now undergoing. A draft EIR/EIS for the program was released in July 1996 and ESA consultation is ongoing. A final EIR/EIS is scheduled for completion in 1999.

CALFED Delta Conveyance

The CALFED Bay-Delta program is carrying out a three-phase process for solutions for the Bay-Delta system. In Phase I, the program identified the problems in the Bay-Delta system, developed guiding principles, and devised three basic alternatives to solving the identified problems. The second phase consisted of preparing a programmatic EIR/EIS covering three main alternatives for conveyance of water across the Delta:

- Alternative 1. Water would be conveyed through the Delta using the current system of channels.
- Alternative 2. Water conveyance through the Delta would be substantially improved by making significant changes to the existing system of channels.

Delta levees protect infrastructure such as EBMUD's Mokelumne River Aqueduct, highways, railroads, and power transmission lines.

- Alternative 3. Water conveyance through the Delta would be substantially improved by making significant changes to the existing system of channels and constructing a conveyance facility, isolated from the Delta's natural channels, to transport part or all of the water intended for export.

Each alternative presents options for water storage, as well as a system for conveying water through and/or around the Delta. The water storage element could include expanding existing storage, constructing new surface storage, or conjunctive use and groundwater banking. Additional storage would increase flexibility in operating the Bay-Delta system, allowing operators to respond to changing conditions and needs throughout the year, and would help respond to the effects of drought. Surface storage could be in the Delta, upstream of the Delta, or south of the Delta. Groundwater storage components include conjunctive use and groundwater banking programs in the Sacramento and San Joaquin Valleys and in the Mojave River Basin.

A public review draft of the PEIR/PEIS was released in March 1998. CALFED expects to issue a revised draft PEIR/PEIS by the end of 1998. The revised draft would identify CALFED's draft preferred alternative. The third phase of the CALFED process would involve staged implementation of the preferred alternative, over a time period perhaps as long as 30 years, and would require site-specific compliance with NEPA and CEQA.

In June 1998, it was announced that the second draft of CALFED's PEIR/PEIS would focus on a first stage of program implementation that would be defined as the period prior to final action on any major new surface storage or conveyance projects that might be addressed in CALFED's draft preferred alternative. The first stage was estimated to span seven to ten years. The first stage was to focus on implementation of demonstration projects and actions associated with CALFED common program elements (see accompanying sidebar) and on further planning for water storage and conveyance actions.

The total costs of the CALFED program are difficult to estimate at this time because of its broad scope and programmatic nature, and because decisions have not yet been reached about specifics of implementation. CALFED's PEIR/PEIS estimated total program costs as potentially in the range of

CALFED Bay-Delta Program Common Programs

The following six common program elements provide the foundation for overall improvement in the Bay-Delta system. Each of the individual elements is a major program of its own.

- Long-Term Levee Protection Plan—Improve reliability of the Delta levees to benefit all users of Delta water and land.
- Water Quality Program—Reduce point and non-point source pollution for the benefit of all water uses and the Bay-Delta ecosystem.
- Ecosystem Restoration Program—Improve habitat, restore critical flows, and reduce conflict with other Delta system resources.
- Water Use Efficiency Program—Provide for efficient use of existing water supplies and assure efficient use of any new supplies developed through the program.
- Water Transfer Policy—Provide a framework to facilitate and encourage a water market to move water among users on a voluntary and compensated basis.
- Watershed Management Coordination—Encourage locally-led watershed management activities that benefit Delta system resources.

$10 billion, over a program life of several decades. There is presently no information available on what portion of those costs would be allocated to any new water supply CALFED would develop.

Mid-Valley Canal

The Mid-Valley Canal was a proposed conveyance facility to supplement water supplies to the eastern San Joaquin Valley. With two components—a main branch and a north branch—the canal would convey existing CVP water supply from the Delta to portions of Merced, Madera, Fresno, Kings, and Tulare Counties and, by exchange, Kern County.

The main branch of the Mid-Valley Canal would convey water from the Mendota Pool down the east side of the valley, providing additional water deliveries to the southern San Joaquin Valley and Tulare Lake Basin. The north branch would divert water out of the Mendota Pool to provide additional water deliveries to the eastern San Joaquin Valley. Water deliveries could be provided for conjunctive use and groundwater banking programs, alleviating groundwater overdraft conditions. Improved groundwater conditions through delivery of surplus Delta flows could increase the reliability of drought year supplies. Because of the uncertainty of Delta exports, this option is deferred from further analysis in this Bulletin as a statewide option.

Surface Storage Facilities

Developing additional surface storage is an important option for improving statewide water supply reliability. New facilities could store water for the environment, agriculture, municipalities, industry, or a combination of these uses. More storage would increase flexibility in operating the Bay-Delta system, improving operators' ability to respond to changing conditions and needs throughout the year. At this time, the only statewide-level studies of new surface storage facilities are those relating to the CALFED program.

Area of Origin Protections

As described in Appendix 2A, there are explicit statutory protections for area of origin water development, with regard to actions taken by SWRCB in administering water rights and by the Department in providing SWP supply. These provisions apply to the construction and operation of CVP and SWP facilities and would apply to any CALFED-related facilities constructed by the projects.

At the time when initial planning was being performed for a statewide water resources development system, the State filed applications for the appropriative water rights (including rights to store water) needed for coordinated development of California's water resources. Some of these State filings were subsequently assigned to CVP or SWP facilities, and some to local projects. SWRCB may not, in acting on water right applications for these State filings (e.g., applications for a new surface storage facility), deprive the county of origin of the water needed for its present and future development. Many of these original State filings have now been assigned and the associated facilities have been constructed.

Water Code Sections 11460 et seq. require the Department, with regard to construction and operation of the SWP, to not deprive areas of origin, or "an area immediately adjacent thereto which can conveniently be supplied with water therefrom," of the water reasonably needed for their beneficial uses. Water agencies in the area of origin and adjoining areas could contract with the Department for SWP supply pursuant to this provision. The terms and conditions contained in the contract would depend on the nature of the agencies' needs. If the agency wished to become a SWP contractor on a par with the existing 29 water contractors, the contract would be negotiated in the same manner as the existing SWP contracts. An area of origin agency with different needs might seek a different contractual format. For example, an alternative contractual form might be negotiated for agencies that could carry out local conjunctive use programs to reduce their need for a firm supply from the SWP. Existing SWP contractors pay a share of the costs of developing SWP supply, plus a transportation charge that reflects the cost of water delivery to a contractor's service area. Actual water supply and transportation charges for an area of origin contractor would be determined by the type of water supply needed and the associated transportation facilities. To date, no area of origin agencies have negotiated water supply contracts with the Department.

CALFED Surface Storage

New water supply provided by the CALFED program would come about by implementing some combination of surface storage facilities and conjunctive use programs (discussed later in this chapter). Bulletin 160-98 describes potential CALFED storage facilities and their water supply contributions for illustrative purposes, but does not attempt to identify which facility or facilities CALFED might construct. As presently scheduled, CALFED would not begin construction of a new surface storage facility until after its initial implementation of common program elements. Given the long lead time associated with moving forward on large storage facilities, new water supply from a CALFED facility may not be available by the Bulletin's 2020 planning horizon. The potential new water supply provided by CALFED storage (quantified later in this chapter) is necessarily a placeholder, as no decision has yet been made on a draft preferred alternative. Quantification of CALFED actions for Bulletin 160-98 is based on information provided in CALFED's March 1998 first draft PEIS/PEIR and supporting technical appendices.

For illustrative purposes, the Bulletin's discussion of new CALFED storage facilities treats some of the facilities as if they were part of the SWP, to provide a benchmark for calculating their yields via operations studies. Many of these sites have been studied historically as potential SWP future water supply facilities, and data available for them reflect that intended purpose. The Bulletin's treatment of these facilities as potential components of the SWP is to facilitate their quantification, and is not intended to be a proposal as to the agency that would actually finance, construct, and own them. To date, there has been no determination of how any new supplies developed by CALFED would be allocated.

The following sections present an overview of the locations where new CALFED surface storage facilities could be developed.

Surface Storage Upstream of the Delta. Review of potential statewide surface storage options upstream of the Delta revealed that most of the water development potential of the eastern Delta and San Joaquin River tributaries is likely to be dedicated to local plans. The Sacramento River Basin presents nearly all the potential for additional development to meet statewide needs.

The Sacramento River Basin produces nearly one-third of California's surface runoff. About 16 maf total reservoir storage throughout the basin regulates much of that runoff to support extensive agricultural development within the region, and also provides significant water supply for export to other regions from CVP and SWP facilities. A potential remains for developing additional storage in the basin, as evidenced by frequent winter outflows in excess of in-basin and Delta needs.

Over the past century, hundreds of potential reservoir storage sites have been examined encompassing every significant tributary of the Sacramento River Basin. The most economical and practicable of those were developed, the largest of which are Shasta, Oroville, Berryessa, Almanor, Folsom, and New Bullards Bar. Options for additional storage are primarily past project proposals that were not developed.

The average annual surplus outflow in the Sacramento River Basin is about 9 maf. While this suggests potential for additional storage development, much of the surplus runoff occurs during short periods in years of exceptional flood runoff. For example, a maximum daily flow of about 600,000 cfs flowed past Sacramento during the floods of February 1986 and January 1997. New storage capacity could be developed to capture a small fraction of this surplus. Prospects for the development of additional onstream surface storage reservoirs are discussed in the sidebar.

Besides the onstream reservoir sites proposed over the years, many potential offstream storage sites have been investigated to develop surplus water in the upper Sacramento River Basin. Major planning on such projects began in the 1970s, in the wake of wild and scenic rivers legislation that effectively eliminated additional development of the North Coast rivers. By then, it was also apparent that new storage sites on the Sacramento River were not environmentally feasible, so attention shifted to various onstream tributary reservoirs and to offstream sites. With one exception (Tuscan Buttes Reservoir on Inks Creek, north of Red Bluff), the most promising offstream storage sites investigated during this time lay west of the river from the Stony Creek Basin (Newville and Glenn Reservoirs) south (from Colusa and Sites Reservoirs) to the Putah Creek Basin (enlarged Lake Berryessa). All these projects would require conveyance facilities to divert surplus flow (usually during flood periods) from the Sacramento River, some with potential pump lifts of 300 to 900 feet. (CALFED's studies of storage options are presently examining whether existing facilities such as the Tehama-Colusa Canal could be modified to serve as conveyance facilities for some of the potential offstream storage sites.) Offstream storage projects of this type can be sited to minimize environmental impacts within the inundation area, but diversions from the river involve engineering and environmental challenges.

There has been a revival of interest in other offstream storage possibilities, some new and some that appeared in the Department's Bulletin 3, *The Califor-*

Prospects for Onstream Surface Storage Upstream of the Delta

The seven areas outlined below contribute more than 80 percent of Sacramento River Basin runoff. The remaining runoff originates within the substantial valley floor area and adjacent low- elevation foothills. With few exceptions, streams draining this area are ephemeral, flowing only during and following storms. No consideration has been given to onstream storage on these minor tributaries or nearby valley floor areas, except for discussion of possible winter storage in rice fields.

Upstream from Shasta Dam

About 26 percent of basin runoff originates in this 6,700-square mile tributary area, primarily in the Pit, McCloud, and upper Sacramento Rivers. The availability of water to support additional storage has long been recognized. In the 1930s, Shasta Dam planners considered a larger project, but opted for construction of storage downstream at the Table Mountain or Iron Canyon sites near Red Bluff. When the downstream dam proved environmentally unacceptable, alternatives examined eventually included enlarging Shasta Dam. New storage upstream is possible, but sites are limited by steep topography and extensive existing power development of the Pit and McCloud systems.

Upper Sacramento River Tributaries, Shasta Dam to Red Bluff

This large, but low-elevation, area contributes about one-eighth of Sacramento River Basin runoff. The principal tributaries (in descending order of runoff) are Cottonwood, Cow, Clear, and Battle Creeks. Clear Creek is fully developed by Whiskeytown Lake (a CVP facility). Several reservoir sites have been investigated on the other tributaries, with primary emphasis on Cottonwood Creek. Previously studied reservoir sites are available in this area, but none have proven viable.

Feather River

This is the Sacramento River's largest tributary and contributes 20 percent of basin runoff, an annual average of about 4.5 maf. Lake Oroville at 3.5 maf regulates Feather River flows in most years, but the huge spills in wet years show that the river could support additional storage. Enlargement of Lake Oroville has not been considered practical and the few upstream sites identified in the past have fallen by the wayside for various environmental and economic reasons. No serious planning attention has been devoted to major reservoir storage in the Feather River Basin since construction of Oroville Dam.

Yuba and Bear Rivers

The Yuba River constitutes 11 percent of Sacramento River Basin runoff, but is substantially diminished by power diversions to the adjacent Bear and Feather Rivers. Still, a significant potential for additional storage remains. Proposals for large reservoirs at the Marysville (or nearby Narrows) site have been discussed in the past 40 years. Upstream development potential is restrained by extensive existing power facilities and diversions. The Bear River is small, but its runoff is bolstered by the diversions from the Yuba River.

American River

With 12 percent of Sacramento Basin runoff, the American River could support more than the 1.0 maf of storage provided by Folsom Lake and the nearly 0.5 maf of upper basin storage. For the past decade, recognition of a flooding hazard along the lower American River has added urgency to finding options, including enlarging Folsom Lake and constructing additional storage upstream at Auburn. The controversy over Auburn Dam prompted reappraisal of storage sites farther upstream and on the South Fork, but none appeared to justify follow-up attention.

Westside Tributaries South of Cottonwood Creek

The principal tributaries in this group are (from south to north): Putah, Cache, Stony, Thomes, Elder, and Red Bank Creeks. The existing Lake Berryessa, which has an unusually high storage/inflow ratio, fully develops Putah Creek. Clear Lake and Indian Valley Reservoir provide about 0.6 maf of active storage in the upper Cache Creek Basin, but only modest potential exists for additional storage in the lower basin. East Park, Stony Gorge, and Black Butte Reservoirs partially control Stony Creek, but some surplus water remains. Thomes, Elder, and Red Bank Creeks are presently uncontrolled; Thomes Creek contributes about two-thirds of the runoff from this northern trio. Potential reservoir sites have been considered on the various westside tributaries, principally within the Stony/Thomes Basins.

Other Tributaries, Feather River to Red Bluff

From south to north, the major streams of this group are Butte, Big Chico, Deer, Mill, and Antelope Creeks. These drainages are narrow, steep canyons with good sustained summer flows. Past studies have identified a few small potential storage sites, but none are considered practical because of environmental considerations (primarily anadromous fish and wilderness issues).

nia Water Plan, in 1957. Among the latter is a potential local project, Waldo Reservoir, to store surplus Yuba River water diverted from the existing Englebright Reservoir. Similar proposals have been developed to store surplus American River water from Folsom Reservoir in the nearby Deer Creek or Laguna Creek Basins. Offstream storage projects of this type are attractive because they eliminate the need for onstream reservoirs and divert from existing facilities upstream from current anadromous fishery habitat.

To illustrate how specific surface storage projects upstream of the Delta compare with one another, Bulletin 160-98 planning criteria were used to screen and evaluate the reservoir sites (Appendix 6G). CALFED is performing its own evaluation of possible storage sites. An initial screening may be included in its final PEIS/ PEIR. More detailed evaluations of the remaining sites would be carried out after CALFED begins to implement initial elements of the common programs.

Off-Aqueduct Surface Storage South of the Delta. Off-aqueduct surface storage south of the Delta has been investigated for many years. CALFED's storage evaluations include reviewing off-aqueduct storage.

The CVP and SWP operate by releasing water from upstream reservoirs, which flows through the Delta and is diverted, together with unstored flows available for export, by the projects' pumping plants located in the south Delta. Storage south of the Delta is provided by San Luis Reservoir, a joint SWP/CVP facility in the San Joaquin Valley. Water pumped at the Banks and Tracy Pumping Plants is transported to San Luis Reservoir during the winter and early spring and later delivered to agricultural and urban water contractors. Additional storage south of the Delta would increase water availability through greater capture of surplus winter runoff, as well as provide for greater flexibility in operating the projects.

Dependable water supplies from the SWP are estimated at about 3.1 and 2.1 maf for average and drought years, respectively. Operation studies show that under 2020 level of demand, there is a 25 percent chance of delivering full entitlement in any given year with existing facilities. Operation studies show similar CVP delivery capabilities to its Delta export service area. (See Chapter 3 for discussion of SWP and CVP operations.) Additional off-aqueduct storage south of the Delta would increase water supply reliability of both projects.

In addition to increasing water supply reliability for both projects, more off-aqueduct storage south of the Delta would allow flexibility in pumping from the Delta. This flexibility would allow for shifting of Delta pumping toward months when the impacts of Delta diversions on fisheries are at their lowest. Having additional storage south of the Delta would allow the projects to operate efficiently by taking advantage of times when maximum pumping is permissible.

Operation of the SWP and CVP is governed by several limiting factors including available water supplies, demands on these supplies by project contractors, Delta water quality standards, instream flow requirements, and conveyance capability. The availability of water supplies varies with natural conditions and upstream development. Winter floods can produce Delta flow rates of up to several hundred thousand cfs, while summer rates can be as low as a few thousand cfs. Annual Delta inflow varies substantially, ranging from more than 70 maf in wet years to less than 7 maf in drought years.

Since the 1950s, alternative off-aqueduct storage reservoir sites south of the Delta have been investigated by the Department. An agreement between the State and federal governments was signed in 1961 for construction and operation of San Luis Reservoir, a joint-use offstream storage facility completed in 1968. Before completion of San Luis Reservoir, it was recognized that additional storage south of the Delta was needed. As a result, a Delta storage development program was authorized by legislative action in 1963-64, and work started to analyze the remaining potential off-aqueduct storage sites in the San Joaquin Valley. Under this program a cursory examination of potential sites identified the Kettleman Plain, Los Banos, and Sunflower sites for more in-depth study. Kettleman and Sunflower Reservoir sites were dropped after reconnaissance level review because of their physical characteristics. The Los Banos site was deemed satisfactory for further study, and a 1966 report recommended additional geological exploration.

In the 1970s, a Delta alternatives study reviewed all drainages south of the Delta and selected Los Vaqueros, Los Banos Grandes, and Sunflower Reservoirs for further studies. In a 1976 Delta alternatives memorandum report, the Sunflower site was again eliminated when compared with the other sites on the basis of low storage availability and marginal foundation conditions. The Los Vaqueros site in Contra Costa County was included in the Department's proposed Delta program and was part of a comprehensive water management program proposed for authorization via 1977-78 legislation. (LBG was an alternative to Los Vaqueros in that legislation.) After that legislation failed passage, Los Vaqueros was included with the Peripheral Canal in SB 200. LBG was not specifically mentioned in SB 200, but the bill provided for additional off-aqueduct storage south of the Delta. In 1980, SB 200 was signed into law, but was overruled by voters in the 1982 general election.

The Los Banos Grandes damsite area, looking westerly toward the Coast Range.

The Department initiated a more comprehensive investigation of alternative off-aqueduct storage reservoirs south of the Delta in 1983, and after an initial examination of 18 storage sites, completed a reconnaissance report on 13 potential San Joaquin Valley sites. The study recommended that LBG be investigated to determine its most cost-effective size, and its engineering, economic, financial, and environmental feasibility. In 1984, the Legislature unanimously approved Assembly Bill 3792, authorizing LBG as a facility of the SWP. The Department released a draft EIR and a feasibility report on LBG in 1990.

Since the 1990 reports, increased restrictions on Delta pumping and rising costs have prompted reconsideration of the LBG proposal. Given the uncertainty of future Delta exports and the reluctance of some SWP contractors to participate in the project, the Department reevaluated the feasibility and optimal size of additional off-aqueduct storage. A subsequent *Alternative South-of-the-Delta Offstream Reservoir Reconnaissance Study* identified all alternative reservoir sites south of the Delta by cursory examination of all topographic possibilities. An overview of sites studied in the past is provided in Appendix 6G.

In-Delta Storage. CALFED has also considered in-Delta storage. A private developer has proposed a water storage project involving four islands in the Delta. The project would divert and store water on two of the islands (Bacon Island and Webb Tract) as reservoir islands, and seasonally divert water to create and enhance wetlands for wildlife habitat on the other two islands (Bouldin Island and Holland Tract). The developer would improve and strengthen levees on all four islands and install additional siphons and pumps on the perimeters of the reservoir islands.

The developer's project would divert surplus Delta inflows, or would manage transferred or banked water for later sale and/or release for Delta export or to meet Bay-Delta water quality or flow requirements. The reservoir islands would be designed to provide a total estimated initial capacity of 238 taf—118 taf from Bacon Island and 120 taf from Webb Tract—at a maximum pool elevation of 6 feet above mean sea level.

A draft EIR/EIS for the Delta Wetlands Project was completed in September 1995. SWRCB held water rights hearings in 1997. Issues included water quality concerns, levee integrity, seepage impacts on adjacent islands, and fishery impacts. SWRCB is currently reviewing and evaluating the evidence to develop a draft decision.

Multipurpose Storage Facilities

Most reservoirs are constructed to serve multiple purposes. As discussed in Chapter 3, multipurpose reservoirs are often operated to prioritize certain uses or to balance competing uses during different times of the year. Good planning policy dictates that new surface storage facilities be designed to accommodate as many purposes—such as water supply, flood control, hydropower generation, fish and wildlife enhancement, water quality management, and recreation—as are practicable.

Although Bulletin 160 is focused on evaluation of water supply options, this focus is not intended to minimize the need to consider the other benefits potentially available from reservoir sites—especially flood control. The January 1997 flooding, the largest and most extensive flood disaster in the State's history, demonstrated the urgent need to improve flood protection levels throughout the Central Valley. The 1997 *Final Report of the Governor's Flood Emergency Action Team* contained a variety of recommendations for improving emergency response management and flood protection in the Central Valley.

The 1997 floods highlighted a fundamental fact of Central Valley geography—the valley floor is relatively flat, and only an extensive system of levees confines floodwaters to those areas where people would

The January 1997 flooding in the Central Valley emphasized the vulnerability of lands protected by levees.

prefer that they remain. At the beginning of the valley's development in the Gold Rush era, much of the valley floor was an inland sea during the winter months and travel was possible only by boat. This condition was once again experienced on a localized scale in 1997, when numerous levee breaks occurred throughout the valley. Although more emphasis is being given to floodplain management and prevention of future development in flood-prone areas, extensive urban development has already occurred in areas that rely on levees for flood protection. Efforts to improve flood protection for these urban areas necessarily include evaluation of upstream storage alternatives—reoperation or enlargement of existing reservoirs and construction of new reservoirs.

From a flood control standpoint, there are locations within the Sacramento and San Joaquin River systems where additional storage (onstream, or perhaps offstream with appropriate diversion and pumping capability) would be particularly useful. Communities in the Sacramento Valley with greatest need for additional flood protection include the Yuba City/Marysville and Sacramento/West Sacramento areas, as identified in the 1997 *Final Report of the Governor's Flood Emergency Action Team*. An enlarged Shasta Lake could provide additional management of flood flows on the Sacramento mainstem. The need for more flood control storage on the Yuba River has been evaluated for some time, in conjunction with reservoir sites such as the old Marysville site, or the more recent Parks Bar alternative. The proposed Auburn Dam on the American River, selected as the preferred flood protection alternative by the State Reclamation Board, would provide much-needed flood protection for the Sacramento area, which has one of the lowest levels of flood protection of any metropolitan area in the nation.

In the San Joaquin Valley, urbanized areas needing additional protection are those affected by flooding on the mainstem San Joaquin River and on its largest tributary, the Tuolumne River. In the January 1997 flood event, runoff at New Don Pedro Dam on the Tuolumne River and Friant Dam on the San Joaquin River exceeded the flood control capability of both reservoirs. On the Tuolumne River, it appears that new upstream reservoirs are a less likely flood control option, given the basin's existing storage development. Enlarging Friant Dam (or constructing its offstream alternative) would be the most probable new storage development option for the San Joaquin River.

Bulletin 160-98 includes Auburn Dam and Friant Dam enlargement as statewide options likely to be implemented (by CALFED or by others) by 2020. According to CALFED, the capital cost of a 2.3 maf Auburn Dam would be about $2.3 billion in 1995 dollars. According to USBR, the cost of raising Friant Dam by 140 feet with 500 taf additional storage is about $580 million. (This estimate, in 1997 dollars, does not include costs associated with purchasing property, the cost of relocating utilities, and mitigation costs.) Potential yields associated with these projects were estimated through operations studies. A 2.3 maf Auburn Reservoir is estimated to provide 620 taf in average years and 370 taf in drought years. An enlarged Friant Dam is estimated to provide 90 taf in average years. As noted in Appendix 6G, an enlarged Shasta Lake would provide major water supply and other benefits, but additional studies of its costs and environmental impacts would be needed before the

Courtesy of California State Library.

High technology (circa 1900) being used to construct a Sacramento River levee south of the then-downtown area.

project could proceed to implementation. It is recommended that feasibility-level studies of enlarging Shasta be initiated to quantify its costs and benefits. Preliminary studies show that a 9 maf enlargement of Shasta would yield about 760 taf in average years and 940 taf in drought years.

Groundwater and Conjunctive Use

The potential sustainable water supply that could be derived from groundwater storage is constrained by the water available to recharge the storage, the available storage capacity, and the wheeling capability of the conveyance facilities. In most areas the sources of recharge are natural percolation from overlying streams, infiltration of precipitation, deep percolation of applied irrigation water, and seepage from irrigation canals and ditches. In some areas, these sources are augmented by artificial recharge.

Potential for Conjunctive Use in the Central Valley

Plans for local development of additional groundwater and conjunctive use programs are covered in Chapters 7–9. This section reviews the potential for groundwater development and conjunctive use as elements of statewide water management, concentrating on the potential for augmenting supplies of the major State or federal water projects. As noted earlier, conjunctive use programs are also a component of CALFED's storage evaluations.

Sacramento Valley. As noted in the previous discussion of surface storage facilities, the Sacramento River Basin constitutes most of the potential for additional water development to meet statewide demands. Just as surface storage reservoirs are being evaluated to develop a portion of the basin's surplus runoff (about 9 maf), managed conjunctive use programs are being evaluated to the same end.

Although there is a tendency to think of Sacramento Valley groundwater in terms of a homogeneous underground reservoir that fluctuates gradually with wet and dry cycles, the reality is more complex. While much of the Sacramento Valley groundwater basin is interconnected, aquifer structure is far from uniform and horizontal movement of groundwater is slow. Differences in groundwater conditions exist from one area of the valley to another. Even within a small subarea, groundwater resources can range from abundance to scarcity within a few miles.

Potential conjunctive use programs must be evaluated on a site-specific basis, just as surface water storage facilities are evaluated. In concept, Sacramento Valley conjunctive use programs would operate by encouraging existing surface water diverters to make greater use of groundwater resources during drought periods. The undiverted surface water would become available for other users, and groundwater extractions would be replaced during subsequent wetter periods through natural recharge, direct artificial recharge, or in-lieu recharge (supply of additional surface water to permit a reduction of normal groundwater pumping).

The DWB provides an example of conjunctive use in the Sacramento Valley. In 1991, 1992, and 1994, the DWB executed contracts to compensate Sacramento Valley agricultural water districts for reducing their diversions of surface water. Most of the reduced surface water diversions were made up by increased groundwater extractions from existing wells. The 1994 program in this area was the largest, amounting to approximately 100 taf. The DWB program included a groundwater monitoring component to evaluate the effects of increased extractions on neighboring nonparticipating groundwater users. Such monitoring programs would be an important component of future conjunctive use programs.

San Joaquin Valley. Potential conjunctive use projects in the San Joaquin Valley would involve recharging empty groundwater storage space for later withdrawal. Although aquifer storage capacity is available (over 50 maf), a lack of recharge water limits opportunity for conjunctive operation. Even with Delta improvements, prospects for additional groundwater conjunctive use storage south of the Delta are limited. From the standpoint of statewide water supply, the areas of conjunctive use potential are those within reach (either directly or through exchange) of the California Aqueduct or CVP facilities. Examples of projects studied in the past include the Kern Water Bank and the Stanislaus/Calaveras River Basin program. The Kern Water Bank project, described in Chapter 8, was initially developed by the Department and was subsequently turned over to the KWB Authority. The KWB is discussed as a local water management option for the Tulare Lake Region in Chapter 8.

The Department and USBR, in coordination with local agencies, evaluated the possibility of a conjunctive use project in the Stanislaus/Calaveras River Basin. SEWD and CSJWCD proposed a conjunctive use project in 1986 for their CVP interim water supply contracts (155 taf/yr). The districts would divert CVP surface water supply in wet years and would pump

Recharge facilities in the Kern Water Bank area. Levees and conveyance facilities have been constructed to manage spreading of water in the recharge areas.

groundwater and divert South Gulch Reservoir supplies in drought years. Water would be stored in the proposed South Gulch Reservoir, an offstream storage reservoir near the Calaveras River, in wet years. In drought years the districts would allow the water to be released to the Stanislaus River for fishery needs, water quality improvement in the southern Delta channels, and CVP and SWP water supply improvement. Subsequent enactment of CVPIA and issuance of SWRCB's Order WR 95-6 substantially reduced the quantities of surface water available to SEWD and CSJWCD. The Department deferred further participation in this program as a source of SWP supply. Local agencies are continuing to evaluate other conjunctive use programs in this area, as described in Chapter 8.

Recent Groundwater Studies with Statewide Scope

The Department is evaluating conjunctive use opportunities that could provide future water supplies for the SWP. USBR suggested that conjunctive use could be a major option for CVP water users in its 1995 report to Congress, *Least-Cost CVP Yield Increase Plan*. CALFED is examining conjunctive use opportunities as part of its storage evaluations.

SWP Conjunctive Use Studies. The Department's investigation of Sacramento Valley conjunctive use potential for additional SWP supply is following three parallel tracks. The first track is an evaluation of the legal and institutional framework to define potential projects and their limitations. The second track is an inventory of water supply infrastructure, water use, and hydrogeologic characteristics of the valley to identify areas most suitable for conjunctive use projects. The third track is a pre-feasibility investigation of specific potential projects. Where appropriate, these studies recommend more comprehensive feasibility studies, or development of small scale demonstration and testing projects. One such project under evaluation, the American Basin conjunctive use project, is discussed in the sidebar. Under the terms of Monterey Agreement contract amendments now in place for most SWP water contractors, only those contractors interested in receiving supplies from the project would participate in it. Since no other SWP conjunctive use projects are currently in active planning, the yield of the potential American Basin project is used as a surrogate for the yield of SWP conjunctive use programs.

Least-Cost CVP Yield Increase Plan. USBR's 1995 yield increase plan evaluated possible actions to replace the water supply that CVPIA dedicated to environmental purposes. The plan identified conjunctive use as offering the largest potential, estimating that active recharge in the Central Valley would yield over 800 taf/yr. A regional groundwater model characterizing the Central Valley was used to identify potential sites for active recharge programs. Table 6-5 lists potential yield estimates from the study. Yield estimates for active recharge programs were based on the availability of floodflows on adjacent rivers. Local water supply availability has almost always limited the potential of a particular site. Implementation of conjunctive use options would require additional feasibility investigations and identification of potential environmental impacts.

Madera Ranch Project. As described in Chapter 8, USBR is in initial stages of evaluating a conjunctive use project known as the Madera Ranch project, which might yield up to 70 taf/yr. Water supplies for the project would come from excess flows available at the Delta for export. USBR, in cooperation with the San Luis and Delta-Mendota Authority, has completed a preliminary investigation of the project and is now evaluating land acquisition. Since supplies from the potential project would be provided only to one group of CVP contractors and not CVP-wide, the project is discussed as a local project in Chapter 8.

TABLE 6-5

CVP Yield Increase Plan Conjunctive Use Options

General Site Locations	*Potential Source(s) of Water*	*Activity*	*Evaluated Capacity[a] (taf)*	*Annual Yield[b] (taf)*
Region 1				
E of Anderson	Upper Sacramento River	Active recharge	60	15
Region 2				
SW and W of Orland, Tehama-Colusa Canal and vicinity	Upper Sacramento River	Active recharge	360	90
Within Glenn County	Groundwater	Developable yield	N/A	55
Region 3				
S of Chico, near Wheatland, E of Sutter Bypass, and NE of Rio Linda	Feather and Bear Rivers and Dry Creek (north of Sacramento)	Active recharge	280	85
Within Yuba County	Groundwater	Developable yield	N/A	25
Region 4				
NW of Woodland and SW of Davis (near Dixon), Yolo Bypass nearby	Cache Creek, Sacramento River	Active recharge	120	30
Region 5				
NE of Galt, SE of Elk Grove, SE of Lodi, and S of Manteca	American (using Folsom South Canal), Cosumnes, Mokelumne, Calaveras, and Stanislaus Rivers	Active recharge	400	185
Region 6				
NW of Volta and at Oro Loma	Delta-Mendota Canal, California Aqueduct	Active recharge	275	200
Region 7				
N of Modesto	Stanislaus or Tuolumne Rivers	Active recharge	100	20
Region 8				
E of Atwater, NE of Merced, W of La Vina, and NE of Red Top	Merced, Chowchilla, Fresno, and San Joaquin Rivers	Active recharge	350	140
Region 9				
none identified				
Region 10				
N of Raisin City, S of Kingsburg, S of Hanford, W of Visalia, and SW of Tipton	Kings, Kaweah, and Tule Rivers	Active recharge	unknown	125
Region 11				
W of McFarland, and SW of Bakersfield	Kern River, California Aqueduct	Active recharge	500	50

[a] Capacity is taken to be the amount of water that can be recharged and extracted over any area without causing a water level fluctuation of more than 30 feet compared to historical water levels and has been estimated using a large-scale regional model. Values are not maximums and are used for comparison purposes.

[b] Location(s) descriptions are reflective of general areas where active recharge programs were estimated to be feasible. Each reference to a city or town represents a single site (NW of Woodland and SW of Davis refers to two potential site areas). Many regions have multiple sites where active recharge is possible.

CALFED Conjunctive Use Component. CALFED is evaluating conjunctive use potential as part of its storage component. The CALFED conjunctive use program will not identify specific projects, but will attempt to identify potential for groundwater development and provide technical support to voluntary local conjunctive use projects. CALFED is defining operating rules and assumptions in order to evaluate potential water supply benefits. Storage for conjunctive use is currently assumed to be 250 taf in the Sacramento Valley and 500 taf in the San Joaquin Valley. Groundwater withdrawal and recharge capacities of 500 cfs are being assumed. Groundwater withdrawal is being assumed to take place only in drought years. Potential water supply benefits of the CALFED conjunctive use program have not been quantified at this time.

Water Marketing

Water agencies are increasingly including marketing as a component of their future resources mix—not just as a drought management technique, but as a source of supply in normal water years. It is becoming increasingly common to see local agency plans with a menu of marketing alternatives which include one-time spot transfers, short or long-term agreements for drought year marketing, and long-term agreements for average year water marketing.

In this update of the *California Water Plan*, water marketing may include:

- A permanent sale of a water right by the water right holder.
- A lease from the water right holder (who retains the water right), allowing the lessee to use the water under specified conditions over a specified period of time.
- A sale or lease of a contractual right to water supply. Under this arrangement, the ability of the holder to transfer a contractual water right is usually contingent upon receiving approval from the supplier. An example of this type of arrangement is a sale or lease by a water agency that receives its supply from the CVP, SWP, or other water wholesaler.

One common concern with marketing proposals is that only real water is sold, and that marketing of paper water is avoided (see sidebar). The difference is that real water involves a change in the place and type of an existing use without harming another legal user of water, while paper water might involve sale of water that would not otherwise be beneficially used during the period of the proposed marketing arrangement. Another common concern is third-party impacts associated with proposed marketing arrangements. This concern must be addressed as appropriate on a site-specific basis for proposed transfers.

For water marketing options identified as likely to be implemented, Bulletin 160-98 water budgets show increases in supply for the gaining regions and reflect corresponding reductions in demand in regions

Feasibility Study for American Basin Conjunctive Use Project

The Department has completed a feasibility investigation of the American Basin conjunctive use project. Discussions are under way with local project participants and potentially participating SWP contractors. If negotiations are successful, CEQA/NEPA compliance and permit acquisition would follow, and initial project operation might begin in 2001. The project area is in southeastern Sutter County, western Placer County, and northwestern Sacramento County. Local water purveyors participating in the project could include South Sutter Water District, Natomas-Central Mutual Water Company, Pleasant Grove-Verona Mutual Water Company, and Placer County Water Agency. Three of the four potential participants have a surface water supply within the project area from either the Bear or Sacramento River systems, and one relies on groundwater.

As evaluated in the feasibility study, the project could develop about 55 taf of water during drought periods to supplement diminished SWP surface water supplies, depending on the number of agencies participating in the project. In the feasibility study, costs of the drought year supply for the SWP were estimated to be on the order of $150/af.

The 40-30-30 Index (see description in Chapter 3) would be used to determine when project recharge and recovery would occur. When the index is classified as above normal or wet, project recharge would occur. Recharge would be accomplished by in lieu means, which would require delivery of SWP water to those in the project area that use groundwater. Construction of new facilities to deliver SWP water from the Feather River to each project participant's service area would be required. When the index is classified as dry or critical, project recovery would occur by groundwater substitution. Groundwater substitution would involve each district forgoing part of its normal surface water supply, by leaving it in the river for use by others. Reductions in surface water supply would be supplemented by extracting groundwater that was placed in the aquifer system earlier.

Is That Real Water?

The initial rush of enthusiasm for water marketing stimulated much discussion about supposedly unused water. Some water users in the State hold rights (statutory or contractual) to more water than they currently use to meet their needs. Why not sell those rights to others?

Such arrangements looked attractive to both prospective sellers and buyers. The sellers would receive payment for something they were not using, while the buyers would meet urgent water needs. This view, however, overlooks the fact that water to meet the transferred rights has been part of the basin supply all along, and has almost always been put to use by downstream water right holders or is supporting an environmental need. This type of marketing arrangement became known as a "paper water" deal: the money goes to the seller, while the water is sold to the buyer from the supply of an uninvolved third party.

A similar outcome can result from some water conservation measures. Changes in irrigation management can reduce drainage outflow that otherwise contributes to the supply of downstream users or meets an instream need. Proposals to market water saved through such drainage reduction can also represent paper water.

The California Water Code includes a number of provisions to regulate and facilitate marketing arrangements (Water Code Sections 1435, 1706, 1725, 1736, 1810d), as well as a "no-injury" clause that prohibits transfers that would harm another legal user of the water. This clause is the basis for prohibiting sale of paper water.

In analyzing water marketing and water conservation proposals, the Department uses the terms real water and new water to contrast with paper water. Real water is water not derived at the expense of any other lawful user, i.e., water that satisfies the Water Code's no injury criterion. New water is water not previously available, created by reducing irrecoverable losses or outflow to the ocean or inland salt sinks. New water, by definition, must be real, but not all real water is new. For example, water made available through land fallowing is real (because it reduces ETAW), but not new.

from which water is being transferred, if specific participants have been identified and the options are large enough to be visible in the water budgets. Presently, the only marketing arrangements that fit this category are those associated with the draft CRB 4.4 Plan.

One of the larger potential water marketing programs identified in Bulletin 160-98 is CVPIA water acquisition for instream flows and wildlife refuges. Impacts of different levels of supplemental water acquisition were described in USBR's draft CVPIA PEIS, which did not identify a preferred quantity of water acquisition. At this time, no long-term purchase agreements have been executed—CVPIA supplemental water acquired to date has been purchased on a year-to-year basis. It is not possible to identify how and where the supplemental water would be obtained in the future, or what other water demands might be reduced as a result of CVPIA water acquisition.

Sources of Water for Marketing

The increased attention to marketing following the 1987-92 drought brought clear recognition that water marketing alone does not create new supplies—it is a process by which supplies developed by other means are moved to a new place of use. In any water marketing agreement, the reliability of the supply acquired by the transferee depends upon the specific details of the agreement and the relative priority of the water rights involved. Potential sources of water that have been most often considered for marketing are described below:

Land Fallowing. A potential source of water for marketing is to forgo growing crops in a given area and move the water that would have been consumed to a different service area. Although there can be some difficulty in quantifying the amount of water made available and its impact on the economy of local agricultural communities, land fallowing is a proven demand reduction technique. Land fallowing may be undertaken on either a permanent basis (land retirement) or only during drought periods in various forms of shortage contingency programs. Drawbacks of fallowing include potential impacts on non-participating third parties.

Crop Shifts. Some of the third party effects of fallowing could be reduced by substituting crops that consume less water for those that would use more. For example, safflower might be planted in place of tomatoes, or wheat in place of corn. The substituted crop is usually less profitable for the grower, so the potential buyer provides an appropriate incentive payment. Such arrangements can produce real water savings, but they introduce a further layer of complexity and uncertainty. (For example, how can it be demonstrated that the higher water-using crop would really have been planted in the absence of the arrangement? And, what are the related effects on groundwater recharge and drainage contributions to downstream surface supplies?) Crop shift proposals were solicited by the Department for the 1991 DWB, but played a limited role. Because crop acreage is market driven, the ability to do large scale crop shifts is limited. Crop shifts are thus expected to have a small role in water marketing.

Water Conservation and Water Recycling. Where conservation or recycling options result in real water savings, conserved water may be available for marketing to other users. Recent proposals to market conserved water have mostly occurred in the agricultural sector, where considerable confusion has sometimes resulted over the distinction between reducing applied water and producing real water savings. Most of California's irrigated areas overlie usable groundwater basins and are linked by networks of surface streams and drains. Water leaving one area usually contributes to the supply of other areas or, in the Central Valley, to required Delta outflow. Under such conditions, real water savings result by reducing consumptive use or by reducing losses to saline sinks.

From a statewide perspective, opportunities for marketing conserved water occur primarily in areas such as the Imperial Valley, where agricultural drainage water flows to the Salton Sea. (Agricultural runoff entering the sea supplies the relatively fresher water needed to sustain the sea's biological resources. The ability to market conserved water that would otherwise flow to the sea must take into consideration impacts of such transfer on the sea.)

From a local perspective, however, the situation may be different. For example, Sacramento Valley conservation measures that reduce agricultural drainage make more water available for use in the conserving area—but at the expense of downstream users. Local districts in such areas have substantial incentive to practice conservation to improve the utility of their existing supplies, but the potential for creating real water for sale to others is limited.

Water recycling in coastal urban areas can create new water, and there is often a potential market for this water among other urban users for landscape or turf irrigation. These sales typically entail multi-jurisdictional partnerships, since the recycled water is most often provided by a wastewater treatment agency but is distributed or supplied to end users by one or more water agencies.

Groundwater Substitution. Many California growers have rights and access to surface water supplies, even though their land may overlie productive groundwater basins. In such cases, a grower may agree to forgo use of surface water rights for a period, substituting groundwater instead. The unused surface water then becomes available for marketing to other users. This technique was tested during the DWBs of 1991, 1992, and 1994. Under favorable conditions (where wells and pumps are already installed), it can produce considerable water on relatively short notice. One major concern with groundwater substitution is the potential impact on neighboring non-participating pumpers. Substantial monitoring is needed to assure there are no unreasonable third-party impacts. Another consideration with groundwater substitution is that additional pumping may induce recharge that depletes usable streamflow. Only that portion of groundwater replenished from future surplus flows is really a new supply. Further experience will be needed to define the potential of this source, resolve concerns over impacts on nearby pumpers and regional surface supplies, and explore possibilities for constructing recharge facilities.

Surface Storage Withdrawals. Existing reservoirs within California have a combined storage capacity of approximately 40 maf. These facilities are operated by a wide spectrum of entities for a variety of water supply, flood control, power, and recreation objectives. At any given time, water may be stored somewhere in the system that is not planned to be released, but could be made available to meet urgent needs, subject to compliance with existing water rights. Such withdrawals come at a price—usually a reduction of power generation or recreational usage, or increased risk of future water supply shortage. Payments to the reservoir owner implicitly include a component to compensate for reduced benefits, increased risk, and other costs. Surface storage withdrawals are easily quantified and clearly represent real water, provided the storage is refilled from future surplus flows. Storage withdrawals played an important role in recent transfers; the refill constraints were handled through a contract clause whereby reservoir owners agreed to defer refill until a time of future high runoff when there would be no detrimental effect on other water users. In the long run, the prospects for such arrangements will tend to diminish as water demands increase in the reservoirs' primary service areas.

Prospects for Water Marketing

Water marketing will continue to play a role in meeting California's water needs, but there will be a continuing shift in emphasis toward systemwide appraisal of impacts and growing recognition of the need to protect the rights of all lawful water users. Water marketing programs (and land retirement or fallowing programs that may be used to supply water for sale) are often controversial in the area where the trans-

Water Code Section 1810 *et seq.*

1810. Notwithstanding any other provision of law, neither the state, nor any regional or local public agency may deny a bona fide transferor of water the use of a water conveyance facility which has unused capacity, for the period of time for which that capacity is available, if fair compensation is paid for that use, subject to the following:

(a) Any person or public agency that has a long-term water service contract with or the right to receive water from the owner of the conveyance facility shall have the right to use any unused capacity prior to any bona fide transferor.

(b) The commingling of transferred water does not result in a diminution of the beneficial uses or quality of the water in the facility, except that the transferor may, at the transferor's own expense, provide for treatment to prevent the diminution, and the transferred water is of substantially the same quality as the water in the facility.

(c) Any person or public agency that has a water service contract with or the right to receive water from the owner of the conveyance facility who has an emergency need may utilize the unused capacity that was made available pursuant to this section for the duration of the emergency.

(d) This use of a water conveyance facility is to be made without injuring any legal user of water and without unreasonably affecting fish, wildlife, or other instream beneficial uses and without unreasonably affecting the overall economy or the environment of the county from which the water is being transferred.

1811. As used in this article, the following terms shall have the following meanings:

(a) "Bona fide transferor" means a person or public agency as defined in Section 20009 of the Government Code with a contract for sale of water which may be conditioned upon the acquisition of conveyance facility capacity to convey the water that is the subject of the contract.

(b) "Emergency" means a sudden occurrence such as a storm, flood, fire, or an unexpected equipment outage impairing the ability of a person or public agency to make water deliveries.

(c) "Fair compensation" means the reasonable charges incurred by the owner of the conveyance system, including capital, operation, maintenance, and replacement costs, increased costs from any necessitated purchase of supplemental power, and including reasonable credit for any offsetting benefits for the use of the conveyance system.

(d) "Replacement costs" means the reasonable portion of costs associated with material acquisition for the correction of unrepairable wear or other deterioration of conveyance facility parts which have an anticipated life which is less than the conveyance facility repayment period and which costs are attributable to the proposed use.

(e) "Unused capacity" means space that is available within the operational limits of the conveyance system and which the owner is not using during the period for which the transfer is proposed and which space is sufficient to convey the quantity of water proposed to be transferred.

1812. The state, regional, or local public agency owning the water conveyance facility shall in a timely manner determine the following:

(a) The amount and availability of unused capacity.

(b) The terms and conditions, including operation and maintenance requirements and scheduling, quality requirements, term or use, priorities, and fair compensation.

1813. In making the determinations required by this article, the respective public agency shall act in a reasonable manner consistent with the requirements of law to facilitate the voluntary sale, lease, or exchange of water and shall support its determinations by written findings. In any judicial action challenging any determination made under this article the court shall consider all relevant evidence, and the court shall give due consideration to the purposes and policies of this article. In any such case the court shall sustain the determination of the public agency if it finds that the determination is supported by substantial evidence.

1814. This article shall apply to only 70 percent of the unused capacity.

ferred water would originate because of potential third-party impacts. Mechanisms for evaluation and approval of water marketing arrangements have been developed, and will likely continue to evolve. For example, USBR developed guidelines for implementing sale of CVP water under CVPIA; the California Water Code directs the Department to facilitate voluntary exchanges and transfers of water; and 1992 changes to State law authorized water suppliers (local public agencies and private water companies) to contract with water users to reduce or eliminate water use for a specified period of time, and to sell the water to other water suppliers and users.

The ability to carry out marketing is dependent on conveyance provided by California's existing rivers, canals, and pipelines. Agencies planning to use long-term marketing arrangements as part of their core water supplies must have access to reliable conveyance for these supplies. The California Water Code requires that public agencies make available unused conveyance capacity if fair compensation is paid and other conditions are met (see sidebar). The CVP and SWP wheel water for marketing; only the SWP can convey water from the Central Valley to the highly urbanized South Coast Region. A long-term Delta fix is necessary for providing reliable conveyance of acquired supplies across the Delta. Actions that constrain agencies' abilities to con-

TABLE 6-6

Sample of Potential Water Purchases (taf)

	Average	*Drought*
Drought Water Bank	—	250
CVPIA Interim Water Acquisition Program	365	365
Zone 7 Water Agency	50	50
Alameda County Water District	15	25
Contra Costa Water District	50	40
Santa Clara Valley Water District	100	100
Westlands Water District	200	200
Metropolitan Water District of Southern California	—	300
San Diego County Water Authority	200	200
Total	**980**	**1,530**

vey water across the Delta limit their ability to enter into marketing arrangements.

As more agencies rely on water marketing to balance future demand and supply, and as several large-scale environmental restoration programs begin acquiring water for fishery and habitat purposes, competition for available water will increase. The availability of water for sale in marketing programs is inherently limited by the willingness of the existing water rights holders to participate in such programs. Table 6-6 shows a few larger marketing arrangements proposed in water agency planning documents to illustrate the magnitude of purchases being considered.

Water marketing depends on the availability of conveyance for the transferred water. For example, the East Branch of the California Aqueduct is the only inter-regional conveyance facility serving rapidly urbanizing areas in the southwestern corner of the Mojave Desert. Availability of aqueduct capacity would dictate the conditions under which transfers to this area could occur.

The following sections describe some specific water marketing proposals. Many local agencies may intend to buy water on the spot market as needed to respond to service area demands, but do not have agreements or defined programs in place at this time.

Drought Year Marketing

Marketing Involving SWP Facilities. The DWB program is a water purchasing and allocation program that allows the Department to purchase water from willing sellers and market the water to buyers under specific critical needs allocation guidelines. The DWB's EIR established the bank as a 5 to 10 year program. Chapter 3 describes past DWB activities. The quantities and prices of water made available in previous years through surplus reservoir releases, groundwater substitution, and land fallowing programs are summarized in Table 6-7. Past experience suggests that about 250 taf/yr could be allocated in the future through similar programs; this quantity is used for the future supplies associated with the DWB.

The Department had proposed a supplemental water purchase program to increase water supply reliability for SWP contractors. A draft programmatic EIR for the six-year program originally proposed transfer of up to 400 taf of water in drought years. The water would be purchased from willing sellers and provided to participating SWP contractors. After a number of public workshops, the Department reevaluated the program and eliminated its groundwater component. Without the groundwater component, the maximum supply available for transfer would have been 200 taf/yr. Additional public comments received on the draft PEIR raised issues that would need to be addressed

TABLE 6-7

Drought Water Bank Summary

Year	*Purchase Price ($/af)*	*Source of Drought Water Bank Water (taf)*				*Amount Allocated[a] (taf)*
		Surplus Reservoir Storage	*Groundwater Substitution*	*Fallowing*	*Total Sources*	
1991	125	147	259	415	821	390
1992	50	32	161	0	193	159
1994	50	33	189	0	222	174

[a] Amount allocated for urban, agricultural, and environmental uses. This represents the actual supply developed by the bank after conveyance and fish and wildlife requirements were met.

in site-specific environmental documents. The Department withdrew the draft PEIR due to the difficulty of addressing site-specific concerns in a programmatic environmental analysis and after reevaluating the potential benefits of the program. The supplemental water purchase program is not considered as a future water management option in the Bulletin.

Semitropic Water Storage District has developed a groundwater storage program with a maximum storage capacity of 1 maf and maximum annual extraction of 223 taf. Under this program, a banking partner may contract with SWSD to deliver its SWP water or other water supplies to SWSD for in-lieu groundwater recharge. At the contractor's request, groundwater would be extracted and delivered to the California Aqueduct or would be pumped by SWSD farmers in exchange for SWP entitlement deliveries. Currently, MWDSC and SCVWD have long-term agreements with SWSD for 350 taf of storage for each district. ACWD has a similar agreement for 50 taf of storage, as does Z7WA for 43 taf. There is about 200 taf of capacity available for other banking partners and for increased commitments by existing partners. Participants are not restricted to SWP contractors, although access to the SWP's conveyance system is necessary. This program, discussed in more detail in Chapter 8, is considered a marketing arrangement in this Bulletin because of the possible exchange of SWSD's SWP entitlement for banked SWP water. The cost of recharging and extracting this water is about $175/af.

A similar marketing agreement has been reached by Arvin-Edison WSD and MWDSC for up to 350 taf of storage in Arvin-Edison's groundwater basin. About 60 taf would be withdrawn and delivered to MWDSC through the California Aqueduct in drought years at a cost of about $200/af, exclusive of delivery costs to member agencies.

Marketing Involving CVP Facilities. Historically, users of CVP water have made intra-district, and sometimes inter-district transfers of project supply. The 1992 enactment of CVPIA provided the authority to market project water outside of project boundaries to nonproject water users.

The San Luis & Delta-Mendota Water Authority, which represents 32 urban and agricultural water districts on the west side of the San Joaquin Valley and in San Benito and Santa Clara Counties, has developed an agreement that will help its members cope with water supply uncertainties. Under a three-way agreement between the authority, SCVWD, and USBR, participating member districts (shortage year providers) can receive some of SCVWD's federal water allocation in normal and above-normal water years in exchange for committing to make available a share of the shortage year provider's federal allocation during drought years. The agreement, which does not require any additional exports from the Delta, will be an internal reallocation of existing federal supplies to allow greater flexibility in meeting urban and agricultural water demands.

Specifically, SCVWD will provide 100 taf of water within a 10-year period for reallocation by USBR to shortage year providers. In exchange, shortage year providers will provide SCVWD with shortage year protection. The agreement directs USBR to reallocate drought year supplies (not to exceed an annual total of 14.3 taf) so that at least 97.5 taf is delivered to SCVWD in years when the CVP's urban water deliveries are 75 percent or less of contract entitlement. As part of the agreement, SCVWD will optimize its use of non-CVP water supplies, which will benefit all CVP irrigation water service contractors in the Delta export service area. Westlands Water District and San Luis Water District have already agreed to become shortage year providers; other authority members may also enter into the agreement over time.

CVPIA authorized marketing of project water outside the CVP service area, subject to numerous specified conditions, including a right of first refusal by existing CVP water users within the service area. As of this writing, no marketing arrangements have either been approved or implemented under this provision. One proposed transfer that had been discussed was between Arvin-Edison WSD and MWDSC.

Marketing Involving Colorado River Aqueduct. In its 1996 session, the Arizona Legislature enacted legislation establishing the Arizona Water Banking Authority. The Authority is authorized to purchase unused Colorado River water and to store it in groundwater basins to meet future needs. Conveyance to storage areas is provided by the Central Arizona Project. The legislation further provided that the Authority may enter into agreements with California and Nevada agencies to bank water in Arizona basins, with specific limitations. Under this legislation, future interstate banking in Arizona would have a maximum drought year yield of 100 taf. As described in Chapter 9, federal regulations to implement interstate banking are being promulgated.

As discussed and quantified in Chapters 7 and 9, a variety of arrangements are being examined as part of the development of CRB's draft 4.4 Plan. Land fallowing programs could be implemented to provide water for marketing to urban areas during drought periods, as demonstrated by one test program conducted in the Colorado River Region. In 1992, MWDSC began a two-year land fallowing test program with Palo Verde Irrigation District. Farmers in PVID fallowed about 20,000 acres of land. The saved water, about 93 taf/yr, was stored in Lake Mead for future use by MWDSC. (The water was subsequently released when flood control releases were made from Lake Mead). MWDSC paid each farmer $1,240 per fallowed acre, making the costs of the water to MWDSC about $135/af. It is expected that similar programs could be implemented in the future by agencies in the South Coast Region and Colorado River Region to provide about 100 taf during drought years.

Every Year Marketing

Permanent Sales. The Monterey Agreement provides that 130 taf of SWP agricultural entitlement be sold to urban contractors on a willing buyer-willing seller basis. Several sales of entitlement have already been implemented. KCWA permanently sold 25 taf/yr of entitlement to MWA and is in the process of finalizing the permanent sale of 7 taf/yr to Z7WA. KCWA is arranging sale of additional entitlement to Castaic Lake Water Agency. As with the SWP, marketing of contractual entitlements among CVP contractors is occurring. The CVP drought year reallocation agreement described above represents a new approach to marketing among project water users.

CVPIA Interim Water Acquisition Program. Sales of developed supplies for environmental purposes (where the transfer occurs as part of a willing buyer-willing seller arrangement, and not as the result of a regulatory action) are a relatively recent occurrence. Under the CVPIA supplemental water provisions, USBR established an interim water acquisition program that was in effect from October 1995 through February 1998. Water was acquired to meet near-term fishery and refuge water supply needs while long-term planning for supplemental water acquisition continued.

As provided in the program's environmental documentation, USBR could acquire up to 100 taf annually on each of the Stanislaus, Tuolumne, and Merced Rivers. Acquired water would be used for instream flows on the three rivers, and for flow and water quality improvements on the San Joaquin River. The specific quantities of water to be acquired each year and associated release patterns would depend upon projected flow conditions in the individual rivers, and projected flow and water quality conditions in the San Joaquin River at Vernalis. USBR would also acquire up to 13 taf of water annually from the Sacramento and Feather River Basins for Sacramento Valley wildlife refuges. Likewise, up to 52 taf would be purchased annually from willing sellers in the San Joaquin Valley for refuges there.

CVPIA AFRP Water Acquisition Program. USBR's 1997 draft PEIS analyzed four alternatives for long-term acquisition of fishery and refuge waters.

- Alternative 1. No water would be acquired to meet fish and wildlife targets.
- Alternative 2. AFRP water would be acquired annually from willing sellers on the Stanislaus (60 taf/yr), Tuolumne (60 taf/yr), and Merced Rivers (50 taf/yr) and on Upper Sacramento River tributary creeks that support spring-run salmon populations. Acquisition amounts on the tributary creeks were not quantified in the PEIS. Acquired water would be managed to meet target instream flows and would also be used to improve flows in the Delta. The acquired AFRP water could not be exported by the CVP or SWP.

Refuge water supply would be acquired to provide the incremental difference between Level 2 and Level 4 refuge supply requirements. Annual water acquisition in the Sacramento River, San Joaquin River, and Tulare Lake Regions would be about 30 taf, 80 taf, and 20 taf, respectively.

- Alternative 3. AFRP water would be acquired annually from willing sellers on the Yuba (100 taf/yr), Mokelumne (70 taf/yr), Calaveras (40 taf/yr), Stanislaus (200 taf/yr), Tuolumne (200 taf/yr), and Merced Rivers (200 taf/yr) and on Upper Sacramento River tributary creeks for in-stream flows. As in Alternative 2, acquisition amounts on the tributary creeks were not quantified in the PEIS. The acquired AFRP water would not be managed for increased flows through the Delta. Therefore, it could be exported if Order WR 95-6 conditions were met. Refuge water would be acquired to meet Level 4 requirements in the same quantities as described in Alternative 2.
- Alternative 4. AFRP water would be acquired annually for instream flow as under Alternative 3. Acquired water would be managed to meet target instream flows and to improve flows in the Delta. Therefore, the acquired water could not be exported by the CVP or SWP. Refuge water would be acquired for Level 4 water supplies in the same manner as described in Alternative 2.

To help put the magnitude of these amounts into perspective, the draft PEIS estimates a reduction of 142,000 acres of irrigated agricultural land would be needed to provide CVPIA water acquisitions under Alternative 4, entailing water acquisition costs of up to $120 million per year. Approximately 21,000 acres would be fallowed in the Sacramento River Region, 118,000 acres would be fallowed in the San Joaquin River Region, and 3,000 acres would be fallowed in the Tulare Lake Region. Since USBR has not yet identified a preferred alternative or specific proposals for transfers, Bulletin 160-98 does not include these CVPIA transfers in the water budgets. To the extent that the acquired water reduces demands by other water users, the water acquisition would have minimal net impact on the water budgets.

Colorado River Marketing Arrangements. Water agencies in the South Coast Region will continue to pursue programs to offset the reduction in existing supplies resulting from California reducing its use of Colorado River water. This subject is covered in detail in Chapter 9. MWDSC and IID have already implemented an agreement to transfer conserved water to urban users in the South Coast Region; a similar agreement was recently executed by SDCWA and IID. Both of these arrangements represent long-term transfers of core supplies. The next step in implementing the IID/SDCWA arrangement is preparation of environmental documentation. Once implemented, transferred amounts would increase over time (up to a 75-year term) to a maximum of 200 taf annually. In order to convey the acquired water, SDCWA negotiated a wheeling agreement with MWDSC for use of capacity in MWDSC's Colorado River Aqueduct.

Water Recycling and Desalting

Water Recycling

The Department, in cooperation with the WateReuse Association of California conducted a water recycling survey as described in Chapter 3. Table 6-8 shows 2020 base level of water recycling and potential future options. These options represent potential maximum levels of recycling. Not all options are expected to be implemented, due to economic and other considerations.

New water supply would be generated by water recycling where the outflow of water treatment plants would otherwise enter a salt sink or the Pacific Ocean. In the Central Valley and other inland communities, outflow from wastewater treatment plants is discharged

TABLE 6-8

2020 Level Water Recycling Options and Resulting New Water Supply (taf)

Projects	*Total Water Recycling*	*New Water Supply*
Base	577	407
Potential options	835	655
Total	**1,412**	**1,062**

TABLE 6-9
Potential 2020 Water Recycling Options by Hydrologic Region (taf)

	Total Water Recycling	*New Water Supply*
North Coast	15	0
San Francisco Bay	101	91
Central Coast	39	37
South Coast	639	527
Sacramento River	6	0
San Joaquin River	7	0
Tulare Lake	25	0
North Lahontan	0	0
South Lahontan	3	0
Colorado River	0	0
Total	**835**	**655**

into streams and groundwater basins and is generally reapplied. Recycling of such outflow would not generate new water supplies. All new recycled water is expected to be produced in coastal regions—the San Francisco Bay, Central Coast, and South Coast regions.

Water agencies in the South Coast Region are concerned that the lack of future high-quality water for blending supplies, or the cost of desalting recycled water, could affect implementation of future water recycling facilities. Due to extensive use of Colorado River water and groundwater supplies that are relatively high in TDS, salt management is an important consideration in marketing recycled water in the region. Salt management options include blending Colorado River water and groundwater supplies with other sources such as SWP water, or treating (i.e., desalting) the recycled water to reduce its salt content. MWDSC and its member agencies and USBR are cooperating in a salinity management study. The study's initial phase focuses on identifying problems and salinity management needs of MWDSC's service area. This study is discussed in Chapter 7.

Table 6-9 shows potential water recycling options by hydrologic region. Two major water recycling programs being planned are the Bay Area regional water recycling program and the Southern California comprehensive water reclamation and reuse study, discussed in detail in Chapter 7.

Desalting

Today, California has more than 150 desalting plants providing fresh water for municipal, industrial, power, and other uses. The freshwater capacity of these plants totals about 66 taf annually, a 100 percent increase since 1990. Common feedwater sources for desalting plants include brackish groundwater, municipal and industrial wastewater, and seawater. Groundwater recovery currently makes up the majority of desalting plant capacity, 45 taf/yr. Wastewater desalting accounts for 13 taf/yr and seawater desalting accounts for 8 taf/yr of total capacity.

Groundwater recovery and wastewater recycling will be the primary uses of desalting in California in the foreseeable future. (The use of desalting in wastewater treatment plants is part of water recycling and is included in the water recycling section.) Improvements in membrane technology will spur considerable growth in these areas, as discussed in Chapter 5. Seawater desalting is expected to grow very slowly.

Groundwater Recovery. High TDS and nitrate levels are common groundwater quality problems. Groundwater recovery programs can be designed to treat mineralized groundwater or groundwater with nitrate contamination, as shown in the examples given in Chapter 5. Currently, most groundwater recovery programs under consideration are located in the South Coast Region (excluding groundwater recovery solely to remediate contamination at hazardous waste sites). Some of the polluted water must be treated and some can be blended with better quality water to meet water quality standards. The potential annual contribution of groundwater recovery by year 2020 is about 110 taf, with 95 taf in the South Coast Region. Options are discussed in the regional chapters.

Seawater Desalting as a Future Water Management Option

Seawater desalting was often viewed with optimism as a future water management option for California in the 1950s and 1960s, because of the proximity of the State's major urban areas to the Pacific Ocean. Most planning efforts then were focused on studies and small-scale or pilot plant demonstration projects. Seawater desalting is expected to have only limited application during the Bulletin 160-98 planning horizon, largely due to its costs. The excerpt below, taken from a 1965 USGS report entitled *Natural Resources of California*, describes an early demonstration project. (A 1 mgd plant, operated continuously, would provide 1.1 taf per year.)

California is cooperating with the Federal Government in a saline water conversion program. The Department of the Interior and the State jointly financed the building of a saline water conversion plant in San Diego on a site donated by the city. Capable of producing 1 million gallons of water a day, it was operated for 2 years before being dismantled in March of 1964 and shipped to Cuba to serve Guantanamo Naval Base there. It is being replaced by a joint effort of the Department [of Interior] and the California Water Resources Board. The State and the Federal Government are also cooperating in the development of a multi-million-gallon saline water conversion plant.

Seawater Desalting. The major limitation to seawater desalting has been its high cost, much of which is directly related to high energy requirements. Seawater desalting costs typically range from $1,000 to $2,000/af depending in part on the extent to which existing infrastructure, such as brine disposal facilities, is present. With few exceptions, its costs are greater than costs of obtaining water from other sources. However, seawater desalting can be a feasible option for coastal communities that are not connected to statewide water distribution infrastructure and have limited water supplies. Because of such circumstances, seawater desalting plants have been constructed in the Cities of Avalon, Santa Barbara, and Morro Bay. Seawater desalting plants can be designed to operate only during drought to improve water supply reliability, as is the case for Santa Barbara's desalter.

During the 1987-92 drought, plans to install and operate several seawater desalting plants were under consideration in the Central Coast and South Coast Regions, including plans for several large distillation plants using waste heat from existing thermal power plants in the South Coast Region. The total potential of the proposed plants was about 123 taf /yr. With the return to average water supply years, most of these plans have been put on hold. Currently, seawater desalting is most favorable as a drought year option. If desalting costs are substantially reduced in the future, plant capacity which is surplus to the plant owners in wetter water years could be used to produce water for conjunctive use or marketing programs.

MWDSC's research distillation plant is the only large non-reverse osmosis facility now under study. MWDSC, in cooperation with the federal government and the Israel Science and Technology Foundation, is completing final design of a 12.6 mgd demonstration desalting plant to evaluate a future full scale 60 to 80 mgd seawater desalting plant. The technology is based on a multiple-effect distillation process which uses heat energy from an adjacent powerplant. The

Mission Basin Brackish Groundwater Desalting Research and Development Project

The Mission Basin groundwater desalting project is an example of the type of desalting projects likely to occur within the Bulletin's planning horizon.

The City of Oceanside owns and operates the Mission Basin Groundwater Desalting Facility. Under current operations, about 2.1 taf/yr of demineralized groundwater supply is produced from treating brackish groundwater through a reverse osmosis process. Because of the plant's successful operation over the past three years, the city plans to expand its production capacity to 7.1 taf/yr, 22 percent of the city's average annual demand. The cost of the expansion is estimated to be $9.0 million. The additional water supply is expected to be available in year 2000.

The Mission Basin aquifer holds about 92 taf of water. The city anticipates that at least half of its future water supply can ultimately be derived from this source. Expansion of the Mission Basin Desalting Facility has several important benefits. It would provide the city with a local source in the event of a natural disaster, such as an earthquake. In addition to reducing the city's reliance on imported water, the quality of water produced at the desalting facility is better than that of the city's imported source (TDS concentration of 400-500 mg/L versus 600-700 mg/L for imported water).

goal is to demonstrate that the multiple-effect distillation process can produce desalted seawater at a cost of less than $1,000/af. If successful, a full scale plant could produce about 85 taf/yr.

Weather Modification

Weather modification (cloud seeding) has been practiced in California for years. Most projects have been located on the western slopes of the Sierra Nevada and in parts of the Coast Range. Before the 1987-92 drought, there were about 10 to 12 weather modification projects operating, with activity increasing during dry years. During the drought the number of projects operating in California had increased to 20. Some projects were subsequently dropped and others suspended operations after the drought ended.

Operators engaged in cloud seeding have found it beneficial to seed rain bands along the coast and orographic clouds over the mountains. The projects are operated to increase water supply or hydroelectric power generation. Although the amounts of water produced are difficult and expensive to determine, estimates range from a 2 to 15 percent increase in annual precipitation, depending on the number and type of storms seeded.

The Department, on behalf of the SWP, planned a five-year demonstration program of cloud seeding in the upper Middle Fork Feather River Basin, beginning in the 1991-92 season. The program was to test the use of liquid propane injected into clouds from generators on a mountain top. The test program was terminated after three years due to institutional difficulties.

A 1993 USBR feasibility study for a cloud seeding program in the watersheds above Shasta and Trinity Dams indicated potential for the Trinity River Basin, but cast doubt on the effectiveness of a project for Shasta Lake. USBR had proposed a cloud seeding demonstration program in the upper Colorado River Basin, but the demonstration program was opposed by the State of Colorado. Presently, USBR is phasing out its participation in weather modification projects.

Cloud seeding is more successful in near-normal water years, when moisture in the form of storm clouds is present to be treated. It is also more effective when combined with carryover storage to take full advantage of additional precipitation and runoff. Institutional issues associated with cloud seeding programs include claims from third-parties who allege damage from flooding or high water caused by the cloud seeding program. Because of the many legal and institutional difficulties surrounding third-party impacts, new cloud seeding projects are deferred from further consideration in this Bulletin.

Monterey County Water Resources Agency's Cloud Seeding Program

MCWRA initiated a cloud seeding program in 1990 to alleviate impacts of the drought and has continued the program as a cost-effective way to augment water supplies. MCWRA's program costs were less than $10/af. In addition to airborne seeding, an experimental ground based propane dispenser was installed for rainfall enhancement in 1991. The program was designed to increase rainfall and runoff in the watersheds of Arroyo Seco (a small undammed tributary of the Salinas River) and San Antonio and Nacimiento Reservoirs.

Monterey County relies solely on groundwater and local surface supplies, and faces chronic groundwater overdraft and seawater intrusion. The area's semiarid, Mediterranean-style climate provides only marginally sufficient rainfall during average years to sustain reservoir releases for aquifer recharge during the summer months. Furthermore, the occurrence interval and typical productivity of weather systems passing over the central coast are such that soil mass only reaches saturation near the end of the rain event, and the weather system moves on prior to the occurrence of substantial runoff. Cloud seeding, in most cases, provides additional rainfall that converts directly into runoff.

The typical interval for cloud seeding in Monterey County is from early November through the end of March. The primary target area is the 650 square miles of combined watershed above Nacimiento and San Antonio Reservoirs. To the north, the Arroyo Seco watershed is a secondary target area. Seeding flights in the early part of the water year cover the entire area, affecting the reservoir drainage areas and Arroyo Seco. This early seeding provides additional runoff to the reservoir system as well as added groundwater recharge in the Arroyo Seco drainage area. Later in the water year when Arroyo Seco flows have reached the confluence with the Salinas River, flights are rerouted to concentrate the seeding effect on the reservoirs.

The five-year program has experienced varying degrees of success in terms of providing additional water supply. Usually the wetter the storms, the greater the moisture available for conversion to precipitation and the more productive the seeding. Overall, evaluations show that rainfall increased about twenty percent above normal for the five-year study period. According to MCWRA, no known adverse environmental effects have occurred as a result of the project.

Other Supply Augmentation Options

This section discusses several other methods to augment water supplies. These options are conceptual, or have not yet been widely practiced. Hence, they are deferred from further evaluation in this Bulletin.

Importing Water from Out of State

Constructing an undersea pipeline, towing water in giant nylon bags, shipping water by tanker, and towing icebergs have all been suggested to help augment California's water supply by importing water from out of state.

The idea of constructing an undersea pipeline to carry fresh water from Alaska to California was studied three decades ago and was last revisited in 1991. As proposed, a 2,600 mile-long suboceanic pipeline would be constructed along the coastline. The pipeline would be sized to carry about 3 maf/yr of Alaskan water from the Stikine and/or Copper Rivers, and would terminate either at Shasta Lake or in Southern California. A preliminary study estimated that the project would cost between $110 and $150 billion and take at least 15 years to complete. A feasibility study by the Congressional Office of Technology Assessment concluded that huge costs and unanswered engineering problems made the idea of building an undersea pipeline unrealistic.

A proposal to fill giant floating nylon bags with water and tow them from Alaska to California had been suggested in the past. During the height of the most recent California drought, a California company sought investors to finance a test run. The water would be filtered, chlorinated, and then loaded into floating bags (the bags float because fresh water is lighter than salt water). An ocean-going tugboat would tow the bags (each holding about 220 af) along the coast. This proposal did not go forward. In 1996, a privately developed water bag delivery system was tested on a pilot scale when two bags of 2.4 af each were towed from Port Angeles, Washington, to Seattle. Some problems emerged in the test run. If implemented at a full scale, costs associated with this option would include towing, constructing, operating, and maintaining the loading/unloading docks and pumps to transfer the bagged water ashore to local treatment and distribution systems.

Shipping water by tankers appears to be the most feasible of the water importation options suggested. Marine transport is a proven alternative to land-based pipelines in the oil industry. A Canadian company is now arranging to ship water to China via tankers. The company was granted Alaska's first water-export permit in 1996. When shipping facilities and a bottling plant are built, the company will begin shipping 390 af/yr of Alaskan water to China using tankers, retrofitted to food grade cargo. The water is to be bottled in a plant to be built by the company and the Chinese government. The City of San Diego is considering a marine transport demonstration project, where a private company would transport up to 20 taf/yr of water from British Columbia to the City of San Diego using tankers. The demonstration project, if implemented, could provide cost and technical data on bulk tanker shipping of water. The U.S. Ocean Pollution Act of 1990, which required phasing out single-hulled oil tankers, presented an opportunity to make tankers available for conversion into bulk water carriers at reduced costs. Tanker haulage could provide a flexible delivery system for emergency supply of water for coastal areas in the event of earthquakes or droughts.

Gray Water

Some residential wastewater can be directly reused by homeowners as gray water. Gray water can be used in subsurface systems to irrigate lawns, fruit trees, ornamental trees, and shrubs and flowers (in finite amounts, depending on the plant types being irrigated). Water from the bathroom sink, washing machine, bathtub, or shower is generally safe to reuse. Care must be taken so that people and pets do not come in contact with gray water. Food irrigated by gray water subsurface systems should be rinsed and cooked before being eaten.

Gray water has been used by some homeowners in coastal urban areas during extreme drought to save their landscaping. In the past, health concerns and lack of information limited use of gray water. In 1992, the Legislature amended the Water Code to allow gray water systems in residential buildings subject to appropriate standards and with the approval of local jurisdictions. There appears to be limited interest in exploring gray water as an option beyond listing its use as a potential urban BMP.

Watershed Management on National Forest Lands

National forest lands provide about half of the State's runoff. A Department study of vegetation management found that thinning trees and shrubs from 33,000 acres of foothill watershed above Lake Oroville might increase average annual runoff by 2.5 taf. USFS estimates that if national forest management as practiced during the 1980s had been practiced earlier, the average annual runoff from national forests would have been increased by about 360 taf (an increase of about 1 percent). Without new storage facilities, only a fraction of this amount would contribute to water supply.

Forest management proposals prepared on behalf of the biomass power industry call for removing excess dead material and invasive species from the forest understory and thinning of the trees themselves. Tree thinning would produce fuel for the biomass power industry. These proposals attempt to return forests to their pre-fire exclusion condition, achieving wildfire reduction and wildlife and water supply benefits. From a water supply perspective, extensive areas of land would have to be managed to increase statewide water supplies. The maximum rate of forest evapotranspiration is reached at about 65 percent tree and shrub cover density. To achieve water savings, it would be necessary to thin trees and shrubs to reduce cover to less than 65 percent, requiring detailed evaluation of potential environmental impacts. Watershed management would require ongoing treatment of forest vegetation to prevent loss of water yield due to regrowth of trees and shrubs.

Currently, no local water agencies are actively pursuing forest management as a component of their future supply. The potential environmental impacts and institutional difficulties of establishing a forest management program suggest that it would be carried out as part of a multipurpose program whose main objectives would be timber management or fire suppression rather than water supply.

Long-Range Weather Forecasting

Accurate advance weather information—extending weeks, months, and even seasons ahead—would be invaluable for planning all types of water operations. Had it been known, for instance, that 1976 and 1977 were going to be extremely dry years, or that the drought would end in 1977, water operations could have been planned somewhat differently and the impacts of the drought could have been lessened. The response to the 1987-92 drought could have been modified to store more water in the winter of 1986-87 and to use more of the remaining reserves in 1992, the last year of the drought.

The potential benefits of dependable long-range weather forecasts could be calculated in hundreds of millions of dollars, and their value would be national. Hence, research programs to investigate and develop forecasting capability would most appropriately be conducted at the national level. The National Weather Service routinely issues 30 and 90 day forecasts; the Scripps Institution of Oceanography in San Diego (until recently) and Creighton University in Omaha, Nebraska, make experimental forecasts. The predictions have not been sufficiently reliable for water project operation. Predictions may be improved by research on global weather patterns, including the El Niño Southern Oscillation in the eastern Pacific Ocean.

Summary of Statewide Supply Augmentation Options

The preceding sections evaluated statewide water management options, including demand reduction measures and large-scale water supply augmentation measures that would provide supply to multiple beneficiaries. Demand reduction and water recycling options are shown in the regional option tabulations in Chapters 7–9, since these options would be implemented by individual local agencies in their service areas. Table 6-10 summarizes options likely to be implemented by 2020 to meet statewide needs. Because these statewide options would provide new water, the opportunity exists for the options' effectiveness to be multiplied through regional reapplication. Therefore, the options would provide regional applied water gains that are greater than the gains shown in Table 6-10.

CALFED

Statewide options include actions that could be taken by CALFED to develop new water supplies. The water supply yield shown for the CALFED Bay-Delta program's preferred alternative is necessarily a placeholder, as a final program environmental document for the Bay-Delta solution has not been completed. The CALFED placeholder does not address specifics of which upstream of Delta storage facilities might be selected, or how conjunctive use programs might be operated. The placeholder assumes dual Delta conveyance (Alternative 3) and approximately 3 maf of storage facilities, with 1 maf of this storage dedicated for environmental uses. Project yield and operating criteria were defined by a DWRSIM operations study. The CALFED placeholder used for Bulletin 160-98 quantification of potential CALFED new water supply does not include water use efficiency measures proposed in a technical appendix to CALFED's March 1998 draft

TABLE 6-10

Statewide Supply Augmentation Options Likely to be Implemented by 2020[a]

Options	*Potential Gain (taf)*	
	Average	*Drought*
CALFED Bay-Delta Program	100	175
SWP Improvements		
Interim South Delta Program	125	100
Conjunctive Use Programs	—	55
Water Marketing (Drought Water Bank)	—	250
Multipurpose Reservoir Projects		
Auburn Dam	620	370
Friant Dam Enlargement	90	0
Total	**935**	**950**

[a] Demand reduction options are shown in the regional option tabulations in Chapters 7–9. Demand reduction options would be implemented by individual local agencies in their service areas.

PEIS/PEIR, because the CALFED operations studies used to quantify program water supply benefits did not incorporate those demand reductions.

Other Statewide Options

Other likely statewide options include specific projects to improve SWP water supply reliability, water marketing through the Department's DWB, and two multipurpose reservoirs. A third potential multipurpose reservoir option, an enlarged Shasta Lake, was not included as a likely option because further studies are needed to quantify the water supply and flood control benefits associated with different potential reservoir sizes. Preliminary studies suggest that a 9 maf enlargement of Shasta Lake would yield 760 taf in average years and 940 taf in drought years. Additional evaluation of this option is recommended.

The two multipurpose reservoir projects included as statewide options – Auburn Reservoir and enlarged Millerton Lake (Friant Dam)—were included as likely options to recognize the interrelationship between water supply needs and the Central Valley's flood protection needs. It is recognized that both projects may have controversial aspects and that neither of them is inexpensive. However, both projects offer enough benefits to justify serious consideration. The lead time for planning and implementing any large reservoir project is long, and it would take almost to this Bulletin's 2020 planning horizon for the projects to be constructed.

The identity of the specific entity(ies) that might implement the two multipurpose reservoir projects is uncertain. USBR, as the owner of the existing Friant Dam and as the federal agency having authorization for operating Auburn, would presumably be a participant. The implementing entity could be a partnership of some combination of federal/State/local agencies.

Allocating Options Yield Among Hydrologic Regions

In Tables 6-11 and 6-12, yields from likely statewide supply augmentation options were allocated among potentially participating hydrologic regions to illustrate how the supplies might be used. Potential supply from a Friant Dam enlargement was shown as remaining in the San Joaquin River and Tulare Lake Regions, where existing Friant supplies are used. For Auburn Dam and CALFED, supply was divided among hydrologic regions served by CVP and SWP facilities. Auburn could also provide supplies for foothill communities that are too small to develop projects on their own, as discussed in Chapter 8. (In neither option is it assumed that the CVP or SWP would contract for the supply—only that conveyance facilities exist to make the water available to potential users.) The Bulletin makes no attempt to allocate costs of these projects between flood protection and water supply.

Uncertainties in the Bulletin Planning Process

Planning about the future is subject to uncertainty. In response to public comments, this section briefly analyzes the effects of some uncertainties on the shortage forecasts and potential options presented in Bulletin 160-98.

Water use forecasts rely on assumptions about population growth, urban per-capita water use, land use and

TABLE 6-11

Likely Statewide Supply Augmentation Options by Hydrologic Region
2020 Average Year (taf)

Region	*CALFED*	*ISDP*[a]	*Conjunctive Use*[a,b]	*DWB*[b]	*Auburn Dam*	*Friant Dam*	*Total*
North Coast	—	—	—	—	—	—	—
San Francisco Bay	—	8	—	—	—	—	8
Central Coast	2	1	—	—	2	—	5
South Coast	15	68	—	—	67	—	150
Sacramento River	—	—	—	—	85	—	85
San Joaquin River	—	—	—	—	—	39	39
Tulare Lake	70	35	—	—	310	51	466
North Lahontan	—	—	—	—	—	—	—
South Lahontan	12	10	—	—	152	—	174
Colorado River	1	3	—	—	4	—	8
Total	**100**	**125**	**—**	**—**	**620**	**90**	**935**

[a] SWP Improvements

[b] The options provide only drought year supplies

cropping patterns, and environmental water requirements. Environmental water requirements are the most difficult to forecast, as they are driven by regulatory and legislative processes. Implementation of CVPIA and SWRCB's Bay-Delta Plan, new ESA restrictions, and FERC relicensing/electric utility deregulation are actions that could significantly modify forecasted environmental demands with the Bulletin 160-98 planning period.

In addition to forecasting water demand components, the Bulletin must also characterize future water management options. The CALFED Bay-Delta program and the draft CRB 4.4 Plan are still in development. These programs have been represented by placeholder throughout the Bulletin. Even if final decisions on the programs were made in the near future, both are long-term programs that will be implemented in phases; some phases may extend beyond this Bulletin's planning horizon.

To illustrate the effects of uncertainties on the Bulletin's water budgets, maximum and minimum applied water shortages associated with potential implementation of SWRCB's Bay-Delta water rights proceeding and CALFED are shown in Table 6-13. For comparison, the Bulletin's forecasted 2020 applied water shortages are 2.4 maf in average years and 6.2 af in drought years with existing facilities and programs. As discussed in earlier chapters, there are no data available at this time to quantify site-specific impacts of new ESA listings, FERC relicensing, and electric utility deregulation.

TABLE 6-12

Likely Statewide Supply Augmentation Options by Hydrologic Region
2020 Drought Year (taf)

Region	*CALFED*	*ISDP*[a]	*Conjunctive Use*[a]	*DWB*	*Auburn Dam*	*Friant Dam*	*Total*
North Coast	—	—	—	—	—	—	—
San Francisco Bay	—	7	18	75	—	—	100
Central Coast	4	1	—	51	1	—	57
South Coast	26	54	22	3	39	—	144
Sacramento River	—	—	—	—	51	—	51
San Joaquin River	—	—	—	—	—	—	—
Tulare Lake	123	28	—	51	185	—	387
North Lahontan	—	—	—	—	—	—	—
South Lahontan	21	7	15	70	91	—	204
Colorado River	1	3	—	—	3	—	7
Total	**175**	**100**	**55**	**250**	**370**	**—**	**950**

[a] SWP Improvements

Several large-scale environmental restoration programs are just beginning. These programs may entail significant acquisition of agricultural land and its conversion to habitat uses, as well as extensive water acquisition for environmental purposes. It is too soon to be able to quantify their water use impacts; these are among the uncertainties that must be resolved over time.

Bulletin 160-98 assumes SWRCB's Order WR 95-6 as the prevailing Bay-Delta standard, with the CVP and SWP meeting the standards under the terms of the Bay-Delta Accord. The alternatives contained in SWRCB's draft EIR for the water rights proceeding would broaden the responsibility for meeting standards to include additional Central Valley water users. Doing so can entail different flow regimes in Valley and Delta waterways, resulting in changes in water supplies. To capture the effects of uncertainties of SWRCB's water rights proceeding, flow Alternative 5 in SWRCB's draft EIR was used to determine the maximum shortage; flow Alternative 6 was used to compute the minimum shortage. Under flow Alternative 5, Bay-Delta standards would be met through monthly average flow requirements established for each of the major watersheds tributary to the Delta. Under flow Alternative 6, Bay-Delta standards would be met solely by operation of the CVP and SWP. Flow objectives at Vernalis on the San Joaquin River would be met by the CVP through releases from the Delta-Mendota Canal via the Newman Waterway into the San Joaquin River.

Implementation of any of the future water management options discussed in the Bulletin would be subject to completing appropriate environmental documentation and obtaining the required permits and approvals, including compliance with ESA requirements. The Tipton Kangaroo rat, listed as endangered under both ESA and CESA, is an example of a listed species found in parts of the San Joaquin Valley where groundwater conjunctive use projects might be planned.

TABLE 6-13

Effects of Alternative Assumptions on 2020 Applied Water Shortages (taf)

	Applied Water Shortage Range	
Region	***Average***	***Drought***
North Coast	0	194
San Francisco Bay	0-13	276-295
Central Coast	172-176	270-276
South Coast	944-1,053	1,270-1,441
Sacramento River	0-85	739-989
San Joaquin River	63-122	711-769
Tulare Lake	264-1,027	1,619-2,071
North Lahontan	10	128
South Lahontan	270-285	303-325
Colorado River	147-149	157-162
Total (rounded)	**1,870-2,920**	**5,670-6,650**

For CALFED implementation, the Bulletin's placeholder assumes dual Delta conveyance (Alternative 3) and approximately 3 maf of surface water storage facilities. Project yield and operating criteria were defined by an operations study which assumed that 1 maf of new storage would be operated to meet CALFED's ecosystem restoration program targets. The maximum shortage condition results from assuming that no new water supply is provided by CALFED (no storage facilities are constructed). The minimum shortage results from assuming approximately 6 maf of surface and groundwater storage. (CALFED's assumption for this scenario is that 1.25 maf of new storage would be operated to meet ERP targets.)

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Options for Future Environmental Habitat Enhancement

A number of programs designed to restore and/ or enhance environmental resources are in various stages of implementation. These programs vary in scope, geographic region, and objective. Some of these programs provide environmental water supplies; others involve structural measures, such as placing spawning gravel or constructing fish screens. Some of these programs are legislatively driven; others have resulted from collaborative efforts among stakeholders. Table 6-14 illustrates the emphasis now being placed on environmental restoration actions, by identifying a variety of funding sources available for fishery-related environmental restoration actions.

This section identifies and describes programs expected to provide future environmental benefits. This section covers a representative sample, and is not meant to be a comprehensive listing of all possibilities statewide.

Central Valley Project Improvement Act

Some CVPIA environmental restoration actions, such as water acquisition and fish screening, are applicable to the entire Central Valley. Site-specific projects, such as construction of the Shasta Dam TCD, are described in Chapters 7–9.

The May 1997 draft Anadromous Fish Restoration Plan proposed habitat restoration actions such as spawning gravel placement and stream channel restoration, acquisition of land for wildlife habitat, construction of fish screens and facilities to improve passage of migrating anadromous fish, and development of plans to prevent habitat degradation due to sedimentation and urbanization. The plan also included target instream flows for rivers and streams in the Central Valley and the Delta. The three tools available for USBR to meet these flow objectives are reoperation of the CVP, dedication and management of 800 taf of CVP yield annually, and water acquisition. Water acquisition efforts were described in the water marketing section of this chapter. Tools available to meet CVPIA's broad goal of doubling anadromous fish populations in the Central Valley include the many physical habitat restoration actions specified in the act, as well as substantial funding from the CVPIA Restoration Fund and from general congressional appropriations.

USBR and USFWS have contributed funding for local agency and privately owned fish screen installation projects and planning studies as part of the anadromous fish screening program. About 20 grants have been executed to date for screening projects and feasibility studies of screening alternatives. Examples of completed and pending projects are described in Chapter 5. USBR and USFWS have completed two spawning gravel replenishment projects on the Sacramento River below Keswick Dam. Additional projects are being planned for the other rivers authorized in the act. The gravel replenishment actions are analo-

Restoring and enhancing riparian habitat helps sustain healthy populations of the species that rely on this habitat. Beavers are an example of a species dependent on riparian habitat.

TABLE 6-14

Environmental Restoration Funding

Program and Responsible Agencies	*Projects/Program Funded Selection Criteria*	*Authorizing Legislation or Agreement*	*Funding Source*	*Funding Allocation*
Program: CVPIA Anadromous Fish Restoration Program **Responsible Agencies:** USBR and USFWS	**Projects/Program Funded:** This program funds environmental restoration actions contributing to the goal of doubling natural production of anadromous fish in Central Valley rivers and streams. The program gives first priority to measures which protect and restore natural channel and riparian habitat values through habitat restoration actions; augment river and stream flows; and implement supporting measures mandated by CVPIA Section 3406(b). **Selection Criteria:** None specified in statute.	CVPIA	Congressional appropriations from CVPIA Restoration Fund and Energy and Water Development Fund	Varies (actual expenditures: federal FY 1995, $0.8 million; FY 1996 $1.4 million)
Program: CVPIA (State cost-sharing program) **Responsible Agencies:** DWR and DFG, in coordination with USBR and USFWS	**Projects/Program Funded:** This program funds environmental restoration projects with mandatory State cost-sharing under CVPIA Section 3406. Projects include the Shasta Dam temperature control device, Red Bluff Diversion Dam fish passage actions, spawning gravel restoration projects, and fish screens. **Selection Criteria:** Projects must be capital outlay actions with mandatory State cost-sharing under CVPIA. California and the United States have executed a master cost-sharing agreement covering crediting and transferring funds for the restoration actions.	CVPIA Proposition 204 1994 State-federal cost-sharing agreement	General obligation bonds	$93 million
Program: Category III Program **Responsible Agencies:** CALFED agencies	**Projects/Programs Funded:** Nonflow related projects to protect and improve Bay-Delta ecological resources. **Selection Criteria:** Selection is based on RFP process.	Bay-Delta Accord	Proposition 204, local water agency contributions, congressional appropriations	Proposition 204 provided $60 million for State contribution.

TABLE 6-14

Environmental Restoration Funding (continued)

Program and Responsible Agencies	*Projects/Program Funded Selection Criteria*	*Authorizing Legislation or Agreement*	*Funding Source*	*Funding Allocation*
Program: CALFED Ecosystem Restoration Program **Responsible Agencies:** CALFED agencies	**Projects/Program Funded:** To be determined, but could include fish screens, spawning gravel restoration projects, and riparian habitat enhancement projects. The funds are not available until an EIR/EIS and a State-federal cost-sharing agreement are completed. **Selection Criteria:** To be determined.	Proposition 204	General obligation bonds	$390 million
Program: Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement) **Responsible Agencies:** DWR and DFG	**Projects/Program Funded:** Fish screens, rearing striped bass, gravel restoration projects, hatchery and other actions to benefit aquatic resources, particularly salmon and striped bass. Geographic scope includes the Central Valley and the Delta. **Selection Criteria:** Actions that benefit aquatic resources, particularly chinook salmon, steelhead, and striped bass. Priority will be given to measures on the San Joaquin River system. The Department and DFG staff review project proposals and submit them to an advisory committee composed of representatives from SWP contractors and the environmental and fishing communities. Recommendations are presented to the directors of the Department and DFG for approval.	Agreement between the Department and DFG to offset direct fish losses in relation to Banks Pumping Plant, dated December 1986	SWP funds administered by the Department	$15 million for fish population recovery program, and additional annual funding to compensate for annual fish losses caused by the Banks Pumping Plant[a]
Program: Tracy Fish Agreement **Responsible Agencies:** USBR and DFG	**Projects/Program Funded:** This agreement between DFG and USBR implements measures to reduce, offset, or replace direct losses of chinook salmon and striped bass in the Delta as a result of Tracy Pumping Plant diversions. **Selection Criteria:** A committee composed of representatives from USBR, DFG, and USFWS screens project proposals. Projects are funded upon recommendation by DFG Director to USBR.	Tracy Fish Agreement between USBR and DFG, dated June 1992	Congressional appropriations for operations and maintenance of CVP, administered by USBR	Approximately $1 million per year. USBR has provided funding totaling $6.5 million during 1992-97

TABLE 6-14

Environmental Restoration Funding (continued)

Program and Responsible Agencies	*Projects/Program Funded Selection Criteria*	*Authorizing Legislation or Agreement*	*Funding Source*	*Funding Allocation*
Program: Commercial Salmon Stamp Account **Responsible Agency:** DFG	**Projects/Program Funded:** Projects to restore salmon populations through habitat restoration and breeding, and projects which provide public education on the importance and biology of salmon. Examples of eligible restoration projects include spawning gravel restoration, bank stabilization, riparian revegetation, fish passage improvement, installation of fish ladders and screens, and short-term salmon breeding. **Selection Criteria:** Projects are evaluated based on benefits to fishery resources, need for work in a particular watershed for target species, and project costs. Project proposals are evaluated and prioritized first by DFG. Projects for salmon habitat restoration and breeding are sent to the Commercial Salmon Trollers Advisory Committee. There are two subaccounts in the program—a commercial salmon stamp dedicated account, and an augmented salmon stamp dedicated account. The commercial salmon stamp dedicated account is statutorily directed to salmon breeding. Expenditures from the other account must meet the recommendations of the advisory committee. Final funding decision is by the Director of DFG.	Fish and Game Code Sections 7860-7863 that impose a stamp fee on commercial salmon fishers, as well as commercial passenger salmon fishing vessel operators	Annual stamp fee which ranges from $85 to $260 depending on salmon landing	Total annual revenue varies from $340,000 to just over $1 million.
Program: California Wildlife, Coastal and Park Land Conservation Initiative (Proposition 70) **Responsible Agency:** DFG	**Projects/Program Funded:** Projects to restore and enhance salmon streams, and wild trout and native steelhead habitat. **Selection Criteria:** Similar to salmon stamp program. Project proposals are initially reviewed by DFG and then sent to the Commercial Salmon Trollers Advisory Committee and to the Proposition 70 subcommittee (a six-member group representing the Commercial Salmon Trollers Advisory Committee and the California Advisory Committee on Salmon and Steelhead Trout) for funding consideration. Final approval for funding is by the Director of DFG.	Proposition 70 of 1988[b]	General obligation bonds	see footnote

[a] Generally, the $15 million funds projects with long-term benefits to fish, while the annual account funds projects to replace fish lost annually at the pumping plant. By 1996, the Department had allocated all of the $15 million and had spent about $6 million in annual mitigation projects.

[b] State FY 1997-98 was the last year of funding under Proposition 70. DFG received $10 million to restore and enhance salmon streams, and $6 million to restore and enhance wild trout and native steelhead habitat and related projects.

gous to an operations and maintenance program, where work would be done periodically on river segments identified as needing more gravel. A monitoring program would be required, both to identify areas that are gravel-limited and to evaluate the effectiveness of the gravel provided.

Category III Program

The Category III funding program was established as part of the 1994 Bay-Delta Accord to address non-flow factors affecting the health of the Bay-Delta ecosystem. A steering committee of agricultural, urban, and environmental stakeholders administered the project selection process

TABLE 6-15

Sample Projects Funded by Category III Program

Project / Program	*Proponent*	*Category III Funds*
Battle Creek Restoration	DFG	$730,000
Durham Mutual Fish Screen and Fish Ladder	Durham Mutual Water Company	up to $416,500
M&T/Parrott Pump Relocation and Fish Screen	Ducks Unlimited, Inc.	$1,550,000
Biologically Integrated Orchard Systems Program	Comm. Alliance w/ Family Farmers Fnd.	$660,000
Sacramento R. Habitat Restoration (Colusa to Verona)	Wildlife Conservation Board	$400,000
Suisun Marsh Screening Project	Suisun Resource Conservation Dist.	up to $950,000
Sacramento River Winter-Run Broodstock Program	Pacific Coast Fed. of Fishermen's Assoc.	$300,000
Western Canal Water District Butte Creek Siphon	WCWD	$2,739,000
Prospect Island Restoration	DWR	up to $2,535,000
Sacramento R. Habitat Restoration (Verona to Collinsville)	DWR/The Reclamation Board	$500,000
Princeton Pumping Plant Fish Screens	Reclamation District 1004	$75,000
Princeton-Codora-Glenn/Provident ID Fish Screen	PCGID/PID	$5,575,000
Cosumnes River Preserve (Valensin Acquisition)	The Nature Conservancy	$1,500,000
Lower Butte Creek Habitat Restoration	The Nature Conservancy	$130,000
Sherman Island Levee Habitat Demonstration	DWR	up to $480,000
Ecological Functions of Restored Wetlands in the Delta	University of Washington	$475,000
Molecular Genetic Identification of Chinook Salmon Runs, Focused on Spring-Run Integrity	Bodega Marine Laboratory	$450,000
Decker Island Tidal Wetland Enhancement	Port of Sacramento	$399,000
Yolo Bypass Habitat Restoration Study	DFG	$226,000
Clear Creek Property Acquisition Assistance	BLM	up to $211,000
Research Program to Address the Introduction of Non-Indigenous Aquatic Species	San Francisco Estuary Institute	$197,000
Sacramento River and Major Tributaries Corridor Mapping	Calif. State University, Chico	$145,200
Fish Screen for Unscreened Diversion on Yuba R.	Browns Valley Irrigation District	$114,750
Effects of Toxics on Central Valley Chinook Salmon	Fox Environmental Management	$110,000
Barrier Intake Screen at Wilkins Slough Diversions	Reclamation District 108	$100,000
San Joaquin River Main Lift Canal Intake Channel Fish Screen Facility	Banta-Carbona Irrigation District	$100,000
Adams Dam Fish Screen and Fish Ladder	Rancho Esquon Partners	up to $100,000
Gorrill Dam Fish Screen and Fish Ladder	Gorrill Land Company	up to $100,000
Fish Screen Testing for Small Unscreened Diversions	Buell and Associates	$90,000
Watershed Management Strategy for Butte Creek	Calif. State University, Chico	$83,000
Establish Battle Creek Watershed Conservancy	Western Shasta Resource Consv. Dist.	$50,000
Inventory of Rearing Habitat for Juvenile Salmon	Calif. State University, Sacramento	$24,500
Total		**$21,515,950**

in 1995 and 1996. During this period, the program funded 32 restoration projects, including land acquisition, fish screening, habitat restoration, and a toxicity study. In 1997, CALFED became the lead agency for implementing the Category III program. Program funding sources include $10 million per year (for 3 years) from water users and $60 million from Proposition 204 funding. The Ecosystem Roundtable, a subcommittee of the Bay-Delta Advisory Council, provides input on selection of Category III projects. Table 6-15 is a sampling of projects funded through 1997. Often, projects that receive part of their funding from the Category III program are also funded in part by CVPIA's AFRP, the 4-Pumps program, or other restoration programs.

The Prospect Island restoration project is an example of a project funded by Category III. Prospect Island, an approximately 1,600-acre tract in the Delta, has a project area of about 1,300 acres in agricultural land use. The project's objectives are to create wetland and shaded riverine aquatic habitat, restore fish and wildlife habitat, and decrease maintenance costs for the Sacramento Deepwater Ship Channel levee. Actions include flooding the interior of the island to create small internal islands, stabilizing existing levees by flattening the slopes, and planting vegetation to provide erosion control. The project is sponsored by USACE (under WRDA Section 1135 authority) and the Department. USBR purchased the project site with CVPIA funds in 1995. After restoration is complete, USFWS will manage the property in conjunction with the nearby Stone Lakes National Wildlife Refuge. Category III has established an endowment fund of $1.25 million for long-term project maintenance.

CALFED Bay-Delta Ecosystem Restoration Program

CALFED's Ecosystem Restoration Program is to provide the foundation for a long-term ecosystem restoration effort that may take several decades to implement. The ERP is included in each of the alternatives being evaluated in the programmatic EIR/EIS. Some proposed actions contained in the plan include:

- Breeching levees for intertidal wetlands.
- Constructing setback levees to increase floodplain and riparian corridors.
- Limiting further subsidence of Delta islands by implementing measures such as restoring wetlands to halt the oxidation of peat soils.
- Controlling introduced species and reducing the probability of additional introductions.
- Acquiring land or water from willing sellers for ecosystem improvements.
- Providing incentives to encourage environmentally friendly agricultural practices.

Congress authorized $430 million over the next three years for the federal share of CALFED programs such as Category III and initial implementation of the ERP, and appropriated $85 million for federal fiscal year 1998. Proposition 204 also included $390 million for implementation of the ERP. This funding will not be available until after CALFED's PEIR/EIS has been completed.

CALFED operations studies, in addition to modeling storage and conveyance elements, also model CALFED's ecosystem restoration common program element through specification of ERP environmental flow targets. In the operations studies, water supplies required to meet ERP flow targets are provided from new storage facilities dedicated to environmental restoration. Water acquisitions from willing sellers are assumed to fully meet flow targets when sufficient flow is unavailable from environmental storage releases.

The ERP outlines several environmental flow objectives to support sustainable populations of plant and animal species in the Bay-Delta. The ERP identifies monthly and 10-day flow event targets for Delta outflow and for many of the river basins within the Bay-Delta watershed. As a simplification, CALFED operations studies focus on flow targets on the Sacramento River at Freeport. (The Freeport flow target is the most significant in terms of total instream flow volume.) Instream flow targets not modeled by the operations studies include: Sacramento River at Knights Landing, Feather River at Gridley, Yuba River at Marysville, American River at Nimbus Dam, Stanislaus River at Goodwin Dam, Tuolumne River at LaGrange, and Merced River at Shaffer Bridge. The additional river flows targeted by the ERP would occur through CVPIA instream flow requirements, releases from new environmental storage created under the CALFED program, and water acquisition from willing sellers.

CALFED operations studies assume that new storage volume is split among the three water using sectors. The placeholder study assumes 3 maf of new surface water storage, with 1 maf dedicated for environmental water uses. Environmental storage is operated to maximize average annual yield by not imposing carryover provisions. Water released from storage to meet ERP flow targets is not diverted at the Delta.

Other Environmental Enhancement Options

SWP's Sherman and Twitchell Islands Wildlife Management Plans

The objective of the management plans is to control subsidence and soil erosion on Twitchell and Sherman Islands, while providing wetland and riparian habitat. The plans also provide recreational opportunities such as walking trails and wildlife viewing. Subsidence would be reduced by minimizing oxidation and erosion of peat soils on the islands and by replacing present agricultural cultivation practices with land use management practices designed to stabilize the soil. Altering land use practices on Twitchell Island could provide up to 3,000 acres of wetland and riparian habitat.

Fish Protection Agreements

USBR and the Department have entered into agreements with DFG to mitigate fish losses at Delta export facilities. Subsequent to execution of USBR's agreement with DFG, CVPIA directed USBR to substantially upgrade Tracy Pumping Plant's fish protection facilities and to construct a new screening facility. Planning studies are now under way for a major upgrade of the existing facility. The Department's 4 Pumps agreement with DFG has funded, or cost-shared in many habitat restoration actions upstream of the Delta, as described previously. Discussions are presently ongoing regarding the possibility of using the remainder of the agreement's capital outlay funds to construct a fish hatchery on the Tuolumne River.

Upper Sacramento River Fisheries and Riparian Habitat Restoration Program

As described in Chapter 2, elements of the 1989 plan prepared under this program were incorporated in CVPIA, or are being considered in forums such as the CALFED program. In 1992, the Resources Agency reconvened the SB 1086 Advisory Council. The council's current charge is two-part: to serve in an advisory capacity to State agencies responsible for actions likely to affect the Upper Sacramento River and adjacent lands, and to complete the council's earlier work on riparian habitat protection and management. The goals for the latter charge include establishing a riparian habitat management area and a governance or management entity for the area. Recommendations are being developed for the boundaries of a riparian habitat conservation area, management objectives by river reach, and the type of governance organization that could most effectively carry out the management plan.

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Financing Local Water Management Options

Implementing and maintaining many of the options discussed in the Bulletin will require a large commitment of funds. When a local agency is confronted with additional expenditures for water management options, it must decide whether the costs of these options will be paid from current or accumulated revenues (pay-as-you-go), or be financed with the proceeds of debt repaid from future revenues. Historically, local water agencies relied on several methods for long-term debt financing, including general obligation bonds, revenue bonds, and assessment bonds. Innovative long-term debt financing strategies, such as bond pools, are being increasingly used.

Financial costs are different from economic costs. Financial costs are the actual expenditures required by a water agency to repay the debt (with interest) incurred to finance the capital costs of an option and to meet operations and maintenance costs. Thus, the objective of financial feasibility studies is to solve cash flow problems. In contrast, economic costs reflect the costs of committing resources needed to construct, operate, and maintain an option for its life, to whomever they may accrue. Economic feasibility studies are used to compare the relative merit of options, to determine the most economically efficient size or configuration of an option, and to allocate costs among beneficiaries. It is possible for options to be financially feasible and economically unjustified, or vice versa. For example, even though an agency can generate the funds to pay for an option, this does not necessarily mean that the option is economically the best of available options. On the other hand, an option may be economically justified but it cannot be financed because of existing debt limitations.

Financial feasibility is becoming an increasingly important consideration in water supply management planning for a number of reasons.

- Future water demands are expected to exceed present supplies. There is thus a need to develop water supply augmentation and demand management programs.
- Compliance with new EPA and DHS drinking water standards is likely to increase capital expenditures by municipal water agencies.
- Some water suppliers have deferred maintenance and/or replacement of aging facilities to the point where increased operation, maintenance, and replacement costs are being incurred.
- Since the 1980s, the federal government has been reducing aid to state and local governments for large-scale water resources projects, a trend which is expected to continue.
- Since the early 1990s, the Legislature has been shifting property tax revenues away from counties and special districts and into the State's general fund.

Sources of Revenues

Whether capital improvements are funded on a pay-as-you-go basis or through debt financing, a water agency must have sufficient revenues to cover capital costs as well as ongoing operation and maintenance costs. The major sources of revenue for publicly-owned systems include water rates charged to customers, property taxes (although use of these has been limited since passage of Proposition 13), and benefit assessments through special improvement districts. (See Chapter 2 for discussion of Proposition 218 and its impacts on assessments.) Because of voter opposition to further tax increases, local governments have increasingly relied upon other revenue sources such as development impact fees from new construction, standby fees, and fees for special services. These alternatives are typically only feasible for agencies with large service areas, so that income from these fees will be significant and reliable. Investor-owned water agencies and mutual water companies are almost exclusively dependent upon water rates to generate revenues. Tables 6-16 and 6-17 show significant sources of revenue for water agencies by type of ownership and by agency size.

Financing Methods

The ability of a public agency to access different financing methods depends upon the enabling legislation under which the agency was formed. Among other things, the enabling legislation will indicate the agency's:

- Authority to issue bonds, the vote required to authorize issuance, and any limitations on the amounts of bonds or on the amount of indebtedness;
- Powers and methods of tax assessments, including whether the assessments are on an ad valorem basis (a tax based on value of property) or are levied according to benefits, and the type of property (land and/or improvements) upon which the assessments may be levied;

TABLE 6-16

Significant Sources of Revenue to Water Agencies by Type of Ownership

Revenue Sources	*Public*	*Investor*	*Mutual*
Water Rates	X	X	X
Property Taxes	X		
Special Improvement District Assessments	X		
Development Impact Fees	X		
Customer Hookup Fees	X		
Special Service Fees	X	X	

TABLE 6-17

Significant Sources of Revenue to Water Agencies by Water Agency Size

Revenue Sources	*Small*	*Intermediate*	*Medium*	*Large*
Water Rates	X	X	X	X
Property Taxes		X	X	X
Special Improvement District Assessments		X	X	X
Development Impact Fees				X
Customer Hookup Fees				X
Special Service Fees				X

- Revenue sources, including charges, rates or tolls for service or commodities, or sales and leases of property; and
- Area over which it can collect taxes and/or sell services or commodities.

Self-Financing

Self-financing is a form of non-debt financing. A water agency can use reserves generated from accumulated revenues and other income to pay for improvements rather than incurring debt. The pay-as-you-go approach generally works best for small or recurring capital expenditures that can be reasonably accommodated in an agency's annual budget. For major capital improvements, a debt financing approach would be more appropriate.

Short-Term Debt Financing

Short-term debt financing typically includes borrowing instruments with maturities of less than 1 year. Short-term borrowing can be used for cash flow borrowing, financing for capital improvements with relatively short lives, and interim financing for long-term capital improvements. Revenue and tax anticipation notes can be used when an agency is experiencing cash flow problems because revenues are occurring unevenly during the fiscal year. Revenue and tax anticipation notes can be used to pay current expenses, with note repayment coming from revenues received later in the fiscal year. Capital items with relatively short lives can be financed through the use of commercial paper—short-term, unsecured promissory notes backed by a line of credit from one or more banks. Short-term financing methods can provide interim financing for the construction of capital improvements which are planned to be financed on a permanent basis at a later date. Examples of interim financing include grant anticipation notes (where the permanent funding could be a grant from another government agency) and bond anticipation notes (where the permanent funding will come through the issuance of long term debt such as bonds).

Conventional Long-Term Debt Financing

Conventional long-term debt financing methods include general obligation bonds, revenue bonds, assessment bonds, and lease or installment sales agreements, all of which are typically used by publicly owned utilities.

General obligation bonds are used to finance improvements benefitting the community as a whole, and are secured by the full faith and credit of the agency. General obligation bonds issued by public water agencies are secured by a pledge of the agency's ad valorem taxing power. Passage of Proposition 13 and its requirement for two-thirds voter approval have limited the ability of agencies to assess additional property taxes which would be needed to fulfill this pledge, reducing the use of these bonds. General obligation bond limits are often established by a water agency's enabling legislation.

Revenue bonds do not require the agency's pledge of full faith and credit. Debt service for these bonds is paid exclusively from a specific revenue source, such as the revenue obtained from the operation of the financed project. Because revenue bonds do not require voter approval, they are now more commonly used than general obligation bonds.

Assessment bonds are issued to finance capital improvements and debt service, are paid through assessments levied upon real property benefitted by such improvements, and are secured by a lien on that property. Under the Mello-Roos Community Facilities Act of 1982, water agencies may establish a community facilities district and levy a special tax upon land within that district. This tax can be used to finance capital improvements (generally distribution systems), new services, or to repay bonds issued for such purposes. Passage of Proposition 218 in 1996 substantially changed the way in which property-related assessments can be imposed by local agencies. In the future, these assessments must be subjected to a vote of the property owners.

Lease or installment revenue bonds have become common as taxpayer resistance and State statutes have limited the taxing and borrowing ability of local agencies, thus reducing use of general obligation bonds. In California, a form of a lease revenue bond is the Certificate of Participation. With a COP, facilities are built or acquired by an agency of the city, and leased to the city, for which the city makes lease payments equal to the principal repayment plus interest. A city, non-profit corporation, or a community redevelopment agency must be used as the intermediary leasing entity, but that agency must give the facilities to the city free and clear without added expense when the indebtedness is repaid.

Innovative Long-term Debt Financing

New long-term debt financing strategies are being developed to assist water agencies in obtaining funding for water system improvements. Bond pools increase access to bond funds for smaller water agencies who might not otherwise be able to obtain funding. Bond pools use a JPA to combine several small bond offerings into a single financial package, minimizing the cost of bond issuance for participating water agencies. The Association of California Water Agencies and the WateReuse Association offer such financial packages.

Privatization occurs when the private sector becomes involved in design, financing, construction, ownership and/or operation of a public facility such as a water system improvement. Privatization can offer advantages. For example, it may provide cheaper or more accessible financing, and it may provide substantial tax advantages to the private sector. Privately arranged financing may be an attractive option when a publicly owned water agency's access to the financial markets is diminished or nonexistent, as is the case for many smaller utilities.

Another potential opportunity for water agencies involves the provision of funds by one agency for water system or on-farm improvements by another agency, in exchange for use of the water conserved. An example is the agreement between MWDSC and IID, where MWDSC is funding IID system improvements in exchange for a 35-year right to use the waters which have been conserved.

Credit Substitution and Enhancement

Although not financing methods, credit substitution and enhancement can assist local agencies in obtaining financing and in lowering the costs of financing. Credit substitution occurs when an agency substitutes its own credit for that of a local agency that is seeking to finance a project. The local agency can improve the quality of its bonds and obtain them at a lower cost. Credit enhancement occurs when an agency guarantees that the debt service obligations will be met, which can be a low-cost and effective way for states to assist local agencies.

TABLE 6-18

Major State and Federal Financial Assistance Programs

Program	*Eligible Projects*	*Administering Agencies*
State		
Safe Drinking Water Bond Laws	Grants/low interest loans for public water system improvements	DWR/DHS
Water Conservation Bond Laws	Low interest loans for water conservation, groundwater recharge, local water supply, and water recycling projects	DWR/SWRCB
Agricultural Drainage Water Management Loan	Low interest loans for agricultural drainage projects	SWRCB
Safe, Clean, Reliable Water Supply Act of 1996 (Proposition 204)	Low interest loans and grants for water conservation, groundwater recharge and water recycling projects	DWR/SWRCB
Federal		
Water and Wastewater Disposal Loans/Grants	Loans and grants to small communities for water and wastewater facilities	Farmers Home Administration
Community Development Block Grants (HUD)	Grants to large communities for water and wastewater facilities	Housing and Urban Development through Department of Housing and Community Development
Small Business Administration Loans	Loans for private water system improvements	Small Business Administration
Federal/State		
Clean Water Act SRF	Low interest loans for water recycling projects	SWRCB
Safe Drinking Water Act SRF	Low interest loans for public water system improvements	DHS

State and Federal Financial Assistance Programs

State and federal financial assistance programs (loans and grants) are available. These programs target varied objectives including safe drinking water, water conservation, water recycling, and water supply development (for example, groundwater recharge projects). Each of these programs has criteria to determine project eligibility and funding. Most of the state and federal programs do not provide funding to investor-owned and mutual companies because this is considered to be adding value to privately owned businesses. The 1996 Safe Drinking Water Act reauthorization may provide about $12 billion from 1997 through 2003 for current and new drinking water programs, including a state revolving fund of $1 billion per year nationally through 2003. Table 6-18 shows some major state and federal financial assistance programs available for water system improvements. Proposition 204 included grants to local agencies for a variety of purposes. For example, the Department is administering two programs to provide loans (and in some cases, grants) to local agencies for water conservation/groundwater recharge facilities ($30 million) and local projects ($25 million). SWRCB is administering loans for water recycling.

Relationship Between Financing and Water Agency Ownership and Size

The types of financing available can vary depending upon the ownership and size of the water agencies. These relationships are discussed below. Table 6-19 summarizes financing methods by type of ownership. Table 6-20 illustrates financing methods typically available to water agencies of different sizes. Table 6-21 summarizes financial assistance programs by ownership type.

Public Water Agencies

In general, public water agencies have access to more financing methods than do investor-owned and mutual water companies. Many financing instruments will be tax-exempt for publicly-owned agencies. The larger public agencies can issue tax-exempt notes and bonds, assess property taxes, issue special assessment bonds, and enter into public/private partnerships to finance capital improvements. A smaller public agency may be unable to secure such financing because either the cost of the method (such as the cost of issuing bonds) or the amount of funds needed to make improvements exceeds the ability of its customers to pay. In these cases, the smaller agencies need to either obtain federal and state assistance, if available, or pursue innovative financing methods. Local public agencies must limit their rates to amounts needed to cover current financing and water costs—they are not allowed to make a profit.

Investor-Owned Water Utilities

Investor-owned utilities can issue equity stock and sell taxable bonds. The California Public Utilities Commission must give authorization prior to the issuance of stocks or bonds by an investor-owned water com-

TABLE 6-19

Financing Methods Available to Water Agencies by Type of Ownership

Method	*Public*	*Investor*	*Mutual*
Self-Financing	X	X	X
Short-Term Financing			
Fixed Rate Notes	X	X[a]	X[a]
Commercial Paper	X	X[a]	X[a]
Floating Rate Demand Notes	X	X[a]	X[a]
Conventional Long-Term Financing			
Equity Shares or Stock		X	X
Bonds (GO and Revenue)	X	X[a]	X[a]
Lease Revenue	X		
Innovative Long-Term Financing			
Bond Pools	X		
Privatization	X		X
Water transfers	X	X	X
Financial Assistance Programs	X	X[b]	X[b]

[a] Taxable instruments.
[b] State and federal loan and grant programs have limited applications for private water agencies.

pany. This method of financing is primarily limited to the larger investor-owned systems. The smaller investor-owned agencies generally do not issue stock and may lack the rate base that would make other financial methods feasible. The CPUC establishes the return on investment that investor-owned utilities are allowed to earn as part of its rate setting authority. Regulated investor-owned utilities are not able to accumulate reserves. Utilities may use short-and long-term taxable bonds and notes.

Mutual Water Companies

A mutual water company is a privately owned company that issues securities in which lot owners are entitled to one share for each lot they own. Mutual water companies have the ability to assess members to raise capital. This does not require approval by either the members or an outside agency. The amount of the assessment may be limited, however, by the ability of the customers to pay. As a requirement of formation of a mutual water company, a sinking fund must be established that provides capital replacement of water facilities at the end of their useful life. Some of the larger mutual companies may be able to use short- and long-term financing instruments such as taxable bonds and notes.

TABLE 6-20

Financing Methods Typically Available to Water Agencies by Water Agency Size

Method	*Small*	*Intermediate*	*Medium*	*Large*
Self-Financing			X	X
Short-Term Financing				
Fixed Rate Notes				X
Commercial Paper				X
Floating Rate Demand Notes				X
Conventional Long-Term Financing				
Equity Shares or Stock			X	X
Bonds (GO and Revenue)				X
Lease Revenue Bonds				X
Innovative Long-Term Financing				
Bond Pools	X	X	X	X
Privatization	X	X	X	X
Water Transfers	X	X	X	X
Financial Assistance Programs	X[a]	X[a]	X[a]	X[a]

[a] State and federal loan and grant programs have limited applications for private water agencies.

TABLE 6-21

Financial Assistance Programs Available to Water Agencies by Type of Ownership

Programs	*Public*	*Investor*	*Mutual*
State			
Safe Drinking Water Bond Laws	X	X[a]	X[a]
Water Conservation Bond Laws	X		
Agricultural Drainage Water Management Loans	X		
Community Development Block Grants	X		
State Revolving Fund for Wastewater	X		
State Revolving Fund for Drinking Water	X	X	X
Federal			
Water and Wastewater Disposal Loans and Grants	X		X
Community Development Block Grants	X		
Small Business Administration Loans		X	

[a] Loans only; grants not provided to privately-owned agencies.

6A

Regional Water Budgets with Existing Facilities and Programs

The following tables show the water budgets for each of the State's ten hydrologic regions with existing facilities and programs. Water use/supply totals and shortages may not sum due to rounding.

TABLE 6A-1

North Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	169	177	201	212
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total	**20,607**	**10,668**	**20,672**	**10,740**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and Desalted	13	14	13	14
Total	**20,607**	**10,491**	**20,672**	**10,546**
Shortage	**0**	**177**	**0**	**194**

TABLE 6A-2

San Francisco Bay Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	1,255	1,358	1,317	1,428
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total	**7,115**	**5,760**	**7,176**	**5,830**
Supplies				
Surface Water	7,011	5,285	7,067	5,417
Groundwater	68	92	72	89
Recycled and Desalted	35	35	37	37
Total	**7,115**	**5,412**	**7,176**	**5,543**
Shortage	**0**	**349**	**0**	**287**

TABLE 6A-3

Central Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	286	294	379	391
Agricultural	1,192	1,279	1,127	1,223
Environmental	118	37	118	37
Total	**1,595**	**1,610**	**1,624**	**1,652**
Supplies				
Surface Water	318	160	368	180
Groundwater	1,045	1,142	1,041	1,159
Recycled and Desalted	18	26	42	42
Total	**1,381**	**1,328**	**1,452**	**1,381**
Shortage	**214**	**282**	**172**	**270**

TABLE 6A-4

South Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	4,340	4,382	5,519	5,612
Agricultural	784	820	462	484
Environmental	100	82	104	86
Total	**5,224**	**5,283**	**6,084**	**6,181**
Supplies				
Surface Water	3,839	3,196	3,625	3,130
Groundwater	1,177	1,371	1,243	1,462
Recycled and Desalted	207	207	273	273
Total	**5,224**	**4,775**	**5,141**	**4,865**
Shortage	**0**	**508**	**944**	**1,317**

TABLE 6A-5

Sacramento River Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,833	4,223	5,839	4,225
Total	**14,664**	**14,106**	**14,917**	**14,282**
Supplies				
Surface Water	11,881	10,022	12,196	10,012
Groundwater	2,672	3,218	2,636	3,281
Recycled and Desalted	0	0	0	0
Total	**14,553**	**13,239**	**14,832**	**13,293**
Shortage	**111**	**867**	**85**	**989**

TABLE 6A-6

San Joaquin River Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,450	6,719
Environmental	3,396	1,904	3,411	1,919
Total	**10,996**	**9,731**	**10,815**	**9,609**
Supplies				
Surface Water	8,562	6,043	8,458	5,986
Groundwater	2,195	2,900	2,295	2,912
Recycled and Desalted	0	0	0	0
Total	**10,757**	**8,943**	**10,753**	**8,898**
Shortage	**239**	**788**	**63**	**711**

TABLE 6A-7

Tulare Lake Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,123	9,532
Environmental	1,672	809	1,676	813
Total	**13,098**	**11,525**	**12,897**	**11,443**
Supplies				
Surface Water	7,888	3,693	7,791	3,593
Groundwater	4,340	5,970	4,386	5,999
Recycled and Desalted	0	0	0	0
Total	**12,228**	**9,663**	**12,177**	**9,592**
Shortage	**870**	**1,862**	**720**	**1,851**

TABLE 6A-8

North Lahontan Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

TABLE 6A-9

South Lahontan Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	238	238	619	619
Agricultural	332	332	257	257
Environmental	107	81	107	81
Total	**676**	**651**	**983**	**957**
Supplies				
Surface Water	322	259	437	326
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**712**	**649**
Shortage	**89**	**92**	**270**	**308**

TABLE 6A-10

Colorado River Region Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	418	418	740	740
Agricultural	4,118	4,118	3,583	3,583
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,367**	**4,366**
Supplies				
Surface Water	4,154	4,128	3,920	3,909
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,221**	**4,208**
Shortage	**69**	**95**	**147**	**158**

6B

Applied Water Shortages by Hydrologic Region with Existing Facilities and Programs

Tables 6B-1 through 6B-4 show applied water shortages by hydrologic region with existing facilities and programs. Water shortages vary widely from region to region. For example, the North Coast and San Francisco Bay Regions are not expected to experience future shortages during average years, but will see shortages in drought years. Most of the State's remaining regions experience average year and drought year shortages now, and are forecasted to experience increased shortages in 2020.

The largest average year shortages are forecasted for the Tulare Lake and South Coast Regions, areas that rely heavily on imported water supplies. Future average year shortages in the Tulare Lake Region reflect groundwater overdraft. Future average year shortages in the South Coast Region reflect forecasted population growth, plus lower Colorado River supplies as California reduces its use of Colorado River water to the State's basic apportionment.

TABLE 6B-1

Applied Water Shortages by Hydrologic Region (taf), 1995-Level Average Year[a]

Region	*Overdraft*	*Other*	*Total*
North Coast	0	0	0
San Francisco Bay	0	0	0
Central Coast	214	0	214
South Coast	0	0	0
Sacramento River	33	78	111
San Joaquin River	239	0	239
Tulare Lake	820	50	870
North Lahontan	0	0	0
South Lahontan	89	0	89
Colorado River	69	0	69
Total (rounded)	**1,460**	**130**	**1,590**

[a] With existing facilities and programs.

TABLE 6B-2

Applied Water Shortages by Hydrologic Region (taf), 1995-Level Drought Year[a]

Region	*Overdraft*	*Other*	*Total*
North Coast	0	177	177
San Francisco Bay	0	349	349
Central Coast	214	68	282
South Coast	0	508	508
Sacramento River	33	834	867
San Joaquin River	239	549	788
Tulare Lake	820	1,042	1,862
North Lahontan	0	128	128
South Lahontan	89	3	92
Colorado River	69	26	95
Total (rounded)	**1,460**	**3,690**	**5,150**

[a] With existing facilities and programs.

TABLE 6B-3

Applied Water Shortages by Hydrologic Region (taf), 2020-Level Average Year[a]

Region	*Overdraft*	*Other*	*Total*
North Coast	0	0	0
San Francisco Bay	0	0	0
Central Coast	102	70	172
South Coast	0	944	944
Sacramento River	85	0	85
San Joaquin River	63	0	63
Tulare Lake	670	50	720
North Lahontan	0	10	10
South Lahontan	89	181	270
Colorado River	61	86	147
Total (rounded)	**1,070**	**1,340**	**2,410**

[a] With existing facilities and programs.

TABLE 6B-4

Applied Water Shortages by Hydrologic Region (taf), 2020-Level Drought Year[a]

Region	*Overdraft*	*Other*	*Total*
North Coast	0	194	194
San Francisco Bay	0	287	287
Central Coast	102	168	270
South Coast	0	1,317	1,317
Sacramento River	85	904	989
San Joaquin River	63	648	711
Tulare Lake	670	1,181	1,851
North Lahontan	0	128	128
South Lahontan	89	219	308
Colorado River	61	97	158
Total (rounded)	**1,070**	**5,140**	**6,210**

[a] With existing facilities and programs.

6C

Estimating a Water Management Option's Unit Cost

A key consideration in the options evaluation process is the appraisal of costs, both financial and economic. Financial costs are the expenditures required to repay debt (with interest) incurred to finance capital costs of a project and to meet operations, maintenance, and replacement costs. Generally, financial costs are spread over a shorter time period than the life of the project. In comparison, economic costs reflect the costs of resources committed to the construction and operation of a project over its life, which can be 50 years or more for many water resources options. It is possible for options to be economically feasible and financially infeasible, or vice versa.

This appendix focuses upon economic costs. Although economic costs can be expressed in many different ways, a useful statistic is the economic cost per acre-foot of option delivery. The mathematical computation of unit cost is not difficult, but does entail several considerations.

Considerations Common to All Options

Data Availability

Cost estimates require extensive data on an option's costs and its operation under different hydrologic conditions. Costs include capital and annual operations, maintenance, and replacement costs. Capital costs are associated with construction and implementation of an option (including transportation and treatment facilities). Examples of capital costs include expenditures for planning, design, right-of-way, construction, and environmental mitigation. Capital costs also include activation costs (operation and maintenance expenditures prior to operations) and reservoir filling costs. OM&R costs include administration, energy, water purchases, water treatment, and replacement costs incurred during the normal course of project use.

For many options (such as surface water reservoirs and groundwater/conjunctive use projects), hydrology is key to evaluating the option's performance. Some options are designed to provide maximum deliveries during average and wet years and minimal deliveries during drought years; others are designed to provide maximum deliveries during drought years with minimal deliveries during other years. Some options can provide a relatively constant supply regardless of water year type.

Because this Bulletin focuses on local options, cost estimates are dependent upon cost and hydrology data available in existing reports and other documents prepared by water agencies. Some difficulties that arise in using this information include:

- Data are inconsistent among the agencies (different hydrologic time periods were used).
- Data are missing or incomplete (sometimes capital costs are reported, but not operating costs).
- Data may be available, but information about assumptions used in their development is not available (reported total capital costs may or may not include environmental mitigation costs).
- Data were developed at different times (information on some options is relatively new, while other data may be 30 years old).
- Data were developed at different levels of study (appraisal level data are being compared to feasibility level data).

Since the Bulletin's intent is to examine options from a statewide perspective at an appraisal level of detail, the approach used has been to acknowledge that these difficulties exist, but to use the available information. The scope of this Bulletin does not permit development of new information for all of the options for which data were collected. The Bulletin's efforts focused on making costs of the statewide options and larger local options comparable, where possible.

Assumptions

Two analysis periods were used—a 50-year period for capital-intensive options (reservoirs, desalting plants, conjunctive use facilities) and a 25-year period for less capital-intensive options (demand reduction).

The analysis used constant dollars, thus excluding price changes occurring as a result of inflation. The time value of money is represented by a 6 percent discount rate. Dollar values are converted to constant 1995 dollars using USBR's cost index or other cost indices as appropriate. Statewide probabilities for the occurrence of drought years and average years are 20 and 80 percent, respectively.

Method of Analysis

A spreadsheet was developed for cost computations. Table 6C-1 shows the results of a sample cost analysis for four hypothetical water management options using this spreadsheet.

Considerations Specific to Some Options

Conservation

In order to achieve savings from many demand reduction options (landscape retrofits, toilet retrofits), water users rather than water districts must purchase additional equipment. Because of the substantial user costs of some conservation options, they must be addressed in cost estimates. Since the Bulletin 160-98 options evaluation process is focused on costs from the water agency perspective, it is assumed that costs of demand reduction options are funded by water agencies, including reimbursements to water users for costs such as landscape replacement or sprinkler controller installation.

Water Recycling

Costs of water recycling vary with the intended use of the water, due to differences in treatment requirements. Costs of recycling projects are highly site-specific, since costs of associated conveyance and distribution systems may constitute a large percent of the total project cost.

Conjunctive Use Projects

Because conjunctive use projects often involve many types of facilities and are operated according to changes in hydrology, computing cost estimates can be complex. Hydrology is key to the operation of many conjunctive use projects because usually the recharge portion of the project is operated in average years and the extraction portion is operated in drought years. Facilities may not be operated during years where there is insufficient water for recharge, or when conditions are too wet to warrant extractions. Although capital costs of a conjunctive use project are not significantly influenced by hydrology, annual O&M costs are sensitive to hydrology because of pumping costs.

Surface Water Reservoirs

Some reservoirs are operated to maximize water supplies during average years and others are operated

TABLE 6C-1

Sample Cost Computation

Option	*Option Delivery (taf)*		*Probabilities (%)*		*Capital Costs (Million $)*	*Annual Variable Costs (Million$)*		*Unit Cost ($/af)*
	Average	*Drought*	*Average*	*Drought*		*Average*	*Drought*	
Groundwater Recharge/ Conjunctive Use	0	15	80.0	20.0	4.0	0.1	0.6	150
Water Transfers[a]	0	2	80.0	20.0	0.0	0.0	0.5	250
Water Recycling	3	3	80.0	20.0	24.0	0.6	0.6	710
Surface Water Reservoir	10	3	80.0	20.0	80.0	1.0	2.0	730

[a] Using existing facilities.

for drought years or emergency storage purposes. Although the capital cost to construct a reservoir will be the same regardless of its operation, the cost of water supply will differ substantially among these operational modes. A reservoir's O&M costs will vary significantly depending upon whether it provides on-stream or off-stream storage (the latter operation will likely have substantial energy costs associated with reservoir filling). Of supply augmentation options, reservoirs are most likely to provide substantial benefits other than water supply, such as recreation, flood control, and power generation. No attempt is made in this Bulletin to allocate the costs among different purposes, because cost allocation goes beyond the Bulletin's appraisal-level scope of analysis.

Water Marketing

Water transfer costs shown in the Bulletin are generally those reported by local agencies for their proposed marketing arrangements. Costs reported by local agencies are often the contractual prices contained in transfer agreements. Such costs usually do not include environmental mitigation costs or costs relating to third-party impacts.

6D

Calculation of Minimum New Water Needs

Calculations of lower bound, or minimum, new water needs from 2020-level applied water budget shortages are presented by hydrologic region in Tables 6D-1 and 6D-2. In an applied water budget, supply and percent reapplication are defined as:

applied water supply = supply from primary sources + supply from reapplication ... (1)

percent reapplication = (supply from reapplication / supply from primary sources) x 100 ... (2)

In the tables, percent reapplication is calculated for each region from primary supplies and reapplied supplies (both surface water and groundwater) according to equation (2). This calculation is performed only in planning subareas that are forecasted to experience shortages in 2020.

Assuming that new supplies from water management options may be reapplied in the same proportion that existing primary supplies are reapplied, an applied water yield and a percent reapplication for the options may be similarly defined as:

applied water yield = new water supply + reapplication potential ... (3)

percent reapplication = (reapplication potential / new water supply) x 100 ... (4)

By substituting equation (4) into equation (3) and rearranging terms, a regional new water need may be defined as a function of a regional applied water shortage:

new water need = applied water shortage / (1 + [reapplication potential/100]) ... (5)

If the potential to reapply new water supplies does not exist in a region, then according to equation (5), the new water need (maximum) is equal to the region's applied water shortage. If the potential to fully reapply new water supplies exists in a region, then equation (5) defines a minimum new water need. In the tables, the water shortage not due to overdraft ("other" shortage) is adjusted downward by the percent reapplication in accordance with equation (5). This value is summed with the overdraft shortage to arrive at the minimum new water need for the region.

As discussed in Chapter 3, regional supplies generated through groundwater overdraft are excluded from the Bulletin 160-98 water budgets because they do not represent sustainable sources of water supply. Excluding these supplies from the water budgets results in additional regional shortages. However, for clarity of presentation, the regional supplies available through reapplication of overdrafted groundwater supplies are not excluded from the water budgets. Therefore, shortages due to overdraft are not adjusted by the percent reapplication in Tables 6D-1 and 6D-2 to arrive at regional new water needs.

Based on the data presented in Table 6D-1, the minimum new water required to satisfy 2020 average year shortages is approximately 2.2 maf. Similarly, Table 6D-2 shows the minimum new water required to satisfy 2020 drought year shortages is approximately 5.4 maf. As discussed in Chapter 6, not all water management options are created equal in their ability to meet new water needs. Demand reduction options, for example, do not provide new water to a region, and no opportunities exist to multiply their effectiveness through reapplication. Therefore, if a region's options mix includes demand reduction options, the region's new water need will be greater than the minimum need.

TABLE 6D-1

Minimum New Water Needs by Hydrologic Region: 2020 Average Year

Region	*Percent[a] Reapplication*	*Shortage (taf)*		*Minimum New Water Need (taf)*
		Overdraft	*Other*	
North Coast	—	0	0	0
San Francisco Bay	—	0	0	0
Central Coast	24.1	102	70	159
South Coast	12.5	0	944	839
Sacramento River	33.3	85	0	85
San Joaquin River	16.4	63	0	63
Tulare Lake	11.4	670	50	715
North Lahontan	5.4	0	10	9
South Lahontan	35.8	89	181	223
Colorado River	24.6	61	86	130
Total (rounded)	**16.4**	**1,070**	**1,340**	**2,220**

[a] Percent reapplication is computed from supply data for PSAs that are forecasted to experience shortages in 2020.

TABLE 6D-2

Minimum New Water Needs by Hydrologic Region: 2020 Drought Year

Region	*Percent[a] Reapplication*	*Shortage (taf)*		*Minimum New Water Need (taf)*
		Overdraft	*Other*	
North Coast	38.8	0	194	140
San Francisco Bay	0.5	0	287	286
Central Coast	17.8	102	168	245
South Coast	10.4	0	1,317	1,192
Sacramento River	26.3	85	904	801
San Joaquin River	17.4	63	648	615
Tulare Lake	24.0	670	1,181	1,623
North Lahontan	16.5	0	128	110
South Lahontan	34.8	89	219	252
Colorado River	25.3	61	97	138
Total (rounded)	**18.8**	**1,070**	**5,140**	**5,400**

[a] Percent reapplication is computed from supply data for PSAs that are forecasted to experience shortages in 2020.

6E

Net Water Budgets

The following tables show the net water budgets for each of the State's ten hydrologic regions with existing facilities and programs, and then California's net water budget with existing facilities and programs. Water use/supply totals and shortages may not sum due to rounding.

TABLE 6E-1

North Coast Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	169	177	201	212
Agricultural	683	714	699	740
Environmental	19,378	9,393	19,378	9,393
Total	**20,230**	**10,283**	**20,278**	**10,344**
Supplies				
Surface Water	20,003	9,887	20,029	9,911
Groundwater	214	239	236	261
Recycled and Desalted	13	14	13	14
Total	**20,230**	**10,139**	**20,278**	**10,186**
Shortage	**0**	**144**	**0**	**158**

TABLE 6E-2

San Francisco Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	1,255	1,358	1,317	1,428
Agricultural	87	96	87	95
Environmental	1,782	1,284	1,782	1,284
Total	**3,124**	**2,738**	**3,185**	**2,808**
Supplies				
Surface Water	3,024	2,267	3,080	2,400
Groundwater	65	87	69	84
Recycled and Desalted	35	35	37	37
Total	**3,124**	**2,389**	**3,185**	**2,520**
Shortage	**0**	**349**	**0**	**287**

TABLE 6E-3

Central Coast Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	243	253	320	334
Agricultural	912	975	884	947
Environmental	84	22	84	22
Total	**1,238**	**1,250**	**1,288**	**1,303**
Supplies				
Surface Water	252	118	301	140
Groundwater	754	826	772	861
Recycled and Desalted	18	26	42	42
Total	**1,024**	**970**	**1,115**	**1,043**
Shortage	**214**	**280**	**172**	**260**

TABLE 6E-4

South Coast Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	3,973	3,999	4,943	5,009
Agricultural	692	722	421	442
Environmental	27	27	31	31
Total	**4,691**	**4,748**	**5,395**	**5,481**
Supplies				
Surface Water	3,400	2,758	3,184	2,704
Groundwater	1,084	1,274	1,155	1,380
Recycled and Desalted	207	207	273	273
Total	**4,691**	**4,240**	**4,612**	**4,357**
Shortage	**0**	**508**	**783**	**1,125**

TABLE 6E-5

Sacramento River Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	765	829	1,139	1,235
Agricultural	6,529	7,251	6,436	7,041
Environmental	3,845	3,260	3,854	3,263
Total	**11,139**	**11,340**	**11,429**	**11,538**
Supplies				
Surface Water	8,814	7,880	9,159	7,895
Groundwater	2,229	2,699	2,184	2,769
Recycled and Desalted	0	0	0	0
Total	**11,043**	**10,579**	**11,344**	**10,665**
Shortage	**96**	**760**	**85**	**873**

TABLE 6E-6

San Joaquin River Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	417	432	673	698
Agricultural	5,818	6,284	5,286	5,784
Environmental	1,249	831	1,263	845
Total	**7,484**	**7,546**	**7,221**	**7,328**
Supplies				
Surface Water	6,190	4,743	6,096	4,696
Groundwater	1,055	2,118	1,063	2,026
Recycled and Desalted	0	0	0	0
Total	**7,245**	**6,861**	**7,159**	**6,722**
Shortage	**239**	**685**	**63**	**606**

TABLE 6E-7

Tulare Lake Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	347	358	514	533
Agricultural	7,659	7,817	7,248	7,386
Environmental	37	37	39	39
Total	**8,043**	**8,211**	**7,801**	**7,957**
Supplies				
Surface Water	6,226	2,894	6,129	2,794
Groundwater	957	3,684	962	3,568
Recycled and Desalted	0	0	0	0
Total	**7,183**	**6,578**	**7,091**	**6,361**
Shortage	**860**	**1,634**	**710**	**1,596**

TABLE 6E-8

North Lahontan Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	32	33	41	42
Agricultural	470	514	470	516
Environmental	174	136	174	136
Total	**675**	**683**	**685**	**695**
Supplies				
Surface Water	531	384	506	378
Groundwater	136	171	161	190
Recycled and Desalted	8	8	8	8
Total	**675**	**564**	**675**	**576**
Shortage	**0**	**120**	**10**	**119**

TABLE 6E-9

South Lahontan Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	160	160	412	412
Agricultural	291	291	230	230
Environmental	107	81	107	81
Total	**558**	**532**	**750**	**724**
Supplies				
Surface Water	244	181	338	234
Groundwater	198	232	201	252
Recycled and Desalted	27	27	27	27
Total	**469**	**440**	**566**	**514**
Shortage	**89**	**92**	**184**	**210**

TABLE 6E-10

Colorado River Region Net Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	312	312	526	526
Agricultural	3,847	3,847	3,412	3,412
Environmental	39	38	44	43
Total	**4,197**	**4,196**	**3,982**	**3,981**
Supplies				
Surface Water	4,047	4,021	3,809	3,800
Groundwater	66	77	79	79
Recycled and Desalted	15	15	15	15
Total	**4,128**	**4,113**	**3,903**	**3,894**
Shortage	**69**	**83**	**79**	**88**

TABLE 6E-11

California Net Water Budget with Existing Facilities and Programs (maf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Net Water Use				
Urban	7.7	7.9	10.1	10.4
Agricultural	27.0	28.5	25.2	26.6
Environmental	26.7	15.1	26.8	15.1
Total	**61.4**	**51.5**	**62.0**	**52.2**
Supplies				
Surface Water	52.7	35.1	52.6	35.0
Groundwater	6.8	11.4	6.9	11.5
Recycled and Desalted	0.3	0.3	0.4	0.4
Total	**59.8**	**46.9**	**59.9**	**46.8**
Shortage	**1.6**	**4.7**	**2.1**	**5.3**

6F

Land Retirement Analysis in Drainage-Impaired Areas

The San Joaquin Valley Interagency Drainage Program's 1990 report stated that 75,000 acres of land with the worst drainage problems would need to be retired by 2040 unless other actions were taken to improve drainage problems in the area. Assuming that land retirement would occur uniformly over time, the Bulletin's 2020 irrigated acreage forecast includes a reduction of 45,000 acres of land due to impaired drainage, as discussed in Chapter 4. Existing or future programs in which land is purchased and then taken out of irrigated agriculture could increase the acreage taken out of production. Considering the region's chronic agricultural water shortages, it is likely that local water agencies would want to keep the water in the region to improve water supplies for remaining irrigated lands, as is being planned in a pending joint financing arrangement between USBR and WWD.

Bulletin 160-98 does not treat land retirement for drainage purposes as a future demand reduction option. The Bulletin's scope is limited to actions whose primary intent is demand reduction or water supply augmentation. Because land retirement for drainage purposes would affect water use, the following analysis has been provided to quantify water supply impacts. Two land retirement scenarios were evaluated. Scenario 1 assumed that the full 75,000 acres of agricultural lands with the worst drainage problems recommended for retirement by 2040 by the interagency program would be retired by 2020, adding 30,000 acres to the base 45,000 acres included in the Department's 2020 agricultural acreage forecast. Scenario 2 assumed the retirement of up to 85,000 acres over the base 45,000 acres for a total of 130,000 retired acres. This included the 30,000 acres in Scenario 1 plus other lands in the westside of the San Joaquin Valley with a selenium concentration of more than 200 ppb in shallow groundwater. For Scenario 2, the 200 ppb selenium criterion was used to benchmark acreage to be retired because of the interagency report's recommendations. The acreage of land underlain by shallow groundwater has fluctuated over time, reflecting hydrologic conditions and the availability of water supplies in the region. There has been no new region-wide monitoring of selenium in shallow groundwater since publication of the 1990 report, and changes in the extent of lands underlain by high selenium groundwater are unknown. (As described in Chapter 4, the interagency drainage program is in the process of updating its 1990 recommendations based on new information.)

To help put these acreage values into perspective, in 1997 USBR's land retirement program issued its first request for proposals from persons who wished to retire land pursuant to the CVPIA program. USBR received proposals totaling 31,000 acres. Based on its 1998 budget, USBR expects to retire about 12,000 acres of the lands proposed, with additional lands expected to be retired in future budget years. In 1998, USBR released an environmental assessment and finding of no significant impact for a demonstration project on about 1,890 acres of lands acquired or planned to be acquired under the land retirement program. The demonstration program would evaluate wildlife habitat management actions on the retired lands. Under a separate agreement with WWD, the agricultural water supplies associated with the lands would remain within WWD, and part of the supplies would be used to irrigate wildlife habitat. Water used for habitat irri-

TABLE 6F-1

Agricultural Depletion Reductions Due to Land Retirement

Crops	Scenario 1 Land Retired (acres)	Scenario 1 Depletions (af/yr)	Scenario 2 Land Retired (acres)	Scenario 2 Depletions (af/yr)
Alfalfa	2,370	8,560	4,740	17,290
Irrigated Pasture	60	220	160	580
Barley	3,080	3,880	9,160	11,540
Wheat	5,850	8,660	14,980	22,170
Cotton	12,830	33,490	41,600	108,580
Safflower	4,390	4,430	9,690	9,790
Sugar Beets	60	170	350	990
Dry Beans	470	900	1,470	2,820
Dry Onions	190	500	520	1,370
Tomatoes (processing)	480	1,280	1,730	4,600
Almonds	110	360	220	690
Pistachios	10	20	80	240
Wine Grapes	100	220	250	550
Total (rounded)	**30,000**	**62,700**	**85,000**	**181,200**

gation would be limited to 0.6 af/acre, to avoid deep percolation of applied water.

Table 6F-1 displays the crops calculated to be retired for both scenarios along with the expected reductions in depletions. Field crops are the primary types of crops calculated to be retired, based on Central Valley Production Model results, with barley, wheat, cotton, and safflower comprising almost 90 percent of total retired acreage for each option.

The costs of land retirement scenarios are measured by the estimated costs to purchase farmland and remove it from irrigated agricultural production. Table 6F-2 shows land retirement costs for either permanently taking the farmland out of agricultural production or for taking it out of irrigated agricultural production.

Implementing land retirement programs can be controversial because of concerns about third-party impacts to those who do not benefit from sale of the land or its associated water supply. (Direct farm income losses to growers should be recovered through land purchase costs.) To illustrate the magnitude of potential third-party impacts, Tables 6F-3 and 6F-4 show economic effects of the land retirement scenarios. These effects would need to be addressed in environmental documentation for land retirement programs. Environmental documentation prepared to date for land retirement activities has not proposed specific mitigation measures for third-party economic impacts. There has thus been no basis for allocating costs in addition to the land purchase price to the costs shown in this analysis. Third-party impacts associated with managed land retirement programs on the westside of the San Joaquin Valley would be of particular concern to city and county governments in the area, because agricultural activities provide the dominant source of employment in many of the small rural communities on the westside.

TABLE 6F-2

Costs of Land Retirement (1995 Dollars)

Land Retirement Assumptions	Scenario 1 Total Cost Per Acre	Scenario 1 Annualized Cost Per Acre[a]	Scenario 1 Cost Per af of Depletions	Scenario 2 Total Cost Per Acre	Scenario 2 Annualized Cost Per Acre[a]	Scenario 2 Cost Per af of Depletions
With No Alternative Uses	1,550	121	55	1,760	138	63
With Grazing	1,420	111	51	1,640	128	59

[a] For a 25 year period and 6% discount rate.

TABLE 6F-3

Land Retirement Analysis—Scenario 1 Economic Impacts (1995 Dollars)

		Direct, Indirect, Induced Effects			
		Value of Production		Employment	
Crops	*Acres Retired*	*Regional[a] ($1,000)*	*Statewide ($1,000)*	*Regional[a] (person years)*	*Statewide (person years)*
Alfalfa	2,370	3,980	4,190	56	58
Irrigated Pasture	60	50	50	1	1
Barley	3,080	1,730	1,960	29	30
Wheat	5,850	5,180	5,510	73	77
Cotton	12,830	32,480	34,650	535	541
Safflower	4,390	3,670	4,000	59	61
Sugar Beets	60	120	120	2	2
Dry Beans	470	750	850	10	10
Dry Onions	190	500	540	7	7
Tomatoes (processing)	480	1,590	1,740	22	23
Almonds	110	710	770	14	14
Pistachios	10	70	70	1	1
Wine Grapes	100	500	560	10	10
Totals (rounded)	**30,000**	**51,300**	**55,000**	**820**	**830**

[a] Includes Fresno, Kern, and Kings Counties.

TABLE 6F-4

Land Retirement Analysis—Scenario 2 Economic Impacts (1995 Dollars)

		Direct, Indirect, Induced Effects			
		Value of Production		Employment	
Crops	*Acres Retired*	*Regional[a] ($1,000)*	*Statewide ($1,000)*	*Regional[a] (person years)*	*Statewide (person years)*
Alfalfa	4,790	8,050	8,460	114	118
Irrigated Pasture	160	120	130	2	2
Barley	9,160	5,140	5,840	86	88
Wheat	14,980	13,240	14,100	187	196
Cotton	41,600	105,300	112,350	1,735	1,756
Safflower	9,690	8,090	8,830	129	134
Sugar Beets	350	680	720	11	12
Dry Beans	1,470	1,920	2,180	32	33
Dry Onions	520	1,360	1,490	19	19
Tomatoes (processing)	1,730	5,740	6,280	80	81
Almonds	220	1,380	1,510	26	27
Pistachios	80	770	840	15	15
Wine Grapes	250	1,250	1,410	24	24
Totals (rounded)	**85,000**	**153,000**	**164,100**	**2,460**	**2,510**

[a] Includes Fresno, Kern, and Kings Counties.

6G

Review and Evaluation of Statewide-Level Storage Facilities That Could Be Included in CAL-FED Alternatives

Evaluation of Onstream Storage Options Upstream of the Delta

The initial screening of storage options included the 34 reservoir sites shown in Table 6G-1. These sites have been investigated, so information was available to support a preliminary assessment. After the initial screening, 15 remaining options were examined in detail. This appraisal relied on previous studies covering traditional project formulation, engineering feasibility, cost, and environmental aspects. The older studies were supplemented by a cursory reexamination of environmental aspects that reflected the most recent information on critical habitat, wetlands, endangered species, and cultural resources. Because past studies were limited, these environmental reexaminations generated few conclusive findings. The larger reservoirs on major waterways tend to have the most potential environmental consequences. And, there is a definite correlation between the intensity of prior studies and the number of known potential environmental problem issues. The potential environmental issues at the 15 retained options are shown in Table 6G-2.

The appraisal process confirmed that larger projects tend to have the potential to produce less costly and more reliable water supply, but have greater potential impacts on the environment. There is no one accepted method to compare options, particularly those of vastly differing size, but clear conclusions emerged from assessing options within similar groups.

Very Large Onstream Reservoirs (Over 1.0 maf)

With the potential to provide up to 10 maf of additional storage, an enlarged Lake Shasta is in a class apart; at large sizes, it could provide new storage at a favorable unit cost, but with substantial financial and environmental consequences. In the 1.0-2.5 maf range, Auburn Reservoir ranks high, but is burdened with well-publicized environmental controversies. As discussed in Chapter 3, there is an urgent need for greater flood protection on the American River, and a dam at Auburn has been identified by the Reclamation Board as the best flood control alternative. A Thomes-Newville development in the Stony Creek basin remains a possibility, provided it is sized to match its limited water supply; the site also has potential for offstream storage of adjacent basin or Sacramento River water.

The Trinity enlargement option involves a new concept that has not been investigated in detail. The fundamental premise is sound: divert surplus water directly from Lake Shasta to an enlarged Trinity Lake on the Trinity River. This would reap some benefits of enlarging Lake Shasta without the associated major disruptions or relocation costs. The less attractive aspects include a 13-mile tunnel, a 1,500-foot pump lift, and substantial energy costs. This option appears to be more costly than enlarging Lake Shasta, but within the range of consideration. More information on environmental aspects would be needed for a better assessment. Experience has shown large projects at this stage often harbor unexpected environmental drawbacks. Currently, enlarging Trinity Lake is characterized as a future possibility, but not yet thoroughly explored.

TABLE 6G-1

Onstream Storage Options Upstream of the Delta

Stream	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Cache Creek	Wilson Valley	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
	Kennedy Flats	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
	Blue Ridge	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
Stony Creek	Newville (Part of Thomes-Newville Complex)	Retain	
Thomes Creek	Thomes Division (Part of Thomes-Newville Complex)	Retain	
	Paskenta	Defer	Defer in favor of alternate site in same general area.
Elder Creek	Gallatin	Defer	Limited water supply to support significant amount of storage.
Red Bank Creek	Schoenfield (Part of Red Bank Project)	Retain	
S.F. Cottonwood Creek	Dippingvat (Part of Red Bank Project)	Retain	
	Rosewood (Dry Creek)	Defer	Limited water supply to support significant amount of storage.
	Tehama	Retain	
M.F. Cottonwood Creek	Fiddlers	Retain	
Cottonwood Creek	Dutch Gulch	Retain	
N.F. Cottonwood Creek	Hulen	Retain	
Lake Shasta Tributaries	Shasta Enlargement	Retain	
	Enlarged Trinity	Retain	
	Squaw Valley (Squaw Valley Cr.)	Defer	Defer due to high costs and substantial environmental impacts.
	Kosk (Pit River)	Retain	
	Allen Camp (Pit River)	Defer	Primarily a local project, not well suited for statewide supply augmentation.
Little Cow Creek	Bella Vista	Defer	Defer due to high costs and substantial environmental impacts.
South Cow Creek	Millville	Retain	
Inks Creek	Wing	Retain	

TABLE 6G-1

Onstream Storage Options Upstream of the Delta (continued)

Stream	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Deer Creek	Deer Creek Meadows	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
Upper Feather River	Abbey Bridge (Red Clover Creek)	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
	Dixie Refuge (Last Chance Creek)	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
Yuba River	Marysville/Narrows	Defer	Defer due to high costs and substantial environmental impacts.
M.F. Yuba River	Freemans Crossing	Defer	Limited water supply to support significant amount of storage and doubtful environmental feasibility.
Bear River	Garden Bar	Defer	Primarily a local project.
N.F. American River	Auburn	Retain	
American River	Folsom Enlargement	Retain	
S.F. American River	Coloma/Salmon Falls	Defer	Defer due to environmental and social/third party impacts.
Cosumnes River	Nashville	Retain	
Mokelumne River	Pardee Enlargement	Defer	Primarily a local project.
San Joaquin River	Millerton Enlargement	Retain	

Large Onstream Reservoirs (0.5 to 1.0 maf)

Tehama and Dutch Gulch reservoirs in the Cottonwood Creek Basin clearly warrant further consideration, possibly at smaller sizes than the 0.7 and 0.9 maf considered in the 1983 USACE feasibility study. As an alternative to Dutch Gulch the upstream Fiddlers Reservoir site has promise, but its optimum size may be smaller than 0.5 maf.

Raising Friant Dam on the San Joaquin River by 120 to 140 feet could more than double the current 520 taf capacity of Millerton Lake. While the expansion would be expensive, it is the only San Joaquin Valley surface storage option that appears to offer potential for statewide supply augmentation. Enlarging Friant Dam also would provide flood control benefits.

Kosk Reservoir on the Pit River and Nashville Reservoir on the Cosumnes River appear to offer some promise for storage in this size range, but scant current information is available on their cost, water supply efficacy, or environmental impacts. Reconnaissance reappraisals could fully assess the practicability of these sites. The Nashville site appears to have significant environmental issues associated with its construction.

Coloma Reservoir on the South Fork American River could provide storage within this size range, but any size over 0.2 maf would inundate the town of Coloma and the Marshall Gold Discovery State Historic Park (which would require legislative authorization under Water Code Section 10001.5). Coloma and the nearby Salmon Falls alternative are unpromising and are deferred from further consideration. Marysville and Narrows sites on the Yuba River also are deferred from further consideration because local interests are evaluating a small facility at a nearby site as a local project.

TABLE 6G-2

Retained Onstream Storage Options and Environmental Issues

Reservoir	*Storage[a] Volume (maf)*	*Potential Environmental Issues*
Very Large Reservoirs		
Shasta Enlargement	up to 14.5	stream/river habitat; wild and scenic rivers; trout fisheries; downstream salmon; downstream seepage and erosion impact; deer; numerous listed and candidate species; cultural resources; disruption of established development
Trinity Enlargement	7.2	stream habitat; wetlands/marshes; sensitive plants; eagles; spotted owls; anadromous fish (Trinity and Sacramento Rivers)
Auburn	0.85 - 2.3	stream habitat; wetlands; wildlife; trout; listed amphibian, insect, and plant species; cultural resources; recreation impacts
Thomes-Newville	1.4 - 1.9	deer; stream habitat; cultural resources; possible minor salmon/steelhead runs
Large Reservoirs		
Tehama	0.5 - 0.7	riparian habitat; salmon/steelhead; deer; upland game; bald eagles; cultural resources; various listed species possible
Dutch Gulch	0.7 - 0.9	riparian habitat; salmon/steelhead; deer; upland game; bald eagles; cultural resources; various listed species possible
Kosk	0.8	stream habitat; deer; elk; bear; upland game; eagles; spotted owls; trout; Big Bend Indian Rancheria
Nashville	0.9	wetland/marsh habitat; stream habitat; deer; upland game
Millerton Enlargement	1.0 - 1.4	stream and upland habitat; disruption of established development
Small to Medium Reservoirs		
Wing	0.25 - 0.5	salmon/steelhead (Battle Creek); deer; several listed bird, amphibian, insect, plant species
Red Bank Project	0.35	stream habitat; California red-legged frog; spring-run salmon
Millville	0.1 - 0.25	stream habitat; salmon
Hulen	0.2 - 0.3	fossils; stream habitat
Folsom Enlargement	1.3	stream and upland habitat; eagles; several listed plant species; cultural resources; disruption of established development
Fiddlers	0.2 - 0.5	stream habitat

[a] Volume shown is total storage volume, including, where applicable, the existing storage capacity of reservoirs to be enlarged.

Small-to-Medium-Sized Onstream Reservoirs (0.1 to 0.5 maf)

Options within this range selected for analysis included three sites on upper Sacramento Valley tributaries that appear to offer acceptable combinations of water supply capability, cost, and environmental compatibility. The largest of these, Wing Reservoir on Inks Creek with a diversion from Battle Creek, could provide over 0.4 maf of storage. The other apparently viable options, both near the lower limit of this size range, are the Red Bank Project on South Fork Cottonwood and Red Bank Creeks, and Millville Reservoir on South Cow Creek. One of the two on-stream reservoirs developed by the Red Bank Project would be used primarily as an offstream storage facility. Hulen Reservoir on North Fork Cottonwood Creek would be high on the list except it would inundate a premier deposit of Cretaceous fossils. (Medium-sized projects involving Cottonwood Creek water, such as the Fiddlers site, are alternatives, not adjuncts, to the larger downstream Tehama and Dutch Gulch storage sites.)

Enlargement of Folsom Lake was among the options considered to provide additional flood control along the lower American River. If that enlargement were practicable, it could provide a valuable increment of water supply storage (depending on the flood operating criteria). That storage would be expensive, so it is unlikely except as an element of a comprehensive flood control package.

The remaining two medium-sized options are Bella Vista Reservoir on Little Cow Creek near Redding and Squaw Valley Reservoir on Squaw Valley Creek near McCloud. These projects appear more expensive and more environmentally disruptive than the competing options. Therefore, they are not considered promising prospects for future development and are deferred from further evaluation.

Evaluation of Offstream Storage Options Upstream of the Delta

The initial screening of upstream of Delta offstream storage options included the 14 proposals in Table 6G-3. The initial screening indicated that eight of those warranted further examination, including a review of past studies and a cursory reexamination of the latest available environmental information. The potential environmental issues identified with the retained options are shown in Table 6G-4. Offstream storage has an inherent environmental advantage because the reservoirs tend to be on minor tributaries, which reduces impacts on live streams and riparian habitat. For most of the larger offstream options, that advantage must be balanced against the potentially severe environmental impacts with diversions from major nearby streams. Evaluating the retained options from that perspective leads to the following general conclusions.

Very Large Offstream Reservoirs (Over 1.0 maf)

Two of the five very large reservoir options have the potential to provide more than 4 maf of new storage, but not without some considerable environmental effects. The existing 1.6 maf Lake Berryessa could be enlarged to provide massive amounts of storage for surplus flows pumped from the lower reaches of the Sacramento River. Past studies have shown the unit cost of storage in the large project sizes would be attractive, though a 31-mile conveyance facility with a 700-foot pump lift would be required. The financial and energy costs of this conveyance would be enormous, as would the environmental consequences. Diversion of around 12,000 cfs from the lower river could prove challenging. Under current conditions, offstream storage of Sacramento River water in an enlarged Lake Berryessa does not appear to hold much promise in the foreseeable future.

TABLE 6G-3

Offstream Storage Options Upstream of the Delta

Watershed	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Putah Creek	Berryessa Enlargement	Retain	
Various	Sites	Retain	
Various	Colusa	Retain	
Stony Creek	Thomes-Newville	Retain	
Stony Creek	Glenn	Retain	
S.F. Cottonwood Creek	Red Bank Project	Retain	
Inks Creek	Tuscan Buttes	Defer	Defer due to substantial environmental impacts.
Bear River	Waldo	Defer	Being actively pursued by Yuba County Water Agency; not considered for statewide supply.
Deer Creek	County Line	Defer	Defer in favor of alternate site in same general area.
Deer Creek	Deer Creek	Retain	
Laguna Creek	Clay Station	Retain	
Calaveras River	Duck Creek	Defer	Defer due to extraordinarily high costs.
Calaveras River	South Gulch	Defer	Primarily a local project, not well suited for statewide supply augmentation.
Littlejohns Creek	Farmington Enlargement	Defer	Primarily a local project, not well suited for statewide supply augmentation.

TABLE 6G-4

Retained Offstream Storage Options and Environmental Issues

Reservoir	*Storage Volume (maf)*	*Potential Environmental Issues*
Very Large Reservoirs		
Berryessa Enlargement	up to 11.5 additional	stream habitat; wetlands; deer and upland game; Putah Creek trout fishery; Sacramento River anadromous fish; listed/sensitive plant species; cultural resources; disruption of established agriculture and recreation; population displacement
Thomes-Newville	1.4 -1.9	deer; stream habitat; cultural resources; possible minor salmon/ steelhead runs
Glenn	6.7 - 8.7	stream habitat; wetlands/vernal pools; deer and upland game; deer winter range; Sacramento River anadromous fish; eagles; cultural resources; population displacement
Sites	1.2 - 1.8	Sacramento River anadromous fish
Colusa	3.0	Sacramento River anadromous fish
Large Reservoirs		
Deer Creek	0.6	vernal pools; meadow/marsh habitat; listed bird, invertebrate, insect, and plant species; cultural resources
Small to Medium Reservoirs		
Red Bank	0.35	stream habitat; California red-legged frog; spring-run salmon
Clay Station	0.2	stream habitat; wetlands; meadow/marsh habitat; listed bird, invertebrate, insect, and plant species

Similarly, a Glenn Reservoir, a combination of Thomes-Newville Reservoir on the North Fork Stony Creek and Rancheria Reservoir on the mainstem of Stony Creek would provide over 8 maf of storage for surplus water of the upper Sacramento River. The two-compartment Glenn Reservoir was conceived as terminal storage for exports from the North Coast rivers. Following passage of the Wild and Scenic Rivers Act of 1972, it was reformulated for offstream storage of water diverted from the Sacramento River. The unit cost of storage appeared reasonable, but controversy over diversions to the Tehama-Colusa Canal cast doubt on the environmental feasibility of diverting large flows to support the large-scale Glenn Reservoir. At this time, a large Glenn Reservoir does not appear to be a likely candidate for early construction. The smaller Thomes-Newville Reservoir (1.4 to 1.9 maf) operated as an offstream storage reservoir remains a possibility.

The other very large offstream storage options, Sites and Colusa Reservoirs, are related, in that the 3 maf Colusa Reservoir represents a northward expansion of the 1.2 to 1.8 maf Sites Reservoir into the Hunter and Logan Creek Basins. Either version of the reservoir would involve minimal environmental impacts within the area of inundation. The drawback is diverting surplus water from the Sacramento River for storage. Past proposals have focused on off-season use of the existing Tehama-Colusa Canal diversion facilities at Red Bluff Diversion Dam and the Glenn-Colusa Irrigation District pumping plant near Hamilton City. Alternative Sites/Colusa conveyance facilities are now being examined. Although the alternative conveyance facilities would likely raise costs, the Sites and Colusa offstream storage options remain the most promising.

Large Offstream Reservoirs (0.5 to 1.0 maf)

Deer Creek Reservoir in northeastern Sacramento County is the only upstream of Delta offstream storage option within this size range. Past investigators have examined a 0.6 maf Deer Creek Reservoir to store surplus water from the American River, delivered from an enlargement of the existing northern reaches of the Folsom South Canal. Another version of the project was considered for flood control, incorporating a gravity diversion direct from Folsom Lake via a new outlet at Mormon Island Dike. Major offstream storage in the Deer Creek area would be ideally suited to develop some of the abundant surplus flow of the American

River without the difficulties associated with Auburn Dam. Also, by diverting directly from Folsom Lake or Lake Natoma, this project would avoid the principal conflicts with anadromous fish. Initial studies indicate a Deer Creek offstream storage project would be expensive—with a unit storage cost several times that of the lower-cost options.

Small to Medium Offstream Reservoirs (0.1 to 0.5 maf)

Two options fall into this range, the Red Bank Project and Clay Station Reservoir. The Red Bank Project would consist of a 100 taf Dippingvat Reservoir and a 250 taf Schoenfield Reservoir. Dippingvat Reservoir would store water from the South Fork of Cottonwood Creek. Water would be diverted from Dippingvat to Schoenfield Reservoir where it would later be released down Red Bank Creek to the Sacramento River. Water could also be released via a new conveyance facility to the Corning Canal or the Tehama-Colusa Canal.

The Clay Station Reservoir is a smaller version of Deer Creek Reservoir, but 8 miles south. Its storage cost would be similar to Deer Creek's (very high). With its small size and high cost, Clay Station Reservoir offers little promise as a statewide water supply option.

Likely Storage Options Upstream of the Delta

Figure 6G-1 shows the location of likely surface storage options upstream of the Delta. This reappraisal of surface reservoir options identified several that appear to offer the best prospects. Foremost in this group, in order of size, are:

- Colusa Reservoir, 3.0 maf offstream
- Thomes-Newville Reservoir, 1.4 to 1.9 maf offstream
- Sites Reservoir, 1.2 to 1.8 maf offstream
- Dutch Gulch Reservoir, 0.7 to 0.9 maf onstream (or its upstream alternative, Fiddlers Reservoir, 0.2 to 0.5 maf)
- Tehama Reservoir, 0.5 to 0.7 maf onstream
- Wing Reservoir, 0.25 to 0.5 maf onstream (with Battle Creek diversion)
- Red Bank Project, 0.35 maf onstream and offstream
- Millville Reservoir, 0.1 to 0.25 maf onstream

A second tier of options offers substantial water supply potential, but with greater environmental impacts and/or economic costs that create some uncertainty about their implementability. From a flood control standpoint, enlarged Shasta, Auburn, and enlarged Millerton would provide important benefits. In order of size, these sites are:

- Enlarged Lake Berryessa, up to 11.5 maf additional offstream
- Enlarged Lake Shasta, up to 10 maf additional onstream
- Glenn Reservoir, 6.7 to 8.7 maf offstream
- Auburn Reservoir, 0.85 to 2.3 maf onstream
- Thomes-Newville Reservoir, 1.4 to 1.9 maf onstream
- Enlarged Millerton Lake, 0.5 to 0.9 maf additional onstream
- Enlarged Folsom Lake, 0.37 maf additional onstream

A third group of options includes one that may be a viable alternative, but for which limited information is available. This site might be characterized as "worthy of a second look" in the future:

- Kosk Reservoir, 0.8 maf onstream

Operation of Storage Upstream of the Delta

Additional surface storage upstream of the Delta would be effective if operated with major water supply reservoirs in the basin, principally Shasta, Oroville, and Folsom. Under California's water rights hierarchy, new facilities may store surplus water that is not needed to meet preexisting rights. Since virtually no surplus water is available during the irrigation season, storage in new projects will be limited to late fall, winter, and early spring. Most storable flow occurs during periods of flood runoff. But, under certain conditions, coordinated operation with other reservoirs may allow occasional storage of fall releases made to achieve mandatory flood reservations.

A Sites Reservoir offstream storage facility provides a good example of how a Sacramento Valley surface project could be operated in coordination with other facilities. A large Sites Reservoir would provide 1.8 maf of storage in the foothills west of Maxwell. The large Sites Reservoir would be formed by constructing two main dams on Stone Corral and Funks Creeks and several smaller saddle dams along the low divide be-

FIGURE 6G-1

Likely Reservoir Sites Upstream of the Delta

tween Funks and Hunters Creeks. A larger Colusa Reservoir, providing 3.0 maf of storage, would be formed by extending the large Sites Reservoir north into the Hunters and Logan Creek drainages.

In this configuration, water would be delivered to the reservoirs by winter use of the existing Tehama-Colusa Canal (which diverts from the river near Red Bluff), and by diversion to the Glenn-Colusa Canal at its pumping site near Hamilton City. A new pumped intertie would deliver Glenn-Colusa Canal water to the Tehama-Colusa Canal, from which it would be lifted a maximum of about 320 feet to Sites/Colusa Reservoirs. In a recently conceived alternative, use of the existing diversions would give way in favor of a single pumping facility south of Chico Landing.

Most of the water available for storage in Sites/ Colusa Reservoirs occurs from December through April. Whenever water and energy were available, operators would make maximum effort to fill Sites/Colusa Reservoirs. As seasonal water demands increased, water would be withdrawn from system reservoirs to meet needs. Since water would have to be pumped to Sites/ Colusa Reservoirs, the optimum operation would favor making the initial withdrawals from onstream reservoirs with higher ratios of inflow to storage (which are more likely to refill in the subsequent wet season). At some point, depending on the dryness of the year and the storage status of other facilities, withdrawals would be made from Sites/Colusa Reservoirs. To minimize potential impacts of the existing diversions on the Sacramento River fisheries, Sites/Colusa Reservoirs would release water back into the two canals in exchange for reduced diversions from the river. Sites/ Colusa Reservoirs would be drawn to minimum pool only in a prolonged series of drought years. In wetter periods, they would operate within a narrow range near full.

Evaluation of Off-Aqueduct Storage Options South of the Delta

In the Department's recent alternative South of Delta offstream reservoir reconnaissance study, all geographically possible off-aqueduct reservoir sites on the west side of the San Joaquin Valley were identified. Alternatives on the east side of the valley were not considered due to the excessive cost of conveyance connections to the California Aqueduct. Ninety-seven dam sites in 46 watersheds were evaluated (Table 6G-5) for their potential to economically improve SWP water supply reliability with minimal environmental and social impacts. For each potential reservoir site, the capital cost and the potential environmental impacts were evaluated and rated at a general level to determine the sites that should be studied in more detail.

The Department's study examined a wide range of storage volumes to evaluate potentially feasible projects based on the future long-term availability of exports from the Delta and the level of SWP contractor participation. Multiple reservoir sizes were considered for each alternative dam site. Volumes from 0.1 to 2 maf of storage were classified into four categories (Table 6G-6).

All sites were evaluated using the same level of detail for each of the screening criteria. To evaluate and compare engineering characteristics, site information was gathered and construction costs were estimated for each alternative. For this purpose, a basic design configuration was selected. The storage capacity and water surface area of each reservoir option were calculated. The embankment volumes of each main dam and associated saddle dams were calculated.

The capital costs of all reservoir options were based on previous cost estimates developed for LBG facilities. Sixteen categories of cost, including mitigation costs, were calculated. A rating of the alternatives was performed based on estimated capital costs per acre-foot of storage. A unit storage cost of above $3,000/af was deemed impractical and was used as a threshold for deferring alternative sites. After deferring alternatives with unit storage costs above the practical threshold, 34 dam sites in 18 watersheds were retained for further consideration. The unit storage cost for each of these options was translated to a 100 point system, with 0 points assigned to a unit cost of $3,000/af of storage and 100 points to a unit cost of $0/af of storage. Unit costs and scores were developed for several reservoir sizes at each site to cover the potential range of storage volume available at each dam site. The unit costs and scores for the reservoir sizes evaluated at each dam site were plotted versus volume. Curves were drawn through the points associated with each dam site to allow interpolation of this information for the entire range of storage volumes available at each dam site.

Environmental criteria were developed by the Department and DFG. Factors affecting the degree of environmental sensitivity of each alternative reservoir site were identified by the Department and DFG, and were reviewed by USFWS. Six environmental screen-

TABLE 6G-5

Watersheds Identified for South of the Delta Storage Options

Watershed	*County*	*Watershed*	*County*
Arroyo Ciervo	Fresno	Los Banos Creek	Merced
Arroyo Hondo	Fresno	Los Gatos Creek	Fresno
Bitter Creek	Kern	Los Vaqueros	Contra Costa
Bitterwater Valley	Kern/San Luis Obispo	McKittrick Valley	Kern
Broad Creek	Kern	Moreno Gulch	Fresno
Buena Vista Creek	Kern	Mustang Creek	Merced
Buena Vista Lake Bed	Kern	Orestimba Creek	Stanislaus
Cantua Creek	Fresno	Ortigalita Creek	Merced
Capita Canyon	Fresno	Oso Creek	Stanislaus
Castac Valley	Kern/Los Angeles	Packwood Creek	Kern
Deep Gulch	San Joaquin	Panoche Hills	Fresno
Del Puerto Canyon	Stanislaus	Panoche/Silver Creek	Fresno/San Benito
Garzas Creek	Stanislaus	Pleito Creek	Kern
Hospital Creek	San Joaquin/Stanislaus	Quinto Creek	Merced/Stanislaus
Ingram Canyon	Stanislaus	Romero Creek	Merced
Ingram/Kern Canyon	Stanislaus	Salado Creek	Merced
Kellogg/Marsh Creek	Contra Costa	Salt Creek	Fresno/Kern/Merced
Kern Canyon	Stanislaus	San Emigdio Creek	Kern
Kettleman Plain	Kings	San Luis Creek	Merced
Laguna Seca Creek	Merced	Sandy Creek	Kern
Little Panoche Creek	Fresno	Santiago Creek	Kern
Little Salado/Crow Creek	Stanislaus	Sunflower	Kings/Kern
Lone Tree Creek	San Joaquin	Wildcat Canyon	Merced/Fresno

ing criteria were developed. The environmental resources information varied among the sites. To ensure that all the options were evaluated equally, all sites used the same level of detail for each of the screening criteria. In evaluating wetland resources, USFWS National Wetland Inventory Maps were used to determine wetland abundance and types at each site. USGS national aerial photographic project maps were used to determine vegetation community abundance and type, and to obtain additional habitat and land use information. Listed and candidate animal and plant species that could potentially be found at the alternative sites were identified by searching the 1995 DFG Natural Diversity Data Base, the fifth edition of the California Native Plant Society's inventory of rare and endangered vascular plants of California, and DFG Wildlife Habitat Relationships System publications.

Economic and environmental sensitivity scores were given equal weight and combined to develop a score for each alternative reservoir site ranging from 0 to 100 points. Table 6G-7 shows the combined ranking of each alternative reservoir site, sorted by the four storage volume categories. Alternative reservoir sites with the highest scores were selected for each storage volume category. A minimum of 4 and a maximum of 10 alternative reservoir sites were chosen for each size category to provide a reasonable variety of alternatives for further evaluation. Using the previously defined categories, alternative reservoir sites were selected for further evaluation. Many of the alternative reservoir sites were selected in more than one size category. As shown in Table 6G-8, a total of 19 reservoir sites in 10 watersheds were retained for more analysis after the initial evaluation. These sites are shown in Figure 6G-2.

Likely Off-Aqueduct Storage Options South of the Delta

After a general evaluation, five sites appeared most favorable: Garzas Creek, Ingram Canyon, Los Banos

TABLE 6G-6

South of the Delta Off-Aqueduct Storage Size Categories

Category	*Storage (maf)*
Small	0.1 - 0.25
Medium	0.25 - 0.5
Large	0.5 - 1.0
Very Large	1.0 - 2.0

TABLE 6G-7

Ranking of Off-Aqueduct Storage Options South of the Delta

Dam Site	*Potential Range of Storage (taf)*	*Unit Cost ($/af)*	*Cost Ranking (0-100)*	*Environmental Sensitivity Ranking (0-100)*	*Combined Ranking (0-100)*
Very Large Reservoirs (1.0 to 2.0 maf)					
LBG/Los Banos Creek (Dam 181)	1,000-2,000	730-550	76-82	31-31	53-56
Garzas Creek (Dam 104)	1,000-1,750	1,600-1,310	47-56	53-52	50-54
Panoche/Silver Creek (Dam 114)	1,000-2,000	1,370-1,210	54-60	47-45	51-52
Orestimba Creek (Dam 171)	1,000-1,140	1,670-1,600	44-47	46-46	45-46
Large Reservoirs (0.5 to 1.0 maf)					
LBG/Los Banos Creek (Dam 181)	500-1,000	1,000-730	67-76	33-31	50-53
Panoche/Silver Creek (Dam 112)	500-1,000	1,620-1,320	46-56	49-47	48-52
Panoche/Silver Creek (Dam 114)	500-1,000	1,830-1,370	39-54	48-47	44-51
Ingram Canyon (Dam 37)	500-980	1,950-1,400	35-53	48-48	42-51
Orestimba Creek (Dam 170)	500-900	1,890-1,410	37-53	49-46	43-50
Garzas Creek (Dam 104)	500-1,000	2,090-1,600	30-47	54-53	42-50
Garzas Creek (Dam 105)	500-630	1,910-1,660	36-45	54-54	45-49
Panoche/Silver Creek (Dam 45)	500-990	2,300-1,920	23-36	59-57	41-47
Garzas Creek (Dam 109)	500-940	2,250-1,730	25-42	54-52	40-47
Orestimba Creek (Dam 171)	500-1,000	1,930-1,670	36-44	48-46	42-45
Medium Reservoirs (0.25 to 0.5 maf)					
LBG/Los Banos Creek (Dam 181)	250-500	1,660-1,000	45-67	35-33	40-50
Panoche/Silver Creek (Dam 112)	250-500	2,250-1,620	25-46	49-49	37-48
Sunflower Valley (Dam 177)	250-500	2,490-1,460	17-51	46-44	31-48
Garzas Creek (Dam 106)	250-310	2,050-1,820	32-39	54-54	43-47
Garzas Creek (Dam 105)	290-500	2,400-1,910	20-36	54-54	37-45
Panoche/Silver Creek (Dam 114)	250-500	2,050-1,830	32-39	49-48	40-44
Orestimba Creek (Dam 170)	250-500	2,630-1,890	12-37	50-49	31-43
Garzas Creek (Dam 104)	250-500	2,950-2,090	2-30	55-54	28-42
Orestimba Creek (Dam 171)	250-500	3,000-1,930	0-36	49-48	24-42
Ingram Canyon (Dam 37)	250-500	3,120-1,950	N/A-35	49-48	N/A-42
Small Reservoirs (0.10 to 0.25 maf)					
Kettleman Plain (Dam 99)	100-250	2,990-1,620	0-46	61-59	30-53
Garzas Creek (Dam 106)	100-250	3,300-2,050	N/A-32	56-54	N/A-43
Garzas Creek (Dam 107)	100-250	3,300-2,020	N/A-33	56-54	N/A-43
Panoche/Silver Creek (Dam 111)	100-240	3,480-2,020	N/A-33	51-49	N/A-41
LBG/Los Banos Creek (Dam 181)	100-250	3,350-1,660	N/A-45	37-35	N/A-40
Panoche/Silver Creek (Dam 114)	100-250	3,560-2,050	N/A-32	51-49	N/A-40
Little Salado/Crow Creek (Dam 63)	100-130	2,810-2,310	6-23	49-48	28-36
Quinto Creek (Dam 54)	110-250	3,120-2,370	N/A-21	50-49	N/A-35
Romero Creek (Dam 56)	100-180	3,410-2,560	N/A-15	53-53	N/A-34
Garzas Creek (Dam 108)	100-250	4,010-2,870	N/A-4	56-55	N/A-30

Creek, Orestimba Creek, and Panoche/Silver Creek. As all past studies have shown, Los Banos Creek is the most cost-effective reservoir option considered for size categories above 250 taf. The next least costly reservoir option ranges from about 50 percent more expensive for the medium size category up to about 100 percent more expensive for the very large category. In the environmental analysis, however, the Los Banos Creek option received the lowest environmental sensitivity rating (or had the most potential impacts) of all alternative sites. This could be because there is a greater level of knowledge about this reservoir site. Los Banos Creek was the highest ranked reservoir option based on total combined rating for reservoir sizes above 250 taf.

A reservoir at Little Salado-Crow Creek would have a high surface area to storage volume ratio. There would be high evaporation losses, making the site unfavorable. Sunflower Reservoir site lies 10 miles west of the California Aqueduct and would require an extended conveyance system. Significant seepage rates would also be expected at this site. These two sites (in addition to Romero Creek, Kettleman Plain, and Quinto Creek) have small storage capacities. Preliminary modeling results indicate that the range of additional surface storage south of the Delta should be around 500 to 2,000 taf. The cumulative environmental impacts of several small to medium reservoirs needed to attain the storage capacity would probably be greater than one larger reservoir. Therefore, the small to medium size reservoir options were deferred.

Enlarging San Luis Reservoir has been considered for additional storage, but because of engineering and economic criteria, this has been deferred. The integrity of an enlarged San Luis Dam has been questioned, and the cost would be high.

TABLE 6G-8

Retained Off-Aqueduct Storage Options
South of the Delta

Watershed	*Dam Site*	*Reservoir Size Category*			
		Small	*Medium*	*Large*	*Very Large*
Garzas Creek	104		X	X	X
	105		X	X	
	106	X	X		
	107	X			
	108	X			
	109			X	
Ingram Canyon	37		X	X	
Kettleman Plain	99	X			
LBG/Los Banos Creek	181	X	X	X	X
Little Salado/Crow Creek	63	X			
Orestimba	170		X	X	
	171		X	X	X
Panoche/Silver Creek	111	X			
	112		X	X	
	114	X	X	X	X
	45			X	
Quinto Creek	54	X			
Romero Creek	56	X			
Sunflower	177		X		

FIGURE 6G-2.

Off-Aqueduct South of the Delta Watershed Sites

Operation of Off-Aqueduct Storage South of the Delta

To illustrate how south of Delta offstream storage would operate, LBG Reservoir is used as a model. This example treats LBG as an SWP facility. To meet CVP service area needs, USBR could participate with the Department in this project.

LBG would be located on Los Banos Creek 6 miles west of the California Aqueduct in the Los Banos Valley area. The main damsite would be about 80 miles south of the Delta. Facilities would consist of a storage reservoir with associated pump-generating plants and conveyance channels. Delta winter flows would be conveyed through the California Aqueduct and pumped into LBG for storage. Operation of the reservoir would be similar to that of San Luis Reservoir, except that LBG would retain about one half to two-thirds of its storage in average years to improve drought year water supply reliability of the SWP.

During periods of low Delta inflow, LBG would provide water supplies south of the Delta to reduce the demand for Delta exports. Added flexibility could permit the SWP to take advantage of seasonal and short-term water quality improvements to enhance the quality of delivered supplies. The 1.73 maf LBG Reservoir examined in the 1990 feasibility study would operate through a range of about 550 to 750 taf each year, filling in the early spring and releasing water to the California Aqueduct between May and September.

7

Options for Meeting Future Water Needs in Coastal Regions of California

This chapter covers the coastal hydrologic regions of the State: the North Coast, San Francisco Bay, Central Coast, and South Coast (Figure 7-1). These four regions make up 29 percent of the State's land area and were home to 78 percent of the State's population in 1995.

FIGURE 7-1
Coastal Hydrologic Regions

The Pulgas Water Temple, owned by the City and County of San Francisco.

FIGURE 7-2

North Coast Hydrologic Region

North Coast Hydrologic Region

. . .

Description of the Area

The North Coast Region comprises the Pacific Ocean coastline from Tomales Bay to the Oregon border, extending inland to the crest of coastal watersheds. The region includes all or large portions of Modoc, Siskiyou, Del Norte, Trinity, Humboldt, Mendocino, Lake, and Sonoma Counties. Small areas of Shasta, Tehama, Glenn, Colusa, and Marin Counties are also within the North Coast Region (Figure 7-2).

Most of the region is comprised of rugged mountains; the dominant topographic features are the Klamath Mountains and the Coast Range. Mountain elevations range from 5,000 feet along the coast to more than 8,000 feet in the Klamath River watershed. Valley areas include the high plateau of the Klamath River Basin in Modoc County, the Eureka/Arcata area, Hoopa Valley in Humboldt County, Anderson Valley, the Ukiah area, Alexander Valley, and the Santa Rosa Plain.

Precipitation in the region varies depending on location and elevation. In the Modoc Plateau of the Klamath River Basin, annual precipitation averages 10 inches, while higher elevation lands of the Smith River Basin in Del Norte County average more than 100 inches of rain per year. The southern portion of the region is drier; Santa Rosa averages about 29 inches of rain annually.

Most land area in the North Coast Region is forest or range land. Irrigated agriculture is concentrated in narrow river valleys such as the Russian River Valley in Sonoma County, and on the high plateau of the Klamath River Basin. The primary crops are pasture, grain, alfalfa, wine grapes, truck crops, and nursery stock. Principal cities in the region include Crescent City, Yreka, Eureka, Fort Bragg, Ukiah, Santa Rosa, and Rohnert Park. Table 7-1 shows the 1995 population and irrigated crop acreage in the region and 2020 forecasts.

Water Demands and Supplies

Because of the water dedicated to the North Coast's wild and scenic rivers, environmental water use comprises the majority of the total water demand in the North Coast Region. Water shortages are expected to occur only under drought conditions, as shown in Table 7-2. These water shortages will be mostly in the USBR's Klamath Project's service area and in some small coastal communities.

Three existing projects provide much of the North Coast's developed surface water supply—USBR's Klamath Project, Humboldt Bay Municipal Water District's Ruth Lake, and USACE's Russian River Project. The primary water storage facilities of USBR's Klamath Project are Upper Klamath Lake, Clear Lake, and Gerber Reservoir. This project was authorized by the Secretary of the Interior in 1905, and is one of the West's earliest reclamation projects. The project's primary purpose is to store and divert water for agricultural use. The project service area includes more than 230,000 acres of irrigable lands in Oregon and

TABLE 7-1

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	606	323
2020	835	335

TABLE 7-2

North Coast Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	169	177	201	212
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total	**20,607**	**10,668**	**20,672**	**10,740**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and Desalted	13	14	13	14
Total	**20,607**	**10,491**	**20,672**	**10,546**
Shortage	**0**	**177**	**0**	**194**

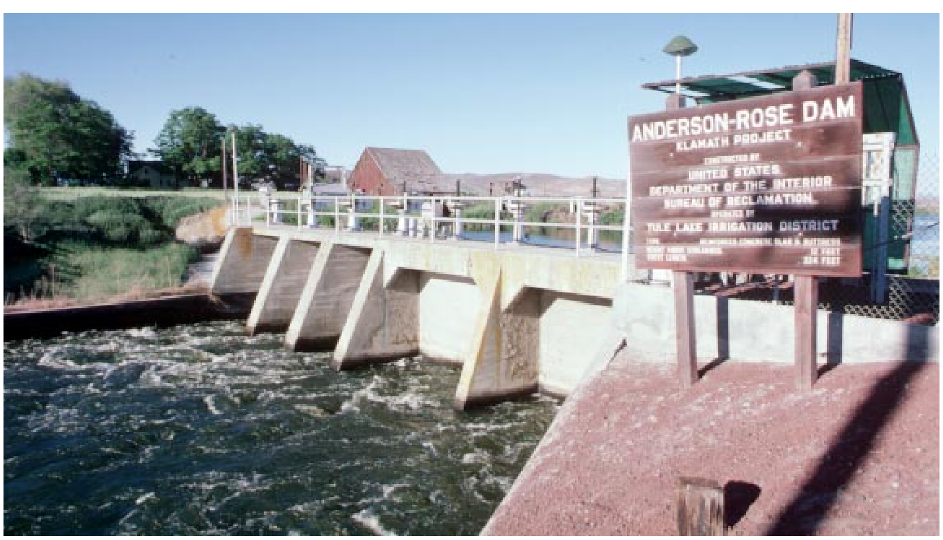
[a] Water use/supply totals and shortages may not sum due to rounding.

California. The project also serves four national wildlife areas—the Lower Klamath, Tule Lake, Clear Lake, and Upper Klamath Refuges.

The 48 taf Ruth Lake is Humboldt Bay Municipal Water District's water storage facility on the Mad River. Downstream Ranney collector wells capture water released from Ruth Lake for distribution in the Eureka-Arcata-McKinleyville area. Humboldt Bay MWD is a water wholesaler with seven municipal, two industrial, and about 200 miscellaneous water customers.

The Trinity River Division of the CVP develops supply for export to the Central Valley and does not deliver water in the North Coast Region. USBR constructed Trinity River facilities in the early 1960s to augment CVP water supplies in the Central Valley. The principal features of the Trinity Division are Trinity Dam and the 2.4 maf Trinity Lake on the upper Trinity River, Lewiston Dam, the 10.7-mile Clear Creek Tunnel that begins at Lewiston Dam and ends at Whiskeytown Lake in the Sacramento River Basin, Spring Creek Tunnel, and Spring Creek Powerplant.

Exports from the Trinity River to the Sacramento River Basin began in 1963. From 1980 through 1995, Trinity River exports averaged 825 taf annually. In 1981, the Secretary of the Interior increased instream flow requirements in the Trinity River from 120 taf to 287 taf in drought years, and 340 taf in wet years. In 1991, the Secretary of the Interior amended the 1981 decision, directing that at least 340 taf be released into the Trinity River for water years 1992 to 1996, pending completion of a USFWS instream flow study. In 1992, CVPIA mandated that the secretarial decision remain in place until the instream flow study was com-



USBR's Anderson-Rose Dam is located on the Lost River in Oregon, just north of the stateline. This Klamath Project facility diverts water to serve irrigation needs on the bed of the former Tule Lake in California and Oregon.

Courtesy of USBR

Trinity Dam and Trinity Lake. Releases from the reservoir are reregulated at Lewiston Dam, 7 miles downstream on the Trinity River. At Lewiston, water is either released back to the Trinity River or diverted through the Clear Creek Tunnel into the Sacramento River Basin.

Courtesy of USBR

pleted, at which time the study's recommendations would be implemented. Currently, a draft Trinity River flow evaluation report recommends that 815 taf, 701 taf, 636 taf, 453 taf, and 369 taf be released in the Trinity River during extremely wet, wet, normal, dry, and critically dry years, respectively. The water year types are based on Trinity Lake inflow.

Lake Mendocino on the East Fork Russian River near Ukiah and Lake Sonoma on Dry Creek near Geyserville are the water storage facilities of USACE's Russian River Project. Sonoma County WA receives most of the water from this project and delivers about 29 taf/yr to Santa Rosa, Rohnert Park, Cotati, and Forestville in the North Coast Region, and another 25 taf/yr to Novato, Petaluma, the Valley of the Moon, and Sonoma in the San Francisco Bay Region. The Russian River Project also regulates flow in the Russian River for agricultural, municipal, and instream uses within Mendocino and Sonoma Counties, and municipal uses in Marin County. Water is diverted from the Eel River into Lake Mendocino through PG&E's Potter Valley Project.

Local Water Resources Management Issues

Klamath River Fishery Issues

The primary water management issue in the Klamath River Basin is the restoration of fish populations that include listed species such as the Lost River and shortnose suckers, coho salmon, and steelhead trout. The Lost River sucker is native to Upper Klamath Lake and its tributaries, and the shortnose sucker is found in the Lost River, Clear Lake, Tule Lake, and Upper Klamath Lake. Both species spawn during the spring. Higher water levels in Upper Klamath Lake have been identified as an aid to recovery of these fisheries. Coho and steelhead were recently listed, and water supply implications will not be known until management plans are completed and recovery goals are established.

To address the need for greater certainty in project operations, USBR began preparing a long-term Klamath Project operations plan in 1995. Difficult and complex issues have delayed completion of the long-term plan. USBR has issued an annual operations plan each year since 1995 as it continues the development of the long-term plan. The Klamath River Compact Commission is facilitating discussions on water management alternatives to address ESA and water supply needs. This three-member commission was established by an interstate compact ratified by Congress in 1957 to facilitate integrated management of interstate water resources and to promote intergovernmental cooperation on water allocation issues. Members include a representative from the Department, the Director of the Oregon Water Resources Department, and a presidentially-appointed federal representative.

Trinity River Fish and Wildlife Management Program

Following completion of the Trinity River Division, fish populations in the Trinity River Basin declined dramatically. The Resources Agency established a statewide task force in 1967 to develop a program to improve the fishery. One of the most significant problems identified was sedimentation from Grass Valley Creek. In 1980, PL 96-335 authorized construction of Buckhorn Mountain Debris Dam on Grass Valley Creek, as well as sediment dredging in the Trinity River below Grass Valley Creek. In 1984, PL 98-541 authorized the Trinity River fish and wildlife management program, providing $57 million (excluding Buckhorn Mountain Debris Dam and sediment dredging costs) to implement actions to restore fish and wildlife populations in the Trinity River Basin to pre-project levels. Congress authorized an additional $15 million in 1993 for purchase of 17,000 acres of the Grass Valley Creek watershed and its restoration. PL 104-143 in 1996 extended the program three years to October 1, 1998, to allow expenditure of funds previously authorized, but not yet appropriated. Reauthorization of the program is currently under consideration. A draft EIS/EIR is being prepared to address proposed streamflow changes and mainstem Trinity River restoration actions.

Water Supplies of Small Coastal Communities

The town of Klamath in Del Norte County obtains its water supply from two wells adjacent to the Klamath River. During the recent drought, seawater intrusion forced the Klamath Community Services District to use an upstream private well in the Hoopa Creek drainage area. All of Klamath's water supply in 1995 was obtained from the private well, and no water was pumped from Klamath CSD's wells. In 1996, Klamath CSD pumped adequate supplies from its two wells, but seawater intrusion during dry years remains a problem. Although the Hoopa Creek drainage area has adequate groundwater supplies, Klamath CSD does not have funding to construct an additional well.

The town of Smith River, 13 miles north of Crescent City, takes its water supply from wells along Rowdy Creek. Water demands in the town of Smith River are expected to exceed the capacity of the town's delivery system if projected growth occurs. (Growth from Brookings, a popular Oregon retirement and resort community about 7 miles north of the stateline, is affecting Smith River.) There are no plans to upgrade Smith River's water system.

Growth in the Crescent City area is creating the need to expand the city's water distribution system, which consists of a Ranney collector well on the Smith River and a 50,000 gallon storage tank. The Ranney collector can produce about 7.8 taf/yr, but the capacity of the existing transmission and storage system is only about 4.5 taf/yr. Crescent City is planning to add new mains, a new pump station, one additional booster pump, and a 4 mg storage tank. The upgraded system will produce 5.9 taf/yr. The estimated cost is $6.7 million. A second phase will make additional distribution system improvements. These new conveyance facilities should meet the city's demands through 2007.

The Weaverville Community Services District in Trinity County serves about 1,370 metered connections. In average water years, demands within the district are met with existing supplies from East and West Weaver Creeks. During drought years, water rationing and building moratoria were needed to reduce demands. In response to drought year demands, a new diversion of up to 3 cfs from the Trinity River was constructed. The Weaverville area is expected to have adequate water supplies to meet demands over the next 30 years.

Trinity County Water Works District #1 is investigating a wastewater treatment and reuse project for the Hayfork area. The project would treat wastewater from individual septic systems, and would eliminate septic tank seepage into local streams. The district's feasibility study identified a gravity collection system with an oxidation pond and two marsh areas as the best alternative for wastewater treatment. The project would treat 160 af annually, and could reuse the treated water to irrigate agricultural lands or landscaping. The estimated cost for this project is $8.9 million.

The City of Rio Dell obtains its water from a well on property owned by the Eel River Sawmill. Pentachlorophenol has been detected in groundwater on the sawmill's property, although not in the city's well water. Rio Dell is planning to find an alternate water supply. The most likely alternative will be treated surface water from the Eel River.

The City of Fort Bragg experiences water shortages during drought years. The water sources for the city are direct diversions from surface water sources. During average rainfall years, water rights from these sources are enough to meet the city's demands to the year 2020. Supplies are inadequate to meet the city's needs during drought years and to maintain instream flows required by DFG. DHS issued an order in 1991 prohibiting new demands on the water system until adequate water supplies were developed. The city has been investigating alternate sources of supply and has implemented water conservation measures and improved existing system capacity. As a result of these corrective measures DHS lifted its order in 1993 and allowed the city to begin issuing building permits, subject to restrictions including no net increase in consumption and implementation of a conservation and retrofit program.

Groundwater use is constrained by limitations in aquifer storage capacity in some coastal communities. Wells on low terraces near the ocean are potentially vulnerable to seawater intrusion. The town of Mendocino is completely dependent on individual wells. A local survey conducted in 1986 showed that about 10 percent of the wells go dry every year and 40 percent go dry during drought years. In 1986, water was trucked in during summer and fall to help reduce shortages. The Mendocino Community Services District investigated new water supply sources, including wells in the Big River aquifer and desalting. To date, no acceptable water source has been identified. In 1990, town residents approved developing a public water system if an adequate water source could be found. The district is currently collecting hydrogeological data on the groundwater basin.

Russian River Environmental Restoration Actions

Water quality issues and barriers to fish migration are of concern in the Russian River Basin. No future water supply shortages are forecasted for the basin, although actions taken to protect recently listed salmonids may affect existing or future diversions. A Russian River Action Plan, prepared by Sonoma County WA in 1997, provides a regional assessment of needs in the watershed and identifies fishery habitat restoration projects in need of funding. The SWRCB is promoting a coordinated Russian River fishery restoration plan.

In 1997, NMFS listed coho salmon and steelhead trout as threatened along part of the Central California coast that includes the Russian River Basin. SCWA, USACE, and NMFS signed an agreement to establish a framework for consultation under Section 7 of the ESA. Under the agreement, USACE and SCWA will jointly review information on their respective Russian river activities to determine impacts to critical habitat.

The Eel-Russian River Commission, composed of county supervisors from Humboldt, Mendocino, Sonoma, and Lake Counties, provides a regional forum for agencies and groups to stay informed about projects and issues affecting the Eel and Russian Rivers. The Commission, formed in 1978 under a joint powers agreement among the counties, was to aid in implementing an Eel-Russian River watershed conservation and development plan. A regional issue currently being addressed by the Commission is the review of a

Currently, the main water issues in the Russian River Basin are related to watershed management and environmental restoration programs.

draft 10-year fishery study by PG&E for its Potter Valley Project, required as a condition of a 1983 FERC license.

A proposed SCWA project would allow fish passage through a flood control structure on Matanzas Creek in downtown Santa Rosa. The original structure, constructed in the early 1960s, does not permit fish passage. SCWA also proposes to install a fish ladder at Healdsburg Dam on the Russian River, a small flashboard dam used in the summer to create a recreational pool.

City of Santa Rosa Long-Term Wastewater Project

In early 1998 the City of Santa Rosa selected an alternative that would recharge depleted geothermal fields in the Geysers area with treated wastewater as part of its long-term wastewater recycling program. Under this alternative, the Santa Rosa Subregional Sewerage System will pump about 11 mgd of treated wastewater to the Geysers for injection into the steamfields. This amount is a little less than half the flow the treatment system is expected to produce at buildout. The project is intended to eliminate weather-related problems of the city's current disposal system and minimize treated wastewater discharges into the Russian River. The project consists of pipeline transmission and distribution systems and is scheduled to be completed by 2001.

SCWA Water Supply and Transmission Project

Sonoma County WA is preparing an EIR to develop additional water supply as well as to expand its existing water transmission system. The project will be implemented under an agreement among SCWA and its water contractors. Components of the project include water conservation, increased use of the Russian River Project, and expansion and revised operation of the water transmission system. Water conservation is planned to provide additional savings of 6.6 taf. The Russian River component will allow for increasing diversions from 75 to 101 taf from the Russian River. This increased use of the Russian River Project water will require construction of additional diversion and conveyance facilities, including new diversion locations. The project will continue to meet existing instream flow requirements associated with the SWRCB's Decision 1610 and will require new water rights applications to SWRCB. The transmission system component has two elements—facilities to divert and treat Russian River Project water, and transmission system improvements allowing for delivery of up to 167 taf/yr. The final EIR is scheduled for late 1998.

Potter Valley Project

PG&E's Potter Valley Project diverts water from the Eel River to the East Fork of the Russian River for power generation and downstream agricultural and municipal water use. The project consists of Scott Dam and Lake Pillsbury, Van Arsdale Diversion Dam and tunnel, and the Potter Valley Powerplant. The project diverts about 159 taf of water and generates about 60 million kWh of energy annually. Releases are limited by required minimum flows on the Eel River and by requirements to maintain reservoir levels in Lake Pillsbury during the summer recreation season. Under the FERC relicensing process, PG&E has been meeting with State and federal agencies to develop instream flow recommendations for the Eel River. Diversions from the Eel River are being evaluated in light of ongoing efforts to restore Eel River fisheries. PG&E is also trying to secure additional operating revenue from the project and, if unsuccessful, may sell or abandon the project. Local agencies have expressed interest in acquiring the project if it were to be sold.

Water Management Options for the North Coast Region

Table 7-3 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 7A-1 in Appendix 7A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options were retained. Reducing outdoor water use to 0.8 ET_o in new development would attain about 1 taf /yr of depletion reductions, while extending this measure to include existing development would reduce depletions by about 6 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would reduce depletions by 3 and 6 taf/yr, respectively. Reducing commercial, institutional, and industrial water use an additional 3 and 5 percent would attain 1 and 2 taf/yr of depletion reductions, respectively. Reducing distribution system losses to 7 and 5 percent would reduce depletions by 6 and 9 taf/yr.

TABLE 7-3

North Coast Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ET_o	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Ewing Reservoir Enlargement	Defer	No demand for additional supply.
New Reservoirs/Conveyance Facilities		
Boundary Reservoir - Lost River, Oregon	Defer	Low yields, high cost.
Beatty Reservoir - Sprague River, Oregon	Defer	High cost, archaeological resources, and sucker habitat.
Chiloquin Narrows Reservoir - Sprague River, Oregon	Defer	High cost, archaeological resources, and sucker habitat.
Montague Reservoir - Shasta River	Defer	Low yields, high cost.
Grenada Ranch Reservoir - Little Shasta River	Defer	Low yields, poor dam site and reservoir geology, high cost.
Table Rock Reservoir - Little Shasta River	Defer	No surplus water, no local interest.
Highland Reservoir - Moffett Creek	Defer	Low yields, high cost.
Callahan Reservoir - Scott River	Defer	Low yields, high cost, no local interest.
Grouse Creek Reservoir - E.F. Scott River	Defer	Reservoir seepage, high cost, no local interest.
Etna Reservoir - French Creek	Defer	Low yields, high cost, no local interest.
Mugginsville Reservoir - Mill Creek	Defer	Low yields, excessive cost.
Various sites in Noyo/Navarro River Basins	Defer	No local interest in offstream storage; unfavorable environmental conditions.
Long/Round/Aspen Valley Reservoirs - Klamath River	Defer	Excessive capital cost, questionable reservoir geology.
Georgia-Pacific Wood Waste Disposal Site	Defer	Site not available.
Georgia-Pacific Replacement Site	Defer	Unfavorable geotechnical conditions.
Georgia-Pacific Site No. 3	Defer	Unfavorable geotechnical conditions.
Newman Gulch Site	Defer	Unfavorable geotechnical conditions.
Large reservoir at Boddy Property Site	Defer	Excessive capital cost.
Smaller reservoir (at Boddy property site or alternate location)	Defer	Excessive capital cost.
Waterfall Gulch Intake Improvement	Defer	Biological, instream flow concerns.
South Basin (City of Fort Bragg)	Defer	Water rights issues.

TABLE 7-3
North Coast Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Groundwater/Conjunctive Use		
New wells	Retain	
Water Marketing		
—	—	—
Water Recycling		
City of Fort Bragg	Defer	Unfavorable costs due to lack of potential users within a reasonable distance.
Desalting		
Brackish Groundwater		
City of Fort Bragg Project	Retain	
Seawater		
City of Fort Bragg Project	Defer	Excessive cost.
Other Local Options		
—	—	—
Statewide Options		
—	—	See Chapter 6.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Agricultural conservation options were deferred from evaluation for this region because they provide little potential to create new water (reduce depletions).

Modifying Existing Reservoirs or Operations

Trinity County Water Works District #1 has considered raising Ewing Dam, which was designed to be raised up to 12 feet to meet future water supply needs. Raising the dam 12 feet to increase reservoir capacity from 800 af to 1.45 taf and modifying the spillway and outlet works would cost $1.5 million. Plans to enlarge the reservoir were halted when Hayfork's primary employer (a lumber mill) closed, reducing the district's customer base by about 10 percent.

New Reservoirs and Conveyance Facilities

Onstream Storage. Eleven onstream reservoirs in the Klamath River Basin were evaluated and deferred, mainly because of high costs and relatively low yields. Cursory investigations of these projects were completed by USBR, the Department, or the Oregon Water Resources Department. Recent studies completed by the City of Fort Bragg identified potential onstream reservoir sites in the Noyo River watershed; however, these sites were deferred due to environmental and economic concerns.

Offstream Storage. USBR investigated three offstream reservoirs in Oregon's Long, Aspen, and Round Valleys adjacent to Upper Klamath Lake. These offstream storage plans were deferred due to high costs.

In 1993, the City of Fort Bragg moved forward with preliminary plans and work on an environmental impact report on what was then its preferred long-term project, which included a 1.5 taf offstream reservoir. Several promising locations were investigated, but geotechnical investigations indicated that all except one of the sites was unsuitable. Further detailed investigations and cost estimates for the most favorable site indicated the site was infeasible due to excessive costs. A smaller reservoir (about 1 taf) was evaluated, but was also not feasible.

Groundwater Development or Conjunctive Use

Surface water sources meet most of the water needs in the coastal regions. Communities with water shortage problems continue to look for possible groundwater sources and well locations to provide adequate supplies at reasonable cost. Although groundwater quality is generally good, supplies are limited by aquifer storage capacity. For example, Fort Bragg began a test program in 1994 to identify possible well sites, but no significant groundwater supply was found. The city has drilled test wells along the Noyo River about two miles upstream of its mouth, and is studying the potential development of a small production well. It appears that the product water may be brackish.

Water Recycling

The City of Fort Bragg had considered a water recycling project which involved using tertiary treated wastewater to replace potable water used at a lumber processing plant. However, water conservation efforts by the plant reduced its water demand by more than 50 percent, rendering this option uneconomical. Other water recycling projects planned in the region would not generate a source of new supply from a statewide perspective. There are several projects planned which would produce about 15 taf of recycled water annually to serve local water management needs for agricultural, environmental, and for landscape irrigation purposes.

Desalting

Interest in desalting for Fort Bragg increased when feasibility studies showed it was economically competitive with storage alternatives. The city evaluated two reverse osmosis alternatives—one involving seawater and one involving brackish water. Both plant designs would produce about 1 taf of potable water in drought years. Major cost components for the seawater plant would include the ocean intake structure, feedwater pipeline to the plant, and plant equipment. The brackish groundwater plant would require wells, well field collection piping, and a feedwater pipeline into the plant. The city is conducting more detailed studies to identify the location of brackish water sources and brine disposal options.

Other Local Options

Fort Bragg has investigated other alternatives that have not proven to be feasible. These alternatives include improving the city's diversion from Waterfall Gulch and new surface water sources in the South Basin. Lowering the intake structure at Waterfall Gulch would capture an additional 110 af/yr, but presents biological and instream flow concerns. New surface water sources have been identified, but these sources had water rights issues.

Options Likely to be Implemented in North Coast Region

Water supplies are not available to meet all of the region's 2020 water demands in drought years. Drought year applied water shortages are forecasted to be 194 taf. No average year shortages are forecasted for 2020. Ranking of retained water management options for the North Coast Region is summarized in Table 7-4. Table 7-5 summarizes options that can likely be implemented by 2020 to relieve the shortages.

The majority of shortages in the region are agricultural and are expected to occur in the Klamath Project area. The economics of crop production have a major influence on the extent to which growers can afford drought year water supply improvements. Additional groundwater development is a possibility in some areas of the Klamath Project, but there are little data available to evaluate this option. The ability to change cropping patterns in the northern part of the region is limited by the area's climatic conditions. There are no quantifiable options available to meet agricultural shortages.

Urban water conservation options could provide 18 taf/yr in water savings. Small communities along the coast generally do not have the financial resources to construct major water supply projects, and therefore will continue to investigate new groundwater supplies.

TABLE 7-4

Options Ranking for North Coast Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o - New Development	M	750	1	1
Outdoor Water Use to 0.8 ET_o -New and Existing Development	M	[b]	6	6
Indoor Water Use (60 gpcd)	M	400	3	3
Indoor Water Use (55 gpcd)	M	600	6	6
Interior CII Water Use (3%)	M	500	1	1
Interior CII Water Use (5%)	M	750	2	2
Distribution System Losses (7%)	M	200	6	6
Distribution System Losses (5%)	M	300	9	9
Groundwater/Conjunctive Use				
New wells - Fort Bragg and other small coastal communities	H	150	[c]	[c]
Agricultural Groundwater Development	M	[b]	[b]	[b]
Desalting				
Brackish Groundwater				
City of Fort Bragg Project	L	770	1	1

[a] All or parts of the amounts shown for highlighted options have been included in Table 7-5.
[b] Data not available to quantify.
[c] Less than 1 taf.

TABLE 7-5

Options Likely to be Implemented by 2020 (taf)
North Coast Region

	Average	*Drought*
Applied Water Shortage[a]	**0**	**194**
Options Likely to be Implemented by 2020		
Conservation	—	18
Modify Existing Reservoirs/Operations	—	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive Use	—	—
Water Marketing	—	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	—	—
Expected Reapplication	—	—
Total Potential Gain	**—**	**18**
Remaining Applied Water Shortage	**0**	**176**

[a] Majority of shortages in this region are agricultural. Most agricultural shortages in this region are expected to occur in the Klamath Project area.

FIGURE 7-3.

San Francisco Bay Hydrologic Region

San Francisco Bay Hydrologic Region

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Description of the Area

The San Francisco Bay Region (Figure 7-3) extends from southern San Mateo County north to Tomales Bay in Marin County, and inland to the confluence of the Sacramento and San Joaquin Rivers near Collinsville. The eastern boundary follows the crest of the Coast Range. The region includes all of San Francisco and portions of Marin, Sonoma, Napa, Solano, San Mateo, Santa Clara, Contra Costa, and Alameda Counties. The San Francisco Bay Region is divided into the North Bay and South Bay planning subareas. Geographic features include the Marin and San Francisco Peninsulas; San Francisco, Suisun, and San Pablo Bays; and the Santa Cruz Mountains, Diablo Range, Bolinas Ridge, and Vaca Mountains of the Coast Range. Streams flow into the bays or to the Pacific Ocean.

The climate within the region varies significantly from west to east. The coastal areas are typically cool and often foggy. The inland valleys and interior portions of San Francisco Bay are warmer, with a Mediterranean-like climate. The average annual precipitation in the region is 31 inches, ranging from 13 inches in Pittsburg to 48 inches at Kentfield, northeast of Mount Tamalpais in Marin County.

The region is highly urbanized and includes the San Francisco, Oakland, and San Jose metropolitan areas. Agricultural acreage is mostly in the north, with the predominant crop being grapes. In the south, more than half of the irrigated acres are in high-value specialty crops, such as artichokes or flowers. Table 7-6 summarizes the population and irrigated crop acreage for the region.

TABLE 7-6

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	5,780	65
2020	7,025	65

Water Demands and Supplies

Table 7-7 shows the water budget for the San Francisco Bay Region. Environmental water demands, primarily Bay-Delta outflow, account for most of the San Francisco Bay Region's water use. Water demands for Suisun Marsh are also included in environmental water needs. As shown in the table, water shortages are forecast only for drought years.

North Bay

Municipal and industrial water use will continue to grow as the population in the North Bay grows. The fastest growing communities have been municipalities in southwestern Solano County, such as Fairfield and Benicia. Growth in the larger communities of Sonoma and Napa Counties, such as Petaluma and Napa, has also been fairly rapid (more than 20 percent during the 1980s). Growth in Marin County has been slow, initially because of a water connection moratorium administered by Marin Municipal WD in the 1970s, and more recently because of the lack of land available for development. Marin MWD imposed a second moratorium on water service connections during the 1987-92 drought. It was lifted in 1993 with the adoption of an integrated water supply program

TABLE 7-7

San Francisco Bay Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	1,255	1,358	1,317	1,428
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total	**7,115**	**5,760**	**7,176**	**5,830**
Supplies				
Surface Water	7,011	5,285	7,067	5,417
Groundwater	68	92	72	89
Recycled and Desalted	35	35	37	37
Total	**7,115**	**5,412**	**7,176**	**5,543**
Shortage	**0**	**349**	**0**	**287**

[a] Water use/supply totals and shortages may not sum due to rounding.

and the signing of a new Russian River water supply contract.

The Suisun Marsh is the only managed wetland in the North Bay that requires deliveries of fresh water. Its annual applied water demand is expected to remain constant at 150 taf. Other environmental demands include instream flows in Walker and Lagunitas Creeks in Marin County.

Table 7-8 lists major water suppliers within the North Bay, along with their primary sources of supply. Each of these agencies serves a number of municipalities or water retailers. Groundwater and small locally developed supplies serve the remainder of the water users in the area. Table 7-9 lists local agency water supply reservoirs (with capacity greater than 10 taf) serving the North Bay.

- Sonoma County WA, which wholesales water throughout Sonoma and Marin Counties, is forecasting no water shortages through 2020, and is not looking at water supply reliability enhancement options.
- Marin MWD was once one of the most vulnerable water suppliers in the State. The district has negotiated a supplemental water supply contract with Sonoma County WA for 10 taf and now expects to have a more reliable supply as it develops infrastructure to import additional Russian River water.
- Napa County Flood Control and Water Conservation District has a contract for SWP water with a maximum entitlement of 25 taf/yr. The City and County of Napa are examining water supply en-

Vineyard acreage in the Napa and Sonoma Valleys is among the State's most expensive agricultural real estate. Grapes—wine grapes, table grapes, and raisin grapes—are one of California's top dollar value crops.

TABLE 7-8

Major North Bay Water Suppliers

Agency	*Primary Source of Supply*
Sonoma County WA	Russian River Project
Marin MWD	Local surface and Sonoma County WA contract
Napa County FC&WCD	Local surface and SWP
Solano County WA	Solano Project and SWP

hancement options to ensure future supply reliability.

- Solano County WA anticipates a water supply deficiency as municipalities in the western part of the county urbanize rapidly without developing additional water supply sources. Solano County WA's 1995 SWP supply was about 21 taf. The agency's annual SWP entitlement is 42 taf. Benicia is the most vulnerable of the agency's service areas to drought conditions because it is entirely dependent on SWP water. Fairfield also is forecasting future drought year shortages. Vallejo has its own supply from the Delta, which is now conveyed through North Bay Aqueduct facilities.

South Bay

The South Bay is highly urbanized—about 16 percent of the State's population lives in 2 percent of the State's land area. A minor portion of South Bay water use is for agriculture. Hayward Marsh is the only identified environmental water use within the South Bay. The marsh, part of the Hayward Regional Shoreline, has an annual freshwater use of approximately 10 taf of reclaimed wastewater from Union Sanitation District. Industrial water use for cooling is primarily associated with independently produced industrial supplies along the Carquinez Strait.

Table 7-10 lists the major water suppliers in the South Bay and their primary sources of supply. Those areas not served by the listed suppliers get their water from groundwater and from small locally developed surface supplies. Alameda County Water District, Zone

The SWP's North Bay Aqueduct terminates at the Napa Turnout Reservoir, a 22 af storage tank. Napa County Flood Control and Water Conservation District is the contractor for this water supply.

TABLE 7-9

Local Agency Reservoirs Serving the North Bay

Agency	*Reservoir*	*Capacity (taf)*	*Year Constructed*	*Region*
USACE/Sonoma CWA[a]	Mendocino	119	1922	North Coast
USACE/Sonoma CWA[a]	Sonoma	381	1982	North Coast
Pacific Gas & Electric	Pillsbury	73	1921	North Coast
Marin MWD	Kent	33	1953/1982[b]	San Francisco Bay
Marin MWD	Nicasio	22	1960	San Francisco Bay
Marin MWD	Soulajule	11	1979	San Francisco Bay
City of Napa	Hennessey	31	1946	San Francisco Bay
City of Vallejo	Curry	11	1926	San Francisco Bay

[a] USACE built Lake Mendocino and Lake Sonoma primarily for flood control. Sonoma County WA operates the facilities for water supply and holds water rights for the supply.

[b] A 16.5 taf reservoir was initially constructed in 1953. The dam was raised in 1982, nearly doubling the capacity.

TABLE 7-10

Major South Bay Water Suppliers

Agency	*Primary Source of Supply*
San Francisco PUC	Hetch Hetchy project and local surface
Santa Clara Valley WD	Local surface, groundwater, CVP, and SWP
Alameda County WD	Local surface, groundwater, SWP, and Hetch Hetchy project
Zone 7 WA	Local surface, groundwater, and SWP
East Bay MUD	Mokelumne River project and local surface
Contra Costa WD	CVP and local surface

7 Water Agency, and Santa Clara Valley Water District recharge and store local and imported surface water in local groundwater basins. Each of the major water agencies supplies several municipalities or water retailers. Table 7-11 lists local agency water supply reservoirs (with capacity greater than 10 taf) serving the South Bay.

- SFPUC provides water to more than 2.3 million people in San Francisco, San Mateo, Santa Clara, and Alameda Counties, and is forecasting drought year shortages through 2020. In 1990 and 1991, wholesale and retail customers received 25 percent supply reductions (based on historical use). In 1991, SFPUC adopted, but did not implement, a 45 percent rationing plan. Recently revised instream flow requirements in the Tuolumne River Basin have reduced the available Hetch Hetchy supply. The city's studies indicate that the annual yield of the Hetch Hetchy system has dropped from 336 taf to 271 taf.
- SCVWD, which supplies water to about 1.7 million people, provides water to 16 municipal and industrial retailers as well as to agricultural users in Santa Clara County. A number of these retailers also contract with SFPUC for water from Hetch Hetchy. The district possesses one of the most diverse supplies in the State, with imported state project and federal project water, locally developed surface supplies, and extensive groundwater recharge programs. Some of the retail agencies in

TABLE 7-11

Local Surface Reservoirs Serving the South Bay

Agency	*Reservoir*	*Capacity (taf)*	*Year Constructed*	*Region*
San Francisco PUC	Lloyd	273	1956	San Joaquin River
San Francisco PUC	Eleanor	27	1918	San Joaquin River
San Francisco PUC	Hetch Hetchy	341	1923	San Joaquin River
San Francisco PUC	Calaveras	97	1925	San Francisco Bay
San Francisco PUC	Crystal Springs	58	1888	San Francisco Bay
San Francisco PUC	San Andreas	19	1870	San Francisco Bay
San Francisco PUC	San Antonio	50	1964	San Francisco Bay
East Bay MUD	Camanche	417	1963	San Joaquin River
East Bay MUD	Pardee	198	1929	San Joaquin River
East Bay MUD	San Pablo	39	1920	San Francisco Bay
East Bay MUD	Briones	61	1964	San Francisco Bay
East Bay MUD	Chabot	10	1892	San Francisco Bay
East Bay MUD	Upper San Leandro	41	1977	San Francisco Bay
Contra Costa WD	Los Vaqueros[a]	100	1998	San Joaquin River
Santa Clara Valley WD	Calero	10	1935	San Francisco Bay
Santa Clara Valley WD	Coyote	23	1936	San Francisco Bay
Santa Clara Valley WD	Leroy Anderson	89	1950	San Francisco Bay
Santa Clara Valley WD	Lexington	20	1953	San Francisco Bay

[a] Reservoir provides emergency storage and water quality regulation. Does not develop local supply.

State Highway 280 parallels San Francisco's Upper and Lower Crystal Springs Reservoirs in San Mateo County. The reservoirs are located on the San Andreas fault zone.

the district are vulnerable to drought deficiencies imposed by the SWP, CVP, and Hetch Hetchy Project. These deficiencies may be intensified by diminished local runoff during drought conditions.

- ACWD serves a population of 292,000 in southwestern Alameda County, adjacent to San Francisco Bay. ACWD's Niles Cone groundwater basin supply is augmented by SWP and Hetch Hetchy supplies. The district is vulnerable to drought deficiencies imposed by SWP or SFPUC.
- Zone 7 WA delivers water in the Livermore-Almaden Valley in eastern Alameda County, serving communities such as Dublin, Livermore, and Pleasanton, as well as agricultural and industrial customers. Z7WA has an annual SWP entitlement of 46 taf.
- EBMUD provides water to 1.2 million people in the remainder of northern Alameda County, and part of western Contra Costa County. Virtually all of the water used by EBMUD comes from the 577-square-mile watershed of the Mokelumne River, which collects runoff from Alpine, Amador, and Calaveras Counties, on the west slope of the Sierra Nevada. EBMUD has water rights for up to 364 taf/yr from the Mokelumne River. In average years, district reservoirs in the East Bay capture an additional 30 taf from local watershed runoff. In drought years, evaporation and other reservoir losses may exceed local runoff.
- CCWD delivers municipal and industrial water throughout central and eastern Contra Costa County. Deliveries from CCWD go up during droughts as industrial diverters stop diverting with their own Delta water rights (because of water quality constraints) and use CCWD's CVP supplies instead. CCWD's 195 taf/yr CVP contract was recently renegotiated to include operation of Los Vaqueros Reservoir, completed in 1998. Under its new CVP contract CCWD will receive 75 percent of the contract amount, or 85 percent

Santa Clara Valley Water District operates an extensive system of groundwater recharge facilities, some of which are incorporated into a regional system of recreational walking/biking trails.

Courtesy of CCWD

CCWD's Los Vaqueros Dam under construction. The reservoir, completed in 1998, does not provide new water supply, but provides terminal storage for CCWD's existing supply and improves service area water quality.

of historical use, during drought periods. Under severe drought conditions, the CVP supply may be reduced to 75 percent of historical use. CCWD has a smaller locally developed source at Mallard Slough, with an associated right to take up to 26.7 taf/yr. Diversions from Mallard Slough are unreliable due to poor water quality. The average annual diversion from this source over the past 20 years was only 5.6 taf.

Small independent water systems, such as those along the San Mateo coast, also suffer water supply reliability problems during droughts. These systems often rely on a single source, such as groundwater, and do not have connections to the larger systems in the Bay Area.

Local Water Resources Management Issues

Bay-Delta Estuary

The CALFED Bay-Delta Program and the 1995 SWRCB Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary are discussed in Chapters 2, 4, and 6. CALFED's ecosystem restoration program could restore wetlands and riparian habitats in the Delta. Other ERP actions in the region could include protection and enhancement of agricultural lands for wildlife, focusing on agricultural land and water management practices that would increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Delta, Suisun Marsh, and north San Francisco Bay.

Suisun Marsh

In 1995, USBR, DWR, DFG, and the Suisun Resource Conservation District began negotiations to update the Suisun Marsh Preservation Agreement. In 1996, the negotiators agreed in principle to 10 joint actions designed to lower soil salinity on Suisun Marsh managed wetlands (especially in the Marsh's western half) and to use water more efficiently. SWRCB will review western Suisun Marsh water quality objectives and water rights issues as part of its Bay-Delta water rights proceeding. More information on the Suisun Marsh can be found in Chapters 2, 4, and 6.

Local Water Agency Issues

North Bay. The primary water supply source for Sonoma County Water Agency, the Russian River, is in the North Coast Hydrologic Region. Issues related to SCWA and the Russian River are discussed in the North Coast Region portion of this chapter. Issues facing other major water suppliers in the North Bay are discussed below.

In 1995, SWRCB issued Decision WR 95-17, establishing instream flow requirements in Lagunitas Creek watershed. Marin MWD estimates that the decision will diminish its supply by 3 taf annually during drought years. In the past, Marin MWD examined desalting as an option to augment its water supply, studying construction of a 10 mgd reverse osmosis desalting plant near the western end of the San Rafael Bridge. The plant's annual yield would be approximately 10 taf at a cost of $1,900/af. The desalting project was included in a 1991 bond measure that was not approved by the voters. The following year, a bond measure for new facilities to bring more Russian River water to Marin County passed, and Marin MWD's need for the desalting option diminished. The new Marin MWD Russian River facilities will be on line by 2020. Since the district has all the necessary permits, this water source is not listed as a future option but is included in the district's base supply.

Napa County voters approved a local ordinance in 1998 which established a 0.5 percent sales tax to

Although lands in the Suisun Marsh are managed primarily to provide waterfowl habitat, a variety of mammals are found there as well.

fund a Napa County flood protection and watershed improvement expenditure plan. The goal of the plan was to "provide flood protection, save lives, protect property, restore the Napa River, Napa Creek, and other tributaries, maintain economic vitality, and enhance riparian environments". The Napa River and Napa Creek Project, a cooperative effort with USACE, is designed to provide 100-year flood protection for the City of Napa and environmental restoration. These objectives will be achieved by creating a flood bypass channel and wetlands; removal, redesign and replacement of floodway obstructions; elevation and relocation of homes; and construction of set-back levees and floodwalls. The design is intended to provide flood protection while allowing the river to meander through wide riparian zones. In other actions, funds would be provided for flood protection, environmental enhancement, and water supply reliability improvements for other communities and unincorporated areas of the County.

USBR and Solano County Water Agency have been involved in water rights actions on Putah Creek upstream and downstream of USBR's Solano Project facilities. In 1995, a settlement agreement was reached with water users in Lake and Napa Counties upstream of Lake Berryessa. The agreement establishes limits on future water development in the Lake Berryessa watershed and allocates water for the upstream users. A court-appointed watermaster will monitor water uses and enforce the terms of the settlement agreement.

Downstream of the Solano Project, disputes center around environmental water use and riparian water rights. The Putah Creek Council brought suit in 1990 against Solano Project water users to increase flows in the lower reaches of the creek. In 1996, the Sacramento County Superior Court ruled on instream flow requirements for Putah Creek downstream from Solano Diversion Dam, where water is diverted to Putah South Canal for delivery to agricultural lands and to communities in Solano County. The judgment cited the public trust doctrine as well as California Fish and Game code requirements and required higher (and year-round) flows from the creek into the Yolo Bypass. SCWA estimates the additional requirements are approximately 10 taf during an average year and 20 taf during a dry year. Solano County interests are appealing the judgment, which has been stayed until the appeal is heard. USBR is seeking an out-of-court settlement of the case. Under the Superior Court judgment, Solano County water users would be responsible for meeting the instream flow requirements in the downstream portion of the creek. Solano County water users have asked SWRCB to participate in the settlement process so that regulation of riparian diversions can be included in the final instream flow requirements for the creek.

SCWA's contract with USBR for Solano Project water supply will expire in 1999. The contract is renewable, but the terms and conditions of the contract will be renegotiated. SCWA will then need to renegotiate its contracts with Solano Project member entities.

SCWA has entered into a multi-year banking and exchange agreement with Mojave Water Agency in the South Lahontan and Colorado River regions. During wet years, SCWA can bank up to 10 taf of its annual SWP entitlement in MWA's groundwater basin. During dry years, SCWA can take part of MWA's SWP entitlement in exchange (up to half the banked amount with a maximum of 10 taf/yr). SCWA pays for part of the transportation cost to convey the water to MWA.

Solano County water agencies are monitoring use of groundwater from the Putah Fan/Tehama Formation groundwater basin because of concerns about the condition of the shared basin. The City of Vacaville, Solano Irrigation District, Maine Prairie Water District, and Reclamation District 2068 have implemented AB 3030 groundwater management plans. SCWA has initiated a groundwater monitoring and data collection program. Vacaville, SID, Dixon, and Solano County developed a 1995 agreement to cooperatively mitigate any adverse conditions related to the basin.

South Bay. San Francisco Public Utility Commission and the Bay Area Water Users Association (SFPUC Bay Area Water contractors) are cooperatively developing a water supply master plan for the PUC's retail and wholesale service areas. Phase 1 of the three-phase plan was recently completed. The preliminary list of water supply options to be considered in Phase 2 includes:

- Short- and long-term Central Valley water transfers.
- Conjunctive use / groundwater banking within the Hetch Hetchy system (Tuolumne River Basin and areas adjacent to the aqueduct).
- Transfers within the Hetch Hetchy system.
- Additional surface storage within the Hetch Hetchy system.
- Conjunctive use / groundwater banking within the Bay Area system.
- Transfers within the Bay Area system.
- Additional surface storage within the Bay Area system.
- Desalting.
- Other local projects.

Phase 2 will ultimately produce a master plan for the PUC system and is scheduled for completion in 1999. Phase 3, the implementation phase of the master plan, will include environmental review, design, and construction of plan elements. Construction is anticipated to begin as early as 2001.

Without improvements to its water supply reliability, SCVWD is forecasted to face the largest drought year shortages in the San Francisco Bay Region. The district released an integrated water resources plan in December 1996 to address water supply reliability through 2020. The primary components of the preferred strategy include water banking, water transfers, water recycling, and water conservation. Components are scheduled to be phased into operation as necessary to meet increasing demands. Implementation of specific components is designed to be flexible, with a list of contingency strategies to meet changing conditions. The plan is to be updated every three to five years.

Alameda County Water District is continuing to monitor and manage saline water intrusion in its bayside aquifers. The district depends upon the Niles Cone groundwater basin, which includes at least three distinct aquifers, for district supplies. The district recharges locally developed water and imported surface water to the basin and extracts recharged supplies. Prior to ACWD's import of surface supplies in the 1960s, the upper two aquifers were overpumped, causing saline intrusion into the basin. In 1974, ACWD began its aquifer reclamation program, which includes nine wells designed to extract and discharge saline groundwater from the basin. Because of further intrusion of saline water during the recent drought, operations have been modified to pump and dispose of greater quantities of saline water. In 1992, a reconnaissance level study was conducted to evaluate the feasibility of desalting water pumped from extraction wells, and blending it with groundwater and imported surface water. This desalting option is discussed in the following section.

ACWD is developing a groundwater model to simulate the effectiveness of its aquifer reclamation program, movement of saline water, and remediation of the basin. Because runoff from the Alameda Creek watershed is used to recharge the groundwater basin, ACWD is working with upstream agencies and the RWQCB to ensure that water quality in Alameda Creek is not compromised due to development or other activities in the watershed.

Zone 7 WA has initiated a water supply master plan program EIR to meet projected water needs. Preliminary estimates indicate a need for 40 to 50 taf of additional water supply by 2020. The water supply program will include imported surface water transfers, conservation, water recycling, and purchase of the South Bay Aqueduct's currently unused conveyance capacity.

In a separate planning effort, Z7WA has been working with local developers on a water transfer agreement to provide water to 9,500 new homes in Dougherty Valley, in southern Contra Costa County. A small portion of the Dougherty Valley development is within EBMUD's existing service area. After Contra Costa County approved the development in 1992, EBMUD indicated that it could not reliably provide water service to all 11,000 new customers. Ultimately, EBMUD agreed to provide service to Dougherty Valley over a lengthy development period, with the condition that developers try to find another source of water. The developers negotiated with Berrenda Mesa Water District, a member agency of Kern County WA, to purchase 7 taf of currently unused SWP entitlement water. Dublin San Ramon Services District agreed to be the water retailer and Z7WA, a wholesaler of SWP water, will treat and deliver water from the South Bay Aqueduct. In addition to paying for the entitlement water and connection fees from Z7WA and DSRSD, developers have agreed to pay Z7WA an additional $18 million for the wholesale service. DSRSD and Z7WA anticipate that the arrangement will result in lower water costs to existing customers and improved reliability. Another condition of the agreement stated that the project could not use existing local Z7WA storage space (primarily the Livermore Valley groundwater basin). Z7WA completed an agreement with Semitropic Water Storage District for 43 taf of groundwater storage, which is also being purchased by the developers. In wet years, excess water from Berrenda Mesa WD will be delivered to SWSD and stored in the groundwater basin. In drought years, Z7WA would receive SWP water in exchange through the SBA.

After the Z7WA / Dougherty Valley arrangement was finalized, the City of Livermore and environmental interests sued Z7WA in an effort to stop similar future arrangements. (The city is one of Z7WA's primary contractors.) A major concern of the plaintiffs is that Z7WA's water supply reliability will be diminished.

EBMUD's board approved a water supply action plan in 1995 to meet the objectives of its 1993 water supply management program EIR for improving supply reliability in its service area. The action plan's recommendation was to construct a Folsom South Canal connection to EBMUD's Mokelumne Aqueduct, to allow the district to use its CVP contract for up to 150 taf/yr of American River water. The project would be designed to operate in accordance with the Alameda County Superior Court's 1990 Hodge Decision, which confirmed the district's right to divert its contract amount subject to the court's physical solution for instream flow requirements in the Lower American River.

In November 1997, EBMUD and USBR released a draft EIR/EIS with two alignment alternatives for conveying American River water and one no project alternative. One alternative incorporates a concept developed by Sacramento County, the City of Sacramento, and EBMUD to construct a joint diversion facility near the American River's confluence with the Sacramento River. American River water would be diverted near the confluence and would be pumped back to the City of Sacramento's Fairbairn Water Treatment Plant. A portion of this water would continue on to the Folsom South Canal where it would be conveyed to the Mokelumne Aqueduct via a pipeline extension from the end of the canal. Water for Sacramento County would be treated at the Fairbairn Water Treatment Plant and conveyed to local water users.

In 1997, San Joaquin County interests proposed a groundwater storage project that would allow EBMUD to store surface water in San Joaquin County aquifers and would provide significant benefits to San Joaquin County water users. A joint powers authority of San Joaquin County water agencies hopes to initiate a pilot project to help assess the feasibility of this conjunctive use proposal. EBMUD has agreed to provide water for the project and is retaining this alternative for consideration to provide more out-of-service area storage and improved supply reliability during droughts. However, a conjunctive use alternative was not included in EBMUD's draft EIR for conveyance of its CVP contract supply.

EBMUD has also been involved in negotiations related to instream flows in the Mokelumne River. EBMUD's 1981 FERC license for operation of hydropower facilities at Pardee and Camanche Reservoirs incorporated an existing instream flow agreement between the district and the DFG. During the 1987-92 drought, poor fishery conditions on the Mokelumne River and fish losses at the district's Camanche fish hatchery prompted FERC to evaluate fishery flows. FERC issued a final EIS in November 1993, which was opposed by all the involved parties. Subsequent negotiations led to preparation of a settlement agreement by EBMUD, DFG, and USFWS which was submitted to FERC for review in June 1997. EBMUD has already implemented the agreement's flows which significantly impact the district's water supply. EBMUD estimates that its 2020 shortage with the new agreement flows would increase from 130 taf to 185 taf. The district will continue to pursue reliability enhancement options to meet the expected increased shortage.

Contra Costa Water District is facing several issues with its CVP supply, which is its primary supply source. CCWD's CVP contract is scheduled to expire in 2010, but CVPIA established financial penalties for not committing to review by 1997. The district is weighing the potential loss of supply associated with renewal against the financial penalties, and expects that the reliability of its 195 taf contractual supply will be reduced due to CVPIA implementation.

Bay Area Regional Water Recycling Program

With passage of Title 16 of PL 102-575 in 1992, USBR joined with Bay Area water and wastewater agencies to fund a study of regional water recycling potential. The Bay Area regional water recycling program (formerly Central California regional water recycling program) was established in 1993 to develop a regional partnership for maximizing Bay Area water recycling. The program is sponsored jointly by USBR, the Department, and 13 Bay Area water and wastewater agencies. During the first phase of the program, completed in April 1996, participating agencies explored potential uses for water recycled from Bay Area wastewater treatment plants. The feasibility study showed that a regional approach would be productive.

A major component of the 1996 feasibility study was assessment of potential recycled water use in the Central Valley and other locations outside the Bay Area. The study determined that marketing the recycled water for agricultural use in the Central Valley was not feasible. A regional water recycling master plan, now in preparation, will focus on recycled water markets in the Bay Area. A limited assessment of agricultural uses immediately south of Santa Clara County will be made, but no further assessment of Central Valley uses will be included. Another major component of the feasibility study was the assessment of options to improve recycled water quality with respect to salinity. Two options originally assessed will not be included in the master plan—on-site agricultural salt management and management of agricultural drainage.

Water quality, especially salinity levels, will need to be managed to ensure the feasibility of Bay Area water recycling. The master plan will consider methods to control salt at the point of origin, including controlling infiltration of saline groundwater into agencies' pipelines. Other salt control methods to be considered include regulation of water softeners, control of industrial discharges, and treatment.

Water Management Options for the San Francisco Bay Region

Table 7-12 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 7A-2 in Appendix 7A) based on a set of fixed criteria discussed in Chapter 6.

Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed the BMPs are considered as options. All urban conservation options were retained. Reducing outdoor water use to 0.8 ET_o in new development would attain about 2 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by about 52 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would attain depletion reductions of 38 and 77 taf/yr, respectively. Reducing commercial, institutional, and industrial water use by an additional 3 percent and 5 percent would attain 11 and 18 taf/yr of depletion reductions, respectively. About 13 taf/yr of depletion reductions would be attained by reducing distribution system losses to 5 percent.

Agricultural. As with urban demand forecasts, agricultural water demand forecasts for 2020 assume that EWMPs are in place and only those efforts which exceed the EWMPs are considered as options. Due to the relatively small amount of irrigated acreage in the region and the high SAE attained on average throughout the region, no significant depletion reductions would accrue.

Modify Existing Reservoirs/Operations

Napa County Flood Control and Water Conservation District has considered reservoir enlargement options which would provide additional offstream storage for Napa River flows. In the South Bay, SCVWD has evaluated enlarging Leroy Anderson Reservoir, which could increase SCVWD's annual supply by about 25 taf. EBMUD has had several proposals to enlarge both of its Mokelumne River reservoirs. The

TABLE 7-12

San Francisco Bay Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Enlarge Lake Hennessey / Napa River Diversion	Retain	
Enlarge Bell Canyon Reservoir	Retain	
Enlarge Bell Canyon Reservoir/ Napa River Diversion	Retain	
Enlarge Pardee Reservoir	Retain	
Enlarge Camanche Reservoir	Retain	
Enlarge Briones Reservoir	Defer	Geologic hazards.
Enlarge Chabot Reservoir	Defer	Substantial residential development.
Enlarge Leroy Anderson Reservoir	Retain	
Upgrade Milliken Treatment Plant	Retain	
Reoperate Rector Reservoir	Retain	
New Reservoirs/Conveyance Facilities		
Chiles Creek Reservoir Project/ Napa River Diversion	Retain	
Enlarge Lake Hennessey /Chiles Creek Project / Napa River Diversion	Retain	
Carneros Creek Reservoir / Napa River Diversion	Retain	
Upper Del Valle Reservoir	Retain	
Buckhorn Dam and Reservoir	Retain	
Upper Kaiser Reservoir	Retain	
Upper Buckhorn Reservoir	Retain	
Middle Bar Reservoir (Amador & Calaveras Counties)	Retain	
Duck Creek Offstream Reservoir	Retain	
Devils Nose Project (Amador County)	Retain	
Clay Station Reservoir (Sacramento County)	Defer	Wetlands, endangered species.
Alamo Creek Reservoir	Defer	Substantial residential development.
Bolinger Reservoir	Defer	Substantial residential development.
Cull Canyon Dam	Defer	Substantial residential development.
Canada del Cierbo Reservoir	Defer	Storage cost too high ($16,000/af).
Curry Canyon Reservoir	Defer	Substantial residential development.

TABLE 7-12

San Francisco Bay Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Lower Kaiser Reservoir	Defer	Storage cost too high ($9,000/af).
Bailey Road Reservoir	Defer	Storage cost too high ($21,000/af).
EBMUD American River Supply	Retain	
Groundwater/Conjunctive Use		
EBMUD/San Joaquin County Conjunctive Use	Defer	Under discussion; not yet defined.
Milliken Creek Conjunctive Use	Retain	
Lake Hennessey /Conn Creek Conjunctive Use	Retain	
Recharge Dumbarton Quarry Pits	Defer	Unsuitable geologic conditions.
Sunol Valley Groundwater Recharge	Defer	Limited aquifer production.
Water Marketing		
Napa/Solano County WA Exchange	Defer	SCWA is not interested in exchange.
Solano County WA	Defer	No proposals identified at this time.
Contra Costa WD	Defer	No proposals identified at this time.
Zone 7 WA/Kern County WA	Retain	
Santa Clara Valley WD/SLDMWA	Retain	
Water Recycling		
Bel Marin Keys Golf Course - North Marin Water District	Retain	
Black Point Golf Links - North Marin Water District	Retain	
Central Marin Water Recycling Project - Marin MWD	Retain	
Golf Course Irrigation, City Park Irrigation - North San Mateo CSD	Retain	
Hercules/Franklin Canyon WRP-Phase 2 - EBMUD	Retain	
Industrial Use - Central Contra Costa Sanitary District	Retain	
Lamorinda - Central Contra Costa Sanitary District	Retain	
Nonpotable Wastewater Reuse Master Plan - Union Sanitation District	Retain	
Phase 1 Water Reclamation Program - Alameda County WD	Retain	
Phase 2 Water Reclamation Program - Alameda County WD	Retain	
San Francisco Water Recycling Master Plan	Retain	
San Ramon Valley Recycled Water Program - DSRSD/EBMUD	Retain	
San Ramon Valley Water Recycling Project - EBMUD	Retain	
South Bay Water Recycling Project - City of Santa Clara	Retain	
South Bay Water Recycling Project - San Jose	Retain	
Zone 1 - Central Contra Costa Sanitary District	Retain	

TABLE 7-12

San Francisco Bay Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Desalting		
Brackish Groundwater		
Alameda County WD Aquifer Recovery Project	Retain	
Seawater		
Marin Municipal WD Desalting Project	Retain	
Other Local Options		
New Surface Water Diversion from Sacramento River by Cities of Benicia, Fairfield, & Vacaville	Retain	
Statewide Options		
—	—	See Chapter 6.

improvement of system yields associated with these projects has not been determined.

Reoperating Rector Reservoir in Napa County would provide an increase of approximately 1.2 taf/yr in system yield. NCFC&WCD is also considering a modification of its Milliken Water Treatment Plant, which would generate a small increase (450 af) in its annual water supply.

New Reservoirs and Conveyance Facilities

Ten new reservoirs were evaluated for Bay Area water agencies. NCFC&WCD investigated several diversion and storage projects, including Chiles Creek Reservoir Project and Carneros Creek Reservoir Project. The viability of these offstream storage projects depends upon the district's ability to make Napa River diversions. (SWRCB has declared the Napa River to

USBR's Folsom South Canal was designed to convey water from the American River below Nimbus Dam to central San Joaquin County. Only part of the canal was actually constructed, and the canal now terminates in southeastern Sacramento County.

Courtesy of USBR

be fully appropriated during parts of the year.) Some agencies, including ACWD, have examined an Upper Del Valle Reservoir Project. EBMUD has considered three new storage reservoirs in its service area and two new reservoirs in the Mokelumne Basin (Middle Bar and Devils Nose projects). These storage options have been inactive since EBMUD's focus on its supplemental water supply project.

As discussed previously, EBMUD and USBR released a draft EIR/EIS in 1997 for EBMUD's diversion of its American River CVP supply. EBMUD estimates that it would receive 112 taf and 70 taf in average and droughts years, respectively. (The draft EIR/EIS evaluates alternatives for conveyance of the water. Project yield remains the same in either of the conveyance alternatives.)

Groundwater Development or Conjunctive Use

EBMUD is continuing discussions with San Joaquin County interests for a joint groundwater storage/conjunctive use project. EBMUD's CVP contract water could be stored in San Joaquin County groundwater basins prior to being diverted into EBMUD's Mokelumne River Aqueduct in northeast San Joaquin County. This option was considered in EBMUD's 1995 Water Supply Action Plan, but not included in EBMUD's draft EIR for conveyance of its CVP contract supply. The yield is currently undefined.

Only two groundwater or conjunctive use options in Table 7-12 were retained for further evaluation. NCFC&WCD has two proposals to construct conjunctive use facilities adjacent to existing surface water facilities. The proposed Milliken Creek conjunctive use project would allow the City of Napa and the Silverado Country Club to share surface and groundwater supplies, and would provide an additional drought year yield of 1.9 taf. The proposed Lake Hennessey/Conn Creek conjunctive use project would make the City of Napa's surface water available to agricultural users in exchange for rights to pump groundwater during droughts. This option would provide an estimated 5 taf during drought years.

Water Marketing

Agencies throughout the Bay Area are proposing to negotiate for new or additional water imports into the region. Most of these proposals are preliminary. Water transfer proposals by SCWA, CCWD, and Z7WA all include transfers from as-yet-unnamed Sacramento Valley water users. The actual amount of water available through these proposals is unknown and the competition for transfers will certainly impact both price and availability. A likely option for Z7WA is the permanent transfer of 7 taf of SWP entitlement from KCWA, as provided for in SWP's Monterey Amendments.

Several agencies in the region already have banking and exchange agreements with agencies in the Tulare Lake, South Lahontan, and Colorado River regions. These agreements among SWP contractors involve exchanges of SWP entitlement. ACWD, Z7WA, and SCVWD are participating in SWSD's groundwater banking program and have long-term contracts for 50, 43, and 350 taf of storage, respectively. SWP entitlement would be delivered to SWSD for groundwater recharge in wet years and SWSD, a member agency of KCWA, would forego a portion of its entitlement in dry years in exchange. SCWA has a similar agreement with MWA in San Bernardino County for up to 10 taf.

SCVWD has also entered into a three-way transfer agreement with the San Luis Delta-Mendota Water Authority and USBR. Under this option, participating member agencies of SLDMWA may receive some of SCVWD's CVP water allocation in normal and above-normal water years, in exchange for committing to make available a share of their CVP allocation during drought years. This option would provide SCVWD with up to 14 taf in drought years and is discussed in more detail in Chapter 6.

Water Recycling

The 1995 water recycling survey identified 16 water recycling options in the San Francisco Bay Region, with a total potential 2020 yield of 101 taf. The average price of recycled water from these options would be just over $500/af, with a range from $100 to over $2,000/af. The most common use for recycled water would be for landscape irrigation. A few options were proposed for industrial or agricultural use.

One consideration in evaluating water recycling proposals is that a number of options may be proposed for the same wastewater treatment plant. These options depend upon different distribution systems and are therefore considered separately for this report. Some of the larger projects with their associated 2020 yield include the South Bay water recycling program (31 taf), the Central Contra Costa Sanitary District industrial use project (20 taf), the San Francisco water recycling management plan (12 taf), and the San

Ramon Valley recycled water project (10 taf). Most of the remaining water recycling options have 2020 yields in the range of 1 to 4 taf.

Desalting

Alameda County WD has evaluated the potential for desalting brackish water to allow increased use of groundwater. Water pumped from the district's aquifer recovery project wells would be desalted and blended with groundwater and Hetch Hetchy water to provide a quality consistent with other sources of supply. The plant would produce 9 taf/yr at a cost of about $500/af.

In the past, Marin MWD examined seawater desalting as an option to augment its water supply. The district studied constructing a 10 mgd reverse osmosis desalting plant. The plant's annual production would be approximately 10 taf at a cost of $1,900/af.

Other Local Options

Solano County WA and its member agencies have been examining several surface water management projects to improve their water supply reliability. One proposal is to apply for additional water rights from the Sacramento River. The Cities of Benicia, Fairfield, and Vacaville have filed an application with the SWRCB to divert an additional 31 taf/yr. The water would be conveyed to the cities via the North Bay Aqueduct. (Vacaville is in the Sacramento River Region and its share is 8.5 taf/yr).

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in San Francisco Bay Region

Water supplies are not available to meet all of the region's 2020 water demands in drought years. Applied water shortages are forecasted to be 287 taf. No average year water shortages are forecasted for 2020. Ranking of retained water management options for the San Francisco Bay Region is summarized in Table 7-13. Table 7-14 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Implementation of BMPs will continue through 2020 and is reflected in the base demand levels for urban water use. Urban conservation options likely to be implemented, based on costs and feasibility, would provide an estimated 57 taf/yr in water savings in the region.

Agencies throughout the region have ambitious plans for water recycling as a future water supply option. These options could provide an additional 24 taf/yr to the region by 2020. EBMUD's American River supply would augment drought year supplies by 70 taf. Water marketing agreements being negotiated with Central Valley agencies will likely add 19 taf/yr in the near future. Statewide options including SWP improvements and drought water bank would likely augment drought supplies by 100 taf.

Many South Bay water purveyors' systems are interconnected, reflecting a common reliance on the SWP, CVP, and Hetch Hetchy facilities for their water supplies. CCWD and SCVWD are connected to the Delta via CVP facilities. In addition, piping to facilitate connections between EBMUD and CCWD and the City of Hayward is in place for emergency transfers. (These connections are of limited capacity to allow for transfers in a catastrophic event.) SCVWD, ACWD, and Z7WA are connected by the SWP's South Bay Aqueduct. SFPUC now has a permanent connection to the SWP, to allow it to take delivery of water transfers wheeled by the SWP. These interconnections facilitate water transfers and are positive factors in water resources management in the South Bay.

TABLE 7-13

Options Ranking for San Francisco Bay Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o- New Development	M	750	2	2
Outdoor Water Use to 0.8 ET_o-New and Existing Development	L	[b]	52	52
Indoor Water Use (60 gpcd)	M	400	38	38
Indoor Water Use (55 gpcd)	M	600	77	77
Interior CII Water Use (3%)	M	500	11	11
Interior CII Water Use (5%)	M	750	18	18
Distribution System Losses (5%)	M	300	13	13
Modify Existing Reservoirs/Operations				
Enlarge Lake Hennessey /Napa River Diversion	M	630	12	-
Enlarge Bell Canyon Reservoir	M	[b]	[b]	2
Enlarge Bell Canyon Reservoir/Napa River Diversion	M	[b]	[b]	4
Enlarge Pardee Reservoir	M	[b]	[b]	30
Enlarge Camanche Reservoir	M	[b]	[b]	15
Enlarge Leroy Anderson Reservoir	M	4,400	[b]	25
Upgrade Milliken Treatment Plant	M	1,770	1	1
Reoperate Rector Reservoir	M	800	-	1
New Reservoirs/Conveyance Facilities				
Chiles Creek Reservoir Project/Napa River Diversion	L	1,170	12	-
Enlarge Lake Hennessey/Chiles Creek Project/ Napa River Diversion	L	1,030	15	-
Carneros Creek Reservoir/Napa River Diversion	L	2,100	12	-
Upper Del Valle Reservoir	M	1,600	5	2
Buckhorn Dam and Reservoir	M	[b]	[b]	23
Upper Kaiser Reservoir	M	[b]	[b]	6
Upper Buckhorn Reservoir	L	[b]	[b]	3
Middle Bar Reservoir	L	[b]	[b]	15
Duck Creek Offstream Reservoir	L	[b]	[b]	15
Devils Nose Project	L	[b]	[b]	23
EBMUD American River Supply	M	850	112	70
Groundwater/Conjunctive Use				
Milliken Creek Conjunctive Use	H	150	-	2
Lake Hennessey/Conn Creek Conjunctive Use	H	280	-	5
Water Marketing				
Z7WA/KCWA (7 taf entitlement)	H	[b]	7	5
SCVWD/SLDMWA	H	[b]	-	14

TABLE 7-13

Options Ranking for San Francisco Bay Region (continued)

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Water Recycling				
Group 1 (Cost < $500/af)	H	500	24	24
Group 2 (Cost $500/af - $1,000/af)	M	1,000	20	20
Group 3 (Cost > $1,000/af)	M	1,500	46	46
Desalting				
Brackish Groundwater				
Alameda County Water District Aquifer Recovery Project	H	510	9	9
Seawater				
Marin Municipal Water District Desalting Project	L	1,900	10	10
Other Local Options				
New Surface Water Diversion from Sacramento River by Cities of Benicia, Fairfield, & Vacaville[c]	M	[b]	22	22
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for the highlighted options have been included in Table 7-14.
[b] Data not available to quantify.
[c] The three cities have applied for 31 taf/yr of supplemental water, part of which would be used in the Sacramento River Region.

TABLE 7-14

Options Likely to be Implemented by 2020 (taf)
San Francisco Bay Region[a]

	Average	*Drought*
Applied Water Shortage	**0**	**287**
Options Likely to be Implemented by 2020		
Conservation	-	57
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	-	70
Groundwater/Conjunctive Use	-	7
Water Marketing	-	19
Recycling	-	24
Desalting	-	9
Other Local Options	-	-
Statewide Options	-	100
Expected Reapplication	-	1
Total Potential Gain	**-**	**287**
Remaining Applied Water Shortage	**0**	**0**

[a] Implementing options to reduce drought year shortages would provide more water than is needed to meet average year needs. In average years, this water could be available for transfer to other regions, or some options could be operated at less than their full capacity.

FIGURE 7-4.
Central Coast Hydrologic Region

Central Coast Hydrologic Region

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Description of the Area

The Central Coast Region (Figure 7-4) extends from southern San Mateo County in the north to Santa Barbara County in the south. The region includes the southern tip of San Mateo County, part of Santa Clara County, most of San Benito County, all of Santa Cruz, Monterey, San Luis Obispo and Santa Barbara Counties, and the northwestern tip of Ventura County. The major topographic features include Monterey and Morro Bays; the Pajaro, Salinas, Carmel, Santa Maria, Santa Ynez and Cuyama Valleys; the Coast Range, and the coastal plain of Santa Barbara County. The region is divided into two planning subareas: Northern (including all counties except San Luis Obispo and Santa Barbara) and Southern (San Luis Obispo and Santa Barbara Counties). Summer temperatures are cool along the coastline and warmer inland. In the winter, temperatures remain cool along the coast but become cooler inland. Annual precipitation ranges from about 10 inches on valley floors at the south end of the region to as much as 50 inches on some of the highest peaks. The year-round frost-free climate of the coastal valleys makes them ideal for production of specialty crops such as strawberries and artichokes.

The principal population centers in the region are Santa Cruz, Hollister, Salinas, Monterey, Paso Robles, San Luis Obispo, Santa Maria, Goleta, and Santa Barbara. Intensive agriculture is found in the Salinas and Pajaro Valleys in the north and the Santa Maria and lower Santa Ynez Valleys in the south. Agricultural acreage has remained fairly stable during recent years, although urban development is encroaching on some valley agricultural lands. In the Pajaro and Salinas Valleys, the major crops include vegetables, specialty crops, and cut flowers. Wine grape acreage has increased in the upper Salinas Valley. The flower seed industry in Lompoc Valley is thriving and attracts many tourists each year. Parts of the upper Salinas Valley and Carrizo Plain are dry-farmed to produce grains. Table 7-15 shows the region's population and crop acreage for 1995 and 2020.

Major economic activities include tourism, agricultural-related processing, and government and

The Pajaro and Salinas Valleys are known for their production of specialty crops. Castroville is sometimes called the artichoke capital of the world.

TABLE 7-15

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	1,347	572
2020	1,946	570

service sector employment. Oil production and transportation sites onshore and offshore are important to the economies of Santa Barbara and San Luis Obispo Counties. San Luis Obispo County has major thermal powerplants at Diablo Canyon and Morro Bay. Military facilities include Hunter-Liggett Military Reservation, Vandenberg Air Force Base, and Camp San Luis Obispo.

Water Demands and Supplies

The water budget for the Central Coast Region is shown in Table 7-16. Groundwater is the primary source of water supply in the region, followed by local surface water. CVP water supply is delivered to the northern part of the region from San Luis Reservoir. SWP Coastal Branch deliveries to the southern part of the region began in 1997. Most of the water shortage in the region is due to groundwater overdraft, although the overdraft is expected to lessen with SWP water deliveries and decreased agricultural demands.

Northern PSA

This planning subarea includes Santa Cruz County, Pajaro Valley, the Monterey Peninsula, and Salinas Valley. Water agencies include Monterey County Water Resources Agency, Monterey Peninsula Water Management District, Marina Coast Water District, California-American Water Company (Carmel), Pajaro Valley Water Management Agency, City of Santa Cruz, and San Benito County Flood Control and Water Conservation District.

The Northern PSA is comprised of a number of medium-to-small independent watersheds. There is limited infrastructure for water transfers among the watersheds and from outside the region. The only water import from outside the region comes from CVP's San Felipe Unit, which imports 53 taf/yr into southern Santa Clara and San Benito Counties.

Groundwater is the primary water source for the subarea. Groundwater recharge is provided by the Pajaro, Salinas, and Carmel Rivers, and by Arroyo Seco. San Clemente and Los Padres Dams on the Carmel River (Monterey County), San Antonio Dam on the San Antonio River (Monterey County), and Nacimiento Dam on the Nacimiento River (San Luis Obispo County) are the region's main surface water storage facilities. Water impounded in these reservoirs is managed to provide groundwater recharge.

Southern PSA

The largest water agencies in the southern PSA are two countywide agencies—the San Luis Obispo County Flood Control and Water Conservation District and the Santa Barbara County Flood Control and Water Conservation District. The Central Coast Water Authority was formed in 1991 to construct, manage, and operate Santa Barbara County's 42 mile portion

TABLE 7- 16

Central Coast Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	286	294	379	391
Agricultural	1,192	1,279	1,127	1,223
Environmental	118	37	118	37
Total	**1,595**	**1,610**	**1,624**	**1,652**
Supplies				
Surface Water	318	160	368	180
Groundwater	1,045	1,142	1,041	1,159
Recycled and Desalted	18	26	42	42
Total	**1,381**	**1,328**	**1,452**	**1,381**
Shortage	**214**	**282**	**172**	**270**

[a] Water use/supply totals and shortages may not sum due to rounding.

of the Coastal Aqueduct. Many small retail agencies and small municipalities provide their own water supplies.

The major source of water in the two counties is coastal groundwater basins. SLOCFC&WCD and SBCFC&WCD contract with the Department for SWP water. The two agencies have contractual entitlements totaling 70.5 taf/yr. Due to the 1987-92 drought, three seawater desalting plants were constructed in the region. The City of Morro Bay's plant has an annual capacity of 670 af and is used when groundwater supplies are limited during dry periods. The City of Santa Barbara's plant has an annual capacity of 7.5 taf and is on standby. (Although the Santa Barbara plant only operated briefly in 1992, it is considered in the base water budget as a drought year supply under 1995 level of development, and as an average and drought year supply in 2020.) The plant at San Simeon Beach State Park has minimal capacity (45 af) and is also on standby.

There are two USBR projects in the subarea. The Cachuma Project provides Santa Ynez River water to the Santa Barbara area; main project facilities are the 205 taf Cachuma Reservoir (Bradbury Dam) and the South Coast Conduit. The Santa Maria Project provides Cuyama River water for irrigation use in the Santa Maria area; main project facilities are Twitchell Dam and Reservoir (240 taf). Another federal reservoir, USACE's 26 taf Santa Margarita Lake (Salinas Dam) provides supply for the City of San Luis Obispo.

Local Water Resources Management Issues

Seawater Intrusion

With Central Coast's limited surface supply and few surface water storage facilities, the growing demand for water is causing an increased dependence on the region's groundwater resources. Because groundwater extractions have exceeded groundwater replenishment, seawater has advanced into some coastal freshwater aquifers, degrading water quality. Seawater intrusion is a major concern in the region.

Several decades of over-pumping groundwater have caused seawater intrusion in the aquifers that supply the Salinas Valley with nearly 100 percent of its fresh water. Seawater has intruded almost 6 miles inland into the 180-foot aquifer and two miles inland into the 400-foot deep aquifer. This intrusion has rendered the groundwater too salty for either municipal or agricultural use. Replenishment of groundwater occurs primarily from percolation of surface water from the Salinas River and its tributaries. The construction of Nacimiento and San Antonio Dams in 1957 and 1965, respectively, has increased replenishment but has

DWR's extension of the Coastal Branch to serve San Luis Obispo and Santa Barbara Counties provides an imported surface water supply that can help reduce overdraft of coastal groundwater basins.

not stopped seawater intrusion. In 1994, SWRCB began investigating the Salinas Valley. The SWRCB suggested that adjudication may be necessary if the local agencies could not halt the seawater intrusion.

In 1998, the MCWRA and the MRWPCA jointly completed a $78 million Salinas Valley reclamation project and Castroville seawater intrusion project. These projects consist of a 19.5 taf/yr tertiary treatment plant and a distribution system that will provide recycled water to 12,000 acres of Castroville area farms. During the low irrigation demand periods in winter, early spring and late fall, recycled water will supply most of the water needed for irrigation. During late spring, summer, and early fall, growers will receive a blend of recycled water and groundwater. The projects will reduce groundwater pumping in the project area, thus reducing seawater intrusion. Additionally, the projects will reduce the amount of secondary-treated wastewater discharged to the Monterey Bay National Marine Sanctuary. The sanctuary is a federally-protected aquatic ecosystem extending from Point Reyes to San Luis Obispo with abundant marine resources including kelp forests, marine mammals, and sea and shore birds.

MCWRA is preparing an EIR and preliminary design for a Salinas Valley water project to solve seawater intrusion and nitrate contamination. Major components of the project include dam modifications and reservoir reoperation, river conveyance and diversion facilities, groundwater recharge, storage for recycled water, distribution systems, and conservation. The project also will include management strategies to address nitrate contamination problems.

Seawater intrusion is also a problem facing the Pajaro Valley. Pajaro Valley Water Management Agency is preparing environmental documents to address water management issues facing the valley, following adoption of a basin management plan in 1993. The plan includes projects to develop local supplies, recharge groundwater, import new water, and adopt conservation measures to help solve groundwater overdraft and attendant seawater intrusion problems. Failing to implement the plan could result in intervention by SWRCB, potentially resulting in basin adjudication and restrictions on extractions. PVWMA is working closely with SWRCB to address groundwater overdraft problems, and SWRCB has reserved $5 million in low interest loan money from the Proposition 204 Seawater Intrusion Control Fund to help assist PVWMA in implementing its basin management plan.

Local Water Agency Issues

Santa Cruz County relies mostly on surface water diversions. Drought years pose a threat of water rationing and shortages because of the lack of adequate storage facilities. Seawater intrusion is a concern for groundwater users. For example after years of stable conditions, groundwater quality in municipal wells in the Soquel-Aptos area began to degrade in 1993-94. Soquel Creek Water District, the largest purveyor in this part of the county, relies primarily on groundwater. As measured in monitoring wells along the Monterey Bay coastline, groundwater quality degraded noticeably in less than 4 years, with chloride concentrations increasing from 20 to 40 mg/L to about 250 to 2,500 mg/L. These conditions occurred despite the district's managing its extractions to maintain coastal groundwater levels above sea level and decreasing its pumping.

Between urban growth and growth in tourism, the Monterey Peninsula is expected to experience more frequent shortages in drought years. Water supply for the area comes from the Carmel River, which has relatively little developed storage. In its Monterey Peninsula water supply project final EIR/EIS, MPWMD chose the 24 taf New Los Padres Reservoir on the Carmel River as its preferred alternative for meeting future water needs. The proposed reservoir would expand the Peninsula's water supply and help protect and restore natural resources on the Carmel River, by providing instream flows. However, voters defeated bonds for the project in a 1995 election. MPWMD staff prepared a water supply alternatives plan in 1996 which included recommendations for expanded groundwater production, additional recycled water use, desalting, and additional conservation programs.

In 1995, SWRCB determined that Cal-Am was diverting approximately 10.7 taf/yr out of the Carmel River Basin without valid water rights. SWRCB ordered that diversions from the river be reduced, and that sources outside of the basin be developed. One of these sources could be additional groundwater production from the Seaside Basin, but use of this basin as a replacement for diversions from the Carmel River is being challenged in litigation. SWRCB indicated that New Los Padres Reservoir should be reconsidered to enhance Carmel River habitat values and to provide for Cal-Am's water supply. In 1996, Cal-Am decided to proceed with the New Los Padres Reservoir, but with a reduced urban yield of 10.7 taf to support only existing water needs, without providing supplies for

The Monterey Bay National Marine Sanctuary is home to a variety of species.

future growth. The remainder of the reservoir's supply would be used for instream flow enhancement.

The City of San Luis Obispo has been pursuing a Salinas Reservoir expansion project to supplement its water supply. The existing reservoir is owned by USACE and is managed by SLOCFC&WCD. The expansion project involves installing spillway gates to expand the storage capacity from about 24 taf to 42 taf. The proposed project would increase the city's annual water supply by about 1.6 taf, but would supply only a portion of the city's expected future water demands. An initial draft EIR was issued in late 1993. A revised draft EIR was issued in May 1997.

Seawater Desalting

Current municipal seawater desalting capacity in the Central Coast Region is almost entirely based on the City of Santa Barbara's desalting plant (7.5 taf/yr). The remainder of the plants are small, less than 750 af/yr in capacity. During the 1987-92 drought, a number of seawater desalting projects were anticipated, but the return of average water years put most of these plants on hold. Only Santa Barbara, Morro Bay, and the San Simeon Beach State Park installed plants because of the drought. Proposed bonds for a 3 mgd seawater desalting plant for Monterey Peninsula Water Management District were rejected by voters in 1992. The plants in Santa Barbara and San Simeon are on standby. The plant at Morro Bay is used only during dry periods when groundwater supplies are limited.

In response to seawater intrusion in its groundwater basin, the Marina Coast Water District completed a 300,000 gpd (340 af/yr) seawater desalting plant in 1997. The plant produces about 14 percent of the district's water supply.

Water Management Options for the Central Coast Region

Table 7-17 shows a list of options for the region, and the results of an initial screening of the options.

The Cuyama River has its headwaters in northwestern Ventura County and flows onto the Cuyama Valley floor in San Luis Obispo and Santa Barbara Counties. As suggested by this photo, the river's flow is ephemeral. Valley agriculture is supported by groundwater.

TABLE 7-17

Central Coast Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Modify Nacimiento Spillway	Retain	
Inter-Lake Tunnel - Nacimiento/San Antonio Reservoirs	Defer	Alternative to preferred Nacimiento spillway modification.
Enlargement of Salinas Reservoir	Retain	
Enlargement of Cachuma Reservoir	Retain	
Enlargement of Lopez Reservoir	Defer	Excessive unit cost.
New Reservoirs/Conveyance Facilities		
College Lake	Retain	
Bolsa De San Cayetano Reservoir	Defer	Fishery and foundation issues; excessive cost.
Corncob Canyon Reservoir	Defer	High level of housing development in canyon.
Pescadero Reservoir	Defer	Fishery and foundation issues; excessive cost.
Gabilan Creek Dam	Defer	Questionable water supply.
Feeder Streams (Various Sites)	Retain	
Chalone Canyon Dam	Defer	Questionable water supply.
Vaqueros Canyon Dam	Defer	Questionable water supply.
New Los Padres Reservoir	Retain	
Nacimiento Pipeline	Retain	
Arroyo Seco Dam	Defer	Impacts to environment, residential and commercial development.
Barloy Dam	Defer	Questionable water supply.
Mathews Dam	Defer	Questionable water supply.
Jerret Dam	Defer	Questionable water supply.
New San Clemente Reservoir	Defer	Strong regulatory agency objections.
San Clemente Creek Reservoir	Defer	High probability of inundating spotted owl habitat.
Cachagua Reservoir	Defer	Questionable supply and located outside MPWMD boundaries.
Canada Reservoir	Defer	Questionable geological conditions at dam site.
Klondike Dam	Defer	Located near active faults; inundation of residential development.
Chupines Creek Reservoir	Defer	Questionable supply and located outside MPWMD boundaries.
Pine Creek	Defer	Potential impacts to environmentally sensitive areas.

TABLE 7-17

Central Coast Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Buckeye Creek	Defer	Located near active faults; unsuitable dam foundation.
Lower Jack	Defer	Environmental impacts; riparian oak grassland.
Santa Rita	Defer	Environmental impacts; riparian oak grassland.
Camuesa and Salsipuedes Reservoirs	Defer	Environmental impacts; presence of endangered species.
Hot Springs, New Gilbraltar, and Round Corral Reservoirs	Defer	Insufficient yield, high unit cost of water.
Groundwater/Conjunctive Use		
College Lake Injection/Extraction Wells	Retain	
Increase Groundwater Development in Seaside Basin	Retain	
Seaside Conjunctive Use	Defer	Insufficient yield.
Salinas River Well System	Defer	Will not produce supply without implementing other new supply component.
Storage and Infiltration Basins/Recharge	Defer	Questionable water supply.
Upper/Lower Carmel Valley Well Development	Defer	Questionable water supply.
Water Marketing		
CVP (San Felipe Project Extension)	Retain	
SWP (Coastal Branch/Salinas River/Nacimiento transfer)	Defer	No current local interest.
Water Recycling		
Aquifer Storage/Recovery - Monterey County Water Resources Agency	Retain	
Castroville Seawater Intrusion Project expansion	Retain	
Santa Cruz Water Reuse Project - Pajaro Valley WMA	Retain	
SSLOCSD Reclamation Project - City of Arroyo Grande	Retain	
SVWD Recycled Water Plant - Scotts Valley Water District	Retain	
Urban Reuse Project - Monterey Regional Water Pollution Control Agency	Retain	
Watsonville Water Resue Project - Pajaro Valley WMA	Retain	
Injected Treated Water/Carmel River Mouth	Defer	Health concerns.
Desalting		
Brackish Groundwater		
City of Santa Cruz	Retain	
Seawater		
Monterey Peninsula Water Management District	Retain	

TABLE 7-17

Central Coast Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Other Local Options		
Weather modification	Defer	Difficult to quantify.
Salinas River Diversion and Distribution Project	Retain	
Statewide Options		
—	—	See Chapter 6.

The retained options were evaluated (Table 7A-3 in Appendix 7A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Reducing outdoor water use to 0.8 ET_o in new development would attain about 4 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by about 13 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would reduce depletions by 8 and 17 taf/yr, respectively. Reducing CII water use by an additional 3 and 5 percent would attain 2 taf and 3 taf of depletion reductions per year, respectively. Reducing distribution system losses to 7 and 5 percent would save 3 and 8 taf/yr.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Agricultural conservation options were deferred for this region, because no significant depletion reductions would be achieved. Excess applied irrigation water recharges aquifers in the major agricultural areas.

Modify Existing Reservoirs or Operations

In the Northern PSA, most of these options involve Nacimiento and San Antonio Reservoirs. The options include raising and widening the spillway at Nacimiento Reservoir, constructing a tunnel or pipeline between the two reservoirs, and changing reservoir operation rules. Any combination of these reservoir modification options would likely be combined with other options (such as improved conveyance facilities or groundwater recharge projects). Some of these options are estimated to cost about $100/af—raising and widening the spillway at Nacimiento Reservoir is one such option. Sediment removal may provide a very small amount of additional supply, and MPWMD is studying the effectiveness of sediment removal from its existing reservoirs (Los Padres and San Clemente).

There are two proposals for reservoir enlargements in the Southern PSA. The Salinas Reservoir enlargement project would install a radial gate to raise the spillway height 19 feet above its existing elevation, increasing the reservoir's storage capacity by about 18 taf, and the City of San Luis Obispo's annual yield by almost 2 taf. In Santa Barbara County raising USBR's Bradbury Dam (Cachuma Reservoir) 50 feet for additional water supply plus an additional 40 feet for flood surcharge storage could result in an additional annual yield of 17 taf at a cost of about $1,200/af. The reservoir would serve coastal areas and the Santa Ynez Valley.

New Reservoirs and Conveyance Facilities

In the Pajaro Valley, constructing a 27-foot high dam at the existing College Lake drainage pump house would create a 10 taf reservoir. The reservoir could be supplied with natural runoff and a supplemental 25 cfs diversion from Corralitos Creek during the winter. Its annual yield of 3.4 taf could be supplied to the coastal or inland distribution systems through a 5-mile, 30-inch diameter pipeline. The cost of this option is estimated to be under $400/af. Other reservoir options include Corncob Canyon and Pescadero Creek, both of which could store up to 10 taf; new water supplies produced by either of these options are estimated to cost about $600/af. Bolsa De San Cayetano (estimated to cost $640/af) could store up to 4 taf. These latter three options were deferred, as shown in Table 7-17.

A dam on Arroyo Seco was removed from further consideration as a water supply project, although

MCWRA may evaluate it as a flood control project. The Monterey Peninsula could receive up to 24 taf/yr from the proposed New Los Padres Reservoir, at a cost of about $400/af. This new reservoir would inundate the existing Los Padres Dam on the Carmel River. Although bonds to fund this option were rejected in a 1995 election, Cal-Am announced its intentions to proceed with a reformulated version of the project with 11 taf of annual yield at a cost of $800/af. SWRCB's requirements that Cal-Am provide a new firm supply for existing uses and improve fishery habitat in the Carmel River make New Los Padres a likely future project.

SLOCFC&WCD has an annual 17.5 taf entitlement from Nacimiento Reservoir, only about 1.3 taf of which is now used. A pipeline would be needed to distribute the remaining 16.2 taf to 18 water purveyors. The preferred pipeline alignment would go through the communities of Paso Robles, Templeton, Atascadero, Santa Margarita, and San Luis Obispo and terminate near Avila Beach. This option is not affected by reservoir modifications under consideration by MCWRA.

There are opportunities to import purchased water wheeled through the CVP or SWP into the Northern PSA. In the Pajaro Valley, an option involves connecting a pipeline to USBR's San Felipe Unit, which serves CVP water from San Luis Reservoir to Santa Clara and San Benito Counties. PVWMA could connect to the San Felipe Unit by constructing a 22-mile pipeline from the Watsonville Turnout. This 42-inch diameter pipeline with a capacity of 75 cfs would be able to deliver a maximum of 20 taf/yr. PVWMA does not have a CVP water service contract. CVPIA banned execution of new water service contracts for an indefinite period of time. The average annual yield of a connection to the San Felipe system is estimated to be 13 taf, if a source of purchased water could be found. Northern Monterey County could also benefit from a San Felipe extension because of its close proximity to the Pajaro Valley.

Groundwater Development and Conjunctive Use

Because groundwater is the primary water source for the Central Coast Region, many options have a groundwater recharge component alone or in combination with surface water development projects. In the Pajaro Valley, options include the Pajaro recharge canal (1.5 taf annually) and the College Lake injection/extraction wells (seven wells to inject diverted surface runoff currently captured in College Lake). These wells would be used to extract groundwater during drought years when deliveries of San Felipe water are reduced. On the Monterey Peninsula, the Seaside groundwater basin has the potential to produce an additional 1 taf/yr. This option may be pursued if legal challenges are resolved, because of SWRCB's order which encourages the maximum use of supplies from Seaside to reduce diversions from the Carmel River. Another option would be to retrofit existing wells in the Seaside Basin to accomplish both injection and extraction, to increase storage and to use Carmel River and other supplies more efficiently. This option would include a series of new wells and a pipeline system from inland areas (Fort Ord) to the Monterey Peninsula. The system would be operated primarily for drought year supply. Yields and costs of this option are unknown at present.

In Santa Cruz County, options include several new wells and deep brackish groundwater wells (with reverse osmosis treatment facilities) in the northern coast area. The new wells would provide an additional water supply of about 3 taf while the brackish wells would be used for drought contingency. The groundwater resources of the north county could be increased by developing small local recharge projects, such as retention basins. However, the incremental yield of these projects would be small since the soils in the area are sandy and runoff is already minimal. There are no physical facilities available for artificial recharge in the Southern PSA, but there are some potential sites along coastal streams in San Luis Obispo County where additional runoff could be used for recharging groundwater basins.

Water Marketing

In the Salinas Valley, SWP water from the Coastal Branch could be purchased and either traded with San Luis Obispo County for that county's existing entitlement to Nacimiento reservoir water or delivered directly through a pipeline constructed at the aqueduct's crossing of the Salinas River. There are presently no local agencies seeking water marketing arrangements using this approach.

PVWMA is evaluating options for assignment of CVP water from project agricultural water contractors and opportunities for participation with SCVWD and San Benito County Flood Control and Water Conservation District (existing CVP San Felipe Division contractors) in water marketing arrangements.

Water Recycling

For the Northern PSA, water recycling options include an aquifer storage and recovery program which would use injection wells to store recycled water produced during the winter, and then would extract this water for irrigation in the Castroville area during the summer months. This program has an estimated annual yield of up to 8.3 taf.

In the Pajaro Valley, a 12 or 18 mgd recycling plant would be constructed adjacent to the existing Watsonville Wastewater Treatment Plant. The 12 mgd plant (about 13.4 taf annually) would treat water from the Watsonville area; the 18 mgd plant (about 20.1 taf annually) would treat water from both Watsonville and Santa Cruz. The 18 mgd option would require constructing a pipeline from Santa Cruz to Watsonville to transport treatment plant effluent.

On the Monterey Peninsula, the Carmel Area Wastewater District/Pebble Beach Community Services District treatment plant could be expanded to provide more recycled water (up to 100 af annually) for use on golf courses, open space, or cemeteries. In 1992, local water agencies studied potential markets for recycled water produced by the regional recycling plant near Marina. Potential uses of recycled water in Fort Ord, Seaside, and other Monterey Peninsula communities having a potential annual demand of up to 1 taf were identified, but the uses were deemed economically infeasible at that time. This study is currently being updated to reflect the conversion of Fort Ord to civilian use.

For the Southern PSA, recycled water projects have been proposed in conjunction with construction of new or expanded municipal wastewater treatment plants. In coastal areas—such as San Luis Obispo Bay, Estero, and south San Luis Obispo County—treated wastewater is discharged to the ocean, and reusing the wastewater would help reduce water supply shortages. (In the City of San Luis Obispo and in communities along the Salinas River, the wastewater recharges the groundwater basin.)

Planned recycling projects in Santa Barbara County include the Santa Barbara regional water reuse project, which would provide 1.6 taf of recycled water annually for landscape irrigation within the City of Santa Barbara, Montecito Water District, and Summerland County Water District. This project would replace potable water being used for irrigation. Other potential projects involve expanding Lompoc's secondary treatment facilities and Santa Barbara's tertiary treatment facilities for an additional annual yield of 2 taf by the year 2000.

Desalting

Several coastal cities in the region have identified desalting options for additional water supply. The City of Santa Cruz is conducting a feasibility study on a 4.5 taf/yr brackish groundwater desalting plant to supplement local water supplies. The Cambria and San Simeon community services districts had plans, recently put on hold, to jointly construct a 320 af/yr (with ultimate capacity of 1.3 taf annually) seawater desalting plant. Monterey Peninsula Water Management District's plans for a 3.4 taf/yr seawater desalting plant were defeated by voters in the 1992 election.

Other Local Options

In the Salinas Valley, a Salinas River diversion and distribution project is being planned to transfer up to 35 taf/yr to northern Salinas Valley to halt seawater intrusion. In the Northern PSA, MCWRA has a weather modification program which targets the watersheds of the Nacimiento and San Antonio Rivers and the Arroyo Seco. MCWRA estimates that increased annual flows into reservoirs ranged from about 8 taf to 68 taf between 1990 to 1994. San Luis Obispo began a 3-year cloud seeding program in January 1991 to produce more runoff in the Salinas and Lopez Watersheds. Although this program has ended, future programs may be a possibility. Future weather modification options are difficult to quantify and are not evaluated in this Bulletin. Weather modification programs are often operated on a year-to-year basis by water agencies, and usually not reliable supply sources in drought years due to a lack of storm systems to seed.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in Central Coast Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 172 taf and 270 taf in average and drought years, respectively. Ranking of retained water management options for the Central Coast Region is summarized in Table 7-18. Table 7-19 summarizes options that can likely be implemented by 2020 to relieve the shortages.

TABLE 7-18

Options Ranking for Central Coast Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8ET$_o$ - New Development	M	750	4	4
Outdoor Water Use to 0.8ET$_o$ - New and Existing Development	M	[b]	13	13
Indoor Water Use (60 gpcd)	M	400	8	8
Indoor Water Use (55 gpcd)	M	600	17	17
Interior CII Water Use (3%)	M	500	2	2
Interior CII Water Use (5%)	M	750	3	3
Distribution System Losses (7%)	M	200	3	3
Distribution System Losses (5%)	M	300	8	8
Modify Existing Reservoirs/Operations				
Modify Nacimiento Spillway	H	120	20	[b]
Enlargement of Salinas Reservoir	M	400	2	[b]
Enlargement of Cachuma Reservoir	L	1,200	17	[b]
New Reservoirs/Conveyance Facilities				
College Lake	M	350	3	-
Feeder Streams (Various Sites)	M	400	[b]	[b]
New Los Padres Reservoir	M	800	11	11
Nacimiento Pipeline	M	950	16	16
Groundwater/Conjunctive Use				
College Lake Injection/Extraction Wells	M	130	2	2
Increase Groundwater Development in Seaside Basin	L	410	1	1
Water Marketing				
CVP (San Felipe Project Extension)	M	580	13	2
Water Recycling				
Group 1 (Cost < $500/af)	H	500	29	29
Group 2 (Cost $500/af - $1,000/af)	M	1,000	8	8
Desalting				
Brackish Groundwater				
City of Santa Cruz	L	1,100	5	5
Seawater				
Monterey Peninsula WMD	L	1,700	3	3
Other Local Options				
Salinas River Diversion and Distribution Project	M	[b]	35	[b]
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 7-19.
[b] Data not available to quantify.

The urban water conservation options beyond BMPs that would likely be implemented would add 32 taf/yr in depletion reductions in the region. Additional reliance on water recycling will be likely in the future to alleviate shortages. Additional water recycling in the region could produce 29 taf/yr of new water supply. Recycled water would be used for landscaping, direct agricultural application, and groundwater recharge.

In the Pajaro Valley, options that would likely be implemented by 2020 would include a pipeline to connect to the CVP's San Felipe Unit to provide an opportunity for water transfers.

Modifying existing reservoirs or constructing new reservoirs are likely options for the region. One likely option to augment water supplies in the Salinas Valley would be to modify Nacimiento's spillway. Raising the spillway 6.5 feet would increase storage capacity by 34 taf, increasing the reservoir's yield by about 20 taf. Other spillway modifications are also being evaluated to allow more water to be released throughout the year for recharge. A long-term water management plan for the Monterey Peninsula would likely include construction of the proposed New Los Padres Dam, which could augment supplies by 11 taf/yr.

In San Luis Obispo County, current planning focuses on the Nacimiento pipeline, which would convey a portion of the county's entitlement of 17.5 taf/yr from Lake Nacimiento in northern San Luis Obispo County. Communities potentially receiving supplies from this option include the City of San Luis Obispo and Cayucos (through an exchange of water from Nacimiento and Whale Rock Reservoirs). In addition, the communities of Paso Robles, Templeton, and Atascadero may also receive supplies for groundwater recharge.

If implemented, the identified options would still leave remaining shortages in drought years of 100 taf.

TABLE 7-19

Options Likely to be Implemented by 2020 (taf)
Central Coast Region

	Average	*Drought*
Applied Water Shortage	**172**	**270**
Options Likely to be Implemented by 2020		
Conservation	32	32
Modify Existing Reservoirs/Operations	22	[a]
New Reservoirs/Conveyance Facilities	27	27
Groundwater/Conjunctive Use	2	2
Water Marketing	13	2
Recycling	29	29
Desalting	–	–
Other Local Options	35	[a]
Statewide Options	5	57
Expected Reapplication	7	21
Total Potential Gain	**172**	**170**
Remaining Applied Water Shortage	**0**	**100**

[a] Data not available to quantify.

FIGURE 7-5

South Coast Hydrologic Region

South Coast Hydrologic Region

. . .

Description of the Area

The South Coast is California's most urbanized hydrologic region (Figure 7-5). Although it covers only about 7 percent of the State's total land area, it is home to roughly 54 percent of the State's population. Extending eastward from the Pacific Ocean, the region is bounded by the Santa Barbara-Ventura County line and the San Gabriel and San Bernardino Mountains on the north, and a combination of the San Jacinto Mountains and low-elevation mountain ranges in central San Diego County on the east, and the Mexican border on the south. Topographically, the region is comprised of a series of broad coastal plains, gently sloping interior valleys, and mountain ranges of moderate elevations. The largest mountain ranges in the region are the San Gabriel, San Bernardino, San Jacinto, Santa Rosa, and Laguna Mountains. Peak elevations are generally between 5,000 and 8,000 feet above sea level; however, some peaks are nearly 11,000 feet high.

The climate of the region is Mediterranean-like, with warm dry summers followed by mild winters. In the warmer interior, maximum temperatures during the summer can be over 90°F. The moderating influence of the ocean results in lower temperatures along the coast. During winter, temperatures rarely descend to freezing except in the mountains and some interior valley locations.

About 80 percent of the precipitation occurs during the four-month period from December through March. Average annual rainfall can range from 10 to 15 inches on the coastal plains and 20 to 45 inches in the mountains. Precipitation in the highest mountains commonly occurs as snow. In most years, snowfall is sufficient to support winter sports in the San Bernardino and San Gabriel Mountains.

There are several prominent rivers in the region, including the Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, and San Luis Rey. Some segments of these rivers have been intensely modified for flood control. Natural runoff of the region's streams and rivers averages around 1.2 maf annually.

The largest cities in the region are Los Angeles, San Diego, Long Beach, Santa Ana, and Anaheim. Although highly urbanized, about one-third of the region's land is publicly owned. About 2.3 million acres is public land, of which 75 percent is national forest. Irrigated crop acreage accounts for a small percent of land use. Table 7-20 shows the region's population and crop acreage for 1995 and 2020.

Water Demands and Supplies

Since the turn of the century, extensive water development has been carried out in the South Coast Region. Steady expansion of population and of the economy led to the demands and financial resources to build large water supply projects for importing water to the region. In 1913, the Los Angeles Aqueduct began importing water from the Owens Valley to the South Coast Region. Los Angeles diversions from the

TABLE 7-20

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	17,299	313
2020	24,327	190

Although the South Coast Region has been extensively urbanized, some species of wildlife have learned to coexist with suburban development. The region's remaining riparian areas still support such common mammals as skunks and raccoons.

Mono Basin began in 1940 when the LAA was extended by about 11 miles (a second conduit was added in 1970). In 1941, MWDSC completed its Colorado River Aqueduct, which now provides about 25 percent of the region's supply. SWP began delivering water from the Delta to the South Coast Region in 1972. Table 7-21 shows the water budget for the region.

Los Angeles Aqueduct

The Los Angeles Department of Water and Power owns and operates the LAA which diverts both surface and groundwater from the Owens Valley and surface water from the Mono Basin. The combined carrying capacity of the aqueduct system is about 760 cfs, or about 550 taf/yr. An average of 400 taf/yr of water is delivered through the LAA with a record 534 taf in 1983. Court-ordered restrictions on diversions from the Mono Basin and Owens Valley have reduced the amount of water the City of Los Angeles can divert (see South Lahontan Region).

Colorado River Aqueduct

MWDSC was created in 1928 to construct and operate the Colorado River Aqueduct to deliver Colorado River water to Southern California. MWDSC wholesales water supplies from the Colorado River and the SWP to water agencies throughout Southern California.

MWDSC and its 27 member agencies (Table 7-22) serve 95 percent of the South Coast Region. Some agencies rely solely on MWDSC for their water supply, while many, like the City of Los Angeles, rely on MWDSC to supplement existing supplies. Between its fiscal years 1970 and 1994, the City of Los Angeles

TABLE 7-21

South Coast Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	4,340	4,382	5,519	5,612
Agricultural	784	820	462	484
Environmental	100	82	104	86
Total	**5,224**	**5,283**	**6,084**	**6,181**
Supplies				
Surface Water	3,839	3,196	3,625	3,130
Groundwater	1,177	1,371	1,243	1,462
Recycled and Desalted	207	207	273	273
Total	**5,224**	**4,775**	**5,141**	**4,865**
Shortage	**0**	**508**	**944**	**1,317**

[a] Water use/supply totals and shortages may not sum due to rounding.

For much of its length, LADWP's aqueduct skirts the eastern flank of the Sierra Nevada.

purchased an average of 130 taf/yr from MWDSC, about 20 percent of the City's total water supply. In 1996, almost 90 percent (447 taf) of San Diego County Water Authority's total water supply was purchased from MWDSC.

MWDSC has received Colorado River water since 1941 under contracts with USBR. These contracts have allowed the diversion of 1.21 maf/yr, as well as 180 taf/yr of surplus water when available. (The maximum capacity of the CRA is 1.3 maf/yr.) California's basic apportionment of Colorado River water is 4.4 maf/yr plus one-half of any surplus water, when available. In the past, California was able to use hydrologic surpluses and the amount apportioned to, but not used by, Nevada and Arizona. With completion of the Central Arizona Project and Arizona's 1996 enactment of a state groundwater banking act, Arizona's use has reached it basic apportionment. California's reduction of Colorado River use from current levels to 4.4 maf / yr has significant implications for the South Coast Region. (See the issues section below and the Colorado River Region in Chapter 9). California's Colorado River use reached a high of 5.4 maf in 1974, and has varied from 4.5 maf to 5.3 maf annually over the past 10 years.

State Water Project

Local agencies contracting with the SWP for part of their supplies are shown in Table 7-23.

MWDSC is the largest SWP contractor, with an annual entitlement of more than 2 maf. In 1992, Castaic Lake Water Agency assumed the SWP contract of Devil's Den Water District in the Tulare Lake

TABLE 7-22

Metropolitan Water District of Southern California Member Agencies

Cities	*Municipal Water Districts*	*Water Authority*
Anaheim	Calleguas	San Diego County
Beverly Hills	Central Basin	
Burbank	Chino Basin	
Compton	Coastal	
Fullerton	Eastern	
Glendale	Foothill	
Long Beach	Las Virgenes	
Los Angeles	Orange County	
Pasadena	Three Valleys	
San Fernando	West Basin	
San Marino	Upper San Gabriel Valley	
Santa Ana	Western of Riverside County	
Santa Monica		
Torrance		

TABLE 7-23

State Water Project Contractors in the South Coast Region

Agency	*Contract Entitlement (taf)*	*SWP Deliveries in 1995 (taf)*
Castaic Lake WA	54.2	27.2
San Bernardino Valley MWD	102.6	0.7
San Gabriel Valley MWD	28.8	12.9
San Gorgonio Pass WA	17.3	0
MWDSC	2,011.5	436.0
Ventura County FCD	20.0[a]	0

[a] Ventura County FCD subleases 1.85 taf/yr to MWDSC.

Region, increasing Castaic's entitlement to 54.2 taf. Within the San Bernardino Valley Municipal Water District service area, groundwater is the major water source, and hence the district has used little of its SWP water. Ventura County Flood Control District also relies mostly on groundwater and has taken delivery of SWP supply only twice, during the drought in 1990 and 1991. San Gorgonio Pass Water Agency (which also serves a portion of the Colorado River Region) lacks the facilities to take delivery of SWP water, and to date has received no supply from the SWP.

The Department is working with the SGPWA and SBVMWD to extend the East Branch of the California Aqueduct to SGPWA, which serves the Banning Pass area of Riverside County (including the communities of Banning and Beaumont), and to provide system improvements to SBVMWD. The Notice of Determination for the final supplemental EIR was filed in March 1998. The project will be constructed in two phases. Phase I construction is scheduled to begin in late 1998 and to be completed by late 2000. A second phase will be constructed to serve the Mentone area if demand increases.

The Department's A.D. Edmonston Pumping Plant lifts California Aqueduct water 1,926 feet across the Tehachapi Mountains to serve Southern California. The maximum plant capacity is 4,480 cfs.

Local Surface Water Supplies

Table 7-24 lists major local storage reservoirs in the region. Most of the larger reservoirs in the region have water supply as their primary purpose. However, several of the larger water supply reservoirs do not develop local supply—they are the terminal facilities of the major conveyance facilities that import water to the region.

Table 7-25 lists local water supply reservoirs in MWDSC's service area with at least 10 taf storage capacity.

About 96 percent of San Diego County's population resides within SDCWA's service area. SDCWA, a wholesale water agency, purchases imported water from MWDSC and delivers the water to its 23 member agencies (Table 7-26) in the western third of San Diego County through two aqueduct systems. SDCWA's maximum annual delivery was 647 taf in 1990. Most of San Diego's in-county water supplies are from local agencies' surface reservoirs. Twenty-four surface reservoirs are located within its service area, with a combined capacity of approximately 569 taf. Some reservoirs are connected to SDCWA's aqueduct system and can receive imported water in addition to surface runoff. In 1995, local water sources provided 118 taf, or 23 percent of the water used in SDCWA's service area. (Since 1980, local surface water supplies have ranged from 33 taf to 174 taf annually.)

TABLE 7-24

Major Reservoirs in the South Coast Region[a]

Reservoir	*Owner*	*Capacity (taf)*	*Primary Purpose*
Casitas	USBR	254	Water Supply
Lake Piru	United WCD	88	Water Supply
Pyramid	DWR	171	Water Supply
Castaic	DWR	324	Water Supply
Big Bear Lake	Big Bear MWD	73	Water Supply
Perris	DWR	132	Water Supply
Mathews	MWDSC	182	Water Supply
Vail	Rancho California WD	51	Water Supply
Henshaw	Vista ID	52	Water Supply
San Vicente	City of San Diego	90	Water Supply
El Capitan	City of San Diego	113	Water Supply
Morena	City of San Diego	50	Water Supply
Whittier Narrows	USACE	67	Flood Control
Prado[b]	USACE	188	Flood Control
Seven Oaks (under construction)	USACE	146	Flood Control
Eastside (under construction)	MWDSC	800	Water Supply

[a] Reservoirs with capacity greater than 50 taf.

[b] 26 taf of storage capacity is used for water supply purposes, for downstream groundwater recharge.

TABLE 7-25

Reservoirs Owned by Water Retailers in MWDSC's Service Area[a]

Reservoir	*Agency*	*Capacity (taf)*
Bard	Calleguas MWD	10
Vail	Rancho California	51
Hemet	Lake Hemet MWD	14
Westlake	Las Virgenes MWD	10
Los Angeles	City of Los Angeles	10
Stone Canyon	City of Los Angeles	11
Santiago	Irvine Ranch WD & Serrano ID	25
Henshaw	Vista ID	52
Barrett	City of San Diego	38
El Capitan	City of San Diego	113
Lake Hodges	City of San Diego	34
Morena	City of San Diego	50
Lower Otay	City of San Diego	50
San Vicente	City of San Diego	90
Sutherland	City of San Diego	30
Loveland	South Bay ID	25
Sweetwater	South Bay ID	28
Railroad Canyon	Temescal Water Company	12

[a] Reservoirs with capacity of at least 10 taf.

The City of San Diego's Murray Dam, shown under construction in 1917, is a multiple arch concrete dam impounding a 6 taf reservoir. The wooden stave pipeline below conveyed supplies for the Cuyamaca Water Company.

Courtesy of Water Resources Center Archives, University of California, Berkeley

Groundwater Supplies

Groundwater is a major local supply source in the remaining counties in MWDSC's service area. For example local supplies developed by individual retail agencies, primarily groundwater, presently account for about 50 percent of Orange County's water use. There are numerous groundwater basins (Figure 7-6) along the coast and inland valleys of the region. Many of these basins are actively managed by public agencies or have been adjudicated by the courts. Some groundwater basins are as large as several hundred square miles in area and have a capacity exceeding 10 maf. The South Coast's current estimated annual groundwater use is about 1.2 maf. Recharge occurs from natural infiltration along river valleys, but in many cases facilities have been constructed to recharge local, imported, or recycled supplies. For example, in average years the Los Angeles Department of Public Works intention-

TABLE 7-26

San Diego County Water Authority Member Agencies

Cities
- Del Mar
- Escondido
- National City
- Oceanside
- Poway
- San Diego

Water Districts
- Helix
- Otay
- San Dieguito
- Vallecitos

Municipal Water Districts
- Carlsbad
- Olivenhain
- Padre Dam
- Rainbow
- Ramona
- Rincon Del Diablo
- Valley Center
- Yuima

Irrigation Districts
- Santa Fe
- South Bay
- Vista

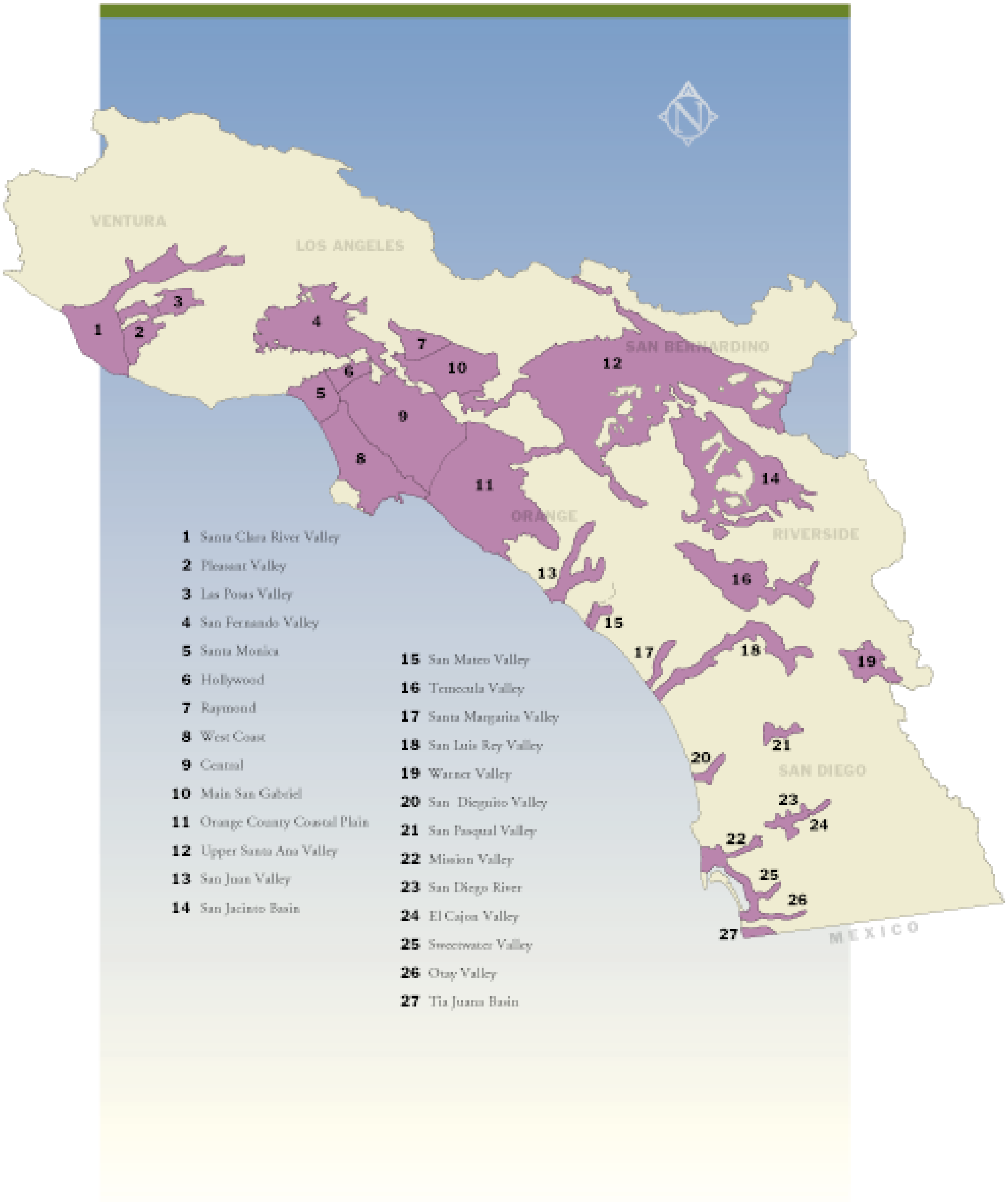
Public Utility District
- Fallbrook

Reservation
- Pendleton Military

Ex-Officio Member
- San Diego County

FIGURE 7-6

South Coast Groundwater Basins



ally recharges 230 taf of local flows, 60 taf of imported water, and 50 taf of recycled water. These surface supplies not only replenish groundwater basins, but can be banked for later use. Programs are in place to bank imported water, when available in wetter periods, to increase groundwater production during the summer season and in drought years. At a 1995 level of development, about 100 taf is banked in average years. This water is included as an average year urban water demand in Bulletin 160-98 water budgets for the South Coast.

Table 7-27 shows adjudicated groundwater basins in the South Coast Region. In the adjudicated groundwater basins, the court appoints watermasters to oversee the court judgement. The court judgement limits the amount of groundwater that can be extracted by parties to the judgement.

Local Water Resources Management Issues

Water Supply Reliability

Since local supplies are insufficient to meet water demands, the region imports more than 60 percent of its supply. A natural disaster or other emergency that would curtail or limit imports to the region would be detrimental. Water supply reliability is a critical issue for the region and water agencies are seeking to ensure a more reliable and adequate supply in case of emergencies.

Eastside Reservoir. MWDSC provides about 60 percent of the water used by the nearly 16 million people living on the coastal plain between Ventura County and the Mexican border. MWDSC is constructing Eastside Reservoir to better manage its water supplies between wet and dry years. The 800 taf reservoir, located near Hemet in southwestern Riverside County, will nearly double the region's existing surface storage capacity and will provide increased terminal storage for SWP and Colorado River supplies. When completed, Eastside Reservoir would provide the entire region with a six-month emergency supply after an earthquake or other disaster. It would also provide water supply for drought protection and peak summer demands.

Under construction in the Domenigoni and Diamond Valleys, the $2 billion project consists of two embankments to block the east and west ends of the valleys, and a saddle dam located along a low point in the hills which form the northern boundary of the reservoir. The reservoir includes a forebay and pumping plant, and the 8-mile, 12-foot diameter Eastside Pipeline. After reservoir completion in 1999, up to four years will be needed to fill the reservoir with imported water. Water from the Colorado River Aqueduct will be delivered through the San Diego Aqueduct to the reservoir forebay and pumped into the reservoir. SWP water will either be delivered from the Santa Ana Valley Pipeline and bypassed around Lake Perris, or taken from Lake Perris and conveyed through MWDSC's system into the reservoir forebay.

The Inland Feeder is a new conveyance facility to deliver SWP water made available by enlargement of the East Branch of the California Aqueduct. Upon its completion in 2004, the Inland Feeder will deliver

Plans to construct a San Diego emergency storage project reflect the area's vulnerability to natural disasters such as earthquakes. Much of the area's supplies are imported through the Colorado River Aqueduct. This photo shows an early example of local conveyance projects—a wooden trestle carrying a flume across the Sweetwater River.

Courtesy of Water Resources Center Archives, University of California, Berkeley

TABLE 7-27

Adjudicated Groundwater Basins in the South Coast Region

Court Name	*Filed in Court*	*Final Decision*	*Watermaster*	*Basin Name, County*
Upper Los Angeles River Area	1955	1979	Superior Court appointee	San Fernando Valley Basin (entire watershed), Los Angeles County
Raymond Basin	1937	1944	Raymond Basin Management Board	Northwest part of San Gabriel Valley Basin, Los Angeles County
Main San Gabriel Basin	1968	1973	9-Member Board appointed by the Los Angeles County Superior Court	San Gabriel Valley Basin, excluding Raymond Basin, Los Angeles County
Central Basin	1962	1965	DWR	Northeast part of Coastal Plain of Los Angeles County Basin, Los Angeles County
West Coast Basin	1946	1961	DWR	Southwest part of Coastal Plain of Los Angeles County Basin, Los Angeles County
Puente	1985	1985	Two consultants, one representing the Walnut Valley WD and Rowland WD; and one for the City of Industry and Industry Urban Development Agency; and a third neutral party	Southwest part of San Gabriel Valley Basin, Los Angeles County
Santa Margarita River Watershed	1951	1966	U.S. District Court appointee	The entire Santa Margarita River watershed, including Santa Margarita Coastal, Murrieta-Temecula and Anza-Cahuilla groundwater basins, San Diego and Riverside Counties
Santa Paula Basin	1991	1996	3 person Technical Advisory Committee from United Water Conservation District, City of Ventura, and Santa Paula Basin Pumpers Association	Sub-basin of Santa Clara River, Ventura County
Chino Basin	1978	1978	9-Member Board	Chino Basin, northwest part of Upper Santa Ana Valley Basin, San Bernardino and Riverside Counties
Cucamonga Basin	N/A	1958	Cucamonga County WD and San Antonio Water Company	Cucamonga Basin, north-central part of Upper Santa Ana Valley Basin, San Bernardino County
San Bernardino Basin Area	1963	1969	One representative each from Western Municipal Water District and San Bernardino Valley Municipal Water District	Northeast part of Upper Santa Ana Basin, San Bernardino and Riverside Counties

water by gravity to Eastside Reservoir via 43.7 miles of tunnels and pipeline that start at Devil Canyon and tie into the CRA and Eastside Pipeline. The Inland Feeder will provide system reliability by linking together the SWP and Colorado River systems, and will improve water quality by allowing greater blending of SWP and Colorado River waters.

San Diego Emergency Water Storage Project. SDCWA does not own or operate treatment or storage facilities. It has a contractual agreement with the City of San Diego to store up to 40 taf of water in San Vicente and Lower Otay Reservoirs. To increase local supplies that would be available during times of emergency, SDCWA has proposed an emergency storage project that could increase the county's total water storage by 90 taf. Use of the project would be limited to emergency situations, such as prolonged drought or catastrophic failure of the San Diego Aqueduct during an earthquake. Although not a water supply development project, the emergency water storage project would provide incidental local supply benefits by allowing capture of additional winter runoff.

Four project alternatives were evaluated. All involved increased surface storage and new distribution systems. Three alternatives additionally involved reservoir reoperation.

- San Vicente stand-alone. Expand San Vicente Reservoir by raising the dam 83 feet to contain 90.1 taf of emergency storage.
- Moosa Canyon construction/Lake Hodges reoperation. Construct a new dam at Moosa Canyon to hold 68 taf and reoperate Lake Hodges to provide 22 taf.
- San Vicente expansion and reoperation. Raise the dam by 65 feet, adding 68 taf of emergency storage and reoperate the reservoir to provide an additional 22 taf.
- Olivenhain construction, Lake Hodges reoperation, and San Vicente expansion. Build a new 320-foot high dam at the Olivenhain site to create 18 taf of emergency storage (24 taf total capacity, with 4 taf reserved for Olivenhain MWD). Reoperate Lake Hodges to provide an additional 20 taf and raise San Vicente Dam by 54 feet to hold an additional 52 taf.

The preferred alternative is the Olivenhain-Hodges-San Vicente project. A new reservoir would be constructed about 1 mile northwest of Lake Hodges in conjunction with Olivenhain Municipal Water District. Olivenhain Reservoir, which would also serve as operational storage for Olivenhain MWD, would be connected to Lake Hodges by a 1.5-mile pipeline. San Vicente Dam would be raised from 234 feet to 288 feet. The Olivenhain-Hodges-San Vicente project would add 90 taf of emergency storage capacity. The final EIR was certified in 1996. In 1997, USACE issued a record of decision on the final EIS and a permit for the project under Section 404 of the federal Clean Water Act. Construction of the $550 million project is scheduled to begin in 1999 and be completed by 2011. SDCWA has agreements with the City of San Diego regarding joint use of San Vicente Reservoir and Lake Hodges, and with Olivenhain MWD concerning joint use of the Olivenhain Reservoir. (Olivenhain MWD had planned to construct a 5 to 8 taf reservoir at the site for its own use if SDCWA did not go forward with a joint project.) Olivenhain MWD would construct a 20 mgd water treatment plant (to be expanded to 80 mgd ultimately) in conjunction with storage at Olivenhain reservoir.

Management of California's Colorado River Water

A major water management issue facing the South Coast Region is California's use of Colorado River water in excess of its basic annual apportionment of 4.4 maf. In the past, Arizona and Nevada were not using the full amount of their annual apportionments, and California was able to use the amount apportioned to, but not used by, Nevada and Arizona, and to use wet year surplus flows. As described in more detail in Chapter 9, the Colorado River Board's draft 4.4 Plan describes how California would reduce its use of river water over time.

The draft CRB 4.4 Plan includes actions that would be taken in two phases. The first phase, extending from the present to 2010 or 2015, would comprise those actions that are now in some stage of planning and implementation. These programs are intended to reduce California's annual use of Colorado River water to about 4.6 to 4.7 maf. The second phase would comprise actions that have not yet been formulated and quantified. Examples of phase one actions include the SDCWA/IID transfer, lining of parts of the All-American and Coachella Canals, and groundwater banking projects associated with surplus Colorado River water that could be conveyed in MWDSC's aqueduct. Examples of potential phase two actions include proposals to desalt water in Salton Sea tributaries and to convey the treated water to the South

Coast Region. (Actions such as agricultural water conservation programs or desalting proposals that would reduce the amount of fresh water inflow to the Salton Sea are subject to environmental review to ensure that they will not significantly affect the sea. A description of the Salton Sea and its environmental resources is provided in Chapter 9.)

The draft CRB 4.4 Plan would in essence reduce California's use of Colorado River water in agricultural areas in the Colorado River Region, transfer conserved Colorado River water to the South Coast Region for urban use, and define how water from wet year surpluses (and the unused apportionments of other states, when available) could be used to help keep the Colorado River Aqueduct full. When California is limited to its basic apportionment of 4.4 maf, MWDSC would only be able to exercise its fourth priority right to 550 taf, as compared to maximum aqueduct capacity of 1.3 maf.

Mono Basin

The City of Los Angeles' water diversions from Mono Basin lowered Mono Lake's water level by more than 40 feet since 1941 and also increased the lake's salinity. (See the South Lahontan Region in Chapter 9 for more detailed discussion of Mono Lake issue.) In 1994, SWRCB adopted Water Right Decision 1631 amending the city's water rights for diverting water from Mono Basin. The decision restricts diversions from the basin to increase and maintain Mono Lake's level to 6,391 feet above sea level. During the period of Mono Lake's transition to the 6,391-foot level (estimated to take about 20 years), the maximum amount of water that Los Angeles can divert from the basin is 16 taf/yr. Long-term Los Angeles diversions from the Mono Basin are projected to be about 31 taf/yr after Mono Lake has reached the 6,391-foot level, or one-third of the city's historical diversions from the Mono Basin.

Restoration of Coastal Wetlands and Estuaries

Ballona Wetlands Preserve. Although the majority of California's wetlands habitat is found in the Central Valley and San Francisco Bay area, there are significant wetlands in the South Coast, as described below. The Ballona wetlands is one of the more well-known South Coast wetlands.

The Ballona Wetlands Preserve, located in Los Angeles County near Marina Del Rey, is one of the few tidal marshes in Southern California. It is a complex of estuary, lagoon, salt marsh, freshwater marsh, and dune habitats. It provides nesting grounds for migrating waterfowl, supports a variety of plant, fish, and animal life, and is home to two endangered species—Belding's Savannah sparrow and the California least tern. The present Ballona wetlands is a small remnant of what existed in the early 1800s, when the wetlands comprised more than 2,000 acres. At the present time, it has been reduced to a little more than 180 acres.

The Ballona Wetlands Preserve was the subject of a long-running debate among private property owners and environmental groups that began in 1984 when the California Coastal Commission approved a land use plan to develop the wetlands. In the years that followed, the parties negotiated a settlement to litigation over the development. The settlement provides for:

- Restoration of 190 acres of salt marsh habitat. Plans are underway to provide the eastern portion of the salt marsh with full tidal flow and expanded habitat for sub-tidal and mudflat organisms. The western portion would be provided with muted tidal flow to protect and enhance existing salt marsh habitat for pickleweed and the Belding's Savannah sparrow.
- A 34-acre freshwater marsh.
- A 25-acre corridor of riparian habitat along Centinela Creek. This area will potentially provide appropriate vegetation for the least Bell's vireo and a wide variety of other birds which nest in riparian trees.
- Restoration of 48 acres of upland, bluff edge, and coastal strand habitat.

When completed, the Ballona Wetlands Preserve will be one of the largest wildlife sanctuaries in any major U.S. city.

Santa Monica Bay. Santa Monica Bay extends about 50 miles from Point Hume to Palos Verdes Point. A coordinated effort to improve the Santa Monica Bay ecosystem began with establishment of the Santa Monica Bay restoration project. SMBRP was included in the Clean Water Act's National Estuary Program in 1988, and was charged with assessing the bay's problems and with producing a bay restoration plan. Implementation of the plan, approved by the Governor in 1994, and by the Administrator of EPA in 1995, is currently under way.

Prado Wetlands Project. OCWD owns 2,150 acres behind Prado Dam in Riverside County where the district operates constructed freshwater wet-

An aerial view of the constructed wetlands behind Prado Dam.

Courtesy of Orange County Water District

lands to reduce the nitrogen concentration of river water. USACE's Prado Flood Control Basin is operated primarily for flood control. Under an agreement with USACE and USFWS, OCWD uses 25.75 taf of the reservoir's capacity for water supply. OCWD diverts Santa Ana River water through 465 acres of constructed wetlands for biochemical nitrogen removal. Because Santa Ana River water provides much of the recharge for Orange County's coastal plain groundwater basin, nitrogen removal is important to improving water quality.

The Prado wetlands are home to several rare and endangered bird and waterfowl species. As part of the three party agreement, OCWD set aside more than 226 acres as habitat for the endangered least Bell's vireo and southwestern willow flycatcher.

Flood Control

As noted earlier, groundwater constitutes most of the local water supply in the region. Local surface water resources are relatively limited. In the Los Angeles-Orange County coastal strip, most of the rivers and streams that drain to the Pacific Ocean have been developed primarily for flood control purposes, rather than for surface water supply. (Some of these reservoirs are operated to provide surface flows for groundwater recharge.) A few of the existing flood control reservoirs are now being evaluated for their potential to provide some, albeit small, water supply benefits, usually by reoperation of the facilities to enhance groundwater recharge and provide limited year-round storage. Several of these facilities are discussed in the water management options section. Below are a few examples of flood control-related water management issues in the region.

Los Angeles River. USACE, in cooperation with Los Angeles County, has constructed an extensive network of flood control facilities on the Los Angeles River, which passes through one of the most intensively urbanized areas in the South Coast Region. (In fact, discussions on transportation issues in the region sometimes mention converting the existing concrete channel into a freeway or high-occupancy-vehicle transit route.) USACE's flood control facilities on the Los Angeles River and its tributaries include 5 major dams, 22 debris basins, and 470 miles of channel modifications.

Flood control operations in coastal Southern California and their interaction with reservoir operations for water supply typically differ from those in Northern California. The Sierran reservoirs in the Central Valley that provide most of California's developed surface water supply are, as a broad generalization, operated from a water supply standpoint to manage snowmelt runoff that occurs over a period of several months, and to hold large volumes of carryover storage throughout the year. Flood control reservoirs in coastal Southern California are operated to provide short-term detention (days to weeks) of peak flows from rainfloods. Many of these reservoirs impound ephemeral streams, or streams whose runoff is so small that little water supply benefit is available.

USACE's facilities on the Los Angeles River were designed to provide temporary detention of peak flows, allowing the floodflows to be released to the Pacific Ocean without exceeding downstream channel capacities. Continually increasing water demands in the South Coast Region have prompted reevaluting operations of some of the larger facilities, to determine if their operations could be modified to provide limited additional water supply. One example is a 67 taf flood control detention basin impounded by Whittier Narrows Dam on Rio Hondo, a Los Angeles River tributary, described in the water management options section.

Santa Ana River. The Santa Ana River has been channelized for almost its entire length throughout the highly urbanized part of Orange County, from the river's mouth near Costa Mesa upstream to the vicinity of Yorba Linda. Prado Dam, located in the Corona area between the Chino Hills and the Santa Ana Mountains, impounds a large flood control detention basin. USACE has constructed several flood control features of the Santa Ana mainstem project, with the most recent facility of that project being Seven Oaks Dam. The 550-foot high Seven Oaks Dam is under construction about 35 miles upstream from Prado Dam and will have a gross storage capacity of about 146 taf.

The existing 134-foot high earthfill Prado Dam has a storage capacity of 188 taf. OCWD manages the water supply provided by the dam for groundwater recharge. Future plans entail enlarging Prado's capacity to 363 taf for flood control and water supply storage. After Prado Dam is enlarged, OCWD would propose to raise the reservoir's minimum pool level to increase water supply benefits. Enlargement would be accompanied by development of a new flood forecasting system for the reservoir. The district is currently undertaking a feasibility study with USACE to evaluate potential water supply gains from Prado's enlargement. Modifying flood control operations would provide an additional 3 to 5 taf of annual supply for groundwater recharge.

Salinity Management Actions

Imported Colorado River water is a significant source of supply for the South Coast Region. The total dissolved solids concentration in imported water has water management implications for the region, affecting the feasibility of water recycling and groundwater recharge programs. Because residential use of water increases TDS concentration, water recycled from a moderately high TDS source water can result in unacceptably high TDS concentrations. Groundwater recharge potential may be restricted because the RWQCB has established TDS requirements for recharge water in some groundwater basins, to protect existing basin water quality.

In 1996, USBR and MWDSC began a joint salinity management study to develop information to support adoption of regional salinity management policies by MWDSC and to coordinate interagency action to solve salinity problems. The study's initial phase focused on identifying problems and salinity management needs in MWDSC's service area.

Phase I identified the average TDS concentration of MWDSC's Colorado River water in 1996 as being about 700 mg/L, and average TDS of MWDSC's SWP supplies as being about 300 mg/L. The City of Los Angeles' water supply from the eastern Sierra Nevada had significantly lower TDS concentration, typically about 160 mg/L. TDS levels in local groundwater supplies in the South Coast Region vary considerably, ranging from 200 mg/L (Cucamonga Basin near Upland) to more than 1,000 mg/L (Arlington Basin near Corona). Table 7-28 shows groundwater supplies by salinity.

Local sources of salinity also contribute significantly. Municipal and industrial use of water add between 250 to 500 mg/L of TDS to wastewater. Key sources of local salts include water softeners (typically contributing from 5 to 10 percent of the salt load) and industrial processes.

The long-term salt balance of South Coast groundwater basins is an important management problem. Smaller basins like the Arlington and Mission groundwater basins were abandoned for municipal supply because of high salinity levels. These basins have only recently been restored through construction of desalting projects. Blending SWP and Colorado River supplies or using the SWP's relatively low TDS supplies for groundwater replenishment has been a goal in some areas. However, without an ocean outfall or stream discharge, some inland agencies that reuse wastewater have salt accumulation problems in their groundwater basins. Some inland agencies have access to a brine line for exporting salt and concentrated wastes to a coastal treatment plant and ocean outfall, while others have not found construction of a brine line economical.

During droughts when use of recycled water projects and marginal quality groundwater are most important, some local supplies may be constrained by water quality problems. Concerns about wastewater TDS have grown with the expansion of water recy-

TABLE 7-28

Salinity of South Coast Region Groundwater Supplies

Annual Production (maf)	*TDS (mg/L)*	*Percent*
<500	1.06	78
500 to 1,000	0.15	11
>1,000	0.15	11
Total	**1.36**	**100**

cling programs. In general, TDS more than 1,000 mg/L is a quality problem for irrigation and industrial reuse customers.

The MWDSC/USBR study's second phase will evaluate regional applications of four TDS management options: local water service control, imported water source control, desalting, and blending.

Groundwater Issues

San Gabriel and San Fernando Valleys. Groundwater contamination in the San Gabriel Valley and San Fernando Valley Basins has come from many sources dating back to the 1940s. Each basin has four areas on EPA's Superfund list.

More than 30 square miles of groundwater under the San Gabriel Valley Basin may be contaminated. Contamination from volatile organic compounds was first detected in 1979 when Aerojet Electrosystems in Azusa sampled nearby wells in Valley County Water District. Subsequently, DHS initiated a well sampling program to assess the extent of contamination. By 1984, 59 wells were found to be contaminated with high levels of VOCs. The most prevalent contaminants were trichloroethene, perchloroethylene, and carbon tetrachloride.

The San Gabriel Basin Water Quality Authority was created by the Legislature in 1993 to be the agency responsible for remediating groundwater contamination in San Gabriel Valley. The authority's mission is to plan and implement groundwater quality management programs and to protect the basin from future contamination. The SGBWQA is governed by a 5-member board, comprised of one member from each of the overlying municipal water districts, one from a city with prescriptive water pumping rights and one from a city without prescriptive water pumping rights. (The three municipal water districts are San Gabriel Valley MWD, Three Valleys MWD, and Upper San Gabriel Valley MWD.)

Currently, four areas of the basin are of concern: Whittier Narrows, Puente Basin, Baldwin Park/Azusa, and El Monte/South El Monte. The SGBWQA is involved in groundwater cleanup projects in these areas. The Whittier Narrows and Puente Basins are also being managed by EPA under its Superfund program. Another concern is that contamination in the South El Monte area might migrate from the San Gabriel Basin through Whittier Narrows and into the Central Basin.

The Arrow Well Treatment Plant in Baldwin Park was the first project implemented by SGBWQA, with a $1.3 million construction grant from SWRCB. The project, completed in 1992, extracts about 3 taf/yr of contaminated groundwater, treats the water, and distributes it to customers. The Big Dalton Well Treatment Project was the second in a series of projects focusing on contamination problems in the Baldwin Park area. The facility, designed to extract and treat approximately 4 taf/yr of contaminated groundwater, is part of a three-well barrier to stop migration of contaminated groundwater. The Monrovia Wells project currently treats approximately 4.6 taf/yr of contaminated groundwater with airstripping, giving the City of Monrovia the ability to use water from contaminated aquifers while preventing the spread of contamination to adjacent clean aquifers. In 1996, legislation was enacted extending SGBWQA's authority to remediate groundwater contamination in the San Gabriel Basin through July 1, 2002.

About 50 percent of the water supply wells in the eastern portion of the San Fernando Valley Basin were found to be contaminated with volatile organic compounds. Many of the wells have been shut down. The RWQCB is investigating area-wide sources of groundwater contamination for four Superfund sites in the San Fernando Valley Basin. Interim clean-up measures include groundwater pumping and treatment.

Actions taken to address groundwater contamination included a basin-wide Superfund investigation, completed in 1992. The study included installation of 87 monitoring wells, development of a basin-wide groundwater flow model, and evaluation of the extent of contamination. Presently, two large-scale plants are in operation—the North Hollywood Treatment Plant (2,000 gpm) which uses aeration with GAC scrubbing and the Burbank Operable Unit (9,000 gpm) which uses aeration with GAC scrubbing and liquid-phase GAC polishing units. The Pollock Wells Treatment Plant (3,000 gpm) is under construction with a start-up date in 1998, and two additional plants, the 5,000 gpm Glendale Operable Unit and the 13,500 gpm Headworks Wells Treatment Plant, are in the planning/preliminary design phase. These plants will collectively treat over 48 taf/yr of San Fernando Basin's groundwater supply. The basin provides urban water supply for Los Angeles, Burbank, Glendale, and La Crescenta.

San Bernardino Valley. As late as the 1940s, the lowest portion of San Bernardino Valley was largely marshlands with abundant springs. Downtown San Bernardino is located over a confined aquifer which experiences high groundwater levels. Buildings have experienced seepage of water into basements or ground floors. High groundwater conditions increase soil liquefaction potential in an area that could be affected by movement along the Cucamonga, San Jacinto, or San Andreas Faults. The presence of unreinforced masonry buildings above the confined aquifer increases the risk of damage in the event of liquefaction.

The Bunker Hill Basin groundwater extraction project involves extracting groundwater from the basin to lower groundwater levels, thereby reducing seismic risks. The water could potentially be sold to help offset project costs. Groundwater extraction for this project will not exceed the perennial yield of the San Bernardino Basin (which includes both Bunker Hill and Lytle Creek Basins). The ultimate goal of the extraction project is to reduce the unacceptably high groundwater levels in the basin. A suggested minimum depth target of 30 feet below ground surface in the confined zone would minimize the risk of liquefaction and other adverse impacts associated with high groundwater. One plan being considered is for San Bernardino Valley Municipal Water District to pump between 20 taf/yr and 70 taf/yr, with larger volumes being extracted as necessary after exceptionally wet seasons.

Ventura County. Groundwater is the main water supply for agricultural and urban use in much of the coastal plain of Ventura County, including Oxnard Plain. Seawater intrusion was initially observed in the late 1940s, following the widespread development of agriculture and food processing in the Oxnard Plain. Increasing water demands in the 1940s led to overdraft of groundwater aquifers underlying the plain.

In the 1990s demand has decreased due to agricultural and urban water conservation measures. Recent estimates show an approximate balance between extractions and recharge because of increased artificial recharge and a reduction in groundwater extraction required by Fox Canyon Groundwater Management Agency. The agency adopted ordinances requiring meter installation on wells extracting more than 50 af/yr, and restricting drilling of new wells in some areas.

In 1991, United Water Conservation District completed construction of the Freeman Diversion improvement project on Santa Clara River. This project increased average annual diversions from the river from 40 taf to 60 taf. The diverted water is used for groundwater recharge and irrigation, reducing agricultural demand for groundwater.

Southern California Comprehensive Water Reclamation and Reuse Study

In 1993 USBR, seven local agencies and the Department began evaluating the feasibility of regional water recycling in Southern California. The seven participating local agencies are: Central and West Basin Municipal Water Districts, City of Los Angeles, City of San Diego, MWDSC, SDCWA, Santa Ana Water Project Authority, and South Orange County Reclamation Authority. Regional planning would take advantage of potential surpluses of recycled water which could serve needs in areas throughout Southern California. The plan of study called for a three-part, six-year comprehensive effort to identify a regional recycling system and develop potential projects.

The study has identified regional and area-wide water recycling potential for 20 and 50 year planning horizons. An economic distribution model will be used to maximize the allocation of recycled water at minimum cost throughout the region.

Water Marketing

The highly urbanized South Coast Region relies substantially on imported water. Water wholesalers serving the region expect to acquire part of their future supplies from water marketing arrangements, using the Colorado River Aqueduct and California Aqueduct to convey the acquired water.

A difficulty associated with future supply from water marketing arrangements—as opposed to from fixed facilities such as reservoirs or water recycling plants—is the greater uncertainty involved in forecasting future contractual arrangements for transfers. For example, SDCWA recently released a request for proposals for entities interested in selling water both on a short-term or long-term basis. Details of marketing arrangements developed would depend on specific terms and conditions negotiated for each arrangement. An urban agency may plan to acquire water from agricultural users in the Central Valley or the Colorado River Region, but terms and conditions of the transfers are subject to negotiation with potential sellers and the availability of conveyance. There are many ways to structure marketing arrangements—long-term agreements for base year transfers that occur every year regardless of hydrology, drought year transfers tied to specific hydrologic criteria, or transfer options that may be exercised based on negotiated criteria. Marketing may also be accomplished through short-term (one year or less) agreements on the spot market. Of note in the South Coast Region, local agencies are now planning to use water transfers for part of their base supplies, a change from past years when marketing arrangements were viewed as primarily drought year supplies.

An example of a base year transfer is the SDCWA/IID transfer described in Chapter 9. The two agencies executed an agreement in 1998 for a long-term transfer that would build up over time to 200 taf/yr. SDCWA would need to use MWDSC's Colorado River Aqueduct to convey the transferred water to the South Coast Region. SDCWA and MWDSC have negotiated an initial wheeling agreement.

New Conveyance Facilities from Colorado River Region to South Coast Region

SDCWA has been studying the feasibility of constructing a new aqueduct from the Imperial Valley to its service area. Two alternatives have been considered—an aqueduct on the U.S. side of the international border that would be used to convey Colorado River water acquired through marketing arrangements with water users in the Colorado River Region, and a joint aqueduct on the Mexican side of the border with the City of Tijuana. SDCWA has completed the first phase of a feasibility study for the U.S. alignment; Proposition 204 authorizes funding for further feasibility-level study of conveyance alternatives. In addition to the usual engineering and environmental considerations associated with large-scale conveyance projects, the ability to implement this project would be affected by the other Colorado River Basin states' concerns about a new California diversion on the river, and by international considerations involved in financing and constructing a project with the Mexican government.

Water marketing arrangements established through the draft CRB 4.4 Plan would be a source of water for a new conveyance facility. Other sources could result from responses to SDCWA's 1998 request for proposals for short-term and long-term marketing arrangements. While new conveyance may be a possible option for the South Coast Region in the long term, the time required to implement such a large scale project and the schedule presently contemplated for implementing the draft CRB 4.4 Plan suggest that a facility would not be constructed within the Bulletin 160-98 planning horizon.

Mexican Border Environmental Quality Issues

Tijuana's excess sewage has plagued San Diego area beaches since the 1930s. During frequent failures of Tijuana's inadequate, antiquated sewage treatment system, millions of gallons of raw sewage have been carried across the border through the Tijuana River to its estuary in San Diego County. San Diego's first attempt to alleviate this problem was in 1965, when the city agreed to treat Tijuana's wastewater on an emergency basis. In 1983, the United States and Mexico signed an agreement stating that Mexico would modernize and expand Tijuana's sewage and water supply system and build a 34 mgd sewage treatment plant. Mexico received a grant for $46.4 million from the Inter-American Development Bank to help finance the expansion and was to spend an additional $11 million to build a wastewater treatment plant 5 miles south of the border. The plant became fully operational in 1988.

In 1990, the United States and Mexico, through the International Boundary and Water Commission, agreed to construct international wastewater treatment facilities in the United States to solve continuing border sanitation problem. Facilities included a 25 mgd secondary treatment plant at a site just north of the international border and a 3.5 mile ocean outfall. Construction of the first phase of the international plant, a 25 mgd advanced primary treatment plant is being completed. Construction of the secondary phase of the international plant is on hold pending the completion of a supplemental environmental impact statement on alternative methods of secondary treatment. The second phase is expected to be complete by December 2000.

EPA and IBWC have completed a supplemental EIS on interim options for discharge of effluent from the international plant prior to completion of the ocean outfall and the secondary treatment component of the plant. The preferred option is a combination of discharging the effluent to the City of San Diego's metropolitan sewerage system and constructing a detention basin to hold flows for discharge during off-peak hours.

Water Management Options for South Coast Region

Southern California's challenge in managing its water resources is driven by one of the most fundamental realities of the West—it is an arid region. The major water agencies in the South Coast Region are extensively involved in water resources management planning. A mixture of water management options will be needed to replace California's reduced supply from the Colorado River and to offer long-term reliability to the region. Table 7-29 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 7A-4 in Appendix 7A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Reducing outdoor water use to 0.8 ET_o in new development would attain 67 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by 246 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would reduce depletions by 110 and 220 taf/yr, respectively. Reducing commercial, institutional, and industrial water use by an additional 3 percent and 5 percent would attain 30 taf/yr and 49 taf/yr of depletion reductions, respectively. Reducing system losses to 5 percent would reduce depletions by 84 taf/yr.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Agricultural water conservation options are limited in the region because of the relatively high SAEs that currently exist, the reliance on high cost, pressurized potable water or groundwater, and the limited agricultural acreage. Improving irrigation management to raise SAEs to 76, 78, and 80 percent in the South Coast would reduce depletions by 4, 7, and 10 taf/yr, respectively. Flexible water deliveries are deferred because most of the water applied for agriculture is delivered on-demand in the region. Canal lining and piping are deferred because of the absence of open canal systems in the region. The spill recovery and tailwater systems option is deferred because of the relatively small acreage under furrow or border irrigation in the region.

Modify Existing Reservoirs or Operations

USACE operates flood control reservoirs in the Los Angeles and San Gabriel River Basins of Los Angeles County. Water conservation benefits could be realized if storage was established in these reservoirs for temporarily impounding storm flows for later release to downstream recharge facilities. The Los Angeles County Department of Public Works and USACE are evaluating the potential for reoperating USACE flood control reservoirs. Preliminary studies have indicated that an additional 17 taf of conservation storage is possible, and USACE is currently performing a feasibility study expected to conclude in 1998.

Prado Dam. As discussed in the water management issues section, construction of Seven Oaks Dam on the Santa Ana River and pending enlargement of the existing Prado Dam create an opportunity to increase water supply storage in Prado Reservoir for recharging Orange County groundwater basins. Modifying Prado Reservoir's flood control operation would provide an additional 3 to 5 taf of annual supply for groundwater recharge.

Hansen and Lopez Dams. Hansen Dam on Tujunga Wash and Lopez Dam on Pacoima Wash are small USACE flood control detention reservoirs (essentially debris basins) located on adjoining drainages in Los Angeles County, in the San Gabriel Mountains above Pacoima. The combined storage capacity of the two reservoirs is about 25 taf. Los Angeles County has cooperated with USACE in completion of a reconnaissance study (1994) and preparation of a feasibility-level study to evaluate possible water supply benefits from reoperating the reservoirs for limited water supply storage. The feasibility study is scheduled to be completed in 1998.

Santa Fe and Whittier Narrows Dams. Santa Fe Dam (32 taf storage capacity) on the San Gabriel River and Whittier Narrows Dam (67 taf storage capacity) on Rio Hondo are USACE dams that impound flood control detention basins in Los Angeles County. The county cooperated with USACE in a 1994 reconnaissance study and feasibility-level evaluation of possible water supply benefits from reoperating the reservoirs to provide limited water supply storage. The feasibility study, scheduled to be completed in 1998, is examining allowing a permanent water conservation pool to be maintained at Santa Fe Dam and expanding the existing conservation storage pool at Whittier Narrows.

New Reservoirs

In an average year, about 200 taf of storm runoff from the Los Angeles River flows to the ocean. A proposed freshwater reservoir project in Long Beach would include an inflatable weir across the Los Angeles River

TABLE 7-29

South Coast Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8ET_o	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Reoperate Prado Dam	Retain	
Reoperate Hansen and Lopez Dams	Retain	
Reoperate Santa Fe and Whittier Narrows Dams	Retain	
New Reservoirs/Conveyance Facilities		
Freshwater Reservoir in Long Beach Harbor	Retain	
New Aqueduct from Imperial Valley to San Diego	Defer	Interstate issues.
Groundwater/Conjunctive Use		
Local Groundwater Banking/Conjunctive Use	Retain	
Water Marketing		
Castaic Lake Water Agency	Retain	
Water Recycling		
Alamitos Barrier - Los Angeles County Sanitation Districts	Retain	
Alamitos Barrier Recycled Water Project - Water Replenishment District	Retain	
Carlsbad Water Reclamation Plan - Encina Basin - P2 - Carlsbad MWD	Retain	
Castaic Lake Water Agency Reclaimed Water Master Plan - LACSD	Retain	
Central City/Elysian Park Water Recycling Project - LADWP	Retain	
City of Escondido Regional Water Recycling Program	Retain	
City of Poway - Escondido Expansion	Retain	
City of Poway - S.D. Expansion	Retain	
City of West Covina - LACSD	Retain	
Dominguez Gap Barrier Recycled Water Project - Water Replenishment District	Retain	

TABLE 7-29

South Coast Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
E. Thornton Ibbetson Century Recycled Water Project - City of Downey	Retain	
East Valley Water Recycling Project Expansion - LADWP	Retain	
El Toro Water District Reclamation	Retain	
Esteban Torres Water Recycling Project - Central Basin MWD	Retain	
Green Acres-Phase 2 - Orange County WD	Retain	
Headworks Water Recycling Project - LADWP	Retain	
Irvine Ranch Water District	Retain	
Los Angeles Harbor Water Recycling Project - LADWP	Retain	
Montebello Forebay Advanced Treatment Plant - Water Replenishment District	Retain	
Non-domestic Irrigation System - Capistrano Valley Water District	Retain	
North City Reclamation Plant - Poway Resources Expansion - City of Poway	Retain	
North San Diego County Reclamation Project Phase 2 - Leucadia County WD	Retain	
OCR Project - CSDOC - Orange County Sanitation District	Retain	
Orange County Regional Reclamation Project - Orange County Water District	Retain	
Puente Hills/Rose Hills Reclaimed Water District System - LACSD	Retain	
San Elijo Joint Powers Authority - Santa Fe Irrigation District	Retain	
San Elijo Joint Powers Authority WRF	Retain	
San Gabriel Valley Groundwater Recharge Demonstration - LACSD	Retain	
San Pasqual Groundwater Management Program - City of San Diego	Retain	
Sepulveda Basin Water Recycling Project - LADWP	Retain	
South Bay Water Reclamation Project - City of San Diego	Retain	
Verdugo-Scholl-Brand Project - City of Glendale	Retain	
Water Repurification Project - City of San Diego	Retain	
West Basin Recycling Project-Phase 2 - West Basin MWD	Retain	
West Los Angeles Extension Expansion - West Basin MWD	Retain	
Westside Water Recycling Project - LADWP	Retain	
Whittier Narrows Recreation Area - Los Angeles County Sanitation Districts	Retain	

TABLE 7-29

South Coast Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Desalting		
Brackish Groundwater		
Capistrano Beach Desalter	Retain	
Huntington Beach Colored Water	Retain	
IRWD Colored Water Treatment Project	Retain	
Laguna Beach GW Treatment Project	Retain	
Mesa Colored Water Project	Retain	
Oceanside Desalter No. 2	Retain	
OCWD Undetermined Colored Water Projects	Retain	
Corona/Temescal Basin Desalter	Retain	
Otay/Sweetwater Desalter	Retain	
Perris Basin Desalter	Retain	
Rubidoux/Western Desalter	Retain	
San Dieguito Basin Desalter	Retain	
San Juan Basin Desalter No. 2	Retain	
San Pasqual Basin Desalter	Retain	
Santee/El Monte Basin Desalter	Retain	
Sweetwater Desalter No.2	Retain	
Tijuana River Valley Desalter	Retain	
Torrance Elm Ave. Facility	Retain	
West Basin Desalter No. 2	Retain	
West Basin Desalter No. 3	Retain	
Western/Bunker Basin Treatment Project	Retain	
Winchester/Hemet Desalter	Retain	
Seawater		
Reverse Osmosis Facilities at South Bay Powerplant	Retain	
Reverse Osmosis Facilities at Encina Powerplant	Retain	
Reverse Osmosis Facilities at Alamitos Powerplant	Retain	
Multiple-effect Distillation Process	Retain	
Other Local Options		
Draft CRB 4.4 Plan	Retain	
Multipurpose Flood Control Basins	Retain	
Statewide Options		
—	—	See Chapter 6.

near its mouth, to direct some of the storm flows into intakes along existing river levees. From the intakes, the storm flow would be pumped or flow by gravity via culverts or tunnels to an offshore reservoir. The reservoir site would be in the vicinity of the existing Long Beach Breakwater in San Pedro Bay. Reservoir dikes would be constructed in the bay with a diaphragm wall constructed through the dikes to prevent leakage of fresh water through the walls of the dam. A bulb of fresh water would be maintained at the bottom of the reservoir to repel seawater. The reservoir could be sized to store 100 taf to 300 taf of storm water during the wet season. This captured storm water could subsequently be distributed for a number of uses, with the most likely use being groundwater recharge. A final feasibility report was issued in March 1998.

The option analyzed consisted of a 100 taf reservoir sited within San Pedro Bay supplying the Montebello Forebay spreading grounds with 71 to 129 taf/yr. The annual cost of the water would be about $1,700/af at 71 taf of supply, decreasing to $1,000/af at 129 taf of supply. Expansion of the project to use additional captured storm water runoff would maximize the reservoir yield at 172 taf/yr, decreasing the annual cost to $800/af.

Groundwater Development and Conjunctive Use

As a result of MWDSC's seasonal storage service pricing program, local agencies are storing imported water in groundwater basins and increasing their groundwater use during the summer and during drought years. It is estimated that an average of 100 taf/yr of groundwater supply is now produced as a result of MWDSC's discount pricing for winter season deliveries. The program provides imported water at an average discount of $125/af during the winter.

MWDSC had identified the potential for 200 taf of additional groundwater production during drought years. To accomplish this additional drought year production, about 600 taf of dedicated storage capacity within the local basins may be required. The cost of the water would be about $350/af. MWDSC is working with Calleguas Municipal Water District on a Las Posas Basin aquifer storage and recovery project. CMWD would develop up to 300 taf of storage in the lower aquifer system of the Las Posas groundwater basin. The project currently provides 70 taf of water supply in drought years, which has been included as 2020 supply in the water budget. MWDSC is pursuing an additional 130 taf/yr of groundwater production in the region.

Water Marketing

Water from the Colorado River Region. Several water marketing arrangements are being planned or implemented as part of the draft CRB 4.4 Plan. These arrangements are described in the section on implementing the draft CRB 4.4 Plan.

Water from the Central Valley. More than half of California's agricultural water use is in the Central Valley. The California Aqueduct could be used for voluntary transfers of some of this water to the South Coast. It is estimated that potential future marketing arrangements from the Central Valley to the South Coast Region could be about 200 taf/yr. Voluntary marketing arrangements would be developed through option agreements, storage programs, and purchases of water through the drought water bank or other similar spot markets.

MWDSC is currently banking water with Semitropic Water Storage District under a long-term transfer agreement to store up to 350 taf. The agreement allows MWDSC to deliver available SWP water in wetter years to SWSD for in-lieu groundwater recharge. In drought years SWSD would release its SWP allocation to MWDSC, and if necessary pump groundwater back into the California Aqueduct to meet its obligations. The drought year yield would be about 60 taf/yr.

A long-term agreement has been completed between MWDSC and Arvin-Edison Water Storage District to store up to 350 taf of water for MWDSC in Arvin-Edison's groundwater basin. Water banked in this program would be provided by both MWDSC and AEWSD. MWDSC would withdraw about 60 taf in drought years under this program.

As specified in the Monterey Amendment, agricultural contractors will make available up to 130 taf of annual SWP entitlement for permanent transfer to urban contractors, on a voluntary basis. Berrenda-Mesa Water District has already completed the transfer of 25 taf of entitlement to MWA. Similar permanent transfers could be negotiated in the South Coast Region. Castaic Lake Water Agency is preparing an EIR for the proposed transfer of 40 taf of SWP entitlement from Wheeler Ridge-Maricopa Water Storage District, a member agency of KCWA. The CLWA service area includes the Santa Clarita Valley in northwestern Los Angeles County and extends into eastern Ventura County.

Implementing the CRB's Draft 4.4 Plan

The draft CRB 4.4 Plan would reduce California's use of Colorado River to the State's basic apportionment while using marketing arrangements and other options to keep a full Colorado River Aqueduct for the South Coast. Phase one elements of the draft CRB 4.4 Plan that have been quantified and would provide water supplies for the South Coast are described below. More detail on the draft plan and its elements is provided in Chapter 9. Chapter 9 also presents an overview of how the use of Colorado River water is apportioned among the basin states and among California entities.

Bulletin 160-98 water budgets assume that the South Coast Region's 2020 base supply from the Colorado River will be limited to MWDSC's fourth priority right of 550 taf, plus any marketing arrangements that have already been implemented (i.e., 107 taf from the MWDSC/IID agreement described in Chapter 3). Actions taken as part of the draft CRB 4.4 Plan to fill the CRA's remaining capacity are treated as future options in the water budgets. As described in Chapter 9 (and shown in Table 9-25), the base water demand forecasts for Bulletin 160-98 include implementation of EWMPs. This conserved water would be another source of water for Colorado River/South Coast marketing arrangements, in addition to those actions that Bulletin 160-98 categorizes as water management options.

Water management options contained in phase one of the draft CRB 4.4 Plan include the SDCWA/IID water transfer, MWDSC intrastate groundwater banking programs, interstate groundwater banking in Arizona, drought year land fallowing programs (such as an MWDSC/PVID program), lining parts of the All American and Coachella Canals, and agricultural water conservation beyond EWMP implementation. As described in Chapter 9, potential South Coast supplies from these options are assumed to be made available for the region after shortages due to groundwater overdraft in the Colorado River Region have been balanced out.

The draft CRB 4.4 Plan further proposes criteria for reoperating Colorado River system reservoirs. The Colorado River has a high ratio of storage capacity to average annual runoff. Projections of consumptive use for the upper basin states suggest that those states will not attain full use of their Compact apportionments until 2060. USBR's surplus declarations to date have not adversely impacted the other states' use of their apportionments—reservoir flood control releases were made in 1997 and 1998. The more significant impediment to implementing revised operating guidelines would be concerns of the other basin states about impacts of an extended period of reoperation on the ability to avoid future shortages. Reservoir reoperation is not numerically evaluated in Bulletin 160-98, because implementing new operations criteria would require agreement of USBR and the remaining basin states, and there is presently no generally accepted proposal available for quantification.

Water management options in phase two of the draft CRB 4.4 Plan have not yet been quantified; implementation of some may extend beyond the Bulletin 160-98 planning horizon. Examples of phase two actions include desalting tributary inflows to the Salton Sea or weather modification programs. For example, USBR had developed a 1993 proposed pilot program to evaluate cloud seeding potential in the upper basin, but had not implemented the program because of opposition from the upper basin states. Large-scale weather modification programs are typically difficult to implement due to institutional and third-party concerns.

Water Recycling

Since the 1970s, Southern California has been a leader in developing water recycling projects. Recycled water is currently used for applications that include groundwater recharge, hydraulic barriers to seawater intrusion, landscape and agricultural irrigation, and direct use in industry. Currently some 80 local recycling projects are producing about 210 taf/yr of new water supply. It is estimated that these existing projects will provide an additional 70 taf /yr of water supply by year 2020.

Almost 40 new water recycling projects were evaluated as future water supply augmentation options for the region. Water recycling could potentially increase by 639 taf by 2020, yielding about 527 taf of new water. The price of recycled water from these options ranges from $180/af to more than $2,500/af. This large range is due to the individual characteristics of proposed projects—some entail major capital costs for construction of new treatment plants while others may involve only distribution systems from an existing plant. For example, projects designed for groundwater recharge are often located near the treatment plant—reducing the costs for distribution. As another example, projects that are designed for landscape irrigation or direct industrial uses will generally be higher in cost because of the extensive distribution system needed for delivery.

In an effort to broaden the potential application of recycled water to include indirect potable use, the City of San Diego has conducted research into advanced treatment and ultimate use of recycled water as a supplement to potable water supplies. This indirect potable reuse concept has been termed repurification by San Diego. The City of San Diego is currently working on a water repurification project (described in Chapter 5) that would produce about 16 taf/yr of repurified water to augment local supplies. The repurified water would be stored in the San Vicente Reservoir and blended with local runoff and imported water.

To evaluate and compare recycling options with other water management options, the water recycling options were grouped by cost into three groups. Group I included those options which cost under $500/af; Group II included those options which cost between $500 and $1,000/af; and Group III included those options which cost more than $1,000/af. The costs used to group these projects are based on the costs reported by local agencies in the Department's 1995 water recycling survey. (These costs are not likely to have all been calculated on the same basis by the local project sponsors.) The local agencies' costs were used to judge the order of magnitude of proposed projects' costs.

A proposed Orange County regional water recycling project is being developed jointly by the Orange County Water District and County Sanitation Districts of Orange County. Wastewater currently discharged into the Pacific Ocean would be recycled to supplement Orange County's potable supplies. The treated wastewater would be used to recharge an aquifer along the Santa Ana River, in lieu of using imported water provided by MWDSC. A plant to treat second-

San Diego Area Water Reclamation Programs

The San Diego County Water Authority and its member agencies are engaged in a long-term effort to reduce regional reliance on imported water supplies. Water recycling is critical to the success of that effort. Two major programs are currently underway.

The San Diego Area water reclamation program is a system of interconnected reclamation facilities designed to serve southern and central San Diego County. When completed, the program will serve an area of more than 700 square miles and add more than 60 taf/yr to the San Diego region's local water supply. Summarized below are the eight participating agencies and each agency's planned reuse. Facilities to be constructed include up to ten new or expanded water recycling plants, a water repurification facility, and hundreds of miles of recycled water delivery pipelines.

Agency	New Water Supply (taf/yr)
City of Escondido	3.2
City of Poway	2.3
City of San Diego	26.9
City of San Diego/San Diego County Water Authority	15.0
Otay Water District	2.9
Padre Dam Municipal Water District	1.9
Sweetwater Authority	7.2
Tia Juana Valley County Water District	2.2
Total	**61.6**

Padre Dam MWD has completed construction of its treatment facility, and has begun delivery of recycled water. The City of San Diego's North City water recycling plant and distribution system have also been completed and are delivering recycled water.

The North San Diego County Area water recycling project will provide more than 15 taf/yr of recycled water to northern coastal and inland San Diego County. The project is a cooperative effort of Carlsbad and Olivenhain MWDs, the Leucadia County Water District and the San Elijo JPA. When completed, the system of interconnected recycling facilities will serve an area of more than 100 square miles, from the coastal communities of Carlsbad, Encinitas and Solana Beach inland to the San Dieguito River Valley. Facilities to be constructed include three new or expanded water recycling facilities, about 65 miles of recycled water delivery pipeline and associated pump stations and storage facilities, and new groundwater recharge and extraction facilities.

ary effluent produced by an existing wastewater treatment plant would be constructed, with a transmission pipeline to convey the recycled water to existing spreading basins located in the Orange County Forebay in Anaheim. Some recycled water would also be injected into a seawater intrusion barrier in Fountain Valley. Another benefit would be that water recycling would decrease the total wastewater treatment discharge to the ocean, which would eliminate or delay the need for a new or expanded ocean outfall. Phase I is planned to produce 50 taf/yr of recycled water by 2002. Phases II and III would produce an additional 50 taf/yr by 2020, reducing Orange County's dependence on imported water.

Desalting

Groundwater. Recovery of mineralized groundwater supplies is an important resource strategy for Southern California. This resource option is usually expensive—because it involves sophisticated technologies and high energy costs. Some groundwater recovery projects serve the dual purpose of managing migration of plumes to prevent further contamination of usable aquifers.

Groundwater desalting plants currently operating include Santa Ana Watershed Project Authority's Arlington Desalter (6.7 taf), the City of Oceanside's Oceanside Desalter No.1 (2.2 taf), and West Basin MWD's West Basin Desalter No.1 (1.7 taf). Construction of Sweetwater Authority's groundwater demineralization plant (3.6 taf) in the Sweetwater River Valley began in 1998. Plans are to expand the plant to produce an additional 4 taf. Additional plants and plant expansions are being planned or constructed throughout the coastal areas of the Los Angeles Basin, with an estimated total installed capacity of 33 taf/yr by 2000. The estimated total net groundwater recovery potential in the South Coast is about 150 taf/yr.

The Santa Ana Watershed Project Authority was formed in 1972 to plan and operate facilities to protect water quality in the Santa Ana River's watershed. The authority is a joint powers agency composed of the five larger water districts that share the watershed—Chino Basin Municipal Water District, Eastern Municipal Water District, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District. SAWPA operates a brine disposal line which facilitates disposal of waste brine from regional desalting plants and operates the Arlington Desalter.

While increases in groundwater recovery are technically feasible, they are challenged by the need for development of new brine lines (or alternative brine disposal options) for inland projects as well as requirements for replenishment in certain groundwater basins. Approximately 20 potential groundwater recovery projects were evaluated with a net yield of 95 taf/yr. Supply costs range from \$300/af to \$900/af. The groundwater recovery projects are grouped by cost into two groups, those projects less than \$500/af and those more than \$500/af.

Seawater. Seawater desalting is sometimes described as the ultimate solution to Southern California's water supply shortfall. Although there is often public support for this resource, seawater desalting is currently limited by high costs, environmental impacts of brine disposal, and siting considerations. Based on current technology, the costs for desalting seawater for potable use ranges from about \$1,000 to \$2,000/af depending on the type of treatment and the distribution system that would be required to deliver the water. Although high costs may currently limit this resource, seawater desalting may prove to be an important strategy in the future. MWDSC, with joint funding from the U.S. Government and Israel Science and Technology Foundation, recently embarked on a demonstration project

Brackish Water Reclamation Demonstration Facility

The Port Hueneme Water Agency was formed to develop and operate a brackish water desalting demonstration facility for its member agencies, all of whom are located in Ventura County. The BWRDF is the cornerstone of the program to improve water quality and reliability and reduce groundwater extractions and seawater intrusion in the Oxnard Plain. BWRDF will provide a full-scale demonstration of side-by-side operation of three brackish water desalting technologies (reverse osmosis, nanofiltration, and electrodialysis reversal). The feasibility of using desalting concentrate for wetlands enhancement is also being studied. Construction of the project has begun and is expected to be completed in 1998. The total capital costs are estimated to be \$15.2 million.

using a multiple-effect distillation process, as described in Chapter 5.

In the past, SDCWA has evaluated the possibility of constructing two reverse osmosis desalting facilities in conjunction with the proposed repowering of the San Diego Gas and Electric South Bay Powerplant and the Encina Powerplant. The capacity of the two plants would total 20 taf/yr. The City of Long Beach and the Central Basin MWD are also collaborating on a study of a reverse osmosis plant with 5.6 taf annual capacity to be located at Southern California Edison's Alamitos Powerplant.

Other Local Options

Chino Basin Water Conservation District has prepared a scoping report on the construction and operation of multipurpose storm water detention and groundwater recharge basins. The proposed project involves San Bernardino County Flood Control District's plans for additional flood control facilities in the City of Ontario. SBCFCD plans to construct a storm water conduit to convey water to existing multipurpose flood control and groundwater recharge basins and to develop a new flood control detention basin. Converting the proposed single-purpose basin into a flood control and groundwater recharge basin could provide additional water supply benefits for the Chino Basin. Although the volume of water to be conserved and developed by these projects is relatively small (about 1 taf), the projects meet specific local needs.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in South Coast Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 944 and 1,317 taf in average and drought years, respectively. Ranking of retained water management options for the South Coast Region is summarized in Table 7-30. Table 7-31 summarizes options that can likely be implemented by 2020 to relieve the shortages. These shortages are primarily attributed to increased urban demands and reduced Colorado River supplies.

To meet the water shortages, water agencies in the South Coast Region are planning to implement additional conservation programs, water recycling, and groundwater recovery, as well as water marketing and other water supply augmentation options. Demand reduction options such as urban conservation are currently an important program for all water agencies in the South Coast. Supply augmentation options to be implemented would include the draft CRB 4.4 Plan and a combination of local and statewide options.

Implementation of BMPs and EWMPs will continue through 2020 and is reflected in the base demand levels for urban and agricultural water use. Additional conservation options likely to be implemented, based on costs and feasibility, would provide 91 taf/yr in depletion reduction.

The South Coast Region will increase its reliance on water marketing as Colorado River supplies are reduced. Options in the first phase of the draft CRB 4.4 Plan could make available up to 172 taf in average years and 410 taf in drought years for transfer to the South Coast Region. Additional banking and marketing arrangements, as well as permanent transfer of SWP entitlement, are likely options for the region, amounting to 37 taf and 27 taf in average and drought years, respectively.

Local groundwater conjunctive use programs will likely add 130 taf of production in drought years. Water recycling will continue to be a source of water supply for Southern California. New projects could provide an additional 367 taf/yr by 2020. Groundwater desalting projects could provide an additional 27 taf/yr.

TABLE 7-30

Options Ranking for South Coast Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o - New Development	M	750	67	67
Outdoor Water Use to 0.8 ET_o -New and Existing Development	L	[b]	246	246
Indoor Water Use (60 gpcd)	M	400	110	110
Indoor Water Use (55 gpcd)	M	600	220	220
Interior CII Water Use (3%)	M	500	30	30
Interior CII Water Use (5%)	M	750	49	49
Distribution System Losses (5%)	M	300	84	84
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	4	4
Seasonal Application Efficiency Improvements (78%)	M	250	7	7
Seasonal Application Efficiency Improvements (80%)	M	450	10	10
Modify Existing Reservoirs/Operations				
Reoperate Prado Dam	H	60	5	5
Reoperate Hansen and Lopez Dams	M	[b]	[b]	[b]
Reoperate Santa Fe and Whittier Narrows Dams	M	[b]	[b]	[b]
New Reservoirs/Conveyance Facilities				
Freshwater Reservoir in Long Beach Harbor	L	1,000	172	—
Groundwater/Conjunctive Use				
Local Groundwater Banking/Conjunctive Use	H	350	—	130
Water Marketing				
Castaic Lake WA/Kern County WA (40 taf entitlement)	H	—	37	27
Water Recycling				
Group 1 (Cost < $500/af)	H	500	391	391
Group 2 (Cost $500/af- $1,000/af)	M	1,000	75	75
Group 3 (Cost > $1,000/af)	M	1,500	61	61
Desalting				
Brackish Groundwater				
Group 1 (Cost < $500/af)	M	500	27	27
Group 2 (Cost $500/af- $1,000/af)	M	1,000	68	68
Seawater				
Reverse Osmosis Facilities at South Bay Powerplant	L	920	5	5
Reverse Osmosis Facilities at Encina Powerplant	L	1,220	15	15
Reverse Osmosis Facilities at Alamitos Powerplant	L	1,700	6	6
Multiple-Effect Distillation Process	L	<1000	85	85
Other Local Options				
Multipurpose Flood Control Basins	H	[b]	[c]	[c]
Draft Colorado River Board 4.4 Plan	H	230	172	410
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 7-31.
[b] Data not available to quantify.
[c] Less than 1 taf.

TABLE 7-31

Options Likely to be Implemented by 2020 (taf)
South Coast Region

	Average	*Drought*
Applied Water Shortage	**944**	**1,317**
Options Likely to be Implemented by 2020		
Conservation	91	91
Modify Existing Reservoirs/Operations	5	5
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	130
Water Marketing	37	27
Recycling	367	367
Desalting	27	27
Colorado River Board's Draft 4.4 Plan	172	410
Statewide Options	150	144
Expected Reapplication	95	116
Total Potential Gain	**944**	**1,317**
Remaining Applied Water Shortage	**0**	**0**

7A

Options Evaluations for Coastal Regions

TABLE 7A-1

Options Evaluation North Coast Region

Option	Evaluation Scores							Rank
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	2	2	1	**13**	**M**
Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use (5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (7%)	3	4	4	2	2	1	**16**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Groundwater/Conjunctive Use								
New wells - Fort Bragg and other small coastal communities	3	4	4	4	3	0	**18**	**H**
Agricultural Groundwater Development	3	1	3	3	3	0	**13**	**M**
Desalting								
Brackish Groundwater								
City of Fort Bragg project	3	1	3	2	2	0	**11**	**L**

TABLE 7A-2

Options Evaluation San Francisco Bay Region

Option	*Evaluation Scores*							
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	1	2	1	**12**	**L**
Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use (5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Modify Existing Reservoirs/Operations								
Enlarge Lake Hennessey / Napa River Diversion	3	2	2	3	3	1	**14**	**M**
Enlarge Bell Canyon Reservoir	3	2	2	2	3	2	**14**	**M**
Enlarge Bell Canyon Reservoir / Napa River Diversion	3	1	2	3	3	1	**13**	**M**
Enlarge Pardee Dam	3	2	2	2	2	3	**14**	**M**
Enlarge Camanche Dam	3	2	2	2	2	3	**14**	**M**
Enlarge Leroy Anderson Reservoir	3	0	2	3	3	2	**13**	**M**
Upgrade Milliken Treatment Plant	3	0	3	4	4	1	**15**	**M**
Reoperate Rector Reservoir	3	1	3	3	4	1	**15**	**M**
New Reservoirs/Conveyance Facilities								
Chiles Creek Reservoir Project / Napa River Diversion	3	0	2	3	3	1	**12**	**L**
Enlarge Lake Hennessey / Chiles Creek Project / Napa River Diversion	3	0	2	2	3	1	**11**	**L**
Carneros Creek Reservoir / Napa River Diversion	3	0	1	2	3	1	**10**	**L**
Upper Del Valle Reservoir	3	0	2	3	3	2	**13**	**M**
Buckhorn Dam and Reservoir	3	1	1	2	3	3	**13**	**M**
Upper Kaiser Reservoir	3	1	1	3	3	3	**14**	**M**

TABLE 7A-2

Options Evaluation San Francisco Bay Region (continued)

Option	*Evaluation Scores* Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
New Reservoirs/Conveyance Facilities (continued)								
Upper Buckhorn Reservoir	3	1	1	1	2	3	**11**	**L**
Middle Bar Reservoir	3	1	1	2	2	2	**11**	**L**
Duck Creek Offstream Reservoir	3	1	1	2	2	3	**12**	**L**
Devils Nose Project	3	1	1	2	2	1	**10**	**L**
EBMUD American River Supply	4	1	3	3	3	2	**16**	**M**
Groundwater/Conjunctive Use								
Milliken Creek Conjunctive Use	3	4	3	3	4	1	**18**	**H**
Lake Hennessey / Conn Creek Conjunctive Use	4	3	4	3	4	1	**19**	**H**
Water Marketing								
Zone 7 WA/KCWA	4	4	4	4	3	0	**19**	**H**
SCVWD/SLDMWA	4	4	4	4	3	0	**19**	**H**
Water Recycling								
Group 1 (Cost < $500/af)	4	3	3	3	3	1	**17**	**H**
Group 2 (Cost $500/af - $1,000/af)	4	2	3	3	3	1	**16**	**M**
Group 3 (Cost > $1,000/af)	4	0	3	3	3	1	**14**	**M**
Desalting								
Brackish Groundwater								
Alameda County WD Aquifer Recovery Project	4	2	3	3	3	2	**17**	**H**
Seawater								
Marin Municipal WD Desalting Project	3	0	2	0	3	1	**9**	**L**
Other Local Options								
New Surface Water Diversion from Sacramento River by Cities of Benicia, Fairfield, & Vacaville	3	3	2	2	3	0	**13**	**M**
Statewide Options								
See Chapter 6.								

TABLE 7A-3

Options Evaluation Central Coast Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	2	2	1	**13**	**M**
Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use (5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (7%)	3	4	4	2	2	1	**16**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Modify Existing Reservoirs/Operations								
Modify Nacimiento Spillway	3	4	4	4	4	0	**19**	**H**
Enlarge Salinas Reservoir	3	3	3	3	3	0	**15**	**M**
Enlarge Cachuma Reservoir	2	0	3	3	3	0	**11**	**L**
New Reservoirs/Conveyance Facilities								
College Lake	2	3	2	1	3	2	**13**	**M**
Feeder Streams (Various Sites)	2	3	3	2	3	0	**13**	**M**
New Los Padres Reservoir	3	1	3	2	3	3	**15**	**M**
Nacimiento Pipeline	4	1	3	3	3	0	**14**	**M**
Groundwater/Conjunctive Use								
College Lake Injection/Extraction Wells	3	4	3	3	3	0	**16**	**M**
Increase Groundwater Development in Seaside Basin	3	3	2	1	2	0	**11**	**L**
Water Marketing								
CVP (San Felipe Project Extension)	3	2	3	2	3	1	**14**	**M**

TABLE 7A-3
Options Evaluation Central Coast Region (continued)

Option	*Evaluation Scores*							
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Water Recycling								
Group 1 (Cost < $500/af)	4	3	3	3	3	1	**17**	**H**
Group 2 (Cost $500/af - $1,000/af)	4	2	3	3	3	1	**16**	**M**
Desalting								
Brackish Groundwater								
City of Santa Cruz	3	0	3	2	3	0	**11**	**L**
Seawater								
Monterey Peninsula Water Management District	3	0	3	1	2	0	**9**	**L**
Other Local Options								
Salinas River Diversion and Distribution Project	3	2	3	3	2	2	**15**	**M**
Statewide Options								
See Chapter 6.								

TABLE 7A-4

Options Evaluation South Coast Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	1	2	1	**12**	**L**
Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use (5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Agricultural								
SAE Improvements (76%)	3	4	3	4	3	1	**18**	**H**
SAE Improvements (78%)	3	3	3	3	2	1	**15**	**M**
SAE Improvements (80%)	2	3	3	2	2	1	**13**	**M**
Modify Existing Reservoirs/Operations								
Reoperate Prado Dam	3	4	4	3	3	0	**17**	**H**
Reoperate Hansen and Lopez Dams	3	3	3	2	3	0	**14**	**M**
Reoperate Santa Fe and Whittier Narrows Dams	3	3	3	2	3	1	**15**	**M**
New Reservoirs/Conveyance Facilities								
Freshwater Reservoir in Long Beach Harbor	2	1	2	2	3	0	**10**	**L**
Groundwater/Conjunctive Use								
Local Groundwater Banking/Conjunctive Use	4	3	4	3	4	0	**18**	**H**
Water Marketing								
Castaic Lake Water Agency	4	4	4	4	3	0	**19**	**H**
Water Recycling								
Group 1 (Cost < $500/af)	4	3	3	3	3	1	**17**	**H**
Group 2 (Cost $500/af - $1,000/af)	4	2	3	3	3	1	**16**	**M**
Group 3 (Cost > $1,000/af)	4	0	3	3	3	1	**14**	**M**

TABLE 7A-4

Options Evaluation South Coast Region (continued)

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Desalting								
Brackish Groundwater								
Group 1 (Cost < $500/af)	3	3	3	3	3	1	**16**	**M**
Group 2 (Cost $500/af - $1,000/af)	3	2	3	3	3	1	**15**	**M**
Seawater								
Reverse Osmosis Facilities at South Bay Powerplant	2	1	2	3	3	0	**11**	**L**
Reverse Osmosis Facilities at Encina Powerplant	2	0	2	3	3	0	**10**	**L**
Reverse Osmosis Facilities at Alamitos Powerplant	2	0	2	3	3	0	**10**	**L**
Multiple-effect Distillation Process	1	1	2	3	3	0	**10**	**L**
Other Local Options								
Draft CRB 4.4 Plan	4	4	3	3	3	3	**20**	**H**
Multipurpose Flood Control Basins	3	3	3	3	3	3	**18**	**H**
Statewide Options								
See Chapter 6.								

8

Options for Meeting Future Water Needs in Interior Regions of California

This chapter covers the interior regions of the State: the Sacramento River, San Joaquin River, and Tulare Lake Hydrologic Regions (Figure 8-1). These regions constitute the Central Valley, which makes up about 38 percent of the State's land area and almost 80 percent of the State's irrigated acres.

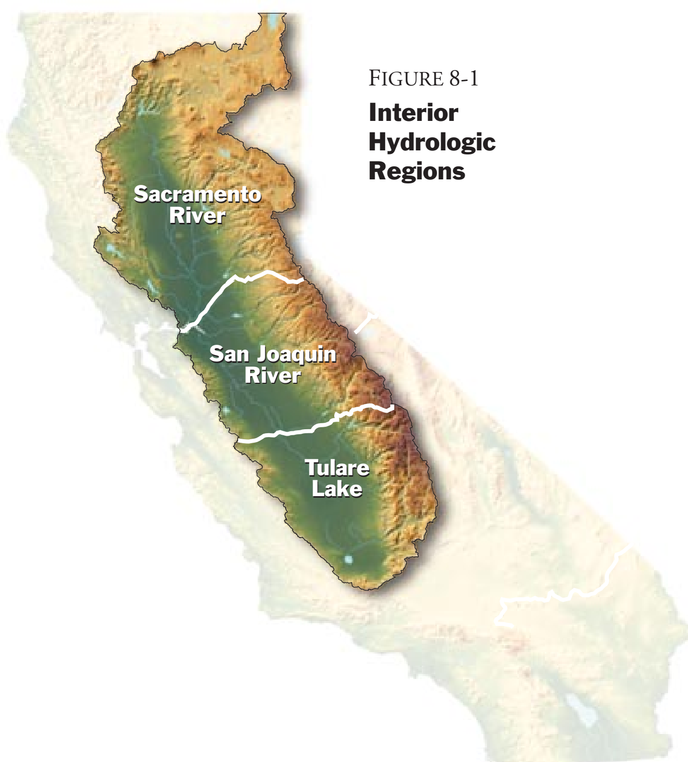


FIGURE 8-1
Interior Hydrologic Regions

The SWP's California Aqueduct.

FIGURE 8-2

Sacramento River Hydrologic Region

Sacramento River Hydrologic Region

. . .

Description of the Area

The Sacramento River Region, the drainage area of the Sacramento River and its tributaries, extends 300 miles from the Oregon border south to Collinsville in the Delta (Figure 8-2). The crest of the Sierra Nevada forms the eastern border of the Sacramento River Region, while the western side is defined by the crest of the Coast Range. The southern portion includes the American River watershed and the northern Delta. The Sacramento River Region includes all or large portions of Modoc, Siskiyou, Lassen, Shasta, Tehama, Glenn, Plumas, Butte, Colusa, Sutter, Yuba, Sierra, Nevada, Placer, Sacramento El Dorado, Yolo, Solano, Lake, and Napa Counties. Small areas of Amador and Alpine Counties are also within the Sacramento River Region. The State's largest river, the Sacramento, flows the length of the valley before entering the Delta. The Sacramento Valley is comprised of eight planning subareas, all of which are hydrologically connected by the Sacramento River.

The region is defined by two distinct features—the foothill and mountain areas of the Sierra Nevada, Cascade, and Coast Ranges, and the valley floor. Mountain elevations range from 5,000 feet along the coast to more than 10,000 feet in the Sierra Nevada. The elevation of the valley floor gradually decreases from 500 feet in the Redding area to just below sea level in the Delta.

Precipitation in the region varies substantially depending on location and elevation. In the foothill and higher mountain areas, precipitation ranges from 40 to more than 80 inches annually. The valley receives less rainfall, with average annual rainfall for Redding and Sacramento being 35 inches and 18 inches, respectively. The mountain areas have cold, wet winters with snow contributing runoff for summer water supply. The valley has mild winters and dry, hot summers.

Base year and future population and crop acreage for the region are provided in Table 8-1. Most of the region's population growth is expected to occur in the southern part of the region in Sacramento, Placer, El Dorado, Sutter, Yolo, and Solano Counties. The Sacramento metropolitan area and surrounding communities are expected to experience significant population growth, as is the Yuba City-Marysville area in Sutter and Yuba Counties. The region includes extensive irrigated agricultural acreage. Rice, irrigated pasture, alfalfa, grain, fruits, nuts, and tomatoes account for about 80 percent of the irrigated crop acreage. Irrigated acreage in the region is expected to change little during the planning period.

Water Demands and Supplies

Water shortages are expected to occur under average and drought conditions, as shown in Table 8-2. The 1995-level average year shortage reflects that groundwater overdraft is not treated as a source of supply. Most of the drought year water shortage is

TABLE 8-1

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	2,372	2,139
2020	3,813	2,150

The 3.5 maf Lake Oroville is the largest of the SWP's storage facilities.

associated with agricultural water use, primarily on the valley floor area north of Sacramento.

Excluding supplies dedicated to environmental purposes, surface water accounts for about 70 percent of the region's average year water supply. Groundwater provides the remaining supply. During drought years, additional groundwater is pumped to compensate for reduced surface water supplies. The region has 43 major reservoirs, with a combined storage capacity of almost 16 maf. About half of this surface capacity is contained in the CVP's Shasta Lake and the SWP's Lake Oroville.

CVP Water Supply

Most of the water delivered by CVP facilities in the Sacramento River Region is for agricultural use. Sacramento and Redding receive part of their water supply from CVP facilities.

The Tehama-Colusa and Corning Canals, supplied from Red Bluff Diversion Dam on the Sacramento River, deliver CVP water to agricultural users and to wildlife refuges. The Tehama-Colusa Canal extends 110 miles south of RBDD, terminating south of Dunnigan in Yolo County. The Corning Canal extends 25 miles south of RBDD, terminating near Corning. Together, the canals serve about 160,000 acres of land in Tehama, Glenn, Colusa, and Yolo Counties. CVP contractors and water rights settlement users also make direct diversions from the Sacramento River. Some of the larger water agencies receiving CVP supplies are listed in Table 8-3. The supplies shown include, where applicable, both project water and water rights settlement (base supply) water.

Releases from Folsom Reservoir on the American River serve Delta and CVP export needs, as well as providing supplies to agencies in the Sacramento metropolitan area. The City of Sacramento is the largest water rights contractor on the American River, with a contract for almost 300 taf/yr. Placer County Water Agency, one of the largest American River project water contractors, also holds a water rights settlement contract for 120 taf/yr. EBMUD holds the largest contract for project water on the American River system (150 taf/yr), which it had originally planned to receive via an extension of the existing Folsom South Canal. (EBMUD's American River supply is described in

TABLE 8-2

Sacramento River Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,833	4,223	5,839	4,225
Total	**14,664**	**14,106**	**14,917**	**14,282**
Supplies				
Surface Water	11,881	10,022	12,196	10,012
Groundwater	2,672	3,218	2,636	3,281
Recycled and Desalted	0	0	0	0
Total	**14,553**	**13,239**	**14,832**	**13,293**
Shortage	**111**	**867**	**85**	**989**

[a] Water use/supply totals and shortages may not sum due to rounding.

Monticello Dam, impounding Lake Berryessa, is the principal feature of USBR's Solano Project. Solano Irrigation District was formed in 1948 to sponsor construction of a reclamation project to serve Solano County.

Chapter 7.) Jenkinson Lake (Sly Park Dam) and Sugar Pine Reservoir serve communities in the foothills east of Sacramento.

Supply from Other Federal Water Projects

Monticello Dam in Napa County impounds Putah Creek to form Lake Berryessa, the principal water storage facility of USBR's Solano Project. The project provides urban and agricultural water supply to Solano County (partly in the Sacramento River Region and partly in the San Francisco Bay Region) and agricultural water supply to the University of California at Davis in Yolo County. Napa County uses about 1 percent of the supply for developments around Lake Berryessa.

Solano County Water Agency is the regional water contractor for both the federal Solano Project and the SWP. Within the Sacramento River Region, SCWA member entities with contracts for Solano Project water include the City of Vacaville (which also receives SWP water and uses groundwater), Solano Irrigation District and Maine Prairie Water District. (The Cities of Fairfield, Vallejo, and Suisun City in the San Francisco Bay Region have SCWA contracts for Solano Project water, as discussed in Chapter 7.) SID contracts for 141 taf/yr of Solano Project water from SCWA and delivers it to agricultural users in Solano County.

TABLE 8-3

Major Sacramento River CVP Water Users

Agency	*Total Supplies from CVP Facilities (taf)*
Anderson-Cottonwood ID	175.0
Glenn-Colusa ID	825.0
Natomas Central MWC	120.2
Princeton-Codora-Glenn ID	67.8
Reclamation District 108	232.0
Reclamation District 1004	71.4
Sutter Mutual WC	268.0

SWP Water Supply

Lake Davis, Frenchman Lake, and Antelope Lake are located on Feather River tributaries in Plumas County and are used primarily for recreation, but also provide water supply to the City of Portola and to local agencies having water rights agreements with the Department. Lake Oroville and Thermalito Afterbay also provide supply within the region. Local agencies that receive water rights water delivered through Thermalito Afterbay include Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District. Agencies in the region holding long-term contracts for SWP supply are Plumas County Flood Control and Water Conservation District, Butte County, Yuba City, and SCWA. SCWA receives its SWP supply from the Delta through the North Bay Aqueduct.

Local Surface Water Supply

Water stored and released from Clear Lake and Indian Valley Reservoir into Cache Creek is diverted

Cache Creek, with Capay Diversion Dam in foreground. Clear Lake and Mount Konocti are in the background.

by the Yolo County Flood Control and Water Conservation District for irrigation in Yolo County. Since 1950, the district has diverted an average of 130 taf annually at Capay Diversion Dam on lower Cache Creek. No water supply from these sources was available during the 1977 and 1990 drought years.

In Sutter County and in western Placer County, agricultural water is supplied by South Sutter Water District from Camp Far West Reservoir on the lower Bear River. SSWD also purchases surface water from Nevada Irrigation District to supplement irrigators' groundwater supplies. NID's supplies come from its reservoirs on the Yuba-Bear River system. Yuba River supplies have also been developed by Yuba County Water Agency, which owns the 966 taf New Bullards Bar Reservoir, the river's largest reservoir.

The Sacramento metropolitan area, served by more than 20 water purveyors, is the largest urban area in the Sacramento Region and is also the largest urban surface water user. Within Sacramento County, the City of Sacramento relies primarily on surface water (approximately 80 to 90 percent); water purveyors in unincorporated areas use both surface water and groundwater. The City of Sacramento diverts its CVP water supply from the American River at H Street, and also diverts from the confluence of the American and Sacramento Rivers. The City of Folsom takes surface water from Folsom Lake.

Groundwater Supply

Most groundwater used in the region comes from alluvial aquifers on the valley floor. The Sacramento Valley is a major groundwater basin, with an estimated 114 maf of water in storage at depths of up to 600 feet. (Only a portion of this amount can be economically used, however.) Well yields in alluvial areas vary significantly depending on location; pumping rates typically range from 100 to 4,000 gpm. Foothill communities using groundwater generally rely on fractured rock sources having yields lower than those found in valley floor alluvium.

Redding supplements its CVP surface water supply with groundwater. Smaller communities in the northern and central Sacramento Valley, such as Anderson, Red Bluff, Marysville, Olivehurst, Wheatland, Willows, Corning, and Williams, rely almost entirely on groundwater and have adequate supplies to meet local demands for the foreseeable future. Woodland, Davis, and Dixon are completely dependent on groundwater. Most residents in unincorporated areas rely on groundwater.

In the Sacramento metropolitan area, groundwater is used by the Cities of Sacramento and Galt, Sacramento County, and local water agencies. Two areas of overdraft exist in Sacramento County, one near McClellan Air Force Base and the other in the Elk Grove area.

Local Water Resources Management Issues

Sierra Nevada Foothills Water Supply

Urbanization of agricultural lands in the Central Valley is an issue currently attracting public attention. An alternative to urban development on valley floor agricultural lands is increasing development on nonarable lands in the adjoining Sierra Nevada foothills. However, the foothill areas also have land use and water supply concerns associated with development pressure, particularly for communities within commuting distance of the valley's major population centers.

Historically the rural foothill counties have had economies based on natural resource development (ranching and logging). Tourism is becoming increasingly important. Although individual foothill communities have experienced relatively high growth rates, the area's overall population is small, and future development is constrained by the high percentage of federal lands managed by the USFS and the National Park Service.

Although extensive development of large-scale water projects has occurred in the foothills, that development serves downstream urban and agricultural water users. The foothills' local water supply infrastructure is limited, with some water users still being served by open ditch and flume systems dating back to gold rush-era mining operations. The area's development pattern of small, geographically dispersed population centers and its lack of a financial base for major capital improvement projects constrains the ability to interconnect individual water systems and to develop centralized sources of water supplies, limiting options for water marketing. The area's small population translates into high per capita costs for water supply improvements. Many individual residences and subdivision developments rely on self-supplied groundwater from wells tapping fractured rock aquifers. Groundwater resources from fractured rock sources are highly variable in terms of water quantity and quality, and are an uncertain source for large-scale residential development.

Management of existing water supplies, especially meeting increasingly stringent drinking water quality requirements, is a challenge for some foothill water systems. As with water supply, interconnections for water treatment purposes are difficult due to geographic and topographic constraints. System consolidations are also complicated by the relatively large percentage of the foothill population living in unincorporated areas, and the correspondingly high number of small, independent water systems. Historically, many isolated developments relying on groundwater as a source of supply also used septic tank systems for waste disposal. Eventually, some of these systems experience groundwater contamination problems, requiring a new water supply or connection to a regional wastewater system, if one exists.

Conveyance system reliability is a concern in foothill areas where sources of surface supply are often limited. Conveyance facilities are vulnerable to localized flooding and earthquake or landslide damage. After the 1997 floods, a landslide destroyed a 30-foot section of Georgetown Divide Public Utility District's canal which supplied water to 9,000 customers in six towns in rural El Dorado County. Nearby, El Dorado Irrigation District also lost the use of a flume diverting from the American River due to another landslide. The district is currently developing alternatives to repair or replace the flume. EID has released a draft EIR for the project, and is proposing to make temporary canal repairs to allow for 40 cfs summer deliveries until permanent repairs can be made.

The communities of Cohasset and Forest Ranch in Butte County are considering building a pipeline to convey part of Butte County's SWP supply to urban users east of Chico. During extended drought conditions some of the wells serving the area have gone dry, requiring that water be hauled by truck. Also in Butte County, the Department's Division of Safety of Dams reduced the allowable operating capacity of Paradise Irrigation District's Magalia Reservoir because of seismic safety concerns. The 2.9 taf capacity reservoir is impounded by a hydraulic fill dam built in 1918. Restoring the 1.5 taf reduction in storage capacity is estimated to cost about $10 million.

Through 2020, no average year water shortages are anticipated in the entire Sierra foothill area stretching from Modoc County on the north to Kern County on the south and including adjacent parts of the Cascade Range foothills. Drought year shortages in 2020 are forecast to be 220 taf, over 60 percent of which are associated with agricultural water use. The area's limited payment capacity and its need for drought year supplies suggests that participation in regional water supply projects with larger water agencies is a viable option. Although local agencies have evaluated a number of new reservoir projects in the past (see water management options section), these projects have not gone forward.

Foothill Area Water Supply from American River Basin

El Dorado County water agencies have made several attempts to develop local supplies in the American River Basin, in anticipation of their service area's future water needs. Originally, USBR's multipurpose Auburn Dam was to provide local supply. When Auburn Dam did not go forward, EID and El Dorado County Water Agency proposed a joint water supply and hydropower project in the late 1970s. The South Fork American River project would have included a large dam at the Alder Creek site, Texas Hill Reservoir on Weber Creek, two diversion dams, and several powerplants. When the SOFAR project did not prove to be financially feasible, a small Alder Creek Reservoir project with a storage capacity of 31 taf was investigated. In 1993, EDCWA released a final EIR for water supply development in EID's service area.

Many foothill areas are served by conveyance systems that had their origins in gold rush-era mining systems. Another reminder of the region's mining history is the ringtail, also known as the "miner's cat". Some early settlers kept ringtails as pets, to control mice. The ringtail lives in rocky and wooded areas in the foothills and in valley riparian areas.

Alternatives included a 7.5 taf/yr CVP water service contract for deliveries from Folsom Reservoir (authorized in PL 101-514), the El Dorado project, Texas Hill Reservoir, Small Alder Reservoir, and the White Rock project. The preferred alternative was identified as a combination of the water service contract, the El Dorado project, and the White Rock project.

EDCWA subsequently executed the CVP water service contract and EID sought to implement the El Dorado project, a proposal to acquire rights to consumptively use water that had been developed by PG&E for hydropower generation. In 1996, SWRCB's Decision 1635 approved EID's water rights filing for 17 taf/yr of consumptive use from PG&E's Caples, Aloha, and Silver Lakes on the South Fork of the American River and its tributaries, based in part on a PG&E agreement to sell facilities of the hydropower project to EID. Several other water right holders petitioned SWRCB to reconsider its decision. EID and PG&E subsequently went to litigation over the sale of the facilities, and EID's EIR for the El Dorado project was found inadequate by a Superior Court judge. The project is currently on hold.

EID's White Rock project is a diversion and conveyance project that would build about 4.5 miles of pipeline, connecting a proposed treatment plant with an existing Sacramento Municipal Utility District penstock. The project would allow more efficient use of El Dorado project water, but would not provide additional water supply.

Alternatives to meeting GDPUD's future water needs were identified in a 1992 planning report that examined a potential reservoir project on Canyon Creek. The reservoir project was found to be unaffordable for the service area. The most promising option to meet future water demands in GDPUD's service area is to divert and convey CVP water from the American River (as part of EDCWA's CVP water service contract authorized by PL 101-514). The additional supplies would be 7.5 and 5.6 taf for average and drought years, respectively.

In the 1990s, USBR conducted an American River water resources investigation to evaluate local area water supply options that would replace the water supply that was to have been provided by the original multipurpose Auburn Dam. The study proposed two alternatives for meeting municipal and agricultural water supply needs in portions of Sacramento, San Joaquin, El Dorado, Placer, and Sutter Counties through 2030—a conjunctive use alternative and an Auburn Dam alternative. Three alternative Auburn Reservoir sizes were studied: 430 taf, 900 taf, and 1,200 taf. The final EIS for this investigation was completed in 1997. In May 1998, USBR issued a record of decision to not proceed with federal actions to meet future water needs in the study area.

Sacramento Area Water Forum

The Sacramento Area Water Forum was formed in 1993 to discuss ways to accommodate two co-equal objectives, providing water supply for the area's planned development and preserving fishery, wildlife, recreational, and aesthetic values of the lower American River. Forum membership includes the Cities of Sacramento, Galt, and Folsom; County of Sacramento; more than twenty urban and agricultural water agencies; several environmental groups; and representatives from the business community and other community groups. In 1995 the forum began meeting jointly with water interests in Placer and El Dorado Counties.

Working together, they developed proposed draft recommendations for their objectives, releasing a *Draft Recommendations for a Water Forum Agreement* in 1997. The proposed solution included seven elements:

- Increased surface water diversions
- Actions to meet customers' needs while reducing diversion impacts on the Lower American River in drier years
- Support for an improved pattern of fishery flow releases from Folsom Reservoir
- Lower American River habitat management
- Water conservation
- Groundwater management
- Water Forum successor effort

Generally, water interests would increase their diversions from the American River in average and wet years and decrease diversions in drought years. PCWA would release stored water from its reservoirs on the Middle Fork of the American River for many of the participating water agencies during drought years as replacement water for their decreased American River diversions. PCWA's participation in these agreements is dependent upon SWRCB approval for changes to conditions of its existing water rights.

The proposal calls for conjunctively managing surface and groundwater supplies to help control declining groundwater levels in parts of Sacramento County, and for implementing water conservation measures. An example of the regional cooperation for stabilizing groundwater levels is a joint pipeline project being carried out by San Juan Water District and Northridge Water District. SJWD has completed the first phase and NWD has completed the second phase of a joint pipeline project which will provide surface water to northern Sacramento County water purveyors. Phase III would extend the pipeline to the Rio Linda WD, McClellan AFB, the westerly Citizen's Utilities service area, and Natomas Central Mutual Water Company area. By providing surface water supplies, the retail purveyors along the pipeline route can reduce their dependence on groundwater, allowing the groundwater basin to recharge.

Colusa Basin Drainage District

A 1995 study by the Colusa Basin Drainage District identified projects to meet six objectives: protect against flood and drainage damages, preserve and enhance agricultural production, capture surface or storm water for increased water supplies, facilitate groundwater recharge to help reduce overdraft and land subsidence, improve and enhance wetland and riparian habitat, and improve water quality. Some projects selected for feasibility and preliminary design studies have potential water supply benefits—two small onstream reservoirs and one groundwater recharge project. These projects are described in the discussion of water management options. Much of the present supply for agricultural water users in the Colusa Basin comes from return flows from CVP water contractors. These irrigation return flows have become an increasingly unreliable supply for Colusa Basin Drain diverters as a result of increased water conservation measures by upstream water users.

Groundwater Management Actions

The Sierra Valley Groundwater Management District adopted an ordinance in 1980 limiting the amount of groundwater extraction in Sierra Valley. A legal challenge led to a repeal of the ordinance by the SVGMD. The district has since focused its efforts on monitoring the basin's groundwater levels and requesting voluntary reductions in extractions.

In 1992, the Tehama County Board of Supervisors amended its county code to enact urgency ordinances prohibiting groundwater mining within the county and extraction of groundwater for export without a permit from the board. In 1996, the Tehama County Flood Control and Water Conservation District adopted a resolution of intent to develop a countywide AB 3030 plan and prepared a draft plan to serve as the basis for developing agreements with groundwater users.

Butte County has enacted two ordinances regulating groundwater extraction. The purpose of one ordinance was to "attempt to reduce potential well interference problems to existing wells and potential adverse impacts to the environment which could be caused by the construction of new wells or the repair or deepening of existing wells. . . ." The ordinance limited pumping rates to 50 gpm per acre. The ordinance also established well spacing requirements based on well pumping capacity; spacing requirements range from 450 feet for a 1,000 gpm well to 2,600 feet for a 5,000 gpm well. The other ordinance was approved by voters in 1996 and regulated export of groundwater out of the county and substitution of groundwater for surface water when surface water is sold. The ordinance gave the Butte County Water Commission permitting authority over groundwater export or groundwater substitution.

Glenn County enacted a groundwater ordinance in 1977. This ordinance required a permit to export groundwater outside the county. A permit can be issued only if it is found that export will not result in overdraft, adverse impacts to water levels, or water quality degradation. The Board of Supervisors may impose permit conditions. Glenn County is preparing an AB 3030 groundwater management plan that is expected to be completed in 1998.

American River Flood Protection

Following the floods of February 1986, USACE reanalyzed American River basin hydrology and concluded that Folsom Dam did not provide an adequate level of flood protection to the downstream Sacramento area, significantly less than the 250-year protection estimated in the late 1940s when Folsom Dam was designed. Local, State, and federal agencies worked together to identify ways to provide additional flood protection for the American River Basin. In December 1991, an American River watershed investigation feasibility report and EIR/EIS were completed, presenting flood protection alternatives. The report recommended a flood control detention dam near Auburn. In 1992, Congress directed USACE to perform additional flood control studies. Three main alternatives were evaluated. Two of the alternatives would increase flood control storage in Folsom Lake, modify the dam's spillway and outlet works, and improve downstream levees. The third alternative would construct a detention dam at Auburn, with downstream levee improvements. USACE studies identified the detention dam as the plan that maximized national economic benefits. The State Reclamation Board endorsed the detention dam as the best long-term solution to reliably provide greater than 1-in-200 year flood protection. In 1996, USACE recommended deferring a decision on long-term solutions and proceeding with the levee improvements common to all three alternatives. Congress authorized $57 million in 1996 for construction of the levee improvements.

The Central Valley's January 1997 flood disaster prompted another examination of American River hydrology. Based on that hydrologic review, the 1986 and 1997 floods are now considered to be about 60-year events. The 1997 flooding also triggered payback provisions of the Sacramento Area Flood Control Agency's agreement with USBR, under which USBR sets aside up to 270 taf of additional winter flood control space in Folsom Lake. (This additional flood control space in the reservoir raises Sacramento's level of protection to about a 77-year event level.) Because the January 1997 flood event was followed by an unusually dry spring, reoperation of Folsom Lake for additional flood control resulted in a loss of supply to USBR. The federal government and SAFCA purchased 100 taf to offset the loss of supply—50 taf from YCWA, 35 taf from PCWA, and 15 taf from GCID.

In its Resolution No. 98-04, the Reclamation Board restated its conclusion that the best long-term engineering solution to reliably provide greater than 1-in-200 year flood protection is to develop additional flood detention storage at Auburn. As an incremental measure to increase the level of flood protection, the Board also voted to support SAFCA's Folsom Modification Plan, described in SAFCA's February 1998 report *Next Steps for Flood Control along the American River*. This plan, costing $75 to $140 million, would

Sacramento River Flood Control Project

Congress authorized the Sacramento River Flood Control Project in 1917 after a series of major Sacramento Valley floods in the late 1800s and early 1900s. The project was built with local, State, and federal funding. The project includes levees, overflow weirs, bypass channels, and channel enlargements. Overflow weirs allow excess water in the main river channel to flow into bypasses in the Sutter Basin and Yolo Basin. The bypass system was designed to carry 600,000 cfs of floodwater past Sacramento—110,000 cfs in the Sacramento River through downtown Sacramento and West Sacramento, and the remainder in the Yolo Bypass. The system has worked exceedingly well over the years.

The capability of the SRFCP was improved upon completion of Shasta Dam in 1945 and Folsom Dam in 1956. The Feather and Yuba River systems did not share in the SRFCP's flood control benefits; however, supplemental protection was provided by the completion of Oroville Dam on the Feather River in 1968 and New Bullards Bar Dam on the Yuba River in 1970. These are large multipurpose reservoirs in which flood control functions share space with water supply functions.

The City of Sacramento experienced several major floods during its early years. The following description of the floods of 1862 is taken from the journal of William Brewer, a member of the California State Geological Survey. "Such a desolate scene I hope never to see again. Most of the city is still under water, and has been for three months. ... Not a road leading from the city is passable, business is at a dead standstill, everything looks forlorn and wretched. Many houses have partially toppled over... some have been carried from their foundations, several streets (now avenues of water) are blocked up with houses that have floated in them, dead animals lie about here and there. . . ."

Courtesy of California State Library

increase flood protection to approximately a 1-in-110 year level. In addition, the Board strongly urged SAFCA to advocate federal flood insurance for all residents and businesses in the Sacramento area having less than a 1-in-200 year level of flood protection. As of July 1998, SAFCA was seeking congressional authorization for USACE participation in Folsom Dam modifications and downstream levee enlargements. The Board currently does not support raising and strengthening the levees downstream from the dam, and would not support State cost-sharing in this effort. Two competing flood control bills, HR 4111 and HR 3698, are pending before Congress. HR 4111 would authorize construction of a small flood control dam, while HR 3698 would rely mostly on levee improvements for flood protection for the Sacramento area.

Yuba River Flood Protection

The Marysville-Yuba City area, located at the confluence of the Feather and Yuba Rivers, relies on levees for much of its flood protection. New Bullards Bar Reservoir on the Yuba River, the only Yuba River Basin reservoir with dedicated flood control storage, regulates less than half the river's runoff. The middle and south forks of the Yuba River, and Deer Creek, have no dedicated flood storage. A large reservoir site (the former Marysville project, and similar sites near the Yuba River Narrows) was studied by USACE, YCWA, the Department, and others at various times in the 1950s and through the 1980s for both water supply and flood control purposes.

USACE, in cooperation with the State Reclamation Board and YCWA, conducted a feasibility study of water resources problems and opportunities in the Yuba River Basin in 1991, after a 1990 reconnaissance study identified a significant flood threat. Preliminary alternatives included modifying existing levees, implementing nonstructural measures, constructing a large or small bypass, reregulating existing flood storage at Oroville and New Bullards Bar Reservoirs, providing new flood storage at Englebright Reservoir, raising Englebright Dam and reregulating flood storage at Englebright and New Bullards Bar Reservoirs, and constructing a single purpose or multipurpose reservoir at the Parks Bar or Narrows damsites. The recommended plan in USACE's 1998 Yuba River Ba-

Flooding on the American River in 1986 and again in 1997 severely tested levee system capabilities. Releases from Folsom Dam in 1986 actually exceeded design capacity of the levee system. In 1997, voluntary evacuation advisories were issued for some parts of the Sacramento metropolitan area. This photo shows the American River at the H Street bridge.

sin Investigation final feasibility report and EIR/EIS was to modify existing levees along the Yuba and Feather Rivers. In response to the significant flood problems experienced in the Marysville-Yuba City area during the January 1997 flood, YCWA began a new investigation of flood control alternatives. The multiyear study will examine a range of alternatives, including storage facilities such as the Parks Bar site. During the 1997 flood event, 35,000 people were evacuated from the Marysville area and 75,000 people were evacuated downstream in Sutter County.

Sacramento River Mainstem Flood Protection and Water Supply

Enlargement of Shasta Reservoir has been examined in the past by USBR and the Department as a water supply option. Reservoir enlargement would also provide additional flood protection on the Sacramento River mainstem. When the project was last reviewed in the 1980s (at a cursory level of detail), its financial costs were high, reflecting the project's magnitude (up to 10 maf of additional storage capacity). Railroad and highway relocations were a substantial cost item. In the wake of the January 1997 flooding, there was renewed interest in reexamining Shasta's enlargement, and in considering a range of potential reservoir sizes. USBR conducted a preliminary study for the CALFED program, reviewing three options. One option would raise the dam 6 feet to add 300 taf of storage at a cost of $123 million. Raising the dam 100 feet would add 4 maf of storage and cost $3.9 billion. Raising the dam 200 feet would add 9.3 maf of storage and cost $5.8 billion. Enlarging Shasta as a statewide water management option could provide the opportunity for local agencies in the region to participate in the project, especially smaller agencies that lack the resources to develop new local projects themselves.

Putah Creek Adjudication

USBR's Solano Project stores and diverts water from Putah Creek. Solano Project operations are subject to a condition reserving water for users upstream of Monticello Dam in Lake Berryessa. In 1990, two project water users (SID and SCWA) commenced an action in Solano County Superior Court to determine all rights to the use of water from Putah Creek and its tributaries. Among other issues, the action required a determination of how rights can be exercised among USBR and upstream water users. An agreement was negotiated among SID, SCWA, USBR, and upstream water users. In 1996, the SWRCB adopted Order WR 96-2, amending appropriative water rights in the upper Putah Creek watershed to be consistent with the negotiated agreement.

Fish Passage at Red Bluff Diversion Dam

USBR's Red Bluff Diversion Dam, completed in 1966, spans the Sacramento River. The dam diverts river water into the Tehama-Colusa and Corning Canals, supplying irrigation and wildlife refuge water. Severe fishery declines in the upper river during the 1970s and 1980s, were partly attributed to the dam and the canal intake screens. The dam delayed upstream passage of migrating adult salmon and steelhead and disoriented downstream migrating juveniles, which made them vulnerable to predation by squawfish. The original fish screens also permitted passage of many juvenile fish into the canals.

In 1986, USBR began raising the gates of the dam between December and March to allow unimpeded fish passage. The gates-up period has been expanded in response to ESA requirements for winter-run chinook salmon; the current objective is to raise the gates for eight consecutive months (September 15 to May 15) each year to allow unimpeded fish passage. New drum fish screens and bypasses were installed at the canal headworks in 1991 and are now operating successfully. As discussed in Chapter 2, USBR and USFWS are operating a research pumping plant at the dam to evaluate the effects of different pump types on fish. The plant supplies a limited amount of water to the canals during the eight months when the dam gates are raised.

Glenn-Colusa Irrigation District Fish Screen

The 175,000 acre Glenn-Colusa Irrigation District has the largest diversion on the mainstem Sacramento River, with a maximum capacity of 3,000 cfs. GCID may divert up to 825 taf from April through October for irrigation supply. GCID also conveys CVP water to three national wildlife refuges—Sacramento, Delevan, and Colusa.

GCID's pumping plant is located on a river side channel upstream of Hamilton City, near Chico. DFG constructed a 40-drum rotary screen fish barrier at the plant's intake in 1982, to prevent entrainment of juvenile fish. The fish barrier did not perform as intended, resulting in an unacceptably high rate of juvenile fish mortality. ESA listing of the winter-run chinook salmon resulted in a 1991 court order restricting GCID's pumping and requiring installation of a new fish screen. CVPIA required DOI to improve fish passage at the pumping plant. GCID installed a temporary flat-plate screen in 1993 while a permanent solution was being developed. An environmental document identifying a preferred fish passage alternative—a new flat-plate screen with a river gradient control facility in the main channel of the Sacramento River—was released in 1997. Construction of the new screen began in 1998.

Fish and Wildlife Restoration Activities in the Sacramento Valley

Many fishery restoration actions or projects are ongoing in the Sacramento Valley. Some of the larger projects are described below.

Mill and Deer Creeks support spring-run chinook salmon, a candidate species under the California ESA. In 1995, State legislation restricted future water development on the creeks, to protect salmon habitat. In addition, local landowners formed the Mill and Deer Creek Watershed Conservancies. The conservancies

USBR's Red Bluff Diversion Dam, with gates raised. The dam was designed to divert Sacramento River water into the Tehama-Colusa Canal. The intake channel for the Corning Canal Pumping Plant connects to the Tehama-Colusa Canal.

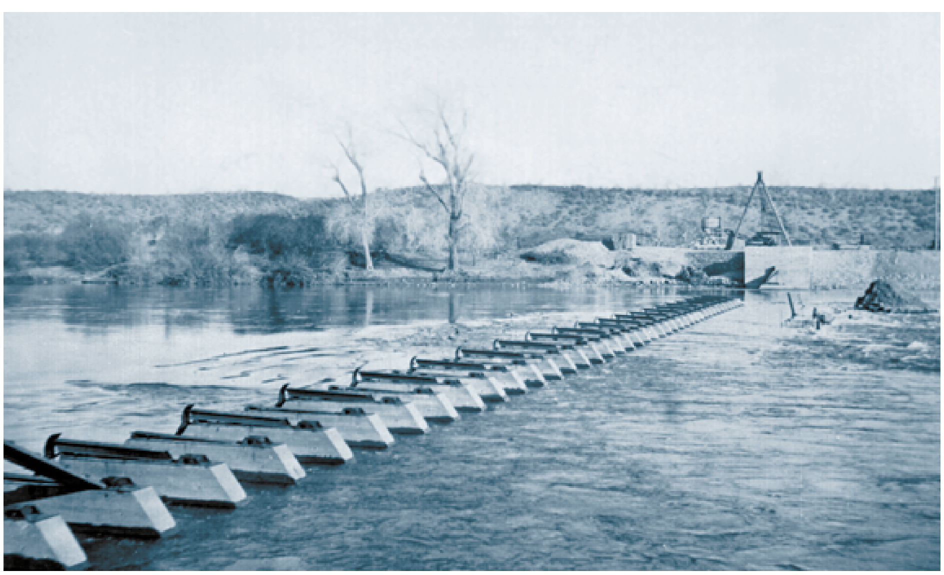
Local agencies have made extensive efforts to improve Butte Creek fish passage, in response to declines in the population of spring-run chinook salmon.

have begun a watershed planning and management process, with funding assistance from an EPA grant. The Department has participated with Mill Creek landowners in a test project to construct wells to provide groundwater supplies in lieu of creek diversions for irrigation during spring fish migration periods. A similar project is being negotiated with Deer Creek water users.

Big Chico Creek supports a small population of spring-run salmon, and some fall-run salmon. M&T Chico Ranch and Parrott Ranch pumps were relocated from the creek to the Sacramento River in 1996 to eliminate reverse flows at the mouth of the creek. Other fishery improvement actions—modification of small temporary dams and a permanent fish ladder, revegetation of Lindo Channel, and development of a fishery management plan—are being investigated.

Butte Creek is presently receiving considerable fishery restoration attention. The creek has a large spring-run salmon population and also supports a small fall run. Recent fishery restoration efforts on Butte Creek began in 1993 when Western Canal Water District and private landowners agreed to remove the Point Four Diversion Dam near Nelson. M&T Chico Ranch and DFG agreed to install a new fish ladder and fish screens at the Parrott-Phelan Dam in 1995. M&T Chico Ranch also dedicated 40 cfs of instream flow for fishery needs on Butte Creek. WCWD installed a siphon under Butte Creek in 1998, allowing removal of its two main dams and two smaller downstream dams from the creek. The siphon separates WCWD's canal system from Butte Creek and eliminates fish losses previously caused by creek diversion. Work began in 1998 on fishery facility modifications to Durham Mutual, Adams, and Gorrill Dams. The Nature Conservancy and California Waterfowl Association are evaluating diversion dams in the Butte Slough and Sutter Bypass for potential fish passage improvements.

Pelger Mutual Water Company and Maxwell Irrigation District installed fish screens on their Sacramento River diversions in 1994. Princeton-Codora-Glenn Irrigation District and Provident



A 1917 construction photo of Anderson-Cottonwood Irrigation District's diversion dam on the Sacramento River. Flashboards are installed during the irrigation season to raise the river's water level for diversions to ACID's main canal. ACID's diversion is one of many Sacramento River Basin sites under study for fish passage Improvements.

Courtesy of Water Resources Center Archives, University of California, Berkeley

Irrigation District started construction on a new screened pumping plant on the Sacramento River, which is expected to be operational in 1998. Reclamation District 108 started building its new fish screen at its Wilkins Slough Diversion on the Sacramento River in 1997. The new screen is expected to be operational in 1999. Reclamation District 1004 is completing final design and will begin construction on its new fish screen and pumping facility in 1998. Natomas Central Mutual Water Company will soon begin feasibility studies for a large screening project on the lower Sacramento River. On the Yuba River, Browns Valley Irrigation District will install a fish screen in 1998.

Clear Creek is another location in the Sacramento River Basin where fishery restoration work has been performed. Additional planned work includes fish passage around McCormick-Saeltzer Dam, gravel placement, and sediment control. Much of the riparian land along Clear Creek below Whiskeytown Reservoir has been acquired by BLM and the Wildlife Conservation Board to preserve its habitat values.

Other Sacramento River Region streams with environmental restoration studies underway are Battle Creek and Lower Stony Creek. Potential restoration work at Battle Creek includes studies of fish passage, instream flows, screened diversions, and hatchery modernization. Glenn County is seeking funding for planning of a Lower Stony Creek watershed restoration program.

Water Needs for Rice Field Flooding

Sacramento Valley rice fields provide overwintering areas for about one-third of all migrating waterfowl in California. Historically, many farmers in the Sacramento Valley have flooded harvested rice fields to attract waterfowl for hunting. Additional rice acreage is now being flooded for rice straw decomposition, due to air quality restrictions on burning rice straw. Most flooding of harvested rice lands begins in mid-October and continues into November. Flooded conditions are usually maintained through March. In 1994-95, the Department studied three Sacramento Valley planning subareas (Northwest Valley, Central Basin West, and Central Basin East) to evaluate fall and winter water use. The study area included approximately 123,000 acres of flooded rice land. The estimated applied water requirement was 260 taf or about 2 af/acre; the estimated ETAW was 107 taf. Fields used for waterfowl hunting have higher water demands than those used for rice straw decomposition. Water demands for flooding to decompose rice straw may decrease in the future if growers are able to find commercial uses for rice straw.

Water Management Options for the Sacramento River Region

Water management options in the Sacramento River Region have been extensively investigated by federal, State and local governments over the last 70 years. Many of the federal and State options were explored for their potential to augment CVP or SWP water supplies. Some projects, once studied as statewide options, are now being reconsidered for meeting future local water supply and flood control needs in the Sacramento River Region. Most large onstream and offstream reservoirs are beyond the development capacity of local water agencies, and are being considered as CALFED options, described in Chapter 6.

Table 8-4 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 8A-1 in Appendix 8A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Urban conservation options were deferred from detailed evaluation because they provide little cost-effective potential to create new water through depletion reductions in the Sacramento River Region.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Agricultural conservation options were deferred. Water that is not consumed by evapotranspiration is recoverable either as surface or groundwater for reapplication downstream.

Modify Existing Reservoirs/Operations

Two reservoir enlargement options were deferred in initial screening. Enlargement of Camp Far West Reservoir was deferred based on economic criteria. A Lower Bear River expansion project that would increase the storage of Lower Bear Reservoir by more than 26 taf was deferred because of several uncertainties includ-

TABLE 8-4

Sacramento River Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ET_o	Defer	No significant depletion reductions attainable.
Indoor Water Use	Defer	No significant depletion reductions attainable.
Interior CII Water Use	Defer	No significant depletion reductions attainable.
Distribution System Losses	Defer	No significant depletion reductions attainable.
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Enlarge Camp Far West Reservoir	Defer	Economics.
Lower Bear River Expansion Project	Defer	Uncertainties with water rights issues.
Reoperate Caples, Aloha, and Silver Lakes	Retain	
New Reservoirs/Conveyance Facilities		
Wilson Creek Reservoir (Glenn County)	Defer	Undetermined yields; primarily flood control project.
Golden Gate Reservoir (Funks Creek, Colusa County)	Defer	Undetermined yields; primarily flood control project.
Dry Creek Reservoir (Lake County)	Retain	
Bear Creek Reservoir (Colusa County)	Defer	Environmental concerns. Conflicts with federal land management policies.
Wilson Valley Reservoir (Lake County)	Defer	Environmental concerns. Conflicts with federal land management policies.
Garden Bar Reservoir (Placer and Nevada Counties)	Defer	Economics.
Long Bar Reservoir (Yuba County)	Defer	Undetermined yields; primarily hydropower project.
Wambo Bar Reservoir (Yuba County)	Defer	Undetermined yields; primarily hydropower project.
Marysville Dam (Yuba County)	Defer	Undetermined yields; economics.
Blue Ridge Reservoir (Yolo County)	Defer	Environmental concerns. Conflicts with federal land management policies.
Thurston Lake Pump-Storage Project (Lake County)	Retain	
Parks Bar Reservoir (Yuba County)	Retain	
Waldo Reservoir (Yuba County)	Retain	
White Rock Project (El Dorado County)	Defer	Reoperation of existing supply; would not provide new water supply.
Texas Hill Reservoir (El Dorado County)	Retain	
Small Alder Reservoir (El Dorado County)	Retain	
Canyon Creek Reservoir (Georgetown)	Defer	Excessive costs.
GDPUD Diversion from American River	Retain	

TABLE 8-4
Sacramento River Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Groundwater/Conjunctive Use		
New Wells (Redding, Butte, and Colusa Basins)	Retain	
USBR/Ducks Unlimited Conjunctive Use	Defer	Would not create new water supply.
Big Valley Conjunctive Use (Lake County)	Retain	
Orland-Artois Groundwater Recharge Basin	Defer	Lack of project data, no yields determined.
Adobe Creek Detention Structure (Lake County)	Defer	Negative environmental impacts.
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply.
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	Retain	
New Surface Water Diversion from Sacramento River by Cities of Benicia, Fairfield, and Vacaville	Retain	
Statewide Options		
—	—	See Chapter 6.

ing water rights issues, coordination with PG&E (the reservoir's owner), and lack of definitive estimates of the project's drought year supply.

The water management issues section described several projects for EID's service area. The El Dorado Project would offer an annual yield of 17 taf for EID through consumptive use of water developed for hydropower at PG&E facilities (Caples, Aloha, and Silver Lakes). No new diversion facilities would be required for the project. Implementation of the El Dorado Project is currently on hold pending negotiations with project opponents.

New Reservoirs

An extensive reevaluation of onstream and offstream Sacramento Valley reservoir sites is being conducted by the CALFED Bay-Delta program. Chapter 6 discusses reservoir sites (such as the offstream Sites Reservoir) being evaluated as statewide water supply options for CALFED.

Onstream Storage. Local efforts to develop American River Basin water supply for rapidly growing foothill communities were described previously. Most recently, EID and EDCWA considered the Texas Hill and Small Alder Reservoir sites, but EDCWA did not include them as preferred alternatives in its plan for EID's service area. The drought year yields from these reservoirs have been estimated at 9.4 taf and 11.3 taf, respectively. If implementation of EDCWA's preferred alternative does not proceed, these options may still be viable. GDPUD has examined a reservoir project on Canyon Creek. The 17 taf reservoir site, located between the Middle and South Forks of the American River, would have an estimated drought year yield of 6 taf. This project was not cost-competitive with other options available to GDPUD.

The Colusa Basin Drainage District has investigated two small reservoirs as part of its integrated watershed management project—a 2.2 taf Wilson Creek Reservoir west of Orland in Glenn County, and

Sites Reservoir (described in Chapter 6 as a CALFED option) could provide some local supply for the region, depending on the project's formulation. This photo shows the dam site area.

a 16.9 taf Golden Gate Reservoir on Funks Creek near Maxwell in Colusa County. The estimated average annual runoff at the Wilson Creek site is 2.4 taf. The construction cost is estimated at $3.3 million. The primary purpose of the proposed reservoir would be flood control, although it offers limited water supply benefits. Golden Gate Reservoir would be formed by a 76-foot high earthfill dam; this dam site is also a component of the Sites/Colusa Reservoir, a CALFED storage option presented in Chapter 6. The estimated average annual runoff at the Golden Gate Dam site is 8.6 taf and the construction cost estimate for the dam and reservoir is $2.5 million. Neither of these projects is included in the Bulletin's detailed options evaluation because potential yields are undetermined. These reservoirs are too small to provide enough carryover storage to significantly increase local drought year water supply reliability.

The Department investigated the Dry Creek Project in Lake County near Middletown in 1965. The project was designed to irrigate 5,700 acres of agricultural lands in the Collayomi and Long Valleys in Lake County. The main project feature would be a 129-foot-high earthfill dam on Dry Creek (a Putah Creek tributary) forming a 6.6 taf reservoir. Updated cost estimates range from $150 to $250/af, assuming a maximum annual yield of 6.6 taf. USACE is conducting a reconnaissance study for a similar facility, scheduled for completion in 1998.

In 1988, YCFC&WCD studied alternative water supply projects in the Cache Creek watershed. The study identified three onstream storage projects—Bear Creek Reservoir in Colusa County and Wilson Valley Reservoir in Lake County, with annual yields of 30 taf each, and Blue Ridge Reservoir in Yolo County, with an annual yield of 100 taf. None of these sites are under active consideration now. Parts of the Cache Creek drainage basin that could be impacted by these projects are managed by BLM and DFG for wildlife habitat and recreational purposes, and a segment of Cache Creek is under study for potential federal designation as a wild and scenic river.

South Sutter Water District had looked at a potential Garden Bar Reservoir on the Bear River, upstream of Camp Far West Reservoir and had determined that the project was not economically feasible.

Many potential Yuba River reservoir sites have been studied to meet basin flood protection and water supply needs. Recent local interest has focused on the Parks Bar Reservoir site on the lower Yuba River (below Englebright Dam) and on Waldo Reservoir, an offstream storage option discussed in the next section. The potential multipurpose Parks Bar Reservoir would have a 640 taf capacity and could provide up to 160 taf of drought year yield. Parks Bar Dam is a flood control alternative previously rejected by the USACE in favor of levee improvements. YCWA is starting a new three-year study to evaluate all basin flood control and water supply options. The study will reevaluate levee improvements, new flood control channels, new storage (including Parks Bar), and reoperation of existing reservoirs.

Offstream Storage. In 1996, YCWA completed a reconnaissance evaluation of the proposed 300 taf offstream Waldo Reservoir. Waldo Dam would be located on Dry Creek, east of Beale Air Force Base in Yuba County. Water would be diverted from the Yuba River by gravity through a tunnel from Englebright Reservoir. The dam would provide flood control benefits on Dry Creek for the City of Wheatland, but would have no direct flood control benefits on the Yuba River. Waldo Reservoir could provide offsetting storage for increased flood control reservation at New Bullards Bar Reservoir and Lake Oroville if YCWA negotiates agreements with the reservoir owners for supply from Waldo Reservoir in exchange for the flood control storage.

Phase I of a feasibility investigation was conducted in 1997 to determine reservoir yield, develop cost estimates, and evaluate environmental issues. The reservoir's average and drought year yields for YCWA's service area would be about 145 and 109 taf, respectively. The cost of water if served in the area of origin would be about $110/af. Phase II of the study began in 1998 and includes analyses of alternatives. Preparation of environmental documentation would begin in 2000 if the project appeared feasible. Environmental issues include flooding of a portion of the Spenceville Wildlife and Recreation Area, remediation of an abandoned copper mine, and instream flows. (The preliminary cost estimates include removal of mine tailings and site remediation in accordance with regulatory requirements.)

A 1988 YCFC&WCD study investigated a potential offstream storage project at Thurston Lake, a natural lake in the Clear Lake watershed. The Thurston Lake pump-storage project was to develop a new water supply and reduce flooding at Clear Lake communities. The project would provide storage of up to 300 taf and yield 60 taf/yr. Water would be pumped from Clear Lake into Thurston Lake during periods of high runoff, reducing downstream flood flows. Preliminary investigations suggest that substantial leakage at the site would occur and that potential water quality problems could result from high boron levels in Thurston Lake.

New Conveyance Facilities

The White Rock conveyance project would divert and convey South Fork American River water from SMUD's White Rock Penstock to EID's proposed Bray Water Treatment Plant near Diamond Springs. The diversion could be made under a 1957 contract and a 1961 supplemental agreement with SMUD, if water rights were granted by SWRCB to EDCWA and EID. The maximum quantity of water that could be diverted annually is about 40 taf. The project would not generate new water.

Groundwater Development or Conjunctive Use

Groundwater is expected to be the primary local option for increasing valley floor water supplies north of Sacramento within this Bulletin's planning horizon. Where supplies are plentiful and of adequate quality, groundwater has a cost advantage over new reservoirs. Groundwater can be developed incrementally by individual farms and domestic users, or by water purveyors. Data are not available to quantify the availability of additional groundwater development.

USBR, in cooperation with Ducks Unlimited, studied a conjunctive use project within GCID to provide long-term groundwater supply to supplement available surface water for rice straw decomposition and waterfowl habitat. In wet years, surplus Sacramento River water would be pumped into GCID's conveyance system for delivery to recharge areas. The study concluded that the project would not provide new water supply.

The Lake County Flood Control and Water Conservation District is investigating a small conjunctive use project in Big Valley near Kelseyville. This project would modify the primary spillway structure of Highland Creek Reservoir to increase storage. The conserved water would be released downstream during the spring and fall for groundwater recharge. Current estimates indicate a project yield of 400 af/yr at a cost of about $30/af. Because the yield would be less than 1 taf/yr, the project was not shown in the list of options likely to be implemented for the region.

The Colusa Basin Drainage District is investigating the Orland-Artois groundwater recharge project in southern Glenn County. Water would be delivered to an abandoned quarry via the Tehama-Colusa Canal during periods of high Sacramento River flows. Preliminary designs for this project estimate groundwater recharge capacity of 1.5 taf per season. The estimated cost of construction ranges from about $363,000 to $513,000. Evaluation of this option was deferred until project yields are determined.

Water Marketing

Intra- and inter-district water transfers have been common among CVP water rights settlement contractors on the Sacramento River. Year-to-year transfers among CVP water users in the region are not considered as new projects for Bulletin 160-98.

Water Recycling

As with conservation, recycling is not a source of new supply in the Sacramento River Region from a statewide perspective. Recycling is a potentially important water source for local purposes, but does not create new water. Several small water recycling projects serve local water needs for agricultural, environmental, and landscape irrigation purposes. In the 1995 base year, about 12.5 taf of wastewater was recycled in the region, an amount expected to increase to 14.5 taf by 2020.

Other Local Options

YCFC&WCD has filed water right applications for supplemental water from the Sacramento River for

Davis, Woodland, and Winters, and for agricultural and fishery uses at UC Davis. YCFC&WCD also filed an application to divert water from Cache Creek for groundwater recharge and to replace groundwater currently being used for irrigation. About 95 taf has been requested under the two applications.

SCWA and its member agencies are examining several surface water management projects. One potential project is an intertie connecting a Solano Irrigation District irrigation canal with the SWP's North Bay Aqueduct. Another potential SCWA project involves permanent or long-term water transfers. The Cities of Fairfield and Benicia in the San Francisco Bay Region and Vacaville in the Sacramento River Region have filed a water right application for supplemental water from the Sacramento River, seeking 12, 10.5, and 8.5 taf/yr, respectively.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the Sacramento River Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 85 taf and 989 taf in average and drought years, respectively. Ranking of retained water management options for the Sacramento River Region is summarized in Table 8-5. Table 8-6 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Costs of new reservoir projects are often prohibitive for agricultural water users, especially when the

TABLE 8-5

Options Ranking for Sacramento River Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Modify Existing Reservoirs/Operations				
Reoperate PG&E Reservoirs	L	[b]	[b]	17
New Reservoirs/Conveyance Facilities				
Dry Creek Reservoir (Lake County)	L	200	7	[b]
Thurston Lake Pump-Storage Project	M	390	[b]	60
Parks Bar Reservoir (Yuba County)	H	[b]	[b]	160
Waldo Reservoir (Yuba County)	H	110	145	109
Texas Hill Reservoir (El Dorado County)	L	[b]	[b]	9
Small Alder Reservoir (El Dorado County)	L	[b]	[b]	11
GDPUD Diversion from American River	M	[b]	8	6
Groundwater/Conjunctive Use				
New Wells (Redding, Butte, and Colusa Basins)	H	[b]	[b]	[b]
Big Valley Conjunctive Use	H	30	—	[c]
Other Local Options				
New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	M	[b]	95	95
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, and Vacaville	M	[b]	8	8

[a] All or parts of the amounts shown for highlighted options have been included in Table 8-6.
[b] Data not available to quantify.
[c] Less than 1 taf.

supplies are needed primarily for drought year shortages. However, Yuba River onstream storage at the Parks Bar site or offstream storage at Waldo Reservoir are promising options. Parks Bar in particular could reduce the flood threat to the Yuba City-Marysville area and downstream levee systems on the Feather and Sacramento Rivers. Parks Bar could provide a drought year yield of 160 taf. Likewise, a 2.3 maf Auburn Dam would provide the Sacramento metropolitan area with substantial flood protection as well as augment the region's average year and drought year supplies by 85 taf and 51 taf, respectively. If options shown in Table 8-6 are implemented, average water year needs of the region would be fully met, although a drought year shortage would remain.

TABLE 8-6

Options Likely to be Implemented by 2020 (taf)
Sacramento River Region

	Average	*Drought*
Applied Water Shortage	**85**	**989**
Options Likely to be Implemented by 2020		
Conservation	—	—
Modify Existing Reservoirs/Operations	—	—
New Reservoirs/Conveyance Facilities[a]	—	160
Groundwater/Conjunctive Use	—	—
Water Marketing	—	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	85	51
Expected Reapplication	—	56
Total Potential Gain[b]	**85**	**267**
Remaining Applied Water Shortage	**0**	**722**

[a] Average year yield of Parks Bar Reservoir has not been quantified.
[b] With construction of Parks Bar Reservoir, average water year needs of region would be exceeded, although there is a substantial drought year shortage. In average water years, the surplus water could be available for use in other regions.

FIGURE 8-3

San Joaquin River Hydrologic Region

San Joaquin River Hydrologic Region

. . .

Description of the Area

The San Joaquin River Region is bordered on the east by the crest of the Sierra Nevada and on the west by the coastal mountains of the Diablo Range (Figure 8-3). It extends from the Delta and the Cosumnes River watershed to the San Joaquin River watershed near Fresno. All or portions of counties within the study area include Alameda, Alpine, Amador, Calaveras, Contra Costa, El Dorado, Fresno, Madera, Mariposa, Merced, Sacramento, San Benito, San Joaquin, Stanislaus, and Tuolumne.

Summer temperatures are usually hot in the valley, and slightly cooler in the Delta and upland areas. In the winter, temperatures are usually moderate in the valley and cool in the Delta and upland areas. Annual precipitation on the valley floor ranges from about 17 inches in the north to 9 inches in the south.

TABLE 8-7

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	1,592	2,005
2020	3,025	1,935

The principal population centers are the Cities of Lodi, Stockton, Tracy, Modesto, Turlock, Merced, and Madera. The northwest part of the area, including Tracy and surrounding communities, is experiencing rapid growth as workers in the San Francisco Bay area accept the longer commute from the valley in exchange for the affordable housing. Table 8-7 shows the 1995 and 2020 population and crop acreage for the region.

TABLE 8-8

San Joaquin River Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,450	6,719
Environmental	3,396	1,904	3,411	1,919
Total	**10,996**	**9,731**	**10,815**	**9,609**
Supplies				
Surface Water	8,562	6,043	8,458	5,986
Groundwater	2,195	2,900	2,295	2,912
Recycled and Desalted	0	0	0	0
Total	**10,757**	**8,943**	**10,753**	**8,898**
Shortage	**239**	**788**	**63**	**711**

[a] Water use/supply totals and shortages may not sum due to rounding.

Flood protection in the Cosumnes River floodplain has historically been provided only by privately-owned levees. As shown here, rural residential development in the floodplain has relied on this limited protection.

Irrigated crop acreage in the area is forecasted to decrease, primarily due to urban development on agricultural lands. The primary crops are alfalfa, corn, cotton, deciduous fruit and nuts, grain, grapes, and pasture. Major employers include agriculture, food processing, and service sector businesses.

The area has many wildlife refuge and wetland areas. The Grasslands area, in western Merced County, is the largest contiguous block of wetlands in the Central Valley and is an important wintering ground for migratory waterfowl and shorebirds on the Pacific Flyway. Wetlands and wildlife areas include managed wetlands on Delta islands, Grassland Resource Conservation District, Los Banos Wildlife Area, Merced National Wildlife Refuge, North Grasslands Wildlife Area, San Luis National Wildlife Refuge, and Volta Wildlife Area. (In 1996, Kesterson National Wildlife Refuge and San Luis National Wildlife Refuge merged, with the combined refuge keeping the San Luis name.) Of the total wetlands in the region, about 40,700 acres are privately owned.

San Francisco's Hetch Hetchy Reservoir in Yosemite National Park. The reservoir is impounded by O'Shaughnessy Dam.

Water Demands and Supplies

Table 8-8 summarizes the region's water demands and supplies. Significant 1995-level and 2020-level water shortages occur in both average and drought years.

Surface Water

Much of the valley floor area receives its water supply from Sierra Nevada reservoirs. Some Sierra Nevada facilities—such as San Francisco's system and EBMUD's system—export water from the region to serve communities in the San Francisco Bay Region. Agricultural lands west of the San Joaquin Valley trough are mostly served by the CVP. Agricultural lands in the northwest corner of the region receive their water supply by direct diversion from Delta waterways. In the foothill and mountain areas, water is either diverted directly from streams and lakes or from local storage reservoirs and conveyance facilities.

In north to south order, the major Sierra Nevada rivers draining to the valley floor in this region are the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and San Joaquin Rivers. The San Joaquin River, which forms the southerly boundary of the region, flows westward out of the mountains then turns north and flows in the valley trough to the Delta.

The Cosumnes River, one of the smaller Sierra Nevada rivers, is unique in that it has no significant reservoirs on its entire length, although it has local irrigation diversions. (USBR's Jenkinson Lake is located on Sly Park Creek, a tributary to the Cosumnes River.) Riparian lands along the lower river are managed as a nature preserve. Flood protection needs on the Cosumnes River were highlighted by the January 1997 floods, when numerous breaks in private levees on the valley floor caused widespread local flooding. As discussed in the following section, proposals for a managed floodway are under consideration.

The Mokelumne River system includes some hydroelectric power development in the upper watershed, but the major reservoirs are EBMUD's Camanche and Pardee Reservoirs, which develop water supply for urban communities in the San Francisco Bay Region. Woodbridge Diversion Dam on the Mokelumne River near Lodi diverts irrigation water from the river to Woodbridge Irrigation District.

The 317 taf New Hogan Reservoir, the only large reservoir on the Calaveras River, was constructed by the USACE to provide flood protection and water supply for the Stockton area. New Hogan maintains a flood control reservation of up to 165 taf. To the south of New Hogan on Littlejohns Creek, USACE constructed Farmington Reservoir to provide additional flood protection for the Stockton area. Stockton East Water District provides the City of Stockton with supply from New Hogan. As part of its New Melones water conveyance project, SEWD constructed facilities linking Farmington Reservoir on Littlejohns Creek to Goodwin Dam on the Stanislaus River.

The CVP's 2.4 maf New Melones Reservoir is the largest reservoir on the Stanislaus River. Up to 450 taf of New Melones' capacity is reserved for flood control storage. Upstream from New Melones are Beardsley Reservoir (98 taf) and Donnells Reservoir (64 taf), owned jointly by Oakdale Irrigation District and South San Joaquin Irrigation District. Downstream from New Melones are Tulloch Reservoir (67 taf) and Goodwin Reservoir (0.5 taf), also owned by OID and SSJID.

The 479 foot-high New Exchequer Dam is a rockfill dam.

SSJID also owns the nearby 35 taf Woodward Reservoir on Simmons Creek. By virtue of an agreement with USBR, OID and SSJID have the ability to store 200 taf in New Melones Reservoir. USBR has entered into contracts with SEWD and Central San Joaquin Water Conservation District for New Melones water supply. SEWD holds a contract for 75 taf/yr of interim supply from New Melones. CSJWCD has CVP contracts for 80 taf/yr, 31 taf of which is interim supply. (Interim supply in this context means supplies that are available until future in-basin demands require use of the water.) USBR must also use New Melones to meet SWRCB San Joaquin River salinity standards at Vernalis. As discussed in the following section, enactment of CVPIA and management of project water dedicated for environmental purposes have created conflicts in meeting the multiple needs that New Melones was intended to serve.

The Tuolumne River (largest of the San Joaquin River tributaries) was developed by three local agencies and the City and County of San Francisco, which constructed Hetch Hetchy Reservoir (360 taf), Lake Lloyd (268 taf) on Cherry Creek, and Lake Eleanor (26 taf) on Eleanor Creek. San Francisco also participated with Modesto and Turlock Irrigation Districts in the construction of New Don Pedro Reservoir. (The reservoir is owned by the irrigation districts, but San Francisco has a water storage agreement with them.) This 2 maf reservoir impounds supplies which are diverted into MID's and TID's canal systems at La Grange Dam. Each district has a small regulatory and offstream storage reservoir on its mainline canal downstream from La Grange—the 29 taf Modesto Reservoir and the 46 taf Turlock Lake. MID serves lands north of the Tuolumne River, and TID serves lands to the south of the river.

New Exchequer Dam impounds Merced ID's 1 maf Lake McClure, the only large water supply reservoir on the Merced River. Merced ID has two small dams downstream regulating flow into its canal system. In 1997, Mariposa Public Utility District completed a small water diversion project on the Merced River. The project included constructing 8 miles of 12-inch pipeline to convey Merced River water to the town of Mariposa and surrounding areas.

The Chowchilla and Fresno Rivers are small relative to their northern neighbors. Each river has only one significant water supply reservoir. Buchanan Dam on the Chowchilla River impounds the 150 taf Eastman Lake, and Hidden Dam on the Fresno River impounds the 90 taf Hensley Lake. Both dams were constructed by the USACE, but their operations were integrated with the CVP. Chowchilla Water District holds a water supply contract for Eastman Lake supply, while Hensley Lake supply is contracted to Madera Irrigation District.

USBR's Friant Dam on the San Joaquin River impounds the 521 taf Millerton Lake. Several hydropower reservoirs are located in the river's upper watershed above Friant; however, the only consumptive use of water associated with them is reservoir evaporation. Total system storage including Millerton Lake is 1.1 maf. CVP water released from Friant Dam is diverted into the Madera Canal to the north and the Friant-Kern Canal (to the Tulare Lake Hydrologic Region) to the south. Chowchilla and Madera Irrigation Districts are the largest CVP water contractors on the Madera Canal. Central California Irrigation District's Mendota Dam, located on the San Joaquin River at its confluence with Fresno Slough/North Fork Kings River, forms Mendota Pool, from which more than 20 agricultural water agencies divert their supplies. As mentioned in Chapter 3, CVP exchange contractors divert Delta-Mendota water from the pool to compensate for the impacts of Friant Dam construction on their prior rights to San Joaquin River water. CVP water delivered to the Mendota Pool from Tracy Pumping Plant is the source of supply for nearby USFWS national wildlife refuges.

CCID, USBR, and others have evaluated the possibility of replacing Mendota Dam with a new facility to improve the structure's operational capabilities. The original dam at this site was constructed in the 1880s by the Miller et Lux Corporation.

Surface water supplies for the part of this region west of the San Joaquin Valley trough are provided largely by the CVP, through the Delta-Mendota Canal and the San Luis Canal reach of the California Aqueduct. CVP contractors receiving DMC supplies in the northern part of the region are small agricultural water agencies. The City of Tracy, with a contract for 10 taf/yr, is the only urban CVP water user in the northern end. Oak Flat Water District is the only SWP contractor served from the California Aqueduct within this region, with a maximum contract entitlement of 5.7 taf. The California Aqueduct and DMC carry water from the Delta into San Luis Reservoir for storage and later delivery. San Luis Reservoir marks the beginning of the State-federal joint use San Luis Canal. Lands adjacent to the San Luis Canal downstream from the reservoir are part of the CVP's service area, and receive their water supply through contracts with USBR. San Luis Water District is one of the larger CVP contractors in this area, receiving its supplies through both the DMC and the SLC.

The northwest corner of this region, including the communities of Byron, Brentwood, and Thornton, receives much of its water supply via direct diversion of surface water from Delta waterways. Local water supply agencies include East Contra Costa Irrigation District and Byron-Bethany Irrigation District.

Groundwater

Groundwater is an important source of supply for the region. Many urban areas rely solely on groundwater for their supply. Groundwater overdraft occurs in much of the valley floor.

Looking upstream at the California Aqueduct (left side of photo) and the Delta-Mendota Canal (right side). Bethany Reservoir is in the upper left corner.

Local Water Resources Management Issues

Cosumnes River Flood Management

The Cosumnes River is unique among Sierra Nevada rivers for its lack of dams and related water development features. Efforts are ongoing to preserve and restore a riparian corridor along the river's path on the valley floor; the relationship of those efforts to recently emphasized floodplain management needs is being evaluated.

The Cosumnes River Preserve was established in 1987 to protect existing stands of valley oak riparian forest and to restore native habitat in flood-prone agricultural fields. The preserve, located between Sacramento and Stockton, is a cooperative effort of organizations including the Nature Conservancy, Ducks Unlimited, BLM, the Department, DFG, Wildlife Conservation Board, and Sacramento County.

The lack of upstream flood control on the Cosumnes River and the resulting periodic flooding have limited urban development in the lower watershed. Much of the agricultural land in the river's lower watershed is protected by private levees which experienced numerous breaks during the January 1997 floods. Nonstructural alternatives for flood control are being investigated, such as breaching levees and establishing levee setbacks to provide more area for flood waters to spread. Private lands have been identified for possible acquisition, subject to the willingness of sellers and the availability of funds.

Integrity of Delta Levees

Delta islands are protected by more than 1,000 miles of levees, and commonly lie 10 to 15 feet below sea level. Failure of these levees could occur as the result of earthquakes or floods, gradual deterioration, and/or improper maintenance. Composed largely of peat soils, many islands are vulnerable to seepage and subsidence. Subsidence of peat soils and settling of levee foundations increase the risk of levee failure.

Oak trees at the Cosumnes River Preserve.

EBMUD's Mokelumne River Aqueduct traverses the southern Delta.

The CALFED Bay-Delta Program identified the Delta levee system as an important resource. The program's strategy for improving its levee system integrity is to implement a Delta levee protection plan that would address levee maintenance, stabilization, subsidence reduction, emergency levee management, beneficial reuse of dredged material, and establishment of habitat corridors.

Interim South Delta Program and Temporary Barriers Project

In 1990, the Department, USBR and the South Delta Water Agency agreed to a draft settlement of a 1982 lawsuit by SDWA against the Department and USBR. The draft agreement focused on short-term and long-term actions to resolve agricultural water supply problems in the south Delta and included provisions to test and construct barrier facilities in certain south Delta channels. The testing program, referred to as the South Delta temporary barriers project, was initiated in 1991. Its objectives were short-term improvement of water conditions for the south Delta and the development of data for the design of permanent barriers. Long-term actions would be implemented through the Interim South Delta Program described in Chapter 6. ISDP's purpose is to improve water levels and circulation in south Delta channels for local agricultural diversions and to enhance the existing water delivery capability of the SWP through improved south Delta hydraulics. ISDP's preferred alternative would cost an estimated $54 million to construct and includes five components: constructing a new intake structure at Clifton Court Forebay; dredging a 4.9-mile reach of Old River; constructing flow control structures at Old River, Middle River, and Grant Line Canal; constructing an operable fish barrier at the head of Old River to benefit San Joaquin River salmon; and increasing diversions into Clifton Court Forebay to maximize pumping at Banks Pumping Plant.

Under the Department's temporary barriers program, small berms have been seasonally installed in the South Delta to improve channel water levels and water quality for Delta irrigators. A seasonal fishery barrier at the head of Old River is also installed as part of this program.

A draft EIR/EIS for ISDP was released in August 1996. The final EIR/EIS is scheduled for completion in late 1998. Meanwhile, installation and removal of temporary barriers in the south Delta continues. The number of temporary barriers installed and the installation schedule varies with hydrologic conditions and endangered species concerns.

San Joaquin County Groundwater Overdraft

Eastern San Joaquin County has a long history of declining groundwater levels. Groundwater extraction to meet agricultural and urban demands has created two pronounced pumping depressions since the late 1940s and early 1950s. The larger depression is between the Mokelumne River and the Stanislaus River. The center of this depression is east of Stockton, where groundwater levels can be more than 70 feet below sea level following the irrigation season. This pumping depression caused poorer water quality from the Delta to migrate toward the City of Stockton. Several municipal wells in west Stockton have been abandoned because of the decline in groundwater quality. The other groundwater depression is between the Cosumnes River and the Mokelumne River, extending north into Sacramento County. Groundwater levels here are more than 30 feet below sea level.

The Department recently completed a study of eastern San Joaquin County as part of a Stanislaus-Calaveras conjunctive use project. Data developed for this study suggested that the annual overdraft in the eastern San Joaquin County was about 70 taf, at a 1990 level of development. A later study completed by USBR as part of its American River water resources investigation estimated overdraft to be about 130 taf at a 2030 level of development. This study concluded that 77 taf/yr of additional supply would be needed to prevent migration of poor quality water into the Stockton area. Several overdraft management options are being considered, all of which require substituting surface water supplies for groundwater use. USBR proposed two major alternatives for providing future water supply—a conjunctive use alternative and a multipurpose Auburn Dam. In its 1998 record of decision for the study, USBR decided that it would not take further action to meet study area future water needs.

San Joaquin County filed a water rights application for an American River diversion of 322 taf in wet years via the Folsom South Canal. The existing canal would be extended, and would be used to provide supplemental supplies to reduce groundwater overdraft. San Joaquin County is also interested in participating in a conjunctive use project with EBMUD, in which EBMUD's American River CVP water would be stored in local groundwater basins prior to being diverted into the Mokelumne River Aqueduct. This approach was considered in EBMUD's 1995 water supply action plan described in the San Francisco Bay Region (Chapter 7), but was not included in EBMUD's draft EIR for conveyance of its CVP supply.

Penn Mine Remediation

Penn Mine is an abandoned copper/zinc mine first worked in the 1860s. Major activity at the site occurred in the early 1900s and during World War II. Mine stormwater runoff and acidic drainage historically entered the Mokelumne River near Campo Seco, above EBMUD's Camanche Reservoir, and caused fish kills in the river from the 1930s through the 1970s. EBMUD, in conjunction with DFG and the Central Valley RWQCB, made surface drainage improvements on the mine property and constructed Mine Run Dam in 1978 to provide storage and to control part of the mine runoff. EBMUD and the RWQCB began onsite neutralization and treatment of acid mine drainage in 1993. Litigation against EBMUD and the RWQCB by environmental organizations led to a negotiated agreement for long-term site remediation. An EIR/EIS completed in 1997 calls for excavation and removal of mine waste materials at the site, removal of Mine Run Dam, further site regrading, and revegetation.

Conservation Storage in Farmington Reservoir

USACE completed a reconnaissance study of Stockton metropolitan area flood control needs in 1997, in cooperation with the City of Stockton, San Joaquin County, and Stockton East Water District. The study evaluated modifying Farmington Reservoir to provide carryover storage. USACE also completed a conjunctive use study in 1997, evaluating Farmington Reservoir's potential to reduce groundwater overdraft in eastern San Joaquin County. Three alternatives were evaluated, including reservoir reoperation to allow year-round diversions at Rock Creek, dam modification for seasonal water storage, and dam modification for long-term water storage. (SEWD operates a Rock Creek diversion structure downstream of Farmington Dam to convey CVP water from the Stanislaus River to its service area during the irrigation season.) USACE's study showed that reoperating Farmington for year-round diversions at Rock Creek and groundwater

Burrowing owls are ground-dwelling owls found in open grassland areas and around cultivated fields. Increasing urbanization in the San Joaquin Valley will reduce the habitat available for these owls.

recharge would be the best alternatives for improving management of available water supplies from Littlejohns Creek and the Stanislaus River. If additional Stanislaus River water supplies became available to SEWD through CVP water deliveries, flood control releases from New Melones, or water marketing, storage in Farmington Reservoir might enhance other water management actions. A USACE study prepared in the 1980s suggested that Farmington Reservoir could be enlarged by as much as 160 taf for conservation storage.

SEWD identified two other actions to augment surface supplies—more groundwater recharge and a short-term transfer of 30 taf from Oakdale Irrigation District and South San Joaquin Irrigation District. The districts are preparing an EIR to market up to 30 taf/yr of their surface supply for 10 years, using existing conveyance facilities.

New Melones Reservoir Water Supply and Operations

SEWD and CSJWCD began constructing facilities in 1991 to convey 155 taf of interim CVP contract supply from New Melones Reservoir to their service areas. Much of the imported water was to be used to reduce local groundwater overdraft. Because of changes in the operation of New Melones Reservoir, little interim CVP water has been delivered to the two districts.

Enactment of CVPIA and the issuance of SWRCB Order WR 95-6, increased project water requirements for environmental purposes. Table 8-9 shows the quantities of environmental supplies provided from New Melones releases.

As discussed in Chapter 2, allocation of responsibility for meeting SWRCB Order WR 95-6 flow requirements is now pending in a water rights hearing before the Board. One alternative for meeting San Joaquin River flow requirements is the Vernalis adaptive management plan, negotiated among the river's water users for sharing their responsibilities for actions such as providing spring pulse flows. USBR is presently analyzing how VAMP implementation would affect New Melones operations.

Additionally, USBR and USFWS plan to conduct an appraisal-level temperature control study for New Melones Reservoir, as called for in CVPIA. The study will identify structural or nonstructural alternatives to control water temperatures in the river downstream from the dam.

Urban Growth Pressures from San Francisco Bay Area

San Joaquin Valley communities within commuting distance of the San Francisco Bay area are experiencing rapid growth, as persons who work in the Bay Area are attracted by lower housing costs in the Valley. During the real estate boom of the late 1980s and early 1990s, there was considerable local concern over water supply availability for proposed new towns on the western edge of the valley. At least nine new communities had been proposed in southwestern San Joaquin County, an area where additional groundwater development is constrained by both quality and quantity of supply. Few of these communities were ultimately approved by local land use planning authorities. One proposed community, New Jerusalem, was initially approved, but an amendment to the county's general plan is being processed to remove the community from the plan. Mountain House is one of the few new towns actually being developed.

TABLE 8-9

New Melones Releases for CVPIA Environmental Purposes (taf)

Water Year[a]	*Dedicated Water*	*Supplemental Water*	*Total*
1993	140.9	0.0	140.9
1994	22.7	45.1	67.8
1995	146.3	4.2	150.5
1996	113.4	0.0	113.4
1997	79.9	50.0	129.9

[a] USBR's water year is from March through February.

East County Water Supply Study

The East County Water Management Association is an organization of eleven cities and local agencies in eastern Contra Costa County—Antioch, Brentwood, Pittsburg, Byron-Bethany ID, East Contra Costa ID, Contra Costa County WA, Contra Costa WD, Diablo WD, Delta Diablo Sanitation District, Contra Costa County Sanitation District No.19, and Ironhouse Sanitary District. In response to urban growth pressures, the association conducted a study to identify and evaluate potential water management strategies for meeting the east county's future water needs. The study identified a variety of potential supplies to meet future water demands through 2040 including in-county surface water, in-county groundwater, recycled water, water transfers from outside the county, conjunctive use, and water conservation.

Because the area has access to surface water supplies through CVP contracts and local diversions, study results indicated that in-county surface water supplies could meet future water demands in average years. Shortages would occur after 2010 in drought years. Current study area groundwater use is about 14.5 taf/yr. Some areas (such as Brentwood, Discovery Bay, Bethel Island, and Hotchkiss Tract) depend entirely on groundwater. Others (such as Pittsburg, Antioch, and DWD) use groundwater to supplement surface water supplies. Groundwater quality problems in the eastern county may limit future groundwater development.

The study evaluated three water supply scenarios:

- Maximized local pooling of surface water supplies. This concept would require negotiation of new agreements for long-term transfer of surplus water supplies from two agricultural districts (ECCID and BBID) to agencies serving urban areas, and changes to the place of use/purpose of use in existing water rights.
- Continued groundwater pumping with maximized local pooling of surface water supplies.
- Continued groundwater pumping with existing levels of local pooling of surface water supplies.

The second scenario ranked the highest among the three scenarios. Spot water transfers and short-term demand reduction would provide drought year supply for this scenario. Recommendations made in the study included:

- ECWMA should commission a comprehensive groundwater study of the east county area. The study should focus on groundwater quantity and quality, and interactions between surface water and groundwater supplies. An in-county conjunctive use program to manage drought year shortages should be evaluated.
- An aquifer storage and recovery program should be investigated in the Randall-Bold water treatment plant area, in the event that ECWMA member agencies are required to limit their Delta diversions at some times of the year.
- ECWMA members should construct dual water distribution systems to facilitate future use of recycled water in all water service areas within the east county.
- Interties between water treatment plant service areas increase reliability and flexibility during emergencies. The Cities of Pittsburg and Antioch, CCWD, and DWD should discuss potential intertie benefits associated with CCWD's reliability improvement project.

Los Banos Grandes Reservoir Studies

The Department has studied potential SWP offstream storage sites south of the Delta, as described in Chapter 6. These studies led to a December 1990 *Los Banos Grandes Facilities Feasibility Report*, which recommended construction of a 1.7 maf reservoir and associated facilities on Los Banos Creek in western Merced County. The Department has placed this project on hold pending a CALFED decision on Delta

Grasslands Bypass Project Drainage Fee System

The fee system has tiered charges based on percent exceedance of monthly and annual selenium loads. These load targets are in accordance with RWQCB waste discharge requirements for agricultural drain water. If load targets are exceeded by more than 20 percent in any given year, the project may be terminated at the discretion of the USBR. An interim review of project performance will be conducted after two years of operation.

Monthly Fees for Percent Exceedance (Dollars)

Year	*0.1 - 10%*	*10.1 - 15%*	*15.1 - 20%*	*20.1 - 25%*	*25+ %*
1	700	1,400	2,100	2,800	2,800
2	1,200	2,200	3,200	4,200	4,200
3	5,200	7,600	10,100	12,500	12,500
4	6,800	10,100	13,400	16,700	16,700
5	8,300	12,500	16,700	20,800	20,800

Annual Fees for Percent Exceedance (Dollars)

Year	*0.1 - 5%*	*5.1 - 10%*	*10.1 - 15%*	*15.1 - 20%*	*20+%*
1	25,000	50,000	75,000	100,000	100,000
2	44,000	79,000	115,000	150,000	150,000
3	63,000	92,000	121,000	150,000	150,000
4	81,000	121,000	160,000	200,000	200,000
5	100,000	150,000	200,000	250,000	250,000

improvements. The project could then be reevaluated in consideration of those improvements and of the needs and financial capabilities of SWP contractors.

Merced Area Conjunctive Use Study

In 1993, the City of Merced and Merced Irrigation District began a two-year water supply planning process for eastern Merced County through 2030. The goals of the study were to manage groundwater, provide a reliable water supply for cities, protect and enhance the economic base of the region, protect MID's water rights, and maintain consensus for the plan. The advisory committee selected a groundwater recharge option as the preferred alternative. The groundwater basin would be operated in combination with a surface water storage and conveyance system. Studies to determine groundwater recharge quantities and locations are currently underway.

Agricultural Drainage

Significant efforts have been made to manage saline drainage water in the region. Closure of San Luis Drain has made it essential for agricultural districts to manage irrigation applications as efficiently as possible onsite until a regional solution for drainage management and disposal is developed. Some agricultural water districts in the region discharge drainage water to the San Joaquin River. Much of the salt and selenium loading in the river originate from Grassland WD's canals and from two sloughs tributary to the river—Mud and Salt Sloughs.

***Grasslands Bypass Channel Project*.** Agricultural drainage from the Grasslands Basin historically discharged to natural channels that meandered through Grasslands Water District. Flows in these channels eventually reach the San Joaquin River via Mud and Salt Sloughs. In an attempt to manage selenium loads entering the San Joaquin River, USBR is operating a 5-year Grasslands bypass demonstration project. A two-mile long channel was constructed to intercept drainage water that would otherwise flow towards Grasslands Water District. The new channel carries drainage water to the existing San Luis Drain, allowing the drainage water to discharge to the San Joaquin River. An agreement for reopening part of the San Luis Drain was signed by USBR and the San Luis and Delta-Mendota Water Authority. The agreement established a drainage incentive fee system to provide monetary incentives for reducing selenium loads discharged to the drain (see sidebar). The project became operational in 1996 and has significantly reduced salt and selenium loads entering Grasslands Water District and Salt Slough.

San Joaquin River Real Time Drainage Monitoring Program. Participants in the San Joaquin River Management Program set up a network of telemetered flow and salinity monitoring stations on the San Joaquin River. Data from the stations were linked to a flow model of the San Joaquin River and its tributaries. Information from the model was distributed to water managers by e-mail. A demonstration of the real-time monitoring effort was carried out in 1996. Grasslands Water District managers were informed that the model predicted a major increase in river flow. The district discharged a significant amount of high salinity water from its waterfowl ponds by partially draining them during the high flow event. This timed discharge resulted in better quality water in the San Joaquin River later that spring. A significant portion of the salt load from Grasslands had already passed through the system by the time agricultural diversions began. In 1997, CALFED approved Category III funding to implement a 2-year program to expand the monitoring network. The program is scheduled to begin in fall 1998.

Enlargement of Friant Dam

At 520 taf, Millerton Lake has a small storage capacity relative to the San Joaquin River's average annual flow. Enlargement of Friant Dam has been considered in the past to augment regional water supplies. Recently, needs for fishery flows and improved management of winter/spring floodwaters have been emphasized. USBR evaluated the potential yield of raising Friant Dam about 140 feet in the 1980s. The Resources Agency's 1995 SJRMP Plan recommended that enlarging Friant be studied for multipurpose use. Assembly Joint Resolution 7 in 1997 urged the federal government to promptly evaluate raising Friant Dam. Raising Friant Dam would provide water supplies for CVP water users and downstream riparian diverters, for SWRCB salinity and fishery flow requirements at Vernalis, and for dilution of agricultural drainage flows discharged to the river. These supplies would be obtained by storing surplus winter floodwaters, increasing flood protection levels for lands downstream. An issue that would need to be addressed is instream flows in the river immediately downstream from the dam, as described below.

Instream Flow Requirements Below Friant Dam

In 1988, the Natural Resources Defense Council filed a suit in U.S. District Court, seeking an injunction and declaratory judgment to prevent USBR from renewing long-term CVP water supply contracts without preparing environmental documentation and to require releases for instream uses from Friant Dam, based on Fish and Game Code Section 5937 and the public trust doctrine. The legal issues were:

- Does federal law require USBR to renew the water contracts subject to NEPA and ESA review?
- Does Fish and Game Code Section 5937 apply to federal projects?
- Has CVPIA preempted Fish and Game Code Section 5937?

The court found that CVPIA's passage had not caused the NEPA and ESA claims to be moot, nor had CVPIA preempted the plaintiff's claim under the Fish and Game Code. The court also ruled that USBR failed to comply with Section 7 of the ESA when it renewed contracts without consulting with federal wildlife regulatory agencies. The court declared all contracts renewed before CVPIA enactment invalid. The case was appealed to the Ninth Circuit Court of Appeals which upheld the District Court's ruling.

In a setting apart from the litigation, the Friant Water Users Authority, Natural Resources Defense Council, and Pacific Coast Federation of Fishermen's Associations have agreed to pursue mutually acceptable restoration activities on the San Joaquin River. Initially, the group has agreed to work on riparian habitat restoration along a 150-mile reach of the river from Friant Dam to the Merced River confluence. The objectives of the effort are to implement a plan for restoring a continuous riparian corridor in the study reach and to construct riparian habitat restoration projects.

Environmental Restoration Activities in the San Joaquin River Basin

Many restoration actions are being evaluated for the San Joaquin River system. Examples of completed actions include:

- A spawning gravel restoration project on the lower Stanislaus River was completed in 1996. This project consisted of constructing riffles and placing gravel for salmon spawning habitat at three sites, river miles 47.4, 50.4, and 50.9.
- A spawning gravel restoration project below Crocker-Huffman Dam on the Merced River was completed in 1990 and repaired in 1996.
- The Magneson Pond isolation project on the Merced River, completed in 1996, consisted of iso-

lating a gravel pit from the river and replacing spawning gravel.

- The M. J. Ruddy spawning gravel project was completed in 1993 on the Tuolumne River. Another project was completed in 1996 to construct channels above the M. J. Ruddy project, to equalize river flows to protect the spawning habitat from washout.
- The La Grange spawning riffle project, completed in 1994, consisted of constructing riffles and placing spawning gravel at three sites along the Tuolumne River.
- Funds from the SWP Four-Pumps Agreement have been used since 1994 to support one DFG warden assigned to enforce fishing regulations (reduce poaching of anadromous fish) on the San Joaquin River system.
- Temporary fish barriers have been constructed and removed on a seasonal basis every year at Hills Ferry on the San Joaquin River (downstream of the mouth of Merced River) and at the head of Old River in the Delta.
- Implementation of the CVPIA dedicated water provision and the Bay-Delta Accord have increased San Joaquin River instream flows. Spring pulse flows have also been provided.
- The 1996 Tuolumne River FERC settlement agreement among Turlock ID, Modesto ID, City and County of San Francisco, DFG, and others increased instream flows from New Don Pedro Reservoir, extended and supplemented fish monitoring requirements, and provided for non-flow fish habitat improvement measures.

Several programs are under way to provide additional fishery benefits in the region. Examples of ongoing fishery restoration projects include:

- The Category III program has contributed funding for a feasibility study of screening at Banta-Carbona Irrigation District's Main Lift Canal intake channel on the San Joaquin River.
- Plans for construction of Tuolumne Fish Hatchery are under way, although several environmental hurdles need to be addressed before a final decision is made to build the fish hatchery. Land for the hatchery was acquired by the Four-Pumps program in 1996.
- USBR is preparing plans to replace CCID's Mendota Dam. Replacement of the dam would improve fish passage and provide increased water supply to Mendota NWR.
- DFG and USFWS plan to restore the channel of a six-mile stretch of the Tuolumne River by isolating or filling gravel pits along the river and restoring spawning gravel habitat.

San Joaquin River Parkway Development

The San Joaquin River Conservancy is a State agency charged with acquiring and managing public lands within the San Joaquin River Parkway. The goal of the conservancy is to preserve and enhance the San Joaquin River's biological diversity, protect its cultural and natural resources, and provide educational and recreational opportunities to local communities.

The San Joaquin River Parkway includes the San Joaquin River and about 5,900 acres of land on both sides of the river, and extends about 22 miles from Friant Dam downstream to the Highway 99 crossing of the river. The parkway is planned as a riparian corridor with trails for hiking, horseback riding, and biking; boating access points; wildlife areas; and education areas. Approximately 1,900 acres are located in Madera County and 4,000 acres in Fresno County, of which approximately 1,600 acres are in public ownership. The conservancy, working with the Wildlife Conservation Board and the San Joaquin River Parkway and Conservation Trust, has been making land acquisitions for the parkway. Other completed projects include habitat restoration efforts and construction of 5 miles of a multiple-use recreation trail.

January 1997 San Joaquin River Region Flood Event

The January 1997 flood event was notable for its sustained rainfall intensity, the volume of floodwater, and the extent of the storm pattern—from the Oregon border down to the southern end of the Sierra. Over a three day period, warm moist winds from the southwest blew over the Sierra Nevada, pouring over 30 inches of rain on watersheds already saturated by one of the wettest Decembers on record. The volume of runoff exceeded the flood control capacity of New Don Pedro Reservoir and Millerton Lake. Although the peak flood release from New Don Pedro Dam was less than half the peak Tuolumne River inflow of 120,000 cfs, it was more than six times the downstream channel's flood control limit of 9,000 cfs. In all, thirty-six levee failures occurred along the San Joaquin River system, along with extensive damage related to high flows and inundation. Most of the damage occurred downstream of the Tuolumne River confluence.

The primary flood control issue facing the San Joaquin River Region is the lack of flood channel capacity. Channels and levees are generally designed for 50-year flood protection. Insufficient channel capacity is especially problematic in the lower San Joaquin River below the Merced River. At the lower end of the system, sediment deposition continues to raise the river bed and reduce channel capacity. Sediment deposition also promotes vegetation growth, thereby increasing channel roughness and further impeding flows. As urban development occurs on lands formerly used for agriculture, the need for higher levels of flood protection becomes more important.

The 1997 *Final Report of the Flood Emergency Action Team* to the Governor detailed several recommendations and possible actions for the San Joaquin River watershed, such as:

- A USACE reconnaissance study for the Tuolumne River to evaluate constructing a flood control impoundment on Dry Creek, restricting development in the floodplain, and developing offstream flood storage to be integrated with water supply storage.
- Acquisition of flood-prone lands (largely agricultural lands) in Stanislaus County which could be added to USFWS's San Joaquin National Wildlife Refuge. The lands would be managed to allow periodic flooding, and would provide temporary storage of flood peaks. A similar approach could be taken at the West Bear Creek Unit of the San Luis National Wildlife Refuge, where floodflows could be temporarily stored on existing refuge lands.
- Increasing the capacity of the lower San Joaquin River by measures such as channel dredging, setback levees, and improving bridge crossings.

Water Management Options for the San Joaquin River Region

Table 8-10 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 8A-2 in Appendix 8A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Urban water conservation options were deferred from detailed evaluation because they provide little cost-effective potential to create new water through depletion reductions.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Changes in irrigation management practices to attain SAEs of 76 to 80 percent would yield less than 1 taf/yr depletion reduction. Flexible water delivery, canal lining and piping, and tailwater recovery could each yield 2 taf/yr depletion reduction.

Modify Existing Reservoirs

Various agencies have looked at raising or modifying existing water supply and/or multipurpose reservoirs. USACE and SEWD are evaluating modifications or reoperation of Farmington Reservoir. Local runoff, plus New Melones or American River supplies, could be used to fill an enlarged reservoir.

New Reservoirs

Onstream Storage. Amador County Water Agency developed preliminary proposals for the Irish Hill and Volcano Reservoir projects. Irish Hill Reservoir, on Dry Creek, would serve areas near Ione with up to 23.7 taf of drought year supply. Volcano Reservoir, on Sutter Creek, would serve the communities of Sutter Creek and Amador City, in addition to providing flood control benefits for Sutter Creek. The estimated drought year supply would be 14.7 taf. Studies on both projects are inactive.

Amador County has participated in studies of the larger Middle Bar and Devils Nose reservoir projects. Alternatives for Middle Bar included a low and high dam, with drought year supplies of 12 taf and 159 taf, respectively. The larger Middle Bar Dam has been considered by EBMUD as a water supply option for its service area in the San Francisco Bay Region. The reservoir, however, could provide some local supply to Amador, Calaveras, and possibly San Joaquin Counties. A number of obstacles such as water rights, a FERC license, and financing would need to be addressed before proceeding with the project. The proposed Devils Nose project would be a hydroelectric power project with incidental water supply benefits, along the north fork and mainstem of the Mokelumne River. As con-

TABLE 8-10

San Joaquin River Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ET_o	Defer	No significant depletion reductions attainable.
Indoor Water Use	Defer	No significant depletion reductions attainable.
Interior CII Water Use	Defer	No significant depletion reductions attainable.
Distribution System Losses	Defer	No significant depletion reductions attainable.
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Retain	
Canal Lining and Piping	Retain	
Tailwater Recovery	Retain	
Modify Existing Reservoirs/Operations		
Reoperate/Enlarge Farmington Reservoir	Retain	
New Reservoirs/Conveyance Facilities		
Montgomery Reservoir Offstream Storage (Merced County)	Retain	
Fine Gold Creek Offstream Storage (Madera County)	Retain	
Irish Hill Reservoir (Amador County)	Retain	
Volcano Reservoir (Amador County)	Defer	Geologic constraints.
Middle Bar Reservoir (Amador County)	Retain	
Devils Nose Reservoir (Amador County)	Retain	
Cape Cod Reservoir (Cosumnes River)	Defer	Major storage unlikely on Cosumnes River.
Bakers Ford Reservoir (Cosumnes River)	Defer	Major storage unlikely on Cosumnes River.
Mid-Valley Canal	Defer	Questionable water supply availability.
Groundwater/Conjunctive Use		
EBMUD/San Joaquin County Conjunctive Use	Defer	Under discussion; not yet defined.
Stockton East WD	Retain	
Madera Ranch	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply in this region.
Desalination		
Brackish Groundwater		
Agricultural Drainage	Defer	No present local agency plans.
Seawater		
—	—	—
Other Local Options		
—	—	—
Statewide Options		
—	—	See Chapter 6.

ceived, the project would include a 470-foot high dam at the Devils Nose site upstream from PG&E's Tiger Creek Forebay and below Salt Springs Reservoir. The reservoir would have a capacity of 145 taf. Water from the reservoir would be released via a 3-mile tunnel to a powerhouse with 41 mW of installed capacity. The proposed Devils Nose project was later merged with a proposed Cross County project, which included a conveyance system from Tiger Creek Afterbay to a 79 mW Cross County Powerhouse. Preliminary operation studies indicate a system yield of 23 to 30 taf/yr. EBMUD had also considered participation in the project. The project is currently dormant.

The Cosumnes River project was examined jointly by El Dorado, Sacramento, Amador, and San Joaquin Counties as a multipurpose project. The proposal included up to six reservoirs with hydroelectric power generation, flood control, and recreation to provide supplemental water supply benefits. Average year yield of the project was estimated at 170 taf. The project would include a 300 taf Cape Cod Reservoir and a 185 taf Bakers Ford Reservoir. The Cosumnes River is one of the few remaining undeveloped Sierra Nevada rivers. Interest in preserving the river's free-flowing characteristics and the difficulties associated with obtaining a FERC license would make large-scale water development on the river unlikely. Project planning is inactive.

Offstream Storage. USBR studied a 240 taf reservoir to store spills from Lake McClure. The proposed Montgomery Reservoir would be constructed on Dry Creek, north of the confluence of Merced River and Dry Creek, near the community of Snelling. Water would be conveyed by a two-way facility from Merced Falls Diversion Dam to Montgomery Reservoir. Releases would be used to improve instream flows and to maintain lower water temperatures for fall-run chinook salmon in the Merced River. Montgomery Reservoir would also provide additional flood protection in the San Joaquin River. About $3 million and three years would be required to complete the feasibility study and environmental review. The project, including the reservoir, conveyance, pumping, and appurtenant facilities has been estimated to cost about $135 million. The yield is estimated to be 35 taf during drought years. The drought year cost of this option is estimated to be $300/af. The project was recommended for further study in SJRMP's Plan.

In 1989, Madera Irrigation District asked USBR to investigate a 350 taf offstream storage project on Fine Gold Creek, a San Joaquin River tributary. Surplus flood flows would be pumped from Millerton Lake to the reservoir for water supply and power generation. Potential benefits also include fishery enhancements and flood protection. The average year yield is estimated to be 42 taf. According to MID's 1991 preliminary cost estimate, the project would cost in excess of $500 million. Project evaluation and investigation was estimated at $3 million, and at least 3 years would be required to complete feasibility and environmental investigations. The Fine Gold Creek project, although not originally formulated as such, is essentially an alternative to enlarging Friant Dam.

New Conveyance Facilities

Since the 1970s, several feasibility studies have been conducted on importing additional Delta supplies to reduce groundwater overdraft in the San Joaquin Valley. USBR's 1981 *A Report on the Mid-Valley Canal Feasibility Investigation* examined the possibility of constructing a canal that would supply portions of Madera, Merced, Fresno, Kings, Tulare, and Kern Counties with additional imported water.

The report suggested that water from the Delta could be conveyed to O'Neill Forebay using available capacity in the California Aqueduct. From O'Neill, a portion of the water would be delivered to Mendota Pool by an enlarged Delta-Mendota Canal, while the remainder would be conveyed to Kern County using available capacity in the California Aqueduct. To provide water to the rest of the service area, the proposal called for the construction of two branches of a new facility called the Mid-Valley Canal. The main branch would lift water from the Mendota Pool and carry it southeast to Fresno, Kings, and Tulare Counties. Madera and Merced Counties would receive their supply via a north branch, also diverting from Mendota Pool. Introduction of this additional water supply to the San Joaquin River Region could reduce groundwater overdraft and enhance wetlands, wildlife habitat, and recreation.

USBR initially identified a firm annual water supply in the Delta of approximately 500 taf available for export to the proposed service area. It was later determined that this supply was unavailable due to increased Delta outflow requirements and curtailment of proposed expansion of CVP facilities. Subsequent enactment of CVPIA and issuance of SWRCB Order WR 95-6 further limited available CVP water supply.

Groundwater Development or Conjunctive Use

Urban and agricultural water users have relied on both surface and groundwater supplies. Many local water purveyors use surface water allocations, purchased water, and excess flood water for groundwater recharge. Natural waterways, local agency canals, and State and federal conveyance facilities create opportunities for groundwater recharge, storage and conjunctive use programs.

EBMUD is continuing discussions with San Joaquin County interests for a joint groundwater storage/conjunctive use project. This option is part of EBMUD's water supply action plan described in Chapter 7; its yield is undefined at this time.

SEWD has proposed to construct a groundwater recharge facility at the northern terminus of the lower Farmington Canal. The canal would be extended about one-half mile, and a series of recharge basins constructed. The proposed facility could include up to 45 five-acre recharge basins, which could provide a combined recharge rate of 100 cfs. Estimated capital costs for the facility are about $14.25 million.

USBR and SLDMWA are investigating a proposed water banking project at Madera Ranch, southwest of the City of Madera. This storage facility would receive surplus water from the Delta for recharge. Water stored during wet years could be pumped in drought years for environmental, urban, and agricultural uses. The recharge pond area would be 3,500 acres and the potential storage capability is estimated to be about 390 taf. When available, flows in the Delta would be conveyed to Mendota Pool for diversion to the project at a rate of up to 400 cfs. Withdrawal capacity from the aquifer would be about 200 cfs, with average annual yield of about 70 taf at a cost of $226/af.

Phase I of the investigation, including geologic testing, and review of legal, financial, and environmental issues, was completed in April 1998. USBR recommends proceeding to Phase 2, pending discussions with the landowner. Two options would be examined in Phase 2. One would be a multi-year commitment to lease the facilities and services developed by the landowner. A second would be for USBR to purchase Madera Ranch property and develop a water banking facility.

Water Recycling

Most municipal and industrial water use in the San Joaquin River Region occurs on the east side of the San Joaquin Valley. Wastewater is generally spread for groundwater recharge. Wastewater that is directly or indirectly discharged to the San Joaquin River becomes available for downstream uses, including Delta outflow requirements. Because of extensive reapplication, no water recycling options within the basin qualify as new sources of supply from a regional viewpoint.

Several small water recycling projects serve local water management or wastewater disposal needs. Recycled water is currently used for golf course or pasture irrigation. The City of Stockton proposes to use recycled water for irrigation, groundwater storage, or transfer to possible future storage reservoirs such as a modified Farmington Reservoir.

Desalting

Many studies have explored saline groundwater desalting on the west side of the San Joaquin Valley. The Department has been involved in three such studies: a wastewater treatment evaluation facility in Firebaugh, a Los Banos demonstration desalting facility, and an Adams Avenue agricultural drainage research center. These studies indicated that production costs for treating agricultural drainage water were about $1,000/af. As discussed in Chapter 5, desalting costs are directly related to feedwater salinity. Today's costs for brackish groundwater treatment are in the range of $500 to $1,000/af, depending on feedwater salinity and the level of infrastructure already in place. Table 8-11 compares the salinity of various water sources.

The approximately 30 taf/yr of agricultural drainage water now collected for the Grasslands Bypass Project represents a source of brackish water available for treatment. Technology is available to treat the water, which would present a new supply to the region (as well as a means to improve San Joaquin River quality). For such a project to be feasible, a brine disposal solution would have to be found, as well as project participants. No such arrangements are currently under negotiation.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the San Joaquin River Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be

TABLE 8-11

Comparison of Salinity of Water Sources

Water Source	*Representative Weight of Solids in 1 Acre-foot of Water*
Mono Lake	110 tons
Salton Sea	60 tons
Seawater	48 tons
Brackish Groundwater (3,000 mg/L TDS)	4 tons
Colorado River at Parker Dam	1 ton
California Aqueduct at Banks Pumping Plant	500 pounds

63 taf and 711 taf in average and drought years, respectively. Ranking of retained water management options for the San Joaquin River Region is summarized in Table 8-12. Table 8-13 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Reoperating Farmington Reservoir in conjunction with SEWD's plans for conjunctive use could augment supplies by 22 taf in average years and 8 taf in drought years.

Constructing Montgomery Reservoir could augment local drought year supplies by about 35 taf. As a statewide option, enlarging Friant Dam could provide 39 taf of additional average year supply for the region.

TABLE 8-12

Options Ranking for San Joaquin River Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Agricultural				
Flexible Water Delivery	L	1,000	2	2
Canal Lining and Piping	L	1,200	2	2
Tailwater Recovery	H	150	2	2
Modify Existing Reservoirs/Operations				
Reoperate Farmington Reservoir (surface supply only)	H	[b]	7	5
Enlarge Farmington Reservoir	M	350	17	8
New Reservoirs/Conveyance Facilities				
Montgomery Reservoir Offstream Storage	H	300	[b]	35
Fine Gold Creek Offstream Storage	M	[b]	42	[b]
Irish Hill Reservoir	L	430	33	24
Middle Bar Reservoir	L	[b]	—	159
Devils Nose Reservoir	L	[b]	[b]	25
Groundwater/Conjunctive Use				
Stockton East WD (includes reoperating Farmington)	H	100	22	8
Madera Ranch	M	230	—	70
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 8-13.
[b] Data not available to quantify.

TABLE 8-13

Options Likely to be Implemented by 2020 (taf)
San Joaquin River Region

	Average	*Drought*
Applied Water Shortage	**63**	**711**
Options Likely to be Implemented by 2020		
Conservation	2	2
Modify Existing Reservoirs/Operations	—	—
New Reservoirs/Conveyance Facilities	—	35
Groundwater/Conjunctive Use	22	8
Water Marketing	—	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	39	—
Expected Reapplication	—	8
Total Potential Gain	**63**	**53**
Remaining Applied Water Shortage	**0**	**658**

FIGURE 8-4

Tulare Lake Hydrologic Region

Tulare Lake Hydrologic Region

. . .

Description of the Area

The Tulare Lake Region includes the southern half of the San Joaquin Valley and the uplands that surround it (Figure 8-4). The San Joaquin River watershed forms the northern boundary of the region, and the Tehachapi Mountains form the southern boundary. The region is bounded to the east by the Sierra Nevada crest and by the Temblor Range to the west. The climate in the valley varies from fog shrouded winters to long, hot summers. The valley typically receives about 6 to 11 inches of rainfall annually, while average precipitation in the mountains range from 12 to 36 inches, mostly in the form of snow. Most of the region's population is located on the east side of the valley. The area includes several rapidly growing cities, the largest of which are Fresno, Bakersfield, and Visalia. Other population centers include Hanford, Clovis, Tulare, Porterville, and Delano. Table 8-14 shows 1995 and 2020 populations and crop acreages.

The major employment sectors in Tulare Lake Region are based on agriculture, although the petroleum industry is important in parts of the valley's west side and in Kern County. In the sparsely populated areas on the west side of the valley, industrial water demands for petroleum recovery and production exceed municipal water demands. Most of the land area in the valley not devoted to urban and industrial purposes is used for agriculture. The predominant crop is cotton, followed by permanent orchards and vineyards. Major orchard crops are almonds and pistachios. Other major crops are alfalfa and pasture, grain, corn, and field and truck crops.

TABLE 8-14

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	1,738	3,127
2020	3,296	2,985

The Friant-Kern Canal extends southwards from Friant Dam, serving lands on the eastern side of the San Joaquin Valley. The canal is almost 152 miles long, and has a maximum capacity of 5,000 cfs.

This region receives runoff from four main river basins—the Kings, Kaweah, Tule, and Kern. The principal flood control and regulatory reservoirs for these rivers are Pine Flat Lake, Lake Kaweah, Success Lake,

The Buena Vista Aquatic Recreation Area, operated by Kern County, is located at the north end of the former Buena Vista Lakebed. The California Aqueduct (seen crossing the top of the photo, at the base of Elk Hills) skirts the lakebed's western edge.

and Isabella Lake. Major water conveyance facilities for the area include the California Aqueduct, the Friant-Kern Canal, and the Cross Valley Canal. Water districts within the region have developed an extensive network of canals, channels, and pipelines to deliver these water sources to users. Under normal conditions, the region has no natural outlet to the ocean. During high runoff years, excess water flows down the Kings River north fork channel toward Mendota Pool and on to the San Joaquin River. In the wettest years Kings River floodwaters reach the Tulare Lake via the south fork of the river. Excess runoff from the Kaweah and Tule Rivers also flows into Tulare Lakebed, flooding leveed agricultural fields.

The Tulare, Buena Vista, and Kern Lakebeds, once the region's drainage sinks, have been converted to agricultural use. Small areas in Buena Vista Lakebed are used for regulation of irrigation waters. Since 1977, excess snowmelt runoff from the Kern River has been transported to the California Aqueduct via the Kern River Intertie to alleviate flooding.

The region has several managed wetlands areas, including Pixley National Wildlife Refuge, Kern National Wildlife Refuge, and Mendota Wildlife Management Area.

Water Demands and Supplies

Table 8-15 shows regional water demands and supplies. Shortages at a 1995 level of development in average water year conditions represent the region's 820 taf of groundwater overdraft and 50 taf of shortages in Westlands Water District's service area.

Under 1995-level average hydrologic conditions, local surface supplies from the Kings, Kaweah, Tule, and Kern River systems are the most significant sources of surface water to the region. The next largest surface water source is the CVP, which delivers water through the joint State-federal San Luis Canal, Coalinga Canal, Friant-Kern Canal, and Cross Valley Canal. The other major source of surface water is the SWP.

The majority of the region's SWP supply is contracted to Kern County Water Agency. KCWA's SWP supply is distributed to fourteen of its member agencies; the largest entitlements go to Wheeler Ridge-Maricopa Water Storage District, Berrenda Mesa Water District, Belridge Water Storage District, and Lost Hills Water District. Since these four districts have limited (or no) groundwater supply, each relies almost entirely on SWP supplies to meet its water demands. Most other KCWA member agencies have Kern River, Friant-Kern Canal, Cross Valley Canal, or groundwater supplies available. Part of the City of Bakersfield's water supplies come from the SWP, via KCWA.

The Friant-Kern Canal conveys CVP supply to 24 long-term contractors in the region. Among the largest contractors for Friant-Kern supply are Arvin-Edison Water Storage District, Lower Tule River Irrigation District, and Delano-Earlimart Irrigation District. The San Luis Canal also distributes CVP supply, most of which goes to Westlands Water District. With an allocation of 1,150 taf/yr, Westlands Water District is CVP's largest contractor. Westlands supplies primarily agricultural users; however, about 5.5 taf/yr is supplied to urban users such as Lemoore Naval Air Station. (Even with a full CVP contract supply,

TABLE 8-15

Tulare Lake Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,123	9,532
Environmental	1,672	809	1,676	813
Total	13,098	11,525	12,897	11,443
Supplies				
Surface Water	7,888	3,693	7,791	3,593
Groundwater	4,340	5,970	4,386	5,999
Recycled and Desalted	0	0	0	0
Total	12,228	9,663	12,177	9,592
Shortage	**870**	**1,862**	**720**	**1,851**

[a] Water use/supply totals and shortages may not sum due to rounding.

Westlands purchases about 200 taf/yr from other sources to meet its growers' normal crop needs.)

Arvin-Edison Water Storage District and KCWA entered into agreements in 1974 for participation in the Cross Valley Canal. AEWSD also entered into water exchange agreements with ten agencies in the Friant-Kern Canal service area. The exchange water is delivered through the California Aqueduct and the Cross Valley Canal to AEWSD facilities. AEWSD receives 128 taf annually of exchange water and makes available to exchange entities the first 174 taf of its Class I and Class II CVP entitlements from the Friant-Kern Canal.

Including overdraft, 2020 average year groundwater extraction is forecasted to be about 5.1 maf for the region. Since groundwater provides a buffer for fluctuating year-to-year surface supplies, its availability is of great importance to the region. Although urban use is expected to increase about 410 taf by 2020, groundwater overdraft is expected to decrease 150 taf (from 820 taf to 670 taf) within the planning horizon due to declining agricultural use. Most of the urban water use in the region is served from groundwater, although the Cities of Fresno and Clovis are taking actions to begin treating surface water supplies.

Local Water Resources Management Issues

Groundwater Overdraft

Annual fluctuations in groundwater levels vary with availability of surface water. About 70 percent of

The Kern River near Oildale, at the edge of the Sierra Nevada foothills.

The former Tulare Lakebed has been reclaimed for farming. Floodwaters from the Sierra now reach the lakebed only in the wettest years.

the region's overdraft occurs in the Kings-Kaweah-Tule Rivers planning subarea. Urban water demands in the subarea are met almost exclusively by groundwater. Agricultural development in the subarea includes 645,000 acres of permanent crops. Overdraft in the region is mitigated to a certain extent by planned recharge programs, over-irrigating crops in wet years, and allowing seepage from unlined canal systems.

Groundwater Banking Programs

The Department, in cooperation with KCWA and local water districts, began developing the Kern Water Bank conjunctive use program in 1985 as a component of the SWP. The proposed KWB program consisted of eight separate projects or elements. The Kern Fan Element was to be constructed on lands owned by the Department. Pursuant to the SWP's Monterey Amendment, the KFE was subsequently transferred to the Kern Water Bank Authority.

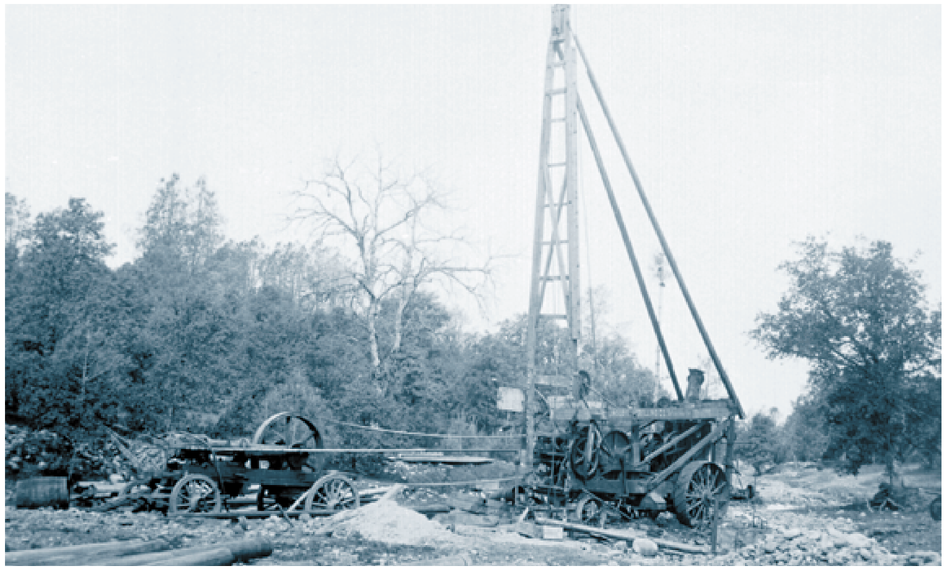
Semitropic Water Storage District is participating in an in lieu groundwater banking project with MWDSC, SCVWD, ACWD, and Z7WA. This project involves expanding SWSD's conveyance system, so that areas normally relying on groundwater will have surface water available in wet years. SWSD water users will receive excess surface water from its banking partners' SWP supply in wet years. In drier years, SWSD would release its SWP allocation to its partners and, if necessary, pump groundwater back into the California Aqueduct to meet its obligations. The maximum storage capacity of SWSD's groundwater basin is 1 maf. Commitments have been made for about 80 percent of the project. The remaining 200 taf of storage is available to other potential banking partners or for expansion of commitments by existing partners.

MWDSC and Arvin-Edison Water Storage District completed negotiations on a 350 taf water banking/exchange program. Water banked in this program would be provided by both AEWSD and MWDSC. AEWSD would provide up to 150 taf of its supplies to MWDSC, depending on the quantity of new water yield developed by the program. MWDSC would provide the remaining portion of the water supplies from its own sources. AEWSD will construct 500-600 acres of new infiltration basins, 15 new extraction wells, and a 4.5 mile pipeline intertie with the California Aqueduct.

Agricultural Drainage

Much of the Tulare Lake Region's agriculturally

California Aqueduct in foreground with the gates at the Kern River Intertie, which was constructed to allow Kern River floodwaters to enter the aqueduct. (In 1995, the intertie was operated in reverse under emergency conditions, to protect the aqueduct from overtopping due to upstream flood inflows.) The design flow for the intertie is 3,500 cfs.



Advances in well drilling technology were key to large-scale development of groundwater in the Central Valley. This photo show the state of technology circa 1914.

Courtesy of Water Resources Center Archives, University of California, Berkeley

rich westside must contend with high groundwater tables and drainage problems. Typically, applied irrigation water builds up above semi-impervious clay layers, creating a shallow, unconfined aquifer of generally poor to unusable quality. Efforts of the San Joaquin Valley Interagency Drainage Program to address westside drainage problems are described in Chapter 4.

Arroyo Pasajero and Other Westside Cross-Drainages

The Department, USBR, and USACE are completing a 5-year feasibility study to identify long-term solutions to flooding and sedimentation problems threatening the California Aqueduct at its crossing of Arroyo Pasajero. The SWP's problems at this uncontrolled ephemeral stream are similar to those being experienced by others in the area. Arroyo flows during the 1995 flood washed out a bridge on Interstate 5, resulting in the deaths of 7 motorists. Long-term solutions currently under consideration for the SWP include a substantial increase in floodwater and sediment storage. The Department is also investigating a similar problem 20 miles north of Arroyo Pasajero at the Cantua Creek stream group. These streams present similar flooding and sedimentation problems for the Aqueduct.

Kings River Fishery Restoration Actions

Kings River Conservation District and the Kings River Water Association are cooperating with USACE in a feasibility study of Kings River fishery habitat improvements associated with USACE's Pine Flat Dam. The study is evaluating impacts of original project construction, riparian habitat restoration downstream of the dam, potential operating strategies to minimize lake level fluctuations during spawning periods, and temperature control methods for trout populations. One component of the study includes a new multi-level intake structure for the reservoir, to better manage downstream river temperatures. USACE is also implementing a related project to install a bypass at the dam's powerplant so that releases can be made through the existing penstocks when the turbines are not in operation. This project will provide temperature control for the downstream trout fishery.

Water Management Options for the Tulare Lake Region

Table 8-16 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 8A-3 in Appendix 8A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Urban conservation options were deferred from evaluation because they provide little cost-effective potential to create new water through depletion reductions in the Tulare Lake Region.

TABLE 8-16

Tulare Lake Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ET_o	Defer	No significant depletion reductions attainable.
Indoor Water Use	Defer	No significant depletion reductions attainable.
Interior CII Water Use	Defer	No significant depletion reductions attainable.
Distribution System Losses	Defer	No significant depletion reductions attainable.
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Defer	Already highly developed; no significant depletion reductions attainable.
Canal Lining and Piping	Defer	No additional depletion reductions attainable.
Tailwater Recovery	Defer	No additional depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Enlarge Pine Flat Dam	Retain	
Enlarge Lake Kaweah (Terminus Dam)	Retain	
Enlarge Success Lake	Defer	Being enlarged for flood control, not water supply.
New Reservoirs/Conveyance Facilities		
Rodgers Crossing Project	Defer	Segment of Kings River designated as a special management area, under the Wild and Scenic Rivers Act.
Mill Creek Reservoir	Defer	Cost too high.
Mid-Valley Canal	Defer	Questionable water supply availability.
Groundwater/Conjunctive Use		
City of Clovis Expansion of Recharge Facilities	Retain	
Kaweah River Delta Corridor Enhancement Recharge	Defer	Minimal yield.
Kern Water Bank Authority Recharge Facilities	Retain	
Buena Vista WSD Recharge	Retain	
Cawelo Water District Recharge	Retain	
Water Marketing		
SLDMWA Internal Reallocation of CVP Supply	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply.
Desalting		
Brackish Groundwater		
Agricultural Drainage	Defer	No present local agency plans.
Seawater		
—	—	—

TABLE 8-16

Tulare Lake Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Other Local Options		
—	—	—
Statewide Options		
—	—	See Chapter 6.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options.

Improving irrigation scheduling would increase SAE to 76 percent, reducing depletions by 7 taf/yr. System improvements including pressure regulation and filtration and better irrigation scheduling would increase SAE to 78 percent and reduce depletions by 12 taf/yr. To reach 80 percent SAE, conversion to more efficient irrigation systems would be needed, reducing depletions by 17 taf/yr. Flexible water delivery is deferred because existing delivery systems in the region are highly developed, and further improvements would result in little depletion reduction at a high cost. Canal lining is deferred because areas in the region where lining and piping could reduce water depletions (the west side of the valley) already have such improvements. Tailwater recovery is not a significant future option because extensive tailwater recovery already occurs in the region.

Modifying Existing Reservoirs and New Reservoirs

Additional Storage in Kings River Basin. Pine Flat Dam, completed in 1954, is a USACE flood control project that also provides supplemental water supply to Kings River Basin water users. In 1974, the Kings River Conservation District commissioned a master plan to evaluate local solutions to flood control and water supply problems. This study identified three projects to improve storage and regulate Kings River flows. In order of cost-effectiveness, they were enlargement of Pine Flat Dam, Rodgers Crossing project, and Mill Creek project.

A 1989 USACE reconnaissance study investigated Kings River Basin flood control and water supply opportunities. After screening several alternatives, enlargement of Pine Flat Dam was retained for further study. A 15-foot increase of gross pool height appeared to have the best benefit/cost ratio. This alternative would increase the reservoir's storage capacity about 92.8 taf and provide an average of 12.7 taf/yr of

Flooding from Arroyo Pasajero spreads out as sheetflow over the lower portion of the Arroyo's alluvial fan. The Arroyo's periodic flooding closes State Highway 269 and threatens the integrity of the California Aqueduct.

Westlands Water District Distribution System

Westlands Water District is the CVP's largest water contractor. Among Central Valley agricultural water districts, WWD is unique both for its size (almost 1,000 square miles) and for its irrigation distribution system—which is based entirely on pipelines, rather than open canals. Altogether the distribution system has over 1,000 miles of buried pipe, varying in diameter from 10 to 96 inches. The basic design flow rate for each farm delivery system is 1 cfs per 80 acres.

additional average year yield. The major benefit would be flood control. The alternative was not economically feasible at the time. The Rodgers Crossing project, a proposed reservoir located upstream of Pine Flat Reservoir, was rendered infeasible when the damsite was included in a river segment subsequently designated as wild and scenic.

Mill Creek is a small, uncontrolled, intermittent stream tributary to the Kings River below Pine Flat Dam. The creek's 77,000 acre watershed produces an average annual runoff of approximately 30 taf. Heavy local rainstorm events occasionally result in flows in excess of 10,000 cfs, high enough to cause damage along the Kings River channel downstream. In the 1970s, USACE studied the feasibility of constructing a dam on Mill Creek, just upstream of its confluence with the Kings River. The benefits of such a project would include additional flood protection, water conservation, power generation, and recreation. The proposed reservoir would have a capacity in excess of 600 taf and would be directly linked with Pine Flat Reservoir by a tunnel, allowing the reservoirs to be operated conjunctively. In wet years, Kings River water that would flood agricultural lands in Tulare Lakebed could be diverted and stored in Mill Creek Reservoir. USACE's studies indicated that the project was not economically viable.

Additional Storage in Kaweah River Basin. Lake Kaweah is located on the Kaweah River about 20 miles east of Visalia. Terminus Dam, completed in 1962 by the USACE, provides flood protection and irrigation water supply to downstream users. A draft USACE feasibility report investigated continuing flood control problems and water resource needs on the Kaweah River and identified three alternative solutions—enlarge Terminus Dam, construct a flood detention dam on Dry Creek above Lake Kaweah, or construct a reservoir on Dry Creek with a connecting tunnel to Lake Kaweah. Upon further study, only Terminus enlargement was considered feasible due to environmental and cultural impacts of facilities on Dry Creek. Enlarging Terminus Dam would involve raising the spillway, increasing flood control storage by about 42 taf. On an average annual basis, the study estimates that in-basin irrigation water supply would increase by 8.4 taf through better regulation of flood flows. Congress authorized enlargement of Terminus Dam in the Water Resources Development Act of 1996. Construction is tentatively scheduled to begin in 2000 and to be completed in 2002. The Terminus Dam enlargement is projected to have a capital cost of about $37 million.

Additional Storage in Tule River Basin. In response to flood protection problems experienced during large storms, Tulare County and the Tule River Association requested USACE to consider providing additional storage in the basin by enlarging Success Lake. Success Lake is estimated to provide about a 55-year level of protection for the City of Porterville. A 1992 reconnaissance study found that a 10-foot increase in gross pool height with a corresponding increased storage capacity of 28 taf was the preferred alternative. The enlargement would provide a 100-year level of flood protection and increase irrigation water supply by 2.8 taf annually. USACE entered into a feasibility cost-sharing agreement with Lower Tule River ID for updating the 1992 study and for preparing an EIR/EIS. The draft feasibility study and EIR/EIS are scheduled to be released in 1998. Since the reservoir enlargement's primary purpose is flood control, the project is not considered further in this chapter as a water supply option.

New Conveyance Facilities

The Mid-Valley Canal and the constraints on its implementation were discussed in the San Joaquin River Hydrologic Region. The conveyance project is presently not feasible because it has no water supply.

Groundwater Development or Conjunctive Use

Many water districts and cities in the region use excess surface water allocations, purchased water, and floodwater for groundwater recharge. Local distribution systems and CVP and SWP conveyance facilities create opportunities for agencies to exchange and purchase surface supplies for groundwater recharge. Opportunities for groundwater recharge or conjunctive use projects are limited in some parts of the region, such as the west side of the valley, because of near-surface poor quality groundwater.

The City of Clovis has an agreement with Fresno Irrigation District entitling the city to an average of 14.9 taf of Kings River water and 1.1 taf of Class II water from Millerton Lake. Currently, the city's surface water supply is used exclusively for groundwater recharge. Existing facilities can recharge approximately 7.8 taf/yr. As the city expands into surrounding agricultural lands and acquires additional water supplies, average annual surface supplies are expected to increase to 30.1 taf by 2015. With this increase in supply, the city is developing new recharge sites to recharge an additional 3.5 taf/yr.

Visalia plans to develop new wells as its water needs grow, estimating that 15 additional wells will be necessary to meet average year water demands in 2020. Visalia is also working with the Kaweah Delta Water Conservation District and Tulare County on a Kaweah River Delta corridor study to investigate multiple use sites for groundwater recharge, floodwater management, and habitat restoration. The study is currently in the feasibility stage. The project would include recharge basins with a storage capacity of about 750 af. A demonstration project has been proposed to model integration of the multiple uses.

Pursuant to Monterey Agreement contract amendments and the transfer of the KFE, KWBA has been operating about 3,000 acres of recharge basins under an emergency CEQA exemption and an interim ESA Section 7 consultation, allowing the authority to recharge winter floodwaters. Since May 1995, KWBA has recharged about 700 taf on behalf of its member agencies. KWBA prepared a 75-year habitat conservation plan/natural community conservation plan covering the use of the 20,000-acre property. The HCP sets aside about 10,000 acres for habitat purposes. ESA listed species found in the project area include the kit fox, kangaroo rat, and blunt-nosed leopard lizard. KWBA plans to expand the recharge facility to 6,800 acres. The cost for this expansion, including additional conveyance structures, is about $30 million.

Buena Vista Water Storage District is planning to construct up to 200 acres of additional facilities to store excess Kern River water. The new facilities are estimated to cost about $250,000.

Cawelo Water District recently entered into an agreement with Texaco Inc. for water generated during oil recovery. A significant amount of water is trapped in oil bearing zones. The quality of much of this water is good, once it has been separated from the oil. The agreement negotiated by Texaco and CWD made possible the construction of an 8 mile pipeline to carry as much as 25 taf/yr of this water to the district. Additionally, Cawelo purchased almost 90 acres of land straddling Poso Creek in 1996. The district will allow the land to be flooded during high flows to enhance groundwater recharge. Work will begin shortly on a feasibility study to address the district's long-term plans for more recharge facilities.

Looking at the upstream face of Terminus Dam, with the outlet works structure in the background.

Water Marketing

As described in Chapter 6, the San Luis and Delta-Mendota Water Authority has negotiated an internal reallocation of its members' CVP supplies with USBR. Under this agreement, participating member agencies of SLDMWA may exchange wet year supplies for drought year supplies with SCVWD. Westlands Water District has initiated a short-term buy-back program for its water users who wish to sell their unused allocation or other supply to the district. The buy-back program would be implemented only if WWD had not finalized transfers from other sources to meet its total supplemental water needs. Marketing under this program would be intra-regional. WWD is also currently preparing a draft programmatic EIR on purchasing and transferring up to 200 taf/yr to its service area. Because details on proposed transfers are not yet available, this program is not included in the water management options evaluation.

Urban and agricultural development have reduced the habitat available to the San Joaquin Valley kit fox, a listed species.

Water Recycling and Desalting

In the Tulare Lake Region, most urban water use occurs on the east side of the San Joaquin Valley. Wastewater produced from urban use is generally recharged to groundwater basins where it reduces groundwater overdraft, or is extracted for other uses. No water recycling projects in the region qualify as new sources of supply from a regional perspective. As discussed in the San Joaquin River Region section, options for desalting agricultural drainage water were deferred for the Tulare Lake Region.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the Tulare Lake Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 720 taf and 1,851 taf in average and drought years, respectively. Ranking of retained water management options for the Tulare Lake Region is summarized in Table 8-17. Table 8-18 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Improvements in agricultural irrigation demand management will likely occur over the entire region, although much of the region is already efficient in its agricultural water management. Areas where further efficiency improvements will have the most effect will be where agricultural lands overlie shallow groundwater of poor quality. The west side of the valley will receive the most benefits from irrigation water conservation practices. These practices could reduce depletion annually by 17 taf if system upgrades are employed to increase SAEs to 80 percent.

The portion of the region's 2020 water shortage attributable to groundwater overdraft is estimated to be 670 taf. Several plans exist to expand recharge facilities or to construct new ones.

The region's local surface supplies have already been extensively developed and further development opportunities are limited. Modification of existing facilities through the enlargement of Lake Kaweah and Pine Flat Lake could produce about 21 taf/yr of additional yield for irrigation supply.

Water Marketing—WaterLink Program

In 1996, an electronic water marketing system went on-line in Westlands Water District. The WaterLink system was designed by the University of California Berkeley and Davis campuses, the Natural Heritage Institute, and farmers and water district staff. The project was funded by a grant from USBR. WaterLink allows district growers to use their home computers to post and read bids, access information on average prices and trading volumes, and negotiate transactions. WaterLink can also be used to schedule water deliveries and eventually to obtain water account balances, a feature that will enable water users to manage their water supplies more effectively. WaterLink is an intra-net system, available only to district growers, to allow them to make internal trades of in-district supplies.

TABLE 8-17

Options Ranking for Tulare Lake Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	7	7
Seasonal Application Efficiency Improvements (78%)	M	250	12	12
Seasonal Application Efficiency Improvements (80%)	M	450	17	17
Modify Existing Reservoirs/Operations				
Enlarge Pine Flat Dam	H	470	13	[b]
Enlarge Lake Kaweah (Terminus Dam)	H	370	8	[b]
Groundwater/Conjunctive Use				
City of Clovis Expansion of Recharge Facilities	H	280	—	11
Kern Water Bank Authority Recharge Facilities	H	60	—	339
Buena Vista Water Storage District Recharge	H	75	—	29
Cawelo Water District Water Banking Project	H	50	—	13
Water Marketing				
SLDMWA internal reallocation of CVP supply	H	[b]	10	—
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 8-18.
[b] Data not available to quantify.

TABLE 8-18

Options Likely to be Implemented by 2020 (taf)
Tulare Lake Region

	Average	*Drought*
Applied Water Shortage	**720**	**1,851**
Options Likely to be Implemented by 2020		
Conservation	17	17
Modify Existing Reservoirs/Operations	21	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive Use	—	392
Water Marketing	10	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	466	387
Expected Reapplication	4	187
Total Potential Gain	518	983
Remaining Applied Water Shortage	**202**	**868**

8A

Options Evaluations for Interior Regions

TABLE 8A-1

Options Evaluation Sacramento River Region

Option	Evaluation Scores							
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Modify Existing Reservoirs/Operations								
Reoperate PG&E Reservoirs	3	3	2	0	1	0	**9**	**L**
New Reservoirs/Conveyance Facilities								
Dry Creek Reservoir (Lake County)	3	3	2	1	3	0	**12**	**L**
Thurston Lake Pump-Storage Project	2	3	2	2	2	2	**13**	**M**
Parks Bar Reservoir (Yuba County)	3	2	2	3	3	4	**17**	**H**
Waldo Reservoir (Yuba County)	3	2	2	3	3	4	**17**	**H**
Texas Hill Reservoir	3	2	2	2	2	1	**12**	**L**
Small Alder Reservoir	3	2	2	2	2	1	**12**	**L**
GDPUD Diversion from American River	3	3	3	3	3	0	**15**	**M**
Groundwater/Conjunctive Use								
New Wells (Redding, Butte, and Colusa Basins)	4	4	3	4	3	0	**18**	**H**
Big Valley Conjunctive Use	3	4	3	2	3	2	**17**	**H**
Other Local Options								
New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	3	3	2	2	3	0	**13**	**M**
New Surface Water Diversion from Sacramento River by Cities of Benicia, Fairfield, and Vacaville	3	3	2	2	3	0	**13**	**M**
Statewide Options								
See Chapter 6.								

TABLE 8A-2

Options Evaluation San Joaquin River Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Agricultural								
Flexible Water Delivery	3	0	3	3	2	1	**12**	**L**
Canal Lining and Piping	3	0	3	3	2	1	**12**	**L**
Tailwater Recovery	3	4	3	3	3	1	**17**	**H**
Modify Existing Reservoirs/Operations								
Reoperate Farmington Reservoir	3	3	3	2	3	3	**17**	**H**
Enlarge Farmington Reservoir	2	3	3	2	3	3	**16**	**M**
New Reservoirs/Conveyance Facilities								
Montgomery Reservoir Offstream Storage	3	3	3	2	3	3	**17**	**H**
Fine Gold Creek Offstream Storage	3	2	2	2	3	3	**15**	**M**
Irish Hill Reservoir	3	2	2	1	3	1	**12**	**L**
Middle Bar Reservoir	3	1	1	2	2	2	**11**	**L**
Devils Nose Reservoir	3	1	1	2	2	1	**10**	**L**
Groundwater/Conjunctive Use								
Stockton East WD	3	3	4	2	3	3	**18**	**H**
Madera Ranch	3	3	4	2	2	2	**16**	**M**
Statewide Options								
See Chapter 6.								

TABLE 8A-3

Options Evaluation Tulare Lake Region

Option	*Evaluation Scores*							
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Conservation								
Agricultural								
SAE Improvements (76%)	3	4	3	4	3	1	**18**	**H**
SAE Improvements (78%)	3	3	3	3	2	1	**15**	**M**
SAE Improvements (80%)	2	3	3	2	2	1	**13**	**M**
Modify Existing Reservoirs/Operations								
Enlarge Pine Flat Dam	3	3	3	4	3	2	**18**	**H**
Enlarge Lake Kaweah (Terminus Dam)	3	3	3	4	3	3	**19**	**H**
Groundwater/Conjunctive Use								
City of Clovis Expansion of Recharge Facilities	4	3	4	3	4	0	**18**	**H**
Kern Water Bank Authority Recharge Facilities	4	4	3	3	4	0	**18**	**H**
Buena Vista Water Storage District Recharge	4	4	3	4	3	0	**18**	**H**
Cawelo Water District Recharge	4	4	4	4	4	0	**20**	**H**
Water Marketing								
SCVWD/SLDMWA Reallocation	4	4	4	4	3	0	**19**	**H**
Statewide Options								
See Chapter 6.								

9

Options for Meeting Future Water Needs in Eastern Sierra and Colorado River Regions of California

This chapter covers the North and South Lahontan Hydrologic Regions in the eastern Sierra, and the Colorado River Hydrologic Region (Figure 9-1). These sparsely populated regions constitute 33 percent of the State's land area.

FIGURE 9-1
Eastern Sierra and Colorado River Hydrologic Regions

USBR's Parker Dam on the Colorado River.

FIGURE 9-2

North Lahontan Hydrologic Region

North Lahontan Hydrologic Region

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Description of the Area

The North Lahontan Region has two planning subareas (Figure 9-2), the Lassen Group and the Alpine Group. The Lassen Group PSA consists of Lassen and Modoc Counties. This high desert area is arid, with relatively flat valley areas adjacent to mountains. Valley elevations are about 4,000 and 4,500 feet for Honey Lake and Surprise Valleys. The Warner Mountains, which form the western boundary of Surprise Valley, range in elevation from about 7,000 to more than 9,000 feet. Annual precipitation ranges from as little as 4 inches in Surprise Valley in Modoc County to over 50 inches in the mountains of the Susan River watershed in Lassen County. The Alpine Group PSA includes parts of Sierra, Nevada, Placer, El Dorado, Alpine, and Mono Counties. The subarea includes the Truckee, Carson, and Walker River drainages. These rivers originate at high elevations on the eastern slopes of the Sierras and flow to terminal lakes or desert sinks in Nevada. Annual precipitation ranges from 8 inches in the valleys to more than 70 inches in the Sierra (much of this amount is snow).

The Lassen Group PSA is rural and sparsely populated. The City of Susanville is the largest population center in the subarea. In the Alpine PSA, more than 90 percent of the population lives in the Lake Tahoe and Truckee areas. The City of South Lake Tahoe and Town of Truckee are the largest communities in the subarea. The Tahoe-Truckee region has many part-time residents and visitors during the summer and winter recreational seasons, reflecting the importance of tourism to the area. Tourism and related recreational opportunities are vital to the region's economy and to much of the region's service-sector employment.

Cattle ranching is the main agricultural land use in the Lassen Group PSA. Irrigated land acreage is small (less than 4 percent of the region's land area). Commercial crop production is limited because of the short growing season. Pasture and alfalfa are the dominant irrigated crops. About 75 percent of the region's irrigated land is in Modoc and Lassen Counties, and most of the remainder is in the Carson and Walker River Basins in Alpine and Mono Counties. Irrigated lands in the Carson and Walker River Basins are almost exclusively pasture at elevations above 5,000 feet. Most of the uplands areas are federally owned and managed as national forest lands. Table 9-1 shows population and crop acreage for the region.

TABLE 9-1
Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	84	161
2020	125	165

Water Demands and Supplies

The water budget for the North Lahontan Region is shown in Table 9-2. Agricultural water demands are generally met with local surface water supplies, when available. Throughout the northern portions of the region, runoff is typically scant and stream flow decreases rapidly after the snowpack melts in the higher elevations.

No major changes in North Lahontan Region water use are anticipated within the Bulletin's planning horizon. Irrigated agriculture is constrained by climate

A majority of the land in the North Lahontan Region is owned by the federal government, managed primarily by USFS and BLM. National forest lands provide habitat for many species of wildlife, including some of California's larger mammals.

and by economically available water supplies. A small amount of agricultural expansion is expected, but only in areas that can support minor additional groundwater development. Likewise, the modest need for additional municipal supplies can be met by expanding present surface systems or increasing groundwater use. Drought year shortages are caused by a reduction in surface water supplies for agriculture and an increase in unit crop irrigation requirements for pasture and alfalfa. No urban water shortages are forecast.

Most of Susanville's water supply comes from groundwater and from Cady and Bagwell Springs. The city has not experienced any water supply shortages nor does it expect any shortages within the next 20 years.

The Honey Lake Valley Groundwater Basin is an interstate groundwater basin. The California portion of the basin is about 45 miles long and 10 to 15 miles wide. Groundwater extracted from the basin is used mainly for irrigation. Groundwater use in the basin appears to be near the basin's perennial yield. A 1987 agreement among the Department, the State of Nevada, and USGS resulted in a study of the groundwater flow system in eastern Honey Lake Valley. Upon conclusion of the study in 1990, the Nevada State Engineer ruled that only about 13 taf could be safely transferred from Nevada's portion of the basin for proposed new water development for Washoe County in Nevada. The Nevada out-of-basin transfer project has not been implemented.

The 7,840-acre Honey Lake Wildlife Area is on the north edge of Honey Lake about 20 miles southeast of Susanville. The HLWA consists of intensively managed wetlands, cropped fields, and uplands adjacent to the 60,000-acre Honey Lake. It provides important habitat for migratory waterfowl, sandhill

TABLE 9-2

North Lahontan Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

[a] Water use/supply totals and shortages may not sum due to rounding.

TABLE 9-3

Major Reservoirs in the Truckee River Basin in California

Reservoir	*Owner*	*Operator*	*Usable Storage (taf)*	*Construction Date*[a]	*Height (Feet)*	*Drainage Area (Square Miles)*
Tahoe	Sierra Pacific Power Company[b]	Truckee-Carson Irrigation District	744.6	1913	18	506
Donner	Sierra Pacific Power Company/ Truckee-Carson Irrigation Dist.	Sierra Pacific Power Company	9.5	1927	14	14
Martis Creek[c]	USACE	USACE	20.4	1971	113	40
Prosser Creek	USBR	USBR	29.8	1962	163	50
Independence	Sierra Pacific Power Company	Sierra Pacific Power Company	17.5	1939	31	8
Stampede	USBR	USBR	226.5	1970	239	136
Boca	USBR	Washoe County Water Conservation District	41.1	1937	116	172

[a] Date existing dam was completed.
[b] USBR manages the facilities under easement from Sierra Pacific Power Company.
[c] Flood control storage only.

cranes, and other birds migrating on the Pacific Flyway. During the irrigation season, most of HLWA's water supply comes from Willow Creek and its tributaries. HLWA has adjudicated water rights, administered by the Department, as established in the 1940 Susan River Decree. Groundwater at the refuge is used for crop irrigation, for maintaining wetlands water levels, and for domestic purposes.

The Truckee River originates above Lake Tahoe. The river's flow downstream from Tahoe City is controlled by a small dam on the lake's outlet. The river flows through northeastern California and northwestern Nevada and terminates in Pyramid Lake, located within the Pyramid Lake Indian Reservation in Nevada. Additional Truckee River Basin storage facilities are listed in Table 9-3.

Most of the water supply developed by Truckee River Basin reservoirs is used in Nevada to meet urban demands in the Reno/Sparks area, irrigation demands, and fish and wildlife requirements in the lower Truckee River in Nevada and in Pyramid Lake. On average, about one-third of the Truckee River's annual flow is diverted through the Truckee Canal in Nevada to irrigate land in the Carson Division of USBR's Newlands Project near Fallon, Nevada.

Truckee River operations have evolved in response to litigation, negotiation, court decrees, agreements, and legislation. The 1915 Truckee River General Electric Decree and the 1935 Truckee River Agreement form the basis of current river operations. The 1944 Orr Ditch Decree established individual water rights in Nevada and, by incorporating the Truckee River Agreement, provided criteria for operating the federal reservoirs to serve those rights.

Modification of Truckee River operations occurred when two Pyramid Lake fish species were listed under the ESA. Cui-ui, the Indian name for a species of sucker found only in Pyramid Lake, were listed as an endangered species in 1967. Lahontan cutthroat trout were initially listed as endangered in 1970 and were subsequently reclassified as threatened in 1975. USBR's Stampede Reservoir, constructed in 1970 to serve irrigation and municipal uses, is operated to provide water for these fish, as required by a 1982 federal court decision. Proposed changes in Truckee River operations are described in the following water management issues section.

In the Truckee Basin within California, the urban water use occurs in and around the Town of Truckee, and is supplied by Truckee Donner PUD. TDPUD is the largest purveyor in the basin, accounting for about half of the water delivered to commercial and residential customers; its supplies are derived from groundwater. The Martis Valley groundwater basin is the principal source of water supply. The areas of Northstar, Squaw Valley, and Glenshire use groundwater from smaller basins or from fractured rock sources. The developed area around Donner Lake is

USBR's Stampede Reservoir is the second largest reservoir in the Truckee River Basin. Lake Tahoe is the largest reservoir in the basin.

Courtesy of USBR

served by surface water. Future water demands in the Truckee Basin are not expected to exceed the interstate allocations contained in the Truckee-Carson-Pyramid Lake Water Rights Settlement Act (PL 101-618), which limits the basin's annual use to 32 taf.

On the California side of the Lake Tahoe Basin, South Tahoe PUD, Tahoe City PUD, and North Tahoe PUD account for most of the water delivered to urban users. Water is supplied from the lake and from groundwater sources. The interstate allocation for California's Lake Tahoe Basin in PL 101-618 would limit future water use in the basin to 23 taf of gross diversions, which represents the basin's estimated future water needs at its full development. Future development in the Lake Tahoe Basin is strictly limited by the bistate Tahoe Regional Planning Agency to protect the basin's environmental quality. In both the Truckee and Tahoe Basins, water use for snowmaking at the area's ski resorts has been addressed in the interstate allocations.

Urban development in the Carson and Walker River Basins is minimal and is clustered around the towns of Markleeville in Alpine County and Bridgeport in Mono County. More than 90 percent of the watershed on the California side is federally owned, primarily under the management of the Toiyabe National Forest. Groundwater is the source of supply for individual users and small community systems located in valley areas. In the upper watershed, communities may lack suitable sites to locate wells and therefore must depend on surface water sources. The Town of Markleeville depends on surface water and experienced a water shortage in 1989 when the stream that supplies the community went dry. Water had to be piped 4 miles from another creek to the town's treatment plant.

In the upper Carson River watershed, water is stored in several very small alpine reservoirs originally constructed to supply irrigation needs. Much of this water is still used for irrigation downstream in Nevada. The largest of the alpine reservoirs is Heenan Lake on Monitor Creek, tributary to the East Fork Carson River, with a capacity of nearly 3 taf. The Carson River supports a popular recreational trout fishery in the upper watershed. DFG has used Heenan Lake for raising Lahontan cutthroat trout to stock at other locations throughout the Sierra. DFG currently manages State-owned lands adjacent to Heenan Lake and has arranged to purchase water on an annual basis to maintain a minimum reservoir pool for fish rearing.

Two special-purpose reservoirs were constructed in the upper Carson watershed to receive treated wastewater effluent exported from South Tahoe PUD in the Lake Tahoe Basin. (Disposal of treated wastewater within the Lake Tahoe Basin was banned to help protect the lake's clarity.) Beginning in the 1960s, wastewater effluent was delivered to Indian Creek Reservoir for subsequent release to agricultural users as a supplemental irrigation supply. In 1989, exports (about 5 taf/yr) were redirected to Harvey Place Reservoir. Indian Creek Reservoir is now used for freshwater recreation.

In addition to several small reservoirs in the upper watershed, the Walker River watershed has two large reservoirs—Topaz Reservoir (an offstream storage facility on the West Walker) and Bridgeport Reservoir on the East Walker. Both of the large reservoirs were built by Walker River Irrigation District to sustain summer irrigation flows in its service area downstream in Nevada. WRID holds California water rights to store 57.6 taf of West Walker water, plus 200 af of local inflow, in Topaz Reservoir. WRID can store up to 39.7 taf in Bridgeport Reservoir. SWRCB has established instream flow and minimum reservoir pool requirements at Bridgeport, in response to fish kills that occurred during the last drought. Both reservoirs are popular local recreational destinations.

Part of the East Fork Carson River—approximately 10 miles from the town of Markleeville to the California/Nevada state line—has been added to the California wild and scenic river system. On the West Walker River, approximately 37 river miles have also been given State designation. The designated reach is from Tower Lake at the headwaters downstream to the confluence with Rock Creek, and about 1 mile of Leavitt Creek.

As occurred in the Truckee River Basin, water right disputes in the Carson and Walker River Basins were settled with federal court decrees. The 1980 Alpine Decree on the Carson River and the 1936 Decree C-125 on the Walker River control most river operations. The decrees established surface water rights, including reservoir storage rights, of water users in both California and Nevada. However, the decrees only quantify individual water rights of parties to the litigation and did not address rights perfected under state law by others—not all existing water uses are necessarily covered in the decrees. PL 101-618 established an interstate allocation in the Carson River Basin; the California allocation corresponds to existing water uses.

Local Water Resources Management Issues

Truckee River Operating Agreement

Negotiation of a proposed Truckee River Operating Agreement and preparation of its draft EIR/EIS have been the major water management activities in the region. A new operating agreement for the Truckee River is required by PL 101-618. Negotiation of a proposed TROA and preparation of an EIR/EIS for the TROA began in 1991. The draft EIR/EIS was released for public review in 1998 and is expected to be completed in 1999.

PL 101-618 settled years of disputes over Truckee and Carson River waters by making an interstate allocation between California and Nevada. It also settled certain tribal water right claims and provided for water supplies for specified environmental purposes in Nevada. The act allocated 23 taf annually to California in the Lake Tahoe Basin and 32 taf annually in the Truckee River Basin below Lake Tahoe. The act allocated water corresponding to existing Carson River Basin water uses to California. The remainder of the

USBR's Prosser Creek Reservoir is one of the Truckee River system reservoirs whose operation would be covered by the TROA.

Truckee and Carson River supply was allocated to Nevada.

When executed, the TROA would establish river operations procedures to meet water rights on the Truckee River and to enhance spawning flows in the lower Truckee River for cui-ui and Lahontan cutthroat trout. TROA would provide for management of water within the Truckee Basin in California, including instream flow requirements and reservoir storage for fishery and recreation uses, and would include procedures for coordinating releases and exchanges of water among the watershed's reservoirs. TROA would become the exclusive federal regulation governing releases of water stored in Lake Tahoe, Martis Creek, Prosser Creek, Stampede, and Boca Reservoirs. The agreement would provide an accounting procedure for surface and groundwater diversions in California's part of the Truckee Basin and would establish criteria to minimize short-term reductions in river flow potentially caused by future well construction near the river.

In 1993, an agreement was signed by Sierra Pacific Power Company, Washoe County Water Conservation District, and Sierra Valley Water Company settling a dispute about when the water company was required to stop diverting water from the Little Truckee River. This agreement, which resolves disputes that had often occurred during droughts, is being incorporated into the proposed TROA.

Walker River

Recent activities in the Walker River Basin have focused on the declining level of Walker Lake in Nevada and the resulting impact on the lake's fishery. Because Walker Lake is a terminal sink, salts accumulate as the lake water evaporates. Declining lake levels have resulted in most Great Basin terminal sinks being too saline to support fisheries. Walker Lake is one of three terminal lakes in Nevada that support fish life. The water level at Walker Lake has declined from an elevation of about 4,080 feet in 1882 to 3,944 feet in 1994; salinity has increased during the same period from about 2,500 mg/L TDS to 13,300 mg/L TDS.

In most years, Walker River is the primary source of inflow to Walker Lake. Flow in the river comes from runoff in the Sierra in California. Upstream agricultural diversions have contributed to reduced inflows, resulting in a declining lake level and increased lake salinity. If the trend continues, the Lahontan cutthroat and the tui chub (an important food source for the trout) may not be able to survive in the lake. To maintain lake salinity at the current level, about 33 taf/yr more inflow is needed. Even with a stable lake level, salinity will slowly increase because Walker Lake has no natural outlet. A solution to Walker Lake problems could affect water users in California and Nevada. Potential tribal water rights claims on the Nevada side of the basin could also affect existing water users.

Lake Tahoe

Lake Tahoe's clarity has been declining as increasing development around the shoreline increases the sediment load and nutrients reaching the lake. Nutrients, such as nitrogen and phosphorous used in lawn or golf course fertilizers, can enter the lake in the form of storm water runoff. Nutrients promote growth of algae, reducing clarity. Clarity of lakes is measured by the depth to which a Secchi disk, a small plastic disk of specific size, is visible. In the late 1960s, average Secchi disk visibility in Lake Tahoe was about 100 feet. Now the figure is closer to 70 feet.

Programs to manage Lake Tahoe water quality by regulating development and preventing pollutants from reaching the lake are being implemented at the federal, state, and local levels. The Tahoe Regional Planning Agency, a bistate agency created by Congress, sets regional environmental standards, issues land use permits (including conditions to protect water quality), and takes enforcement actions throughout the basin. TRPA's regional plan provides for achievement and maintenance of environmental targets by managing growth and development. In addition to its regulatory activities, TRPA carries out a capital improvement program to repair environmental damage done before its regional plan was adopted. TRPA has identified nearly $500 million in capital improvements needed to achieve environmental targets. Federal, state, and local governments have invested nearly $90 million in erosion control, storm water drainage, stream zone restoration, public transit, and other capital projects. Over 70 percent of the land in the Tahoe Basin is controlled by the USFS's Lake Tahoe Basin Management Unit. The LTBMU has implemented a watershed restoration program and a land acquisition program to prevent development of sensitive private lands.

In recent years, federal and state agencies have increased funding to protect the environment of Lake Tahoe. The State of Nevada approved a $20 million bond measure to perform erosion control and other measures on the east side of the lake. In California, Proposition 204 provides $10 million in bond funds for land acquisition and programs to control soil erosion, restore watersheds, and preserve environmentally sensitive lands.

Leviathan Mine

Leviathan Mine, an abandoned sulfur mine located in Alpine County, is one of the most significant abandoned mine sites in the region. From 1863 to 1952, operations at the site involved tunnel mining. Later, the site was converted to an open-pit operation. Under this operation, tailings and overburden material were placed in (or washed into) streams, creating water pollution problems with acid mine drainage and metals. The mine was ultimately abandoned, leaving an open pit, waste and spoil areas, and surface water drainage and erosion problems. Neither the owner nor the county had the resources to clean up the site.

In 1980, SWRCB approved a pollution abatement project for Leviathan Mine. The remediation project included channeling Leviathan Creek, filling and regrading the mine pit, excavating and regrading the waste dump, creating onsite evaporation ponds, regrading the spoil areas, and improving drainage. The State acquired the site in 1983 and the project was completed in 1985. Although the project reduced the amount of acid mine drainage reaching the creek, contamination problems still occur today from pond overflows, acidic springs, seepage, and erosion. The RWQCB is currently involved in activities to further reduce the pollution.

Sierra Nevada Ecosystem Project

The Sierra Nevada Ecosystem Project was an assessment of forests, key watersheds, and significant natural areas on federal lands. In 1996, the University of California released its *Sierra Nevada Ecosystem Study*, the result of a three year, congressionally-mandated study of the entire Sierra Nevada, with primary emphasis on gathering and analyzing data to assist Congress in future management of the mountain range. The study stated that "excluding the hard-to-quantify public good value of flood control and reservoir-based recreation, the hydroelectric generating, irrigation, and urban use values of water are far greater than the combined value of all other commodities produced in the Sierra Nevada." The report estimated the value of water at 60 percent of that of all commodities produced in the foothills and mountains of the Sierra Nevada.

January 1997 Flood Event

The January 1997 flood was among the most significant floods on record in the North Lahontan Region. Lake Tahoe recorded its highest level since 1917 at an elevation of 6,229.39 feet. This elevation was the lake's highest since the 1935 Truckee River Agreement, which limited the operating range of Lake Tahoe's surface elevation to between 6,223.0 feet (its natural rim) and 6,229.1 feet. Flood damage occurred along the Truckee's channel immediately downstream from the lake, although the greatest economic damages occurred in the Reno-Sparks area. In California, flooding in downtown Truckee caused the closure of major highways. Downstream from Truckee, the river washed away Floriston Dam, a diversion dam used by Sierra Pacific Power Company to divert water to its run-of-river hydroelectric plant at Farad.

Stream flows along the Carson and Walker River systems exceeded previous flood records. Flows along the East Fork Carson River at Markleeville and West Fork Carson River at Woodfords peaked at 21,000 cfs and 8,000 cfs, respectively, considerably above the record peak flows attained in 1963 and in excess of a 100-year flood event for these reaches of the river. The East Walker River near Bridgeport and West Walker River near Coleville peaked at 1,810 cfs and 6,220 cfs, respectively, also above previously record flows. In Mono County, about 8 miles of U.S. Highway 395 were washed out, isolating the communities of Coleville and Walker. At the lower mouth of the Walker Canyon, homes and properties in the community of Walker were damaged when the West Walker River spilled its banks.

Water Management Options for the North Lahontan Region

Table 9-4 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-1 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6. Potential options to augment water supplies during drought conditions are water conservation, groundwater pumping, and reservoir construction. Land is idled during droughts if water is not available. In Mono County, cutbacks in surface water deliveries

TABLE 9-4

North Lahontan Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ETo	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Defer	No significant depletion reductions attainable.
Distribution System Losses	Defer	No significant depletion reductions attainable.
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modifying Existing Reservoirs/Operations		
—	—	—
New Reservoirs/Conveyance Facilities		
Petes Valley Reservoir	Defer	High costs.
Willard Creek Reservoir	Defer	High costs.
Goat Mountain Reservoir	Defer	High costs.
Crazy Harry Gulch Reservoir	Defer	High costs.
Honey Lake Dike and Reservoir	Defer	Water quality inadequate for agriculture. Very low yields with large estimated capital costs.
Long Valley Creek Reservoir	Defer	Very little firm yield.
Hope Valley Reservoir	Defer	High costs.
Leavitt Meadows Reservoir	Defer	Site is located on the West Walker River, upstream of a reach designated as wild and scenic. Also subject to interstate water issues with Nevada.
Pickle Meadow Reservoir	Defer	Same concerns as Leavitt Meadows site.
Roolane Reservoir	Defer	Same concerns as Leavitt Meadows site.
Mountain Lakes Reservoir	Defer	Same concerns as Leavitt Meadows site.
Groundwater/Conjunctive Use		
Agricultural Groundwater Development	Retain	
Eastside Warner Mountain Recharge	Defer	DFG concerns about potential wildlife impacts have diminished local interest in a pilot program and/or reconnaissance level planning study.
Water Marketing		
—	—	—
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply in this region.

TABLE 9-4

North Lahontan Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
—	—	—
Statewide Options		
—	—	—

during the recent drought resulted in pasture not being irrigated.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Urban conservation options in this region provide little potential for depletion reductions. Reducing outdoor water use to 0.8 ET_o in new and existing development would only conserve about 1 taf/yr. Likewise, reducing indoor water use to 55 gpcd would conserve about 1 taf/yr.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. The efficiency of border irrigation systems used for alfalfa and pasture can be improved through leveling fields and better managing applications. No significant depletion reductions are expected in the region, however, since most alfalfa irrigation occurs in Honey Lake Valley where excess applied irrigation water recharges the groundwater basin.

New Reservoirs or Conveyance Facilities

In 1992, the Department investigated six potential reservoir sites in Lassen County that could provide up to 20 taf of storage. Sites were located on the Susan River, Willow Creek, and Long Valley Creek. An analysis of project costs indicates that the reservoirs were not economically feasible for agricultural water users in the region.

In the late 1950s and early 1960s, the Department examined potential reservoir sites in Mono County that could serve agricultural lands in California. USBR, USGS, NRCS, and WRID have studied these and other potential sites in California that could provide water for Nevada uses. Projects that serve Nevada only are not included as options. The four potential sites in Mono County located on the West Walker River have similar economic constraints as the sites in Lassen County. They are also subject to interstate water rights concerns.

Groundwater Development or Conjunctive Use

Although groundwater is available in the larger valleys used for irrigated agriculture, water needs are usually met from surface water. Groundwater cannot be economically used to replace surface water uses because of pumping costs.

Modoc County Resource Conservation District investigated groundwater recharge on six creeks which drain the east slopes of the Warner Mountains in Surprise Valley. This project would recharge the alluvial fans using existing stream channels or constructed recharge facilities. Experimental construction of recharge areas on one or two of the creeks was proposed, but potential environmental impacts and lack of funding prevented implementation. This option was deferred.

Options Likely to be Implemented in the North Lahontan Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 10 taf and 128 taf in average and drought years, respectively. Ranking of retained water management options for the North Lahontan Region is summarized in Table 9-5. Table 9-6 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Although groundwater could be developed to help meet drought year water needs, it is not ranked highly due to its cost. During droughts, pasture irrigation will probably continue to be curtailed.

TABLE 9-5

Options Ranking for North Lahontan Region

Option	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o – New and Existing Development	M	[a]	1	1
Indoor Water Use (55 gpcd)	M	600	1	1
Groundwater/Conjunctive Use				
Agricultural Groundwater Development	M	[a]	[a]	[a]

[a] Data not available to quantify.

TABLE 9-6

Options Most Likely to be Implemented by 2020 (taf)
North Lahontan Region

	Average	*Drought*
Applied Water Shortage[a]	**10**	**128**
Options Likely to be Implemented by 2020		
Conservation	—	—
Modify Existing Reservoirs/Operations	—	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive Use	—	—
Water Marketing	—	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	—	—
Expected Reapplication	—	—
Remaining Applied Water Shortage	**10**	**128**

[a] Majority of shortages in this region are agricultural.

FIGURE 9-3

South Lahontan Hydrologic Region

South Lahontan Hydrologic Region

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Description of the Area

The South Lahontan Region encompasses the area from the drainage divide between the Walker River and Mono Lake Basin to the divide south of the Mojave River (Figure 9-3). The region is bordered on the east by the Nevada stateline and on the west by the crest of the southern Sierra Nevada and San Gabriel Mountains. The region includes all of Inyo County and parts of Mono, San Bernardino, Kern, and Los Angeles Counties. Prominent geographic features of the region are Owens Valley and Death Valley. The region contains the highest and lowest points in the lower 48 states—Mount Whitney (elevation 14,495 feet) and Death Valley (elevation 282 feet below mean sea level).

The region includes several closed drainage basins and many desert valleys containing central playas, or dry lakes. Major waterbodies in the region are, from north to south, Mono Lake, Owens River, and Mojave River. The Amargosa River contains water only during rare flash floods. Floodwaters in the Amargosa River would eventually flow south to a sink area at the Silver Lake and Soda Lake Playas. This sink area is also the terminus of the Mojave River, which flows eastward from its headwaters in the San Bernardino Mountains across the Mojave Desert to the playa lakes. Average annual precipitation for the region's valleys ranges between 4 and 10 inches. Death Valley receives only 1.9 inches annually. The Sierra Nevada can receive up to 50 inches annually, much of it in the form of snow. In some years, the community of Mammoth Lakes can have snow accumulations of more than 10 feet.

The Joshua Tree, a member of the yucca family, is endemic to the Mojave Desert.

Although sparsely populated, the region contains some rapidly growing urban areas, including the Cities of Lancaster and Palmdale in Antelope Valley (Los Angeles County) and the Cities of Victorville, Hesperia, and Apple Valley in San Bernardino County. Many residents in these areas have chosen a long commute to the greater Los Angeles area in exchange for affordable housing. Future population growth in the region is expected to be concentrated in communities within commuting distance of the Los Angeles area. Bishop, Ridgecrest, and Barstow are other population centers in the region. The economies of these and other small towns in the eastern part of the region are tied to the region's military facilities and other governmental employers, and to providing services for travelers and tourists.

Public lands constitute about 75 percent of the region's area, providing a major recreational resource. Popular destinations in the region include the Mono Lake area, June Lakes and Mammoth Lakes, Inyo National Forest, Death Valley National Monument, and the recently created Mojave National Preserve. Only about 1 percent of the region's land is used for urban and agricultural purposes. Most of the irrigated acreage, primarily alfalfa and pasture, is in the Mono-Owens PSA. (This PSA includes Owens Valley, the Lake Crowley area northwest of Bishop, and Hammil and Fish Lake Valleys.) Some deciduous orchard acreage is found in the western part of the region. Table 9-7 shows population and crop acreage for the region.

The Owens River, with the Sierra Nevada in the background.

TABLE 9-7

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	713	61
2020	2,019	45

Major perennial waterbodies in the region are Mono Lake and Owens River. Since relatively little surface water is available in the rest of the region, the region's environmental water use is concentrated in the Mono Lake-Owens Valley corridor. The major environmental water use requirements are associated with maintenance of Mono Lake levels and fishery instream flow requirements for the Owens River system. DFG operates four fish hatcheries in the Mono-Owens area: Mt. Whitney, Big Springs, Hot Creek, and Black Rock Hatcheries.

The largest surface water development in the region is the Los Angeles Aqueduct and its associated facilities, described in the following section. There are also a few relatively small, high-elevation dams operated by Southern California Edison for nonconsumptive hydropower purposes. These dams do not provide water supply for the region. SWP's 75 taf Lake Silverwood on the East Branch of the California Aqueduct regulates and stores imported water.

Water Demands and Supplies

The water budget for the South Lahontan Region is shown in Table 9-8. Increased environmental water demands from recently settled court actions involving LADWP's water diversions from the Owens Valley and Mono Lake are reflected in the base water budget. A pending order issued by an air pollution control district in 1997 could increase environmental water demands in the region. This increase is not included in the water budget because final action has not yet been taken (see the local water resources management issues section).

Los Angeles Aqueduct

The Los Angeles Aqueduct is the region's major water development feature, although it does not serve water to the region. In 1913, the first pipeline of LAA was completed and began conveying water from Owens Valley to the City of Los Angeles. The aqueduct was extended north of the Mono Basin and diversions be-

TABLE 9-8

South Lahontan Region Water Budget (taf)[a]

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	238	238	619	619
Agricultural	332	332	257	257
Environmental	107	81	107	81
Total	**676**	**651**	**983**	**957**
Supplies				
Surface Water	322	259	437	326
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**712**	**649**
Shortage	**89**	**92**	**270**	**308**

[a] Water use/supply totals and shortages may not sum due to rounding.

gan in 1940. A second pipeline was completed in 1970, increasing the aqueduct's annual delivery capacity to about 550 taf/yr. Both aqueducts terminate at the 10 taf Los Angeles Reservoir in the South Coast Region. The first aqueduct begins at the intake on Lee Vining Creek and the second begins at Haiwee Reservoir.

There are eight reservoirs in the LAA system with a combined storage capacity of about 323 taf (Table 9-9). These reservoirs were constructed to store and regulate flows in the aqueduct. The northernmost reservoir is Grant Lake in Mono County. Six of the eight reservoirs are located in the South Lahontan Region. Bouquet and Los Angeles Reservoirs are in the South Coast Region.

TABLE 9-9

Los Angeles Aqueduct System Reservoirs

Reservoir	*Capacity (taf)*	*County*
Grant	47	Mono
Crowley	183	Mono
Pleasant Valley	3	Inyo
Tinemaha	6	Inyo
Haiwee	39	Inyo
Fairmont	0.5	Los Angeles
Bouquet	34	Los Angeles
Los Angeles	10	Los Angeles

Water from both aqueducts passes through 12 powerplants on its way to Los Angeles. The annual energy generated is over 1 billion kWh, enough to supply the needs of 220,000 homes.

State Water Project

The East Branch of the California Aqueduct follows the northern edge of the San Gabriel Mountains, bringing imported water to Silverwood Lake. Table 9-10 shows SWP contractors in the region and their contractual entitlements.

Antelope Valley-East Kern Water Agency, the largest SWP contractor in the region, serves 5 major and 16 small municipal agencies, as well as Edwards AFB, Palmdale Air Force Plant 42, and U.S. Borax and Chemical Facilities. AVEK was formed to bring imported water into the area.

Mojave Water Agency was created in 1960 in response to declining groundwater levels in the area. Communities within MWA's boundaries have no source of supply other than groundwater. Communi-

TABLE 9-10

SWP Contractors in the South Lahontan Region

Contractor	*Annual Entitlement (taf)*	*1995 Deliveries (taf)*
Antelope Valley-East Kern WA	138.4	47.3
Crestline-Lake Arrowhead WA	5.8	0.4
Littlerock Creek ID	2.3	0.5
Mojave WA	75.8	8.7
Palmdale WD	17.3	7.0

ties served by MWA include Barstow, Apple Valley, Hesperia, and Victorville. While most of MWA's service area is within the South Lahontan Region, the service area extends into the Colorado River Hydrologic Region (the Lucerne and Johnson Valleys and the Morongo Basin). Part of MWA's SWP entitlement (7.3 taf) is allocated to that area.

MWA has taken little of its SWP entitlement to date, due to lack of conveyance facilities. In 1994, MWA completed its Morongo Basin pipeline, a 71-mile pipeline with a capacity of 100 cfs from the SWP's East Branch to the Mojave River (7 miles) and then 20 cfs to Morongo Basin and Johnson Valley. This pipeline allows MWA to bring SWP water into part of its large (almost 5,000 square miles) service area. In 1997, MWA began construction of its 71-mile Mojave River Pipeline (94 cfs capacity) to bring imported water to Barstow and neighboring cities. The El Mirage Aqueduct is the next proposed addition to its distribution system. The aqueduct would deliver approximately 4 taf of imported water annually from the East Branch to the westernmost subarea of the Mojave River Basin near El Mirage. Imported water would be used to recharge the area's overdrafted groundwater basin.

In 1997, MWA and Berrenda Mesa Water District (a member agency of KCWA) concluded the permanent transfer of 25 taf of SWP annual entitlement, thereby increasing MWA's total annual entitlement to 75.8 taf.

Littlerock Reservoir is one of the few surface water storage facilities in the Mojave Desert area. The original dam at this site was a multi-arch concrete structure. This photo shows the dam after its seismic rehabilitation.

Local Surface Water Supplies

The Mammoth Community Water District supplies the town of Mammoth Lakes, located at the northern end of the region. About 70 percent of MCWD's supply comes from Lake Mary, the largest of a number of small alpine lakes in the Mono Lakes Basin. At present, the remainder of MCWD's supply comes from groundwater. Although MCWD serves a permanent population of only about 5,000 people, its average daily population is about 13,000, with peak weekends and holiday periods reaching 30,000 people per day. These wide fluctuations in service levels above the base population are typical of the recreational and resort communities in the area.

Although the Mojave River appears on maps as a major waterway in the region, it is an ephemeral stream for much of its length. Local communities extract groundwater, which is recharged by river flows, but do not directly divert significant amounts of surface water from the river. There is one dam on the Mojave River at the base of the San Bernardino Mountains—Mojave River Forks Dam, a 90 taf USACE flood control facility.

The 3.5 taf capacity Littlerock Reservoir provides water supply to Littlerock Creek Irrigation District and to Palmdale Water District. PWD funded most of a recent seismic rehabilitation of the 1924-vintage dam in exchange for control of the water supply for 50 years. Water from Littlerock Reservoir may be released into a ditch that conveys flows to PWD's Lake Palmdale, a 4.2 taf storage reservoir.

In the San Bernardino Mountains, Lake Arrowhead, owned by the Arrowhead Lake Association, is a 48 taf reservoir providing recreational opportunities and water supply for lakeshore residents.

Groundwater Supplies

Historically the South Lahontan Region has relied mostly on groundwater, which is the only water supply available in most parts of the region. Groundwater basin capacities in the Mojave River and Antelope Valley PSAs, for example, total about 70 maf each. (Economically usable storage is significantly less than this amount.) Water quality influences groundwater use. Some areas in the Mono-Owens area have highly mineralized groundwater due to geothermal activity, while saline groundwater is not uncommon in areas near playa lakes.

The Mojave River groundwater basin is a large alluvial formation in the Mojave Desert, the only local

Surface water is found in most desert waterways only after infrequent storms. If local groundwater resources are not sufficient to supply an area's needs, water must be imported to augment local supplies. This photo shows the Mojave River bed at Red Rock Canyon.

water source for residents in the western third of San Bernardino County (part of the basin is in the Colorado River Region). The Mojave River and groundwater basin act as one water source, with the river recharging the basin and groundwater discharging in several places to provide surface flows in the river. The basin is divided into subareas at hydrogeologic boundaries including the Helendale and Waterman Faults. The operational storage capacity of the basin is about 4.9 maf; currently there is about 3.0 maf of water in storage. The basin has experienced declining groundwater levels due to overextractions (see Mojave River adjudication section).

The Antelope Valley groundwater basin underlies the closed drainage in the westernmost part of the Mojave Desert in northern Los Angeles and southeastern Kern Counties. It provides most of the local water supplies to users in the high desert from the San Gabriel Mountains to the Sierras, including Edwards Air Force Base. Agricultural pumping from the basin has declined for several decades while urban extraction has increased due to rapid population growth.

Local Water Resources Management Issues

Owens Valley Area

In 1972, Inyo County filed suit against the City of Los Angeles, claiming that increased groundwater pumping for the second aqueduct was harming the Owens Valley environment. Inyo County asked that LADWP's groundwater pumping be analyzed in an

Searles Lake

The Mojave Desert has numerous playa lakes, dry or semi-dry lakebeds that occupy topographic low points in closed drainage basins. Playa lakes contain surface water only briefly after the region's infrequent rains. There may, however, be high groundwater levels immediately beneath an apparently dry lakebed. Groundwater found near these lakebeds is usually too mineralized for most beneficial uses, because salts have been concentrated in lakebed deposits during evaporation of the surface waters. Searles Lake in northwestern San Bernardino County is an example of an extremely mineralized playa lake.

Within geologic time, California's climate was much wetter than it is today. During the late Quaternary Period, the Owens River flowed into several (now dry) lakes in the Mojave Desert, filling Searles Lake to a depth of over 600 feet. Long-term deposition of evaporates in the lakebed created thick layers of salts and borate minerals. These deposits have been the basis of extensive mining operations at the lake, estimated to have produced more than $1 billion worth of mineral commodities.

Borax mining at the lakebed began as early as 1874. Current mining techniques entail pumping brines from lakebed sediments and processing them at onsite chemical plants to produce commodities such as sodium carbonate, sodium borate, and sodium sulfate. These chemicals are used in the manufacture of drugs, dyes, glass, glazes, paper, soap, detergent, enamel, chemical products, abrasives, gasoline additives, fire retardants, and metal alloys.

EIR. LADWP prepared an EIR in 1976 and another in 1979, both of which the Third District Court of Appeals found inadequate. In 1983, Inyo County and LADWP decided to work together to develop an EIR and water management plan to settle the litigation.

A third EIR was prepared jointly by LADWP and Inyo County and released in 1990. In 1991, both parties executed a long-term water management agreement delineating how groundwater pumping and surface water diversions would be managed to avoid significant decreases in vegetation, water-dependent recreational uses and wildlife habitat. Several entities challenged the adequacy of the EIR and in 1993 were granted *amici curiae* status by the Court of Appeals, allowing them to enter in the EIR review process. An agreement was subsequently executed in 1997, ending 25 years of litigation between Los Angeles and Inyo County.

LADWP and Inyo County have begun discussions on how to implement provisions of the agreements and EIR. Timelines for many provisions have already been developed and plans for major activities such as rewatering the Lower Owens River are under review.

Surface water diversions for Owens Valley agriculture from the Owens River began in the 1800s. The Los Angeles Aqueduct was completed in 1913. Owens Lake became a dry lakebed by 1929. On windy days, airborne particulates from the dry lakebed violate air quality standards in the southern Owens Valley. In 1997, the Great Basin Unified Air Pollution Control District ordered the City of Los Angeles to implement control measures at Owens Lake to mitigate the dust problems. Under the order, 8,400 acres of lakebed would be permanently flooded with a few inches of water, another 8,700 acres would be planted with grass and irrigated, and 5,300 acres would be covered with a four-inch layer of gravel. This order could reduce the city's diversions by 51 taf/yr or about 15 percent of its supply. In July 1998, a compromise was reached when LADWP agreed to begin work at Owens Lake by 2001 and to ensure that federal clean air standards would be met by 2006. In turn, the APCD agreed to scale back the improvements sought in its 1997 order. Under this agreement, LADWP's dust-control strategy may include shallow flooding, vegetation planting, and gravel placement. The implementation schedule requires that 6,400 acres of lakebed be treated by the end of 2001. By the end of 2006, an additional 8,000 acres would be treated, plus any additional lakebed necessary to bring particulate counts into compliance with federal air quality standards. The plan hinges on final approval from the Los Angeles City Council, the APCD's board, and the State Air Resources Board. The agreement also requires EPA to grant a 5-year extension of Clean Air Act requirements that direct states to abate particulate pollution by 2001 or seek an extension until 2006.

Mono Basin

Mono Lake, located east of Yosemite National Park at the base of the eastern Sierra Nevada, is the second largest lake completely within California. It is recognized as a valuable environmental resource. The lake is famous for its tufa towers and spires, structures formed by years of mineral deposition by its saline waters. The lake has no outlet. There are two islands in the lake that provide a protected breeding area for large colonies of California gulls and a haven for migrating waterfowl.

Much of the water flowing into Mono Lake comes from snowmelt runoff. Since 1941, LADWP has diverted water from Lee Vining, Walker, Parker, and Rush Creeks into tunnels and pipelines that carry the water to the Owens Valley drainage. There it is conveyed, together with Owens River flows, to Los Angeles via the LAA.

Diversions from its tributaries lowered Mono Lake's water level from elevation 6,417 feet in 1941 to a historic low of 6,372 feet in 1981. With decreased inflow of fresh water, the lake's salinity increased dramatically. When water levels drop to 6,375 feet or lower, a land bridge to Negit Island is created, allowing predators to reach gull rookeries; this first happened in 1978 and again during the 1987-92 drought.

As a result of these impacts, the lake and its tributaries have been the subject of extensive litigation between the City of Los Angeles and environmental groups since the late 1970s. In 1983, the California Supreme Court ruled that SWRCB has authority to reexamine past water allocation decisions and the responsibility to protect public trust resources where feasible. SWRCB issued a final decision on Mono Lake (Decision 1631) in 1994. The amendments to LADWP's water right licenses are set forth in the order accompanying the decision.

The order sets instream flow requirements for fish in each of the four streams from which LADWP diverts water. The order also establishes water diversion criteria to protect wildlife and other environmental resources in the Mono Basin. These water diversion criteria prohibit export of water from Mono Basin until the lake level reaches 6,377 feet, and restrict Mono Basin water exports to allow the lake level to rise to an elevation of 6,391 feet in about 20 years. Once the water level of 6,391 feet is reached, it is expected that LADWP will be able to export about 31 taf/yr of water from the basin. The order requires LADWP to prepare restoration plans for the four streams from which it diverts and to restore part of the waterfowl habitat which was lost due to lake level decline. In May 1997, parties to the restoration planning process presented a signed settlement on Mono Basin restoration to the SWRCB. If approved, the settlement would guide restoration activities and annual monitoring through 2014. Parties to the settlement include LADWP, the Mono Lake Committee, DFG, State Lands Commission, DPR, California Trout, National Audubon Society, USFS, BLM, and The Trust for Public Land.

Key features of stream restoration plan include restoring peak flows to Rush, Lee Vining, Walker, and Parker Creeks; reopening abandoned channels in Rush Creek; and developing a monitoring plan. One of the restoration actions required by SWRCB—bypassing sediment around LADWP diversion dams—was deferred for further analysis. The waterfowl habitat restoration plan proposes that a Mono Basin waterfowl habitat restoration foundation administer a $3.6 million trust established by LADWP. Five of the parties to the agreement would serve as initial members of the foundation. Activities would include annual monitoring, restoring open water habitat adjacent to the lake, and rewatering Mill Creek. LADWP would continue its brine shrimp productivity studies, open several channels on Rush Creek, and make its Mill Creek water rights available for rewatering Mill Creek, based on the recommendations of the foundation.

The plans are being considered by SWRCB and a decision is expected at the end of 1998.

Mojave River Adjudication

The Mojave River groundwater basin has experienced overdraft since the early 1950s, with the largest increase in overdraft occurring in the 1980s. About 80 percent of basin recharge comes from the Mojave River. In 1990, the City of Barstow filed a complaint in Superior Court against the City of Adelanto seeking an average annual guaranteed flow of 30 taf to mitigate reduced runoff and declining groundwater levels in the Barstow area. The complaint also requested a writ of mandate against MWA to compel it to import water from the SWP. MWA filed a cross-complaint requesting a determination of water rights in the basin.

In 1991, the court ordered that the litigation be placed on hold to give parties time to negotiate a settlement and to develop a solution to the overdraft. A Mojave Basin adjudication committee was formed to facilitate data gathering and to draft a stipulated judgment and physical solution. The court's final ruling on basin adjudication was issued in January 1996. In its ruling, the court emphasized that the area has been in overdraft for decades and that MWA must alleviate overdraft through conservation and purchase of supplemental water. MWA was appointed as the basin watermaster.

The adjudication stipulated that any party pumping more than 10 af/yr became a party to the judgment and is bound by it. The judgment stated that each party has a right to its base annual production, which was its highest usage between 1986 and 1990. The judgment also required MWA to reduce this amount by at least 5 percent each year for four years as one way to achieve a physical solution to the longstanding overdraft. Any party exceeding its annual allotment must purchase replenishment water from MWA or from other parties to the judgment. If there is still overdraft after the end of the first five years of the stipulated judgment, water use in overdrafted subareas will be further reduced. The judgment recognized five basin subareas and required that if an upstream subarea does not meet its obligation to a downstream subarea, the upstream area must pay for supplemental water.

Supplemental water for the Mojave River Basin will come from MWA's SWP entitlement, or from water marketing arrangements, and will be delivered through the California Aqueduct. In March 1997, MWA began constructing its Mojave River pipeline, extending about 71 miles from the California Aqueduct to Newberry Springs, a rural community east of Barstow. MWA also recently purchased the permanent right to 25 taf of additional SWP annual entitlement, nearly a 50 percent increase from the agency's previous entitlement. The combination of reduced pumping, increased SWP deliveries and other imports, and new delivery facilities are expected to reduce overdraft in the basin.

Antelope Valley Water Management

The Antelope Valley Water Group was formed in 1991 to provide coordination among valley water agencies and other interested entities. AVWG members include the Cities of Palmdale and Lancaster, Edwards AFB, AVEK, Antelope Valley United Water Purveyors Association, Los Angeles County Waterworks Districts, PWD, Rosamond Community Services District, and Los Angeles County. AVWG completed an Antelope Valley water resources study in 1995 to address regional water management issues.

The study evaluated the valley's existing and future water supplies from groundwater, the SWP, Littlerock Reservoir, and recycling, and compared these supplies with projected water demands. The study concluded that water supply reliability is low in the study area—full 1998 demands would be met only half the time without overdrafting groundwater resources. The study recommended water conservation, recycling, and conjunctive use measures to reduce expected shortages. The study identified three sites (two on Amargosa Creek and one on Littlerock Creek) with high potential for groundwater recharge through spreading and identified SWP water, recycled water, and local runoff as potential recharge sources. The study also identified several potential groundwater injection sites within existing Los Angeles County Waterworks and PWD municipal wellfields. Treated SWP water was identified as a potential recharge source.

In 1996, PWD adopted a water facilities master plan for its service area, updating a 1988 plan. PWD relies on three water sources: Littlerock Reservoir, local groundwater, and SWP water. The plan indicates that about 40 percent of PWD supply is from groundwater. Declining groundwater levels have been a local concern in the Palmdale area, although extractions presently appear to be within the basin's perennial yield. The plan also indicates that existing supplies are insufficient to meet drought demands. Average year shortages are projected to occur by 2005.

To meet drought year demands, the plan calls for the construction of up to 12 new production wells. The plan's draft EIR identified declining groundwater levels as an unavoidable impact of constructing new wells. Mitigation measures recommended included conservation and drought year demand reduction, conjunctive use programs (as identified in the Antelope Valley water resources study), acquisition of an additional 3.1 taf/yr of SWP entitlement, participation in water transfers, and development of recycled water.

Interstate Groundwater Basins

California and Nevada share three interstate groundwater basins in the South Lahontan Region: Fish Lake Valley, crossed by Highway 168 east of Westgard Pass; Pahrump Valley, located to the east of Death Valley; and Mesquite Valley, just south of Pahrump Valley. Groundwater extraction on the California side of the border supports small-scale agricultural development, largely for alfalfa. Pahrump Valley is the most populated of the three valleys; most of its development is located in Nevada around the community of Pahrump. Pahrump and Mesquite Valleys are within about 35 miles of the rapidly growing Las Vegas metropolitan area. In the early 1990s, the Southern Nevada Water Authority proposed exporting groundwater from several rural counties in central Nevada to help meet Las Vegas' rapidly increasing need for water. Opposition by rural Nevada counties to SNWA's proposal caused SNWA to defer this project. Inyo County residents have historically been concerned about the proximity of Las Vegas to the interstate basins, although no new interstate issues have come up since SNWA's proposed project.

Water Management Options for the South Lahontan Region

Table 9-11 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-2 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Reducing outdoor water use to 0.8 ET_o in new development would attain 20 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by 31 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would attain depletion reductions of 7 and 15 taf/yr, respectively. Reducing CII water use by an additional 3 and 5 percent would attain 2 and 4 taf/yr of depletion reductions, respectively. Reducing distribution system losses to 7 and 5 percent would save 4 and 12 taf/yr, respectively.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs

TABLE 9-11

South Lahontan Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Remove Sediment from Littlerock Reservoir	Defer	Excessive costs for additional yield.
New Reservoirs/Conveyance Facilities		
—	—	—
Groundwater/Conjunctive Use		
—	—	—
Water Marketing		
Mojave Water Agency	Retain	
Palmdale Water District	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options in this region do not generate new water supply.
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
Line Palmdale Ditch	Defer	No net increase in supply.
Reduce Outflow to Playa Lakes	Defer	Restrictions on use of flows that provide recharge to overdraft basins. Costs are high and water quality is poor.
Statewide Options		
—	—	See Chapter 6.

are considered as options. It is estimated that water savings of 2, 3, and 5 taf/yr could be achieved in this region, by improving SAE to 76, 78, and 80 percent, respectively. Options for flexible water delivery and canal lining and piping are not feasible in this region because most water supply comes from individual wells with minimal conveyance facilities.

Modify Existing Reservoirs or Operations

Sediment has accumulated in Littlerock Reservoir and minor additional yield could be realized by removing the sediment. Studies are now under way to evaluate the costs and benefits of this option. Preliminary estimates indicate that the cost of this option is in the order of $2,000/af. Because of the high costs, this option was deferred.

New Reservoirs or Conveyance Facilities

There are no proposed new reservoir developments in this region. The region's aridity and consequent lack of surface water resources make new reservoirs infeasible. Future local water resources development will be based on groundwater sources.

Water Marketing

The California Aqueduct could convey purchased water to MWA's distribution system to supply some of the region's rapidly urbanizing areas. MWA has entered into a multi-year banking and exchange agreement with Solano County Water Agency. During wet years, SCWA can bank up to 10 taf of its annual SWP entitlement in MWA's groundwater basin. During drought years, SCWA can take part of MWA's SWP entitlement in exchange (up to half the banked amount with a maximum of 10 taf/yr). MWA is also pursuing two demonstration water marketing projects of 2 taf each. PWD is seeking to purchase 3.1 taf/yr of SWP entitlement from Central Valley agricultural water purveyors. Other voluntary marketing arrangements could be developed through option agreements, storage programs, and purchases of water through the DWB or other spot markets.

Capacity has been developed to store additional imported supplies in the Mojave River Basin at MWA's Rock Springs groundwater recharge facility near Hesperia. Additional recharge facilities in the Barstow area are in the final planning stages, which would further increase MWA's ability to take delivery of imported supplies when its Mojave River Aqueduct is completed. Sufficient basin storage is available to store water in wet years when more SWP supplies or purchased supplies might be available.

Water Recycling

Water recycling options are deferred for this region because planned projects would not generate new supply.

Other Local Options

The ditch that conveys water from Littlerock Reservoir to Palmdale Lake has an estimated 20 percent conveyance loss, which could be reduced by canal lining. Canal lining would reduce groundwater recharge by approximately 1 taf/yr, resulting in no net increase in water supply. This option was deferred.

Some flow of the Mojave River reaches Soda Lake where the flow is lost to evaporation. Annual outflow past Afton Canyon averages 8.4 taf. However, the basin adjudication restricts use of flows that provide recharge to downstream subareas of the basin that are in overdraft. Reducing outflow to Soda Lake was deferred as an option.

Likewise, local storm runoff collects in many small playas throughout the basin. These playas generally do not contribute to groundwater recharge, due to the low permeability of playa soils. Water collected in the playas evaporates, rather than recharging groundwater. Diversion or collection of runoff to playas and recharging it to groundwater basins could increase groundwater supplies by eliminating the evaporation. Six dry lakebeds could potentially store an additional 1.8 taf once every five years. Costs for this option are $1,000 to $3,300/af. Water quality at the playas is generally poor, with high levels of salts and minerals. This option was deferred.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the South Lahontan Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 270 taf in average years and 308 taf in drought years. Most of the region's shortage will be in the Mojave River planning subarea. Water shortages in the Antelope Valley subarea are forecast only in drought years. Ranking of retained water management options for the South Lahontan Region is summarized in Table 9-12. Table 9-13 summarizes options that can likely be implemented by 2020 to relieve the shortages. The options likely to be implemented in this region include SWP supplies and water transfers conveyed by the California Aqueduct.

TABLE 9-12

Options Ranking for South Lahontan Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o-New Development	M	750	20	20
Outdoor Water Use to 0.8 ET_o-New and Existing Development	M	b	31	31
Indoor Water Use (60 gpcd)	M	400	7	7
Indoor Water Use (55 gpcd)	M	600	15	15
Interior CII Water Use (3%)	M	500	2	2
Interior CII Water Use (5%)	M	750	4	4
Distribution System Losses (7%)	M	200	4	4
Distribution System Losses (5%)	M	300	12	12
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	2	2
Seasonal Application Efficiency Improvements (78%)	M	250	3	3
Seasonal Application Efficiency Improvements (80%)	M	450	5	5
Water Marketing				
Mojave Water Agency	H	b	4	4
Palmdale Water District (3.1 taf SWP entitlement)	H	b	3	2
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 9-13.
[b] Data not available to quantify.

TABLE 9-13

Options Most Likely to be Implemented by 2020 (taf)
South Lahontan Region

	Average	*Drought*
Applied Water Shortage	**270**	**308**
Options Likely to be Implemented by 2020		
Conservation	56	56
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	-
Water Marketing	7	6
Recycling	-	-
Desalting	-	-
Other Local Options	-	-
Statewide Options	174	204
Expected Reapplication	33	42
Total Potential Gain	**270**	**308**
Remaining Applied Water Shortage	**0**	**0**

FIGURE 9-4

Colorado River Hydrologic Region

Colorado River Hydrologic Region

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Description of the Area

The Colorado River Region encompasses the southeastern corner of California. The region's northern boundary, a drainage divide, begins along the southern edge of the Mojave River watershed in the Victor Valley area of San Bernardino County and extends northeast across the Mojave Desert to the Nevada stateline. The southern boundary is the Mexican border. A drainage divide forms the jagged western boundary through the San Bernardino, San Jacinto, and Santa Rosa Mountains, and the Peninsular Ranges (including the Laguna Mountains). The Nevada stateline and the Colorado River (the boundary with Arizona) delineate the region's eastern boundary (Figure 9-4).

Covering over 12 percent of the total land area in the State, the region is California's most arid. It includes volcanic mountain ranges and hills; distinctive sand dunes; broad areas of Joshua tree, alkali scrub, and cholla communities; and elevated river terraces. Much of the region's topography consists of flat plains punctuated by hills and mountain ranges. The San Andreas fault traverses portions of the Coachella and Imperial Valleys. A prominent topographic feature is the Salton Trough in the south-central part of the region.

The climate for most of the region is subtropical desert. Average annual precipitation is much higher in the western mountains than in the desert areas. Winter snows generally fall above 5,000 feet; snow depths can reach several feet at the highest levels during winter. Most of the precipitation in the region falls during the winter; however, summer thunderstorms can produce rain and local flooding. Despite its dry climate and rugged terrain, the region contains large and productive agricultural areas and popular vacation resorts. Table 9-14 shows the region's population and crop acreage for 1995 and 2020.

TABLE 9-14
Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	533	749
2020	1,096	750

Coachella Valley date palms. The Colorado River Region is the main location in California where dates are grown for commercial production.

Most of the population is concentrated in the Coachella and Imperial Valleys. Major cities in the Coachella Valley include Palm Springs, Indio, and Palm Desert. Other urban centers in the region are the Cities of El Centro, Brawley, and Calexico in Imperial Valley; the Cities of Beaumont and Banning in the San Gorgonio Pass area; and the Cities of Needles and Blythe along the Colorado River.

Agriculture is an important source of income for the region. Almost 90 percent of the developed private land is used for agriculture, most of which is in the Imperial, Coachella, and Palo Verde Valleys. The primary crops are alfalfa, winter vegetables, spring melons, table grapes, dates, Sudan grass, and wheat. Recreation and tourism are another important source of income for the region. In Coachella Valley, the Palm Springs area and adjoining communities are an important resort and winter golf destination. Recreational opportunities provided by the more than 100 golf courses in the Coachella Valley, water-based recreation on the Colorado River and Salton Sea, and desert camping all contribute to the area's economy.

Water Demands and Supplies

Table 9-15 shows the water budget for the Colorado River Region. Agricultural water demand makes up the majority of the water use in the region. There are two major areas where water is used for wildlife habitat in the region, the Salton Sea National Wildlife Refuge and the Imperial Wildlife Area. There are also several private wetlands.

About 90 percent of the region's water supply is from surface deliveries from the Colorado River (through the All American and Coachella Canals, local diversions, and the Colorado River Aqueduct by means of an exchange for SWP water). Other supplies are from groundwater, SWP water, local surface water, and recycled water. Bulletin 160-98 base year groundwater overdraft in the region was estimated to be about 70 taf and occurs in the Coachella Valley.

Major water agencies in the region are the Palo Verde Irrigation District, Imperial Irrigation District, Coachella Valley Water District, Bard Water District, Mojave Water Agency, Desert Water Agency, and San Gorgonio Pass Water Agency.

The region's primary shortages with existing supplies are expected to occur in the Coachella planning subarea because of groundwater overdraft. (In the future, reduction in California's Colorado River water use to the State's basic apportionment creates an average year shortage of as much as 0.9 maf in the South Coast Region. This 2020 shortage is shown in the South Coast water budget.)

Supplies from the Colorado River

Most of the water supply in the region comes from the Colorado River, an interstate (and international) river whose use is apportioned among the seven Colorado River Basin states by a complex body of statutes, decrees, and court decisions known collectively as the law of the river. Table 9-16 summarizes key elements of the law of the river. USBR acts as the watermaster for the Colorado River, and all users of Colorado River water must contract with USBR for their supplies. Figure 9-4 shows the locations of key Colorado River storage and conveyance facilities.

TABLE 9-15

Colorado River Region Water Budget (taf)[a]

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	418	418	740	740
Agricultural	4,118	4,118	3,583	3,583
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,367**	**4,366**
Supplies				
Surface Water	4,154	4,128	3,920	3,909
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,221**	**4,208**
Shortage	**69**	**95**	**147**	**158**

[a] Water use/supply totals and shortages may not sum due to rounding.

Hoover Dam and Lake Mead. Lake Mead and Lake Powell are the largest of the Colorado River system reservoirs.

Courtesy of USBR

TABLE 9-16

Key Elements of the Law of the River

Document	*Date*	*Main Purpose*
Colorado River Compact	1922	Equitable apportionment of the water from the Colorado River system between the two basins. The Upper Basin and the Lower Basin are each provided a basic apportionment of 7.5 maf annually of consumptive use. The Lower Basin is given the right to increase its consumptive use an additional 1 maf annually.
Boulder Canyon Project Act	1928	Authorized USBR to construct Boulder (Hoover) Dam and the All American Canal (including the Coachella Canal), and gave congressional consent to the Colorado River Compact. Also provided that all users of Colorado River water must enter into a contract with USBR for use of the water.
California Limitation Act	1929	Limited California's share of the 7.5 maf annually apportioned to the Lower Basin to 4.4 maf annually, plus no more than half of any surplus waters.
Seven Party Agreement	1931	An agreement among PVID, IID, CVWD, MWDSC, City of Los Angeles, City of San Diego, and County of San Diego to recommend to the Secretary of Interior how to divide use of California's apportionment among the California water users. Details are shown in Table 9-17.
U.S. - Mexican Treaty	1944	Guarantees Mexico a supply of 1.5 maf annually of Colorado River water.
U.S. Supreme Court Decree in A***rizona v. California, et al.***	1964	Apportions water from the mainstream of the Colorado River among the Lower Division states. When the Secretary determines that 7.5 maf of mainstream water is available, it is apportioned 2.8 maf to Arizona, 4.4 maf to California, and 0.3 maf to Nevada. Also quantifies tribal water rights for specified tribes, including 131,400 af for diversion in California.
Colorado River Basin Project Act	1968	Requires Secretary of the Interior to prepare long-range operating criteria for major Colorado River reservoirs.
U.S. Supreme Court Decree in ***Arizona v. California, et al.***	1979	Quantifies Colorado River mainstream present perfected rights in the Lower Basin states.

TABLE 9-17

Annual Apportionment of Use of Colorado River Water
(all amounts represent consumptive use)

Interstate/International		
Upper Basin States (Wyoming, Utah, Colorado, New Mexico, small portion of Arizona)		7.5 maf
Lower Basin States (Arizona, Nevada, California)		7.5 maf
	Arizona	2.8 maf
	Nevada	0.3 maf
	California	4.4 maf
Republic of Mexico[a]		1.5 maf

[a] Plus 200 taf of surplus water, when available. Water delivered to Mexico must meet specified salinity requirements.

Intrastate (Seven Party Agreement)[b]	
Priority 1	Palo Verde Irrigation District (based on area of 104,500 acres).
Priority 2	Lands in California within USBR's Yuma Project (not to exceed 25,000 acres).
Priority 3	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys, and Palo Verde Irrigation District for use on 16,000 acres in the Lower Palo Verde Mesa.
Priorities 1 through 3 collectively are not to exceed 3.85 maf/yr. There is no specified division of that amount among the three priorities.	
Priority 4	MWDSC for coastal plain of Southern California-550,000 af/yr.
Priority 5	An additional 550,000 af/yr to MWDSC, and 112,000 af/yr for the City and County of San Diego[c].
Priority 6	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys, and Palo Verde Irrigation District for use on 16,000 acres in the Lower Palo Verde Mesa, for a total not to exceed 300,000 af/yr.
Total of Priorities 1 through 6 is 5.362 maf/yr.	
Priority 7	All remaining water available for use in California, for agricultural use in California's Colorado River Basin.

[b] Indian tribes and miscellaneous present perfected right holders that are not identified in California's Seven Party Agreement have the right to divert up to approximately 85 taf /yr (equating to about 50 taf/yr of consumptive use) within California's 4.4 maf basic apportionment. These users are presently consumptively using approximately 32 taf/yr (assuming about 25 taf/yr of unmeasured return flow).

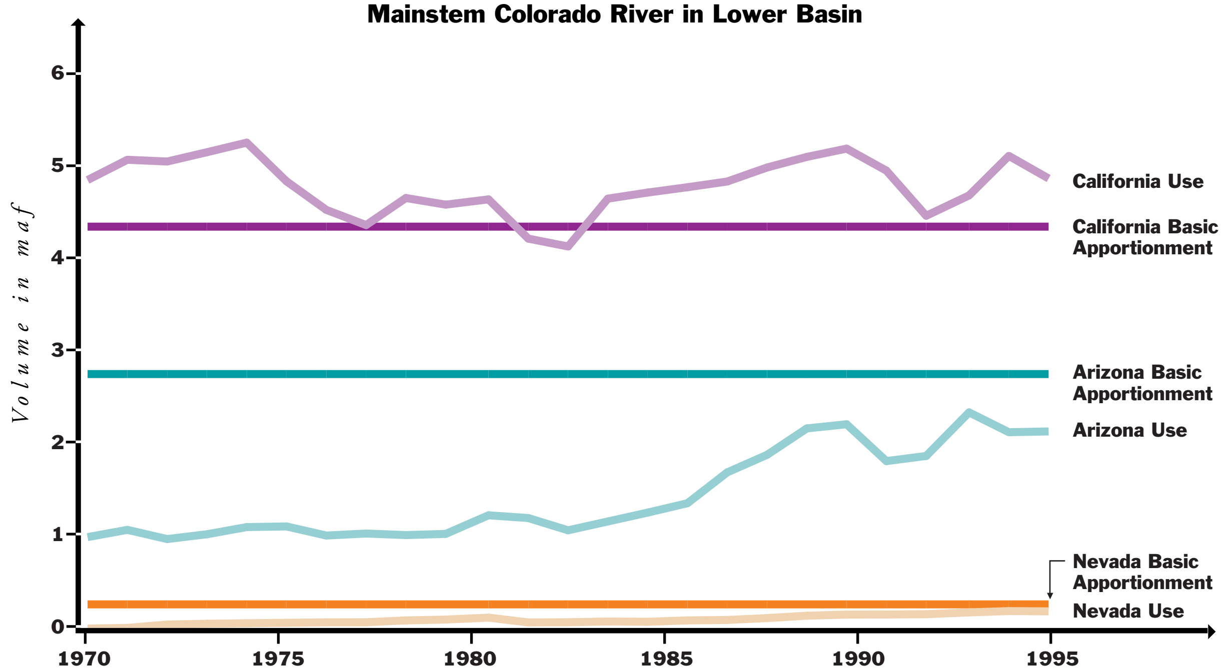
[c] Subsequent to execution of the Seven Party Agreement, San Diego executed a separate agreement transferring its apportionment to MWDSC.

Within California, local agencies' apportionments of Colorado River water were established under the Seven Party Agreement (Table 9-17), which has been incorporated into water delivery contracts which the Secretary of the Interior has executed with California water users. Uses occurring within a state are charged to that state's allocation. Thus, federal water uses or uses associated with federal reserved rights (e.g., tribal water rights) must also be accommodated within California's basic apportionment of 4.4 maf/yr plus one-half of any available surplus water.

The major local agencies in California using Colorado River water in the Colorado River Region are PVID, BWD, IID, and CVWD. The Reservation Division of USBR's Yuma Project provides water to Colorado River Indian tribes in California. The remainder of California's Colorado River water use occurs in the South Coast Region (Chapter 7). Figure 9-5 is a plot of Lower Basin states' apportionments compared with historical Colorado River water use. As shown in the figure, California's use has historically exceeded its basic apportionment, because California has been allowed to divert Arizona's and Nevada's unused apportionments, and to divert surplus water. With completion of the Central Arizona Project and the 1996 enactment of a state groundwater banking act,

FIGURE 9-5

Basic Apportionment and Consumptive Use of Mainstem Colorado River in Lower Basin



Arizona used more than its basic apportionment in 1997. Reduction of California's Colorado River use from current levels to 4.4 maf annually (when surplus water is not available) has significant water management implications for the South Coast Region. In calendar year 1996, actual consumptive use of the Lower Basin states (without considering USBR's unmeasured return flow credit of 239 taf) was:

Nevada	241 taf
Arizona	2,813 taf
California	5,256 taf
Total Lower Basin	8,310 taf

Within the Colorado River Region, IID, BWD, and PVID receive virtually all of their supplies from the Colorado River. IID and CVWD's Colorado River supplies are diverted into USBR's All American Canal at Imperial Dam; CVWD is served from the Coachella Branch of the AAC. PVID diverts via the Palo Verde Canal from the Colorado River near Blythe. BWD receives its supplies from facilities of USBR's Yuma Project, which serves lands in both California and Arizona.

The interstate allocations provided in the 1922 Compact were made after a period of relatively wet hydrology on the Colorado River. Some have suggested that the allocations overstate the river's normally available water supply, even without consideration of subsequent calls on that water supply for tribal water rights and endangered species fishery water needs. Table 9-18 provides an overview of average river hydrology. While consumptive use from the mainstem in the Lower Basin is assumed to be its basic apportionment of 7.5 maf, Upper Basin use is still well below its Colorado River Compact apportionment. Current

TABLE 9-18

Estimated Colorado River Flow and Uses[a]

	maf
Average Flow (1906-95)	
Upper Basin	15.1
Lower Basin	1.4
Total	**16.5**
Current Uses	
Upper Basin	3.8
Lower Basin (mainstem)[b]	7.5
Mexico	1.5
Mainstem Evaporation and Losses	1.9
Total	**14.7**
Average Flow into Reservoir Storage (16.5 - 14.7)	**1.8**

[a] Prepared by the CRB.

[b] Reflects restriction on MWDSC's diversion as Central Arizona Project and Southern Nevada Water System increase diversions to Arizona's and Nevada's basic apportionments.

USBR's Imperial Dam on the Colorado River. The structures in the foreground are a series of desilting basins used to reduce the sediment load of river water before it enters the All American Canal.

Courtesy of USBR

projections are that the Upper Basin will not reach its full Compact apportionment until after 2060.

Supplies from Other Sources

Local agencies contracting with the SWP for part of their supplies are shown in Table 9-19.

Neither CVWD nor DWA have facilities to take direct delivery of SWP water. Instead, both agencies have entered into exchange agreements with MWDSC, whereby MWDSC releases water from its Colorado River Aqueduct into the Whitewater River for storage in the upper Coachella Valley groundwater basin. In turn, MWDSC takes delivery of an equal amount of the agencies' SWP water. San Gorgonio Pass Water Agency, which serves the Banning/Beaumont area, also lacks the facilities to take delivery of SWP water, and to date has received no actual supply from the SWP. SGPWA will receive SWP supply when the Department completes its extension of the East Branch of the California Aqueduct in 2000.

Groundwater, local surface water, and water recycling provide the remaining supplies for this region. CVWD, working with DWA, has an active groundwater recharge program for the upper end of the Coachella Valley (generally, the urbanized part of the valley). CVWD recharges groundwater with imported Colorado River supplies and with Whitewater River flows using percolation ponds constructed in the Windy Point area. CVWD and DWA levy extraction fees on larger groundwater users in the upper Coachella

TABLE 9-19

SWP Contractors in the Colorado River Region

Agency	*Maximum Annual Contract Entitlement (taf)*	*SWP Deliveries in 1995 (taf)*
Coachella Valley WD	23.1	23.1
Desert Water Agency	38.1	38.1
Mojave Water Agency[a]	75.8	8.7
San Gorgonio Pass Water Agency	17.3	0

[a] Contract entitlement covers both South Lahontan and Colorado River Regions; 7.3 taf of this amount is allocated to Colorado River Region.

Valley. Imperial Valley, the largest water-using area in the region, does not have significant supplies of usable groundwater.

Local Water Resources Management Issues

Management of California's Colorado River Water

The major water management issue in this region is California's use of Colorado River water in excess of its basic annual apportionment of 4.4 maf. In the past, Arizona and Nevada were not using the full amount of their basic apportionments, and in accordance with the law of the river, California was able to use the amount apportioned to, but not used by, Nevada and Arizona. Discussions among the seven basin states and ten Colorado River Indian Tribes over changes to Colorado River operating criteria and ways for California to reduce its Colorado River water use began as early as 1991. The drought in Northern California prompted California to request that USBR make surplus water available, so that maximum use could be made of Colorado River water in Southern California. These discussions over changes to reservoir operations and how surplus or shortage conditions could be established continued for a time in a forum known as the "7/10 process."

More recently, the California local agencies, working through the Colorado River Board of California, have been developing a proposal for discussion with the other basin states to illustrate how, over time, California would reduce its use to the basic apportionment of 4.4 maf/yr. Drafts of the proposal, known as the Colorado River Board draft 4.4 Plan, have been shared with the other states. Efforts are being made to reach intrastate consensus on the plan in 1998. As Bulletin 160-98 goes to press, the most current version of the draft plan is the December 1997 version. The following text is based on that version.

As currently formulated, the draft plan would be implemented in two phases. The first phase (between the present and 2010 or 2015) would entail implementing already identified measures (such as water conservation and transfers) to reduce California's Colorado River water use to about 4.6 to 4.7 maf/yr. The second phase would implement additional measures to reduce California's use to its basic annual 4.4 maf apportionment in those years when neither surplus water nor other states' unused apportionments was available. One of the fundamental assumptions made in the plan is that MWDSC's Colorado River Aqueduct will be kept full, by making water transfers from agricultural users in the Colorado River Region to urban water users in the South Coast Region. (The Colorado River Aqueduct's capacity is a maximum of

Imperial Irrigation District, formed in 1911, acquired conveyance facilities constructed by a bankrupt privately owned irrigation company. In 1918, IID constructed Rockwood Heading (shown here) on the original canal system. Keeping the canal system from being choked by the Colorado River's high sediment loading was difficult; note the dredge shown in the background. These early facilities were subsequently replaced by the All American Canal.

Courtesy of Imperial Irrigation District.

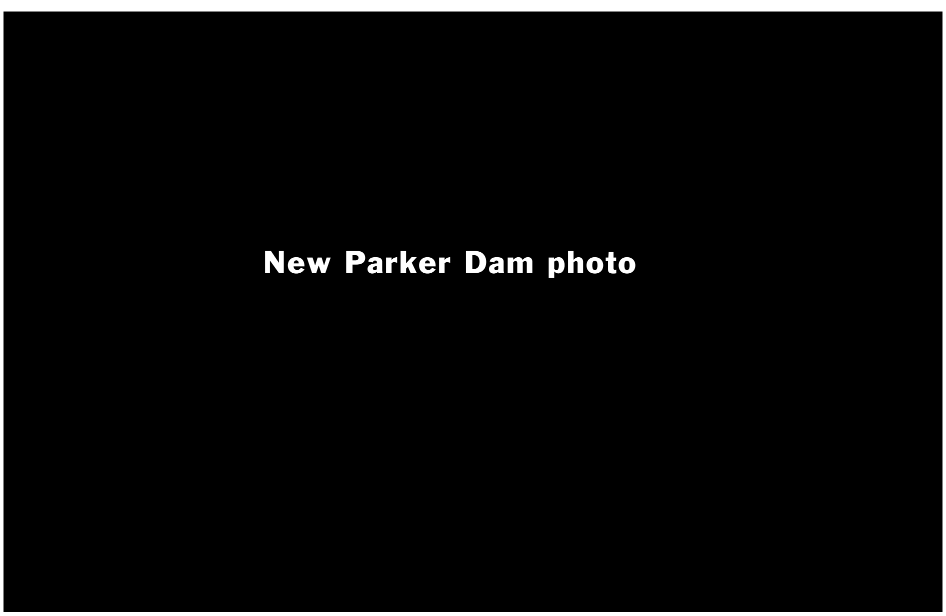
1.3 maf/yr. However, as shown in Table 9-17, MWDSC has a fourth priority right to only 550 taf annually—the remaining capacity of the aqueduct has historically been filled with unused apportionment water of other entities or with water from hydrologic surpluses.)

In the December 1997 draft plan, specific actions were included in the first phase: core water transfers (every year water transfers) such as the existing IID/MWDSC agreement and the proposed IID/SDCWA transfer; seepage recovery from unlined sections of the All American and Coachella Canals; drought year water transfers similar to the PVID/MWDSC pilot project; groundwater banking in Arizona; and conjunctive use of groundwater in areas such as the Coachella Valley. The actions are described in more detail below. The draft plan recognizes that transfers of conserved water must be evaluated in the context of preserving the Salton Sea's environmental resources, and also that plan elements must address environmental impacts on the lower Colorado River and its listed species.

Other actions to occur as part of the first phase would include implementation of the San Luis Rey Indian water rights settlement authorized in PL 100-675 and implementation of measures to administer agricultural water entitlements within the first three priorities of the Seven Party Agreement. Examples of such measures include quantifying amounts of water conserved or transferred, and annually reconciling water use with water allocations (e.g., overrun accounting).

An important element of the CRB draft 4.4 plan is the concept that existing reservoir operating criteria be changed by USBR to make optimum use of the river's runoff and available basin storage capacity. California agencies developed new proposed operating criteria that are included in the draft plan. The draft plan contemplates that changes in operating criteria would be part of both the first and second phases. The other basin states have been cautious in their reaction to California's proposals for reservoir reoperation, and have suggested, for example, that new criteria should not be implemented until California has prepared the environmental documents and executed the agreements that would be needed to begin implementation of the plan. (In its 1995 five-year review of Colorado River operating criteria, USBR had announced that it planned no changes to existing criteria.)

The second phase of the CRB draft 4.4 plan would include additional average year and drought year water transfers. Specifics on these transfers would be developed during the first phase of plan implementation. One suggested component is construction of desalting facilities on rivers tributary to the sea, to divert and treat agricultural drainage water that would otherwise enter the sea. The treated water could be conveyed to urban water users in the South Coast Region via the Colorado River Aqueduct. As with any alternative that would reduce the amount of relatively fresh water reaching the sea, the environmental impacts of this approach would require careful evaluation. Other components of the second phase would include further transfers of conserved agricultural water to the



USBR's Parker Dam on the Colorado River impounds Lake Havasu. At this location, the Colorado River forms the stateline between California and Arizona. MWDSC's Colorado River Aqueduct and the Central Arizona Project divert from Lake Havasu.

South Coast and further work on reservoir operating criteria. Implementation of some elements of phase two of the plan may extend beyond the Bulletin 160-98 planning horizon.

Tribal Water Rights

Colorado River Indian Tribes. As a result of the 1964 U.S. Supreme Court decree in Arizona v. California, California's basic apportionment of Colorado River water was quantified and five lower Colorado River Indian Tribes were awarded 905 taf of annual diversions, 131 taf of which were allocated for diversion in and chargeable to California pursuant to a later supplemental decree.

In 1978, the tribes asked the court to grant them additional water rights, alleging that the U.S. failed to claim a sufficient amount of irrigable acreage, called omitted lands, in the earlier litigation. The tribes also raised claims called boundary land claims for more water based on allegedly larger reservation boundaries than had been assumed by the court in its initial award. In 1982, the special master appointed by the Supreme Court to hear these claims recommended that additional water rights be granted to the Indian tribes. In 1983, however, the Supreme Court rejected the claims for omitted lands from further consideration and ruled that the claims for boundary lands could not be resolved until disputed boundaries were finally determined. Three of the five tribes—Fort Mojave Indian Tribe, Quechan Indian Tribe, and Colorado River Indian Tribe—are pursuing additional water rights related to the boundary lands claims. A settlement has been reached on the Fort Mojave claim and may soon be reached on the CRIT claim. Both settlements would then be presented to the special master. The Quechan claim has been rejected by the special master on the grounds that any such claim was necessarily disposed of as part of a Court of Claims settlement entered into by the tribe in a related matter in the mid-1980s. As with all claims to water from the mainstem of the Colorado River and any determination by the special master, only the U.S. Supreme Court itself can make the final ruling.

If both the Fort Mojave and CRIT settlements were approved, the tribes would receive water rights in addition to the amounts granted them in the 1964 decree.

San Luis Rey Indian Water Rights Settlement Act. The San Luis Rey Indian Water Rights Settlement Act (Public Law No. 100-675; 102 Stat. 4000 [1988]) is to provide for the settlement of the reserved water rights claims of the La Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians. Litigation (affecting the interests of the United States, the City of Escondido, the Escondido Mutual Water Company, the Vista Irrigation District, and the Bands) and proceedings before the Federal Energy Regulatory Commission involved tribal water rights claims to the waters of the San Luis Rey River and questions about the validity of rights-of-way granted by the U.S. across tribal and allotted lands. The act authorizes and directs the Secretary of the Interior to arrange for a 16 taf/yr supplemental supply of water to benefit the Bands and the local communities. This supply can be obtained either from water development from public lands in California outside the service area of the CVP, from water salvaged as the result of lining part of the AAC or Coachella Canal, or through a contract with MWDSC. Title II of PL 100-675 authorized the Secretary of the Interior to line parts of the canals, and permitted the Secretary to enter into an agreement or agreements with PVID, IID, CVWD, and/or MWDSC for the construction or funding. The act did not authorize appropriation of federal funds for canal lining.

Colorado River Board of California

The Colorado River Board of California is the State agency responsible for administering California's Colorado River water allocation, and for dealing with the other basin states on river management issues. The Board is composed of six members representing the California agencies who were signatories to the 1931 Seven-Party Agreement, two public members, and two ex-officio members (the directors of the Department and DFG). The six local agencies represented on the CRB are CVWD, IID, LADWP, MWDSC, PVID, and SDCWA. CRB's office and staff are located in Glendale.

Water Conservation Programs

There have been several large-scale water conservation actions involving Colorado River water users, as shown in Table 9-20.

Salton Sea

The present day Salton Sea was formed in 1905, when Colorado River water flowed through a break in a canal that had been constructed along the U.S./Mexican border to divert the river's flow to agricultural lands

TABLE 9-20

Existing Colorado River Region Water Conservation Actions

Year	*Action*	*Participants*	*Comments/Status*	*Estimated Savings*
1980	Line 49 miles of Coachella Branch of All American Canal	USBR, CVWD, MWDSC	Project completed.	132 taf/yr
1988	IID distribution system improvements and on-farm water management actions	IID, MWDSC	Multi-year agreement, extends into 2033. Projects MWDSC has funded include canal lining, regulatory reservoir and spill interceptor canal construction, tailwater return systems, non-leak gates, 12-hour delivery of water, drip irrigation systems, linear-move irrigation systems, and system automation. MWDSC has funded over $150 million for conservation program costs through 1997.	107 taf/yr in 1998
1992	Groundwater banking in Arizona	MWDSC, CAWCD, SNWA	Test program to bank up to 300 taf.	MWDSC and SNWA have stored 139 taf in Arizona groundwater basins.
1992	PVID land fallowing	PVID, MWDSC	Project completed. Two-year land fallowing test program. Covered 20,215 acres in PVID. MWDSC paid $25 million to farmers over a two-year period.	Total of 186 taf was made available from the program, although the water was subsequently released from Lake Mead when flood control releases were made from the reservoir.
1995	Partnership agreement	USBR, CVWD	Provides, among other things, for studies to optimize reasonable beneficial use of water in the district.	N/A

in the Imperial Valley. Until that break was repaired in 1907, the full flow of the river was diverted into the Salton Sink, a structural trough whose lowest point is about 278 feet below sea level. Within geologic time, the Colorado River's course has altered several times. At times, the river discharged to the Gulf of California as it does today. At other times it flowed into the Salton Sink. Lake Cahuilla, the most recent of several prehistoric lakes to have occupied the Salton Sink, dried up some 300 years ago.

Over the long term, the sea's elevation has gradually increased, going from a low on the order of -250 feet in the 1920s to its present level of about -226 feet. The sea's maximum elevation in recent years was -225.6 in 1995. Since some shoreline areas are relatively flat, a small change in elevation can result in a large difference in the extent of shoreline submerged. Levees have been constructed to protect adjacent farmland and structures at some sites along the shoreline; the remaining managed acreage of the Salton Sea National Wildlife Refuge is also protected from the sea by levees.

The Salton Sea is the largest lake located entirely within California, with a volume of about 7.5 maf at its present elevation of -226 feet. The sea occupies a closed drainage basin—if there were no inflows to maintain lake levels, its waters would evaporate as did those of prehistoric Lake Cahuilla. The area's average annual precipitation is 3 inches or less, while average annual evaporation is in excess of 5 feet. The sea receives over 1 maf of inflow annually, primarily from

A false-color infrared satellite photo of the Salton Sea (January 1998 Landsat 5). The irrigated areas in Imperial Valley are clearly visible to the south of the sea, as are the Algodones Dunes to the southeast. The City of Mexicali and irrigated acreage in the Mexicali Valley can also be seen.

agricultural drainage. The largest sources of inflow (about 80 percent of the total) are the New and Alamo Rivers which drain agricultural lands in the Mexicali and Imperial Valleys and flow into the sea's southern end. The New River also receives untreated and minimally treated wastewater flows from the Mexicali area; monitoring results generally indicate that pollution associated with wastewater discharges does not reach the sea because of its distance from the Mexican border.

In 1924, President Coolidge issued an executive order withdrawing seabed lands lying below elevation -244 feet for the purpose of receiving agricultural drainage water. That order was expanded in 1928 to lands below elevation -220 feet. The sea supports water-based recreational activities, and has had a popular corvina fishery. During the 1950s, the highest per capita sport fishing catches in California were from the Salton Sea. Over the years, concerns about the sea's salinity have been voiced in the context of maintaining the recreational fishery that was established with introduced species able to tolerate high salinities.

The sea also provides important wintering habitat for many species of migratory waterfowl and shorebirds, including some species whose diets are based exclusively on the fish in the sea. Wetlands near the sea and adjoining cultivated agricultural lands offer the avian population a mix of habitat types and food sources. An area at the sea's south end was established as a national wildlife refuge in 1930, although most of that area is now under water as a result of the sea's rising elevation. Some of the 380 bird species wintering in the area include pelicans, herons, egrets, cranes, cormorants, ibises, ducks, grebes, falcons, plovers, avocets, sandpipers, and gulls. The Salton Sea is considered to be a major stopover point for birds migrating on the Pacific Flyway, and has one of the highest levels of bird diversity of refuges in the federal system.

Historically, salinity has been the water quality constituent of most concern at the sea. Present levels are about 44,000 mg/L TDS (seawater is about 35,000 mg/L TDS). This high level of salinity reflects long- term evaporation and concentration of salts found in its inflow. Selenium has been a more recent constituent of interest, due to its implications for

Roadrunners are one of the bird species found year-round in the Salton Sea area.

aquatic species. Although selenium levels in the water column in the sea are less than the federal criterion of 5*ug*/L, this concentration can be exceeded in seabed sediment and in influent agricultural drainage water. Agricultural drain flows also contribute significant nutrient loading to the sea, which supports large algal blooms at some times of the year. These algal blooms have contributed to odor problems and low dissolved oxygen levels in some areas of the sea.

Over the years, USBR and others have considered potential solutions to stabilize the sea's salinity and elevation. Most recently, the Salton Sea Authority (a joint powers authority consisting of Riverside and Imperial Counties, IID, and CVWD) and others have been performing appraisal level evaluations of some of the frequently suggested alternatives. Categories of alternatives considered include:

- Diking off part(s) of the sea to create evaporation pond(s) adjoining the primary water body. This approach would divert part of the sea's water into managed impoundments, where the water would be concentrated into a brine and the salts would eventually be removed. The facilities would be sized to maintain a primary waterbody at some desired salinity concentration and elevation. The desired salinity concentration would probably be near that of ocean water (or slightly greater) to maintain the recreational fishery.
- Pumping Salton Sea water and exporting it to some other location. Possible discharge locations include nearby dry desert lakebeds (to create evaporation ponds), evaporation ponds to be constructed near the sea, the Gulf of California, or the Laguna Salada in Mexico.
- Building treatment facilities (such as a desalting plant) to remove salts from inflows to the sea.
- Importing fresh water to the sea. The most apparent source would be the Colorado River, but only in years when flood control releases were being made in excess of U.S. needs.

Maintaining a viable Salton Sea has several water management implications. First will be the actions needed to stabilize the sea's salinity in the near-term, such as the Authority's diking proposal. Eventually, a long-term solution will need to be developed. A wide range of costs has been mentioned for a long-term solution, including amounts in the billion-dollar range. Some of the possible long-term solutions suggested would entail constructing facilities in Mexico, bringing a greater level of complexity to their implementation. Other water management programs in the region, such as proposals to transfer conserved agricultural water supplies, will have to be evaluated in terms of their impacts on the sea. Recent proposals to desalt water in the Alamo or New Rivers and to transport that water in the Colorado River Aqueduct to the South Coast for urban water supply have raised concerns about maintaining the sea's environmental productivity. Such proposals might be implemented as part of the second phase of CRB's draft 4.4 Plan. (In 1997, CVWD filed an application with the SWRCB for water rights to storm water flows and drainage flows in the Whitewater River at the sea's northern end. MWDSC made a similar filing for agricultural drainage flowing into the sea's southern end.)

Congressional legislation introduced in 1998 would authorize expenditure of federal funds for a multi-year study of the sea's resources and potential solutions for managing its salinity.

Coachella Valley Groundwater Overdraft

Most PSAs within the Colorado River Region have sufficient water to meet future water needs, with the exception of Coachella Valley. Groundwater overdraft is occurring in the upper (urbanized) part of the valley; DWA and CVWD have been managing extractions in that basin to minimize future overdraft. Imported surface water at the upper end of the valley has provided a source of recharge water.

Groundwater overdraft is also occurring in the

Groundwater recharge ponds at Windy Point, to the east of San Gorgonio Pass in Riverside County. Water from the Whitewater River, along with Colorado River Aqueduct supplies exchanged for SWP deliveries of CVWD and DWA, provides recharge in the upper Coachella Valley area.

lower (agricultural) portion of the valley, an area that roughly coincides with CVWD's Improvement District No.1. CVWD estimates that actual 1995 water use within the district was about 520 taf, part of which was supplied by overdrafting the groundwater basin. (Irrigators in the lower valley are supplied by surface water from the Coachella Canal and by groundwater.) The district is in the process of preparing a groundwater management plan for the lower valley, and has considered alternatives including basin adjudication, water conservation, water recycling, and direct or in lieu recharge with water imported from the Colorado River or from the SWP. CVWD estimates that overdraft in the lower valley is about 170 taf/yr. Overdraft calculated from Bulletin 160-98 water budgets is 70 taf/yr for the upper and lower valley combined.

Lower Colorado River Environmental Water Issues

Listed fish species on the mainstem of the Colorado River include the Colorado squawfish, razorback sucker, humpback chub, and bonytail chub. Restoration actions to protect these fish may affect reservoir operation and streamflow in the mainstem and tributaries. Other species of concern in the basin include the bald eagle, Yuma clapper rail, belted kingfisher, southwestern willow flycatcher, and Kanab ambersnail.

In 1993, USFWS published a draft recovery implementation plan for endangered fish in the upper Colorado River Basin. The draft plan included protecting instream flows, restoring habitat, reducing impacts of introduced fish and sportsfish management, conserving genetic integrity, monitoring habitat and populations, and increasing public awareness of the role and importance of native fish.

Problems facing native fish in the mainstem Colorado River and its tributaries will not be easily resolved. For example, two fish species in most danger of extinction, the bonytail chub and razorback sucker, are not expected to survive in the wild. Although there was a commercial razorback fishery until 1950, in recent years most stream and reservoir fisheries in the basin have been managed for non-native fish. These management practices have harmed residual populations of natives. Many native fish are readily propagated in hatcheries, and thus recovery programs include captive broodstock programs to maintain the species. Reestablishing wild populations from hatchery stocks will have to be managed in concert with programs to manage river habitat. For example, although 15 million juvenile razorback suckers were planted in Arizona streams from 1981-90, the majority of these planted fish were likely eaten by introduced predators. In 1994, the states of Colorado, Wyoming, and Utah reached an agreement with USFWS on protocols for stocking non-native fish in the Upper Basin—stocking protocols consistent with native fish recovery efforts. In a program which began in 1989, USBR and other state and federal agencies have cooperated to capture, rear, and successfully reintroduce about 15,000 razorback sucker larvae in Lake Mojave.

Instream flows in the mainstem and key tributaries are being evaluated as components of native fish recovery efforts. State and federal agencies are conducting studies to estimate base flow and flushing flow needs for listed and sensitive species in various river reaches. An example of flushing flow evaluation occurred in the spring of 1996 when releases from Glen Canyon Dam were increased for several days to attempt to redistribute sediment and create shallow water habitat in the mainstem below the dam.

In a 1997 court action involving the southwestern willow flycatcher, an environmental group filed a lawsuit against USBR and USFWS under the ESA's citizen suit provisions. The group alleged that USBR's operation of Lake Mead was endangering the flycatcher's habitat at the upper end of Lake Mead. The federal district court for Arizona ruled in favor of USBR, but the environmental group appealed the district court's decision to the Ninth Circuit Court of Appeals. The appellate court subsequently declined to hear the case, letting the district court's decision stand.

Lower Colorado River Multi-Species Conservation Program

In 1995, DOI executed partnership agreements with California, Nevada, and Arizona to develop a multi-species conservation program for ESA-listed species and many non-listed, but sensitive, species within the 100-year floodplain of the lower Colorado River, from Glen Canyon Dam downstream to the Mexican border. In 1996, a joint participation agreement was executed to provide funding for the program. USFWS has designated the LCRMSCP steering committee as an ecosystem conservation and recovery implementation team pursuant to ESA. The steering committee is composed of representatives from the three states, DOI, Indian tribes, water agencies, power agencies, environmental organizations, and others.

The conservation program will work toward recovery of listed and sensitive species while providing for current and future use of Colorado River water and power resources, and includes USBR's Colorado River operations and maintenance actions for the lower river. Over 100 species will be considered in the program, including the southwestern willow flycatcher, Yuma clapper rail, and the four listed fish species mentioned above. Developing the program is estimated to take three years. Costs of program development and implementation of selected interim conservation measures, estimated at $4.5 million, are to be equally split between DOI and the nonfederal partners.

USBR initiated a formal Section 7 consultation process with USFWS, who issued a five-year biological opinion on USBR operation and maintenance activities from Lake Mead to the southerly international boundary with Mexico in 1997. USBR has estimated that the cost of implementing the biological opinion's reasonable and prudent alternatives and measures could be as high as $26 million.

The steering committee is currently participating in funding several interim conservation measures. These include a razorback sucker recovery program at Lake Mojave, restoration of Deer Island near Parker, Arizona, and a "Bring Back the Natives" program sponsored by the National Fish and Wildlife Foundation.

Water Management Options for the Colorado River Region

The only forecasted shortages within the Colorado River region are those resulting from groundwater overdraft in Coachella Valley. Implementing the draft CRB 4.4 Plan entails developing options in the Colorado River Region to keep MWDSC's Colorado River Aqueduct flowing at its full capacity, as described earlier. The reduction in California's use of Colorado River water to the basic 4.4 maf apportionment reduces the supply available to California by as much as 0.9 maf/yr.

Table 9-21 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-3 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6. These options could be used for implementing the draft CRB 4.4 Plan and for reducing the Colorado River Region's groundwater overdraft.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options were retained. Reducing outdoor water use to 0.8 ET_o in new development would attain 9 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by 18 taf/yr. Reducing indoor water use to 60 gpcd and 55 gpcd would reduce depletions by 2 and 3 taf/yr, respectively. Reducing commercial, institutional, and industrial water use by 3 percent and 5 percent would save 1 and 2 taf/yr, respectively. Reducing distribution system losses to 7 and 5 percent would result in 9 and 13 taf/yr of depletion reductions, respectively.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with

TABLE 9-21

Colorado River Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Retain	
Canal Lining and Piping	Retain	
Tailwater Recovery	Retain	
Modify Existing Reservoirs/Operations		
Reoperating Colorado River System Reservoirs	Defer	Concurrence of USBR and other basin states not yet obtained.
New Reservoirs/Conveyance Facilities		
Additional Conveyance Capacity for Colorado River Water	Defer	California's current excess use of Colorado River water.
Groundwater/Conjunctive Use		
Groundwater Recharge Project at East Mesa	Defer	Scoped as one-time program.
Water Marketing		
Interstate banking	Retain	
Intrastate banking and transfers	Retain	
Land fallowing program	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply.
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
Desalting local drainage water	Defer	To be evaluated in phase 2 of draft CRB 4.4 Plan.
Lining All American Canal	Retain	
Additional Lining of Coachella Canal	Retain	
Weather Modification	Defer	Complicated by interstate management issues.
Statewide Options		
—	—	See Chapter 6.

TABLE 9-22

Potential Colorado River Water Conservation Programs

Program	*Participants*	*Comments/Status*	*Estimated Savings*
Lining of All American Canal	USBR, IID CVWD, MWDSC	Authorized by PL 100-675. Final EIS/EIR published. Preferred alternative is constructing a new, lined parallel canal.	Not implemented yet. Potential of 67.7 taf/yr savings.
Agreement for a long-term transfer of up to 200 taf/yr	IID, SDCWA	SCDWA and IID executed an agreement in 1998. Initial agreement negotiated for wheeling water in MWDSC's Colorado Aqueduct. EIR/EIS not yet prepared.	Not implemented yet - up to 200 taf/yr savings.
Additional lining of Coachella Canal	USBR, others	Authorized by PL 100-675. Draft EIR/EIS issued.	Not implemented yet. Potential of 25.68 taf/yr savings.

the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Improving seasonal application efficiency to 80 percent from the base of 73 percent could reduce depletions by 50 taf/yr. Improving flexible water delivery, canal lining (on-farm and distribution system), and tailwater recovery systems could together realize 140 taf/yr in depletion reductions. However, the ability to implement conservation options that would reduce the amount of fresh water inflow to the Salton Sea must be evaluated on a project-specific basis. Goals for preservation of the sea's environmental resources may limit the extent of feasible conservation measures.

Land Fallowing. Programs such as the Palo Verde test land fallowing program could be implemented to provide water for transfer to urban areas in the South Coast Region during drought periods. In 1992, MWDSC conducted a two-year land fallowing test program with PVID. Under this program, growers in PVID fallowed about 20,000 acres of land. The saved water, about 93 taf/yr, was stored in Lower Colorado River reservoirs for future use by MWDSC (the water was later released when Colorado River flood control releases were made from Lake Mead). MWDSC paid each grower $1,240 per fallowed acre, making the cost of the water to MWDSC about $135/af. Similar programs could be implemented in the future to provide about 100 taf/yr during drought years. Future land fallowing agreements would need to consider the availability of storage for the transferred water.

Potential Sources of Water for Intrastate Marketing

The ability to market conserved water has already been demonstrated in the region. Table 9-22 summarizes some potential sources of water for intrastate transfers. Such transfers could make up some of the shortages in the South Coast Region resulting from California reducing its use to California's basic apportionment of 4.4 maf.

Construction of additional conveyance capacity from the Colorado River Region to the South Coast Region has been a recent subject of discussion. Proposition 204 provides funding for a feasibility study of a new conveyance facility from the Colorado River to the South Coast Region. Conveyance facilities mentioned include a new aqueduct from the Imperial Valley area to San Diego (on the United States side of the border), as well as San Diego's participation in enlarging the existing aqueduct serving Tijuana, Mexico. Tijuana's situation is similar to San Diego's, in that Tijuana is seeking to expand its urban supplies by negotiating transfer of agricultural water from the Mexicali Valley. Figure 9-6 is a map of the U.S. - Mexican border area, showing the area's larger water facilities. A preliminary engineering study of constructing a new canal from Imperial Valley to SDCWA's service area has been prepared for SDCWA. Additional work, including geotechnical exploration and environmental studies, would be needed to evaluate the project's feasibility. The preliminary study highlighted the need to evaluate desalting the water that the aqueduct would supply, to enable San Diego's continued reliance on a high level of water recycling. New conveyance facilities from the Colorado River Region to the South Coast Region have been deferred from evaluation in Bulletin 160-98 because it does not appear that they would be constructed within the Bulletin's planning horizon, given the other basin states' concerns about California's

FIGURE 9-6

U.S.-Mexican Border Region

use of Colorado River water and the international complexities associated with a joint project with Mexican agencies.

SDCWA and IID have been negotiating a potential transfer of water saved due to extraordinary conservation measures within IID. The agencies initially executed a 1995 MOU concerning negotiation of a transfer agreement, followed by 1998 execution of an agreement specifying the transfer's terms and conditions. The agreement has a minimum 45-year term, and can be extended for an additional 30 years. An initial transfer of 20 taf would begin in 1999, with the annual quantity of transferred water increasing to a maximum of 200 taf. In order to transfer the acquired water, SDCWA (a member agency of MWDSC) has negotiated an initial wheeling agreement with MWDSC for use of capacity in MWDSC's Colorado River Aqueduct. Environmental documentation for the transfer is pending.

Past conservation projects in the region have included land fallowing, canal lining, distribution system reservoir and spill interceptor canal construction, and irrigation distribution system improvements. Some proposed projects to recover canal seepage include:

- ***Lining part of the All American Canal.*** Public Law 100-675 authorized the Secretary of the Interior to line the canal or to otherwise recover canal seepage, using construction funds from PVID, IID, CVWD, or MWDSC. USBR's environmental documentation evaluated a parallel canal alternative, several in-place lining alternatives, and a well field alternative, and concluded that the preferred alternative was the construction of a concrete-lined canal parallel to 23 miles of the existing canal. The parallel canal alternative has the potential to conserve an estimated 67.7 taf annually of Colorado River water. Recently, the well field alternative has been reevaluated and found to be infeasible. The well field alternative, although less expensive than canal lining, has been set aside because of international concerns about groundwater extraction near the border.
- ***Lining the Remaining Section of the Coachella Canal.*** This project would involve lining the remaining 33.4 miles of the Coachella Canal, which loses about 32.4 taf/yr through seepage. Four alternatives that have been identified are conventional lining, underwater lining, parallel canal, and no action. It is estimated that the preferred alternative, conventional lining, would conserve 25.7 taf/yr.

Intrastate Groundwater Recharge or Banking

IID has proposed a groundwater recharge project at East Mesa in the Imperial Valley. The proposed recharge project would divert a portion of flood control releases from Lake Mead to a recharge site or sites located along the alignment of the old, unlined Coachella Canal. (The old canal was abandoned when an adjacent lined canal was constructed.) IID estimates that up to 20 taf could be recharged in 1998. IID prepared a mitigated negative declaration for a one-time program in 1998, when flood control releases are occurring. Since Colorado River flood control releases have historically been infrequent, future water supply for such a recharge program would be available only occasionally. This option was scoped as a one-time project and is not considered as a 2020-level option in Bulletin 160-98.

MWDSC has executed agreements with three entities to study the potential of groundwater banking arrangements that would involve storing surplus Colorado River water, when available, in groundwater basins near its Colorado River Aqueduct. The water would be withdrawn for use in the South Coast in drought years. An agreement with Cadiz Land Company covered a potential project that would entail constructing a 35-mile pipeline from the Cadiz Valley/Fenner Valley area, and diverting up to 100 taf/yr of surplus Colorado River water to storage. Estimated available groundwater storage capacity is 500 taf, with drought year withdrawal capability of 100 taf. This arrangement could additionally have a marketing component; perhaps 20 to 30 taf/yr of recharge in Cadiz and Fenner Valleys could be blended with Colorado River water and delivered to the South Coast Region. An agreement with Catellus Development Company covered a potential groundwater storage site in the Mojave Desert with an estimated capacity of 600 taf. The withdrawal capability of this site is estimated at about 150 taf/yr. A third agreement was with CVWD. CVWD is presently performing pilot studies to estimate recharge and withdrawal capabilities in the lower valley. (MWDSC and CVWD have already been evaluating increased recharge at the upper end of the valley, in the Whitewater River drainage basin.)

Technical studies of the feasibility of these projects remain to be completed, and environmental documentation has not yet been prepared. It appears likely that at least 100 taf/yr of drought year supplies could be provided through this group of potential storage sites.

Interstate Banking/Conservation

Under an existing agreement between MWDSC and the Central Arizona Water Conservation District, MWDSC can store a limited amount of Colorado River water in Arizona for future use. The Southern Nevada Water Authority is also participating in the program. The agreement stipulates that MWDSC and SNWA can store up to 300 taf in central Arizona through the year 2000. As of 1997, MWDSC has placed 89 taf in storage and SNWA has placed 50 taf in storage, for a total of 139 taf. About 90 percent of the stored water can be recovered, contingent upon the declaration of a surplus. When MWDSC is able to draw on this source, it can divert up to a maximum of 15 taf in any one month. The stored water would be made available by Arizona foregoing the use of part of its normal supply from Central Arizona Project. MWDSC plans to recover the stored water at times in the future when its Colorado River Aqueduct diversions may be limited. Like the East Mesa project described in the preceding section, this interstate project was a one-time action, and is not considered as a 2020-level option in Bulletin 160-98.

In its 1996 session, the Arizona Legislature enacted legislation establishing the Arizona Water Banking Authority. The Authority is authorized to purchase unused Colorado River water and to store it in groundwater basins to meet future needs. Conveyance to storage areas is provided by the Central Arizona Project. The legislation further provided that the Authority may enter into agreements with California and Nevada agencies to bank water in Arizona basins, with the following limitations:

- Regulations governing interstate banking would need to be promulgated by the Secretary of the Interior.
- The Arizona Department of Water Resources finds that DOI's regulations adequately protect Arizona's rights to Colorado River water.
- The ability to bank interstate water would be subordinate to banking of water to supply Arizona needs.
- Interstate banking would be precluded in years when Arizona is using its full apportionment of 2.8 maf (including water being delivered to Arizona for banking by Arizona agencies), unless surplus conditions were declared for the river system.
- Interstate withdrawals from the bank are limited to 100 taf/yr, although there is no statutory limitation on annual deposits.

Under this legislation, future interstate banking in Arizona would have a maximum annual yield of 100 taf. However, Arizona may effectively limit withdrawals in drought years by declining to decrease its diversions of surface water to allow recovery of the banked water. USBR released draft rules and regulations for the interstate banking program for public comment in December 1997, and is presently reviewing the public comments.

Reoperating Colorado River System Reservoirs

Member agencies represented by the CRB have discussed proposing reservoir operating criteria to the Secretary of the Interior that would benefit California while protecting the apportionments of the other basin states and satisfying Mexican treaty obligations. Such criteria would also constitute part of the package of actions for California to transition its use of river water from current levels to 4.4 maf/yr. Operations studies have evaluated specific shortage and surplus criteria for the river system, including selection of desired probabilities for water supply reliability and reservoir operating elevations.

Results of the operations studies performed by CRB and by USBR suggest that there could be minimal hydrologic risk to using reservoir reoperation—particularly as a limited-term measure to help California reduce its Colorado River use—as a water management option for this region. As described in Chapter 3, the Colorado River has a high ratio of storage capacity to average annual runoff. Projections of consumptive use for the upper basin states suggest that those states will not attain full use of their compact apportionments until after year 2060. USBR's surplus declarations to date have not adversely impacted the other states' use of their apportionments—for example, flood control releases were made both in 1997 and 1998, and are expected in 1999. The more significant impediment to implementing reoperation would be concerns of the other basin states about impacts of an extended period of reoperation on future shortages, considering the river's variable year to year runoff.

For Bulletin 160-98, reservoir reoperation is not evaluated as a water management option and no numerical evaluation is made, since consensus of USBR and the basin states has not yet been obtained.

Weather Modification

A fundamental management issue associated with

Colorado River water supplies is the apparent overstatement of the Compact apportionment relative to the river's historical hydrology. There have been proposals over the years to augment the river's base flow to provide additional supplies. For example, USBR had developed a proposed pilot program in 1993 to evaluate cloud seeding potential in the Upper Basin. The State of Colorado did not favor moving ahead with this program.

Weather modification has recently been raised again as part of a possible menu of options to resolve California's use in excess of the 4.4 maf basic apportionment, although no specific proposals have been made. In concept, this option would entail cloud seeding in the Upper Basin to increase runoff, and might yield a 5 percent increase in base flow from the area seeded. Large-scale weather modification projects are typically difficult to implement due to institutional and third-party concerns, and can require several years of study and testing prior to being placed in operational status. Weather modification on the Colorado River is also complicated by interstate management issues. This option has been deferred for these reasons.

Options for Coachella Valley

As discussed earlier, MWDSC has executed an agreement with CVWD to study banking of surplus Colorado River water, when available, in the lower Coachella Valley. Banking programs typically entail putting more water into the groundwater basin than is extracted, to address losses and to avoid potential localized impacts to existing basin pumpers. Over the long term this extra recharge would help stabilize groundwater basin levels. CVWD is presently in the planning stages of expanding its existing pilot recharge/extraction site in the lower valley. CVWD also plans to form a groundwater replenishment district to help manage overdraft.

MWDSC and CVWD are evaluating additional recharge possibilities in the Whitewater River drainage at the north end of the valley. Water recharged in this area could come from surplus Colorado River flows, from year-to-year purchases of SWP water or purchase of SWP entitlement, or from other water marketing arrangements that could take advantage of SWP/CRA conveyance. For example, CVWD purchased about 39 taf of water from other SWP contractors in 1996, on a one-time basis. Additional recharge possibilities in the Whitewater drainage have not yet been quantified, and are not evaluated further in Bulletin 160-98.

CVWD could, as other SWP urban water contractors are doing, participate in the permanent transfer of agricultural entitlement water provided for in the Monterey Agreement contract amendments. CVWD could also purchase water from other sources, by way of exchange with MWDSC, subject to negotiation of conveyance in the SWP and CRA. Since no specific proposals are currently pending, this option is not quantified in the Bulletin.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the Colorado River Region

Applied water shortages are forecasted to be 147 taf in average years and 158 taf in drought years. Ranking of retained water management options for the Colorado River Region is summarized in Table 9-23. Table 9-24 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Options identified for this region will likely be used for reducing Coachella Valley overdraft and for managing water to benefit the South Coast Region, as called for in CRB's draft 4.4 Plan. An evaluation of these options is shown in Table 9A-3 in Appendix 9A. Bulletin 160-98 assumes that water made available by option implementation is first allocated to reduce overdraft within the region, and that remaining water is then available for use in the South Coast Region.

For readers interested in comparing Bulletin 160-98 options with the draft CRB 4.4 Plan, Table 9-25 summarizes the Bulletin's findings in a format similar to that used in the draft CRB 4.4 Plan. There is an important differences between the two documents—Bulletin 160-98 assumes that water conservation due to EWMP implementation occurs as part of base demand forecasts and not as an optional measure. Actions that may be implemented as part of phase two of the draft CRB 4.4 Plan are not shown in the table, because they have not yet been formulated and quantified.

TABLE 9-23

Options Ranking for Colorado River Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o - New Development	M	750	9	9
Outdoor Water Use to 0.8 ET_o -New and Existing Development	M	[b]	18	18
Indoor Water Use (60 gpcd)	M	400	2	2
Indoor Water Use (55 gpcd)	M	600	3	3
Interior CII Water Use (3%)	M	500	1	1
Interior CII Water Use (5%)	M	750	2	2
Distribution System Losses (7%)	M	200	9	9
Distribution System Losses (5%)	M	300	13	13
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	22	22
Seasonal Application Efficiency Improvements (78%)	M	250	36	36
Seasonal Application Efficiency Improvements (80%)	M	450	50	50
Flexible Water Delivery	L	1,000	30	30
Canal Lining and Piping	L	1,200	45	45
Tailwater Recovery	H	150	65	65
Water Marketing				
Intrastate Banking	H	[b]	—	100
Interstate Banking	M	[b]	—	50
Land Fallowing Program	M	140	—	100
Other Local Options				
Lining All American Canal	H	120	68	68
Additional Lining of Coachella Canal	H	[b]	26	26
Statewide Options				
See Chapter 6.				

[a] All parts of the amounts shown for the highlighted options have been included in Table 9-24.
[b] Data not available to quantify.

TABLE 9-24

Options Likely to be Implemented by 2020 (taf)

Colorado River Region[a]

	Potential Gain (taf)	
	Average	*Drought*
Applied Water Shortage	**147**	**158**
Options Likely to be Implemented by 2020		
Conservation[b]	215	215
Modify Existing Reservoirs/Operation	—	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive	—	—
Water Marketing	—	250
Recycling	—	—
Desalting	—	—
Other Local Options	94	94
Statewide Options	8	7
Expected Reapplication	2	2
Total Potential Gain	**319**	**568**
Remaining Applied Water Shortage	**0**	**0**

[a] Options in excess of regional needs to reduce groundwater overdraft are available for implementing the draft CRB 4.4 Plan in South Coast Region.

[b] Water supply for San Diego CWA/IID transfer provided by agricultural conservation which could be any mix of base demand forecast EWMP implementation (210 taf) and future agricultural conservation options (190 taf).

TABLE 9-25

Future Actions Described in Bulletin 160-98

That Could be Part of Draft CRB 4.4 Plan Implementation[a]

Action	Potential Gain (taf)	
	Average	*Drought*
Agricultural conservation[b] to meet SDCWA/IID Agreement	200	200
Other agricultural conservation[b] from EWMP implementation and optional conservation measures	200	200
Intrastate groundwater banking from MWDSC agreements with Cadiz, Catellus, or Coachella	—	100
Interstate groundwater banking from Arizona groundwater bank	—	50
Possible future land fallowing agreement between MWDSC and PVID	—	100
Lining All American Canal	68	68
Additional lining of Coachella Canal	26	26
Statewide Options	8	7
Total	**502**	**751**

[a] Since this table shows future actions, it does not include the 1980 Coachella Canal lining, 1988 MWDSC/IID agreement, or 1992 MWDSC/CACWD/SNWA agreement described earlier in this chapter.

[b] These actions are subject to environmental review to ensure that reduced depletions will not have significant impacts to the Salton Sea.

9A

Options Evaluations for Eastern Sierra and Colorado River Regions

TABLE 9A-1

Options Evaluation North Lahontan Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New and Existing Development	3	1	4	2	2	1	**13**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Groundwater/Conjunctive Use								
Agricultural Groundwater Development	3	1	3	3	3	0	**13**	**M**

TABLE 9A-2

Options Evaluation South Lahontan Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	2	2	1	**13**	**M**
Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use (5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (7%)	3	4	4	2	2	1	**16**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Agricultural								
SAE Improvements (76%)	3	4	3	4	3	1	**18**	**H**
SAE Improvements (78%)	3	3	3	3	2	1	**15**	**M**
SAE Improvements (80%)	2	3	3	2	2	1	**13**	**M**
Water Marketing								
Mojave Water Agency	4	4	4	4	3	0	**19**	**H**
Palmdale Water District	4	4	4	4	3	0	**19**	**H**
Statewide Options								
See Chapter 6.								

TABLE 9A-3

Options Evaluation Colorado River Region

Option	*Evaluation Scores*							
	Engineering	*Economics*	*Environ-mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	2	2	1	**14**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	2	2	1	**13**	**M**
Residential Indoor Water Use (60 gpcd)	3	3	4	2	2	1	**15**	**M**
Residential Indoor Water Use (55 gpcd)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	3	3	4	2	2	1	**15**	**M**
Interior CII Water Use(5%)	3	2	4	1	2	1	**13**	**M**
Distribution System Losses (7%)	3	4	4	2	2	1	**16**	**M**
Distribution System Losses (5%)	2	3	4	2	2	1	**14**	**M**
Agricultural[a]								
SAE Improvements (76%)	3	4	3	4	3	1	**18**	**H**
SAE Improvements (78%)	3	3	3	3	2	1	**15**	**M**
SAE Improvements (80%)	2	3	3	2	2	1	**13**	**M**
Flexible Water Delivery	3	0	3	3	2	1	**12**	**L**
Canal Lining and Piping	3	0	3	3	2	1	**12**	**L**
Tailwater Recovery	3	4	3	3	3	1	**17**	**H**
Water Marketing								
Interstate Banking	3	3	3	2	3	0	**14**	**M**
Intrastate Banking	3	3	3	3	3	2	**17**	**H**
Land Fallowing Program	3	3	4	3	2	1	**16**	**M**
Other Local Options								
Lining the All American Canal	3	4	3	2	4	3	**19**	**H**
Additional Lining of Coachella Canal	3	4	3	2	4	3	**19**	**H**
Statewide Options								
See Chapter 6.								

[a] Implementability subject to environmental impact review on Salton Sea.

10

Conclusions

This chapter assesses California's water future, based on today's conditions and on options being considered by California's water purveyors. The Department's Bulletin 160 series does not forecast a particular vision or preferred future (such as statewide use of xeriscape landscaping or favoring production of certain agricultural crops over others), but instead attempts to forecast the most probable future based on today's data, economic conditions, and public policies.

Although no forecast can be perfect, several key trends appear inevitable. California's population will increase dramatically by 2020. How growth is accommodated and the land use planning decisions made by cities and counties have important implications for future urban and agricultural water use. California's agricultural acreage is forecasted to decline slightly by 2020 (reflecting the State's increasing urbanization), as is its agricultural water use. California agriculture is still anticipated to lead the nation's agricultural production because of advantages such as climate and proximity to domestic and export markets. As the State's population expands, greater attention will be directed to preserving and restoring California ecosystems and to maintaining the natural resources which have attracted so many people to California.

The 1848 discovery of gold at Sutter's Mill on the American River led to California's statehood in 1850. California celebrates its sesquicentennial in 2000.

Miners in the Sierra, *painting by Charles Nahl and Frederick Wenderoth, 1851. Courtesy of Smithsonian Institution*

This chapter begins by reviewing water supply and demand information and the statewide applied water budget with existing facilities and programs presented in Chapter 6. Water management options identified as likely to be implemented in Chapters 6-9 are then tabulated and included in a state-

TABLE 10-1
California Water Budget with Existing Facilities and Programs (maf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	8.8	9.0	12.0	12.4
Agricultural	33.8	34.5	31.5	32.3
Environmental	36.9	21.2	37.0	21.3
Total	**79.5**	**64.7**	**80.5**	**66.0**
Supplies				
Surface Water	65.1	43.5	65.0	43.4
Groundwater	12.5	15.8	12.7	16.0
Recycled and Desalted	0.3	0.3	0.4	0.4
Total	**77.9**	**59.6**	**78.1**	**59.8**
Shortage	**1.6**	**5.1**	**2.4**	**6.2**

wide applied water budget with options. The chapter ends with an evaluation of how actions planned by water purveyors statewide would affect forecasted water shortages, and a summary of key findings.

Future with Existing Facilities and Programs

Table 10-1 repeats the California water budget with existing facilities and programs shown in Chapter 6. (Regional water budgets with existing facilities and programs are shown in Appendix 6A and in the regional chapters.)

Water Supply

As described in Chapter 3, Bulletin 160-98 water budgets do not account for the State's entire water supply and use. Less than one-third of the State's precipitation is quantified in the water budgets. Precipitation provides California with nearly 200 maf of total water supply in average years. Of this renewable supply, about 65 percent is depleted through evaporation and transpiration by vegetation. This large volume of water (approximately 130 maf) is excluded from Bulletin 160 water supply and water use calculations. The remaining 35 percent stays in the State's hydrologic system as runoff.

Over 30 percent of the State's runoff is not explicitly designated for urban, agricultural, or environmental uses. Similar to precipitation depletions by vegetation, non-designated runoff is excluded from the Bulletin 160 water supply and water use calculations.

The State's remaining runoff is available as renewable water supply for urban, agricultural, and environmental uses in the Bulletin 160 water budgets.

About 65 percent of the precipitation that falls on California's land surface is consumed through evaporation and transpiration by vegetation. The remaining 35 percent comprises the water supply that may be managed or dedicated for urban, agricultural, and environmental purposes.

In addition to this supply, Bulletin 160 water budgets include a few supplies that are not generated by intrastate precipitation. These supplies include imports from the Colorado and Klamath Rivers and new supplies generated by water recycling and desalting.

The State's 1995-level average year applied water supply—from intrastate sources, interstate sources, and return flows—is about 78 maf. Even assuming a reduction in Colorado River supplies to California's 4.4 maf basic apportionment, average year statewide supply is projected to increase 0.2 maf by 2020 without additional water supply options. This projected increase in water supply is due mainly to higher CVP and SWP deliveries in response to higher 2020 level

USBR's Corning Pumping Plant diverts water from the Tehama-Colusa Canal into the Corning Canal, which supplies agricultural users in southern Tehama County. California's Central Valley provides about 80 percent of the State's agricultural production.

demands (for example, from CVP urban water users in the Central Valley and from SWP urban water users in the South Coast and South Lahontan Regions). Additional groundwater extraction and facilities now under construction will also provide new supplies. The State's 1995-level drought year supply is about 60 maf. Drought year supply is projected to increase slightly by 2020 without future water supply options, for the same reasons that average year supplies are expected to increase.

Bulletin 160-98 estimates statewide groundwater overdraft of about 1.5 maf/yr at a 1995 level of development. Increasing overdraft in the 1990s reverses the trend of basin recovery seen in the 1980s. Most increases are occurring in the San Joaquin and Tulare Lake Regions, due primarily to Delta export restrictions associated with SWRCB's Order WR 95-6, ESA requirements, and reductions in CVP supplies.

Water recycling is a small, yet growing, element of California's water supply. At a 1995 level of development, water recycling and desalting produce about 0.3 maf/yr of new water (reclaiming water that would otherwise flow to the ocean or to a salt sink), up significantly from the 1990 annual supply of new water. The California Water Code urges wastewater treatment agencies located in coastal areas to recycle as much of their treated effluent as possible, recognizing that this water supply would otherwise be lost to the State's hydrologic system. Greater recycled water production at existing treatment plants and additional production at plants now under construction are expected to increase new recycled and desalted supplies by nearly 30 percent to 0.4 maf/yr by 2020.

Water Demand

California's estimated demand for water at a 1995 level of development is about 80 maf in average years and 65 maf in drought years. California's water demand in 2020 is forecasted to reach 81 maf in average years and 66 maf in drought years. California's increasing population is a driving force behind increasing water demands.

California's population is forecasted to increase to 47.5 million people by 2020 (about 15 million people more than the 1995 base). Forty-six percent of the State's population increase is expected to occur in the South Coast Region. Even with extensive water conservation, urban water demand will increase by about 3.2 maf in average years. (Bulletin 160-98 assumes that all urban and agricultural water agencies will implement BMPs and EWMPs by 2020, regardless of whether they are cost-effective for water supply purposes.)

Irrigated crop acreage is expected to decline by 325,000 acres—from the 1995 level of 9.5 million acres to a 2020 level of 9.2 million acres. Reductions in forecasted irrigated acreage are due primarily to urban encroachment and to impaired drainage on lands in the western San Joaquin Valley. Increases in water use efficiency combined with reductions in irrigated agricultural acreage are expected to reduce average year water demand by about 2.3 maf by 2020. Shifts from lower to higher value crops are expected to continue, with an increase in permanent plantings such as orchards and vineyards. This trend would tend to harden agricultural demands associated with permanent plantings, making it less likely that this acreage would be temporarily fallowed during droughts.

Average and drought year water needs for environmental use are forecasted to increase only slightly by 2020. Drought year environmental water needs are considerably lower than average year environmental water needs, reflecting the variability of unimpaired flows in wild and scenic rivers. North Coast wild and scenic rivers constitute the greatest component of environmental water demands. CVPIA implementation, Bay-Delta requirements, new ESA restrictions, and FERC relicensing could significantly modify environmental demands within the Bulletin 160-98 planning period.

Water Shortages

The shortage shown in Table 10-1 for 1995 average water year conditions reflects the Bulletin's assumption that groundwater overdraft is not available as a supply. Groundwater overdraft represents a significant portion of the 2020 average water year shortage. Forecasted water shortages vary widely from region to region, as shown in Table 10-2 and presented graphically in Figure 10-1. For example, the North Coast and San Francisco Bay regions are not expected to experience future shortages during average water years but are expected to see shortages in drought years. Most of the State's remaining regions experience average year and drought year shortages now, and are forecasted to experience increased shortages in 2020. The largest future shortages are forecasted for the Tulare Lake and South Coast regions, areas that rely heavily on imported water supplies. These regions are also where some of the greatest increases in population are expected to occur.

As discussed in Chapter 6, there are uncertainties associated with the magnitude of forecasted shortages. Chapter 6 presented a range of potential shortage amounts for programs whose uncertainties could be quantified—CALFED and SWRCB Bay-Delta water right actions. Other uncertainties cannot be quantified now—impacts of future ESA listings and FERC relicensing. Furthermore, the evaluation of water management options performed for the Bulletin was based on the options' present affordability to local agencies. Circumstances that increase or decrease options' affordability will correspondingly affect forecasted shortages.

What is apparent is that Californians face water shortages now, and will face increasing shortages in the future. The shortages shown in Table 10-2 highlight the need for future water management actions to reduce the gap between forecasted supplies and demands. As Californians experienced during the most recent drought (especially in 1991 and 1992), drought year shortages are large. Urban residents faced cutbacks in supply and mandatory rationing, some small rural communities saw their wells go dry, agricultural lands were fallowed, and environmental water supplies were reduced. By 2020, without additional facilities and programs, these conditions will worsen.

Finding reliable water supplies for the more than 15 million new Californians will be a challenge for the State's water purveyors. Almost half of the State's forecasted 2020 population increase is expected to occur in the South Coast Region.

Water shortages have direct and indirect economic consequences. Direct consequences include costs to residential water users to replace landscaping lost during droughts, costs to businesses that experience water supply cutbacks, or costs to growers who fallow land because supplies are not available. Indirect conse-

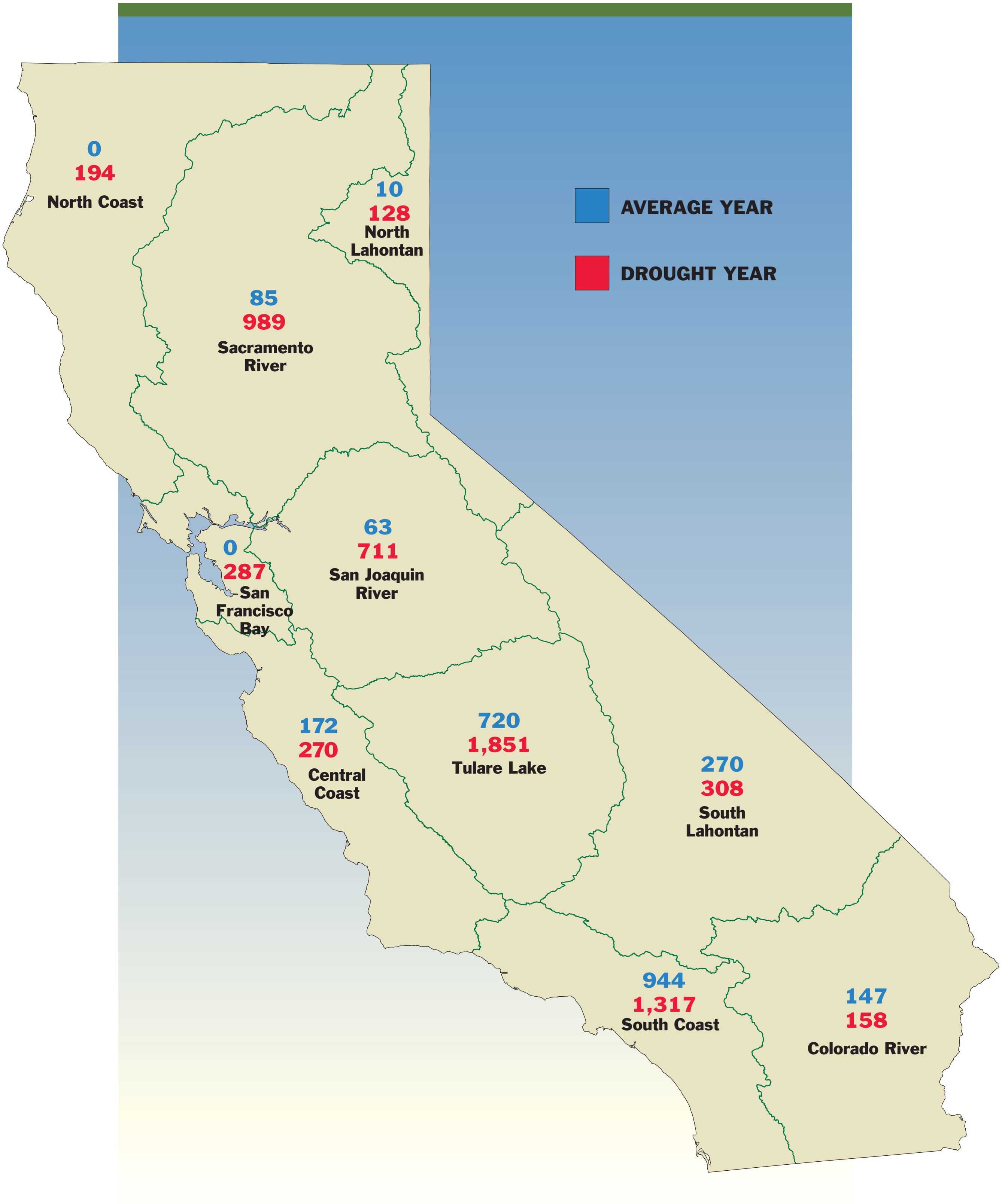
TABLE 10-2

Applied Water Shortages by Hydrologic Region (taf) with Existing Facilities and Programs

	1995		*2020*	
Region	*Average*	*Drought*	*Average*	*Drought*
North Coast	0	177	0	194
San Francisco Bay	0	349	0	287
Central Coast	214	282	172	270
South Coast	0	508	944	1,317
Sacramento River	111	867	85	989
San Joaquin River	239	788	63	711
Tulare Lake	870	1862	720	1,851
North Lahontan	0	128	10	128
South Lahontan	89	92	270	308
Colorado River	69	95	147	158
Total (rounded)	**1,590**	**5,150**	**2,410**	**6,210**

FIGURE 10-1

2020 Shortages by Hydrologic Region with Existing Facilities and Programs (taf)



The January 1997 flood disaster was the largest in the State's history. Flooding forced more than 120,000 people from their homes, and over 55,000 people were housed in temporary shelters. Nearly 300 square miles of agricultural land were flooded. Livestock and wildlife were trapped by the flooding.

quences include decisions by businesses and growers not to locate or to expand their operations in California, and reductions in the value of agricultural lands. Other consequences of shortages are less easily measured in economic terms—loss of recreational activities or impacts to environmental resources, for example.

Summary of Options Likely to be Implemented

The options summarized in this section represent water purveyors' strategies for meeting future needs. This information relies heavily on actions identified by local water agencies, which collectively provide about 70 percent of the State's developed water supply. As described earlier, water management options likely to be implemented were selected based on a ranking process that evaluated factors such as technical feasibility, cost, and environmental considerations. This process is most effective in hydrologic regions where local agencies have prepared plans for meeting future needs in their service areas. Affordability is a key factor for local agencies in deciding the extent to which they wish to invest in alternatives to improve their water service reliability. Water agencies must balance costs and quantity of supply (and sometimes quality of supply) based on their service area needs.

The Bulletin 160 series focuses on water supply. The statewide compilation of likely options has not been tailored to meet other water-related objectives such as flood control, hydropower generation, recreation, or nonpoint source pollution control. The evaluation process used to select likely options ranked the options based on their ability to provide multiple benefits, as described in Chapter 6. For example, one aspect of the relationship between water supply and flood control needs is illustrated in the sidebar on reservoir reoperation.

The results shown in Table 10-3 were obtained by adding statewide options identified as likely in Chapter 6 to regional options identified as likely in Chapters 7-9.

Options shown in Table 10-3 include demand re-

Reservoir Reoperation for Flood Control

The January 1997 floods demonstrated that Central Valley flood protection needs improvement. The 1997 *Final Report of the Governor's Flood Emergency Action Team* identified many actions that could be taken to increase valley flood protection, including better emergency preparedness, floodplain management actions, levee system improvements, construction of new floodways, temporary storage of floodwaters on wildlife refuges, reoperation or enlargement of existing reservoirs to increase flood storage, and construction of new reservoirs. The latter two actions have water supply implications. Reoperating existing reservoirs to provide greater flood control storage usually comes at the expense of water supply. Reoperation is particularly problematical in the San Joaquin River Basin, where water supplies are already limited. As more demands are placed on existing water supplies, reservoir reoperation will become increasingly difficult to implement. In contrast, enlarging reservoirs or constructing new reservoirs can provide both water supply and flood control benefits.

TABLE 10-3

Summary of Options Likely to be Implemented by 2020, by Option Type (taf)

Option Type	*Average*	*Drought*
Local Demand Reduction Options	**507**	**582**
Local Supply Augmentation Options		
Surface Water	110	297
Groundwater	24	539
Water Marketing	67	304
Recycled and Desalted	423	456
Statewide Supply Options		
CALFED Bay-Delta Program	100	175
SWP Improvements	117	155
Water Marketing (Drought Water Bank)	—	250
Multipurpose Reservoir Projects	710	370
Expected Reapplication	**141**	**433**
Total Options	**2,199**	**3,561**

duction beyond BMP and EWMP implementation included in Table 10-1. Future demand reduction options are options that would produce new water supply through reduction of depletions. For these optional water conservation measures to have been identified as likely, they must be competitive in cost with water supply augmentation options.

Local supply augmentation options comprise the largest potential new drought year source of water for California. (Local options include implementation of the draft CRB 4.4 Plan to reduce California's use of Colorado River water.) In Table 10-3 and in the water budgets, only water marketing options that result in a change of place of use of the water (from one hydrologic region to another), or a change in type of use (e.g., agricultural to urban) have been included. Considerably more marketing options have been described in earlier chapters than are shown in the water budgets, reflecting local agencies' plans to purchase future supplies from sources yet to be identified. Where the participants in a proposed transfer are known, the selling region's average year or drought year supply has been reduced in the water budgets. Presently, the only transfers with identified participants that are large enough to be visible in the water budgets are those associated with the draft CRB 4.4 Plan. Water agencies' plans to acquire water through marketing arrangements will depend on their ability to find sellers and on the level of competition for water purchases among water agencies and environmental restoration programs (such as CVPIA's AFRP or CALFED's ERP).

Possible statewide options include actions that could be taken by CALFED to develop new water supplies. The timing and extent of new water supplies that CALFED might provide are uncertain at the time of the Bulletin's printing. Bulletin 160-98 uses a placeholder analysis for new CALFED water supply development to illustrate the potential magnitude of new water supply the program might provide. The placeholder does not address specifics of which surface storage facilities might be selected, since this level of detail is not available. Water supply uncertainties associated with CALFED's selection of a draft preferred alternative were discussed in Chapter 6.

Other statewide options include specific projects to improve SWP water supply reliability, the State's drought water bank, and two multipurpose reservoirs. A third potential multipurpose reservoir option, an enlarged Shasta Lake, was recommended for further study because additional work is needed to quantify benefits and costs associated with different reservoir sizes.

The two multipurpose reservoir projects included as statewide options—Auburn Reservoir and enlarged Millerton Lake (Friant Dam)—were included to emphasize the interrelationship between water supply needs and the Central Valley's flood protection needs. Both reservoir sites offer significant flood protection benefits. Both projects have controversial aspects, and neither of them is inexpensive. However, they merit serious consideration. The lead time for planning and implementing any large reservoir project is long, and it would take almost to the Bulletin 160-98 2020 planning horizon for these projects to be constructed.

Implementing new water management options must be done in accordance with environmental protection requirements, including requirements for protection of species of special concern, such as this badger.

The potential future water management options summarized in this section are still being planned. Their implementation is subject to completion of environmental documents, permit acquisition, compliance with regulatory requirements such as those of ESA, and availability of funding. The permitting processes will address mitigating environmental impacts and resolving third-party impacts. If water management options are delayed or rendered infeasible as a result of these processes, or if their costs are increased to the point that the options are no longer affordable for the local sponsors, statewide shortages will be correspondingly affected.

Implementing Future Water Management Options

Table 10-4 was developed by combining the regional and statewide analyses of water management options with the water budget with existing facilities and programs (Table 10-1). Table 10-4 illustrates the effect these options would have on future shortages. (Appendix 10A shows regional water budgets with option implementation.) The table indicates that water management options now under consideration by water purveyors throughout the State will not reduce shortages to zero in 2020. The difference between av-

TABLE 10-4

California Water Budget with Options Likely to be Implemented (maf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	8.8	9.0	11.8	12.1
Agricultural	33.8	34.5	31.3	32.1
Environmental	36.9	21.2	37.0	21.3
Total	**79.5**	**64.7**	**80.1**	**65.5**
Supplies				
Surface Water	65.1	43.5	66.4	45.4
Groundwater	12.5	15.8	12.7	16.5
Recycled and Desalted	0.3	0.3	0.8	0.9
Total	**77.9**	**59.6**	**79.9**	**62.8**
Shortage	**1.6**	**5.1**	**0.2**	**2.7**

TABLE 10-5

Water Shortages by Hydrologic Region With Likely Options (taf)

Region	*1995* *Average*	*1995* *Drought*	*2020* *Average*	*2020* *Drought*
North Coast	0	177	0	176
San Francisco Bay	0	349	0	0
Central Coast	214	282	0	100
South Coast	0	508	0	0
Sacramento River	111	867	0	722
San Joaquin River	239	788	0	658
Tulare Lake	870	1,862	202	868
North Lahontan	0	128	10	128
South Lahontan	89	92	0	0
Colorado River	69	95	0	0
Total (rounded)	**1,590**	**5,150**	**210**	**2,650**

erage year and drought year water shortages is significant. Water purveyors generally consider shortages in average years as basic deficiencies that should be corrected through long-term demand reduction or supply augmentation measures. Shortages in drought years may be managed by such long-term measures in combination with short-term actions used only during droughts. Short-term measures could include purchases from the State's drought water bank, urban water rationing, or agricultural land fallowing. Agencies may evaluate the marginal costs of developing new supplies and conclude that the cost of their development exceeds that of shortages to their service areas, or exceeds the cost of implementing contingency measures such as transfers or rationing. As water agencies implement increasing amounts of water conservation in the future (especially plumbing fixture changes), there will be a correspondingly lessened ability to implement short-term drought response actions such as rationing. Demand hardening will influence agencies' decisions about their future mix of water management actions.

Ability to pay is another consideration. Large urban water agencies frequently set high water service reliability goals and are able to finance actions necessary to meet the goals. Agencies supplying small rural communities may not be able to afford expensive projects. Small communities have limited populations over which to spread capital costs and may have difficulty obtaining financing. If local groundwater resources are inadequate to support expected growth, these communities may not be able to afford projects such as pipelines to bring in new surface water supplies. Small rural communities that are geographically isolated from population centers cannot readily interconnect with other water systems.

Agricultural water agencies may be less able to pay for capital improvements than urban water agencies. Much of the State's earliest large-scale water development was for agriculture, and irrigation works were constructed at a time when water development was inexpensive by present standards. Agricultural users today may not be able to compete with urban users for development of new supplies. Some agricultural water users have historically been willing to accept lower water supply reliability in return for less expensive water supplies. It may be less expensive for some agricultural users to idle land in drought years rather than to incur capital costs of new water supply development. This can be particularly true for regions faced with production constraints such as short growing seasons or lower quality lands — areas where the dominant water use may be irrigated pasture. In areas such as the North Lahontan Region, for example, local agencies generally do not have plans for new programs or facilities to reduce agricultural water shortages in drought years. Table 10-5 shows forecasted shortages by hydrologic region to illustrate the effects of option implementation on a regional basis. The same information is presented graphically in Figure 10-2.

Local agencies that expect to have increased future demands generally do more water supply planning than do agencies whose demands remain relatively level. Most agricultural water agencies are not planning for greater future demands, although some agencies are examining ways to improve reliability of their existing supplies. Cost considerations limit the types of options available to many agricultural users. The agricultural sector has thus developed fewer options that could be evaluated in statewide water supply planning. Many

FIGURE 10-2

2020 Shortages by Hydrologic Region with Likely Options (taf)

options have been generated from planning performed by urban agencies, reflecting Urban Water Management Planning Act requirements that urban water suppliers with 3,000 or more connections, or that deliver over 3 taf of water per year, prepare plans showing how they will meet service area needs.

Geography plays a role in the feasibility of implementing different types of options, and not solely with respect to the availability of surface water and groundwater supplies. Water users in the Central Valley, Bay Area, and Southern California having access to major regional conveyance facilities have greater opportunities to rely on water marketing arrangements and conjunctive use options than do water users isolated from the State's main water infrastructure.

Bulletin 160-98 Findings

Bulletin 160-98 forecasts water shortages in California by 2020, as did the previous water plan update. The water management options identified in the Bulletin as likely to be implemented by 2020 would reduce, but not completely eliminate future shortages. Water agencies faced with meeting future needs must determine how those needs can be met within the statutory and regulatory framework affecting water use decisions, including how the needs can be met in a manner equitable to existing water users. Land use planning decisions made by cities and counties—locations where future growth will or will not be allowed, housing densities, preservation goals for open space or agricultural reserves—will have a significant influence on California's future water demands. Good coordination among local land use planning agencies and water agencies, as well as among water agencies themselves at a regional level, will facilitate finding solutions to meeting future needs.

Bulletin 160-98 makes no specific recommendations regarding how California water purveyors should meet the needs of their service areas. It is the water purveyors themselves who must make these decisions. The purpose of Bulletin 160-98 is to forecast the future based on today's conditions. Clearly, different agencies and individuals have different perspectives about how the future should be shaped. The CALFED discussions, for example, illustrate conflicting values among individuals and agencies.

There is not one magic bullet for meeting California's future water needs—not new reservoirs, not new conveyance facilities, not more groundwater extraction, not more water conservation, not more water recycling. Each of these options has its place. The most frequently used methods of providing new water supplies have changed with the times, reflecting changing circumstances. Much of California's early water development was achieved by constructing reservoirs and diverting surface water. Advances in technology, in the form of deep well turbine pumps, allowed substantial groundwater development. More recent improvements in water treatment technology have made water recycling and desalting feasible options. Today, water purveyors have an array of water management options available to meet future water supply reliability needs. The magnitude of potential shortages, especially drought year shortages, demonstrates the urgency of taking action. The do-nothing alternative is not an alternative that will meet the needs of 47.5 million Californians in 2020.

California water agencies have made great strides in water conservation since the 1976-77 drought. Bulletin 160-98 forecasts substantial demand reduction from implementing presently identified urban BMPs and agricultural EWMPs, and assumes a more rigorous level of implementation than water agencies are now obligated to perform. Presently, less than half of California's urban population is served by retailers that have signed the urban MOU for water conservation measures. Less than one-third of California's agricultural lands are served by agencies that have signed the corresponding agricultural MOU. Bulletin 160-98 assumes that all water purveyors statewide will implement BMPs and EWMPs by 2020, even if the actions are not cost-effective from a water supply perspective. Water conservation offers multipurpose benefits such as reduced urban water treatment costs and potential reduction of fish entrainment at diversion structures. The Bulletin also identifies as likely additional demand reduction measures that would create new water and would be cost-competitive with supply augmentation options. These optional demand reductions are almost as large as the average year water supply augmentation options planned by local agencies.

California water agencies have also made great strides in water recycling. By 2020, total recycling could potentially be almost 1.4 maf, which would exceed the goal expressed in Section 13577 of the Water Code that total recycling statewide be 1 maf by 2010. (The potential 2020 total recycling of 1.4 maf would be equivalent to about 2 percent of the State's 2020 water supply.) Water recycling offers multipurpose benefits, such as reduction of treatment plant discharges to waterbodies. Cost is a limiting factor in implementing recycling projects. When economic considerations are taken into account, the potential new water supply (water new to the State's hydrologic system) from recycling is forecasted to be about 0.8 maf.

Clearly, conservation and recycling alone are not sufficient to meet California's future needs. Bulletin 160-98 has included all of the conservation and recycling measures likely to be implemented by 2020. Adding supply augmentation options identified by California's water purveyors still leaves a shortfall in meeting forecasted demands. Review of local agencies' likely supply augmentation options shows that relatively few larger-scale or regional programs are in active planning, especially among small and mid-size water agencies. This outcome reflects local agencies' concerns about perceived implementability constraints associated with larger-scale options, and their affordability.

In the interests of maintaining California's vibrant economy, it is important that the State of California take an active role in assisting water agencies in meeting their future needs. New storage facilities are an important part of the mix of options needed to meet California's future needs. Just as water conservation and recycling provide multiple benefits, storage facilities offer flood control, power generation, and recreation in addition to water supply benefits. The devastating January 1997 floods in the Central Valley emphasized the need for increased attention to flood control. Apart from CALFED's investigation of storage alternatives, little planning is currently being done for storage projects that would meet regional or statewide needs. It is important for small and mid-size water agencies who could not develop such facilities on their own to have access to participation in regional projects. The more diversified water agencies' sources of supply are, the better their odds of improved water supply reliability.

An appropriate State role would be for the Department to take the lead in performing feasibility studies of potential storage projects—not on behalf of the SWP, but on behalf of all potentially interested water agencies. State funding support is needed to identify likely projects, so that local agencies may determine how those projects might benefit their service areas. In concept, the Department could use State funding to complete project feasibility studies, permitting, and environmental documentation for likely new storage facilities, removing uncertainties that would prevent smaller water agencies from funding planning studies themselves. This concept is not new. Historically, Department investigations into the State's water resources (for example, Bulletin 3, the original *California Water Plan*) formulated projects that were later built by local agencies.

Agencies wishing to participate in projects shown to be feasible in Department studies would repay their share of the State planning costs as a condition of participation in a project. Feasible projects would likely be constructed by a consortium of local agencies acting through a joint powers agreement or other contractual mechanism. The water users would be responsible for construction costs.

Meeting California's future needs will require cooperation among all levels of government—federal, State, and local. Likewise, all three of California's water-using sectors—agricultural, environmental, and urban—must work together to recognize each others' legitimate needs and to seek solutions to meeting the State's future water shortages. When the Bay-Delta Accord was signed in 1994, it was hailed as a truce in one of the State's longstanding water wars. The Accord, and the efforts by California agencies to negotiate a resolution to interstate and intrastate Colorado River water issues, represent a new spirit of fostering cooperation and consensus rather than competition and conflict. Such an approach will be increasingly necessary, given the magnitude of the water shortages facing California. Mutual accommodation of each others' needs is especially important in drought years, when water purveyors face the greatest water supply challenges. With continued efforts to prepare for the future, California can have safe and reliable water supplies for urban areas, adequate long-term water supplies to maintain the State's agricultural economy, and restoration and protection of fish and wildlife habitat.

10A

Regional Water Budgets with Likely Options

The following tables show the water budgets for each of the State's ten hydrologic regions with options identified as likely. Water use/supply totals and shortages may not sum due to rounding.

TABLE 10A-1

North Coast Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	169	177	201	194
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total	**20,607**	**10,668**	**20,672**	**10,722**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and Desalted	13	14	13	14
Total	**20,607**	**10,491**	**20,672**	**10,546**
Shortage	**0**	**177**	**0**	**176**

TABLE 10A-2

San Francisco Bay Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	1,255	1,358	1,317	1,371
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total	**7,115**	**5,760**	**7,176**	**5,773**
Supplies				
Surface Water	7,011	5,285	7,067	5,607
Groundwater	68	92	72	96
Recycled and Desalted	35	35	37	70
Total	**7,115**	**5,412**	**7,176**	**5,773**
Shortage	**0**	**349**	**0**	**0**

TABLE 10A-3

Central Coast Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	286	294	347	359
Agricultural	1,192	1,279	1,127	1,223
Environmental	118	37	118	37
Total	**1,595**	**1,610**	**1,592**	**1,620**
Supplies				
Surface Water	318	160	477	287
Groundwater	1,045	1,142	1,043	1,161
Recycled and Desalted	18	26	71	71
Total	**1,381**	**1,328**	**1,592**	**1,519**
Shortage	**214**	**282**	**0**	**100**

TABLE 10A-4

South Coast Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	4,340	4,382	5,435	5,528
Agricultural	784	820	455	477
Environmental	100	82	104	86
Total	**5,224**	**5,283**	**5,993**	**6,090**
Supplies				
Surface Water	3,839	3,196	4,084	3,832
Groundwater	1,177	1,371	1,243	1,592
Recycled and Desalted	207	207	667	667
Total	**5,224**	**4,775**	**5,994**	**6,090**
Shortage	**0**	**508**	**0**	**0**

TABLE 10A-5

Sacramento River Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,833	4,223	5,839	4,225
Total	**14,664**	**14,106**	**14,917**	**14,282**
Supplies				
Surface Water	11,881	10,022	12,282	10,279
Groundwater	2,672	3,218	2,636	3,281
Recycled and Desalted	0	0	0	0
Total	**14,553**	**13,239**	**14,918**	**13,560**
Shortage	**111**	**867**	**0**	**722**

TABLE 10A-6

San Joaquin River Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,448	6,717
Environmental	3,396	1,904	3,411	1,919
Total	**10,996**	**9,731**	**10,813**	**9,607**
Supplies				
Surface Water	8,562	6,043	8,497	6,029
Groundwater	2,195	2,900	2,317	2,920
Recycled and Desalted	0	0	0	0
Total	**10,757**	**8,943**	**10,814**	**8,949**
Shortage	**239**	**788**	**0**	**658**

TABLE 10A-7

Tulare Lake Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,106	9,515
Environmental	1,672	809	1,676	813
Total	**13,098**	**11,525**	**12,880**	**11,426**
Supplies				
Surface Water	7,888	3,693	8,292	4,167
Groundwater	4,340	5,970	4,386	6,391
Recycled and Desalted	0	0	0	0
Total	**12,228**	**9,663**	**12,678**	**10,558**
Shortage	**870**	**1,862**	**202**	**868**

TABLE 10A-8

North Lahontan Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

TABLE 10A-9

South Lahontan Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	238	238	568	568
Agricultural	332	332	252	252
Environmental	107	81	107	81
Total	**676**	**651**	**927**	**901**
Supplies				
Surface Water	322	259	651	578
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**926**	**901**
Shortage	**89**	**92**	**0**	**0**

TABLE 10A-10

Colorado River Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	418	418	715	715
Agricultural	4,118	4,118	3,393	3,393
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,152**	**4,151**
Supplies				
Surface Water	4,154	4,128	3,852	3,852
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,152**	**4,151**
Shortage	**69**	**95**	**0**	**0**

Abbreviations and Acronyms

A

AB	Assembly Bill
AAC	All American Canal
ACID	Anderson-Cottonwood Irrigation District
ACWD	Alameda County Water District
AD	allowable depletion
ADWR	Arizona Department of Water Resources
AEWSD	Arvin-Edison Water Storage District
af	acre-foot/acre-feet
AFB	Air Force Base
AFRP	Anadromous fish restoration program (or plan)
AMD	acid mine drainage
AOP	advanced oxidation process
APCD	air pollution control district
ARP	aquifer reclamation program
ARWI	American River Watershed Investigation
ARWRI	American River Water Resources Investigation
ASR	aquifer storage and recovery
AVEK	Antelope Valley-East Kern Water Agency
AVWG	Antelope Valley Water Group

B

BARWRP	Bay Area regional water recycling program
BAT	best available technology
BBID	Byron-Bethany Irrigation District
BDAC	Bay-Delta Advisory Council
B/C	benefit-to-cost (ratio)
BLM	Bureau of Land Management
BMP	Best management practice
BVWSD	Buena Vista Water Storage District
BWD	Bard Water District
BWRDF	Brackish water reclamation demonstration facility

C

CAL-AM	California-American Water Company
Cal/EPA	California Environmental Protection Agency
CALFED	State (CAL) and federal (FED) agencies participating in Bay-Delta Accord
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CCID	Central California Irrigation District
CCMP	Comprehensive conservation and management plan
CCWD	Colusa County Water District or Contra Costa Water District
CDI	capacitive deionization
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CII	commercial, industrial, and institutional
CIMIS	California irrigation management information system
CLWA	Castaic Lake Water Agency
CMWD	Calleguas Municipal Water District
COA	Coordinated Operation Agreement
COG	Council of Governments
CMO	crop market outlook
COP	certificate of participation
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
CRB	Colorado River Board
CRIT	Colorado River Indian Tribes
CSD	community services district
CSIP/SVRP	Castroville Seawater Intrusion Project/ Salinas Valley Reclamation Project
CSJWCD	Central San Joaquin Water Conservation District
CUWCC	California Urban Water Conservation Council

CVHJV	Central Valley Habitat Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley production model
CVWD	Coachella Valley Water District
CWA	Clean Water Act
CWD	Coastal Water District, Cawelo Water District, or county water district

D

D-1485	State Water Resources Control Board Water Right Decision 1485
DAU	detailed analysis unit
DBCP	dibromochloropropane
DBP	disinfection by-products
DCID	Deer Creek Irrigation District
D/DBP	disinfectant/disinfection by-product
DDT	dichloro diphenyl trichloroethane
DEIR	draft environmental impact report
DEIS	draft environmental impact statement
DFA	California Department of Food and Agriculture
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DMC	Delta-Mendota Canal
DOE	Department of Energy
DOF	California Department of Finance
DOI	Department of the Interior
DPR	Department of Parks and Recreation or Department of Pesticide Regulation
DU	distribution uniformity
DWA	Desert Water Agency
DWB	DWR's Drought Water Bank
DWD	Diablo Water District
DWR	California Department of Water Resources
DWRSIM	DWR's operations model for SWP/CVP system

E

EBMUD	East Bay Municipal Utility District
ec	electrical conductivity
ECCID	East Contra Costa Irrigation District
ECWMA	East County Water Management Association
ED	electrodialysis
EDB	ethylene dibromide
EDCWA	El Dorado County Water Agency
EDF	Environmental Defense Fund
EDR	electrodialysis reversal
EID	El Dorado Irrigation District
EIR	environmental impact report
EIS	environmental impact statement
ENSO	El Niño Southern Oscillation cycle
EPA	U.S. Environmental Protection Agency or Energy Policy Act of 1992
ERP	ecosystem restoration program or plan
ESA	Endangered Species Act
ESP	emergency storage project
ESU	evolutionarily significant unit
ESWTR	Enhanced Surface Water Treatment Rule
ET	evapotranspiration
ET_o	reference evapotranspiration
ETAW	evapotranspiration of applied water
EWMP	efficient water management practice

F

FAIRA	Federal Agriculture Improvement and Reform Act
FC&WCD	flood control and water conservation district
FCD	flood control district
FERC	Federal Energy Regulatory Commission
FY	fiscal year

G

GAC	granular activated carbon
GBUAPCD	Great Basin Unified Air Pollution Control District
GCID	Glenn-Colusa Irrigation District
GDPUD	Georgetown Divide Public Utility District
GO	general obligation
gpcd	gallons per capita per day
gpf	gallons per flush
gpm	gallons per minute

H

HCP	habitat conservation plan
HLWA	Honey Lake Wildlife Area
HR	House Resolution
HUD	Department of Housing and Urban Development

I

IBWC	International Boundary and Water Commission
ICR	information collection rule
ID	irrigation district or improvement district
IE	irrigation efficiency
IEP	Interagency Ecological Program
IID	Imperial Irrigation District
IOT	intake opportunity time
IRP	integrated resources planning
IRWD	Irvine Ranch Water District
ISDP	Interim South Delta Program

J

JPA	joint powers authority

K

KCWA	Kern County Water Agency
KPOP	Klamath Project Operations Plan
KRCC	Klamath River Compact Commission
KWB	Kern Water Bank
KWBA	Kern Water Bank Authority
kWh	kilowatt hour

L

LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LAFCO	local agency formation commission
LBG	Los Banos Grandes
LCRMSCP	Lower Colorado River Multi-Species Conservation Program
LEPA	low-energy precision application
LMMWC	Los Molinos Mutual Water Company
LTBMU	Lake Tahoe Basin Management Unit

M

m	meter
maf	million acre-feet
MCL	maximum contaminant level
MCWD	Marina Coast Water District or Mammoth Community Water District
MCWRA	Monterey County Water Resources Agency
MF	microfiltration or Middle Fork
mgd	million gallons per day
mg/L	milligrams per liter
M&I	municipal & industrial
MID	Madera Irrigation District, Maxwell Irrigation District, Merced Irrigation District, or Modesto Irrigation District
MMWC	McFarland Mutual Water Company
MMWD	Marin Municipal Water District
MOU	memorandum of understanding
MPWMD	Monterey Peninsula Water Management District
MRWPCA	Monterey Regional Water Pollution Control Agency
MTBE	methyl tertiary butyl ether
MUD	municipal utility district
mW	megawatt
MWA	Mojave Water Agency
MWD	municipal water district
MWDOC	Municipal Water District of Orange County
MWDSC	Metropolitan Water District of Southern California

N

NAWMP	North American Waterfowl Management Plan
NCFC&WCD	Napa County Flood Control and Water Conservation District
NCMWC	Natomas-Central Mutual Water Company
NED	national economic development (plan)
NEPA	National Environmental Policy Act
NF	nanofiltration or North Fork
NGO	non-governmental organization
NID	Nevada Irrigation District
NISA	National Invasive Species Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOP	notice of preparation
NPDES	national pollutant discharge elimination system
NPDWR	national primary drinking water regulations
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWD	Northridge Water District
NWR	National Wildlife Refuge

O

OCWD	Orange County Water District
OID	Oakdale Irrigation District
O&M	operations and maintenance

P

PAC	powdered activated carbon
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	perchloroethylene
PCGID/PID	Princeton-Codora-Glenn Irrigation District/Provident Irrigation District
PCWA	Placer County Water Agency
PEIR	programmatic environmental impact report
PEIS	programmatic environmental impact statement
PG&E	Pacific Gas and Electric Company
PGVMWC	Pleasant Grove-Verona Mutual Water Company
PL	Public Law
PMWC	Pelger Mutual Water Company
ppb	parts per billion
PROSIM	USBR's operations model for the CVP/SWP
PSA	planning subarea
psi	pounds per square inch
PTA	packed-tower aeration
PUC	public utility commission
PUD	public utility district
PVID	Palo Verde Irrigation District or Pleasant Valley Irrigation District
PVWMA	Pajaro Valley Water Management Agency
PWD	Palmdale Water District

R

RBDD	Red Bluff Diversion Dam
RCD	resource conservation district
RD	reclamation district
RDI	regulated deficit irrigation
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board

S

SAE	seasonal application efficiency
SAFCA	Sacramento Area Flood Control Agency
SAWPA	Santa Ana Watershed Project Authority
SB	Senate Bill
SBCFC&WCD	Santa Barbara County Flood Control and Water Conservation District
SBVMWD	San Bernardino Valley Municipal Water District
SCCWRRS	Southern California comprehensive water reclamation and reuse study
SCE	Southern California Edison
SCVWD	Santa Clara Valley Water District
SCWA	Solano County Water Agency or Sonoma County Water Agency
SDCWA	San Diego County Water Authority
SDWA	Safe Drinking Water Act or South Delta Water Agency
SEIS	supplemental environmental impact statement
SEWD	Stockton East Water District
SF	South Fork
SFBJV	San Francisco Bay Joint Venture
SFEP	San Francisco Estuary Project
SFPUC	San Francisco Public Utility Commission
SFWD	San Francisco Water Department
SGPWA	San Gorgonio Pass Water Agency
SID	Solano Irrigation District
SJBAP	San Joaquin Basin Action Plan
SJRMP	San Joaquin River Management Plan (or Program)
SLC	San Luis Canal
SLD	San Luis Drain
SLDMWA	San Luis & Delta-Mendota Water Authority
SLOCFC&WCD	San Luis Obispo County Flood Control and Water Conservation District
SMBRP	Santa Monica Bay restoration project
SMUD	Sacramento Municipal Utility District
SNWA	Southern Nevada Water Authority
SOC	synthetic organic compound
SOFAR	South Fork American River (project)
SPPC	Sierra Pacific Power Company
SRCD	Suisun Resource Conservation District
SRF	state revolving fund
SRFCP	Sacramento River Flood Control Project
SRI	Sacramento River index
SSA	Salton Sea Authority
SSJID	South San Joaquin Irrigation District
SSWD	South Sutter Water District

STPUD	South Tahoe Public Utility District
SVGMD	Sierra Valley Groundwater Management District
SVOC	semi-volatile organic compound
SVRID	Stanford Vina Ranch Irrigation District
SVRP	Salinas Valley reclamation project
SWP	State Water Project
SWPP	source water protection program or supplemental water purchase program
SWRCB	State Water Resources Control Board
SWSD	Semitropic Water Storage District

T

taf	thousand acre-feet
TCC	Tehama-Colusa Canal
TCD	temperature control device
TCE	trichloroethylene
TDPUD	Tahoe Donner Public Utility District
TDS	total dissolved solids
THM	trihalomethane
TID	Turlock Irrigation District
TID-MID	Turlock Irrigation District and Modesto Irrigation District
TOC	total organic carbon
TROA	Truckee River Operating Agreement
TRPA	Tahoe Regional Planning Agency

U

UC	University of California
UCD	University of California at Davis
UF	ultrafiltration
ULFT	ultra low flush toilet
USBR	U.S. Bureau of Reclamation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet
UWCD	United Water Conservation District

V

VAMP	Vernalis adaptive management plan
VOC	volatile organic compound

W

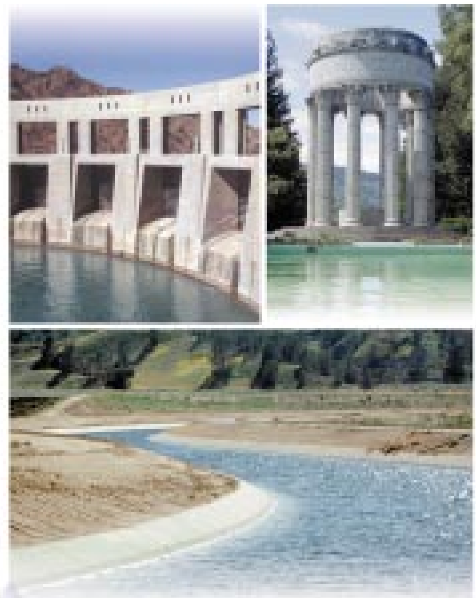
WA	water agency, water authority, or wildlife area
WCD	water conservation district
WCWD	Western Canal Water District
WD	water district
WMD	water management district
WMI	watershed management initiative
WQA	water quality authority
WQCP	water quality control plan
WR 95-6	SWRCB Order WR 95-6
WRCD	Westside Resource Conservation District
WRDA	Water Resources Development Act
WRF	water reclamation facility or water recycling facility
WRID	Walker River Irrigation District
WSD	water storage district
WTP	water treatment plant
WWD	Westlands Water District
WWTP	wastewater treatment plant

Y

YCFC&WCD	Yolo County Flood Control and Water Conservation District
YCWA	Yuba County Water Agency

Z

Z7WA	Zone 7 Water Agency



California Water Plan Update Bulletin 160-98

Volume 2

November 1998

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Glossary

A

active storage capacity the usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity.

afterbay a reservoir that regulates fluctuating discharges from a hydroelectric power plant or a pumping plant.

agricultural drainage (1) the process of directing excess water away from root zones by natural or artificial means, such as by using a system of drains placed below ground surface level; also called subsurface drainage; (2) the water drained away from irrigated farmland.

alluvium unconsolidated soil strata deposited by flowing water.

anadromous fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

applied water demand the quantity of water delivered to the intake of a city's water system or factory, the farm headgate or other point of measurement, or a marsh or other wetland, either directly or by incidental drainage flows. For instream use, it is the portion of the stream flow dedicated to instream use or reserved under the federal or State legislation.

aquifer a geologic formation that stores water and yields significant quantities of water to wells or springs.

arid a term describing a climate or region in which precipitation is so deficient in quantity or occurs so infrequently that intensive agricultural production is not possible without irrigation.

artificial recharge addition of surface water to a groundwater reservoir by human activity, such as putting surface water into spreading basins.

average annual runoff for a specified area is the average value of annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

average year water demand demand for water under average hydrologic conditions for a defined level of development.

B

best management practice (BMP) a generally accepted practice for some aspect of natural resources management, such as water conservation measures, drainage management measures, or erosion control measures. Most frequently used in this Bulletin to refer to water conservation measures adopted by the California Urban Water Conservation Coalition.

biota living organisms of a region, as in a stream or other body of water.

brackish water water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water.

bromide a salt which naturally occurs in small quantities in sea water; a compound of bromine.

C

chaparral a major vegetation type in California characterized by dense evergreen shrubs with thick, hardened leaves.

closed basin a basin whose topography prevents surface outflow of water.

confined aquifer a water-bearing subsurface stratum that is bounded above and below by formations of impermeable, or relatively impermeable, soil or rock.

conjunctive use the operation of a groundwater basin in combination with a surface water storage and conveyance system. Water is stored in the groundwater basin for later use by intentionally recharging the basin during years of above-average water supply.

D

Decision 1485 operating criteria standards for operating the CVP and SWP under Water Right Decision 1485 for the Sacramento-San Joaquin Delta and Suisun Marsh, adopted by the State Water Resources Control Board in August 1978.

Decision 1631 a water right decision specifying required Mono Lake levels, adopted by the State Water Resources Control Board in 1994.

deep percolation percolation of (irrigation) water through the ground and beyond the lower limit of the root zone of plants into groundwater.

demand management alternatives water management programs—such as water conservation or drought rationing—that reduce demand for water.

dependable supply the average annual quantity of water that can be delivered during a drought period.

depletion the water consumed within a service area and no longer available as a source of supply. For agriculture and wetlands, it is ETAW (and ET of flooded wetlands) plus irrecoverable losses. For urban water use, it is ETAW (water applied to landscaping or home gardens), sewage effluent that flows to a salt sink, and incidental ET losses. For instream use, it is the amount of dedicated flow that reaches a salt sink.

desalting a process to reduce the salt concentration of sea water or brackish water.

detailed analysis unit (DAU) the smallest study area used by the Department for analyses of water demand and supply. Generally defined by hydrologic features or boundaries of organized water service agencies. In major agricultural areas, a DAU typically includes 100,000 to 300,000 acres.

discount rate the interest rate used to calculate the present value of future benefits and future costs or to convert benefits and costs to a common time basis.

dissolved organic compounds carbon-based substances dissolved in water.

dissolved oxygen (DO) the amount of oxygen dissolved in water or wastewater, usually expressed in milligrams per liter, parts per million, or percent of saturation.

distribution uniformity (DU) a measure of the variation in the amount of water applied to the soil surface throughout an irrigated area, expressed as a percent.

drainage area the area of land from which water drains into a river; for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called watershed or river basin.

drought condition hydrologic conditions during a defined period when rainfall and runoff are much less than average.

drought year supply the average annual supply of a water development system during a defined drought period.

E

efficient water management practice (EWMP) an agricultural water conservation measure, such as those adopted under the MOU regarding water conservation.

effluent wastewater or other liquid, treated or in its natural state, flowing from a treatment plant or process.

environmental water the water for wetlands, for the instream flow in a major river or in the Bay-Delta, or for a designated wild and scenic river

estuary the lower course of a river entering the sea where tidal action meets river flow.

evapotranspiration (ET) the quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.

evapotranspiration of applied water (ETAW) the portion of the total evapotranspiration which is provided by irrigation and landscape watering.

F

firm yield the maximum annual supply from of a water development project under drought conditions, for some specified level of demands.

forebay a reservoir at the intake of a pumping plant or power plant to stabilize water levels; also a storage basin for regulating water for percolation into groundwater basins.

fry a recently hatched fish.

G

gray water waste water from a household or small commercial establishment. Gray water does not include water from a toilet, kitchen sink, dishwasher, washing machine, or water used for washing diapers.

gross reservoir capacity the total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes dead (or inactive) storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).

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.

groundwater basin a groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

groundwater overdraft the condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.

groundwater recharge the natural or intentional infiltration of surface water into the zone of saturation (i.e., into groundwater).

groundwater storage capacity volume of void space that can be occupied by water in a given volume of a formation, aquifer, or groundwater basin.

groundwater table the upper surface of the zone of saturation, in an unconfined aquifer.

H

hardpan a layer of nearly impermeable soil beneath a more permeable soil, formed by natural chemical cementation of the soil particles.

head ditch the water supply ditch at the head of an irrigated field.

hydraulic barrier a barrier developed in an estuary by release of fresh water from upstream reservoirs to prevent intrusion of seawater into the body of fresh water. Also, a barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

hydrologic balance an accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time.

hydrologic basin the drainage area upstream from a given point on a stream.

hydrologic region a study area consisting of multiple planning subareas. California is divided into 10 hydrologic regions.

I

instream use use of water within its natural watercourse as specified in an agreement, water rights permit, etc. For example, the use of water for navigation, recreation, fish and wildlife, aesthetics, and scenic enjoyment.

irrecoverable losses the water lost to a salt sink or lost by evaporation or evapotranspiration from a conveyance facility or drainage canal, or in fringe areas of cultivated fields.

irrigated acreage land area that is irrigated, which is equivalent to total irrigated crop acreage minus the amount of acreage that was multiple-cropped.

irrigation return flow applied water that is not transpired, evaporated, or infiltrated into a groundwater basin but that returns to a surface water body.

L

land subsidence the lowering of the natural land surface due to groundwater (or oil and gas) extraction.

laser land leveling precision leveling of cultivated fields to improve irrigation efficiency.

laterals the part of an irrigation districts's delivery system that conveys water from the district's main canals to turnouts for farmers' fields

leaching the flushing of salts from the soil by the downward percolation of applied water.

leaching requirement the theoretical amount of irrigation water that must pass (leach) through the soil beyond the root zone to keep soil salinity within acceptable levels for sustained crop growth.

level of development in a planning study, the practice of holding water demands constant at some specified level so that hydrologic variability can be studied.

M

maximum contaminant level (MCL) the highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

moisture stress a condition of physiological stress in a plant caused by lack of water.

multipurpose project a project, usually a reservoir, designed to serve more than one purpose, and whose costs are normally allocated among the different functions it provides. For example, a project that provides water supply, flood control, and generates hydroelectricity.

N

National Pollutant Discharge Elimination System (NPDES) a provision of Section 402 of the federal Clean Water Act that established a permitting system for discharges of waste materials to water courses.

net water demand (net water use) the amount of water needed in a water service area to meet all requirements. It is the sum of evapotranspiration of applied water in an area, the irrecoverable losses from the distribution system, and the outflow leaving the service area; does not include reuse of water within a service area.

nonpoint source waste water discharge other than from point sources. See also point source.

nonreimbursable costs the part of project costs allocated to general statewide or national beneficial purposes and funded from general revenues, rather than by water users.

normalized demand the process of adjusting actual water use in a given year to account for unusual events such as dry weather conditions, government price support programs for agriculture, rationing programs, or other unusual conditions.

O

overdraft see *groundwater overdraft.*

P

pathogens viruses, bacteria, or other organisms that cause disease.

perched groundwater groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater.

perennial yield the maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

permeability the capability of soil or other geologic formations to transmit water.

phytoplankton minute plants, such as algae, that live suspended in bodies of water.

planning subarea (PSA) an intermediately-sized study area used by the Department, consisting of multiple detailed analysis units.

point source a specific site from which wastewater or polluted water is discharged into a water body.

pollution (of water) the alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

project yield the water supply attributed to all features of a project, including integrated operation of units that could be operated individually.

pump lift the distance between the groundwater table and the overlying land surface.

pumped storage project a hydroelectric powerplant and reservoir system using an arrangement whereby water released for generating energy during peak load periods is stored and pumped back into the upper reservoir, usually during periods of reduced power demand.

pump-generating plant a plant which can either pump water or generate electricity, depending on the direction of water flow.

R

recharge basin a surface facility constructed to infiltrate surface water into a groundwater basin.

recycled water urban wastewater that becomes suitable, as a result of treatment, for a specific beneficial use. Also called reclaimed water. See also *water recycling.*

return flow the portion of withdrawn water not consumed by evapotranspiration or system losses which returns to its source or to another body of water.

reuse the additional use of previously used water. As used in this report, it is not water that has been recycled for beneficial use at a wastewater treatment plant.

reverse osmosis a method to remove salts and other constituents from water by forcing water through membranes.

riparian located on the banks of a stream or other body of water. Riparian water rights are rights held by landowners adjacent to a natural waterbody.

runoff the volume of surface flow from an area.

S

salinity generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as an electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also t*otal dissolved solids.*

salinity intrusion the movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

salmonid fish species belonging to the salmon family, including salmon and trout.

salt sink a saline body of water, such as the ocean.

salt-water barrier a physical facility or method of operation designed to prevent the intrusion of salt water into a body of fresh water (see hydraulic barrier).

Seasonal Application Efficiency (SAE) the sum of ETAW and cultural water requirements divided by applied water.

seepage the gradual movement of a fluid into, through, or from a porous medium.

self-produced water a water supply (often from wells) developed and used by an individual or entity. Also called "self-supplied water."

service area the geographic area served by a water agency.

soluble minerals naturally occurring substances capable of being dissolved.

spreading basin see *recharge basin.*

spreading grounds see *recharge basin.*

supply augmentation alternatives water management programs—such as reservoir construction or groundwater extraction—that increase supply.

surface supply water supply from streams, lakes, and reservoirs.

T

tailwater applied irrigation water that runs off the end of a field. Tailwater is not necessarily lost; it can be collected and reused on the same or adjacent fields.

tertiary treatment in wastewater treatment, the additional treatment of effluent beyond that of secondary treatment to obtain higher quality of effluent.

total dissolved solids (TDS) a quantitative measure of the residual minerals dissolved in water that remain after evaporation of a solution. Usually expressed in milligrams per liter. Abbreviation: TDS. See also *salinity*.

transpiration an essential physiological process in which plant tissues give off water vapor to the atmosphere.

trihalomethane (THM) a chlorinated halogen compound such as chloroform, carbon tetrachloride or bromoform.

U

unimpaired flow the flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

W

wastewater domestic or municipal sewage or effluent from an industrial process.

water quality description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water recycling the treatment of urban wastewater to a level rendering it suitable for a specific beneficial use.

water service reliability the degree to which a water service system can successfully manage water shortages.

watershed see *drainage basin.*

water table see *groundwater table.*

water transfers marketing arrangements that can include the permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; the sale or lease of a contractual right to water supply.

water year a continuous 12-month period for which hydrologic records are compiled and summarized. Different agencies may use different calendar periods for their water years.

Conversion Factors

Quantity	To convert from customary unit	To metric unit	Multiply customary unit by	To convert to customary unit, multiply metric unit by
Length	inches (in)	millimeters (mm)●	25.4	0.03937
	inches (in)	centimeters (cm)	2.54	0.3937
	feet (ft)	meters (m)	0.3048	3.2808
	miles (mi)	kilometers (km)	1.6093	0.62139
Area	square inches (in^2)	square millimeters (mm^2)	645.16	0.00155
	square feet (ft^2)	square meters (m^2)	0.092903	10.764
	acres (ac)	hectares (ha)	0.40469	2.4710
	square miles (mi^2)	square kilometers (km^2)	2.590	0.3861
Volume	gallons (gal)	liters (L)	3.7854	0.26417
	million gallons (10^6 gal)	megaliters (ML)	3.7854	0.26417
	cubic feet (ft^3)	cubic meters (m^3)	0.028317	35.315
	cubic yards (yd^3)	cubic meters (m^3)	0.76455	1.308
	acre-feet (ac-ft)	thousand cubic meters (m^3 x 10^3)	1.2335	0.8107
	acre-feet (ac-ft)	hectare-meters (ha - m)■	0.1234	8.107
	thousand acre-feet (taf)	million cubic meters (m^3 x 10^6)	1.2335	0.8107
	thousand acre-feet (taf)	hectare-meters (ha - m)■	123.35	0.008107
	million acre-feet (maf)	billion cubic meters (m^3 x 10^9)◆	1.2335	0.8107
	million acre-feet (maf)	cubic kilometers (km^3)	1.2335	0.8107
Flow	cubic feet per second (ft^3/s)	cubic meters per second (m^3/s)	0.028317	35.315
	gallons per minute (gal/min)	liters per minute (L/min)	3.7854	0.26417
	gallons per day (gal/day)	liters per day (L/day)	3.7854	0.26417
	million gallons per day (mgd)	megaliters per day (ML/day)	3.7854	0.26417
	acre-feet per day (ac-ft/day)	thousand cubic meters per day (m^3 x 10^3/day)	1.2335	0.8107
Mass	pounds (lb)	kilograms (kg)	0.45359	2.2046
	tons (short, 2,000 lb)	megagrams (Mg)	0.90718	1.1023
Velocity	feet per second (ft/s)	meters per second (m/s)	0.3048	3.2808
Power	horsepower (hp)	kilowatts (kW)	0.746	1.3405
Pressure	pounds per square inch (psi)	kilopascals (kPa)	6.8948	0.14505
	head of water in feet	kilopascals (kPa)	2.989	0.33456
Specific capacity	gallons per minute per foot of drawdown	liters per minute per meter of drawdown	12.419	0.08052
Concentration	parts per million (ppm)	milligrams per liter (mg/L)	1.0	1.0
Electrical conductivity	micromhos per centimeter	microsiemens per centimeter (mS/cm)	1.0	1.0
Temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32)/1.8	(1.8 x °C) + 32

● When using "dual units," inches are normally converted to millimeters (rather than centimeters).

■ Not used often in metric countries, but is offered as a conceptual equivalent of customary western U.S. practice (a standard depth of water over a given area of land).

◆ ASTM Manual E380 discourages the use of billion cubic meters since that magnitude is represented by giga (a thousand million) in other countries. It is shown here for potential use for quantifying large reservoir volumes (similar to million acre-feet).

Other Common Conversion Factors

1 cubic foot=7.48 gallons=62.4 pounds of water

1 cubic foot per second (cfs)=450 gallons per minute (gpm)

1 cfs=646,320 gallons a day=1.98 ac-ft a day

1 acre-foot=325,900 gallons=43,560 cubic feet

1 million gallons=3.07 acre-feet

1 million gallons a day (mgd)=1,120 ac-ft a year