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Summary of Volume II

Bulletin 160-93 is organized into two volumes. Volume I discusses statewide issues; presents an overview of current and future water management activities while detailing statewide water supplies and water demands; and updates various elements of California's statewide water planning. Volume II examines current water demands and available supplies in each of the State's ten major hydrologic regions; discusses regional and local water-related issues; and details forecasts of supplies and demands for each region to the year 2020.

To best illustrate overall demand and supply availability, two water supply and demand scenarios, an average year and a drought year, are presented for the 1990 level of development and for forecasted development in 2020. Shortages shown under average conditions are chronic shortages indicating the need for additional long-term water management measures. Shortages shown under drought conditions can be met by both long-term and short-term measures, depending on the frequency and severity of the shortage and water service reliability requirements.

Regional water budgets present 1990 level and future water demands to 2020 and compare them with supplies from existing facilities and water management programs, and with future demand management and water supply augmentation programs. Future water management programs are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a higher likelihood of being implemented by 2020.

California's Water Supply Availability

Average year supply is the average annual supply of a water development system over a long period. For this report the SWP and CVP average year supply is the average annual delivery capability of the projects over a 70–year study period (1922–91). For a local project without long–term data, it is the annual average deliveries of the project during the 1984–86 period. For dedicated natural flow, it is the long–term average natural flow for wild and scenic rivers, or it is environmental flows as required for an average year under specific agreements, water rights, court decisions, and congressional directives.

Drought year supply is the average annual supply of a water development system during a defined drought period. For this report, the drought period is the average of water years 1990 and 1991. For dedicated natural flow, it is the average of water years 1990 and 1991 for wild and scenic rivers, or it is environmental flows as required under specific agreements, water rights, court decisions, and congressional directives.

- Level II options are those programs that could fill the remaining gap shown in the balance between supply and urban, agricultural, and environmental water demands. These options require more extensive investigation and alternative analyses.

At the end of this chapter is the California Water Budget and a brief overview of local water management issues. The remaining chapters of Volume II discuss water demands, water supplies, and water management issues related to each of the ten major hydrologic regions of the State (Figure S-1). Appendix C presents regional planning subarea and land ownership maps and Appendix D lists hydroelectric facilities of the State by region.

Public Involvement

California's water policies are still evolving as new statutes, court decisions, and agreements become effective. In light of this, the California legislature passed and Governor Wilson signed AB 799 in 1991 requiring the California Water Plan be updated every 5 years. This water plan update was developed with extensive public involvement including an outreach advisory committee made up of urban, agricultural, and environmental interests. This committee was established in June 1992 to review and comment on the adequacy of work in progress. That process has been valuable in developing Bulletin 160-93 into a comprehensive water plan for water management in California.

In addition, the California Water Commission held hearings in each of the State's ten hydrologic regions during January and February 1994, to receive public comments about the November 1993 draft *California Water Plan Update.* After considering comments received from over 100 individuals, the commission developed several recommendations which added policy guidance for the final water plan update. Public comments are, to the extent applicable, incorporated into this report or are included in Appendix B,Volume I.

Water Supply

Since the last water plan update in 1987, *California Water: Looking to the Future, Bulletin 160-87,* evolving environmental policies have introduced considerable uncertainty about much of the State's developed water supply. For example, the winter-run chinook salmon and the Delta smelt were listed under the State and federal Endangered Species Acts, imposing restrictions on Delta exports, and the Central Valley Project Improvement Act (P.L. 102-575) was passed in 1992, reallocating over a million acre-feet of CVP supplies for fish and wildlife. Other actions that could have far-reaching consequences are the EPA's proposed standards for the Bay-Delta Estuary and future State Water Resources Control Board Bay-Delta standards.

Figure S-1. Hydrologic Regions in California

These actions affect the export capability from California's most important water supply hub, the Sacramento-San Joaquin Delta, while also imposing restrictions on upstream diverters. The Delta is the source from which two-thirds of the State's population and millions of acres of agricultural land receive part or all of their supplies. Today, areas of the State relying on the Delta for all or a portion of their supplies find these supplies unreliable. Such uncertainty of water supply delivery and reliability will continue until issues involving the Delta and other long-term environmental water management concerns are resolved. Table S-1 shows California water supplies, with existing facilities and water management programs (under SWRCB Water Rights Decision 1485). Water supplies shown do not take into account recent actions to protect aquatic species for the 1990 level of development and forecasted 2020 development.

Table S-1. California Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(millions of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	10.1	8.1	10.1	8.1	10.2	8.3	10.3	8.4
Local imports(1)	1.0	0.7	1.0	0.7	1.0	0.7	1.0	0.7
Colorado River	5.2	5.1	4.4	4.4	4.4	4.4	4.4	4.4
CVP	7.5	5.0	7.7	5.1	7.7	5.2	7.7	5.2
Other federal	1.2	0.8	1.3	0.8	1.3	0.8	1.3	0.8
SWP(1)	2.8	2.1	3.2	2.0	3.3	2.0	3.3	2.0
Reclaimed	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ground water(2)	7.1	11.8	7.1	12.0	7.2	12.1	7.4	12.2
Ground water overdraft(3)	1.3	1.3	—	—	—	—	—	—
Dedicated natural flow	27.2	15.3	27.4	15.4	27.4	15.4	27.4	15.4
TOTAL	63.5	50.4	62.4	48.9	62.7	49.1	63.0	49.4

(1) 1990 SWP supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins to the South Coast hydrologic region.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Annual reductions in total water supply for urban and agricultural uses could be in the range of 500,000 af to 1,000,000 af in average years and 2,000,000 to 3,000,000 af in drought years. These reductions result mainly from compliance with the ESA biological opinions and proposed EPA Bay-Delta standards. While these impacts do not consider the potential reductions in Delta exports due to "take limits" under the biological opinions, they basically fall within the 1,000,000-to-3,000,000-af range for proposed additional environmental demands for protection and enhancement of aquatic species.

Californians are finding that existing water management systems are no longer able to provide sufficiently reliable water service to users. In most areas of the State, as a result of the 1987-92 drought, water conservation and rationing became mandatory for urban users, many agricultural areas had surface water supplies drastically curtailed, and environmental resources were strained. Until a Delta solution that meets the needs of urban, agricultural, and environmental interests is identified and implemented, there likely will be water supply shortages in both dry and average years.

While the six-year drought stretched California's developed supplies to their limits, innovative water management actions, water transfers, water supply interconnections, and changes in project operations to benefit fish and wildlife all helped to reduce the harmful effects of the prolonged drought. Today, water managers are looking into a wide variety of demand management and supply augmentation programs to supplement, improve, and make better use of existing resources. The following sections summarize results from regional and statewide analyses of water supplies and the water supply benefits of Level I water management programs. Tables S-2 and S-3 list the major water management programs included in Level I analyses and described in more detail in Chapter 11 of Volume I. The contribution of these programs to future regional water supplies is included in Table S-4, which shows water supplies for the 1990 level of development and compares them to forecasted supplies in 2020, with Level I water management programs in place. Note that Delta supplies are assumed to be operated under SWRCB D-1485 criteria, and that areas receiving Delta supplies are already impacted by reduced export capability as a result of recent actions to protect aquatic species through criteria more stringent than D-1485. As such, statewide and regional water supplies are overstated.

Table S-2. Level I Demand Management Programs

Program	*Applied Water Reduction* (1,000 AF)	*Net Water Demand Reduction* (1,000 AF) *average*	*drought*	*Economic Unit Cost* ($/AF)[a]	*Comments*
Long-term Demand Management:					
Urban Water Conservation	1,300	900	900	315-390[b]	Urban BMPs
Agricultural Water Conservation	1,700	300	300	Not Available	Increased irrigation efficiency
Land Retirement	130	130	130	60	Retirement of land with drainage problems in west San Joaquin Valley; cost is at the Delta.
All American Canal Lining	68	68	68	—	Water conservation project; increases supply to South Coast Region
Short-term Demand Management:					
Demand Reduction	1,300	0	1,000	Not Available	Drought year supply
Land Fallowing/Short-term Water Transfers	800	0	800	125	Drought year supply; cost is at the Delta.

(a) Economic costs include capital and OMP&R costs discounted over a 50-year period at 6 percent discount rate. These costs do not include applicable transportation and treatment costs.
(b) Costs are for the ultra-low-flush toilet retrofit and residential water audit programs.

Table S-3. Level I Water Supply Management Options

Program	Type	Capacity (1,000 AF)	Annual Supply (1,000 AF) average	Annual Supply (1,000 AF) drought	Economic Unit Cost ($/AF)[1]	Comments
Statewide Water Management:						
Long-term Delta Solution	Delta Water Management Program	—	200	400	Not Available	Under study by Bay/Delta Oversight Council; water supply benefit is elimination of carriage water under D-1485.
Interim South Delta Water Management Program	South Delta Improvement	—	60	60	60	Final draft is scheduled to be released in late 1994
Los Banos Grandes Reservoir[2 & 7]	Offstream Storage	1,730[3]	250-300	260	260	Schedule now coincides with BDOC process
Kern Water Bank[7]						
• Kern Fan Element	Ground Water Storage	1,000	90	140	105-155	Evaluation under way
Local Elements	Ground Water Storage	2,000	90	290	180-460	Schedule now coincides with BDOC process
Coastal Branch–Phase II (Santa Ynez Extension)	SWP Conveyance Facility	57	N/A	N/A	630-1,110	Notice of Determination was filed in July 1992; construction began in late 1993.
American River Flood Control[4]	Flood Control Storage	545[3]	—	—	—	Feasibility report and environmental documentation completed in 1991.
Local Water Management:						
Water Recycling	Reclamation	1,321	923	923	125-840	New water supply
Ground Water Reclamation	Reclamation	200	100	100	350-900	Primarily in South Coast
El Dorado County Water Agency Water Program	Diversion from South Fork American River		24	23[5]	280	Certified final Programmatic EIR identifying preferred alternative; water rights hearings, new CVP contract following EIR/EIS preparation
Los Vaqueros Reservoir-Contra-Costra Water District	Offstream Storage Emergency Supply Water Quality	100	N/A	N/A	320-950	EIR certified in October 1993, 404 permit issued in April 1994.
EBMUD	Conjunctive Use and Other Options		N/A	43	370	Final EIR certified in October 1993
New Los Padres Reservoir-MPWMD	Enlarging existing reservoir	24	22	18	410	T&E species, steelhead resources, cultural resources in Carmel River
Domenigoni Valley Reservoir-MWDSC	Offstream storage of SWP and Colorado River water, drought year supply	800	0	264	410	Final EIR certified
Inland Feeder-MWDSC	Conveyance Facilities	—	—	—	—	
San Felipe Extension-PVWA	CVP Conveyance Facility		N/A	N/A[5]	140	Capital costs only; convey 18,000 AF annually
City of San Luis Obispo-Salinas Reservoir	Enlarging existing reservoir	18	—	1.6	—	Final EIR is expected to be certified in 1994.

(1) Economic costs include capital and OMP&R costs discounted over a 50-year period at 6 percent discount rate. These costs do not include applicable transportation and treatment costs.
(2) Annual supply and unit cost figures are based on Delta water supply availability under D-1485 with an Interim South Delta Water Management Program in place.
(3) Reservoir capacity.
(4) Folsom Lake flood control reservation would return to original 0.4 MAF.
(5) Yield of this project is in part or fully comes from the CVP.
(6) N/A: Not Applicable
(7) These programs are only feasible if a Delta Water Management Program is implemented.

Local surface water development includes direct stream diversions as well as supplies in local storage facilities. As a result of economic, environmental, and regulatory obstacles, local agencies are finding it difficult to undertake new water projects to meet their needs where supply shortfalls exist or are projected to occur in the future. Thus, many local and regional water agencies are advocating or implementing incentive programs for water conservation to reduce demand where such programs are cost effective. Implementation of urban Best Management Practices and agricultural Efficient Water Management Practices will reduce demands in the future, and reductions caused by these practices were incorporated into water demand forecasts to 2020. (See the *Demand Reduction* section in this chapter.) However, these practices only partially improve water service reliability. Local water agencies should continue to plan for water demand management and supply augmentation actions to increase or assure water service reliability to meet future needs.

Ongoing local water supply programs include the Metropolitan Water District of Southern California's Domenigoni Valley Reservoir, East Bay Municipal Utility District's water management program, El Dorado County Water Agency's water program, City of San Luis Obispo's Salinas Reservoir enlargement, and Monterey Peninsula Water Management District's New Los Padres Reservoir. By 2020, additional local surface water management programs could improve local annual supplies by about 40,000 af and 344,000 af for average and drought years, respectively.

Local imported supplies are undergoing transition. Court-ordered restrictions on diversion from the Mono Basin and Owens Valley have reduced the amount of water the City of Los Angeles can receive. These restrictions have brought into question the reliability of Mono-Owens supply for the South Coast Region.

Table S-4. California Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(millions of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	10.1	8.1	10.2	8.2	10.2	8.3	10.3	8.4
Local imports[1]	1.0	0.7	1.0	0.8	1.0	1.0	1.0	1.0
Colorado River	5.2	5.1	4.4	4.4	4.4	4.4	4.4	4.4
CVP	7.5	5.0	7.7	5.2	7.7	5.2	7.7	5.2
Other federal	1.2	0.8	1.3	0.8	1.3	0.8	1.3	0.8
SWP[1]	2.8	2.1	3.4	2.1	3.9	3.0	4.0	3.0
Reclaimed	0.2	0.2	0.7	0.7	0.8	0.8	0.9	0.9
Ground water[2]	7.1	11.8	7.1	11.9	7.2	12.2	7.3	12.3
Ground water overdraft[3]	1.3	1.3	—	—	—	—	—	—
Dedicated natural flow	27.2	15.3	27.5	15.4	27.5	15.4	27.5	15.4
TOTAL	63.5	50.4	63.3	49.5	64.0	51.2	64.5	51.6

(1) 1990 SWP supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins to the South Coast hydrologic region.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Colorado River supplies to the Colorado River and South Coast regions for urban and agricultural uses could decline from about 5,200,000 af to California's basic apportionment of 4,400,000 af annually. With Arizona and Nevada using less than their apportionment of water, their unused supply of Colorado River water was made available to meet California's requirements during recent years. Southern California was spared from severe rationing during most of the 1987-92 drought primarily as a result of about 600,000 af annually of surplus and unused Colorado River water that was made available to the Metropolitan Water District of Southern California. Even with this supply, however, much of Southern California experienced significant rationing in 1991. Supplemental Colorado River water cannot be counted on to meet needs in the future as Arizona and Nevada continue to use more of their allocated share of Colorado River water.

Local imported supplies are discussed in detail in the following chapters about each hydrologic region. Chapter 3, Volume I, includes a general summary of the major local imported water supply projects.

Central Valley Project yield will remain about the same. The U. S. Bureau of Reclamation is required by the CVPIA to study replacement sources for 800,000 af of water recently allocated to environmental uses in the Central Valley, but has no authority under CVPIA to implement projects identified in this study. Additional supplies needed for potential future CVP conveyance facilities, such as the San Felipe extension, will probably come from reallocation of already contracted CVP supplies.

Table S-5. State Water Project Supplies
(millions of acre-feet)

Level of Development	*SWP Delivery Capability*[1]				*SWP Delta Export Demand*
	With Existing Facilities		*With Level I Water Management Programs*[2]		
	average	*drought*	*average*	*drought*	
1990	2.8	2.1	—	—	3.0
2000	3.2	2.0	3.4	2.1	3.7
2010	3.3	2.0	3.9	3.0	4.2
2020	3.3	2.0	4.0	3.0	4.2

(1) Assumes D-1485. SWP capability is uncertain until solutions to complex Delta problems are implemented and future actions to protect aquatic species are identified. Includes SWP conveyance losses.
(2) Level I programs include South Delta Water Management Programs, long-term Delta Water Management Programs, the Kern Water Bank (including Local Elements), and Los Banos Grandes facilities.
Note: Feather River Service Area supplies are not included. FRSA average and drought supplies are 927,000 and 729,000 AF respectively.

State Water Project supply studies were conducted to evaluate the delivery capability of the Project with: (1) existing facilities and (2) Level I water management programs under SWRCB D-1485 operating criteria (see Table S-5). SWP supplies for the 1990 level were 2,800,000 af and 2,100,000 af for average and drought years, respectively. SWP 1990 average supply is normalized and does not reflect additional supplies delivered to offset reduction of Mono-Owens deliveries to South Coast Region. Additional Level I programs include the South Delta Water Management Program, long-term Delta water management programs, the Kern Water Bank (including local elements), Los Banos Grandes Reservoir, and the Coastal Branch Extension of the

California Aqueduct. With the Level I programs, SWP supplies could increase to about 4,000,000 af and 3,000,000 af in average and drought years by the year 2020.

Table S-6. Use of Ground Water by Hydrologic Region[1]

(thousands of acre-feet)

Hydrologic Region	1990		2000		2010		2020	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
North Coast	263	283	275	295	286	308	298	316
San Francisco Bay	100	139	126	174	160	174	165	174
Central Coast	688	762	694	769	695	776	698	781
South Coast	1,083	1,306	1,100	1,325	1,125	1,350	1,150	1,375
Sacramento River	2,496	2,865	2,463	2,985	2,426	3,033	2,491	3,038
San Joaquin River	1,098	2,145	1,135	2,202	1,156	2,227	1,161	2,252
Tulare Lake	915	3,773	918	3,758	921	3,726	926	3,758
North Lahontan	121	146	128	154	138	165	147	173
South Lahontan	221	252	220	237	226	271	258	271
Colorado River	80	80	79	79	80	80	79	79
TOTAL	7,100	11,800	7,100	12,000	7,200	12,100	7,400	12,200

(1) Average year ground water use represents use of prime supply of ground water basins. Ground water overdraft is not included.

California's ground water resources played a vital role in helping the State through the 1987-92 drought. Recent studies by DWR indicate that many of the San Joaquin Valley's ground water aquifers substantially recovered from the 1976-77 drought during the late 1970s and early 1980s when surface runoff and Delta exports were above average. Conjunctive use operations, which helped make this possible, will continue to be refined and made more effective in the future. The 1990 level average annual net ground water use in California is about 8,400,000 af, including 1,300,000 af of ground water overdraft. During droughts, ground water use is increased significantly to offset reduction in surface water supplies, as shown in Table S-6. Annual ground water overdraft has been reduced by about 700,000 af since 1980, when ground water overdraft was last studied (see Table S-7). This reduction has mainly occurred in the San Joaquin Valley and is due to the benefits of imported supplies to the San Joaquin River and Tulare Lake regions, and construction and operation of Hidden and Buchanan dams. These local reservoirs provided controlled surface water releases and opportunities for greater ground water recharge during the 1970s and 1980s.

Average ground water use (not including overdraft) shown in Table S–6 represents use of the prime supply of ground water. Prime supply of a ground water basin is the average annual natural recharge of the basin by deep percolation of rainfall and percolation from streambeds and lakes.

Ground water overdraft in a basin can induce movement of water from adjacent areas. If the adjacent areas contain poor quality water, degradation would occur in the basin. There is a west-to-east ground water gradient in the San Joaquin Valley from Merced County to Kern County. Poor quality ground water moves eastward along this gradient, displacing good quality ground water in the trough of the valley. The total dissolved solids in the west side of the valley generally ranges from 2,000 to 7,000 milligrams per liter; the east-side water from 300 to 700 milligrams per liter. This adverse effect of overdraft and possible degradation of ground water quality in San Joaquin Valley has been evaluated and included in ground water overdraft analyses.

Table S-7. Ground Water Overdraft by Hydrologic Region
(thousands of acre-feet)

Region	*1990*
North Coast	0
San Francisco Bay	0
Central Coast	240
South Coast	20
Sacramento River	30
San Joaquin River	210
Tulare Lake	650
North Lahontan	0
South Lahontan	70
Colorado River	80
STATEWIDE	1,300

Because ground water is usually used to replace much of the shortfall in surface water supplies, recent limitations on Delta exports will exacerbate ground water overdraft in the San Joaquin River and Tulare Lake regions, and in other regions receiving a portion of their supplies from the Delta. For example, in 1993, an above-normal runoff year, environmental restrictions limited CVP deliveries to 50 percent of contracted supply for federal water service contractors from Tracy to Kettleman City.

Water reclamation programs such as water recycling, reclamation of contaminated ground water, ocean water desalting, and desalting of agricultural drainage water were evaluated (see Volume I, Chapter 11 for a detailed discussion of these problems). Projected water recycling is based on evaluation of water recycling data presented in *Future Water Recycling Potential, 1993 Survey*, a report by the WateReuse Association of California, and information provided by local water and sanitation districts. Table S-8 shows the estimated water recycling contribution (new water supply) to water supply by hydrologic region.

Ground water reclamation programs could be implemented to recover degraded ground water. Currently, most ground water reclamation programs in the planning process are in Southern California. The supply benefit of ground water reclamation by the year 2000 is estimated at about 90,000 af and is included with ground water supplies.

Table S-8. Total Water Recycling and Resulting New Water Supply by Hydrologic Region
(thousands of acre-feet)

Hydrologic Regions	1990 Total Water Recycling	1990 New Water Supply	2000 Total Water Recycling	2000 New Water Supply	2010 Total Water Recycling	2010 New Water Supply	2020 Total Water Recycling	2020 New Water Supply
North Coast								
Existing	14	11	—	—	—	—	—	—
Level I	—	—	23	14	23	17	23	20
Level II	—	—	2	2	4	4	6	6
San Francisco Bay								
Existing	36	36	—	—	—	—	—	—
Level I	—	—	74	74	111	111	119	119
Level II	—	—	20	20	40	40	59	59
Central Coast								
Existing	40	15	—	—	—	—	—	—
Level I	—	—	74	59	87	70	87	70
Level II	—	—	0	0	0	0	0	0
South Coast								
Existing	140	82	—	—	—	—	—	—
Level I	—	—	632	481	814	580	888	679
Level II	—	—	110	110	246	246	302	302
Sacramento River								
Existing	9	0	—	—	—	—	—	—
Level I	—	—	10	0	11	0	11	0
Level II	—	—	0	0	0	0	0	0
San Joaquin River								
Existing	24	0	—	—	—	—	—	—
Level I	—	—	30	0	35	0	48	0
Level II	—	—	0	0	0	0	0	0
Tulare Lake								
Existing	63	0	—	—	—	—	—	—
Level I	—	—	68	0	73	0	80	0
Level II	—	—	0	0	0	0	0	0
North Lahontan								
Existing	8	8	—	—	—	—	—	—
Level I	—	—	8	8	8	8	8	8
Level II	—	—	1	1	1	1	1	1
South Lahontan								
Existing	13	13	—	—	—	—	—	—
Level I	—	—	13	13	14	14	14	14
Level II	—	—	1	1	1	1	2	2
Colorado River								
Existing	7	7	—	—	—	—	—	—
Level I	—	—	26	9	37	12	43	13
Level II	—	—	0	0	0	0	0	0
TOTAL								
Existing	354	172	—	—	—	—	—	—
Level I	—	—	958	658	1,213	812	1,321	923
Level II	—	—	134	134	292	292	370	370

Water Demand

Extensive evaluation and analyses of water demand were conducted for this water plan update. These analyses recognize the water demands of all beneficial uses: urban, agricultural, environmental, and other uses including water-based recreation, and power generation. Water-based recreation is discussed more extensively in Volume I, Chapter 9. Table S-9 summarizes statewide estimated water demands.

Definitions of Terms

- **Applied water:** The amount of water from any source needed to meet the demand of the user. It is the quantity of water delivered to any of the following locations:
  - The intake to a city water system or factory;
  - The farm headgate;
  - A marsh or wetland, either directly or by incidental drainage flows; this is water for wildlife areas; and
  - For existing instream use, applied water demand is the portion of the stream flow dedicated to instream use or reserved under the federal or State Wild and Scenic Rivers Acts or the flow needed to meet salinity standards in the Sacramento-San Joaquin Delta under SWRCB standards.
- **Average year demand:** The demand for water under average weather conditions for a defined level of development.
- **Depletion:** The water consumed within a service area and no longer available as a source of water supply. For agriculture and wetlands it is ETAW plus irrecoverable losses. For urban areas it is the exterior ETAW, sewage effluent that flows to a salt sink, and incidental ET losses. For instream needs it is the dedicated flow that proceeds to a salt sink.
- **Drought year demand:** The demand for water during a drought period for a defined level of development. It is the sum of average year demand and water needed for any additional irrigation of farms and landscapes due to the lack of precipitation or increase in evapotranspiration during drought.
- **Evapotranspiration:** The quantity of water transpired (given off) and evaporated from plant tissues and surrounding soil surfaces. Quantitatively, it is expressed in terms of volume of water per unit acre of depth of water during a specified period of time. Abbreviation: ET.
- **Evapotranspiration of applied water:** The portion of the total evapotranspiration which is provided by irrigation. Abbreviation: ETAW.
- **Irrecoverable losses:** The water lost to a salt sink or water lost by evaporation or evapotranspiration from conveyance facilities or drainage canals.
- **Net water demand:** The amount of water needed in a water service area to meet all the water service 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, including treated municipal outflow.
- **Normalized demand:** The result of adjusting actual water use in a given year to account for unusual events such as dry weather conditions, government interventions for agriculture, rationing programs, etc.

Table S-9. California Water Demand
(millions of acre-feet)

Category of Use	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Urban								
Applied water demand	7.8	8.1	9.3	9.7	10.9	11.4	12.7	13.2
Net water demand	6.8	7.1	7.9	8.3	9.2	9.6	10.5	11.0
Depletion	5.7	6.0	6.4	6.7	7.3	7.7	8.4	8.8
Agricultural								
Applied water demand	31.1	32.8	30.2	31.9	29.4	31.1	28.8	30.4
Net water demand	26.8	28.2	26.1	27.4	25.4	26.7	24.9	26.1
Depletion	24.2	25.6	23.7	25.1	23.2	24.6	22.8	24.1
Environmental								
Applied water demand	28.8	16.8	29.3	17.3	29.3	17.3	29.3	17.3
Net water demand	28.4	16.4	28.8	16.8	28.8	16.8	28.8	16.8
Depletion	24.4	12.9	24.7	13.3	24.7	13.3	24.7	13.3
Other(1)								
Applied water demand	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Net water demand	1.5	1.5	1.5	1.4	1.5	1.4	1.5	1.4
Depletion	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
TOTAL								
Applied water demand	68.0	58.0	69.1	59.2	69.9	60.1	71.1	61.2
Net water demand	63.5	53.2	64.3	53.9	64.9	54.5	65.7	55.3
Depletion	55.3	45.5	55.8	46.1	56.2	46.6	56.9	47.2

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Urban Water Demand

Urban water demand forecasts are primarily based on statewide population projections which show an increase of almost 19 million people from 1990 to 2020, from roughly 30 million to 49 million people. About half the projected population increase will happen in the South Coast Region. Population projections for the *California Water Plan Update* are based on the Department of Finance baseline series. The DOF population estimates are taken from the 1990 census as the base year. Table S-10 shows projections of population by hydrologic region.

Urban annual net water demand could increase from 6,800,000 af in 1990 to 10,500,000 af by 2020, after accounting for implementation of conservation measures that are forecasted to reduce urban annual net water demand by about 900,000 af. Urban water demand forecasts are based on: (1) population projections; and (2) unit urban water use values, considering probable effects of future water conservation measures, and trends such as increases in multi-family housing and greater growth in warmer inland areas of the State. Table S-11 shows urban water demand forecasts by hydrologic region. A comprehensive analysis of unit urban water use is presented in Volume I, Chapter 6.

Table S-10. Population Projections by Hydrologic Region
(millions)

Hydrologic Regions	*1990*	*2000*	*2010*	*2020*
North Coast	0.6	0.7	0.8	0.9
San Francisco	5.5	6.2	6.6	6.9
Central Coast	1.3	1.5	1.8	2.0
South Coast	16.3	19.3	22.1	25.3
Sacramento River	2.2	2.9	3.5	4.1
San Joaquin River	1.4	2.0	2.6	3.2
Tulare Lake	1.5	2.2	2.8	3.5
North Lahontan	0.1	0.1	0.1	0.1
South Lahontan	0.6	1.0	1.4	1.9
Colorado River	0.5	0.6	0.8	1.0
TOTAL	30.0	36.5	42.5	48.9

Agricultural Water Demand

To compute agricultural water demand, the *California Water Plan Update* integrates the results of three forecasting methods used to estimate irrigated agricultural acreage and crop type:

- Review of local historical crop acreage along with the availability of water and impacts of urban encroachment;
- Crop Market Outlook; and
- Central Valley Production Model.

Every five to seven years since 1948, DWR has physically surveyed agricultural land use to help assess the locations and amounts of irrigated crops. Acreages of crops grown are estimated on a yearly basis, using the annual crop data produced by county Agricultural Commissioners (adjusted on the basis of DWR land use surveys) and estimates of urban expansion onto irrigated agricultural land.

The Crop Market Outlook is based on the expert opinion of bankers, farm advisors, commodity marketing specialists, and others regarding trends in factors which affect crop production in California. Several factors are evaluated, but the four primary ones are: (1) the current and future demand for food and fiber by the world's consumers; (2) the shares of the national and international markets for agricultural productions that are met by California's farmers and livestock producers; (3) technical factors, such as crop yields, pasture carrying capacities, and livestock feed conversion ratios; and (4) competing output from dryland (non-irrigated) acres in other states. The results determine the forecasted future potential California production of various crops.

Table S-11. Urban Water Demand by Hydrologic Region
(thousands of acre-feet)

Hydrologic Region	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
North Coast								
Applied water demand	168	177	186	195	204	214	219	230
Net water demand	168	177	186	195	204	214	219	230
Depletion	110	112	119	122	127	132	136	142
San Francisco Bay								
Applied water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Net water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Depletion	1,079	1,175	1,185	1,271	1,247	1,362	1,287	1,403
Central Coast								
Applied water demand	273	277	315	321	365	373	420	429
Net water demand	229	233	263	268	304	311	349	357
Depletion	203	206	235	239	272	278	315	321
South Coast								
Applied water demand	3,851	3,997	4,446	4,617	5,180	5,381	6,008	6,244
Net water demand	3,511	3,641	4,010	4,161	4,623	4,799	5,309	5,514
Depletion	3,341	3,463	3,536	3,677	3,993	4,158	4,596	4,785
Sacramento River								
Applied water demand	744	807	911	989	1,076	1,167	1,231	1,335
Net water demand	744	807	911	989	1,076	1,167	1,231	1,335
Depletion	236	257	293	318	349	378	400	434
San Joaquin River								
Applied water demand	495	507	663	684	839	867	1,029	1,063
Net water demand	353	366	468	490	587	616	717	752
Depletion	192	194	258	265	332	340	410	420
Tulare Lake								
Applied water demand	523	523	716	716	892	892	1,116	1,116
Net water demand	214	214	292	292	364	364	454	454
Depletion	214	214	292	292	364	364	454	454
North Lahontan								
Applied water demand	37	38	43	44	46	48	51	52
Net water demand	37	38	43	44	46	48	51	52
Depletion	14	15	17	18	19	20	21	21
South Lahontan								
Applied water demand	187	193	292	302	409	423	550	565
Net water demand	123	125	191	198	269	277	360	372
Depletion	123	125	191	198	269	277	360	372
Colorado River								
Applied water demand	301	301	399	399	512	512	621	621
Net water demand	204	204	272	272	349	349	424	424
Depletion	204	204	272	272	349	349	424	424
TOTAL								
Applied water demand	7,800	8,100	9,300	9,700	10,900	11,400	12,700	13,200
Net water demand	6,800	7,100	7,900	8,300	9,200	9,600	10,500	11,000
Depletion	5,700	6,000	6,400	6,700	7,300	7,700	8,400	8,800

The Central Valley Production model is an economic model which accounts for crop production costs in different areas of the Sacramento and San Joaquin valleys in conjunction with the effect of overall production levels on the market prices for California crops. This helps to estimate how the total California production will be distributed among counties.

Some crop shifts are expected to happen as growers move from low price to high price crops. Alfalfa and pasture lands are forecasted to decrease by about 331,000 acres, mostly in the San Joaquin and Tulare Lake regions. Crop acreages expected to increase include vegetables, nuts (almonds and pistachios), and grapes, while low-quality (bulk) wine grape acreage is decreasing in the San Joaquin Valley, the acreage of high-quality table wine grapes is increasing in other regions.

Table S-12. California Crop and Irrigated Acreage by Hydrologic Region[1] 1990
(normalized, in thousands of acres)

Irrigated Crop	*NC*	*SF*	*CC*	*SC*	*SR*	*SJ*	*TL*	*NL*	*SL*	*CR*	*Total*
Grain	82	2	28	11	303	182	297	6	1	76	988
Rice	0	0	0	0	494	21	1	1	0	0	517
Cotton	0	0	0	0	0	178	1,029	0	0	37	1,244
Sugar beets	2	0	5	0	75	64	35	0	0	35	216
Corn	1	1	3	5	104	181	100	0	0	8	403
Other field	3	1	16	4	155	121	135	0	1	55	491
Alfalfa	53	0	27	10	141	226	345	43	34	256	1,135
Pasture	121	5	20	20	357	228	44	110	19	32	956
Tomatoes	0	0	14	9	120	89	107	0	0	13	352
Other truck	21	10	321	87	55	133	204	1	2	187	1,021
Almonds/pistachios	0	0	0	0	101	245	164	0	0	0	510
Other deciduous	7	6	20	3	205	147	177	0	4	1	570
Citrus/olives	0	0	18	164	18	9	181	0	0	29	419
Grapes	36	36	56	6	17	184	393	0	0	20	748
TOTAL crop area[1]	326	61	528	319	2,145	2,008	3,212	161	61	749	9,570
Double crops	0	0	98	30	44	53	65	0	0	102	392
Irrigated land area	326	61	430	289	2,101	1,955	3,147	161	61	647	9,178

(1) Total crop area is the land area plus the amount of land with multiple crops.

The 1990 level (base year) crop acreage and crop types are based on agricultural land use surveys which have been normalized to take into account the impact of the 1987-92 drought, government set-aside programs, and other annual crop acreage fluctuations. Tables S-12 and S-13 show the 1990 and 2020 level California crop and irrigated acreage by hydrologic region, respectively. Forecasts of agricultural water needs are based on: (1) agricultural acreage forecasts, (2) crop type forecasts, (3) crop unit applied water and unit evapotranspiration of applied water values (in acre-feet for each crop acre), and (4) estimates of future water conservation.

Table S-13. California Crop and Irrigated Acreage by Hydrologic Region 2020 (Forecasted)

(thousands of acres)

Irrigated Crop	*NC*	*SF*	*CC*	*SC*	*SR*	*SJ*	*TL*	*NL*	*SL*	*CR*	*Total*
Grain	72	2	23	1	295	179	258	9	0	70	909
Rice	0	0	0	0	482	15	0	1	0	0	498
Cotton	0	0	0	0	0	178	949	0	0	67	1,194
Sugar beets	10	0	5	0	72	45	25	0	0	40	197
Corn	1	0	6	2	115	183	98	1	0	3	409
Other field	3	1	15	0	158	122	130	0	0	26	455
Alfalfa	65	0	24	6	152	156	240	52	26	226	947
Pasture	122	4	15	6	320	171	22	104	19	30	813
Tomatoes	0	0	15	4	132	88	85	0	0	14	339
Other truck	28	11	347	43	65	201	350	2	1	203	1,250
Almonds/pistachios	0	0	0	0	125	263	173	0	0	0	561
Other deciduous	7	6	19	3	217	151	178	0	2	2	585
Citrus/olives	0	0	16	116	29	11	190	0	0	30	392
Vineyard	38	40	81	3	24	189	363	0	0	15	753
TOTAL crop area	346	64	566	184	2,186	1,952	3,061	169	48	726	9,302
Double crops	0	0	137	12	72	68	90	0	0	123	502
Irrigated land area	346	64	429	172	2,114	1,884	2,971	169	48	603	8,800

Agricultural water needs were evaluated by determining crop types and acreages for each region. Forecasts indicate that irrigated agricultural acreage will decline by about 378,000 acres between 1990 and 2020, from 9,178,000 acres to about 8,800,000 acres. This decline represents a 700,000-acre reduction from a peak in 1980.

For the State as a whole, agricultural annual net water demand will decrease by about 1,900,000 af, from 26,800,000 af in 1990 to 24,900,000 af in 2020. Many of agriculture's unit applied water values have decreased during the past decade. Part of this decrease is due to improvements in irrigation efficiency and increased emphasis on water conservation since the 1976-77 drought. Table S-14 shows the 1990 level and future agricultural water demands by hydrologic region. For a comprehensive analysis of agricultural water use, refer to Volume I, Chapter 7.

Table S-14. Agricultural Water Demand by Hydrologic Region
(thousands of acre-feet)

Hydrologic Region	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
North Coast								
Applied water demand	839	915	868	948	891	972	907	989
Net water demand	744	760	748	764	761	776	771	787
Depletion	592	647	611	669	627	686	637	698
San Francisco Bay								
Applied water demand	92	103	94	104	94	104	94	103
Net water demand	88	99	90	100	90	100	90	99
Depletion	80	89	82	90	82	90	82	89
Central Coast								
Applied water demand	1,140	1,178	1,166	1,206	1,182	1,220	1,189	1,233
Net water demand	893	961	910	982	920	991	921	1,003
Depletion	884	950	901	971	911	980	911	992
South Coast								
Applied water demand	727	753	632	655	499	518	382	396
Net water demand	644	668	569	592	458	474	356	370
Depletion	644	668	569	592	458	474	356	370
Sacramento River								
Applied water demand	7,848	8,645	7,698	8,517	7,592	8,475	7,558	8,333
Net water demand	6,788	7,394	6,602	7,222	6,506	7,184	6,497	7,049
Depletion	5,477	6,123	5,426	6,149	5,439	6,151	5,437	6,151
San Joaquin River								
Applied water demand	6,298	6,757	6,052	6,500	5,817	6,227	5,665	6,080
Net water demand	5,778	6,217	5,561	5,967	5,346	5,695	5,215	5,572
Depletion	4,719	5,064	4,605	4,909	4,490	4,777	4,383	4,678
Tulare Lake								
Applied water demand	9,613	9,849	9,306	9,518	9,075	9,281	8,833	9,038
Net water demand	7,723	7,895	7,518	7,685	7,347	7,505	7,169	7,320
Depletion	7,704	7,876	7,499	7,666	7,328	7,486	7,150	7,301
North Lahontan								
Applied water demand	522	587	523	589	525	591	536	602
Net water demand	460	511	458	510	457	508	469	521
Depletion	378	426	385	433	393	442	399	449
South Lahontan								
Applied water demand	317	321	266	270	258	262	253	257
Net water demand	290	293	242	245	235	238	231	234
Depletion	290	293	242	245	235	238	231	234
Colorado River								
Applied water demand	3,705	3,705	3,598	3,598	3,453	3,453	3,363	3,363
Net water demand	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
Depletion	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
TOTAL								
Applied water demand	31,100	32,800	30,200	31,900	29,400	31,100	28,800	30,400
Net water demand	26,800	28,200	26,100	27,400	25,400	26,700	24,900	26,100
Depletion	24,200	25,600	23,700	25,100	23,200	24,600	22,800	24,100

Environmental Water Demand

Estimates of environmental water demand are based on water needs of managed fresh water wetlands (and Suisun Marsh), environmental instream flow needs, Delta outflow, and wild and scenic rivers. Wetlands water needs were tabulated from investigation of existing public and private wildlife refuges and inclusion of additional wetlands water demand required by the CVPIA. Environmental instream flow needs were compiled by reviewing existing fishery agreements, water rights, and court decisions pertaining to water needs of aquatic resources of streams. Additional flows in the Trinity River, as noted in the CVPIA, are also included in projections of environmental instream demand. Environmental water needs in drought years are considerably lower than in average years, reflecting the variability of the natural flows of rivers and lower fishery flow requirements such as in D-1485 for the Bay-Delta during drought. Table S-15 summarizes environmental water needs by hydrologic region. Furthermore, regulatory agencies have proposed a number of changes in instream flow needs for major rivers, including the Sacramento and San Joaquin. These proposed flow requirements are not necessarily additive; however, an increase from 1,000,000 af to 3,000,000 af is presented to envelop potential environmental water needs that could result from proposed additional instream needs and actions under way by regulatory agencies. (A more comprehensive discussion of environmental water needs is presented in Volume I, Chapter 8.)

Demand Reduction—Water Conservation

Water conservation has become an accepted method for helping to reduce water demand in California. Therefore, water conservation, including urban Best Management Practices and agricultural Efficient Water Management Practices, was incorporated into water demand computations and forecasts of demand to 2020. More than 100 of California's major urban water agencies have agreed to BMPs. Those measures, which are detailed in Chapter 6 of Volume I, are expected to reduce urban annual applied water demand by about 1,300,000 af by 2020. The annual depletion and net water reduction from urban BMPs could amount to 935,000 af. This amount is in addition to 400,000 af annual net savings as the result of urban conservation measures put into place between 1980 and 1990. Agricultural water conservation, land retirement, and crop shifting would reduce agricultural annual applied water by about 2,300,000 af by 2020. Agricultural water conservation, through improved irrigation efficiency, could reduce agricultural annual applied water by about 710,000 af by 2020 and depletions by 330,000 af. Although water conservation measures will reduce water demand, they alone are not sufficient to eliminate forecasted shortages during the next 30 years with available supplies.

Table S-15. Environmental Water Needs by Hydrologic Region
(thousands of acre-feet)

Hydrologic Region	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
North Coast								
Applied water demand[1]	19,199	9,299	19,326	9,426	19,326	9,426	19,326	9,426
Net water demand[1]	19,087	9,187	19,212	9,312	19,212	9,312	19,212	9,312
Depletion[1]	19,085	9,185	19,210	9,310	19,210	9,310	19,210	9,310
San Francisco Bay								
Applied water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Net water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Depletion	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Central Coast								
Applied water demand	4	2	4	2	4	2	4	2
Net water demand	1	0	1	0	1	0	1	0
Depletion	1	0	1	0	1	0	1	0
South Coast								
Applied water demand	2	2	6	6	6	6	6	6
Net water demand	2	2	6	6	6	6	6	6
Depletion	2	2	6	6	6	6	6	6
Sacramento River								
Applied water demand	3,927	3,493	4,117	3,638	4,117	3,638	4,117	3,638
Net water demand	3,717	3,299	3,860	3,442	3,860	3,442	3,860	3,443
Depletion	168	168	207	207	207	207	207	208
San Joaquin River								
Applied water demand	599	511	744	656	744	656	744	656
Net water demand	554	466	670	582	670	582	670	582
Depletion	190	190	306	306	306	306	306	306
Tulare Lake								
Applied water demand	82	82	136	136	136	136	136	136
Net water demand	34	34	56	56	56	56	56	56
Depletion	34	34	56	56	56	56	56	56
North Lahontan								
Applied water demand	17	17	17	17	17	17	17	17
Net water demand	17	17	17	17	17	17	17	17
Depletion	17	17	17	17	17	17	17	17
South Lahontan								
Applied water demand	128	122	128	122	128	122	128	122
Net water demand	128	122	128	122	128	122	128	122
Depletion	73	67	73	67	73	67	73	67
Colorado River								
Applied water demand	39	39	44	44	44	44	44	44
Net water demand	39	39	44	44	44	44	44	44
Depletion	39	39	44	44	44	44	44	44
TOTAL								
Applied water demand	28,800	16,800	29,300	17,300	29,300	17,300	29,300	17,300
Net water demand	28,400	16,400	28,800	16,800	28,800	16,800	28,800	16,800
Depletion	24,400	12,900	24,700	13,300	24,700	13,300	24,700	13,300

(1) Includes 17.8 MAF and 7.9 MAF flows for North Coast Wild and Scenic Rivers for average and drought years, respectively.

Table S-16 summarizes annual applied water reductions and depletions due to conservation from 1990 to 2020 by hydrologic region. Reductions in depletion caused by water conservation vary greatly, depending on the opportunity for water reuse within an area. For example, Sacramento River Region water is reused extensively, thus the reduction of 265,000 af of applied agricultural water will not result in any reduction in depletion for the region. Effective water conservation in any region is the reduction in depletion, which is defined as reduction of the ETAW, irrecoverable losses from distribution systems, and outflow to the ocean or a salt sink. Therefore, a larger water savings potential exists in the western San Joaquin Valley, Colorado River, and coastal regions, where excess applied water generally enters saline sinks (Salton Sea or the ocean) or saline ground water basins and cannot be economically reused. Outflow from water service areas within the Sacramento region is generally "reused" within the region and is also used to maintain water quality and flow standards in the Bay-Delta. Reductions in applied water can reduce pumping and treatment costs and diversions from streams, thus benefiting fish and wildlife. However, care must be taken to look at impacts on downstream reuse such as other farms or managed fresh water wetlands that rely on excess applied water from upstream farms.

Table S-16. Annual Applied Water and Depletion Reductions Due to Conservation from 1990 to 2020 by Hydrologic Region
(thousands of acre-feet)

	Urban		*Agricultural*		*Total*	
HSA	*Applied Water Reductions*	*Reductions in Depletion*	*Applied Water Reductions*	*Reductions in Depletion*	*Applied Water Reductions*	*Reductions in Depletion*
NC	65	55	0	0	65	55
SF	250	250	0	0	250	250
CC	30	30	20	0	50	30
SC	610	490	65	10	675	500
SR	110	25	265	0	375	25
SJ	60	20	40	20	100	40
TL	65	20	130	90	195	110
NL	5	0	0	0	5	0
SL	50	10	10	10	60	20
CR	40	35	200	200	240	235
TOTAL	1,285	935	730	330	2,015	1,265

California Water Budget

The California Water Budget, Table S-17, compares total net water demand with supplies from 1990 through 2020. (Delta supplies assume SWRCB's D-1485 operating criteria.) Average annual supplies for the 1990 level of development, including 1,300,000 af of ground water overdraft, were generally adequate to meet average demands. However, during drought, 1990 level supplies were insufficient to meet demand, which resulted in a shortage of over 2,700,000 af under D-1485 operating criteria in 1990. In drought years 1991 and 1992, these shortages were reflected in urban mandatory water conservation, agricultural land fallowing and crop shifts, reduction of environmental flows, and short-term water transfers.

Table S-17. California Water Budget
(millions of acre-feet)

Water Demand/Supply	*1990* average	*1990* drought
Net Demand		
Urban—with 1990 level of conservation	6.8	7.1
—reductions due to long-term conservation measures (Level I)	0	0
Agricultural—with 1990 level of conservation	26.8	28.2
—reductions due to long-term conservation measures (Level I)	0	0
—land retirement in poor drainage areas of San Joaquin Valley (Level I)	—	—
Environmental	28.4	16.4
Other[1]	1.5	1.5
Subtotal	63.5	53.2
Proposed Additional Environmental Water Demands[2]		
Case I - Hypothetical 1 MAF	—	—
Case II - Hypothetical 2 MAF	—	—
Case III - Hypothetical 3 MAF	—	—
Total Net Demand	63.5	53.2
Case I	—	—
Case II	—	—
Case III	—	—
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies		
Developed Supplies		
Surface Water[3]	27.9	22.1
Ground Water	7.1	11.8
Ground Water Overdraft[3]	1.3	1.3
Subtotal	36.3	35.2
Dedicated Natural Flow	27.2	15.3
TOTAL Water Supplies	63.5	50.5
Demand/Supply Balance	0.0	-2.7
Case I	—	—
Case II	—	—
Case III	—	—
Level 1 Water Management Programs[4]		
Long-term Supply Augmentation		
Reclaimed	—	—
Local	—	—
Central Valley Project	—	—
State Water Project	—	—
Short-Term Drought Management		
Potential Demand Management	—	1.0
Drought Water Transfers	—	0.8
***Subtotal* - Level I Water Management Programs**	—	1.8
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	0.0
NET TOTAL Demand Reduction/Supply Augmentation	0.0	1.8
Remaining Demand/Supply Balance Requiring Level II Options	0.0	-0.9
Case I	—	—
Case II	—	—
Case III	—	—

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Proposed Environmental Water Demands—Case I-III envelop potential and uncertain demands and have immediate and future consequences on supplies from the Delta, beginning with actions in 1992 and 1993 to protect winter run salmon and delta smelt (actions which could also protect other fish species).

Table S-17. California Water Budget
(millions of acre-feet)

2000		2010		2020	
average	drought	average	drought	average	drought
8.3	8.7	9.9	10.3	11.4	11.9
-0.4	-0.4	-0.7	-0.7	-0.9	-0.9
26.4	27.7	25.8	27.1	25.4	26.6
-0.2	-0.2	-0.3	-0.3	-0.4	-0.4
-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
28.8	16.8	28.8	16.8	28.8	16.8
1.5	1.4	1.5	1.4	1.5	1.4
64.3	53.9	64.9	54.5	65.7	55.3
1.0	1.0	1.0	1.0	1.0	1.0
2.0	2.0	2.0	2.0	2.0	2.0
3.0	3.0	3.0	3.0	3.0	3.0
—	—	—	—	—	—
65.3	54.9	65.9	55.5	66.7	56.3
66.3	55.9	66.9	56.5	67.7	57.3
67.3	56.9	67.9	57.5	68.7	58.3
27.8	21.5	28.1	21.6	28.2	21.7
7.1	12.0	7.2	12.1	7.4	12.2
—	—	—	—	—	—
34.9	33.5	35.3	33.7	35.6	33.9
27.4	15.4	27.4	15.4	27.4	15.4
62.3	48.9	62.7	49.1	63.0	49.3
—	—	—	—	—	—
-3.0	-6.0	-3.2	-6.4	-3.7	-7.0
-4.0	-7.0	-4.2	-7.4	-4.7	-8.0
-5.0	-8.0	-5.2	-8.4	-5.7	-9.0
0.5	0.5	0.6	0.6	0.8	0.8
0.0	0.1	0.0	0.3	0.0	0.3
0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.1	0.6	1.0	0.7	1.0
—	1.0	—	1.0	—	1.0
—	0.8	—	0.8	—	0.8
0.7	2.5	1.3	3.8	1.5	3.9
0.1	0.0	0.1	0.2	0.1	0.2
0.7	2.5	1.4	4.0	1.6	4.1
—	—	—	—	—	—
-2.3	-3.5	-1.8	-2.4	-2.1	-2.9
-3.3	-4.5	-2.8	-3.4	-3.1	-3.9
-4.3	-5.5	-3.8	-4.4	-4.1	-4.9

(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

The forecasted 2020 net demand for urban, agricultural, and environmental water needs amounts to 65,700,000 af in average years and 55,300,000 af in drought years, after accounting for future reductions of 1,300,000 af in net water demand due to increased water conservation efforts (resulting from implementation of urban BMPs, and increased agricultural irrigation efficiencies) and another 130,000-af reduction due to future land retirement. It should be noted that several pending actions designed to protect and restore aquatic species will increase environmental water needs in a range of 1,000,000 to 3,000,000 af. These actions include:

- Biological opinions for winter-run salmon and Delta smelt, which place operational constraints on Delta exports and vary yearly.
- Implementation of the CVPIA—the allocation of 800,000 af of annual CVP supplies for environmental water use in the Central Valley streams and about 200,000 af for wetlands.
- EPA's proposed Bay-Delta standards: the total impacts on urban and agricultural water supplies will not be known until final standards are adopted sometime in 1994 and later implemented.
- SWRCB's water quality control plan for the Bay-Delta and subsequent water right proceedings: in March 1994, SWRCB began a series of workshops to review Delta protection standards and examine proposed EPA standards. The total impacts on water supply for urban and agricultural use will not be known until a final plan is adopted and the water rights proceedings are completed.

Considering that much of the hypothetical range for additional environmental water has now been mandated or formally proposed by the above actions, California is now facing more frequent and severe water supply shortages for the year 2000 and beyond. In 1993, an above-normal year, some CVP contractors had their supplies cut by 50 percent. These unanticipated shortages point to the need for a quick resolution of Delta problems through federal cooperation and participation as well as the need to move forward with demand management and supply augmentation programs at both the State and local levels.

By 2020, without additional facilities and improved water management, annual shortages of 3,700,000 to 5,700,000 af could occur during average years, again depending on the outcome of various actions listed above. Average year shortages are considered chronic and indicate the need for implementing long-term water supply augmentation and management measures to improve water service reliability. Similarly, by year 2020, annual drought year shortages could increase to 7,000,000 to 9,000,000 af under D-1485 operating criteria, also indicating the need for long-term measures.

However, water shortages would vary from region to region and sector to sector. For example, the South Coast Region's population is expected to increase to over 25 million people by 2020, requiring an additional 1,800,000 af of water each year. Population growth and increased demand, combined with a possibility of reduced supplies from the Colorado River, mean the South Coast Region's annual shortages for 2020 could amount to 400,000 af for average years and 850,000 af in drought years; this is before consideration of the additional 1,000,000 to 3,000,000 af of environmental water needs, which could reduce existing SWP supplies from the Delta. Thus, forecasted shortages could be larger if solutions to complex Delta problems are not found and implemented along with proposed local water management programs and additional facilities for the SWP.

Implementation of Level I water management programs could reduce but not eliminate forecasted shortages in 2020 by implementing short-term drought management options (demand reduction through urban rationing programs or water transfers that reallocate existing supplies through use of reserve supplies and agricultural land fallowing programs) and long-term demand management and supply augmentation options (increased water conservation, agricultural land retirement, additional water recycling, benefits of a long-term Delta solution, more conjunctive use programs, and additional south-of-the-Delta storage facilities). These Level I programs combined leave a potential shortfall in annual supplies of about 2,100,000 to 4,100,000 af in average years and 2,900,000 to 4,900,000 af in drought years by 2020. The shortfall must be made up by Level II water supply augmentation and demand management programs. (Volume I, Chapter 11 explains these programs.) The California Water Budget, Table S-17, indicates the potential magnitude of water shortages that can be expected in average and drought years if no actions are taken to improve water supply reliability.

Local Water Supply Issues

The following sections highlight local issues of concern. Each regional chapter contains more specific information on water supply issues affecting that region.

In the **North Coast Region**, a number of smaller communities have continuing water supply reliability problems, often related to the lack of economic base to support water management and development costs. Small communities along the coast, such as Moonstone, Smith River, and Klamath, either experience chronic water shortages or have supplies inadequate to meet projected growth. Water use is already low due to conservation, so most of these problems will have to be solved by either constructing or upgrading community water systems.

In the **San Francisco Bay Region**, Marin Municipal Water District has relied, in part, on imported supply from Sonoma County Water Agency and extensive conservation efforts by its customers to ensure adequate supplies throughout the recent drought. Under 2025 demand conditions, without supplemental supplies, the district estimates a 40-percent deficiency once every 10 years. To improve reliability, MMWD has negotiated an agreement with SCWA to import an additional 10,000 af. This supplemental supply, in conjunction with the district's water conservation and water management plans, should limit water shortages to about 10 percent once every 10 years.

Imported supplies by the City of San Francisco, Santa Clara Valley Water District, and East Bay Municipal Utilities District also suffered deficiencies during the 1987-92 drought. During 1991, the City of San Francisco was able to reduce expected rationing from 45 to 25 percent through purchases of 50,000 af from the 1991 State Drought Water Bank and 20,000 af from Placer County Water Agency. Customers were still required to reduce indoor use by 10 percent and outdoor use by 60 percent. During 1989-91, Santa Clara Valley Water District was able to get through with 25 percent rationing by purchasing 69,000 af from Yuba County, 14,000 af from Placer County, and 20,000 af from the State Drought Water Bank.

Water supplies in much of the **Central Coast Region** are greatly dependent upon the region's ground water basins; the storage in these basins is small and fluctuates from year to year. Since ground water and limited local surface supplies are its primary source of water, the region is vulnerable to droughts. As ground water extractions exceed ground water replenishment, several of the region's coastal aquifers are experiencing overdraft conditions, allowing sea water intrusion. The 1987-92 drought required many communities in the region to implement stringent water conservation programs. The cities of Santa Barbara and Morro Bay constructed sea water desalination plants to improve their water service reliability.

The **South Coast Region** is home to more than one half of the State's population, 16 million people. The region's population is expected to increase to more than 25 million people by 2020. Such growth poses several critical water supply difficulties, most notably increased demand with limited ability to increase supply. Further, imports from Mono Lake tributaries, Owens Valley, and the Colorado River will be reduced and limits on Sacramento-San Joaquin Delta exports could further reduce water service reliability in the South Coast Region. MWDSC has several programs in progress to improve its water delivery and supply capability, including the construction of Domenigoni Valley Reservoir, and supports improved Delta transfer capabilities to improve reliability of its SWP supplies.

Sacramento River Region water users are concerned about protecting their area's ground water resources from export. Organized ground water management efforts in the region are currently under way in Butte, Colusa, Glenn, Shasta, Tehama, and Yolo counties. Also, several foothill areas that rely heavily on ground water are finding those supplies limited. With many people relocating to these areas, concern about ground water availability and the potential for its contamination is increasing.

Flood protection is another major concern for the region, especially along the Sacramento and American rivers near Sacramento. In 1991, the U.S. Army Corps of Engineers completed a feasibility report and environmental documentation for a flood detention dam at the Auburn site in combination with levee modification along the lower American River to increase flood protection for the Sacramento area. The report, however, generated much controversy over whether Auburn Dam should be a flood detention only (dry dam) or multipurpose dam.

Foothill areas of both the **San Joaquin River** and **Tulare Lake regions** share the Sacramento River Region's problem of limited water supplies. Major concerns for this region's agricultural community are agricultural drainage disposal and treatment costs and potential reduction of imported supplies. CVP supplies will be reduced by the CVPIA, and both the CVP and SWP supplies are impacted by endangered species actions and other actions proposed to protect aquatic species in the Delta. These actions will also cause ground water overdraft to increase in these regions.

In the **North Lahontan Region** years of disputes over the waters of the Truckee and Carson rivers led to the 1990 enactment of the Truckee-Carson-Pyramid Lake Water Rights Settlement Act. This federal act makes an interstate allocation of the rivers between California and Nevada, provides for the settlement of certain Native American water rights claims, and provides for water supplies for specified environmental purposes in Nevada. The act allocates to California 23,000 af annually in the Lake Tahoe Basin, 32,000 af annually in the Truckee River Basin below Lake Tahoe, and water corresponding to existing water uses in the Carson River Basin. Provisions of the Settlement Act, including the interstate water allocations, will not take effect until several conditions are met, including negotiation of the Truckee River Operating Agreement required by the act.

Growth has long been a major issue in the Tahoe Basin and strict controls have been adopted by local agencies under the lead of the Tahoe Regional Planning Agency. These controls have been very effective. For example, the City of South Lake Tahoe grew by only 4 percent in the 1980s, while population of the Lassen County portion of the region increased by nearly 30 percent over the same period. Potential ground water export from the Honey Lake Valley is a controversial issue in the North Lahontan Region. The Truckee Meadows Project, as proposed, could export at least 13,000 af of ground water annually from the Nevada portion of Honey Lake Valley to the Reno area. Lassen County and the Pyramid Lake Paiute Indian Tribe oppose the project on the grounds that it would deplete the local ground water supply and harm the environment. The U.S. Bureau of Land Management, which must issue a right-of-way permit before the 80-mile pipeline project can be implemented, released a draft Environmental Impact Statement in May 1993. In March 1994, the Secretary of the Interior suspended work on the EIS until significant environmental issues are resolved. The issues include the ground water model used in the EIS, impacts to ground water cleanup activities at the Sierra Army Depot, and reduction of inflows to Pyramid Lake.

Water exports from the **South Lahontan Region** have been the subject of litigation since the early 1970s. In 1972, the County of Inyo sued the City of Los Angeles claiming that increased ground water pumping for export was harming the Owens Valley. Consequently, the City of Los Angeles and Inyo County implemented enhancement projects to mitigate the impacts of ground water pumping. In 1989, the parties reached agreement on the long-term ground water management plan for Owens Valley and the EIR was accepted by the court.

Another long-standing issue is the Los Angeles Department of Water and Power diversions from Mono Lake tributaries and the impact of these diversions on the lake level. As a result of extensive litigation between the City of Los Angeles and a number of environmental groups, LADWP is now prohibited by court order from diverting from the tributaries until the lake level stabilizes. SWRCB concluded Mono Lake water rights hearings in February 1994. A draft decision regarding lake levels and stream flows on the four tributaries is expect in late 1994. The Mono-Owens system had provided 17 percent of LADWP's water supply and 1.5 percent of its hydroelectric energy supply. Replacement water and energy are being sought. One source of replacement water will be from water reclamation projects to be funded by the Environmental Water Fund, which was created by the Legislature in 1989 to fund projects mutually agreed upon by LADWP and the Mono Lake Committee.

The **Colorado River Region** faces increasingly difficult issues involving water quality. In the late 1960s, 1970s, and early 1980s, the Salton Sea suffered from high water levels caused by increased agricultural runoff, treated urban waste water, and above-average rainfall. In 1984, the State Water Resources Control Board (responding to DWR's referral of the matter to the SWRCB following an investigation at the request of a farmer), adopted Water Rights Decision 1600, and required Imperial Irrigation District to prepare a conservation plan and take other steps to improve its delivery system. Following a 1988 SWRCB order, Imperial Irrigation District implemented a program with funds provided by MWDSC to conserve water. The sea level has stabilized somewhat during recent years, due in part to conservation measures taken by IID. The Salton Sea dilemma illustrates the complexity and opportunities for cooperative solutions of water management issues in California.

The greenery surrounding Big Lagoon in Humboldt County is typical of the North Coast area. The region has the highest average annual rainfall in the State.

North Coast Region

The North Coast Region comprises all of the California area tributary to the ocean from the mouth of Tomales Bay north to the Oregon border and east along the border to a point near Goose Lake. It encompasses over 12 percent of the State's area, including redwood forests, inland mountain valleys, and the desert-like Modoc Plateau.

Much of the region is mountainous and rugged. Only 13 percent of the land is classified as valley or mesa, and more than half of that is in the northeastern part around the Upper Klamath River Basin. The dominant topographic features in the region are the California Coast Range and the Klamath Mountains. The eastern boundary is formed by mountains that average around 6,000 feet above sea level with a few peaks over 8,000 feet. About 400 miles of ocean shoreline form the western boundary of the region.

Average annual precipitation in the North Coast Region is 53 inches, ranging from over 100 inches in eastern Del Norte County to less than 15 inches in the Lost River drainage area of Modoc County. A relatively small fraction of the precipitation is in the form of snow. Only at elevations above 4,000 feet does snow remain on the ground for appreciable periods. The heavy rainfall concentrated over the mountains makes this region the most water-abundant area of California. Mean annual runoff is about 28,886,000 af, which constitutes about 40 percent of the State's total natural runoff. There is also 1,860,000 af of average annual runoff flowing into the region from Oregon.

Population

Much of the North Coast Region is sparsely populated. Most of the population (nearly 60 percent) lives in and around Santa Rosa, within the Russian River Basin. Most of the remainder of the population is concentrated in the Eureka-Arcata-McKinleyville area around Humboldt Bay and the Crescent City area. Other sizable towns include the county seats of Yreka (Siskiyou), Weaverville (Trinity), and Ukiah (Mendocino).

Overall, the North Coast Region's population has grown from 467,890 in 1980 to 571,750 in 1990 and accounts for 1.9 percent of California's population. During the

Region Characteristics

Average Annual Precipitation: *53 inches* ***Average Annual Runoff:*** *28,886,000 af*

Land Area: *19,590 square miles* ***1990 Population:*** *571,750*

1980s, the population in the Santa Rosa area grew by 31 percent, due primarily to spillover from the Bay Area, while essentially no growth occurred in the Modoc and Siskiyou county portions of the region. Average annual population growth rate in the northern half of the region has been relatively slow at 3 percent. One exception is Crescent City, which had a population increase of 81 percent in 1991, resulting from the annexation of the new Pelican Bay State Prison. Previous growth rates in Crescent City have been 6.5 percent and 14 percent in 1989 and 1990, respectively.

Rapid growth is projected for the Santa Rosa area over the next 30 years, while only moderate expansion is expected in Humboldt County. The traditional economic bases of timber, cattle, and fishing are in a state of flux. Recreation, government, and retirees are becoming the major growth generating activities in the north part of the region. Table NC-1 shows regional population projections to 2020.

Table NC-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Upper Klamath	29	34	39	43
Lower Klamath-Smith	46	62	75	88
Coastal	160	189	211	233
Russian River	337	403	464	510
TOTAL	572	688	789	874

Land Use

About 97 percent of the land area is forest or range land. Much of this land lies within national forests, State and national parks, and Indian reservations. A considerable amount of the remainder is privately owned forest land, often held in large ownerships. Only about 326,000 acres (2.6 percent) of the region's area are irrigated. Of that total, 225,900 acres lie in the Upper Klamath River Basin, above the confluence of the Scott and Klamath rivers. (See Appendix C for maps of the planning subareas and land ownership in the region.) In the Upper Klamath area, the main irrigated crops are pasture and alfalfa, grain, and potatoes. Orchards and vineyards are found in the Russian River drainage area. Pasture, alfalfa, and grain are the predominant crops in irrigated areas throughout the remainder of the region.

Besides small areas of urban and agricultural development (mainly around the Santa Rosa and Eureka areas) land is used for timber production and wildlife habitat. Land use issues in the region include activities causing soil erosion, such as road construction, gravel mining, and logging. Figure NC-1 shows land use, imports, and exports in the North Coast Region.

Water Supply

About 94 percent of the region's 1990 level average water supply is dedicated natural runoff, primarily for wild and scenic rivers. Summer water supplies are limited because rainfall and runoff are much less. The few surface water supply projects that exist on tributary streams are small and provide limited carryover capacity to deal with extended months of low rainfall. Larger water supply projects include the U.S. Bureau of Reclamation's Klamath Project, the U.S. Army Corps of Engineers' Russian River Project (Lakes Mendocino and Sonoma), and the Humboldt Bay Municipal Water velopment and use of water, and (2) further cooperation between the states in the equitable sharing of water resources. The compact is administered by the Klamath River Compact Commission, which is chaired by a federal representative appointed by the President. The commission provides a forum for communication between the various interests concerned with water resources in the upper Klamath River Basin. Its recent activities have focused on water delivery reductions caused by drought and operating restrictions to protect two species of endangered sucker fish. Other pressing issues are water supplies for wildlife refuges and upper basin impacts on anadromous fisheries in the lower Klamath River.

The USBR constructed the Trinity River Division in the early 1960s to augment CVP water supplies in the Sacramento and San Joaquin valleys. The principal features of this part of the CVP are Trinity Dam and the 2,477,700 af Clair Engle Lake on the upper Trinity River and the 10.7-mile Clear Creek Tunnel beginning at Lewiston Dam and ending at Whiskeytown Lake in the Sacramento River Basin. Exports from the Trinity River began in May 1963. Long-term average annual exports are about 881,000 af. From 1980 through 1992, these exports have averaged 864,000 af annually. There are no in-basin deliveries of water from the Trinity River Division. However, the CVPIA allocated a minimum of 340,000 af per year through 1996 for instream environmental use. A permanent flow release criteria is scheduled to be established by 1996 by the Secretary of the Interior based on the results of a 12-year flow evaluation study.

The Russian River Project, constructed by the Corps of Engineers, includes Lake Mendocino (122,400 af), formed by Coyote Dam on the East Fork of the Russian River near Ukiah, and Lake Sonoma (381,000 af) behind Warm Springs Dam on Dry Creek near Geyserville. Lake Mendocino was completed in 1958 and Lake Sonoma in 1982. Both reservoirs provide flood protection, reservoir recreation, and water supply for urban, agricultural, and instream uses. Most of the water supply made available by the Russian River Project is contracted to the Sonoma County Water Agency. The SCWA delivers about 29,000 af per year via aqueduct to Santa Rosa, Rohnert Park, Cotati, and Forestville. In addition, the agency exports approximately 25,000 af per year from the North Coast's Russian River Project to the San Francisco Bay Region. This water is delivered via several aqueducts to Novato, Petaluma, the Valley of the Moon, and Sonoma areas.

The principal reaches and major tributaries of the Klamath, Eel, and Smith rivers are designated Wild and Scenic under federal and State law, and therefore are protected from large scale water development. Figure NC-2 shows the region's 1990 level sources of supply and Table NC-3 shows water supplies with existing facilities and water management programs. There is no SWP, CVP, or Colorado River water supplied to this area, and none of the ground water basins are overdrafted.

Supplies with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses to determine their feasibility.

Water demand within the North Coast Region is met by projects which range from relatively large and well-organized municipal systems serving communities such as Yreka, Weaverville, Hayfork, Willits, Crescent City, and Fort Bragg to small residential or agricultural water systems (usually based on ground water) in locations like Mendocino, Garberville, and Shelter Cove. Future improvements in many of these systems are planned to improve water supply reliability. For example, Weaverville Community Services District, supplied by East Weaver Creek, is planning to construct a 5-mile pipeline to the Trinity River to meet its future needs.

Table NC-3. Water Supplies with Existing Facilities and Programs
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	438	433	450	446	470	463	483	481
Local imports	2	2	2	2	2	2	2	2
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	471	471	471	471	471	471	471	471
SWP	0	0	0	0	0	0	0	0
Ground water	263	283	275	295	286	308	298	316
Overdraft(1)	0	0	—	—	—	—	—	—
Reclaimed	11	11	11	11	11	11	11	11
Dedicated natural flow	18,850	8,950	18,973	9,073	18,973	9,073	18,973	9,073
TOTAL	20,035	10,150	20,182	10,298	20,213	10,328	20,238	10,354

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

The projected 30-percent increase in average urban water demand by 2020 can be provided largely by upgrading existing water supply systems. However, there is currently no economically or environmentally feasible solution to significantly augment dry-year irrigation supplies in the North Coast Region.

Due to the absence of large urban concentrations or extensive agriculture, and the cool wet weather patterns, the North Coast did not experience large-scale water shortages during the 1987-92 drought. Therefore, most of this region did not have to reduce water use significantly. Unlike most other regions, water conservation in the North Coast does not benefit another hydrologic area where either the water supply originates in or flows to. However, water conservation can play a vital role in reducing urban demand and waste water treatment costs.

Areas irrigated with surface water will likely continue to manage with water available from existing facilities. A few additional wells are expected to augment irrigation supplies in the Butte Valley-Tule Lake area. Pressure for additional ground water development in areas like Scott and Shasta valleys will be greater if some salmon races are listed or if strict application of Department of Fish and Game code regulations reduce the supplies available from existing water developments or natural runoff.

Present water supplies and modest expansion of local water sources will generally be adequate to meet the region's expected municipal and industrial demands over the next 30 years. The Humboldt Bay-McKinleyville area will continue to be adequately served by Ruth Reservoir on the Mad River, with supplies possibly augmented by ground water. The system draws water from the Mad River through Ranney collector wells that are being undercut by erosion of streambed gravels. Humboldt Bay Municipal Water District is investigating the problem and hopes to solve it soon. HBMWD system may ultimately be expanded to serve the Trinidad-Moonstone area, which is experiencing water supply deficiencies.

Crescent City has an adequate supply from the Smith River but needs to increase system transmission and storage capacity. It may also be facing construction of an expensive surface water treatment facility. Trinity County Waterworks District No. 1 serves the town of Hayfork from the 800-af Ewing Reservoir. Growth in the service area has almost reached the design capacity of the existing system, and the district plans to enlarge its offstream reservoir within the next few years. This expansion was planned at the time the project was constructed in the late 1960s. The Weaverville Community Services District plans to divert from the Trinity River at Douglas City to provide needed future water supplies.

Table NC-4 shows water supplies with additional facilities and water management programs. There are no CVP or SWP supplies to this area and ground water overdraft within the region is not expected.

Table NC-4. Water Supplies with Level I Water Management Programs
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	438	433	450	446	470	463	483	481
Local imports	2	2	2	2	2	2	2	2
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	471	471	471	471	471	471	471	471
SWP	0	0	0	0	0	0	0	0
Ground water	263	283	272	292	280	302	289	307
Overdraft(1)	0	0	—	—	—	—	—	—
Reclaimed	11	11	14	14	17	17	20	20
Dedicated natural flow	18,850	8,950	18,973	9,073	18,973	9,073	18,973	9,073
TOTAL	20,035	10,150	20,182	10,298	20,213	10,328	20,238	10,354

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

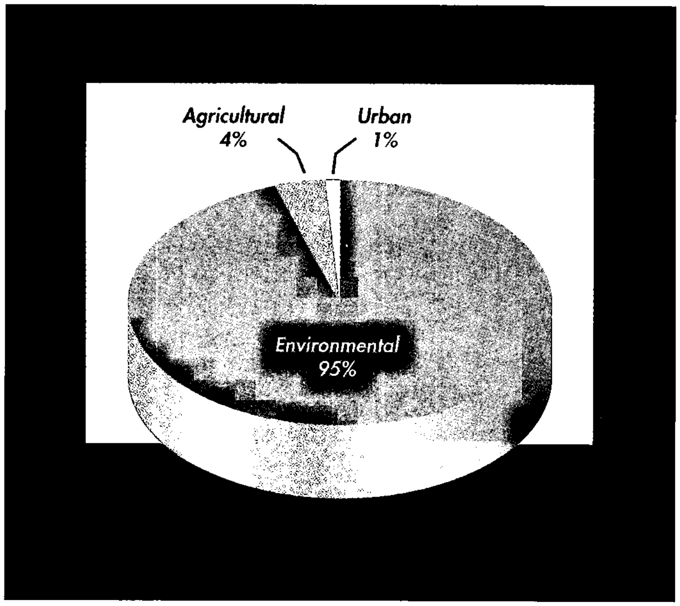
Water Use

Although the North Coast Region produces nearly half of California's surface runoff, urban and agricultural water use within the region is relatively low because it is sparsely populated and has few irrigated acres. Irrigation accounts for 744,000 af of the region's net water use, while municipal and industrial use is 168,000 af. These water needs are generally met by small local developments and limited ground water extractions. Because of economic and physical restrictions on development of new irrigated areas and the small estimated population growth, neither irrigation nor municipal and industrial uses are expected to increase greatly. Annual water use in the region is forecasted to increase 203,000 af by 2020.

Urban Water Use

The current total urban water use in the North Coast Region, 168,000 af per year, represents about 2.5 percent of the State's total urban water use. Per capita use varies from around 130 gpcd in the Humboldt Bay area to about 300 gpcd in the warmer inland area of the Lost River Basin. Municipal use in areas directly influenced by the coastal climate is up slightly from the 1980 level, while use in the interior valleys remains level. Around 54,000 af per year was used by high water-using industries (primarily wood and pulp processing plants in the Humboldt Bay area) in 1990. This has at least temporarily decreased by 22,000 af per year as a result of the recent indefinite closure of the Simpson pulp mill. This annual water supply will be available in Humboldt Bay Municipal Water District's Ruth Reservoir to future users or to supply the Simpson pulp mill if it reopens. Because of the present uncertainty over the length of the mill closure, the area's water use is forecasted to remain at preclosure levels until the year 2000. Table NC-5 shows urban water demands for the region to 2020.

Figure NC-3. North Coast Region Net Water Demand (1990 Level Average Conditions)



Volume 1, Chapters 6 and 7, contains a detailed explanation of the methods used in estimating regional water use. The impacts of water conservation and best management practices are also discussed in those chapters.

Figure NC-4. North Coast Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

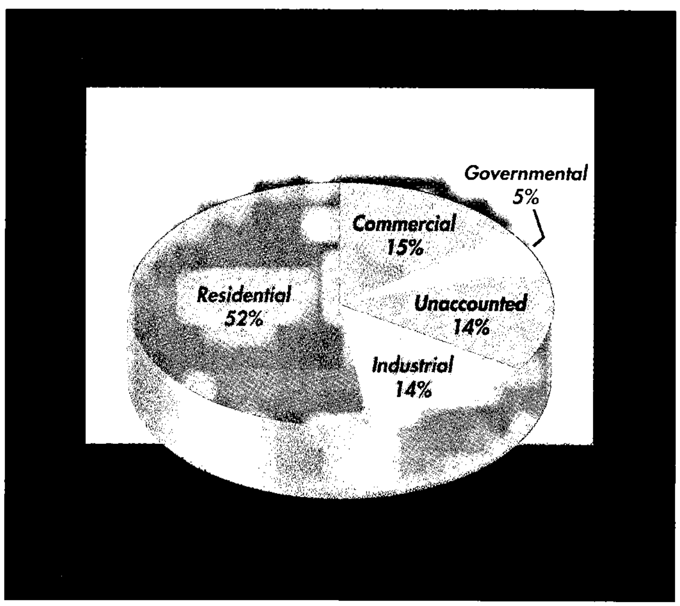


Table NC-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Upper Klamath								
Applied water demand	10	10	11	11	13	13	14	14
Net water demand	10	10	11	11	13	13	14	14
Depletion	5	5	5	5	6	6	7	7
Lower Klamath-Smith								
Applied water demand	10	11	13	14	16	17	18	19
Net water demand	10	11	13	14	16	17	18	19
Depletion	6	6	8	8	9	10	11	12
Coastal								
Applied water demand	78	80	84	84	87	88	92	93
Net water demand	78	80	84	84	87	88	92	93
Depletion	71	71	75	75	77	78	80	81
Russian River								
Applied water demand	70	76	78	86	88	96	95	104
Net water demand	70	76	78	86	88	96	95	104
Depletion	28	30	31	34	35	38	38	42
TOTAL								
Applied water demand	168	177	186	195	204	214	219	230
Net water demand	168	177	186	195	204	214	219	230
Depletion	110	112	119	122	127	132	136	142

Agricultural Water Use

Total irrigated acreage within the North Coast Region in 1990 was 326,000 acres. The number of irrigated acres in the region is expected to remain nearly level over the next three decades. Table NC-6 summarizes irrigated land and Table NC-7 shows evapotranspiration of applied water by crop in the region. Figure NC-5 shows 1990 crop acreages, evapotranspiration, and applied water for major crops. The applied

Sprinkler systems such as the one shown are commonly used to irrigate crops, in this case pasture land, in the North Coast Region. In the inland valleys, there is more irrigable land than can be irrigated with existing supplies.

water and net demand shown in Table NC-8 were derived from irrigated acreages by applying unit water use factors determined by DWR. These unit use factors, which are unique to each detailed analysis unit (a portion of a planning subarea), reflect local conditions of climate and cultural practices. Applied water amounts vary with the source of water supply (surface or ground water and the type of water year). In drought years additional irrigation is required to replace water normally supplied by rainfall and to meet higher-than-normal evapotranspiration demands. The trend of unit water use in the region is generally stable. The values employed in the trend calculations are representative of current water use in the region and estimates of future agricultural use are based on the 1990 unit use values. Net agricultural water use in the region is expected to increase by only one percent by 2020.

Table NC-6. Irrigated Crop Acreage
(thousands of acres)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Upper Klamath	226	232	236	239
Lower Klamath-Smith	13	13	13	13
Coastal	32	34	36	38
Russian River	55	55	55	56
TOTAL	326	334	340	346

Climate, soils, water supply, and remoteness from markets limit the crops that can be grown profitably throughout most of the region. In the inland valley areas, there is more irrigable land than can be irrigated with existing supplies. During dry years, the region experiences substantial water deficiencies that are greatest in the arid inland portions of the region. The agricultural trend in the past decade has been one of land consolidation and slow growth; this reflects the low crop values, lack of additional low-priced surface water supplies, and use of only the most economically developable ground water sources.

Table NC-7. 1990 Evapotranspiration of Applied Water by Crop

Irrigated Crop	*Total Acres (1,000)*	*Total ETAW (1,000 AF)*
Grain	82	119
Sugar beets	2	4
Corn	1	2
Other field	3	4
Alfalfa	53	128
Pasture	121	253
Other truck	21	33
Other deciduous	7	10
Vineyard	36	26
TOTAL	326	579

Table NC-10. Wetland Water Needs
(thousands of acre-feet)

Wetland	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Lower Klamath NWR								
Applied water demand	115	115	115	115	115	115	115	115
Net water demand	77	77	77	77	77	77	77	77
Depletion	76	76	76	76	76	76	76	76
Butte Valley WA								
Applied water demand	10	10	10	10	10	10	10	10
Net water demand	10	10	10	10	10	10	10	10
Depletion	10	10	10	10	10	10	10	10
Clear Lake NWR								
Applied water demand	42	42	42	42	42	42	42	42
Net water demand	28	28	28	28	28	28	28	28
Depletion	28	28	28	28	28	28	28	28
Tule Lake NWR								
Applied water demand	180	180	180	180	180	180	180	180
Net water demand	120	120	120	120	120	120	120	120
Depletion	119	119	119	119	119	119	119	119
Shasta Valley Refuge								
Applied water demand	0	0	4	4	4	4	4	4
Net water demand	0	0	2	2	2	2	2	2
Depletion	0	0	2	2	2	2	2	2
Arcata Marsh								
Applied water demand	2	2	2	2	2	2	2	2
Net water demand	2	2	2	2	2	2	2	2
Depletion	2	2	2	2	2	2	2	2
TOTAL								
Applied water demand	349	349	353	353	353	353	353	353
Net water demand	237	237	239	239	239	239	239	239
Depletion	235	235	237	237	237	237	237	237

The principal wetland uses of water occur in the Lower Klamath, Tule Lake, and Clear Lake national wildlife refuges and the State's Butte Valley Wildlife Area. A major share of the wildlife water needs in Butte Valley are met by approximately 3,000 af per year of ground water. The other refuges in the region are served from surface supplies. The prevalent crops grown in the refuges are wheat, alfalfa, barley, millet, and milo. Alkali bulrush is an important naturally occurring food source for wildlife found in most of these areas. The predominant types of wildlife using the refuges are Canadian, snow, and white-fronted geese; mallard, pintail, gadwall, teal, canvasback, and redhead ducks; and pheasant. Other wildlife species such as songbirds, raptors, shorebirds, antelope, and deer also depend heavily on the refuges and agricultural land during the winter.

Environmental water use within this region will probably remain relatively unchanged to 2020. However, releases below existing dams could be modified in response to the findings of future instream flow need studies and the potential endangered species listing of declining fish populations. Existing instream flow requirements downstream from a number of major dams are shown in Volume 1, Chapter 8.

Other Water Use

Figure NC-6 shows water recreation areas in the North Coast Region which attract over 10 million people annually. This area has rugged natural beauty and some of the most renowned fishing streams in North America. It has diverse topography, including scenic ocean shoreline; a forested belt immediately inland, which includes more than half of California's redwoods; and extensive inland mountainous areas, including 10 wilderness areas, managed mainly by the U.S. Forest Service. Over 40 State parks and one national park are in the region. In addition to the natural attractions, the area contains scores of small reservoirs which are extensively used for recreation. Rafting and canoeing are popular on the Smith, Klamath, Salmon, Trinity, Eel, and Russian rivers.

Public recreation use of national forests and small local reservoirs is probably several times that of parks. The job base and economic value of travel and recreation have exceeded that of the lumber industry in some Northern California counties. The demand for recreation in the region is expected to continue growing. Table NC-11 shows the total water demands for this region.

Table NC-11. Total Water Demands
(thousands of acre-feet)

Category of Use	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Urban								
Applied water demand	168	177	186	195	204	214	219	230
Net water demand	168	177	186	195	204	214	219	230
Depletion	110	112	119	122	127	132	136	142
Agricultural								
Applied water demand	839	915	868	948	891	972	907	989
Net water demand	744	760	748	764	761	776	771	787
Depletion	592	647	611	669	627	686	637	698
Environmental[1]								
Applied water demand	19,199	9,299	19,326	9,426	19,326	9,426	19,326	9,426
Net water demand	19,087	9,187	19,212	9,312	19,212	9,312	19,212	9,312
Depletion	19,085	9,185	19,210	9,310	19,210	9,310	19,210	9,310
Other[2]								
Applied water demand	1	1	1	1	1	1	1	1
Net water demand	36	35	36	35	36	35	36	35
Depletion	9	9	9	9	9	9	9	9
TOTAL								
Applied water demand	20,207	10,392	20,381	10,570	20,422	10,613	20,453	10,646
Net water demand	20,035	10,159	20,182	10,306	20,213	10,337	20,238	10,364
Depletion	19,796	9,953	19,949	10,110	19,973	10,137	19,992	10,159

(1) Includes 17.8 MAF and 7.9 MAF for North Coast Wild and Scenic Rivers, respectively.
(2) Includes major conveyance facility losses, recreation uses, and energy production.

Identifying the Primary Causes of Fishery Declines. Fish populations have declined precipitously on all north coast streams since the 1960s. Many people tend to identify dams as the main cause of these fishery declines, yet undammed streams such as the Smith, Van Duzen, and Mattole rivers have also suffered steep reductions in salmon populations. There are many factors contributing to fishery declines, such as prolonged drought, commercial ocean fishing, logging, importing of fish from other stream systems, poaching, overfishing, and disease.

The Klamath River is one of several Wild and Scenic Rivers in the North Coast Region. The Klamath and Trinity rivers are the focus of many regional environmental issues, including increased instream flows and endangered species habitat.

Endangered Species. Two species of sucker fish found in the Klamath Project area have been listed as endangered under the federal and State Endangered Species acts. In response, the USFWS imposed restrictions on project operations that reduced dry-period water supply capabilities. As a result, roughly 7,000 acres of normally irrigated land in California was taken out of production in 1992. This modified operation of the Klamath Project, to accommodate the needs of the listed suckers, also reduced flows below Iron Gate Dam that are critical to salmon and steelhead survival in the middle and lower Klamath. This problem was alleviated in 1993 by heavy rainfall.

Pelican Bay State Prison. Opened in December 1989, Pelican Bay State Prison houses 4,000 inmates. An independent water supply line serves the prison from Crescent City's Ranney collectors on the Smith River. The prison currently uses about 672 af annually, and waste water from the prison facilities is treated on-site. A Del Norte County advisory measure allowing the Department of Corrections to build a second prison was passed by the voters and construction is likely to proceed. It appears that the increased water demand can be met through increased use of Smith River supplies.

Humboldt Bay Municipal Water District. This district supplies an average of 62,000 af per year in the Humboldt Bay area, including Eureka, Arcata, McKinleyville, and several pulp and lumber mills. The district's supply from Ruth Reservoir on the Mad River is allocated through existing contracts. About 4,480 af per year of unallocated supply is available to meet future demands or alleviate drought conditions. The HBMWD considered enlarging Ruth Reservoir, but engineering aspects of the project do not appear to be feasible and recent changes in health regulations would require expensive additional treatment of water from that source. Complying with the surface water treatment rules established in the 1986 amendment to the Safe Drinking Water Act presents a difficult, costly challenge for the Eureka area. Further, water from HBMWD's Ranney collectors in the Mad River has been designated as ground water under the influence of surface water and must be filtered. A regional filtration plant is estimated to cost $16 million. Thus, HBMWD is considering the feasibility of developing ground water to replace a portion of the Mad River supply for residential and commercial use only. About 50,400 af of the district's 62,720-af average annual water use (80 percent) was normally supplied to the Eureka pulp mills. This water does not require treatment. Since closure of the Simpson pulp mill, the district will deliver only about 28,000 af per year to this industry.

Russian River Instream Flow Decision and Supply Allocations. With water available from Lake Sonoma (Warm Springs Dam), and State Water Resources Control Board Decision 1610 defining instream flow requirements and operating criteria, most major water supply reliability questions in the Russian River Basin have been resolved to beyond 2010. However, there is growing concern over the extent of sedimentation in Lake Pillsbury and Lake Mendocino and the resulting reductions in dry-year carryover water supplies. Additionally, Mendocino County is concerned that Decision 1610 will prevent the county from obtaining additional water from the Russian River. Through the Eel-Russian River Commission, the two counties are exploring possibilities for augmenting available water supplies, including construction of additional storage on the upper Eel River and conjunctive use of ground water with existing surface supplies.

Water Supply Reliability Problems in Small Communities. A number of smaller communities throughout the region have continuing supply problems, often related to the lack of economic base to support water supply management and development costs. For example, the areas north and south of the town of Trinidad in Humboldt County depend on small springs and shallow wells which provide an inadequate supply during late summer and fall. They have attempted to hook up to Trinidad's system, supplied from Luffenholtz Creek, but have been unsuccessful due to local fears of overtaxing this small system. The City of Willits has had chronic problems with turbidity, taste, and odor in its Morris Reservoir and high arsenic, iron, and manganese levels in its well supply. These problems have been largely solved by the construction of Centennial Dam and associated treatment facilities.

The City of Fort Bragg has water shortage problems and has hired a consultant to investigate alternative solutions. The city's historic ability to use surface waters has been impaired by several factors, including fish bypass requirements, possible listing of the coho salmon as an endangered species, and additional water quality standards relating to treatment resulting in substantial new capital and operating expenditures. The city has undertaken a substantial amount of study work on alternative sources of supply, including ground water, water recycling, additional surface sources, and sea water desalination. Desalination is now seriously considered as an alternative to increasing the City of Fort Bragg's water supply reliability.

Many north coast ground water wells located on low terraces near the ocean are vulnerable to sea water intrusion if over-pumped. For example, the well serving the relocated town of Klamath has recently begun pumping sea water. Several small communities along the coast, such as Moonstone, Smith River, and Hiouchi, either experience chronic water shortages or have inadequate supplies to meet projected growth in the future. Water use is already very low due to extensive conservation, so most of these problems will likely need to be solved by constructing or upgrading community water systems. Factors hindering development of community systems are a low population base contributing to lack of funding, and community disagreements on the desirability of growth.

Lakes Earl and Talawa. To increase wildlife habitat, these linked lakes north of Crescent City are being allowed to reach higher levels than historically permitted. Local fears that these actions would interfere with operation of surrounding septic systems have subsided after a year of higher lake levels without significant problems. The lake levels are kept higher by breaching an ocean-formed sandbar at the common outlet when the water reaches approximately 10 feet in elevation. Agreement among agencies on the maximum allowable levels has not been reached yet, and studies continue. Higher late-summer levels in these lakes could increase water availability to surrounding shallow wells. Recent objections to higher uncontrolled lake levels has been expressed by a representative of Pacific Shores subdivision, which was formed in the 1960s.

Water Balance

Water budgets were computed for each planning subarea in the North Coast Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown. This depends on (1) how supplies are allocated within the region, (2) a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and (3) the overall level of reliability deemed necessary to the sustained economic health of the region. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table NC-12 presents water demands for the 1990 level and for future water demands to 2020 and compares them with (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options.

Regional net water demands for the 1990 level of development totaled 20,035,000 and 10,159,000 af for average and drought years, respectively. Those demands are forecasted to increase to 20,238,000 and 10,364,000 af, respectively, by the year 2020, after accounting for a 55,000-af reduction in urban water demand resulting from water conservation measures. Urban net water demand is forecasted to increase by about 51,000 af by 2020, primarily due to expected increases in population; agricultural net water demand is forecasted to increase by about 27,000 af, primarily due to an expected increase in vineyards in the region. Environmental net water demands are increasing by 125,000 af, due primarily to implementation of the CVPIA, which increases Trinity River flows for fisheries by about 123,000 af, and a 2,000-af increase in wetland water needs.

Average annual supplies are generally adequate to meet average net water demands in this region out to the year 2020. However, during drought, present supplies are insufficient to meet present demands and, without additional water management programs, annual drought year shortages are expected to continue to be nearly 9,000 af.

The only Level I water management program planned for this region is in the Russian River PSA. That program is 9,000 af of water recycling, which will reduce ground water pumping for this area by a similar amount. The remaining shortage of 9,000 af is in the Upper Klamath PSA, which requires both additional short-term drought management and future Level II water management programs, depending on the overall level of water service reliability deemed necessary by local agencies.

Table NC-12. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Net Demand								
Urban—with 1990 level of conservation	168	177	210	219	247	257	274	285
—reductions due to long-term conservation measures (Level I)	—	—	-24	-24	-43	-43	-55	-55
Agricultural—with 1990 level of conservation	744	760	748	764	761	776	771	787
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Environmental	19,087	9,187	19,212	9,312	19,212	9,312	19,212	9,312
Other(1)	36	35	36	35	36	35	36	35
TOTAL Net Demand	20,035	10,159	20,182	10,306	20,213	10,337	20,238	10,364
Water Supplies w/Existing Facilities								
Developed Supplies								
Surface Water	922	917	934	930	954	947	967	965
Ground Water	263	283	275	295	286	308	298	316
Ground Water Overdraft(2)	0	0	—	—	—	—	—	—
Subtotal	1,185	1,200	1,209	1,225	1,240	1,255	1,265	1,281
Dedicated Natural Flow	18,850	8,950	18,973	9,073	18,973	9,073	18,973	9,073
TOTAL Water Supplies	20,035	10,150	20,182	10,298	20,213	10,328	20,238	10,354
Demand/Supply Balance	0	-9	0	-8	0	-9	0	-10
Level I Water Management Programs								
Long-term Supply Augmentation								
Reclaimed	—	—	3	3	6	6	9	9
Local	—	—	0	0	0	0	0	0
Central Valley Project/ Other Federal	—	—	0	0	0	0	0	0
State Water Project	—	—	0	0	0	0	0	0
***Subtotal* - Level I Water Management Programs**	0	0	3	3	6	6	9	9
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	-3	-3	-6	-6	-9	-9
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	-9	0	-8	0	-9	0	-10

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Looking from Marin County, the Golden Gate Bridge spans the bay into San Francisco. The City of San Francisco is typical of the densely urbanized areas of the region.

San Francisco Bay Region

The San Francisco Bay Region extends from Pescadero Creek in southern San Mateo County to the mouth of Tomales Bay in the north and inland to the confluence of the Sacramento and San Joaquin rivers near Collinsville. The total land area of the region is about 3 percent of the State's area. For much of the following discussion, the region is divided into the North Bay and South Bay planning subareas, which are divided by the bay waterways. (See Appendix C for maps of the planning subareas and land ownership in the region.)

The highest peaks of the Coast Range, which make up much of the eastern boundary, are over 3,000 feet above sea level. Other prominent geographic features include San Francisco, San Pablo, and Suisun bays, and the San Francisco and Marin peninsulas. The region also includes many small creeks which flow to the Pacific Ocean or into the bays.

The climate is generally cool and often foggy along the coast, with warmer Mediterranean-like weather in the inland valleys. The average high temperature is nearly 10 degrees higher inland than at San Francisco, resulting in higher outdoor water use in the inland areas. The gap in the hills at Carquinez Strait allows cool air to flow at times from the Pacific Ocean into the Sacramento Valley. Most of the interior North Bay and the northern parts of the South Bay also are influenced by this marine effect. The southern interior portions of the South Bay, by contrast, experience very little marine air movement. Average precipitation ranges from 14 inches at Livermore in the South Bay to almost 48 inches at Kentfield in Marin County in the North Bay.

Population

The region is highly urbanized and includes the San Francisco, Oakland, and San Jose metropolitan areas. There are large undeveloped areas in the western, northern, and southern parts of the region. In 1990, 18 percent of the State's total population lived in the region and almost 88 percent, or 4,800,000, of those residents lived in the South Bay. During the1980s, the region's population grew by approximately 695,000; the North Bay grew by about 20 percent and the South Bay grew by 14 percent.

In the North Bay PSA, the inland cities of Fairfield, Vallejo, Benicia, and Suisun City grew by 33, 36, 59, and 105 percent, respectively, from 1980 to 1990. These cities

Region Characteristics

Average Annual Precipitation: *31 inches* ***Average Annual Runoff:*** *1,245,500 af*

Land Area: *4,400 square miles* ***Population:*** *5,484,000* alone accounted for an increase of almost 70,000 people during the decade. Over the same period, most of the cities in Marin County grew very slowly. San Rafael, the county's largest city, grew at a modest 8 percent, while Fairfax actually declined in population. Further north and east, Petaluma and Napa grew by 28 and 22 percent, respectively.

The most rapid growth in the South Bay PSA also took place in the eastern part of that area. A number of cities had growth rates greater than 40 percent during the 1980s, including Dublin, Martinez, Pittsburg, Pleasanton, and San Ramon. Hercules, in the northern part of the PSA, grew by 282 percent. Growth during the 1980s was numerically significant in the larger urban centers: Oakland (32,905), Fremont (41,394), San Francisco (44,985), and San Jose (152,702). Table SF-1 shows regional population projections.

Table SF-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
North Bay	680	817	889	941
South Bay	4,804	5,398	5,722	6,003
TOTAL	5,484	6,215	6,611	6,944

Land Use

Land use in the region is truly diverse. The San Francisco Bay Region is home to the world-famous Napa Valley and Sonoma County wine industry; international business and tourism in San Francisco; the technological development and production in the "Silicon Valley"; as well as urban, suburban, and rural living. Urban land accounts for 23 percent (655,600 acres) of the land area. Irrigated agricultural land in 1990 was 61,400 acres. Forecasted land use reflects an increase in urban areas to 870,900 acres, or 37 percent of the region's land area, by 2020. Point Reyes National Recreation Area, as well as other federal and State parks and reservoirs, make up a small portion of the total region.

While a relatively large portion of the land area is urbanized, a wide variety of crops also are grown in the region. Agricultural land use is strongly influenced by the climatic and urban growth factors mentioned above. In almost every area of the region, urban development is encroaching on agricultural lands.

Within the North Bay, vineyards account for over three-fourths of the irrigated acres in Sonoma and Napa counties. There are 4,200 acres of pasture and about 3,900 acres of deciduous trees (primarily walnuts, prunes, and pears in Solano County) in the North Bay. The coastal area of the South Bay supports rangeland, flowers, and a number of high-value specialty vegetables, such as artichokes. Vegetables, flowers, vineyards, and many suburban ranchettes with irrigated pasture are found in the Santa Clara Valley. Alfalfa, truck crops, and wine grapes are grown in the Livermore Valley. Figure SF-1 shows land use, imports, and exports in the San Francisco Bay Region.

Water Supply

Water supply sources include local surface water, imported surface water (both locally developed and purchased from other local agencies), ground water, Central Valley Project water, other federal project water (Solano Project), State Water Project

North Marin Water District supplements its imported Sonoma County Water Agency supply with just over 1,000 af from Stafford Lake. The City of Napa uses local surface supply from Lake Hennessey and Lake Milliken, and St. Helena receives water from Bell Canyon Reservoir. The City of Vallejo gets water from Lake Curry in Napa County. Vineyards along the Napa River annually divert approximately 6,000 af from the river for irrigation and frost protection. Since no major local supply projects are anticipated, the local surface supplies are forecasted to remain constant through 2020.

Table SF-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	365	253	365	253	365	253	365	253
Local imports	539	503	563	514	587	514	591	514
Colorado River	0	0	0	0	0	0	0	0
CVP	180	160	213	183	228	183	232	183
Other federal	54	44	54	44	54	44	54	44
SWP(1)	182	124	213	126	208	121	208	122
Ground water(2)	100	139	126	174	160	174	165	174
Overdraft(3)	0	0	—	—	—	—	—	—
Reclaimed	36	36	36	36	36	36	36	36
Dedicated natural flow	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
TOTAL	6,071	4,344	6,185	4,415	6,253	4,410	6,266	4,411

(1) SWP supplies may be higher in any year to help recharge ground water basins for drought years.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Imports by Local Agencies. In the North Bay, water is imported from the Russian and Eel rivers (North Coast Region) by Sonoma County Water Agency and from the Delta by the City of Vallejo through the SWP. Sonoma County Water Agency delivers water from the Russian River Project (which includes Lake Mendocino and Lake Sonoma, and the Potter Valley Project) to eight principal contractors, including four in the San Francisco Bay Region (Petaluma, Sonoma, Valley of the Moon, and North Marin water districts).

Marin Municipal Water District currently supplements its local supply with 4,300 af from Sonoma County Water Agency, according to their "Off-peak Water Agreement." MMWD recently negotiated a new agreement with SCWA for an additional 10,000 af "as available." MMWD is now seeking to make these contracts as reliable as possible by working with SCWA, expanding its own conveyance facilities, and supporting SCWA in its SWRCB water rights permit application.

Ground water. The North Bay 1990 level average supply of ground water is about 24,000 af. The increase in ground water supply during drought years reflects a greater dependence on ground water during periods of surface water deficiencies. Future ground water supply is projected to remain fairly constant.

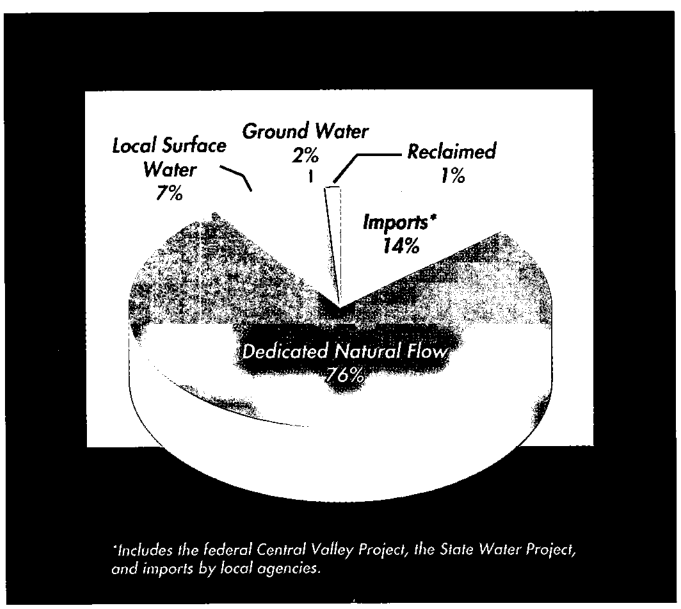
The larger alluvial basins in the North Bay PSA include Suisun-Fairfield Valley, Napa Valley-Sonoma Valley, Petaluma Valley, and Novato Valley. Ground water levels indicate the basins are probably not in overdraft. Estimated ground water storage in the basins is 1,700,000 af. Salt water intrusion has been a problem in the bayside portions of the Sonoma and Napa valleys, but this has been substantially mitigated by using imported surface water instead of ground water. The ground water quality in the North Bay is generally good. Some isolated areas experience elevated levels of dissolved solids, iron, boron, hardness, and chloride. High levels of nitrates occur in the Napa and Petaluma valleys as a result of past agricultural practices.

Other Federal Projects. Solano County Water Agency contracts for water from Lake Berryessa via the Solano Project and delivers it to farmers and cities within the county. The project was built by the U.S. Bureau of Reclamation and began operation in 1959. The project has an annual dependable supply of 201,000 af but can deliver as much as 212,000 af. The majority of the Solano Project entitlement water goes to agricultural users in the Sacramento River Region. The 1990 level average project supply for the North Bay is 54,000 af. The drought year supply shows a 15-percent deficiency, which was imposed by the USBR in 1991. Solano County Water Agency supplies are projected to increase only slightly through 2020.

State Water Project. The SWP delivers water through the North Bay Aqueduct to the Solano County Water Agency and Napa County Flood Control and Water Conservation District. The Aqueduct extends over 27 miles from Barker Slough to the Napa Turnout Reservoir in southern Napa County. Maximum SWP entitlements are for 67,000 af annually. The Aqueduct also conveys water for the City of Vallejo, which purchased capacity in the NBA.

Water Recycling. About 800 af of recycled water is used in Marin, Napa, and southern Sonoma counties, primarily for landscape irrigation. In Solano County, over 2,000 af of water is recycled by the Fairfield-Suisun Sewer District for agricultural irrigation, mostly on turf farms. The total 1990 average and drought year recycled water supply in the North Bay is 3,000 af.

Figure SF-2. San Francisco Bay Region Water Supply Sources (1990 Level Average Conditions)

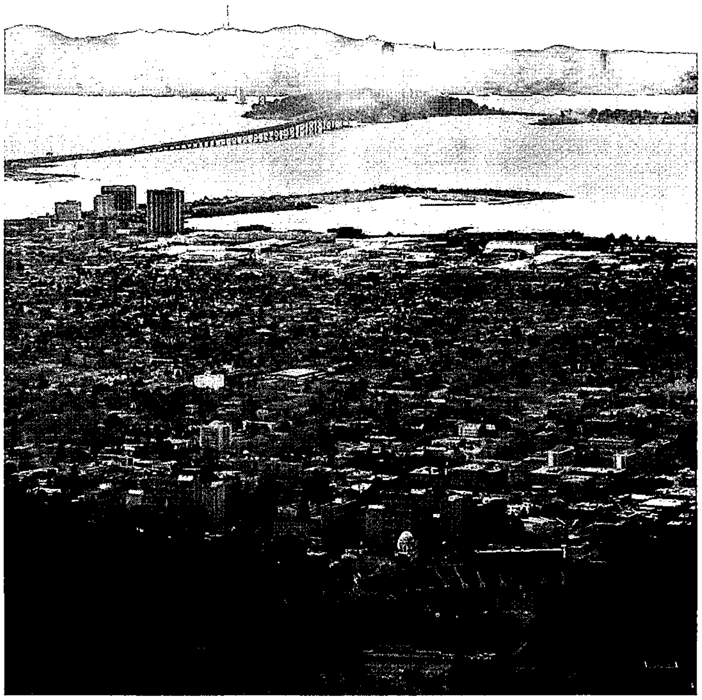


South Bay. The 1990 average local surface supply for the South Bay is 139,000 af. The drought year shortage is significantly affected by a 67-percent reduction in local surface supplies. Future supplies from existing facilities should remain relatively constant through 2020.

Imports by Local Agencies. San Francisco Water District imports Tuolumne River water via the 150-mile-long Hetch Hetchy System. In addition to supplying water to the City and County of San Francisco, SFWD sells water wholesale to 30 water districts, cities, and local agencies in Alameda, Santa

Clara, and San Mateo counties. SFWD now has three pipelines capable of delivering 336,000 af annually to the Bay Area.

EBMUD imports water from the Mokelumne River through its aqueducts and delivers water to much of Alameda and Contra Costa counties. The district supplies water to approximately 1,200,000 people in 20 cities and 15 unincorporated communities. EBMUD has water rights and facilities to divert up to 364,000 af annually from the Mokelumne River, depending on streamflow and water use by other water rights holders.



The San Francisco Bay Region relies on imported water for most of its urban and agricultural supplies. Increases in population will require water supply planners to face the challenges of meeting increased demand with limited supply.

Ground water. The major ground water basins of the South Bay PSA include Santa Clara Valley, Livermore Valley, and the Pittsburg Plain. The total ground water storage in the South Bay basins is estimated to be 6,500,000 af.

Artificial recharge programs are in place in several South Bay localities. Alameda County Flood Control & Water Conservation District, Zone 7, uses several abandoned gravel pits to recharge ground water in the Livermore Valley. Alameda County Water District uses a series of artificial barriers and abandoned gravel pits to slow runoff and increase percolation in and along Alameda Creek.

Santa Clara Valley Water District has supplemented the ground water basin yield by developing an extensive recharge program. SCVWD augments the natural recharge by artificial recharge in percolation ponds and streambeds of major creeks in the Santa Clara Valley subbasins. Ground water users pay for ground water replenishment through a ground water charge based on measured ground water use. SCVWD manages an extensive conjunctive use program and during water supply shortages provides a financial incentive to influence water retailers to choose between ground water and treated surface water.

These programs have resulted in a general rise to near-historic highs in ground water levels in many of the basins. Recharge and surface water substitution in the Pittsburg Plain were successful in restoring ground water basins which were overdrafted in the past. These efforts mitigated or eliminated low ground water level problems, such as salt water intrusion in the Pittsburg Plain. Land subsidence in northern Santa Clara Valley has also been controlled. Alameda County Water District has begun an Aquifer Reclamation Program to mitigate salt water intrusion into its ground water basin near San Francisco Bay. The program includes pumping and disposing of saline water using a series of wells and creating a salinity intrusion barrier using 4-5 wells in the upper aquifer. The district anticipates that the basin's annual perennial yield will be increased 3,500 af at the completion of the Aquifer Reclamation Program.

Ground water quality is still a problem to various degrees in many South Bay locations. The Livermore Valley has elevated levels of dissolved solids, chloride, boron, and hardness. The highly urbanized areas of the Santa Clara Valley have experienced ground water pollution over large areas from organic solvents used in electronics manufacturing. However, SCVWD has an extensive ground water protection program to administer ground water cleanup operations and to prevent degradation of the ground water basin through well sealing and ground water quality monitoring.

Central Valley Project. CVP water is delivered through the Contra Costa Canal to Contra Costa Water District and through the San Felipe Project to SCVWD. CCWD delivers water throughout eastern Contra Costa County, including a portion of the district in the San Joaquin River Region. CVP water was first delivered by CCWD in 1940. The current contract with USBR is for a supply of 195,000 af per year. The district also has a right to divert almost 27,000 af from Mallard Slough on Suisun Bay. Most of CCWD's demands are met through direct diversions from the Delta through the Contra Costa Canal. CCWD has very little regulatory or emergency water supply storage to replace Delta supplies when water quality is poor. As a result, CCWD service area voters authorized funding for Los Vaqueros Reservoir in 1988. The proposed reservoir will improve supply reliability and water quality by allowing the district to pump and store water from the Delta during high flows.

SCVWD's maximum entitlement from the CVP's San Felipe Division, which became operational in 1987, is 152,500 af. Average 1990 deliveries to the region are about 93,200 af. By 1989, much sooner than anticipated, the district was requesting, but did not receive, its full entitlement to reduce impacts of the 1987-92 drought. Normally, about one-half of the CVP water is used for recharge; the rest is used as direct supply.

State Water Project. The South Bay Aqueduct conveys SWP water to SCVWD, ACFC&WCD Zone 7, and ACWD. The aqueduct is over 42 miles long beginning at SWP's South Bay pumping plant on Bethany Reservoir and ending at the Santa Clara Terminal Facilities. SWP water is used in South Bay PSA for municipal and industrial supply, agricultural deliveries, and ground water recharge.

Water Recycling. There are several water recycling projects in the South Bay PSA which provide 33,000 af to various uses such as environmental, industrial, landscape, and construction.

Supplies with Additional Facilities and Water Management Programs

With increasing populations and the resulting increased water demand, Bay Area water agencies are looking at a number of options to increase supplies as well as ensure the reliability of their existing water sources. Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Supplies in the North Bay are adequate during average years to meet the water demand through 2020. For drought years, shortages range from 36,000 af in 1990 to 67,000 af in 2020 with existing facilities. With additional facilities, drought year shortages are reduced to about 33,000 af in 2020. Some areas that may have difficulty meeting water demand include MMWD, the Solano Project service area, and SWP contractor service areas. MMWD has the ability to use unused conveyance space in Sonoma County Water Agency and NMWD aqueducts, thus improving the water district's water supply reliability through water transfer. In November 1992, district voters approved funding for a program which includes building new facilities to eliminate or at least lessen the district's reliance on surplus capacity in NMWD and SCWA aqueducts.

With existing facilities, the South Bay's shortages would be about 30,000 af in 2020 during average years. During drought years, with existing facilities, shortages will increase from 272,000 af in 1990 to 417,000 af in 2020. With additional facilities, the South Bay will be able to meet average year demands to 2020 and drought year supply shortages would be reduced to about 228,000 af. Each of the six major water agencies in the South Bay is served by at least one of the import water systems connected to the Delta. These connections allow the transfer of water from agencies upstream of the Delta. Table SF-4 shows regional water supplies with additional (Level I) water management programs.

Table SF-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	365	253	365	253	365	253	365	253
Local imports	539	503	563	557	587	557	591	557
Colorado River	0	0	0	0	0	0	0	0
CVP	180	160	213	183	228	183	232	183
Other federal	54	44	54	44	54	44	54	44
SWP(1)	182	124	220	130	212	200	216	201
Ground water(2)	100	139	87	194	87	194	110	198
Overdraft(3)	0	0	—	—	—	—	—	—
Reclaimed	36	36	74	74	111	111	119	119
Dedicated natural flow	4,615	3,085	4,609	3,079	4,609	3,079	4,609	3,079
TOTAL	6,071	4,344	6,185	4,514	6,253	4,621	6,296	4,634

(1) SWP supplies may be higher in any year to help recharge ground water basins for drought years.
(2) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Water Supply Reliability and Drought Management Strategies. The San Francisco Bay Region weathered both the 1976-77 and 1987-92 droughts with moderate but only temporary impacts. These experiences verify that the region's flexibility to move water efficiently is a valuable asset in drought years. Three major factors contribute to this flexibility and the region's successful drought strategies: (1) effective water conservation and rationing programs, (2) available interconnections between water providers, and (3) diversity of water sources. While the region's dependency on somewhat less reliable imported supplies is substantial in drought years, water sources are geographically diverse and emergency supplies and water transfers can help alleviate drought impacts. The following paragraphs describe some recent drought management actions taken in the region.

During the 1976-77 drought, MMWD received supplemental water through an elaborate sequence of interconnections. The transfer involved delivery of SWP water made available by agencies in Southern California, which took more water from the Colorado River. Water was conveyed through the South Bay Aqueduct and then by exchange and interconnected through the water systems of the SFWD, City of Hayward, and EBMUD, to a temporary pipeline across the Richmond-San Rafael Bridge. During the 1987-92 drought, MMWD customers achieved a 39-percent reduction in water use during the voluntary reduction period targeted at 25 percent.

Another example of drought-induced interconnections occurred during the recent drought when SFWD requested DWR to install the San Antonio turnout from the SWP South Bay Aqueduct that had also been used in the 1976-77 drought.

EBMUD has facilities to transfer water to both CCWD and the City of Hayward, while SFWD is able to transfer water to SCVWD. All of the major agencies of the South Bay have access to facilities capable of transferring water from other agencies upstream of the Delta. These transfers can be brought in through the Contra Costa Canal (CVP), the South Bay Aqueduct (SWP), or the San Felipe Project (CVP). During the recent drought, EBMUD adopted both voluntary and mandatory water use reduction programs of up to 25 percent.

SCVWD received 32 percent of its maximum CVP supply in 1991, which included 10,000 af of hardship supply. In addition, it received 30 percent of its SWP supply. As a result of these deficient supplies, the district elected to purchase 14,000 af of water from Placer County Water Agency, 26,000 af of water from Yuba County, and 20,000 af from the 1991 State Drought Water Bank. In addition to supplementing its supplies, the district instituted conservation programs designed to save 25 percent of 1987 water use.

Locally imported supplies by SFWD and EBMUD also suffered deficiencies during the recent drought. The Hetch Hetchy deficiency was reduced from an initial 45 to 25 percent for 1991. Customers were required to reduce indoor use by 10 percent and outdoor use by 60 percent. The deficiency reduction was made possible by purchases of 50,000 af from the 1991 State Drought Water Bank and 20,000 af from PCWA.

ACWD and ACFC&WCD, Zone 7 were both subject to 80-percent deficiencies in their 1991 SWP supplies. ACWD received 14,800 af from the 1991 State Drought Water Bank and an increase in its share of Lake Del Valle supplies. These supplemental supplies allowed the district to scale back its rationing plan to 25 percent reductions. ACFC&WCD, Zone 7 was able to make up for SWP deficiencies by increased ground water pumping. ACFC&WCD, Zone 7 also acquired a small supplemental supply from the 1991 State Drought Water Bank and instituted a conservation education program with a 25-percent reduction goal.

Future Water Management Options. Since 1975 MMWD has had one of the least reliable supplies in the Bay Area. The district had to rely on supplemental imported supply from Sonoma County Water Agency and a very responsive reduction effort by customers to ensure adequate supplies throughout the 1987-92 drought.

Assuming "base case" growth to 2025 and no supplemental supplies, the district had estimated a 40-percent deficiency once every 10 years. MMWD's new contract with SCWA will decrease that deficiency to approximately 10 percent.

MMWD currently has no participation rights in SCWA facilities and uses excess capacity in SCWA's and NMWD's systems to convey Russian River water to Novato and into the MMWD system. MMWD developed and voters approved an Integrated Water Resources Management Program, which includes conservation, recycled water, and facilities expansion to accommodate the increased imported supply from the Russian River. The program is intended to provide sufficient supply to the district through 2025 and allows for manageable deficiencies in dry years, which will minimize costs and environmental impacts.

Other suppliers in the area are much less vulnerable. Solano County Water Agency's principal contractors, for example, have very reliable supplies. Using historic hydrology and 2010 demands, Solano County Water Agency forecasts no supply deficiencies for the system.

EBMUD's supply is vulnerable in at least three ways: (1) drought, (2) decreasing availability of supplies due to increased use by senior water rights holders and an increasing emphasis on environmental needs, and (3) the integrity of its delivery system, especially the security of the aqueducts from earthquakes or floods as they cross the Delta. EBMUD has recently completed work on an Updated Water Supply Management Program that includes a number of improvements to its water supply system. A detailed discussion of this program is in Volume I, Chapter 11. A main element of EBMUD's program is the conjunctive use of ground water. In average and wet years, available water would be stored in ground water aquifers in the lower Mokelumne River basin and withdrawn in dry years. This program will yield 43,000 af in drought years. EBMUD's Board of Directors has also directed the district's staff to continue working with San Joaquin County water interests regarding development of a joint conjunctive use project, with the option of using the district's contract with USBR for 150,000 af per year of American River water.

Local imported supply would increase by 43,000 af in the future for drought years, reflecting EBMUD's conjunctive use alternative. American River water is potentially available from a previously unused CVP contract for 150,000 af that was originally to be delivered through Folsom South Canal to the Mokelumne Aqueducts. The district is still considering building its own extension of the Folsom South Canal so water could be delivered to its aqueducts.

As described previously, CCWD is pursuing the development of Los Vaqueros Reservoir near Byron to secure additional reliability and better quality for its water supplies. In addition, water recycling projects are becoming a cost-effective method of meeting increased demand in the San Francisco Bay Region. By 2020, the region could have an additional supply of about 83,000 af of recycled water to help meet its demands.

Water Use

Water use in the region has undergone dramatic changes over the last 40 years. A 1949 land use survey recorded 163,000 acres of irrigated agriculture in the region; the 1990 level land use analysis showed 61,400 acres, a 62-percent reduction. The 1990 level agricultural net water demand was 88,000 af. Urban water demand was 1,186,000 af; and environmental water use was about 4,775,000 af. Almost all environmental water use in the region is associated with the Suisun Marsh demands and required Delta outflow. Total water use is forecasted to increase from approximately 6,071,000 af in 1990 to 6,296,000 af in 2020, primarily due to population increases. Figure SF-3 shows the distribution of 1990 level net water demands for the San Francisco Bay Region.

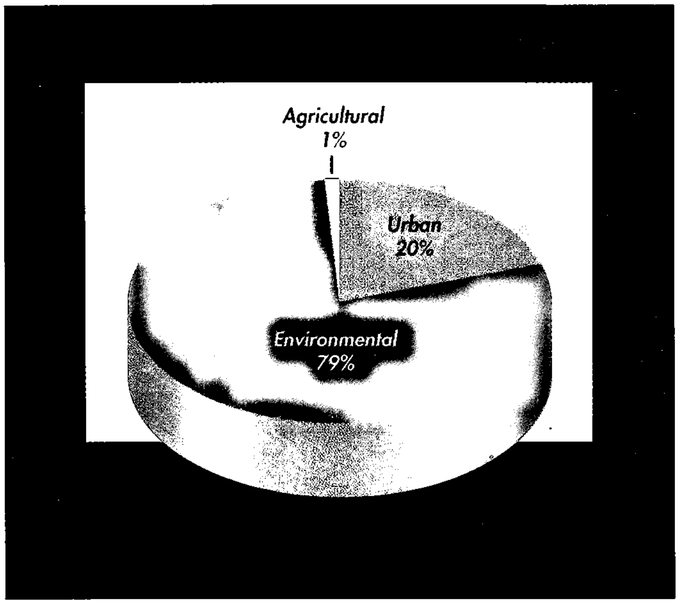


Figure SF-3. San Francisco Bay Region Net Water Demand (1990 Level Average Conditions)

Urban Water Use

Urban water demand is computed using population and per capita water use. Census data and State Department of Finance projections were used to tabulate the region's population. Per capita use in the region varies significantly, depending on factors such as climate, income, population density, residential yard size, and volume of commercial and industrial use. Generally, per capita use showed an upward trend after the 1976-77 drought to pre-drought levels. Recently, per capita use values have dropped again, although not to the levels of the previous drought. This most recent drop is due to conservation efforts during the 1987-92 drought. After a return to near-normal use, per capita use is forecasted to continue to drop slowly over the next three decades due to implementation of Best Management Practices (Volume I, Chapter 6).

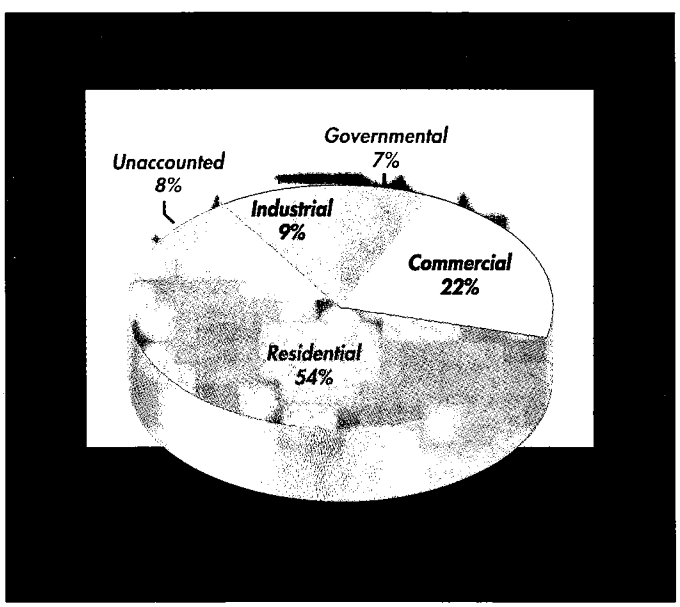


Figure SF-4. San Francisco Bay Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

South Bay. The climate of the South Bay is warmer as you move inland from the coast. The area produces many high-value crops including artichokes, brussels sprouts, and cut flowers. The Santa Clara Valley was historically one of the garden spots for California agriculture. Urbanization over the last 40 years has reduced irrigated agricultural acreage from over 100,000 acres to less than 17,000 in 1990. Most of the remaining lands in production are along the Highway 101 corridor, north of Morgan Hill. Crops grown are primarily high-value truck, fruit, and nut crops. Also, one- to five-acre suburban ranchettes, with sprinkler-irrigated pasture for horses, are now found on formerly nonirrigated range land and compete for limited ground water supplies.

Table SF-6. Irrigated Crop Acreage
(thousands of acres)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
North Bay	44	48	48	48
South Bay	17	16	16	16
TOTAL	61	64	64	64

The Livermore Valley is partially separated from interior Bay climate patterns by the Diablo Range. The valley is significantly warmer, reflected in higher outdoor water use. There are approximately 2,500 acres of irrigated agriculture, primarily vineyards, grain, and truck crops.

Table SF-6 shows the irrigated agricultural land use by PSA and for the region, for 1990 through 2020. Table SF-7 shows 1990 evapotranspiration of applied water by crop. Table SF-8 summarizes the 1990 and forecasted agricultural water demand in the region.

Table SF-7. 1990 Evapotranspiration of Applied Water by Crop

Irrigated Crop	*Total Acres (1,000)*	*Total ETAW (1,000 AF)*
Grain	2	1
Corn	1	1
Other field	1	1
Pasture	5	11
Other truck	10	19
Other deciduous	6	10
Vineyard	36	27
TOTAL	61	70

Table SF-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
North Bay								
Applied water demand	57	65	59	65	59	66	59	66
Net water demand	53	61	55	61	55	62	55	62
Depletion	48	55	50	55	50	56	50	56
South Bay								
Applied water demand	35	38	35	39	35	38	35	37
Net water demand	35	38	35	39	35	38	35	37
Depletion	32	34	32	35	32	34	32	33
TOTAL								
Applied water demand	92	103	94	104	94	104	94	103
Net water demand	88	99	90	100	90	100	90	99
Depletion	80	89	82	90	82	90	82	89

Environmental Water Use

The Suisun Marsh and Hayward Marsh are the only identified managed wetlands in the San Francisco Bay Region requiring water supplies. The Suisun Marsh consists of approximately 55,000 acres of managed wetlands. The State owns about 10,000 acres while about 44,000 acres are under private ownership and managed as duck clubs. The estimated water demand of the marsh is about 150,000 af per year. The additional instream demands for the Suisun Marsh are about 15,000 af in an average year and 145,000 af during drought years and is included in environmental instream water needs (Table SF-10). Additional Suisun Marsh instream demands are based on an estimated supplemental flow required over the eight-month period when Suisun Marsh Salinity Gates are operational to meet SWRCB D-1485 standards downstream of the gates in the Delta. The Hayward Marsh is a part of the Hayward Shoreline Marsh Expansion Project. The project represents an effort by several local agencies working together to create the largest wetlands restoration project on the west coast. The 1,800-acre site is managed by the East Bay Regional Park District. As part of the project, 10,000 af of recycled water from the Union Sanitary District is blended with the Bay's brackish water and applied to the 145-acre marsh, restoring habitat for fish, waterfowl, and the endangered salt marsh harvest mouse. Table SF-9 shows wetlands water needs.

Table SF-9. Wetland Water Needs
(thousands of acre-feet)

Wetland	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Suisun Marsh								
Applied water demand	150	150	150	150	150	150	150	150
Net water demand	150	150	150	150	150	150	150	150
Depletion	150	150	150	150	150	150	150	150
Hayward Marsh								
Applied water demand	10	10	10	10	10	10	10	10
Net water demand	10	10	10	10	10	10	10	10
Depletion	10	10	10	10	10	10	10	10
TOTAL								
Applied water demand	160	160	160	160	160	160	160	160
Net water demand	160	160	160	160	160	160	160	160
Depletion	160	160	160	160	160	160	160	160

The largest environmental water use in the region is for Delta outflow to meet SWRCB D-1485 salinity requirements, which requires about 4,600,000 and 2,940,000 af for average and drought years, respectively. Other instream flows for small streams throughout the region were not included in the water use tables. Environmental instream water needs are shown in Table SF-10 and includes Suisun Marsh instream needs. Recent and future actions to protect aquatic species in the Delta will increase environmental water needs for this region. Volume I, Chapter 8 presents a broad discussion of water needs for the Bay-Delta.

Table SF-10. Environmental Instream Water Needs
(thousands of acre-feet)

Stream	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Bay-Delta								
Applied water demand	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
Net water demand	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
Depletion	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
TOTAL								
Applied water demand	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
Net water demand	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
Depletion	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085

Other Water Use

Other water demand includes water losses by major conveyance facilities in the region, water needs of recreational facilities, and water demand of power plants and other energy production. Figure SF-6 shows water recreation areas in the San Francisco Bay Area. Table SF-11 shows the total water demand for 1990 and forecasts to 2020 for the San Francisco Bay Region.

Table SF-11. Total Water Demands
(thousands of acre-feet)

Category of Use	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Urban								
Applied water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Net water demand	1,186	1,287	1,298	1,390	1,365	1,486	1,406	1,530
Depletion	1,079	1,175	1,185	1,271	1,247	1,362	1,287	1,403
Agricultural								
Applied water demand	92	103	94	104	94	104	94	103
Net water demand	88	99	90	100	90	100	90	99
Depletion	80	89	82	90	82	90	82	89
Environmental								
Applied water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Net water demand	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Depletion	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Other(1)								
Applied water demand	4	4	4	4	4	4	4	4
Net water demand	22	21	22	21	23	21	25	21
Depletion	22	21	22	21	23	21	25	21
TOTAL								
Applied water demand	6,057	4,639	6,171	4,743	6,238	4,839	6,279	4,882
Net water demand	6,071	4,652	6,185	4,756	6,253	4,852	6,296	4,895
Depletion	5,956	4,530	6,064	4,627	6,127	4,718	6,169	4,758

(1) Includes major conveyance facility losses, recreation uses, and energy production.

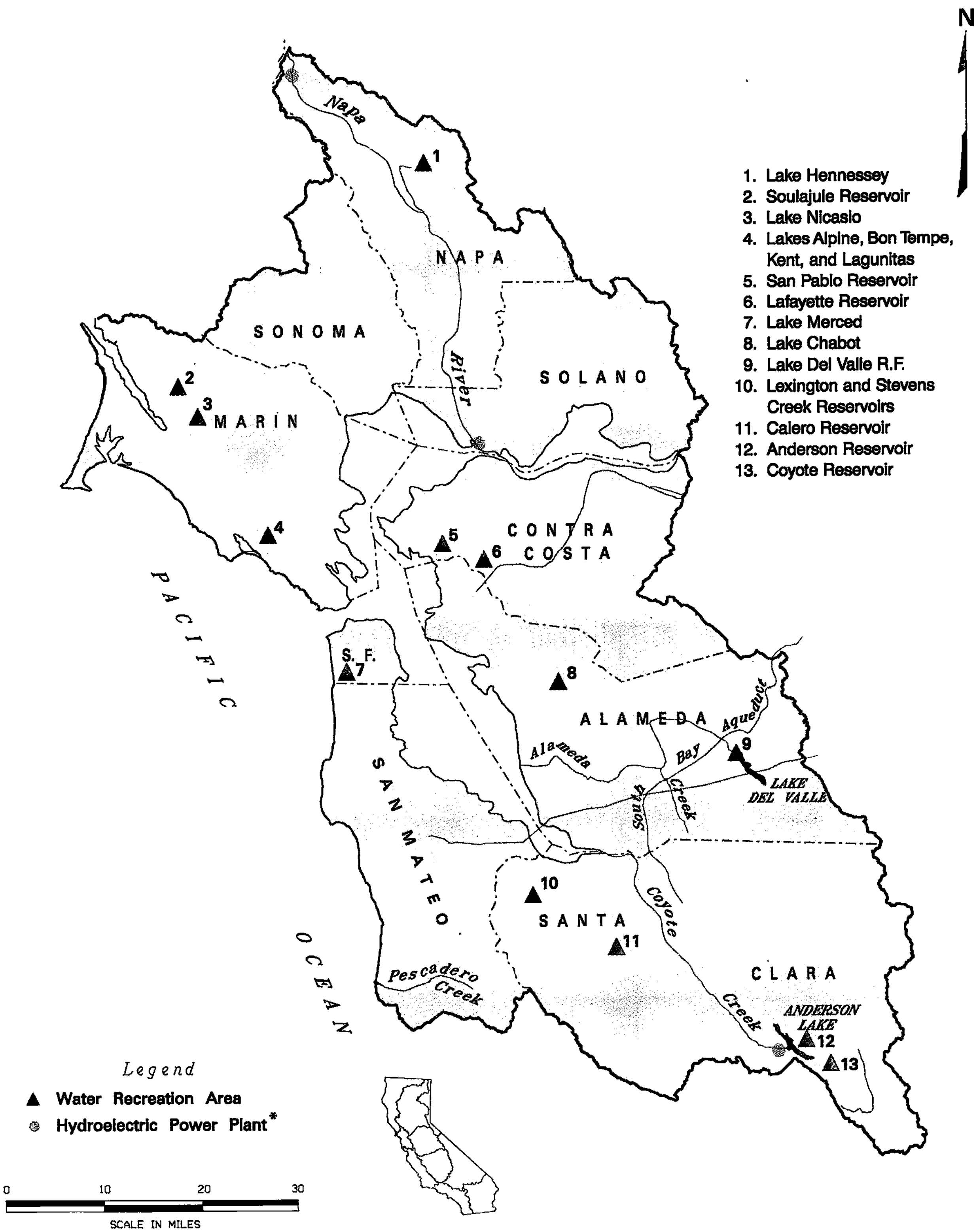
Issues Affecting Local Water Resource Management

The principal water management issues facing the region are population growth and environmental concerns. The following paragraphs describe legislation, litigation, and issues affecting the region.

Legislation and Litigation

EBMUD Supplies. The SWRCB held hearings in November 1992 regarding instream flow requirements for the Mokelumne River. The Department of Fish and Game, private fishing groups, and environmental interest groups want to increase flows below Camanche Reservoir to protect the river's fishery. In addition, several water agencies in the Sierra foothills, San Joaquin County, and the Delta contend that they should receive some priority in the distribution of Mokelumne River water. If the SWRCB rules against EBMUD, the district could be forced to take a large portion of its water from the Delta rather than through the Mokelumne Aqueducts. Lower quality water from the Delta would mean increased treatment costs which would be passed on

Figure SF-6. San Francisco Bay Region
Hydroelectric Power Plants and Water Recreation Areas



*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

to EBMUD customers. In a separate process, the Federal Energy Regulatory Commission is reviewing the district's hydropower operations. In November 1993, FERC issued a final EIS which recommends fish flows significantly greater than the district's Lower Mokelumne River Management Plan. The district filed a motion for a technical conference to provide additional information which the district believes should be the basis for revision of FERC's final decision. Final settlement is expected in 1994.

EBMUD diverted its contracted American River water only once, during the 1976-77 drought, when the district took 25,000 af from the Delta to supplement its depleted supplies under an emergency agreement with USBR. In 1972, a suit was filed protesting EBMUD's right to divert water at Folsom South Canal. In 1986, the SWRCB affirmed the right and referred the lawsuit to Alameda Superior Court for litigation. A preliminary decision in 1989 confirmed the right to divert water at Folsom South Canal and established minimum flows for the American River below Nimbus Dam that would be required before EBMUD could divert its supplies. A final decision was made in 1990, which cleared the way for the district to seriously consider a connection between the canal and the Mokelumne Aqueducts. An EIS/EIR will focus on technical, public health and safety, social, and environmental factors for the project. EBMUD, Sacramento County, Environmental Defense Fund, and DFG are cooperatively conducting fishery studies on the American River.

Recently EBMUD filed a lawsuit against Contra Costa County to block use of scarce EBMUD water for a housing development. The county certified an EIR for the Dougherty Valley development despite the concerns about water supply expressed by the district. EBMUD told the county that it does not have the water to supply the proposed 11,000-home development.

CVPIA. Implementation of the 1992 CVPIA will have some cost impacts on Bay Area water users in the form of higher prices for CVP water. The Act allocates a portion of CVP water to environmental uses and allows municipal and industrial users to purchase water from agricultural users. (See Volume I, Chapter 2.)

Local Issues

Slow-growth Movement. Anti-growth sentiment is increasing in some Bay Area communities as was evident during many of the 1992 local elections. Napa and Contra Costa counties elected several slow-growth candidates. Marin County residents had opposed efforts to improve their water system delivery capabilities beyond limited expansion of local supplies, fearful that more water would mean uncontrolled growth. The Marin Municipal Water District has had for the last three years a moratorium on new connections within its service area due to limited water supplies. The operational yield of present district facilities indicated a 5,000 af deficit for 1990. After more than 20 years of consistently rejecting plans to import more surface water, voters narrowly approved financing to increase the district's capacity to import water from the Sonoma County Water Agency in order to reduce the frequency and severity of drought year shortages.

Contra Costa Water District. The quality and reliability of CCWD's Delta water supply has been an issue for the district. The proposal to build Los Vaqueros Reservoir addresses a number of related issues for the district's water supply and the Delta. The proposed reservoir would be an offstream storage facility and would allow more flexibility in CCWD's operations. Specifically, the district could divert higher quality water to Los Vaqueros Reservoir during high flows in the Delta. Los Vaqueros water would then be available to improve water quality by blending with water delivered throughout the year from the Delta and to provide emergency storage. By storing water at certain times of the year, the district could shut down its pumps during periods when the fisheries are most sensitive to large diversions. CCWD is planning to have the project online by 2000.

Lagunitas Creek. The SWRCB has not established permanent instream flow requirements below Peters Dam on Lagunitas Creek. Interim regulations require an average of 4,000 af annually to preserve or enhance the anadromous fishery of the creek. Significant changes in the permanent requirements would reduce Marin MWD's operational yield.

Drinking Water Standards. The California Department of Health Services is rewriting its surface water treatment requirements to comply with the Environmental Protection Agency's new drinking water standards. SFWD was recently given an extension of its operating permit to propose specific plans to meet DHS requirements. SFWD estimates that new facilities for treating Hetch Hetchy supplies, if required, could cost about $50 million.

Water Balance

Water budgets were computed for each planning subarea in the San Francisco Bay Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary to the sustained economic health of the region. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table SF-12 presents water demands for the 1990 level and for future water demands to 2020 and compares them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options. Regional net water demands for the 1990 level of development totaled 6,071,000 and 4,652,000 af for average and drought years, respectively. Those demands are forecasted to increase to 6,296,000 and 4,895,000 af, respectively, by the year 2020, after accounting for a 250,000-af reduction in urban water demand resulting from additional long-term water conservation measures.

Urban net water demand is forecasted to increase by 470,000 af by 2020, without additional long-term water conservation measures, primarily due to expected increases in population, while agricultural net water demand remains essentially level. Environmental net water demands under SWRCB D-1485 would remain the same but could increase substantially depending on the outcome of several actions currently being undertaken to protect aquatic species.

Average annual supplies with existing water management programs are inadequate to meet average net water demands in this region, resulting in a shortage of about 30,000 af by 2020. During droughts, without additional water management programs, annual drought year shortages are expected to increase to about 484,000 af by 2020.

Table SF-12. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	1,186	1,287	1,409	1,501	1,559	1,680	1,656	1,780
—reductions due to long-term conservation measures (Level I)	—	—	-111	-111	-194	-194	-250	-250
Agricultural—with 1990 level of conservation	88	99	90	100	90	100	90	99
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Environmental	4,775	3,245	4,775	3,245	4,775	3,245	4,775	3,245
Other[1]	22	21	22	21	23	21	25	21
TOTAL Net Demand	6,071	4,652	6,185	4,756	6,253	4,852	6,296	4,895
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	1,356	1,120	1,444	1,156	1,478	1,151	1,486	1,152
Ground Water	100	139	126	174	160	174	165	174
Ground Water Overdraft[3]	0	0	—	—	—	—	—	—
Subtotal	1,456	1,259	1,570	1,330	1,638	1,325	1,651	1,326
Dedicated Natural Flow	4,615	3,085	4,615	3,085	4,615	3,085	4,615	3,085
TOTAL Water Supplies	6,071	4,344	6,185	4,415	6,253	4,410	6,266	4,411
Demand/Supply Balance	0	-308	0	-341	0	-442	-30	-484
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed	—	—	38	38	75	75	83	83
Local	—	—	0	43	0	43	0	43
Central Valley Project/ Other Federal	—	—	0	0	0	0	0	0
State Water Project	—	—	7	4	4	79	8	79
***Subtotal* - Level I Water Management Programs**	0	0	45	85	79	197	91	205
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	-45	14	-79	14	-61	18
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	-308	0	-242	0	-231	0	-261

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated(note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

With Level I water management programs, supplies would meet the future water demand of the region in average years. However, during droughts, shortages could be reduced to about 261,000 af per year by 2020. This remaining shortage requires both additional short-term drought management, water transfers and demand management programs, and future Level II water management programs, depending on the overall level of water service reliability deemed necessary by local agencies. This region depends on export from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on SWRCB D-1485 operating criteria for Delta supplies and do not take into account recent actions to protect aquatic species in the estuary. As such, regional water supply shortages are understated.

Morro Rock provides a stunning backdrop for these boats anchored in Morro Bay. Morro Bay is a popular community on the Central Coast whose primary industries are commercial ocean fishing and tourism.

Central Coast Region

The Central Coast Region accounts for about 7 percent of California's total land area. It encompasses the area adjacent to the Pacific Ocean including Santa Cruz County in the north through Santa Barbara County in the south to the Diablo and Temblor mountain ranges on the east. Its topographic features include Monterey and Morro Bay; the Pajaro, Carmel, Santa Maria, Cuyama, and Salinas valleys; and a number of mountain ranges. The Central Coast Region is best known for its rugged Pacific coastline, scenic bays, and redwood forests.

The varied geography of the region creates diverse climates. During the summer months, temperatures are generally cool along the coastline and warm inland. In the winter, temperatures remain cool along the coast and become even cooler inland.

Annual precipitation in the region ranges from 14 to 45 inches, usually in the form of rain. The average annual precipitation near the City of Salinas is about 14 inches while in the higher elevations of the Big Sur area, approximately 30 miles south of Monterey along the coast, precipitation averages about 40 inches a year. In 1983, the Big Sur area had a surprising 85 inches of rain. Average annual precipitation in the southern coastal basins ranges from 12 to 20 inches, with most of it occurring from November through April. The southern interior basins usually receive 5 to 10 inches per year, the mountain areas receiving more than the valley floors.

Population

With a 1990 population slightly under 1.3 million, the Central Coast Region contains roughly 4 percent of California's population. While most of California experienced a substantial population increase over the past 10 years, growth in this region exceeded the State's average. The collective population of incorporated cities in the Salinas Valley increased 37 percent during the past decade. Population centers along the coast, such as San Luis Obispo and Santa Maria, also had large population increases of 23 and 54 percent, respectively. In addition, significant increases were recorded in the Santa Ynez Valley and smaller communities in Salinas Valley. An inviting atmosphere of good weather, clean air, and close proximity to the mountains and urbanized areas encouraged this growth. However, building moratoriums limited population growth in the area near Santa Barbara.

Region Characteristics

Average Annual Precipitation: *20 inches* ***Average Annual Runoff:*** *2,477,000 af*

Land Area: *11,280 square miles* ***1990 Population:*** 1,292,900

Population growth in the northern part of the region is also associated with space availability and affordable housing prices. While above the national average, the cost of homes in this area is affordable compared to many other parts of California. Much of the region's growth is the result of people migrating from the San Francisco Bay and Los Angeles areas. Current growth in the region's northern area is primarily in and around Hollister, Salinas, and the Watsonville area. Table CC-1 shows population projections to 2020 for the region.

Table CC-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Northern	702	823	969	1,129
Southern	591	699	792	888
TOTAL	1,293	1,522	1,761	2,017

Despite the population increases, much of the region is sparsely populated. The principal population centers are Santa Cruz, Salinas, Watsonville, Monterey, San Luis Obispo, Santa Maria, Santa Barbara, and Lompoc. Most of the region's future population growth continues to be in areas showing recent growth.

The economy in many areas of the region is tied to military installations. Fort Ord, Hunter-Liggett Military Reservation, Camp Roberts, and Vandenberg AFB are the major military facilities in the region. The Monterey Peninsula area is now preparing for the closure of Fort Ord. The cities of Seaside and Marina will suffer the greatest impacts, but the entire area is expected to be affected by the loss of military personnel, civilian workers, and their families.

Land Use

Publicly-owned lands constitute approximately 28 percent of the region's area. The four major military installations within the region occupy 340,000 acres. (See Appendix C for maps of the planning subareas and land ownership in the region.) The abundance of state parks and national forest land (Los Padres, 1.3 million acres) offers the public many recreational opportunities. Elkhorn Slough National Estuarine Research Reserve, one of the few remaining coastal wetlands, showcases miles of scenic wetlands and rolling hills. The slough is on a migratory flyway and is an important feeding and resting ground for a variety of waterfowl. Irrigated and nonirrigated agriculture still remains the dominant land use for most of the Central Coast region. Intensive agriculture exists in the Salinas and Pajaro valleys in the north and the Santa Maria and lower Santa Ynez valleys in the south. Moderate levels of agricultural activity also occur near the Upper Salinas, South Coast, and Cuyama areas. Most of the region's irrigated agriculture is in the northern and southwestern valleys, and in recent years irrigated acreage has remained fairly stable. Figure CC-1 shows land use, along with imports and exports for the Central Coast Region.

Wine grape acreage has increased in the upper Salinas Valley in San Luis Obispo County but decreased in the lower valley within Monterey County. However, acreage planted to vegetables and other truck crops far surpassed that planted to vineyards and orchards. Cut flowers, strawberries, and specialty crops, such as asparagus, mushroom, artichokes, and holly, are distinctive to the region's northern area. The flower seed industry in Lompoc Valley is a thriving business which also attracts many

The average water supply for the Central Coast Region for the 1990 level of development is estimated at 1,143,000 af. In 1990, ground water pumping amounted to 82 percent of total supplies, 21 percent of which was in excess of the estimated prime supply and is considered overdraft.

Supply with Existing Facilities and Water Management Programs

There are in excess of 60 reservoirs within the Central Coast Region, the majority of which are owned by private concerns. The reservoirs in the region are used for residential and municipal water needs, flood control, recreation, irrigation, and riparian habitat. The major reservoirs in the region are listed in Table CC-2.

Table CC-2. Major Reservoirs

Reservoir Name	*River*	*Capacity (1,000 AF)*	*Owner*
Santa Margarita Lake	Salinas	24	US Army Corps of Engineers
San Antonio	San Antonio	335	MCWRA
Nacimiento	Nacimiento	340	MCWRA
Gibralter	Santa Ynez	9	City of Santa Barbara
Cachuma (Bradbury)	Santa Ynez	190	U.S. Bureau of Reclamation
Whale Rock	Old Creek	41	Department of Water Resources
Lopez	Arroyo Grande Creek	52	SLOCFCWCD
Vaquero (Twitchell)	Cuyama River	240	U.S. Bureau of Reclamation

In the Northern PSA, ground water is the primary source of water for both urban and agricultural use. The Carmel, Pajaro, and Salinas rivers provide most of the ground water recharge for the area. The San Antonio and Nacimiento reservoirs regulate the Salinas River. Table CC-3 shows water supplies with existing facilities and water management programs.

Basins in the Southern PSA are smaller, but important to their local communities. These shallow basins underlie seasonal coastal streams. During years with normal or above-normal rainfall, aquifers in the basins are continuously replenished by creek flows. In years of below-normal precipitation, the creek flows are intermittent, flow is insufficient for both agricultural and municipal uses, wells become dry, and sea water intrudes into some coastal ground water basins.

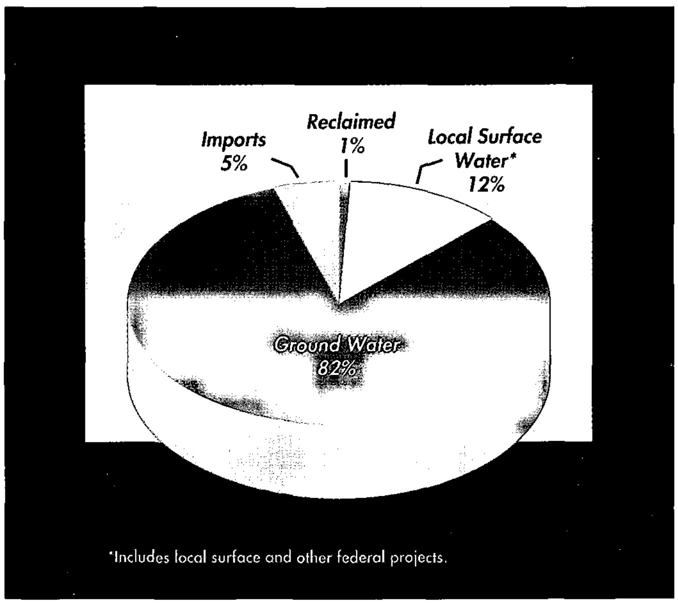


Figure CC-2. Central Coast Region Water Supply Sources (1990 Level Average Conditions)

Table CC-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Surface								
Local	76	56	76	56	76	56	76	56
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	53	19	56	19	80	23	83	23
Other federal	65	46	65	46	65	46	65	46
SWP	0	0	0	0	0	0	0	0
Ground water(1)	688	762	694	769	695	776	698	781
Overdraft(2)	245	245	—	—	—	—	—	—
Reclaimed	15	15	23	23	23	23	23	23
Dedicated natural flow	1	0	1	0	1	0	1	0
TOTAL	1,143	1,143	915	913	940	924	946	929

(1) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Water Supply Reliability and Drought Management Strategies. Many large and small communities in the region have initiated both voluntary and mandatory water conservation practices. Practices range from voluntary water conservation and limited outdoor watering to mandatory water rationing and little or no outdoor watering. The City of Salinas relies on outdoor watering restrictions based upon time-of-day water use limitation, and voluntary water conservation practices. Recently, many of the communities which mandated water rationing during the drought have elected to implement a voluntary water conservation program. For example, Monterey has an outdoor watering schedule based upon time-of-day restrictions, and the city's water waste ordinance is still in effect. The communities of Watsonville and Santa Cruz have voluntary water conservation programs in place. Water runoff from overwatering is prohibited in these communities.

The Marina County Water District in Monterey County, near Fort Ord, has stepped up its conservation efforts to deal with the issue of drought and sea water intrusion. In 1991, the Marina County Water District adopted an ordinance designed to prohibit water waste and encourage conservation efforts. Water conservation projects initiated included a low-flow showerhead retrofit program, resulting in the replacement of one-third of all showerheads in the district. A water audit program was also initiated to provide owners of both businesses and residences with a personalized water conservation plan.

Water supply shortages occurred in the South Coast, San Luis Obispo, Morro Bay, and North Coast areas of the region because of the 1987-92 drought in the Central Coast Region. Dwindling surface water supplies forced retail water agencies in these areas to depend more on limited ground water supplies and water conservation to make up deficits. Portions of the Southern PSA experienced unprecedented supply shortages. In the summer of 1990, retail water agencies in the service area of Lake

Cachuma were confronted with the prospect that only 12 months of supply remained in that reservoir. Two of these agencies were the Goleta Water District and the City of Santa Barbara. The Goleta Water District began implementing a mandatory water rationing program in 1988 for all urban and agricultural customers within its service area. The historical water use by all customers was evaluated and a percentage reduction was assigned to each; financial penalties were established to prevent noncompliance. In addition, the agency established a rebate program that involved the purchase and installation of ultra-low-flush toilets for residential customers, passed ordinances that temporarily banned certain water-related activities, and vigorously advertised water conservation. The conservation efforts by retail customers exceeded the savings levels imposed by the district and resulted in extra water supplies being delivered to agricultural customers.

The City of Santa Barbara implemented similar strategies in combating supply shortages. The city also established a drought patrol to monitor water use behavior, and penalties and citations were handed out to violators. In addition, the city examined and approved action to: 1) import emergency SWP water from Ventura County and 2) examine the potential of sea water desalination. An emergency pipeline was installed to bring SWP water into the Santa Barbara-Carpenteria area from Casitas Lake in Ventura County by exchange, and a sea water desalination plant was constructed in 1991-92 that is capable of producing 7,500 af per year. The plant operated until early June 1992, when it was shut down; the plant will remain on stand-by mode due to plentiful surface supplies. The cost to produce the water was relatively high for an area that relies on existing local surface supplies and ground water.

To minimize the impacts of the drought, the City of Morro Bay operated a sea water desalting plant with a capacity of 400 gallons per minute. This plant is operated under an emergency-only permit (drought emergency). The city has applied to the California Coastal Commission for a permit to use the plant on an as-needed basis.

During the height of the drought, the counties of San Luis Obispo and Santa Barbara relaxed certain health restrictions on the use of gray water for residential landscape irrigation. Homeowners in San Luis Obispo County were permitted to use secondary washing machine rinse water for irrigation but were required to discharge the water underground.

In Santa Barbara, irrigation with grey water was permitted on nonedible plant materials only and homeowners were required to discharge the water through drip systems or leach lines. Regulations on the grey water use were not relaxed in other parts of the region.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Increased use of SWP water in the Southern PSA and CVP water in the Northern PSA will require additional transportation facilities. As outlined in the water supply section, many agencies are looking to these import sources for their future supplies.

Local alternatives being examined include increasing capacity in local storage reservoirs or, in some cases, authorizing new projects. Cloud seeding and desalination are showing to be effective in parts of the region. The following sections summarize water management programs under active consideration in the region.

To improve the reliability of water supplies in the Monterey Bay area, the Monterey Peninsula Water Management District has taken a number of actions including water conservation, water reclamation, and investigating several water development alternatives. Improvements to the system also are needed to provide water for municipal and industrial as well as environmental needs of the area. Current supply is inadequate during drought years when shortages develop due to lack of adequate storage facilities. The Monterey Peninsula Water Management District investigated 32 water supply alternatives before selecting five alternatives for final analysis. The preferred environmentally superior alternative is the 24,000-af New Los Padres Reservoir, with or without desalination. The New Los Padres Dam would be on the Carmel River and would completely inundate the existing dam and reservoir. The New Los Padres Reservoir could provide 22,000 af of supply in an average year to the Monterey Peninsula's water supply system.

Table CC-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	76	56	100	78	100	78	100	78
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	53	19	56	19	100	30	103	30
Other federal	65	46	65	46	65	46	65	46
SWP	0	0	53	25	53	43	53	43
Ground water(1)	688	762	678	768	682	775	686	780
Overdraft(2)	245	245	—	—	—	—	—	—
Reclaimed	15	15	67	67	78	78	78	78
Dedicated natural flow	1	0	17	6	17	6	17	6
TOTAL	1,143	1,143	1,036	1,009	1,095	1,056	1,102	1,061

(1) Average ground water use is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into the ground water basins.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Many areas within the Southern PSA use local surface water projects and ground water extractions as their primary sources of water. Surface water storage facilities include Salinas Reservoir, Twitchell Reservoir, and Lake Cachuma. Annual precipitation and spring runoff from nearby mountains determine the reliability of these vital water supplies. In some instances, emergency measures, such as those in 1990 when local and SWP water from Ventura County was wheeled to Santa Barbara, must be implemented to ensure an adequate supply of water. In 1992, Santa Barbara and San Luis Obispo counties approved extending the Coastal Branch of the SWP, which will increase their future water supply reliability. Table CC-4 shows water supplies with additional Level I water management programs.

Agencies within San Luis Obispo County have requested 4,830 af from the SWP, while requests from Santa Barbara County total 42,486 af. Availability of SWP supplies in Santa Barbara and to a lesser degree San Luis Obispo counties will lessen the severity and frequency of water supply shortages and will help alleviate ground water overdraft. The County of San Luis Obispo is also negotiating to take delivery of its full entitlement of 17,500 af of Nacimiento Reservoir water by the year 2000.

The City of San Luis Obispo has actively been pursuing the Salinas Reservoir Expansion Project to supplement its water supply. The project involves installation of spillway gates to expand the storage capacity of the existing reservoir from about 23,840 af to 41,790 af. This project will increase the reservoir storage by about 17,950 af and increase the City annual supplies by about 1,650 af. The Environmental Impact Report for the project is expected to be certified in 1994.

The City of Lompoc has voted not to take its 4,000-af entitlement of SWP water and plans to negotiate for federal water from Lake Cachuma. Currently, Lake Cachuma water goes to residents in the Santa Barbara area and to the Santa Ynez River Water Conservation District.

Other measures to augment water supplies are under consideration by various water agencies. Cloud seeding has been effective in the Monterey County mountains. Desalination, reservoir enlargement, and importing surface water are options to increase surface water supplies. The USBR completed a study of the cost effectiveness of extending the San Felipe Project of the federal CVP, which would deliver water to the Pajaro Valley. Several local government and water agencies are preparing water management plans which will address short-, medium-, and long-term schemes to reduce water use and bring in additional water.

Water recycling will play an increasing role in supplies for nonconsumptive use. The Carmel Area Wastewater District will begin construction during 1993 of a water recycling project that will serve seven golf courses and two recreational areas in the Pebble Beach area of Monterey County. Plans call for enough recycled water to meet almost 100 percent of the users' irrigation demands. The project is being developed with the Pebble Beach Community Services District.

Water recycling facilities have been built by the City of Santa Barbara and by the Goleta Water District. The City recently completed Phase II of its project, bringing the total delivery capability of the City to about 1,200 af per year. Goleta Sanitary District and Goleta Water District have recently dedicated a desalination plant with a capacity of 2,300 gallons per minute.

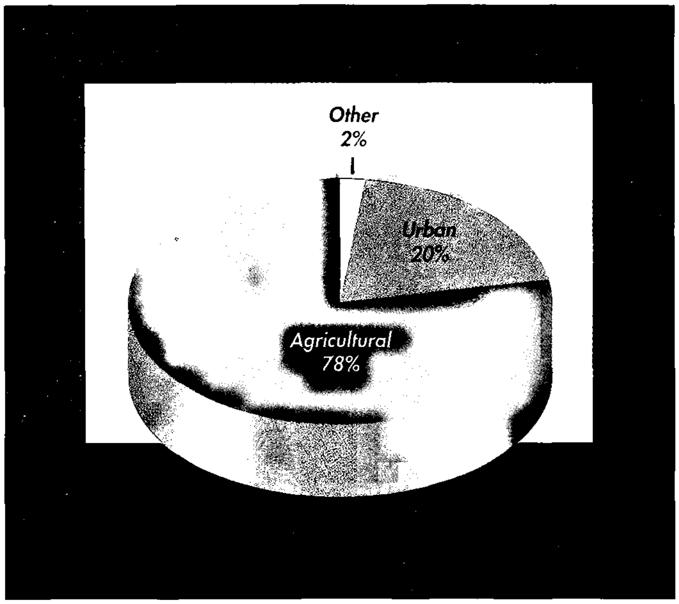
The Monterey Regional Water Pollution Control Agency was formed in the 1970s to seek solutions to the problem of water pollution, and is comprised of a dozen local entities. During the late 1970s the MRWPCA began purchasing the treatment plants and outfalls owned by its member agencies. To comply with regulations of the SWRCB and the U.S. EPA, old outfalls were replaced by a large outfall discharging two miles offshore. The installation of interceptor pipelines and pump stations to divert waste water from Pacific Grove, and the upgrade of the Monterey Treatment Plant were completed in 1981. In 1983, a series of interceptor pipelines, pump stations, and a new ocean outfall were completed.

The Monterey County Water Resources Agency is in the process of screening nine major project alternatives, each with several components, to bring the Salinas Basin into balance and reduce sea water intrusion. Some of the alternatives include enlarging the capacities of San Antonio and Nacimiento reservoirs, constructing a tunnel to transport water from Nacimiento to San Antonio, constructing dams on the Arroyo Seco River and Chalone Creek, and developing a dispersed well system and transportation system to convey water from south Monterey County to water deficient areas in north Monterey County.

Water Use

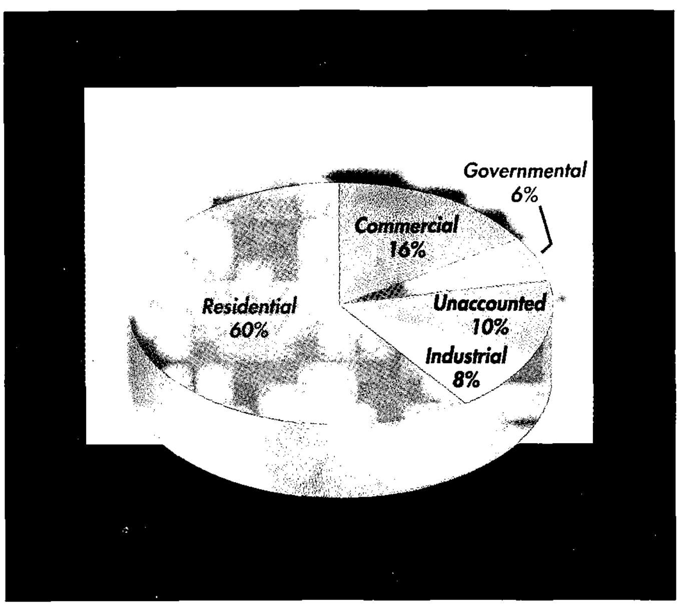
In 1990, water use in the region was divided 60 and 40 percent between the Northern and Southern PSAs, respectively. Agricultural water use accounts for 78 percent of the region's total water use, while urban water use is 20 percent of the total. The remainder of the region's water use is for energy production, environmental needs, conveyance losses, and recreation. The 1990 level net water use in the region is about 1,143,000 af. Forecasts indicate that average annual water demand will increase about 13 percent to 1,291,000 af by 2020. Figure CC-3 shows net water demand for the 1990 level of development. The 1990 level drought demand is 1,213,000 af and is projected to increase to 1,379,000 by 2020.

Figure CC-3. Central Coast Region Net Water Demand (1990 Level Average Conditions)



Urban Water Use

Figure CC-4. Central Coast Region Urban Applied Water Use by Sector (1990 Level Average Conditions)



Population in the Central Coast is expected to grow by about 56 percent by 2020 to over 2 million people. Figure CC-4 shows applied urban water demand, by sector, for the 1990 level of development. Table CC-5 shows urban water demand projections to 2020.

In the Southern PSA, average 1990 level per capita use for the San Luis Obispo and Santa Barbara

Table CC-7. 1990 Evapotranspiration of Applied Water by Crop

Irrigated Crop	*Total Acres (1,000)*	*Total ETAW (1,000 AF)*
Grain	28	5
Sugar beets	5	8
Corn	3	3
Other field	16	17
Alfalfa	27	68
Pasture	20	51
Tomatoes	14	21
Other truck	321	415
Other deciduous	20	28
Vineyard	56	61
Citrus/olives	18	27
TOTAL	528	704

About one-third of the wine grape acreage in the Salinas Valley has been converted to low-volume irrigation systems in recent years. There has also been a slight trend towards buried drip irrigation in vegetable crops in the same area. This trend is even more pronounced in San Benito County. About one-fourth of these plantings are currently using this method. In this same area the small acreage of new deciduous tree plantings are on low-volume systems. Water conservation measures implemented by growers for their irrigation operations are often related to operating-cost reductions. Drip, low-flow emitters, and sprinklers are used for many of the grape, citrus, and subtropical fruit orchards (vineyards are also retrofitted with overhead sprinklers for frost protection). Growers also use hand-moved sprinklers to meet pre-irrigation and seed germination requirements for most truck, corn, tomato, and some field crops; this is usually followed by furrow irrigation. Seedling transplants for some truck crops eliminate the need for seed germination irrigation.

Rows of lettuce stretch out to the horizon in Salinas Valley. Irrigated crop acreage in the region is forecasted to increase only slightly.

Table CC-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Northern								
Applied water demand	705	711	735	742	766	773	781	787
Net water demand	551	594	569	615	587	634	593	647
Depletion	542	583	560	604	578	623	583	636
Southern								
Applied water demand	435	467	431	464	416	447	408	446
Net water demand	342	367	341	367	333	357	328	356
Depletion	342	367	341	367	333	357	328	356
TOTAL								
Applied water demand	1,140	1,178	1,166	1,206	1,182	1,220	1,189	1,233
Net water demand	893	961	910	982	920	991	921	1,003
Depletion	884	950	901	971	911	980	911	992

Environmental Water Use

The recent drought has created problems for the fish and wildlife in the region. Along the rivers, riparian habitat has diminished. Likewise, the lack of precipitation has weakened or killed trees and native vegetation in the foothill and mountain areas, creating potential fire problems, insect infestation, and disease.

Sea gulls sun themselves on rocks along the shore of Monterey Bay. The bay is home to the California sea otter, which is now enjoying a resurgence in its population.

The Carmel River, San Luis Obispo Creek, Santa Ynez River, and other coastal streams have historically been habitats for steelhead. However, steelhead migration has been reduced by dam construction, low flows due to surface water diversions, ground water pumping, poor water quality, and habitat degradation. A number of projects have been proposed for these systems, ranging from dam enlargements on the Carmel and Santa Ynez rivers to a water reclamation project on San Luis Obispo Creek. Environmental net water demand accounts for 1,000 af. Table CC-9 shows the total environmental instream water needs for the region.

Table CC-10. Total Water Demands
(thousands of acre-feet)

Category of Use	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Urban								
Applied water demand	273	277	315	321	365	373	420	429
Net water demand	229	233	263	268	304	311	349	357
Depletion	203	206	235	239	272	278	315	321
Agricultural								
Applied water demand	1,140	1,178	1,166	1,206	1,182	1,220	1,189	1,233
Net water demand	893	961	910	982	920	991	921	1,003
Depletion	884	950	901	971	911	980	911	992
Environmental								
Applied water demand	4	2	4	2	4	2	4	2
Net water demand	1	0	1	0	1	0	1	0
Depletion	1	0	1	0	1	0	1	0
Other(1)								
Applied water demand	17	18	17	18	17	18	17	18
Net water demand	20	19	20	19	20	19	20	19
Depletion	20	19	20	19	20	19	20	19
TOTAL								
Applied water demand	1,434	1,475	1,502	1,547	1,568	1,613	1,630	1,682
Net water demand	1,143	1,213	1,194	1,269	1,245	1,321	1,291	1,379
Depletion	1,108	1,175	1,157	1,229	1,204	1,277	1,247	1,332

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Legislation and Litigation

Nacimiento Releases. Over the past several years, two lawsuits were filed seeking to control the water releases from Nacimiento Reservoir. The first one was filed by a group of homeowners and interested individuals in the Nacimiento area. Initially, the group obtained a temporary restraining order preventing water releases from the reservoir. However, the order was later released and the plaintiff's request for an injunction was denied. In addition, the court found that the Monterey County Water Resources Agency was not required to comply with CEQA in setting its yearly release schedule. The second lawsuit was settled shortly after it was filed by a recreation concessionaire at Nacimiento to maintain the recreation at the reservoir during the drought. The Monterey County Water Resources Agency agreed to retain water in the reservoir for recreation uses for the year, but the action did not set a precedent for future years.

Regional Issues

Cloud Seeding. In early 1990, the Monterey County Water Resources Agency initiated a cloud seeding program which was designed to increase rainfall and runoff for the Arroyo Seco River, as well as the San Antonio and Nacimiento reservoirs. As part of the rainfall enhancement program, aircraft seeding operations dispensed silver iodide. An experimental radio-controlled, ground-based propane dispenser was also installed in the Arroyo Seco area. Overall, the Monterey County Water Resources Agency concluded that rainfall increased from 12-16 percent for water year 1990-91, 16 to 20 percent for water year 1991-92, and preliminary results show an increase from 12 to 21 percent for water year 1992-93.

Santa Barbara County proposed a cloud seeding design for the 1992-93 winter program similar to the previous year. The proposed project design is ideally suited to conduct a state-of-the-art operation. The key components are a dedicated weather radar, a seeding aircraft, remotely controlled ground generators, a computerized GUIDE model, and an experienced weather modification meteorologist familiar with the area.

For the past two years, in San Luis Obispo County, the City of San Luis Obispo, and Zone 3 of the San Luis Obispo County Flood Control and Water Conservation District conducted a cloud seeding program.

Local Issues

Pajaro Valley Shortages. The Pajaro Valley is experiencing adverse effects from the recent drought, most notably ground water overdraft and accelerated sea water intrusion. About 70 homes in one development along the coastline have had their water supply affected by sea water intrusion. Local homeowners installed expensive water purification equipment, purchased bottled water, or trucked in water to solve the problem. The homeowners currently are negotiating with City of Watsonville officials to obtain a potable water supply. Watsonville officials proposed a pipeline from the city limits to the Sunset Beach area at a cost of $10,000 per home. The pipeline construction project will take approximately three years to complete, but will provide a potable water supply for the residents.

To better manage its water resources, the Pajaro Valley Water Management Agency, in cooperation with the USBR, is preparing a Basin Management Plan for the Pajaro Valley. To meet the future demands of the area, a combination of alternatives must be employed.

Pajaro Valley Water Augmentation. A Basin Management Plan for the Pajaro Valley was approved in December 1993 by the directors of the Pajaro Valley Water Management Agency. Key elements of the preferred alternative include a dam on College Lake to create a 10,000-af reservoir and a connection to the San Felipe branch of the CVP, and a coastal pipeline to meet the needs of agricultural users between Highway 1 and the ocean. The proposed San Felipe extension involves transporting water from the existing Santa Clara Conduit, a key feature of the San Felipe Division, which delivers water from San Luis Reservoir into Santa Clara County, with a fork into San Benito County. The pipeline, with a capacity up to 67 cfs, could provide a maximum annual volume of 19,900 af annually for municipal and industrial, as well as agricultural, water use in the Watsonville area. The supply for the San Felipe extension will probably come from reallocation of CVP supply. To date, no contract negotiations have occurred to bring water into the Watsonville area; however, PVWMA and USBR held several discussions to develop a process to address PVWMA needs under the CVPIA.

The Salinas Basin aquifers have been in a state of overdraft for many years resulting in sea water intrusion in the coastal areas. The rate of sea water intrusion has increased rapidly because of increased agricultural production, urban development, and the effects of the recent drought. Evidence of seawater intrusion has been detected in wells a few miles from the City of Salinas.

The Monterey County Water Resources Agency continues to investigate several methods to bring the Salinas Basin into balance. These methods include both water management measures and capital facilities projects.

Monterey Peninsula Problems. Improvements to the Monterey Peninsula's water supply system are needed for several reasons. Water supply in average rainfall years far exceeds demand; however, the area is vulnerable to climate variability and the impact of multi-year droughts. When dry years occur, shortages rapidly develop due to inadequate storage on the Carmel River and increased pumping and overdraft of ground water basins. Urban growth has also contributed to the need for an increased drought period water supply. Tourism, a major industry for the region, has also increased since construction of the Monterey Bay Aquarium. Without an increase in the water supply for the region, the risk of more frequent shortages in dry years will increase. The Monterey Peninsula Water Management District has taken a number of actions to address the need for a reliable water supply. The district has already implemented several programs, including an urban water conservation program.

Water Balance

Water budgets were computed for each Planning Subarea in the Central Coast Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas, which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some local areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table CC-11 presents water demands for the 1990 level and for future water demands to 2020 and balances them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options.

Regional net water demands for the 1990 level of development totaled 1,143,000 and 1,213,000 af for average and drought years, respectively. Those demands are forecasted to increase to 1,291,000 and 1,379,000 af, respectively, by the year 2020, after accounting for a 30,000-af reduction in urban water demand resulting from additional long-term water conservation measures.

Urban net water demand is forecasted to increase by about 52 percent by 2020, due to projected increases in population. Agricultural net water demand is forecasted to increase by about 3 percent, primarily due to an expected increase in double cropping in the region. Environmental net water demands, under existing rules and regulations, will remain essentially level; however, there are several Central Coast Region streams where increases in instream flow for fisheries have been proposed.

Average annual supplies, including 245,000 af of ground water overdraft, were generally adequate to meet average net water demands in 1990 for this region. However, during drought, present supplies are insufficient to meet present demands and, without additional water management programs, annual average and drought year shortages by 2020 are expected to increase to about 345,000 and 450,000 af, respectively.

Table CC-11. Water Budget
(thousands of acre-feet)

Water Demand/Supply	*1990* average	*1990* drought	*2000* average	*2000* drought	*2010* average	*2010* drought	*2020* average	*2020* drought
Net Demand								
Urban—with 1990 level of conservation	229	233	276	281	327	334	379	387
—reductions due to long-term conservation measures (Level I)	—	—	–13	–13	–23	–23	–30	–30
Agricultural—with 1990 level of conservation	893	961	910	982	920	991	921	1,003
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Environmental	1	0	1	0	1	0	1	0
Other[1]	20	19	20	19	20	19	20	19
TOTAL Net Demand	1,143	1,213	1,194	1,269	1,245	1,321	1,291	1,379
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	209	136	220	144	244	148	247	148
Ground Water	688	762	694	769	695	776	698	781
Ground Water Overdraft[3]	245	245	—	—	—	—	—	—
Subtotal	1,142	1,143	914	913	939	924	945	929
Dedicated Natural Flow	1	0	1	0	1	0	1	0
TOTAL Water Supplies	1,143	1,143	915	913	940	924	946	929
Demand/Supply Balance	0	–70	–279	–356	–305	–397	–345	–450
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed	—	—	44	44	55	55	55	55
Local	—	—	24	22	24	22	24	22
Central Valley Project/ Other Federal	—	—	0	0	20	7	20	7
State Water Project	—	—	53	25	53	43	53	43
***Subtotal* - Level I Water Management Programs**	0	0	121	91	152	127	152	127
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	–19	–4	–16	–4	–15	–4
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	–70	–177	–269	–169	–274	–208	–327

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

With planned Level I water management programs, average and drought year shortages could be reduced to 208,000 and 327,000 af, respectively. The remaining shortage requires both additional short-term drought management, water transfers, and demand management programs, and future long-term Level II water management programs, depending on the overall level of water service reliability deemed necessary by local agencies, to sustain the economic health of the region. This region depends on export from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on D-1485 operating criteria for Delta supplies and do not take into account recent actions to protect aquatic species in the estuary. As such, regional water supply shortages are understated.

Los Angeles is California's most populated urban area. Urban land use accounts for 25 percent of the total land area in the South Coast Region.

South Coast Region

The most urbanized region in California is the South Coast. 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, the Mexican border on the south, and a combination of the San Jacinto Mountains and low-elevation mountain ranges in central San Diego County on the east. 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. (See Appendix C for maps of the planning subareas and land ownership in the region.)

The climate of the region is Mediterranean-like, with warm and dry summers followed by mild and wet 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 of December through March. Average annual rainfall quantities can range from 10 to 15 inches on the coastal plains and 20 to 45 inches in the mountains. Precipitation in the higher mountains commonly occurs as snow. In most years, snowfall quantities are sufficient to support a wide range of 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 1,200,000 af annually.

Population

Growth has been fairly steady since the first boom of the 1880s. The1990 population was up 26 percent from 12,970,000 in 1980. Much of the population

Region Characteristics

Average Annual Precipitation: *18.5 inches* ***Average Annual Runoff:*** *1,227,000 af*

Land Area: *10,950 square miles* ***1990 Population:*** *16,292,800*

increase is due to immigration, both from within the United States and from around the world. Most of the region's coastal plains and valleys are densely populated. The largest cities are Los Angeles, San Diego, Long Beach, Santa Ana, and Anaheim. Each of these is among California's top ten most populated cities; Los Angeles and San Diego also are the second and sixth largest cities in the United States, respectively. The region is also home to six of the State's ten fastest growing cities in the 50,000 to 200,000 population range. These are Corona, Fontana, Tustin, Laguna Niguel, National City, and Rancho Cucamonga. Areas undergoing increased urbanization include the coastal plains of Orange and Ventura counties, the Santa Clarita Valley in northwestern Los Angeles County, the Pomona/San Bernardino/Moreno valleys, and the valleys north and east of the City of San Diego. The region's population is expected to increase by 55 percent by 2020. Table SC-1 shows regional population projections to 2020.

Table SC-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Santa Clara	834	1,063	1,301	1,556
Metropolitan Los Angeles	8,501	9,445	10,376	11,505
Santa Ana	4,023	5,155	6,230	7,384
San Diego*	2,935	3,610	4,191	4,870
TOTAL	16,293	19,273	22,098	25,315

* The San Diego PSA includes parts of Riverside and Orange counties.

Land Use

Despite being so urbanized, about one-third of the region's land is publicly owned. Approximately 2,300,000 acres is public land, of which 75 percent is national forest. Urban land use accounts for about 1,700,000 acres, and irrigated cropland accounts for 288,000 acres. Figure SC-1 shows land use in the South Coast Region.

The major industries in the region are national defense, aerospace, recreation and tourism, and agriculture. Other large industries include electronics, motion picture and television production, oil refining, housing construction, government, food and beverage distribution, and manufacturing (clothing and furniture). While defense, aerospace, and oil refining are currently in a decline, the South Coast Region has a strong and growing commercial services sector. International trading, financing, and basic services are major economic contributors to the region.

One of the most important land use issues in the South Coast Region is whether to prohibit housing and other urban land uses from spreading into the remaining agricultural land and open space. Some of the region's agricultural land is currently protected through the State's Williamson Act. Some local governments have established agricultural preserves in their areas. The desire to retain open space in the Los Angeles area also has led to parkland status for parts of the Santa Monica Mountains. Preservation of coastal wetlands and lagoons in the region is another prime concern. A 1993 agreement between federal, State, and local agencies to protect endangered gnatcatcher habitat is a good example of protection of open space to benefit wildlife.

Table SC-2. Major Reservoirs

Reservoir Name	*River*	*Capacity (1,000 AF)*	*Owner*
Casitas	Coyote Creek	254	USBR
Lake Piru	Piru Creek	88.3	United WCD
Pyramid	Piru Creek	171.2	DWR
Matilija	Matilija Creek	1.5	Ventura CO FCD
Castaic	Castaic Creek	323.7	DWR
Cogswell	San Gabriel	8.9	Los Angeles CO FCD/Dept. of Public Works
San Gabriel	San Gabriel	42.4	Los Angeles CO FCD/Dept. of Public Works
Big Bear Lake (Bear Valley)	Bear Creek	73.4	Big Bear MWD
Perris	Bernasconi Pass	131.5	DWR
Mathews	Trib Cajalco Creek	179.3	MWDSC
Lake Hemet	San Jacinto River	13.5	Lake Hemet MWD
Railroad Canyon	San Jacinto River	11.9	Temescal Water Co.
Irvine Lake (Santiago Creek)	Santiago Creek	25.0	Serrano ID/Irvine Ranch WD
Skinner	Tucalota Creek	44.2	MWDSC
Vail	Temecula Creek	50.0	Rancho California WD
Henshaw	San Luis Rey River	53.4	Vista ID
Lake Hodges	San Dieguito River	37.7	City of San Diego
Sutherland	Santa Ysabel Creek	29.0	City of San Diego
San Vicente	San Vicente Creek	90.2	City of San Diego
El Capitan	San Diego River	112.8	City of San Diego
Cuyamaca	Boulder Creek	11.8	Helix WD
Lake Jennings	Quail Canyon Creek	9.8	Helix WD
Murray	Chaparral Canyon	6.1	City of San Diego
Lake Loveland	Sweetwater River	25.4	Sweetwater Authority
Sweetwater	Sweetwater River	28.1	Sweetwater Authority
Lower Otay	Otay River	49.5	City of San Diego
Morena	Cottonwood Creek	50.2	City of San Diego
Barrett	Cottonwood Creek	37.9	City of San Diego
Miramar	Big Surr Creek	7.3	City of San Diego
Seven Oaks	Santa Ana	146	COE under construction
Prado	Santa Ana	183.2	COE 1941

There are numerous ground water basins along the coast and inland valleys of the region. Many of these basins are adjudicated or managed by a public agency (see Volume I, Chapters 2 and 4). Recharge occurs from natural infiltration along river valleys, but in many cases, basin recharge facilities are in place using local, imported, or reclaimed supplies. Some ground water basins are as large as several hundred square miles in area and have a capacity exceeding 10,000,000 af. The current estimated annual net ground water use approaches 1,100,000 af.

Basins close to the coast often have troubles with sea water intrusion. Historically, additional recharge or a series of injection wells forming a barrier have been used to mitigate this problem. Other ground water quality concerns are high TDS, nitrates, PCE, sulfates, pesticide contamination (DBCP), selenium, and leaking fuel storage tanks.

Approximately 82,000 af of new water was produced by recycled water in 1990, about 2 percent of the region's supply. Recycled water is most often used for irrigating freeway and other urban landscaping, golf courses, and some agricultural land; it is also used in ground water recharge and sea water barrier projects. The Central and West Basin Water Replenishment Districts recharge the Central and West Coast ground water basins with 50,000 af per year of recycled water. The Orange County Water District injects about 5,000 af of recycled water into the ground at the Alamitos Barrier Project. This process prevents further sea water intrusion into the district's ground water supply and frees imported supplies for other uses.

Drought Water Management Strategies. To minimize the impacts caused by the shortfalls in imported surface water supplies, most agencies in the region established and implemented rationing programs during the 1987-92 drought to bring demand in line with supplies. Customer rationing allotments were determined by the customer's use prior to the drought. Rationing levels, or reductions, ranged from 15 to 50 percent.

Programs implemented by the cities of San Diego and Los Angeles are typical of the efforts agencies throughout the region made to combat recent drought-induced shortages. The City of San Diego implemented a 20-percent rationing program for its customers during 1991; a 10-percent program had been in place since 1988. Other programs and activities by San Diego included establishing customer rebates for the installation of ultra-low-flush toilets, distributing free showerheads, providing turf and home audit service, expanding the existing public information program (with a 24-hour hotline), establishing a field crew to handle waste-of-water complaints, constructing a xeriscape demonstration garden, and retrofitting city water facilities. Landscape designs for new private and public construction are regulated for water conservation by a 1986 city ordinance. San Diego also has ordinances that permit enacting water conservation measures and programs during critical water supply situations and that require all residential dwellings to be retrofitted prior to resale.

The City of Los Angeles has had a rationing program in place since 1986. The program was mandatory for all its customers until early in 1992, when it was revised to voluntary status. The program originally called for a 10-percent reduction; however, it was amended to 15 percent during 1992 when the State's water supply situation worsened. Programs established by Los Angeles are similar to those described for San Diego. Los Angeles also established a "drought buster" field program with staff patrolling neighborhoods looking for water wasters. Table SC-3 shows the region's water supplies with existing facilities and programs.

Water Management Options with Existing Facilities. MWDSC is pursuing additional supplies to replace those it has lost under recent court rulings. Water use in its service area has increased from 2,800,000 af in 1970 to 4,000,000 af in 1990. The increase reflects a large population growth. Moreover, the City of Los Angeles is increasing its reliance upon MWDSC's water to make up for its loss of imported water from the Mono-Owens Basin. Following are highlights of major MWDSC water supply and demand management programs, most of which are in place, that would provide options for additional supplies, especially in critical years.

The Imperial Irrigation District-MWDSC Water Conservation program began in January 1990. In return for financing certain conservation projects, MWDSC is entitled to the amount of water saved by IID except under limited conditions specified in the agreement. Conservation projects include lining existing canals, constructing local reservoirs and spill interceptor canals, installing nonleak gates and automation equipment, and instituting distribution system and on-farm management activities.

Table SC-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Surface								
Local	254	118	254	118	254	118	254	118
Local imports(1)	425	208	425	208	425	208	425	208
Colorado River(2)	1,266	1,230	656	656	656	656	656	656
CVP	0	0	0	0	0	0	0	0
Other federal	22	21	22	21	22	21	22	21
SWP(1)	1,225	1,032	1,744	1,085	1,899	1,152	1,901	1,156
Ground water(3)	1,083	1,306	1,100	1,325	1,125	1,350	1,150	1,375
Overdraft(4)	22	22	—	—	—	—	—	—
Reclaimed	82	82	82	82	82	82	82	82
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	4,379	4,019	4,283	3,495	4,463	3,587	4,490	3,616

(1) 1990 supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins. SWP supply was used in 1990 to replace reduction of supplies from Mono and Owens basins, putting additional demand on Delta supplies. SWP supplies may be higher in any year to help recharge ground water basins for drought years.
(2) Colorado River supplies for the year 2000 and beyond reflect elimination of surplus and unused Colorado River supplies and the availability of 106,000 AF from the Colorado River region as a result of currently agreed upon conservation programs being implemented by Imperial Irrigation District. Miscellaneous perfected rights and future court decision on Indian water rights could impact Colorado River supplies to the South Coast Region.
(3) Average ground water is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into ground water basins. However, the ground water includes ground water reclamation.
(4) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

MWDSC has an advance delivery agreement with Desert Water Agency and Coachella Valley Water District for ground water storage. Under this agreement MWDSC makes advance deliveries of Colorado River water (conditions permitting) to the two agencies for recharging the Coachella Valley ground water basin. MWDSC, in turn, may use the SWP entitlements of the two agencies (up to 61,200 af per year). Water stored in the basin was used by the two agencies during the recent drought, enabling MWDSC to make full use of available DWA and CVWD entitlements.

Under the Chino Basin and San Gabriel Basin Cyclic Storage Agreement, imported water is delivered to and stored in the Chino and San Gabriel basins. When water supplies are abundant, advance deliveries of MWDSC's ground water replenishment supplies are provided for later use. When imported supplies are limited, MWDSC has the option of meeting the replenishment demands through surface deliveries or a transfer of the stored water. MWDSC's maximum storage entitlements are 100,000 af in the Chino Basin and 142,000 af in the San Gabriel Basin. As of July 1990, 28,000 af was stored in the Chino Basin and 58,000 af in the San Gabriel Basin. MWDSC is also planning for additional conjunctive use programs.

MWDSC promotes water reclamation through its Local Projects Program of 1981. Under this program, the district provides financial assistance for local water reclamation projects which develop new water supplies. The program's primary focus is on increasing the use of recycled water in landscape irrigation and industry, thereby reducing the demand for potable water supplies. To date, MWDSC is participating in 32 projects, with a total ultimate yield of 147,000 af per year. Currently, four additional projects submitted to MWDSC for inclusion in the program are in various stages of review. These proposed projects have a combined estimated ultimate yield of 21,700 af per year.

MWDSC promotes conjunctive use at the local agency level under its Seasonal Storage Service Program of 1989 by discounting rates for imported water placed into ground water or reservoir storage. The discounted rate and program rules encourage construction of additional ground water production facilities allowing local agencies to be more self-sufficient during shortages. Additionally, the program is designed to reduce the member agencies' dependence upon district deliveries during the peak summer demand months. As of December 31, 1992, approximately 1,240,000 af of water was delivered as Seasonal Storage Service.

The West Basin Municipal Water District began reclaiming 1.5 mgd (1,680 af annually) of brackish ground water with a new desalination plant in the City of Torrance in 1993. This facility will help contain a seawater plume that has moved inland since the construction of the West Coast seawater injection barrier in the late 1950s.

Other water management options include water banking, short-term fallowing of farm land, desalination, reclaiming waste water (water recycling) and brackish ground water, water conservation, and additional offstream storage facilities for imported supplies.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

With planned Level I programs, 2020 average and drought year shortages could be reduced to 373,000 and 848,000 af, respectively, under Decision 1485 operating criteria for Delta supplies. A shortage of this magnitude could have severe economic impacts on the region. This remaining shortage requires both additional short-term drought management, water transfers, and demand management programs, and future long-term and Level II programs depending on the overall level of water service reliability deemed necessary, by local agencies, to sustain the economic health of the region. In the short-term, some areas of this region that rely on Delta exports for all or a portion of their supplies face greater uncertainty in terms of water supply reliability due to the uncertain outcome of actions undertaken to protect aquatic species in the Delta. Local water districts are seeking to improve water service reliability of their service area through water transfers, water recycling, conservation, and supply augmentation. The following paragraphs summarize the various water management programs under active consideration in the South Coast Region.

Water Management Options with Additional Facilities. The U.S. Bureau of Reclamation is studying the potential for recycled water use under its "Southern California Comprehensive Water Reclamation Study." The goal of the $6 million, three-phase study is to "identify opportunities and constraints for maximizing water reuse in Southern California." Phase I is expected to be complete in one year; the scheduling of phases II and III will be determined during the first phase. Expected completion date is March 1999. The USBR believes the success of the study depends on the active participation of local and State agencies.

MWDSC authorized preliminary studies for a 5-mgd (5,600-af-per-year) desalination pilot plant (distillation method). Although the location is undecided, plans call for the plant to be near an existing power plant on the coast. Planned ultimate capacity of the plant is 100 mgd (112,000 af per year).

The Colorado River Banking Plan is a proposal that would create an additional water supply for MWDSC by making use of available SWP water in place of Colorado River water. Under the plan, MWDSC would adjust its Colorado River diversions according to the availability of water from the SWP. In years when SWP supplies are adequate, MWDSC would take more of its SWP water and correspondingly less Colorado River water. The difference between available Colorado River water and MWDSC's actual diversions would remain in Lake Mead and be credited to a water management account. Any additional water lost by spills or evaporation due to the storage of such water would be deducted from the water management account.

MWDSC, the Southern Nevada Water Authority, and the Central Arizona Water Conservation District have implemented a program to demonstrate the feasibility of interstate underground storage of Colorado River water. From 1992 to 1993, 100,000 af of Colorado River water, unused by Arizona, California, and Nevada, was diverted through the Central Arizona Project to water users in Central Arizona who reduced ground water pumping and used Colorado River water instead, thereby increasing water in ground water storage. In the future, following a flood-control release from Lake Mead or a determination that surplus Colorado River water is available, MWDSC and SNWA will be able to divert a portion of Arizona's Colorado River water while Arizona water users use the previously stored water. This arrangement protects Central Arizona water users from shortages and creates an additional water supply for MWDSC and SNWA. MWDSC and SNWA have expressed interest in storing additional Colorado River water underground in Central Arizona.

A scene of typical new housing starts in the South Coast Region, in this case in the City of Irvine. The region's population is projected to increase substantially by 2020, creating an even larger demand for not only housing, but water supplies as well.

A draft Environmental Impact Report/Statement for a water storage and exchange program between MWDSC and Arvin-Edison was issued in 1992. The program would allow MWDSC to store up to 800,000 af of water in Arvin-Edison's ground water basin. This stored water would be recovered in dry years when Arvin-Edison would pump MWDSC's stored water in exchange for MWDSC receiving a portion of Arvin-Edison's Central Valley Project water via the California Aqueduct. Arvin-Edison would benefit from the program by higher ground water levels and an improved distribution system, to be funded by MWDSC, while MWDSC would have water in storage. The final EIR/EIS for the program has been delayed pending resolution of environmental and institutional issues in the Sacramento-San Joaquin Delta.

The Semitropic/Metropolitan Water Storage and Exchange Program would involve ground water storage and recovery operation. Under the program, MWDSC would store water in the ground water basin underlying the Semitropic Water Storage District when Metropolitan's water supplies are in excess of its demand. During shortage years, Semitropic would pump MWDSC's stored water from the ground water basin into the California Aqueduct through facilities owned and operated by Semitropic. A minimum pumpback of 40,000 to 60,000 af per year would be guaranteed. In addition, Semitropic could exchange a portion of its SWP entitlement water for MWDSC's stored water, thereby substantially increasing the annual yield of this program. An initial agreement to store water in 1993 was executed and approximately 45,000 af of MWDSC's 1992 SWP carryover entitlement water was stored.

In October 1991, MWDSC certified the final EIR for the Eastside Reservoir Project (Domenigoni Valley Reservoir). Final design and land acquisition activities for the reservoir are proceeding. The ERP, combined with the ground water storage program, will: (1) maximize ground water storage by regulating imported water supplies for conjunctive use programs, (2) provide emergency water reserves if facilities are damaged as a result of a major earthquake, (3) provide supplies to reduce water shortages during droughts, (4) meet seasonal operating requirements, including seasonal peak demands, and (5) preserve operating reliability of the distribution system. This conjunctive use program should eventually provide two years of drought or carryover storage protection for MWDSC (528,000 af). The project should be completed by 1999.

Under the Ground Water Recovery Program of 1991, MWDSC will improve regional water supply reliability by providing financial assistance for local agencies to recover contaminated ground water. The goal of the Ground Water Recovery Program is to recover 200,000 af per year of degraded ground water. About half of this ultimate annual production will be untapped local yield. The remainder will require replenishment from MWDSC's imported water to avoid basin overdraft. Those projects will produce water, including during droughts, but will only receive replenishment water when imported supplies are available. Currently, MWDSC has approved participation of eight projects, with an estimated ultimate production of 21,800 af per year. The program is expected to reach its goal of 200,000 af per year by the year 2004. The net projected yield associated with natural replenishment from the Ground Water Recovery Program through the year 2020 is:

Year	Net Projected Yield Acre-Feet Per Year
1993	1,554
2000	86,100
2010	95,540
2020	95,540

Local surface water supplies provide a small contribution to the South Coast Region, making up only about 6 percent of the region's total supplies. For the most part, during drought years, these surface supplies dry up. However, during the winter, this region can be hit with devastating floods. Many people speculate that more local surface reservoirs could help alleviate the region's need for increased imported supplies. However, the cost of developing local surface water supply projects for rare or limited runoff makes them impractical at present. Table SC-4 shows water supplies with additional Level I facilities and programs.

San Diego County Water Authority has developed a Water Resources Plan that evaluates current and future demands, and available local and imported supplies. A specified plan of resource development was adopted that satisfies the SDCWA's reliability goal of meeting all demand during average years, and no less than 88 percent of demand during a drought year. The recommended resource mix includes imported supplies, additional local supply development, and full implementation of Best Management Practices. Local supply development includes water recycling, ground water, and desalination. Carryover storage and transfers were identified to help meet the dry-year supply reliability goal. The plan examines both average water year supplies and drought year supplies and recommends a practical implementation schedule for resource development.

Table SC-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	254	118	254	118	254	118	254	118
Local imports(1)	425	208	425	208	425	472	425	472
Colorado River(2)	1,266	1,230	724	724	724	724	724	724
CVP	0	0	0	0	0	0	0	0
Other federal	22	21	22	21	22	21	22	21
SWP(1)	1,225	1,032	1,770	1,067	2,142	1,832	2,235	1,832
Ground water(3)	1,083	1,306	1,159	1,384	1,195	1,419	1,219	1,444
Overdraft(4)	22	22	—	—	—	—	—	—
Reclaimed	82	82	481	481	580	580	679	679
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	4,379	4,019	4,835	4,003	5,342	5,166	5,558	5,290

(1) 1990 supplies are normalized and do not reflect additional supplies delivered to offset the reduction of supplies from the Mono and Owens basins. SWP supply was used in 1990 to replace reduction of supplies from Mono and Owens basins, putting additional demand on Delta supplies. SWP supplies may be higher in any year to help recharge ground water basins for drought years.
(2) Colorado River supplies for the year 2000 and beyond reflect elimination of surplus and unused Colorado River supplies, the availability of 106,000 AF from the Colorado River region as a result of currently agreed upon conservation programs being implemented by Imperial Irrigation District, and the availability of 68,000 AF from the Colorado River region as a result of an IID/MWDSC agreement negotiated but not yet executed relating to the lining of a portion of the All American Canal. Miscellaneous perfected rights and future court decision on Indian water rights could impact Colorado River supplies to the South Coast Region.
(3) Average ground water is prime supply of ground water basins and does not include use of ground water which is artificially recharged from surface sources into ground water basins. Ground water includes supply from ground water reclamation. For example, the MWDSC ground water recovery program could provide additional supplies of 85,000 AF by year 2000 and 95,000 AF by 2010 and beyond.
(4) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Water Use

Urban water demands for the South Coast Region have progressively increased over the last decade due to tremendous population growth rates and rapidly expanding urbanized areas. In many areas, urban expansion has led to reductions in agricultural acreage and water use. Figure SC-3 shows the distribution of 1990 level net water demands for the region.

Urban Water Use

Total municipal and industrial applied water use in 1990 was about 3,851,000 af (Table SC-5), an increase of 1,071,000 af from 1980. The increase is attributed to population and economic growth. Table SC-5 shows that 1990 applied urban water use in the Metropolitan Los Angeles planning subarea is about half of the region's total. Forecasts indicate that urban applied water use in the region will increase by 56 percent between 1990 and 2020.

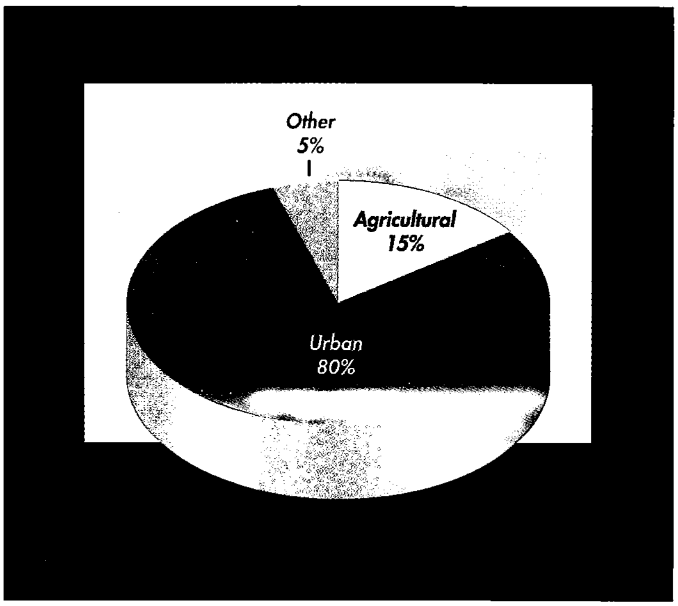


Figure SC-3. South Coast Region Net Water Demand (1990 Level Average Conditions)

Although overall demands have increased since 1980, per capita water use has leveled off somewhat in older urbanized areas. There are modest increases in the newer urbanized areas, particularly in the warmer interior sections of the region. Since there is little space for expansion, the older urban core areas are being renovated and converted from one type of use to another, such as single-family residential to multi-family residential. Such conversions tend to decrease household water use because of associated reductions in exterior water use with multi-family housing structures.

Average 1990 per capita water use by PSA for the region is 211 gpcd. This daily per capita value ranges from 246 gallons for the Santa Ana PSA to 204 gallons in the Metropolitan Los Angeles PSA. With continued water conservation, the region's average per capita water use is expected to increase slightly to 212 gpcd by 2020, primarily due to growth in inland areas of the region. Figure SC-4 shows 1990 level applied urban water demand by sector.

Table SC-6. Irrigated Crop Acreage
(thousands of acres)

Planning Subarea	1990	2000	2010	2020
Santa Clara	118	110	94	71
Metropolitan Los Angeles	7	6	5	5
Santa Ana	83	66	48	30
San Diego*	111	105	88	78
TOTAL	319	287	235	184

* The San Diego PSA includes portions of Riverside and Orange counties.

The five major crops produced in the region are subtropical fruit, truck (vegetables and nursery products), improved pasture, grains, and alfalfa (Table SC-7). Slightly more than half of the total cropped acres and gross applied water in the region is associated with citrus and subtropical fruit orchards. Citrus (mostly oranges, lemons, and grapefruit) is found in all parts of the South Coast Region, but the largest amounts are in the San Diego and Santa Clara PSAs. Avocados are generally grown in the hills above the Santa Clara River in Ventura County and in the hills in the extreme southwestern part of Riverside County (Santa Ana PSA) and San Diego County. The region also has a substantial cut-flower industry. Truck crops follow citrus and subtropical fruit in terms of planted and harvested acres and use of applied water. Small acreages of irrigated grain are cultivated in southern San Diego County, southwestern San Bernardino County, and southwestern Riverside County. Irrigated pasture and alfalfa are grown primarily in southwestern San Bernardino County.

Table SC-7. 1990 Evapotranspiration of Applied Water by Crop

Irrigated Crop	Total Acres (1,000)	Total ETAW (1,000 AF)
Grain	11	2
Corn	5	7
Other field	4	8
Alfalfa	10	26
Pasture	20	55
Tomatoes	9	20
Other truck	87	123
Other deciduous	3	8
Vineyard	6	9
Citrus/olives	164	282
TOTAL	319	540

Vineyards in Pomona Valley are on the decline; however, modest acreages in southwestern Riverside County have remained stable since 1980. Deciduous tree crops are relatively small, but there is a concentration of apples and pears in central San Diego County.

Unharvested avocados hang in trees in Fallbrook, an agricultural community near San Diego. Agricultural land use is declining in the region.

Even though the region's forecasted acres are expected to decline, subtropical fruits, vegetables and flowers, truck crops, and nursery products will continue to produce significant revenues on the remaining acres.

Water conservation efforts by the growers will contribute to the reduction of agricultural water demands in the region. Most citrus and subtropical growers use the latest irrigation system technologies of drip emitters and low-flow sprinklers. Growers are also managing their irrigation operations with more efficiency. The best potential for conservation beyond current achievements will be in the citrus and subtropical orchard irrigation operations. Much of the potential for savings will occur by the end of the decade, possibly up to an additional 5 percent. Increased use of drip irrigation, improved furrow irrigation, plastic mulches, and irrigation scheduling services will save water in the other crop categories too.

Table SC-8 shows 1990 level and forecasted agricultural water demand in the region. Drought year demands reflect the need for additional irrigation to replace water normally supplied by rainfall and to meet higher-than-normal evapotranspiration demands. The region's total applied agricultural water use is expected to decrease 47 percent by 2020. Urbanization of irrigated agricultural land is the main factor in this reduction. Other factors include continued improvements in on-farm irrigation operations and irrigation system technologies. Decreases range from about 66 percent to 34 percent among the PSAs.

Table SC-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Santa Clara								
Applied water demand	245	256	222	233	184	193	138	145
Net water demand	214	224	197	207	167	175	126	133
Depletion	214	224	197	207	167	175	126	133
Metropolitan Los Angeles								
Applied water demand	15	16	11	12	10	11	9	9
Net water demand	13	14	10	11	9	9	8	8
Depletion	13	14	10	11	9	9	8	8
Santa Ana								
Applied water demand	227	232	179	181	127	129	77	78
Net water demand	186	190	149	152	109	110	68	69
Depletion	186	190	149	152	109	110	68	69
San Diego								
Applied water demand	240	249	220	229	178	185	158	164
Net water demand	231	240	213	222	173	180	154	160
Depletion	231	240	213	222	173	180	154	160
TOTAL								
Applied water demand	727	753	632	655	499	518	382	396
Net water demand	644	668	569	592	458	474	356	370
Depletion	644	668	569	592	458	474	356	370

Environmental Water Use

Currently, the State's San Jacinto Wildlife Area occupies approximately 5,000 acres, and there are applications to increase the size of the facility by 1,600 acres. The SJWA is run by the Department of Fish and Game. It is unique in that it is the first such operation in the State to use recycled water. Eastern Municipal Water District supplies the facility with recycled water from its Hemet/San Jacinto Water Reclamation Plant. Recycled water allocations to the SJWA are 2,200 af a year, even though only 400 af and 800 af were used in 1990 and 1991, respectively. By the year 2000, the allocation will be 4,500 af. Table SC-9 shows wetland water needs to 2020.

Additional environmental water supply requirements may be needed for the Sespe Wilderness. This preserve is in the Ventura County portion of the Los Padres National Forest and totals approximately 219,700 acres. A portion of Sespe Creek has been added to the federal list of Wild and Scenic Rivers.

Table SC-9. Wetland Water Needs
(thousands of acre-feet)

Wetland	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
San Jacinto WA								
Applied water demand	2	2	6	6	6	6	6	6
Net water demand	2	2	6	6	6	6	6	6
Depletion	2	2	6	6	6	6	6	6
TOTAL								
Applied water demand	2	2	6	6	6	6	6	6
Net water demand	2	2	6	6	6	6	6	6
Depletion	2	2	6	6	6	6	6	6

Other Water Demand

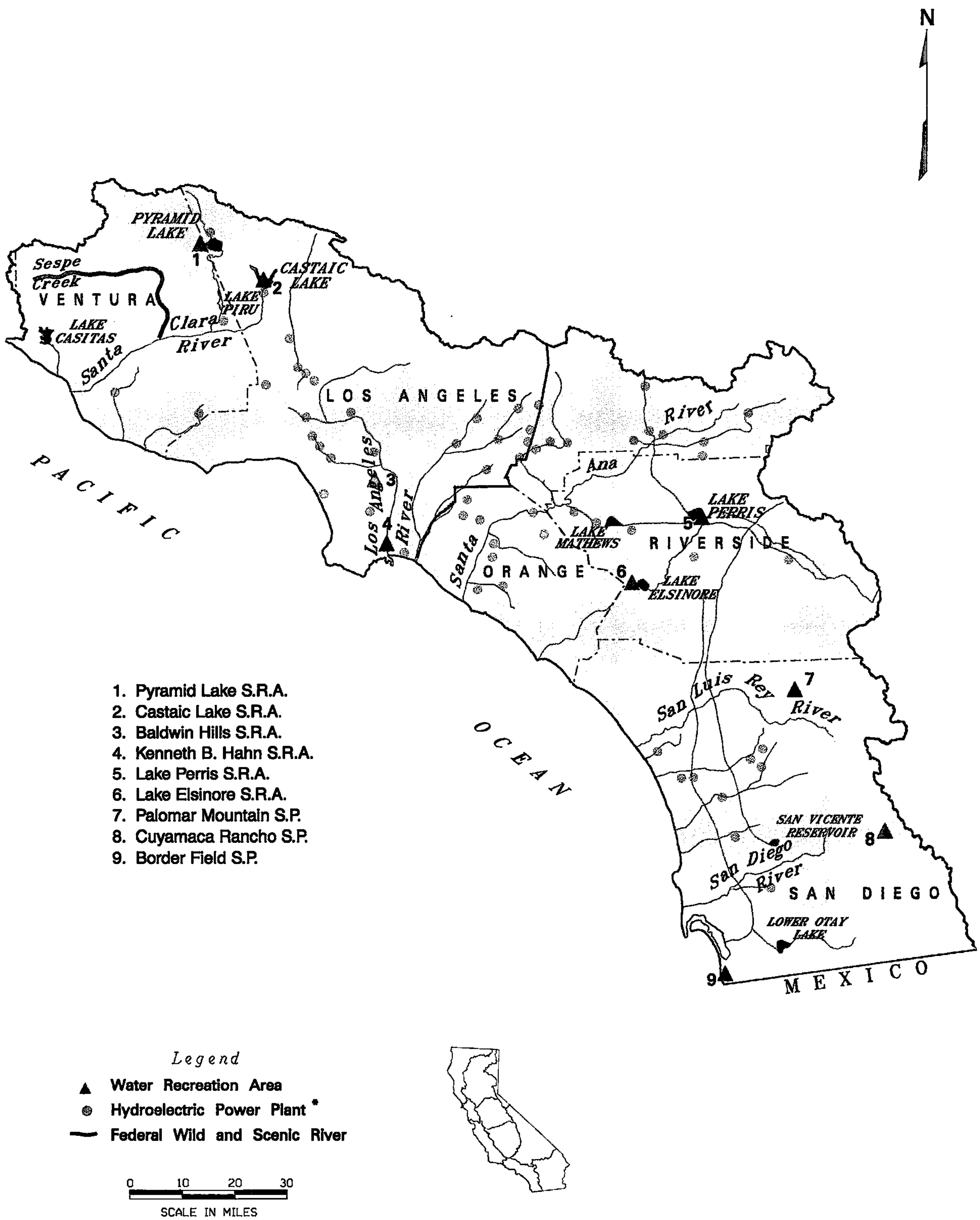
Recreational water use in the South Coast Region amounted to almost 23,000 af in 1990. Most recreational facilities in the region consist of campgrounds and parks, and their use entails water for lawns, toilets, showers, and facility maintenance and public service. Use in the Santa Clara, Metropolitan Los Angeles, Santa Ana, and San Diego PSAs in 1990 amounted to about 8,000 af; 8,000 af; 3,000 af; and 3,000 af, respectively. Figure SC-6 shows water recreation areas in the South Coast Region.

Conveyance losses account for 160,000 af and are realized in the transmission of water via the three major aqueducts in the region. Cooling water for power plants amounts to 35,000 af, while approximately 5,000 af is used to inject water in deep wells to extract oil. Table SC-10 shows total water demand forecasts to 2020 for the South Coast Region.

Issues Affecting Local Water Resource Management

Each PSA in the region has its own set of geographic and demographic conditions which present several water management issues. In general, though, the South Coast Region faces several critical water supply issues, most notably increasing demand with limited ability to increase supply, and ground water degradation. The most significant events in recent years regarding regional water supplies were the court decisions regarding Mono Lake and Colorado River diversions.

Figure SC-6. South Coast Region
Hydroelectric Power Plants, Wild and Scenic Rivers, and Water Recreation Areas



*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

Table SC-10. Total Water Demands
(thousands of acre-feet)

Category of Use	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Urban								
Applied water demand	3,851	3,997	4,446	4,617	5,180	5,381	6,008	6,244
Net water demand	3,511	3,641	4,010	4,161	4,623	4,799	5,309	5,514
Depletion	3,341	3,463	3,536	3,677	3,993	4,158	4,596	4,785
Agricultural								
Applied water demand	727	753	632	655	499	518	382	396
Net water demand	644	668	569	592	458	474	356	370
Depletion	644	668	569	592	458	474	356	370
Environmental								
Applied water demand	2	2	6	6	6	6	6	6
Net water demand	2	2	6	6	6	6	6	6
Depletion	2	2	6	6	6	6	6	6
Other(1)								
Applied water demand	62	57	67	62	72	67	72	67
Net water demand	222	210	227	215	232	220	232	220
Depletion	222	210	227	215	232	220	232	220
TOTAL								
Applied water demand	4,642	4,809	5,151	5,340	5,757	5,972	6,468	6,713
Net water demand	4,379	4,521	4,812	4,974	5,319	5,499	5,903	6,110
Depletion	4,209	4,343	4,338	4,490	4,689	4,858	5,190	5,381

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Legislation and Litigation

Legislation and litigation played a very important part in developing water supplies for the South Coast Region. Most court decisions and legislation that affect the region are those which also affect statewide water resources. A complete discussion of these decisions and laws are in Volume I, Chapter 2.

MWDSC is the largest water purveyor in the region; it has 27 member agencies, some of whom rely solely on MWDSC for their water supply. Many other agencies, like the City of Los Angeles, rely on MWDSC to supplement their existing water supplies. MWDSC lost a large part of an extremely important supply of water when its Colorado River entitlement was cut by 662,000 af; the City of Los Angeles lost a large part of an important supply of water when its Mono Lake and Owens Valley water supplies were reduced.

A brief synopsis of agreements and litigation which affect regional water matters follows:

Untreated Sewage from Mexico. Tijuana's excess sewage has plagued the City of San Diego and its South Bay 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 nuisance was in 1965, when the city agreed to treat Tijuana's waste 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 the waste water treatment plant, 5 miles south of the International Border. Phase I of the facility was completed in January 1987. The plant was fully operational in September 1987, only to break down a month later. In May 1988, the facility was again operational.

A future facility will be funded jointly by Mexico and the U.S. at a cost of $192 million. Additional phases will be added as needed, with an ultimate capacity of 100 mgd. The effluent will be discharged to the Pacific Ocean just north of the Mexican border and will meet U.S. standards.

San Bernardino Ground Water. As late as the 1940s, the lowest portion of the San Bernardino Valley was composed mainly of springs and marshlands. It now boasts a thriving urban complex and industrial center, but ground water levels in the area remain high, impairing the use of some buildings. The San Bernardino Valley Municipal Water District began alleviating the high ground water problem by pumping ground water from the pressure area to the Colton-Rialto Basin through the Baseline Feeder.

In 1969, the Superior Court of Riverside County, in response to a lawsuit filed by the Western Municipal Water District of Riverside County against the East San Bernardino County Water District, limited the amount of water that can be produced or exported from the San Bernardino Basin area. The ruling requires the SBVMWD to replenish the basin when ground water pumping exceeds the specified amount.

Local Issues

Ventura County Ground Water. Ground water is the main water supply for irrigation and urban uses over much of the coastal plain of Ventura County (including the Oxnard Plain). As a result of increasing water demand, the ground water aquifers underlying the plain have been overdrafted. The overdraft within the United Water Conservation District averaged 18,900 af per year during 1976-85. The Fox Canyon Ground Water Management Agency was formed to manage the ground water resources underlying the Fox Canyon aquifer zone. To eliminate the overdraft in all aquifer zones, the agency adopted ordinances requiring meter installation on all wells pumping more than 50 af per year. The objective of the ordinances is to limit the amount of ground water that can be pumped and to restrict drilling of new wells in the North Las Posas Basin. In February 1991, United Water Conservation District completed construction of the Freeman Diversion Improvement Project on the Santa Clara River. The improved structure increases average annual diversions by about 43 percent, from 40,000 af to 57,000 af. The diverted water is used for ground water recharge and agricultural irrigation, thereby reducing agricultural ground water demand.

In an effort to prevent degradation of the Ojai ground water basin, a coalition of growers, public agencies, water utilities, and pumpers decided in early 1990 to have legislation enacted to form the Ojai Basin Ground Water Management Agency. Its activities include implementing agency ordinances; monitoring key wells; determining amounts of extractions, ground water in storage, and operational safe yield; surveying land use within the agency's boundaries; compiling water quality data; and recharging the basin.

Water Balance

Water budgets were computed for each planning subarea in the South Coast Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table SC-11 presents water demands for the 1990 level and for future water demands to 2020 and compares them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management programs.

Regional net water demands for the 1990 level of development totaled 4,379,000 and 4,521,000 af for average and drought years, respectively. Those demands are forecasted to increase to 5,903,000 and 6,110,000 af, respectively, by the year 2020. This forecast accounts for a 490,000-af reduction in urban water demand resulting from implementation of long-term conservation measures, and a 10,000-af reduction in agricultural demand resulting from additional long-term water conservation measures.

Urban net water demand is projected to increase by about 1,798,000 af by 2020, primarily due to expected increases in population; agricultural net water demand is forecasted to decrease by about 288,000 af, primarily due to lands being taken out of production resulting from the high cost of imported water supplies and urbanization. Environmental net water demands, under existing rules and regulations, are forecasted to increase from 2,000 to 6,000 af annually due to increased acreage at the San Jacinto Wildlife Area.

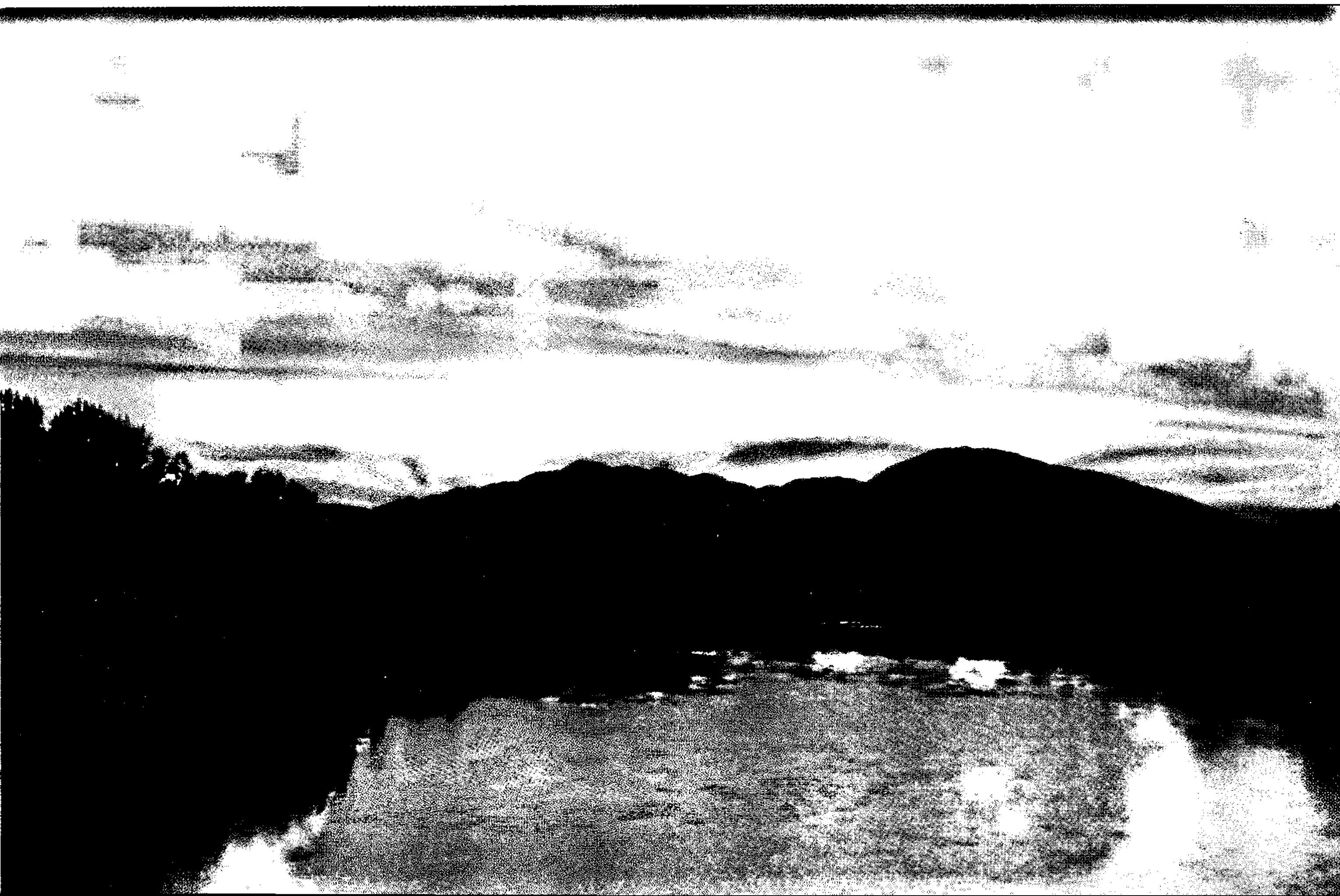
Average annual supplies, including 22,000 af of ground water overdraft, were generally adequate to meet average net water demands in 1990 for this region. However, during drought, present supplies are insufficient to meet present demands and, without additional water management programs, annual average and drought year shortages are expected to increase to nearly 1,413,000 and 2,494,000 af by 2020, respectively. With implementation of Level I programs, shortages could be reduced to 373,000 af and 848,000 af for average and drought years, respectively. This region depends on exports from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on Decision 1485 operating criteria for Delta supplies and do not take into account reduction of Delta supplies due to recent actions to protect aquatic species in the estuary. As such, regional water supply shortages are understated.

Table SC-11. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	3,511	3,641	4,228	4,379	5,004	5,180	5,799	6,004
—reductions due to long-term conservation measures (Level I)	—	—	–218	–218	–381	–381	–490	–490
Agricultural—with 1990 level of conservation	644	668	572	595	465	481	366	380
—reductions due to long-term conservation measures (Level I)	—	—	–3	–3	–7	–7	–10	–10
Environmental	2	2	6	6	6	6	6	6
Other[1]	222	210	227	215	232	220	232	220
TOTAL Net Demand	4,379	4,521	4,812	4,974	5,319	5,499	5,903	6,110
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	3,274	2,691	3,183	2,170	3,338	2,237	3,340	2,241
Ground Water	1,083	1,306	1,100	1,325	1,125	1,350	1,150	1,375
Ground Water Overdraft[3]	22	22	—	—	—	—	—	—
Subtotal	4,379	4,019	4,283	3,495	4,463	3,587	4,490	3,616
Dedicated Natural Flow	0	0	0	0	0	0	0	0
TOTAL Water Supplies	4,379	4,019	4,283	3,495	4,463	3,587	4,490	3,616
Demand/Supply Balance	0	–502	–529	–1,479	–856	–1,912	–1,413	–2,494
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed	—	—	399	399	498	498	597	597
Local	—	—	0	0	0	264	0	264
Colorado River	—	—	68	68	68	68	68	68
State Water Project	—	—	26	22	243	680	334	676
***Subtotal* - Level I Water Management Programs**	0	0	493	489	809	1,510	999	1,605
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	36	36	47	46	41	41
Remaining Demand/Supply Balance Requiring Short-term Demand Management and/or Level II Options	0	–502	0	–954	0	–356	–373	–848

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

Sunset over the Sacramento River near Redding. The river provides many recreational opportunities, habitat for fish and wildlife, and water supplies for much of the region.



Sacramento River Region

The Sacramento River Region contains the entire drainage area of the Sacramento River and its tributaries and extends almost 300 miles from Collinsville in the Sacramento-San Joaquin Delta north to the Oregon border. The crest of the Sierra Nevada and Cascade Ranges form the region's eastern border; the western side is defined by the crest of the Coast Range. The vast watershed of the American River and the northern Sacramento-San Joaquin Delta form the southern border. Snow-capped Mt. Shasta, rising 14,162 feet above sea level, dominates the north end of the region, followed by Mt. Lassen, at 10,457 feet above sea level. Both mountains are part of the Cascade Range. About 100 miles south of those mountain peaks stand the Sutter Buttes, which are the remnants of a prehistoric volcano, and have been called the smallest mountain range in the world. Winding its way through the entire region is the State's largest river, the Sacramento. The region contains 17 percent of the State's total land area. (See Appendix C for maps of the planning subareas and land ownership in the region.)

The climate varies considerably in the region. However, three distinct climate patterns can be defined: (1) The northernmost area, mainly high desert plateau, is characterized by cold, snowy winters with only moderate rainfall, and hot, dry summers. This area depends on melting snowpack to provide a summertime water supply. Average annual precipitation in the area ranges from 10 to 20 inches. (2) Other mountainous parts in the north and east have cold, wet winters with major amounts of snow providing considerable runoff for the summer water supply. These higher mountainous areas may receive precipitation during any month of the year. Summers are usually mild and precipitation totals from about 20 to over 80 inches. (3) The Sacramento Valley, the south-central part of the region, has mild winters with less precipitation. Precipitation usually occurs from October through May. Summers in the valley are hot and dry with virtually no precipitation from June to September. Sacramento's average annual precipitation is 18 inches.

Population

The 1990 census showed 535,000 more people in the region than in 1980, a 32-percent increase. Immigration from other parts of California played a big role in the increase. The fastest growing town was Loomis, a foothill community about 25 miles

Region Characteristics

Average Annual Precipitation: *36 inches* ***Average Annual Runoff:*** *22,389,700 af*

Land Area: *26,960 square miles* ***Population:*** *2,208,900* northeast of Sacramento, where there was a 344-percent population increase between 1980 and 1990. The City of Sacramento had the greatest number of new residents: more than 93,600 additional people. More than half of the region's population lives in the greater metropolitan Sacramento area. Other fast-growing communities include Vacaville, Dixon, Redding, Chico, and various Sierra Nevada foothill towns. Table SR-1 shows population projections to 2020 for the Sacramento River Region.

Table SR-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Shasta-Pit	31	35	39	43
Northwest Valley	110	132	153	176
Northeast Valley	187	258	311	365
Southeast	253	329	400	467
Central Basin West	242	328	390	461
Central Basin East	1,267	1,629	1,977	2,316
Southwest	53	72	91	110
Delta Service Area	66	85	108	125
TOTAL	2,209	2,869	3,467	4,063

Land Use

A wide variety of crops is grown in the Sacramento River Region, where agriculture is the largest industry. The region produces a significant amount of the overall agricultural tonnage in California, especially rice, grain, tomatoes, field crops, fruit, and nuts. Because of comparatively mild weather and good soil, some double cropping occurs in the region. The largest acreage of any single crop is rice, which represents about 23 percent of the total.

The Sacramento River Region supports about 2,145,000 acres of irrigated agriculture (22 percent of State total). About 1,847,000 acres are irrigated on the valley floor. The surrounding mountain valleys within the region add 298,000 irrigated acres (primarily pasture and alfalfa) to the region's total. Crop statistics show that irrigated agricultural acreage in the region peaked during the 1980s and has since declined. The main reason for this decline is the conversion of irrigated agricultural lands to urban development. The comparison of 1980 and 1990 crop patterns shows that grain, field, rice, and pasture crops decreased by 137,000 acres. On the other hand, orchard, alfalfa, and tomato crops gained a total of 106,000 acres. The net decrease between 1980 and 1990 was 31,000 acres of irrigated crops.

The rapid growth in single and multi-family housing has had a major impact on the Sacramento County area, as well as the surrounding areas like Placer, El Dorado, Yolo, Solano, and Sutter counties. Most of the development has been along the major highway corridors and has taken some irrigated agricultural land out of production. Suburban "ranchette" homes on relatively large parcels often surround the urban areas, sometimes converting previously non-irrigated areas into irrigated pasture or small orchards. Most of the land in these "ranchette" areas is typically non-irrigated. Figure SR-1 shows land use, imports, and exports for the Sacramento River Region.

Table SR-2. Major Reservoirs

Reservoir Name	*River*	*Capacity (1,000 AF)*	*Owner*
McCloud	McCloud River	35.2	PG&E
Iron Canyon	Pit River	24.2	PG&E
Lake Britton	Pit River	40.6	PG&E
Pit No. 6	Pit River	15.9	PG&E
Pit No. 7	Pit River	34.6	PG&E
Shasta	Sacramento	4,552.0	USBR
Keswick	Sacramento	23.8	USBR
Whiskeytown	Clear Creek	241.1	USBR
Lake Almanor	Feather River	1,143.8	PG&E
Mountain Meadows	Feather	23.9	PG&E
Butt Valley	Butt Creek	49.9	PG&E
Bucks Lake	Bucks Creek	105.6	PG&E
Antelope	Indian Creek	22.6	DWR
Frenchman	Little Last Chance Creek	55.5	DWR
Lake Davis	Big Grizzly Creek	84.4	DWR
Little Grass Valley	Feather	94.7	Oroville-Wyandotte ID
Sly Creek	Lost Creek	65.7	Oroville-Wyandotte ID
Thermalito	Feather	81.3	DWR
Oroville	Feather	3,537.6	DWR
Bullards Bar (New Bullards Bar)	Yuba River	966.1	Yuba Co. WA
Jackson Meadows	Yuba River	69.2	Nevada ID
Bowman Lake	Canyon Creek	68.5	Nevada ID
French Lake	Canyon Creek	13.8	Nevada ID
Lake Spaulding	Yuba River	74.8	PG&E
Englebright	Yuba River	70.0	USCE
Scotts Flat	Deer Creek	48.5	Nevada ID
Rollins	Bear River	66.0	Nevada ID
Camp Far West	Bear River	104.0	South Sutter WD
French Meadows	American River	136.4	Placer Co. WA
Hell Hole	Rubicon River	207.6	Placer Co. WA
Loon Lake	Gerle Creek	76.5	SMUD
Slab Creek	American River	16.6	SMUD
Caples Lake	Caples Creek	26.6	PG&E
Union Valley	Silver Creek	277.3	SMUD
Ice House	Silver Creek	46.0	SMUD
Folsom Lake	American River	976.9	USBR
Lake Natoma	American River	9.0	USBR
East Park	Stony Creek	50.9	USBR
Stony Gorge	Stony Creek	50.4	USBR
Black Butte	Stony Creek	143.7	USCE
Clear Lake	Cache Creek	313.0	Yolo Co. FCWCD
Indian Valley	Cache Creek	300.0	Yolo Co. FCWCD
Lake Berryessa	Putah Creek	1,600.0	USBR

Table SR-3. Water Supplies with Existing Facilities and Programs
(thousands of acre-feet)

Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Surface								
Local	3,105	2,818	3,138	2,844	3,238	2,958	3,294	3,015
Local imports	8	8	8	8	8	8	8	8
Colorado River	0	0	0	0	0	0	0	0
CVP	2,529	2,115	2,628	2,205	2,627	2,206	2,632	2,217
Other federal	238	215	241	215	242	215	242	215
SWP	2	1	7	5	10	8	13	11
Ground water	2,496	2,865	2,463	2,985	2,426	3,033	2,491	3,038
Overdraft[1]	33	33	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow	3,323	2,905	3,323	2,905	3,323	2,905	3,323	2,905
TOTAL	11,734	10,960	11,808	11,167	11,874	11,333	12,003	11,409

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Mountains and Foothill Areas. It is often thought that the Sierra Nevada foothills of California have a lot of water because of the many creeks, rivers, and reservoirs in the area. However, water is scarce in much of the foothill area because many creeks that carry high flows during winter and spring become dry or nearly dry during summer and fall. This is also true for foothill regions on the west side of the Sacramento Valley, including the Clear Lake and Lake Berryessa areas. Most of the water for the more densely populated mountain and foothill areas comes from local surface sources.

Mining operations of the Gold Rush era brought about the first water development in the Sierra area. When hydraulic mining operations ceased, some of the mining ditches were incorporated into what eventually became part of PG&E's hydroelectric power system or local water supply systems, such as that of the Nevada Irrigation District. Currently, these remnants of the early mining days provide both agricultural and urban water supplies. The conveyance systems tend to have large but not irrecoverable losses. A number of areas lack distribution systems to convey surface water to the places of need.

Although ground water is a lesser source of water in the foothills, it plays an important role in meeting the needs of many individuals. Ground water within the mountain counties exists mostly in fractured rock. Ground water quality in this area is generally good, depending on the rock type from which the water is produced. Locally significant ground water quality problems may occur where ground water is in contact with radon-or uranium-bearing rock, or sulfide mineral deposits that contain heavy metals. Moderate levels of hydrogen sulfide can be found in the volcanic and geothermal areas in the western portion of the region. There is also a potential for ground water quality degradation where septic systems have been constructed in high density subdivisions.

Valley Area. Geologically, the Sacramento Valley is a trough partially filled with clay, silt, sand, and gravel deposited through millions of years of flooding. Although ground water is in all the younger sediments, only the more permeable sand and gravel aquifers provide enough for pumping. Throughout the valley these younger sediments overlie older marine sediments that contain brackish or saline water. The depth to saline water in the Sacramento Valley ranges from less than 500 feet in the north to over 3,000 feet in the south.

Ground water quality in the Sacramento Region is generally excellent. However, there are areas with local ground water contamination or pollution. In some parts of the region, elevated levels of naturally occurring chemicals make ground water use problematic.

While ground water is available in most valley areas, surface water is often less expensive and therefore preferred for irrigation use. Agriculture's water supply varies considerably, with many irrigation districts supplying surface water through an intricate distribution system of sloughs, ditches, and canals devoted to conveying irrigation water. Sacramento Valley water users have some of the oldest rights to the surface water. Some water rights go back before the Gold Rush to old Spanish land grants.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

No major additional water supply facilities are currently scheduled to come on line by the year 2020 in this region. However, El Dorado County Water Agency has issued a Final Environmental Impact Report for the El Dorado Project, which will augment supplies in the El Dorado Irrigation District service area. The preferred alternative includes: (1) obtaining consumptive use rights to PG&E water currently used solely for power generation; (2) increasing the district's contract for Central Valley Project water from Folsom Reservoir; and (3) constructing the White Rock Project, which will convey water from the South Fork American River to proposed EID treatment and distribution facilities. The additional supplies from this alternative are 17,000 af of supply (average and drought) from PG&E water, and 7,500 and 5,600 af for average and drought years, respectively, from Folsom Reservoir. (These increments of Sacramento River Region supply will come from the allocation of existing CVP supplies.) The White Rock Project is strictly a conveyance project, which will not supplement EID's water supply. Table SR-4 shows water supplies with Level I water management programs.

Water Service Reliability and Drought Water Management Strategies. Urban areas in the central part of the region generally have sufficient supplies to survive dry periods with only voluntary cutbacks. However, communities in Butte, Lake, and Shasta counties, and areas served from Folsom Lake have had to use rationing or water transfers during recent droughts to manage shortages.

The Redding Basin is fundamentally an area of abundant water supplies, but outlying areas are subject to severe shortages in dry years due to the terms of U.S.

Bureau of Reclamation contracts and the lack of alternative supplies. Small districts located virtually in the shadow of Shasta Dam face chronic water shortages.

Table SR-4. Water Supplies with Level I Water Management Programs
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	3,105	2,818	3,138	2,846	3,238	2,961	3,288	3,021
Local imports	8	8	8	8	8	8	8	8
Colorado River	0	0	0	0	0	0	0	0
CVP	2,529	2,115	2,628	2,211	2,627	2,212	2,638	2,223
Other federal	238	215	241	215	242	215	242	215
SWP	2	1	7	5	10	8	13	11
Ground water	2,496	2,865	2,463	2,985	2,426	3,034	2,491	3,040
Overdraft(1)	33	33	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow	3,323	2,905	3,323	2,905	3,323	2,905	3,323	2,905
TOTAL	11,734	10,960	11,808	11,175	11,874	11,343	12,003	11,423

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Mountain valley areas in the region that depend on surface water are generally irrigated to the extent water is available; when water runs low or runs out, irrigation is cut back. This type of drought management is a way of life for the ranchers. Holders of riparian and pre-1914 water rights on perennial streams generally enjoy reliable supplies, even during droughts. They are technically subject to restriction during times of shortage, but, as a practical matter, such restrictions have not been enforced in the past.

The 30 percent of the region's lands that are irrigated with ground water generally enjoy a very reliable supply. Ground water levels may decline moderately during an extended drought, but the main result is a modest drop in well production and an increase in pumping costs.

Much of the rural foothill area relies on ground water to meet water needs. Ground water supplies are highly variable and do not contain significant volumes due to the nature of the fractured rock characteristic of the area. Droughts can severely reduce supplies in such areas.

The majority of diverters along the Sacramento and Feather Rivers existed before major CVP and State Water Project reservoirs were constructed. Their water rights were filed long before the federal and State projects were built; some go back to before the turn of the century. The diverters executed water rights settlement contracts with the USBR and DWR after the CVP and SWP water rights were filed. These contracts generally provide for maximum deficiencies of only 25 to 50 percent in extremely dry years, whereas CVP and SWP contractors can receive much larger deficiencies.

CVP contractors account for 20 percent of the region's water use and are subject to sizable cutbacks in drought years; some contractors suffered a 75-percent reduction in 1991. The effects of such cuts depend on what alternatives are available. Some areas can fall back on ground water; others have no feasible alternatives.

A final category of water users includes those who depend primarily on return flow from upstream areas. These users usually do not have a firm water right because an upstream user is not generally obliged to continue to provide return flows. The recent drought, the resulting water banking activities, and increased emphasis on water conservation have reduced return flows available for downstream users. Among those affected have been State and federal wildlife areas and various privately owned duck clubs.

Water Management Options with Existing Facilities. Changes in the surface water allocation within the region will probably result from pressure for environmental restoration, negotiations for renewal of CVP contracts, expanded conjunctive use of surface and ground water, and various proposals and designs for water transfers. Cumulatively, these changes could stimulate substantial increases in ground water use in the region. Water transfers are becoming increasingly important throughout California. Since the Sacramento River system potentially is the major source of future water transfers, this region will probably experience more water transfer activities in the future.

Water conservation efforts in this region usually result in limited actual water savings because water not consumptively used is available for reuse downstream. Most water delivered in the Sacramento Region that is not consumptively used is returned to surface or ground water sources from which it may be diverted and used again. Some water users would find themselves without a supply if upstream users did not provide surplus runoff from their "inefficient" application of water. If return flows were reduced by upstream water conservation efforts, downstream users who have the rights to do so would elect to divert more water from the Sacramento River to meet their needs.

Water Management Options with Additional Facilities. Many potential surface water developments within the Sacramento River Region have been examined over the last 40 years. Most of these studies were geared primarily to producing additional water supplies for use in other regions of the State. Agricultural payment capacity within the Sacramento River Region generally is insufficient to justify expensive new reservoir projects.

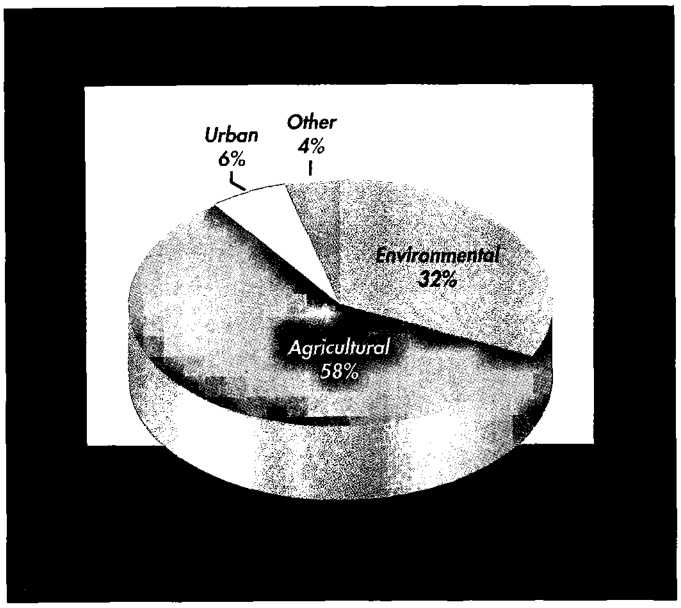
The most attractive surface water projects in the Sacramento River Region have already been built. High construction costs and the increasing emphasis on environmental considerations have greatly restricted the remaining options for additional surface water development. A few reservoir projects remain under consideration within the region, but none is far enough along in the planning and environmental review analysis to be constructed within the 30-year forecast presented here.

Additional ground water development will most likely meet a significant share of the limited increasing water demands of the region. The potential for developing new supplies from ground water is most favorable in the northern portion of the Sacramento Valley; the southern portion is already operating close to perennial yield in many areas. From the standpoint of overall basin management, increasing use of ground water will come partially at the expense of depleting existing surface supplies. Table SR-4 shows water supplies with additional facilities and programs. The indicated future increases in surface water and CVP supplies reflect the buildup in urban demands under existing contracts.

Water Use

The 1990 level annual net water use in the Sacramento River Region is 11,734,000 af, and net use is forecasted to increase to 12,036,000 af in the year 2020. Since 1980, urban use has increased while agricultural use has remained relatively stable except for the peak in irrigated acreage during the early 1980s. A minor increase in irrigated agricultural acreage is forecast, but there will be limited reductions in some areas, primarily due to urban encroachment onto agricultural land. Overall, agricultural water use in the Sacramento River Region is expected to decline slightly during the next 30 years as agricultural irrigation efficiencies continue to improve. Environmental use is expected to increase by 143,000 af by 2020 under existing fishery and wetland requirements. Figure SR-3 shows net 1990 level water demands for the Sacramento River Region.

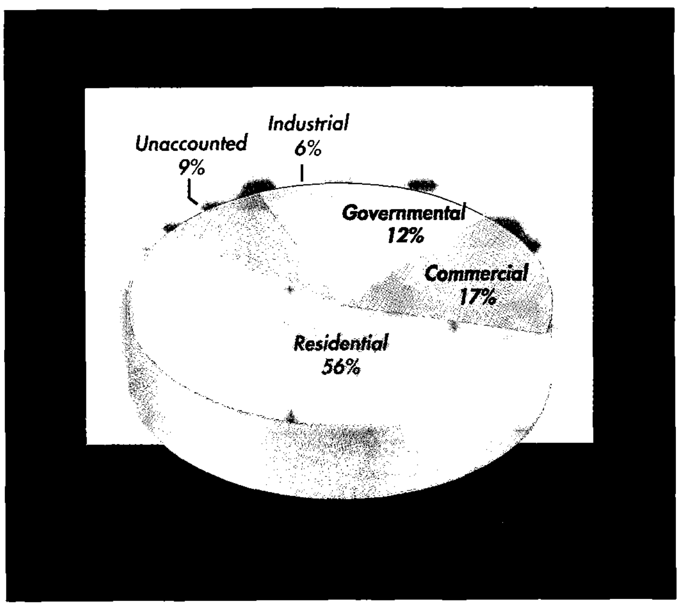
Figure SR-3. Sacramento River Region Net Water Demand (1990 Level Average Conditions)



Urban Water Use

A few of the larger cities in the region take a major share of their water supplies from the major rivers. But throughout most of the Sacramento River Region, ground water is the principal source of water for urban and rural dwellers. In the last decade, rapid growth on the outskirts of cities with surface supplies has led to a number of residential developments using ground water.

Figure SR-4. Sacramento River Region Urban Applied Water Use by Sector (1990 Level Average Conditions)



An average of 75 percent of the total residential water use is for landscaping. Per capita water use averages 248 gallons per day for valley residents. In the northern part of the region per capita water use ranges from about 200 to around 350 gpd. The higher unit use is generally associated with the hot, dry floor of the northern Sacramento Valley. Overall, daily per capita urban water use of 300 gallons has not changed significantly over past years except during droughts. At those times, communities with high water use have reduced their use by employing standard water conservation methods.

Overall, the region's population is expected to more than double by 2020. Municipal and industrial use is expected to increase along with the region's population from 1990 to 2020. Much of the growth will be in the southern part of the region including El Dorado, Placer, and Sacramento counties.

The high-water-using industries of the region are closely tied to agriculture and forestry. Tomato and stone fruit processing, sugar mills, paper pulp, and lumber mills consume large amounts of water and many have their own supplies. Table SR-5 summarizes the applied and net urban water demands for the region. Figure SR-4 shows applied 1990 level urban water use by sector.

New housing construction in Sacramento County. Many new homes are being built in the flood plain. The pumps shown in the foreground pump rainfall runoff from the area into the Sacramento River during storms.

Table SR-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Shasta-Pit								
Applied water demand	11	13	13	15	14	16	15	18
Net water demand	11	13	13	15	14	16	15	18
Depletion	5	6	6	7	7	8	7	9
Northwest Valley								
Applied water demand	53	54	61	63	68	70	77	79
Net water demand	53	54	61	63	68	70	77	79
Depletion	19	20	24	24	27	28	31	32
Northeast Valley								
Applied water demand	55	58	75	79	90	95	104	110
Net water demand	55	58	75	79	90	95	104	110
Depletion	27	29	37	39	45	47	52	55
Southeast								
Applied water demand	74	81	92	101	110	120	126	138
Net water demand	74	81	92	101	110	120	126	138
Depletion	25	28	32	35	37	41	43	47
Central Basin West								
Applied water demand	71	76	86	94	100	108	116	125
Net water demand	71	76	86	94	100	108	116	125
Depletion	22	22	26	28	31	33	36	38
Central Basin East								
Applied water demand	448	490	543	593	644	704	736	803
Net water demand	448	490	543	593	644	704	736	803
Depletion	127	140	154	170	185	202	211	232
Southwest								
Applied water demand	9	10	13	14	16	17	19	20
Net water demand	9	10	13	14	16	17	19	20
Depletion	4	5	6	6	7	8	9	9
Delta Service Area								
Applied water demand	23	25	28	30	34	37	38	42
Net water demand	23	25	28	30	34	37	38	42
Depletion	7	7	8	9	10	11	11	12
TOTAL								
Applied water demand	744	807	911	989	1,076	1,167	1,231	1,335
Net water demand	744	807	911	989	1,076	1,167	1,231	1,335
Depletion	236	257	293	318	349	378	400	434

Almost all of this increase is expected to occur north of the Sutter Buttes where there exist adequate farmable soils with sufficient available surface and ground water supplies. The crops projected to have the largest increase in acreage are almonds, miscellaneous truck crops, tomatoes, vineyard, corn, and miscellaneous deciduous orchards.

Environmental Water Use

Instream flow requirements of major streams in the region are listed in Table SR-9. The instream applied water for each river listed is based on the largest fish flow

Table SR-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Shasta-Pit								
Applied water demand	440	469	433	463	440	470	449	479
Net water demand	379	395	374	391	380	397	386	404
Depletion	330	358	325	352	330	358	335	363
Northwest Valley								
Applied water demand	472	569	490	590	505	609	508	612
Net water demand	466	487	485	507	504	527	510	534
Depletion	356	433	374	455	388	471	392	476
Northeast Valley								
Applied water demand	306	353	306	353	310	358	310	358
Net water demand	298	312	299	314	304	319	303	318
Depletion	231	268	235	272	239	278	239	278
Southeast								
Applied water demand	358	426	355	423	351	418	351	418
Net water demand	343	388	341	384	338	380	338	380
Depletion	261	306	261	306	261	304	261	306
Central Basin West								
Applied water demand	2,830	3,081	2,804	3,052	2,803	3,049	2,812	3,057
Net water demand	2,193	2,483	2,181	2,467	2,173	2,454	2,181	2,451
Depletion	1,896	2,153	1,919	2,179	1,947	2,210	1,970	2,235
Central Basin East								
Applied water demand	2,907	3,124	2,781	3,020	2,660	2,960	2,605	2,799
Net water demand	2,612	2,753	2,471	2,635	2,371	2,588	2,332	2,444
Depletion	1,950	2,151	1,923	2,132	1,886	2,080	1,852	2,042
Southwest								
Applied water demand	74	77	72	74	70	74	70	73
Net water demand	71	72	68	69	67	69	68	68
Depletion	50	51	47	48	46	47	45	46
Delta Service Area								
Applied water demand	461	546	457	542	453	537	453	537
Net water demand	426	504	383	455	369	450	379	450
Depletion	403	403	342	405	342	403	343	405
TOTAL								
Applied water demand	7,848	8,645	7,698	8,517	7,592	8,475	7,558	8,333
Net water demand	6,788	7,394	6,602	7,222	6,506	7,184	6,497	7,049
Depletion	5,477	6,123	5,426	6,149	5,439	6,151	5,437	6,151

specified in the entire reach of the river. Instream net water needs in each river is the portion of applied water which flows throughout the river or is the flow leaving the region. Total 1990 level instream net water needs for this region were about 3,323,000 af.

The Sacramento River Region contains the largest and the most wetlands areas in the State, totalling approximately 175,000 acres. Water for these wetlands is from several sources, including CVP supplies, agricultural return flows, and ground water. The estimated wetland applied water, shown in Table SR-10, is about 484,000 af. The forecasted needs for year 2000 are expected to go up by 30 percent due to the 1992 CVP Improvement Act which allocated more water to wetlands. In the year 2000, 629,000 af would be allocated for wetlands. The CVP Improvement Act is discussed in Volume I, Chapter 2.

The Butte and Sutter basins contain large wetlands areas which serve as critical habitat for migratory waterfowl in the Pacific Flyway. There are about 13,000 acres of publicly owned and managed waterfowl habitat in the Butte Basin. In addition, private hunting clubs maintain more than 30,000 acres of habitat during normal years. The Sutter Basin has almost 2,600 acres of publicly owned waterfowl habitat, all in the Sutter National Wildlife Refuge. Private duck hunting clubs provide an additional 1,500 acres of waterfowl habitat.

Table SR-9. Environmental Instream Water Needs
(thousands of acre-feet)

Stream	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Sacramento River								
Applied water demand	1,903	1,702	1,903	1,702	1,903	1,702	1,903	1,702
Net water demand	1,903	1,702	1,903	1,702	1,903	1,702	1,903	1,702
Depletion	0	0	0	0	0	0	0	0
Yuba River								
Applied water demand	280	240	325	240	325	240	325	240
Net water demand	174	150	174	150	174	150	174	150
Depletion	0	0	0	0	0	0	0	0
Feather River								
Applied water demand	977	784	977	784	977	784	977	784
Net water demand	977	784	977	784	977	784	977	784
Depletion	0	0	0	0	0	0	0	0
American River								
Applied water demand	234	234	234	234	234	234	234	234
Net water demand	234	234	234	234	234	234	234	234
Depletion	0	0	0	0	0	0	0	0
Others(1)								
Applied water demand	49	49	49	49	49	49	49	49
Net water demand	35	35	35	35	35	35	35	35
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	3,443	3,009	3,488	3,009	3,488	3,009	3,488	3,009
Net water demand	3,323	2,905	3,323	2,905	3,323	2,905	3,323	2,905
Depletion	0	0	0	0	0	0	0	0

(1) Includes Clear Creek, Bear River, Cache Creek, and Putah Creek.

Table SR-10. Wetland Water Needs
(thousands of acre-feet)

Wetland	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Modoc NWR								
Applied water demand	20	20	20	20	20	20	20	20
Net water demand	17	17	17	17	17	17	17	17
Depletion	15	15	15	15	15	15	15	15
Sacramento NWR								
Applied water demand	43	43	50	50	50	50	50	50
Net water demand	43	43	50	50	50	50	50	50
Depletion	18	18	18	18	18	18	18	18
Colusa NWR								
Applied water demand	19	19	25	25	25	25	25	25
Net water demand	19	19	25	25	25	25	25	25
Depletion	9	9	9	9	9	9	9	9
Butte Sink NWR								
Applied water demand	2	2	2	2	2	2	2	2
Net water demand	1	1	1	1	1	1	1	1
Depletion	1	1	1	1	1	1	1	1
Delevan NWR								
Applied water demand	24	24	30	30	30	30	30	30
Net water demand	24	24	30	30	30	30	30	30
Depletion	12	12	12	12	12	12	12	12
Sutter NWR								
Applied water demand	9	9	30	30	30	30	30	30
Net water demand	4	4	30	30	30	30	30	30
Depletion	4	4	4	4	4	4	4	4
Gray Lodge WA								
Applied water demand	44	44	44	44	44	44	44	44
Net water demand	38	38	38	38	38	38	38	38
Depletion	21	21	21	21	21	21	21	21
Ash Creek WA								
Applied water demand	13	13	13	13	13	13	13	13
Net water demand	12	12	12	12	12	12	12	12
Depletion	12	12	12	12	12	12	12	12
Upper Butte Basin WA								
Applied water demand	0	0	56	56	56	56	56	56
Net water demand	0	0	49	49	49	49	49	49
Depletion	0	0	27	27	27	27	27	27
Yolo Bypass WA								
Applied water demand	0	0	8	8	8	8	8	8
Net water demand	0	0	8	8	8	8	8	8
Depletion	0	0	2	2	2	2	2	2
Stone Lakes NWR								
Applied water demand	0	0	40	40	40	40	40	40
Net water demand	0	0	40	40	40	40	40	40
Depletion	0	0	10	10	10	10	10	10
Butte Basin Refuge								
Applied water demand	125	125	125	125	125	125	125	125
Net water demand	79	79	79	79	79	79	79	79
Depletion	33	33	33	33	33	33	33	33

Table SR-10. Wetland Water Needs (Continued)
(thousands of acre-feet)

Wetland	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Colusa Basin Refuge								
Applied water demand	108	108	108	108	108	108	108	108
Net water demand	80	80	80	80	80	80	80	80
Depletion	25	25	25	25	25	25	25	25
American Basin Refuge								
Applied water demand	31	31	31	31	31	31	31	31
Net water demand	31	31	31	31	31	31	31	31
Depletion	7	7	7	7	7	7	7	7
Sutter Basin Refuge								
Applied water demand	16	16	16	16	16	16	16	16
Net water demand	16	16	16	16	16	16	16	16
Depletion	4	4	4	4	4	4	4	4
Yolo Basin Refuge								
Applied water demand	21	21	21	21	21	21	21	21
Net water demand	21	21	21	21	21	21	21	21
Depletion	5	5	5	5	5	5	5	5
Sherman Island Refuge								
Applied water demand	9	9	9	9	9	9	9	9
Net water demand	9	9	9	9	9	9	9	9
Depletion	2	2	2	2	2	2	2	2
Cosumnes River Refuge								
Applied water demand	0	0	1	1	1	1	1	1
Net water demand	0	0	1	1	1	1	1	1
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	484	484	629	629	629	629	629	629
Net water demand	394	394	537	537	537	537	537	538
Depletion	168	168	207	207	207	207	207	208

Other Water Use

Figure SR-6 shows water recreation areas in the Sacramento Region Table SR-11 shows the total water demands for the region.

Issues Affecting Local Water Resource Management

Legislation and Litigation

Bay/Delta Proceedings and Other Delta Issues. A comprehensive discussion of the Bay/Delta hearings and other Delta issues can be found in Volume I, Chapters 2 and 10.

Sacramento River Fisheries and Riparian Habitat Management Plan (Senate Bill 1086). The salmon and steelhead fishery in the upper Sacramento River has declined greatly in the last few decades. Contributing to this decline are problems on the river's main stem: unsuitable water temperatures, toxic heavy metals from acid mine drainage, degraded spawning gravels, obstructions to fish migration, fish losses from diversions and harvest, and riparian habitat loss. In 1986, the Legislature enacted Senate Bill 1086, which called for development of a riparian habitat inventory and an Upper Sacramento River Fisheries and Riparian Habitat Management Plan. The final plan contained a conceptual Riparian Habitat Restoration Plan recommending two major actions dealing with riparian habitat along the river and its major tributaries. It also contained a more specific Fishery Restoration Plan, listing 20 actions to help restore the salmon and steelhead fisheries of the river and its tributaries. In September 1989, the Legislature approved Senate Concurrent Resolution No. 62, declaring a State policy to implement the recommendations of the management plan.

About half of the proposed restoration actions are now under way, funded by a combination of federal, State, and local sources, but progress in obtaining major federal funding has been slow. The CVP Improvement Act includes many of the CVP-related fishery restoration measures recommended by the SB 1086 plan. This act should accelerate implementation of the major actions needed to restore the upper Sacramento River salmon and steelhead fisheries by providing needed funding.

Glenn-Colusa Irrigation District Intake Screen Deficiencies. The GCID has 720,000 af of prior water rights supplemented by 105,000 af of CVP contract water. In May 1972, Department of Fish and Game constructed a 40-drum rotary fish screen at the intake to the GCID main pump station. The rotary drum screen is one of the largest ever built, allowing a diversion from the Sacramento River of 3,000 cfs. However, the design performance of the screens was never realized, primarily because local river bed erosion gradually lowered the water surface. This resulted from the cutoff of a large downstream river bend during the high water of 1970, which dropped the normal water surface elevation at the screen by approximately 31/2 feet. The ensuing operational deficiencies caused high juvenile fish mortalities.

In 1987, GCID and DFG entered into a joint memorandum of understanding to fund an investigation of potential solutions. The engineering firm CH^2M Hill was selected to perform this investigation. Their proposed solution was a new V-type screen combined with gradient restoration in the river. In 1989, the U.S. Army Corps of Engineers was directed by special federal legislation to proceed with engineering and design to restore the river hydraulics near the screen to 1970 conditions. The Corps has recently completed an initial design and environmental assessment of a gradient restoration project.

The listing of the winter-run chinook salmon in 1991 required GCID to consult with the National Marine Fisheries Service on operating the existing screen and constructing a new screen. A court order set requirements for operating the existing screen which limit the amount of water GCID can divert. In the summer of 1992 a second contractor, HDR Engineering, Inc., was hired by the State under a cost-sharing agreement with GCID to perform a feasibility-level study of selected screen design alternatives and prepare environmental documentation.

The CVPIA of 1992 includes fishery mitigation at the GCID pumping plant in the Act's list of mandatory environmental restoration actions. USBR will participate with other parties, including the Reclamation Board, in implementing the work required by the Act. In 1993, GCID completed a flat plate screen to provide interim fishery protection pending completion of a long-term solution.

Regional Issues

Water Transfers. Individuals and water districts from several counties have recently sold or considered selling surface water and ground water to downstream users. As a result, many north valley water users are concerned about protecting ground water resources from export. Surface water transfers caused considerable controversy in local areas (see Volume I for a more complete discussion of water transfers and the 1991 State Drought Water Bank). Organized ground water management efforts are currently under way in Butte, Colusa, Glenn, Shasta, Solano, Sutter, Sacramento, Tehama, and Yolo counties.

Endangered Species. Threatened and endangered species are affecting management of the region's water supplies. While few specific water supply requirements have yet been established for individual species, a number of operating restrictions may be considered that will impact the statewide water demand balance. For example, the listing of the winter-run chinook salmon has had a major impact on GCID operations, and pumping into the North Bay Aqueduct has been restricted to protect the threatened Delta smelt. Other Sacramento River water diverters are concerned about the listing of additional fish runs. Additionally, the bank swallow, a State threatened species, has limited bank protection efforts along the Sacramento River.

Foothill Development. Although some foothill areas have abundant surface water supplies, several rely heavily on ground water to meet their needs. With many people relocating to foothill and mountain regions, there is increasing concern about ground water availability in hard rock areas and the potential for contaminating these supplies. In many mountain counties, homes are built on small parcels away from regional sewer systems and municipal water supplies. Most of these homes rely on a single well for their potable water supply and a septic system to dispose of their sewage. In many areas where this development is occurring, there is no readily available alternative water supply if the ground water becomes depleted or contaminated.

In some areas, current development will cause water supply needs to exceed available supplies. Downstream areas have already developed the least costly reservoir sites, and a number of recent State and federal mandates further limit water development. Financial and other local agency constraints can make it virtually impossible for these regions to develop supplies on their own.

Local Issues

Sacramento River Water Quality. Water quality in the entire watershed is generally excellent, making it one of the most desirable water sources in the State.

Table SR-11. Total Water Demands
(thousands of acre-feet)

Category of Use	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Urban								
Applied water demand	744	807	911	989	1,076	1,167	1,231	1,335
Net water demand	744	807	911	989	1,076	1,167	1,231	1,335
Depletion	236	257	293	318	349	378	400	434
Agricultural								
Applied water demand	7,848	8,645	7,698	8,517	7,592	8,475	7,558	8,333
Net water demand	6,788	7,394	6,602	7,222	6,506	7,184	6,497	7,049
Depletion	5,477	6,123	5,426	6,149	5,439	6,151	5,437	6,151
Environmental								
Applied water demand	3,927	3,493	4,117	3,638	4,117	3,638	4,117	3,638
Net water demand	3,717	3,299	3,860	3,442	3,860	3,442	3,860	3,443
Depletion	168	168	207	207	207	207	207	208
Other(1)								
Applied water demand	1	1	1	1	1	1	1	1
Net water demand	485	421	468	412	465	411	448	411
Depletion	71	60	71	60	71	60	71	60
TOTAL								
Applied water demand	12,520	12,946	12,727	13,145	12,786	13,281	12,907	13,307
Net water demand	11,734	11,921	11,841	12,065	11,907	12,204	12,036	12,238
Depletion	5,952	6,608	5,997	6,734	6,066	6,796	6,115	6,853

(1) Includes major conveyance facility losses, recreation uses, and energy production.

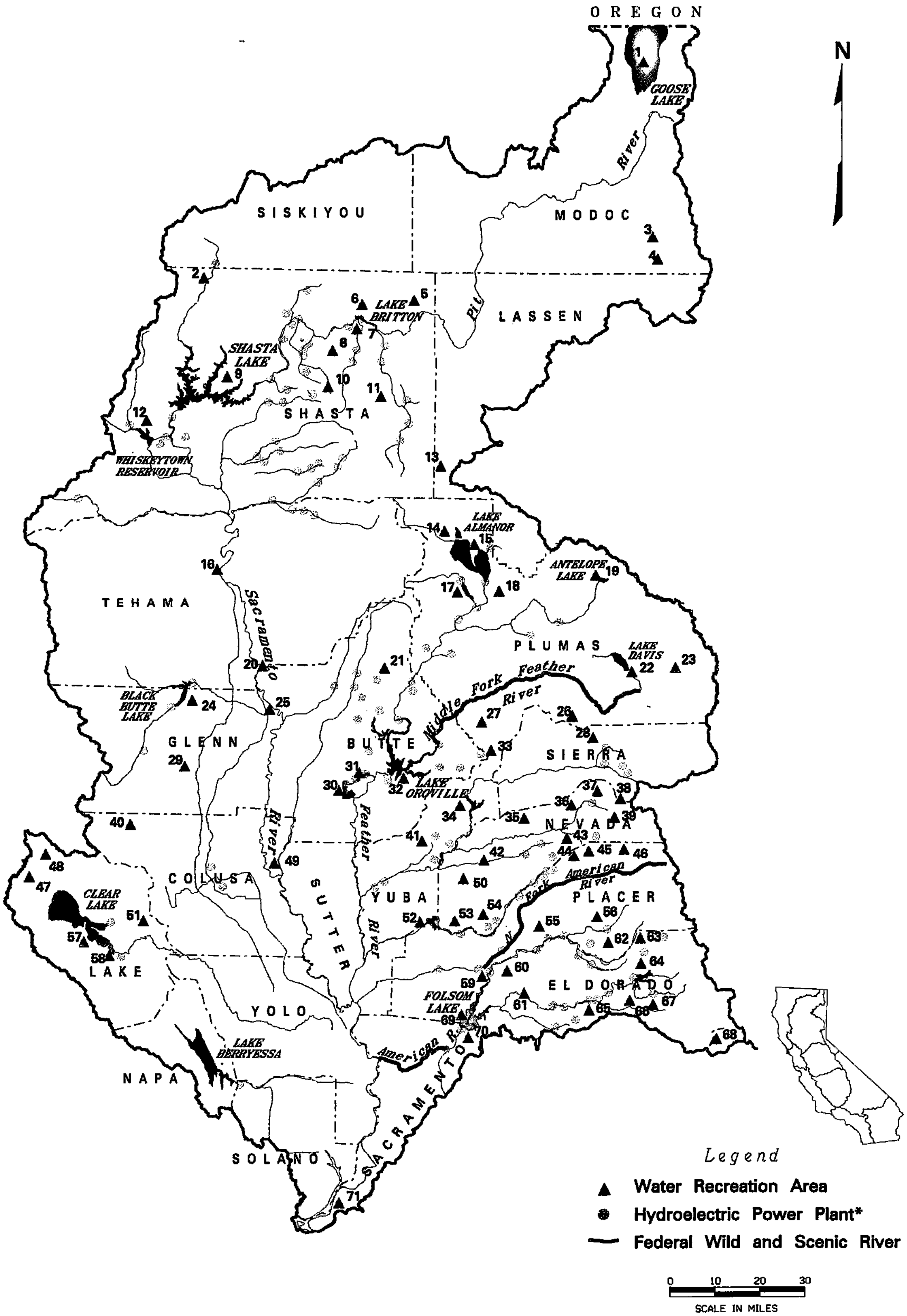
Figure SR-6. Sacramento River Region
Water Recreation Areas

Shown on map.

1. Goose Lake
2. Castle Crags S.P.
3. West Valley Reservoir
4. Blue Lake
5. Ahjumaw Lava Springs S.P.
6. Tule Lake
7. McArthur-Burney Falls M.S.P.
8. Lake McCloud
9. Shasta Lake
10. Iron Canyon Reservoir
11. Lake Britton
12. Whiskeytown Reservoir
13. Crater Lake
14. Manzanita Lake
15. Lake Almanor
16. William B. Ide Adobe S.H.P.
17. Butte Valley Reservoir
18. Round Valley Reservoir
19. Antelope Lake R.F.
20. Woodson Bridge S.R.A.
21. Snag Lake
22. Lake Davis
23. Frenchman Lake
24. Black Butte Lake
25. Bidwell River Park S.R.A.
26. Plumas-Eureka S.P.
27. Bucks Lake
28. Lakes Basin Recreation Are
29. Stony Gorge Reservoir
30. Thermalito Afterbay R.F.
31. Thermalito Forebay R.F.
32. Lake Oroville S.R.A.
33. Little Grass Valley Reservoir
34. New Bullards Bar Reservoir
35. Malakoff Diggins S.H.P.
36. Bowman Lake
37. Jackson Meadow Recreation Area
38. Boca Reservoir
39. Prosser Creek Reservoir
40. Plaskett Lake
41. Collins Lake
42. South Yuba Trail Project
43. Lake Spaulding
44. Lake Valley Reservoir
45. Eagle Lake
46. Martis Creek Lake
47. Blue Lakes-Lake County
48. Lake Pillsbury
49. Colusa-Sacramento River S.R.A.
50. Scotts Flat Lake
51. Indian Valley Reservoir
52. Camp Far West Lake
53. Rollins Lake
54. Englebright Reservoir
55. Sugar Pine Reservoir
56. French Meadows Reservoir
57. Clear Lake S.P.
58. Anderson Marsh S.H.P.
59. Auburn S.R.A.
60. Stumpy Meadows Reservoir
61. Marshall Gold Discovery S.H.P.
62. Hell Hole Reservoir
63. Loon Lake
64. Union Valley Reservoir
65. Jenkinson Lake Sly Park R.A.
66. Ice House Reservoir
67. Wrights Lake
68. Echo Lake
69. Folsom lake S.R.A.
70. Lake Natoma
71. Brannan Island S.R.A.

Figure SR-6. Sacramento River Region

Hydroelectric Power Plants, Wild and Scenic Rivers and Water Recreation Areas



However, the system is vulnerable to pollution from sources such as the July 1991 toxic spill from a train derailment into the Sacramento River near Dunsmuir. The upper Sacramento River is slowly recovering from that metam sodium spill, which killed essentially all life for miles of this river system. Native rainbow trout from tributaries are redistributing themselves in the river, and the smaller benthic organisms are steadily returning to the river. DFG continues to closely monitor the river's recovery. Current plans are to restrict sport fishing until there is substantial recovery of the river's historic wild trout population.

Problems such as turbidity and high pesticide concentrations affect not only the fisheries but also the drinking water supplies. One of the most significant water quality problems on the upper Sacramento River is heavy metals loading caused by acid mine drainage from a region of past copper/lead/zinc mining above Redding. The major contributor, Iron Mountain Mine, is included in EPA's Superfund program, and remedial and water quality enforcement actions have been under way there for many years. Acid mine drainage from this region has caused significant fish losses in the Sacramento River. USBR operates Spring Creek Debris Dam, upstream of Keswick Reservoir, to control runoff from part of the Iron Mountain area. Mine drainage is impounded in the reservoir and released when downstream flows are large enough to provide dilution. Sometimes when Spring Creek Reservoir is full, releases must be made from Shasta Reservoir to provide dilution. This reduces CVP yield but is necessary to protect the fishery. Additional reservoir storage is planned as part of EPA's remedial program for Iron Mountain Mine. Another alternative would be to bypass the mine by diverting streams upstream of the mine directly to Keswick.

Discharges from paper mills near Anderson have also caused water quality problems. Other problems relate to degraded agricultural return flows, particularly those bearing significant pesticide residues.

Sacramento County Supplies. The county is heavily dependent on ground water for its agricultural and urban water needs. However, this reliance has caused ground water levels to decline considerably in some areas of the county over the past 70 years. Currently, Sacramento County is responsible for purveying water to only a small part of the total urbanized areas of the county; however, the county will serve the majority of new growth areas south of the American River. At this time, no surface water supplies exist to meet this future demand, and ground water availability is under study. The county is also investigating a multifaceted conjunctive use program to meet short-term and long-term water demands in the area.

North Delta Contract. On January 28, 1981, DWR and North Delta Water Agency signed the North Delta Contract. One of the water quality standards in the contract is measured at Emmaton on Sherman Island, where salinity fluctuates widely in low flow conditions due to tidal influences. The North Delta Contract allows DWR to construct an overland facility as an alternative to meeting the Emmaton Standard. The Overland Facility would divert water from Threemile Slough and deliver it to other parts of the island where offshore water is of higher salinity. In 1986, however, Sherman Island landowners requested that DWR purchase their land instead of building the overland facility.

The Western Delta Water Management Program was developed to satisfy and include the landowners' desire to develop Sherman Island into a wildlife refuge. The program would: (1) improve levees for flood control; (2) protect Delta water quality; (3) meet water supply and water quality needs of Sherman Island; (4) provide habitat for waterfowl and wildlife; (5) minimize oxidation and subsidence on Sherman Island; (6)

protect the reliability of the SWP, Contra Costa Canal, and the CVP; (7) protect Highway 160 and utilities; and (8) provide additional recreational opportunities.

DWR has been negotiating land purchases with the landowners. To date, DWR owns or has offers accepted for about 13 percent of the island. In 1991, as part of these efforts, DWR negotiated a draft agreement that had elements of water banking and acknowledges the intent to have DWR purchase lands.

El Dorado County Supplies. Currently El Dorado County has problems with distribution, storage, and water rights. The 1992 Cleveland fire in El Dorado County destroyed a large portion of the PG&E El Dorado canal. The canal supplies about one third of El Dorado Irrigation District's water supply. PG&E has repaired the damaged portion of the canal, and it is back in operation. The American River watershed produces ample water, but other agencies hold the water rights, leaving El Dorado County deficient. The El Dorado County Water Agency and El Dorado Irrigation District have jointly filed for additional water rights from the American River Basin.

El Dorado County Water Agency has issued a final EIR for the El Dorado Project, which will augment supplies in EID's service area. EDCWA has determined that combining water right permits, contractual entitlements, and water exchanges with the construction of water facilities will provide a viable supplemental water supply to the year 2020.

Placer County Distribution. Currently, Placer County lacks sufficient delivery capacity to meet its future demands. There is currently no permanent system to deliver American River water supplies to western Placer County, which has American River water rights, entitlement to water from PG&E's Yuba-Bear system, and a CVP contract for American River water with the USBR. These supplies are sufficient to meet 2020 needs. The county is studying various delivery systems to serve western Placer County's agricultural needs.

Redding Basin Supplies. An active planning effort is under way to provide for the future water supply for developing areas in and around the cities of Redding, Anderson, and Shasta Lake in south-central Shasta County. The Redding Area Water Council is considering local water transfers, conjunctive use of ground water, and additional surface water developments. It is also anticipated that a local ground water management program will be developed.

Cloud Seeding. A number of cloud seeding operations are conducted in the region, including programs by PG&E in the Feather River Basin and Solano County Water Agency in the Lake Berryessa watershed. In 1991, DWR initiated a prototype project to augment snowpack by cloud seeding using ground-based propane dispensers in Plumas and Sierra counties. These dispensers are expected to produce a 10-percent increase in snow depths within an area in the upper Middle Fork Feather River Basin during average and dry years. Increased snow depths are forecasted to result in an additional downstream water yield of 22,400 af in a year of near-normal precipitation. The project suspends operation when it appears that the year will have a heavy snow pack. By seeding approximately 50 percent of all suitable storms, it will take an estimated five years to statistically determine the percentage increase in snow depth (and ultimate water yield) produced by the project. Environmental monitoring of the effects of this new technology is an important component of the program. There has been local resistance to this program because of the possible additional burden on Plumas County resulting from increased snow depths. DWR has committed to pay for any additional snow removal costs attributed to seeding.

Control of Upper Sacramento River Water Temperatures. During the summer and fall of 1990-92, extremely low water elevations in Shasta Lake caused Sacramento River water temperatures to rise above safe levels for fall-and winter-run salmon. Large amounts of water from the lowest lake intakes, bypassing the power generators, had to be released to prevent fish mortalities. These releases were expensive and could have been avoided if the dam was equipped with a multi-level temperature control structure. Design of such a structure is presently under way but construction is still several years away. The estimated cost is $80 million and the funding source will be the CVP Improvement Act. A construction contract could be awarded as early as the 1994-95 fiscal year.

Butte and Sutter Basins. The water-related problems of the Butte and Sutter basins include fish passage and habitat degradation, water quality, flooding and drainage problems, and water rights. The issues are complex because of competing uses and the maze-like pattern of water flow. Spring salmon runs in the Butte Creek watershed have decreased from around 20,000 in 1960 to less than 500 in 1992. The studies completed under SB 1086 toward a Sacramento River Fisheries Management Plan identified Butte Creek as a watershed in urgent need of fisheries mitigation work. The Butte and Sutter basins also provide a major part of the waterfowl wetland habitat in the Sacramento Valley, but are in need of more dependable water supplies.

This area's greatest water management issue from a local perspective is the widely perceived need for local ground water basin management. Local concern is motivated by fears that other areas of the State may try to purchase ground water to the possible detriment of the local economy and rural lifestyle. The Butte Basin Water Users Association recently formed to develop a ground water management plan that would protect local interests in the area north of the Sutter Buttes. Another new organization, the Northern California Water Association, was formed to protect the water rights of Sacramento Valley area farmers.

Colusa Basin Drainage and Flooding. The Colusa Basin comprises over 1,000,000 acres of valley floor and foothill lands in the southwest part of the Sacramento Valley. It includes portions of Glenn, Colusa, and Yolo counties. Over 450,000 acres of the valley land within the basin are normally irrigated and it contains about one-third of the total irrigated acreage of the Sacramento Valley.

The basin has historically experienced flooding, drainage, water quality, and subsidence problems. In 1984, a task force was created to develop solutions to basin problems following the passage of SB 674. This legislation authorized DWR's Colusa Basin Appraisal, which was completed in 1990. In 1987, the California Legislature passed the Colusa Basin Drainage District Act, creating a multi-county district to implement solutions to the area's flooding and drainage problems.

The Drainage District Act required that an economically feasible initial plan be developed. In November 1988, the Board of Directors for the Colusa Basin Drainage District was organized and began work on the District's initial plan. DWR's 1990 Colusa Basin Appraisal was used as a guideline for implementing the initial plan. The appraisal concluded that the potential for structural solutions to Colusa Basin problems is limited and recommended that a management plan be implemented to address drainage problems first, then flooding.

The plan in its present form lacks the necessary support to be adopted through a district election, and a vote on the plan is currently not scheduled. The board plans to consider modifications that could broaden the scope of the initial plan to include new district objectives such as water transfers and ground water management. The district has worked to establish a Memorandum of Understanding with the three counties and Reclamation District 2047. Negotiations for these agreements are ongoing but the major area of contention is how much private landowners would be assessed to implement the management plan and which landowners should be included.

Water Quality in Clear Lake. The most severe problem in Lake County is the nutrient-rich character of Clear Lake water. High nutrient levels cause uncontrollable algae growth, with its associated odor and aesthetic problems. Nutrient sources include septic leach lines, sewage treatment plants, and runoff water from upland areas. The predominant blue-green algae form thick mats and scums, which residents and tourists find noxious. Decomposition of the dense algal growths also causes severe dissolved oxygen reduction in the water column, which at times kills fish. Lake County received a Clean Lakes grant from the U.S. EPA to analyze methods for the control of the nuisance algae. The county contracted with the University of California at Davis to conduct this work. Elevated mercury levels have been found in fish from the "Oaks arm" of the lake, prompting DFG to advise against eating fish from the lake. The source of mercury is an abandoned mercury mine at Sulphur Bank near Clear Lake Oaks. In late 1992, the U.S. EPA awarded funds to UCD to investigate the significance of the mercury problem and develop remedial measures.

West Delta Program. DWR is implementing a unique land use management program that could effectively control subsidence and soil erosion on Sherman and Twitchell islands, while also providing significant wildlife/waterfowl habitat values. DWR and DFG have jointly developed the Wildlife Management Plan for Sherman and Twitchell islands to accomplish this objective. The plan is also designed to benefit wildlife species that occupy wetland, upland, and riparian habitat on the islands, and provide recreational opportunities for hunting and wildlife viewing. Property acquired and habitat developed through DWR's contribution will be available for use as mitigation for impacts associated with ongoing DWR Delta water management programs.

This plan would significantly reduce subsidence by minimizing oxidation and erosion of the peat soils on the islands by replacing present farming practices with land use management practices designed to stabilize the soil. Such practices range from minimizing tillage to establishing wetland habitat. Altering land use practices on Sherman and Twitchell islands could provide up to 13,600 acres of managed wildlife and waterfowl habitat and responds directly to the underlying need for additional wetlands, as expressed in national and State policies for wetlands enhancement and expansion. Delta issues are also discussed in the San Joaquin Region chapter.

Water Balance

Water budgets were computed for each Planning Subarea in the Sacramento River Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas, which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table SR-12 presents water demands for the 1990 level and for future water demands to 2020 and compares them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management programs. Regional net water demands for the 1990 level of development totaled 11,734,000 and 11,921,000 af for average and drought years, respectively. Those demands are forecasted to increase to 12,036,000 and 12,238,000 af, respectively, by the year 2020, after accounting for a 25,000-af reduction in urban water demand resulting from implementation of long-term conservation measures.

Urban net water demand is forecasted to increase by about 487,000 af by 2020, due to expected increases in population, while agricultural net water demand is projected to decrease by about 291,000 af, primarily due to changes in cropping patterns. Environmental net water demands, under existing rules and regulations, will increase by 143,000 af, reflecting increased water allocation to wildlife refuges in the Sacramento Valley.

Average annual supplies, including 33,000 af of ground water overdraft, were generally adequate to meet average net water demands in 1990 for this region. However, during drought, present supplies are insufficient to meet present demands by about 961,000 af per year. Without additional water management programs, annual drought year shortages are expected to decrease to about 829,000 af by 2020. This decrease is due primarily to reductions in agricultural water use.

Several environmental improvement actions currently in progress, including implementation of the CVPIA, have proposed increases for instream flow for fisheries that could further reduce the availability of supplies for urban and agricultural use in the region.

Level I water management programs would reduce drought year shortages by only about 14,000 af. The remaining 815,000 af drought shortage requires both additional short-term management programs, and future long-term Level II programs depending on the overall level of water service reliability deemed necessary, by local agencies, to sustain the economic health of the region.

Table SR-12. Water Budget
(thousands of acre-feet)

Water Demand/Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Net Demand								
Urban—with 1990 level of conservation	744	807	922	1,000	1,095	1,186	1,256	1,360
—reductions due to long-term conservation measures (Level I)	—	—	-11	-11	-19	-19	-25	-25
Agricultural—with 1990 level of conservation	6,788	7,394	6,602	7,222	6,506	7,184	6,497	7,049
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Environmental	3,717	3,299	3,860	3,442	3,860	3,442	3,860	3,443
Other[1]	485	421	468	412	465	411	448	411
TOTAL Net Demand	11,734	11,921	11,841	12,065	11,907	12,204	12,036	12,238
Water Supplies w/Existing Facilities								
Developed Supplies								
Surface Water	8,360	8,004	8,467	8,244	8,533	8,410	8,662	8,486
Ground Water	2,496	2,865	2,463	2,985	2,426	3,033	2,491	3,038
Ground Water Overdraft[2]	33	33	—	—	—	—	—	—
Subtotal	10,889	10,902	10,930	11,229	10,959	11,443	11,153	11,524
Dedicated Natural Flow	3,323	2,905	3,323	2,905	3,323	2,905	3,323	2,905
TOTAL Water Supplies	11,734	10,960	11,808	11,167	11,874	11,333	12,003	11,409
Demand/Supply Balance	0	-961	-33	-898	-33	-871	-33	-829
Level I Water Management Programs								
Long-term Supply Augmentation								
Reclaimed[3]	—	—	0	0	0	0	0	0
Local	—	—	0	2	0	3	-6	6
Central Valley Project/ Other Federal	—	—	0	6	0	6	6	6
State Water Project	—	—	0	0	0	0	0	0
***Subtotal* - Level I Water Management Programs**	0	0	0	8	0	9	0	12
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	0	0	0	1	0	2
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	-961	-33	-890	-33	-861	-33	-815

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(3) Because of existing reuse within region, reclaimed water does not add supply to the region.

The Merced River cascades down rocks in Yosemite National Park. The Merced River is one of four in the San Joaquin River Region which have significant instream flow requirements.

San Joaquin River Region

Located in the heart of California, the San Joaquin River Hydrologic 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. It extends from the Delta and the Cosumnes River drainage south to include all of the San Joaquin River watershed. (See Volume I, Chapter 10 for details about the Sacramento-San Joaquin Delta area.) It is rich in natural wonders, including the Yosemite Valley, Tuolumne Meadows, Moaning Caverns, and Calaveras Big Trees. The region comprises about 10 percent of California's land area. (See Appendix C for maps of the planning subareas and land ownership in the region.)

The region is diverse but can be divided into two main topographies and associated climates: (1) the mountain and foothill areas and (2) the valley area. The climates of many of the upland areas west of the valley resemble those of foothills. Precipitation in the mountainous areas varies greatly. The annual precipitation of several Sierra Nevada stations averages about 35 inches. Snowmelt runoff from the mountainous areas is the major contributor to local water supplies for the eastern San Joaquin Valley floor. The climate of the valley floor is characterized by long, hot summers and mild winters, and average annual precipitation ranges from 17 inches in the northeast to 9 inches in the south.

Population

About 5 percent of the State's population lives in the region. From 1980 to 1990, the region's population grew 41 percent, primarily in Merced, Stanislaus, and San Joaquin counties. Communities such as Stockton, Modesto, Merced, and Tracy, once valley farm centers, are now major regional urban centers. These communities and their smaller neighboring cities, such as Lodi, Galt, Madera, and Manteca, are expected to continue expanding into the mostly agricultural northern San Joaquin Valley. Several counties expect their populations to nearly double by 2010.

Some of this growth is due to the expansion from the San Francisco Bay Area and Sacramento. Nine new communities have been proposed for development in southern San Joaquin County, two of which were approved, New Jerusalem and Riverbrook, with proposed populations of 22,000 and 7,000, respectively. As currently proposed, these developments would increase the county's population by about 30,000 people

Region Characteristics

Average Annual Precipitation: *13 inches*   ***Average Annual Runoff:*** *7,933,300 af*

Land Area: *15,950 square miles*   ***1990 Population:*** *1,430,200*

and require about 4,000 acres. The relatively inexpensive housing available in the area offsets the long commute to Bay Area jobs for some San Joaquin County residents. Larger cities such as Stockton and Modesto are industrial and commercial centers in their own right.

In contrast to the large valley urban centers, separated by flat agricultural fields and linked by freeways, the foothills are sprinkled with small communities connected by small two-lane roads. Much of the foothill population lives along the old Mother Lode route of the 1849 Gold Rush, Highway 49. Towns such as Jackson, Angels Camp, San Andreas, Sonora, and Oakhurst have grown significantly in the last decade. Off from the north-south trending Highway 49 is a series of roads that lead to Sierra Nevada mountain passes. These mountain roads (Highways 88, 4, 108, 120) generally follow east-west trending ridges, which are separated by one of the nine major river systems draining the Sierra. The economies of mountain communities along these routes depend on tourist and travel industries. These communities are also retirement areas for many former Bay Area or Southern California residents.

The western side of the region, south of Tracy, is sparsely populated. Small farming communities provide services for farms and ranches in the area, all relatively close to Interstate 5, the chief north-south transportation route in California.

Historically, the economy of the San Joaquin River Region has been based on agriculture. By far, agriculture and food processing are still its major industries. Other major industries include the production of chemicals, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products, and various other commodities. Table SJ-1 shows population projections to 2020 for the San Joaquin River Region.

Table SJ-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Sierra Foothills	140	214	284	357
Eastern Valley Floor	312	376	445	536
Delta Service Area	156	229	315	423
Western Uplands	64	109	150	197
East Side Uplands	44	60	66	92
Valley East Side	653	905	1,192	1,489
Valley West Side	61	82	103	127
West Side Uplands	0	0	0	0
TOTAL	1,430	1,975	2,555	3,221

Land Use

Much of the Sierra Nevada Range is national forest land, while the San Joaquin Valley is predominantly agricultural. In the Sierra Nevada, there are the El Dorado, Stanislaus, and Sierra national forests and Yosemite National Park. The valley constitutes about 3,500,000 acres, the eastern foothills and mountains total 5,800,000 acres, and the western coastal mountains comprise 900,000 acres.

Public lands amount to about one-third of the region. The national forest and park lands encompass over 2,900,000 acres of the region; state parks and recreational areas and other State-owned property account for about 80,000 acres; and Bureau of

Table SJ-2. Major Reservoirs

Reservoir Name	*River*	*Capacity (1,000 AF)*	*Owner*
New Melones	Stanislaus	2,420	U.S. Bureau of Reclamation
New Don Pedro	Tuolumne	2,030	Turlock and Modesto Irrigation Districts
Hetch Hetchy	Tuolumne	360	City of San Francisco
Lake McClure	Merced	1,024	Merced Irrigation District
San Luis	N/A	2,040	USBR and Dept. of Water Resources
Shaver	San Joaquin	135	Southern California Edison
Pardee	Mokelumne	210	East Bay Municipal Utility District
Salt Springs	Mokelumne	142	Pacific Gas & Electric Company
Millerton	San Joaquin	520	U.S. Bureau of Reclamation
Edison	San Joaquin	125	Southern California Edison
Lloyd (Cherry) Lake	Tuolumne	269	City of San Francisco
Mammoth Pool	San Joaquin	123	Southern California Edison
Camanche	Mokelumne	417	East Bay Municipal Utility District
New Hogan	Calaveras	317	U.S. Army Corps of Engineers
Eastman	Chowchilla	150	U.S. Army Corps of Engineers
New Spicer Meadow	Tuolumne	189	CCWD

The U.S. Bureau of Reclamation completed New Melones Dam in 1979, and the reservoir was initially filled in 1983. According to USBR's 1980 New Melones allocation report, this reservoir has an estimated annual additional yield of 180,000 af. None of this yield has been delivered yet. To date, Stockton East Water District has contracted with USBR for 75,000 af of interim water; Central San Joaquin Water District has contracted for 49,000 af of average and drought year supply and 31,000 af of interim New Melones water. Some of the facilities to transport this water were completed in 1993, and 20,000 af was requested by the two districts but no delivery was made because the interim water supply was used to meet CVPIA requirements. Water supplies vary by areas in the region, as discussed below.

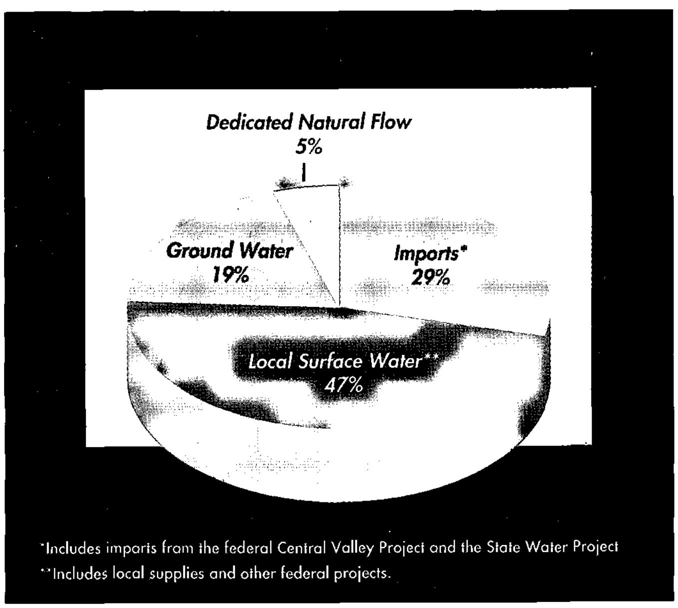
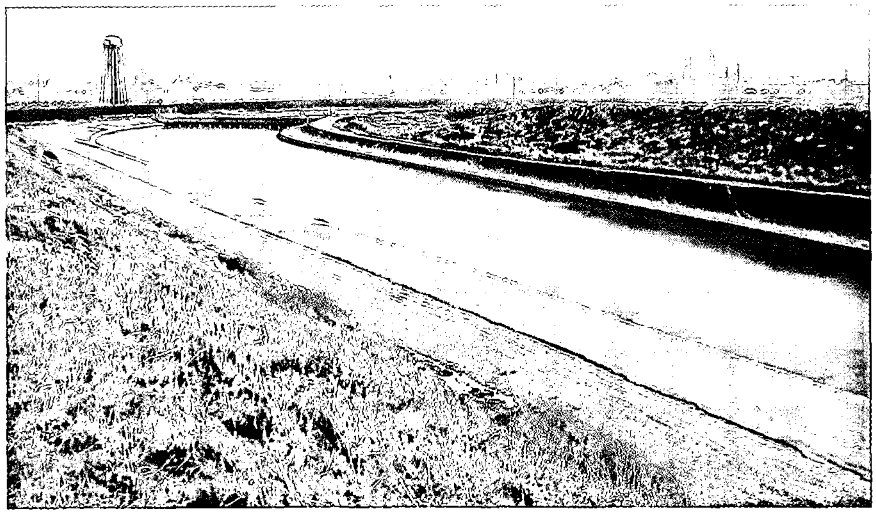


Figure SJ-2. San Joaquin River Region Water Supply Sources (1990 Level Average Conditions)

Mountain and Foothill Areas. The major mountain and foothill areas of the region include the west side Sierra Nevada mountain counties of Mariposa, Tuolumne, Calaveras, Amador, and portions of Alpine and El Dorado. There are dozens of small communities in these counties, generally located along Highway 49. Most of these communities, and the sparse agricultural land in the area, receive their water from local surface supplies. In the 1850s, hydraulic mining for gold and other minerals promoted the construction of an extensive network of canals and ditches to bring water from main rivers and tributaries to the mine sites. When the mining industry waned, power companies, like Pacific Gas and Electric Company, took control of many of these facilities. Today, in addition to supplying water to hydroelectric power plants, these facilities convey water to many of the small mountain communities. For example, in Amador County, the Cosumnes River supplies water to the community of Plymouth and the Mokelumne River supplies water to the communities of Jackson and Ione. In Calaveras County, water is distributed via pipelines and ditches from the Stanislaus and Calaveras rivers to the communities of Angels Camp, Arnold, and Jenny Lind. In Tuolumne County, water from the Lyons Reservoir is diverted to several communities along Highway 108, including Tuolumne, Jamestown, Columbia, and Sonora. Groveland receives water from the Hetch Hetchy system.

In addition to surface water, many of these mountain communities pump ground water from hard rock wells and old mines to augment their surface supplies. Ground water generally is no more than about 15 percent of the total supply for most of them. Valley Springs in Calaveras County is an exception; it relies entirely on ground water for its water needs. The communities of Plymouth and Mariposa had to turn to ground water to supplement surface supplies during the 1976-77 and the 1987-92 droughts. Also, for many mountain residents who are not connected to a water conveyance system, ground water is their only source.



The Delta-Mendota Canal is one of the major canal systems distributing water in the San Joaquin River Region. The canal is part of the Central Valley Project.

Valley Area. The nine major river systems feeding into the valley from the Sierra Nevada provide more than 50 percent of the region's total supply. Irrigation districts transport much of the local surface water to valley agricultural users. Modesto Irrigation District and Turlock Irrigation District supply both agricultural and municipal users through the Modesto and Turlock Canals. Other irrigation districts, such as Merced, Oakdale, and South San Joaquin, operate similar facilities. The Folsom South Canal used to divert about 17,000 af from the American River for cooling at the Rancho Seco Nuclear Power Plant, which has been closed. The canal continues to deliver water for agricultural uses in local districts, such as Galt Irrigation District.

Adding to the valley's surface water supply are three major canal systems: the California Aqueduct, Delta-Mendota Canal, and Madera Canal. The CVP also delivers water from its Mendota Pool, O'Neil Forebay, and Millerton Lake facilities. Only the

Oak Flat Water District receives water from the SWP. Within the Delta service area, agricultural water users pump directly from Delta sloughs and water courses. The City of Stockton can receive up to 25,000-af-per-year surface flows from the New Hogan Reservoir via the Stockton East Pipeline (from Stockton East Water District) in an effort to correct the condition of ground water overdraft in its service area. The community of Tracy receives about 5,000 af annually from the CVP Delta-Mendota Canal.

In an average year, about 19 percent, or 1,307,000 af, of the region's water requirements are met by pumping ground water. Agriculture uses about 70 percent of the ground water pumped. The other 30 percent is used to meet a variety of water demands including urban, rural residential, industrial, and environmental. On the valley floor, the majority of communities, industries, and rural residents rely on ground water as their primary or only source of water supply. Some of the wildlife refuges in the region may also use ground water to supplement their surface water supplies, especially in years of below-normal surface deliveries.

The availability and use of ground water for the region is influenced mainly by water quality problems. The valley floor is essentially one large ground water basin consisting of alluvial sediments. Much of the western portion of the valley is underlain by the Corcoran clay, which generally lies at depths between 100 and 400 feet. The Corcoran clay divides the basin sediments into confined and unconfined aquifers. On the west side, high total dissolved solids and sulfates are found in varying degrees in both the confined and unconfined aquifers. East of the San Joaquin River, the valley is underlain by older, less productive sediments. The shallow ground water quality is generally very good here and several water districts have drainage wells that pump into their distribution systems. However, in some areas of the central and northeastern portion of the valley, nitrates and organic contaminants have been found, mostly localized around point sources.

Ground water overdraft for the 1990 level is estimated at about 209,000 af a year. Areas most affected are found in San Joaquin and Madera counties, with an estimated 70,000 and 45,000 af of overdraft, respectively. Table SJ-3 shows water supplies with existing facilities and water management programs.

Table SJ-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	3,030	2,844	3,011	2,803	2,979	2,781	3,003	2,797
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	1,998	1,388	2,055	1,449	2,066	1,462	2,064	1,462
Other federal	155	34	156	34	158	36	160	37
SWP	5	3	4	3	4	3	4	3
Ground water	1,098	2,145	1,135	2,202	1,156	2,227	1,161	2,252
Overdraft(1)	209	209	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow	331	243	331	243	331	243	331	243
TOTAL	6,826	6,866	6,692	6,734	6,694	6,752	6,723	6,794

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Supply with Additional Facilities and Water Management Programs

The San Joaquin River Region withstood drought conditions by employing several water management options: conservation, exchanges, transfers, and supplementing surface supplies with ground water. In the long run, however, with continued population growth and shifts in types of water use, the region's water resource managers will also look for strategies that increase surface supply reliability and provide for additional recharge of ground water basins. Means of improving water quality will have to be built into these strategies. Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Other than planned SWP additions, there are no other major water supply facilities currently scheduled to come on line by 2020. Table SJ-4 shows water supplies with Level I water management programs.

Table SJ-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	3,030	2,844	3,013	2,804	2,981	2,782	3,005	2,798
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	1,998	1,388	2,055	1,449	2,066	1,462	2,064	1,462
Other federal	155	34	156	34	158	36	160	37
SWP	5	3	5	4	5	3	5	3
Ground water	1,098	2,145	1,132	2,200	1,163	2,236	1,158	2,253
Overdraft(1)	209	209	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow(2)	331	243	431	248	431	248	431	248
TOTAL	6,826	6,866	6,792	6,739	6,804	6,767	6,823	6,801

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(2) Increase in dedicated natural flow reflects implementation of EBMUD Water Supply Management Program.

Water Supply Reliability and Drought Water Management Strategies. From 1987 through 1992, the San Joaquin River Region, like much of California, endured drought conditions. Many of the cities in the region had restricted water use even though ground water is the predominant source of supply. Drought-related problems developed, such as increased pumping depths, well failures, and accelerated degradation of water quality, but generally, there was no substantial reduction in supply. Nevertheless, conservation programs were introduced in nearly all of the region's communities in reaction to the drought. Cities that were completely metered, like Stockton, implemented comprehensive conservation programs. However, a lack of water metering precludes the monitoring or implementing of mandatory rationing in most communities. A number of other practices have been employed, ranging from voluntary water conservation with limitations on outdoor watering to water rationing by allowing little or no outdoor watering. For example, the City of Modesto restricted outdoor water use based on several factors: the season, the day of the week, and the time of day. For indoor water use, the city relied on voluntary water conservation. The cities of Merced, Tracy, and Turlock had programs similar to Modesto. Because of the ability of the east side water agencies, supplying both urban and agricultural users, to supplement reduced surface water allocations with ground water, annual crop acreages remained fairly stable during the drought.

The foothill community of Mariposa relies on surface water and was hit hard by the reduced surface runoff. Its water supply comes from a 440-af water storage reservoir on Stockton Creek. At one point, residents were on a strict rationing program that fluctuated with the available water supply. Per capita restrictions were as low as 100 gallons per day for the first person of a household and 50 gpd for each additional person. In comparison, most San Joaquin Valley residents use ground water, and though most cities were practicing time of day or day of week outdoor watering restrictions and other conservation programs, water consumption still averaged about 250 gpcd.

On the west side of the region, normally about 90 percent of the surface supply is obtained from the CVP. Over 60 percent of this comes by way of exchange contracts for San Joaquin River water which provides farmers with good quality water. These contractors received only 75 percent of their normal entitlements in 1991 and 1992.

Those areas on the west side, which receive contract water from the Delta-Mendota or San Luis Canals, experienced severe cuts in water supply during 1991 and 1992. Only 25 percent of the entitlement amounts were delivered. Many of these areas lacked sufficient ground water pumping capabilities to fully make up for the cuts. There were substantial reductions in cropped acreage and under irrigation of permanent crops, resulting in decreased crop yields. Some State Drought Water Bank water and federal hardship water was used primarily to ensure the survival of permanent crops.

Water Management Options with Additional Facilities. In 1984, the California Legislature authorized the proposed Los Banos Grandes Reservoir in western Merced County as a facility of the SWP. Los Banos Grandes would store water pumped from the Delta through the California Aqueduct during wet months, primarily November through March. Stored water would be released during water-short periods for use by agencies with contracts for water from the SWP. This 1,730,000-af reservoir would help provide a more dependable water supply for the people and farms served by the SWP. (See Volume I, Chapter 11.) Although only one water district in the region could benefit directly, the reservoir would provide other indirect benefits to the area, such as recreational opportunities and supplemental flood protection. The feasibility of the reservoir is being reevaluated in the light of proposed Delta standards and requirements of Delta smelt and winter-run salmon biological opinions.

The Mariposa Public Utility District in Mariposa County is developing the Saxon Creek Water Project, which will bring additional water to the 2,000 residents living within the district. The project involves tapping the Merced River and delivering water via a pipeline. The project is small, about 900 af annually at full development, but important to the community of Mariposa. It will help to provide a reliable water supply in an area that is already straining its water resources.

Water Use

Agricultural water demand is about 85 percent of the region's total demand of 6,826,000 af. Urban demand, which includes urban residential, industrial, and rural residential, comprises approximately 5 percent of total demand. Environmental water use for the region's wetlands and instream fishery requirements represent about 8 percent of the total water demand. Other water use includes recreation, water used for power plant cooling, and water lost during conveyance; this category constitutes about 2 percent of total demand. Figure SJ-3 shows net water demand for the 1990 level of development.

Urban Water Use

The 1990 level urban applied water demand in the region totaled almost 495,000 af, an increase of about 91,000 af since 1980. This increase was primarily due to an increase in population. Average per capita water use is about 309 gallons per day. Per capita values range from about 350 gallons per day in Modesto, one of the larger cities, to 200 gallons per day and less in small communities like Dos Palos and Riverbank. Higher per capita water use in communities like Modesto is generally due to a high concentration of industries. In the case of Modesto, food processing comprises a large segment of the industrial activity. Figure SJ-4 shows the 1990 level urban applied water use by sector. Table SJ-5 shows applied water and net urban water demand to 2020.

Most urban water supply agencies in the region do not meter deliveries to residential customers. Generally, commercial and industrial deliveries are metered. Outdoor use probably accounts for about one-half of total urban use for most of the region. Warm summers and associated high water requirements for landscaping are the main factors behind this region's urban water use being higher than the statewide average.

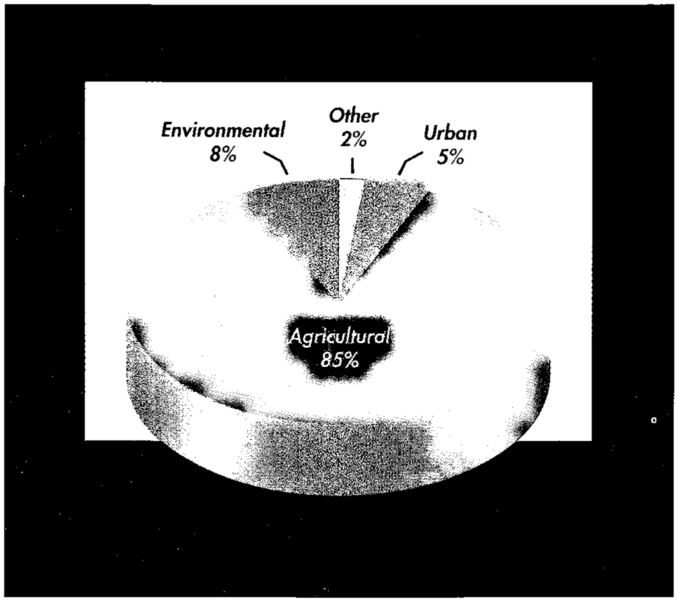


Figure SJ-3. San Joaquin River Region Net Water Demand (1990 Level Average Conditions)

Population projections indicate that more than twice as many people would reside in the San Joaquin River Region by 2020. Such growth is expected to drive the conversion of some agricultural lands to urban development. This may further stretch water supplies in some areas, or just shift water use from agricultural to urban. Given these population increases, urban net water demand could double by 2020.

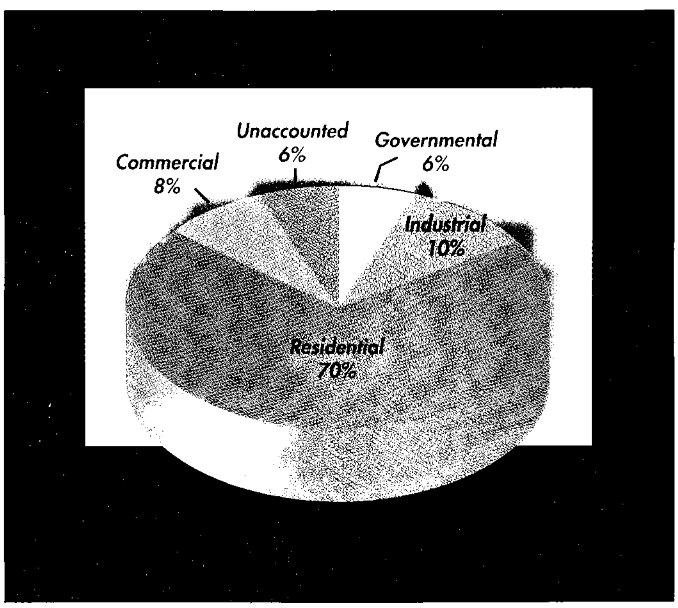


Figure SJ-4. San Joaquin River Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

Table SJ-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Sierra Foothills								
Applied water demand	36	40	54	59	71	77	87	95
Net water demand	38	43	56	62	73	80	89	98
Depletion	10	11	15	16	20	22	25	27
Eastern Valley Floor								
Applied water demand	80	84	97	105	114	124	134	147
Net water demand	80	84	97	105	114	124	134	147
Depletion	23	24	27	30	32	35	39	42
Delta Service Area								
Applied water demand	35	37	50	54	65	71	85	92
Net water demand	35	37	50	54	65	71	85	92
Depletion	10	10	14	16	19	21	25	27
Western Uplands								
Applied water demand	37	38	45	46	51	53	59	60
Net water demand	37	38	45	46	51	53	59	60
Depletion	4	4	6	6	8	8	10	11
East Side Uplands								
Applied water demand	11	11	15	15	16	16	23	23
Net water demand	5	5	6	6	7	7	10	10
Depletion	5	5	6	6	7	7	10	10
Valley East Side								
Applied water demand	279	280	378	381	493	497	605	610
Net water demand	149	150	202	205	263	267	322	327
Depletion	131	131	178	179	232	233	284	286
Valley West Side								
Applied water demand	17	17	24	24	29	29	36	36
Net water demand	9	9	12	12	14	14	18	18
Depletion	9	9	12	12	14	14	17	17
West Side Uplands								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	495	507	663	684	839	867	1,029	1,063
Net water demand	353	366	468	490	587	616	717	752
Depletion	192	194	258	265	332	340	410	420

Agricultural Water Use

Agriculture accounts for 85 percent of the total applied water in the San Joaquin Region. The industry can best be described as widely diverse. Major crops in the region that encompass over 100,000 acres each are alfalfa, almonds, grapes, grain, corn, and cotton. Table SJ-6 shows irrigated crop acreage for the region to 2020. Table SJ-7 shows 1990 crop acreages and evapotranspiration of applied water. Figure SJ-5 shows crop acreages, ETAW, and applied water for major crops.

Table SJ-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Sierra Foothills								
Applied water demand	20	24	22	26	25	34	29	34
Net water demand	17	21	19	23	22	31	26	31
Depletion	15	17	16	19	20	25	21	25
Eastern Valley Floor								
Applied water demand	886	1,038	850	996	823	946	809	946
Net water demand	873	1,027	827	987	791	903	778	903
Depletion	639	749	630	737	621	717	614	717
Delta Service Area								
Applied water demand	739	830	719	805	694	774	681	755
Net water demand	690	772	673	749	650	721	639	705
Depletion	552	620	542	606	532	591	522	578
Western Uplands								
Applied water demand	40	47	38	44	36	42	34	40
Net water demand	43	49	40	46	38	44	37	42
Depletion	30	35	29	34	28	32	27	31
East Side Uplands								
Applied water demand	7	7	7	7	7	7	7	7
Net water demand	4	4	4	4	4	4	4	4
Depletion	4	4	4	4	4	4	4	4
Valley East Side								
Applied water demand	3,193	3,366	3,059	3,230	2,926	3,086	2,841	3,012
Net water demand	2,840	2,995	2,726	2,881	2,608	2,757	2,533	2,691
Depletion	2,340	2,468	2,271	2,398	2,200	2,326	2,138	2,269
Valley West Side								
Applied water demand	1,413	1,445	1,357	1,392	1,306	1,338	1,264	1,286
Net water demand	1,311	1,349	1,272	1,277	1,233	1,235	1,198	1,196
Depletion	1,139	1,171	1,113	1,111	1,085	1,082	1,057	1,054
West Side Uplands								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	6,298	6,757	6,052	6,500	5,817	6,227	5,665	6,080
Net water demand	5,778	6,217	5,561	5,967	5,346	5,695	5,215	5,572
Depletion	4,719	5,064	4,605	4,909	4,490	4,777	4,383	4,678

Environmental Water Use

The region contains wildlife refuges, wetlands, and stretches of rivers that are designated Wild and Scenic under the California Wild and Scenic Rivers Act. The Grasslands area in western Merced County is an important stop along the Pacific Flyway for migrating waterfowl. In addition to the Grasslands area, there are ten other major wetlands that contribute to the region's environmental water demands. Water for conserving these wildlife habitats accounts for about 3 percent of the region's total net water demand. Refuges also provide areas for recreational use, a habitat for native vegetation, and flood and erosion control. Table SJ-9 summarizes forecasted wetland water needs for the region.

Instream flows are waters flowing in a natural stream channel providing vital support for fisheries. Four rivers in the region, the Mokelumne, Merced, Stanislaus, and Tuolumne, have significant instream flow requirements. (See Volume I, Chapter 8.) The region's annual water requirement for instream flows is 331,000 af. Table SJ-10 summarizes environmental instream needs for the region. In addition, the following minimum instream flows are required which are not included in Table SJ-10. At Merced Falls on the Merced River, 3 cubic feet per second is required for the minimum flow through the fish ladder. Below New Exchequer Dam on the Merced River, DFG requires annual flow release of 180 to 220 cfs during November 1 to April 1, plus spring flushing flows.

The California Wild and Scenic Rivers Act of 1972 provides for the preservation of the natural watercourse and character of certain rivers in the State. In the San Joaquin River Region portions of the Tuolumne and Merced rivers are designated wild and scenic. The upper stretch of the Tuolumne River, below Hetch Hetchy Reservoir and above New Don Pedro Reservoir, was designated wild and scenic in 1984. In 1992, a bill was passed designating an eight-mile stretch of the Merced River from Briceburg to Bagby as wild and scenic. Much of the river was already given this status in 1987. In addition to protecting the river from development, the 1992 bill allows the county to proceed with the Saxon Creek Water Project, providing a reliable water supply to the community of Mariposa. Waterways designated as wild and scenic are protected by law from the construction of dams or diversion structures that would alter the natural free-flowing character of these rivers. The Saxon Creek Project involves pumping water from the Merced River at times when flows are high enough that the waterway would not be adversely affected. The region's current environmental net water demands are about 554,000 af annually; this is expected to increase by 21 percent to 670,000 af annually by 2020.

Table SJ-9. Wetland Water Needs
(thousands of acre-feet)

Wetland	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Cosumnes River Preserve								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
San Luis NWR								
Applied water demand	13	13	19	19	19	19	19	19
Net water demand	11	11	15	15	15	15	15	15
Depletion	11	11	15	15	15	15	15	15
Merced NWR								
Applied water demand	14	14	16	16	16	16	16	16
Net water demand	11	11	13	13	13	13	13	13
Depletion	11	11	13	13	13	13	13	13
Volta WA								
Applied water demand	10	10	16	16	16	16	16	16
Net water demand	8	8	13	13	13	13	13	13
Depletion	8	8	13	13	13	13	13	13
Los Banos WA								
Applied water demand	17	17	25	25	25	25	25	25
Net water demand	13	13	20	20	20	20	20	20
Depletion	13	13	20	20	20	20	20	20
Los Banos-Wolfson Refuge								
Applied water demand	7	7	7	7	7	7	7	7
Net water demand	6	6	6	6	6	6	6	6
Depletion	6	6	6	6	6	6	6	6
Kesterson NWR								
Applied water demand	4	4	10	10	10	10	10	10
Net water demand	3	3	8	8	8	8	8	8
Depletion	3	3	8	8	8	8	8	8
Grassland RCD								
Applied water demand	125	125	180	180	180	180	180	180
Net water demand	100	100	144	144	144	144	144	144
Depletion	100	100	144	144	144	144	144	144
East Grassland Refuge								
Applied water demand	38	38	38	38	38	38	38	38
Net water demand	31	31	31	31	31	31	31	31
Depletion	31	31	31	31	31	31	31	31
Kesterson Mitigation Refuge								
Applied water demand	0	0	62	62	62	62	62	62
Net water demand	0	0	49	49	49	49	49	49
Depletion	0	0	49	49	49	49	49	49
Delta Refuge								
Applied water demand	40	40	40	40	40	40	40	40
Net water demand	40	40	40	40	40	40	40	40
Depletion	7	7	7	7	7	7	7	7
TOTAL								
Applied water demand	268	268	413	413	413	413	413	413
Net water demand	223	223	339	339	339	339	339	339
Depletion	190	190	306	306	306	306	306	306

Table SJ-10. Environmental Instream Water Needs
(thousands of acre-feet)

Stream	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Mokelumne River								
Applied water demand	14	14	14	14	14	14	14	14
Net water demand	14	14	14	14	14	14	14	14
Depletion	0	0	0	0	0	0	0	0
Merced River								
Applied water demand	84	67	84	67	84	67	84	67
Net water demand	84	67	84	67	84	67	84	67
Depletion	0	0	0	0	0	0	0	0
Stanislaus River								
Applied water demand	110	98	110	98	110	98	110	98
Net water demand	110	98	110	98	110	98	110	98
Depletion	0	0	0	0	0	0	0	0
Tuolumne River								
Applied water demand	123	64	123	64	123	64	123	64
Net water demand	123	64	123	64	123	64	123	64
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	331	243	331	243	331	243	331	243
Net water demand	331	243	331	243	331	243	331	243
Depletion	0	0	0	0	0	0	0	0

Other Water Use

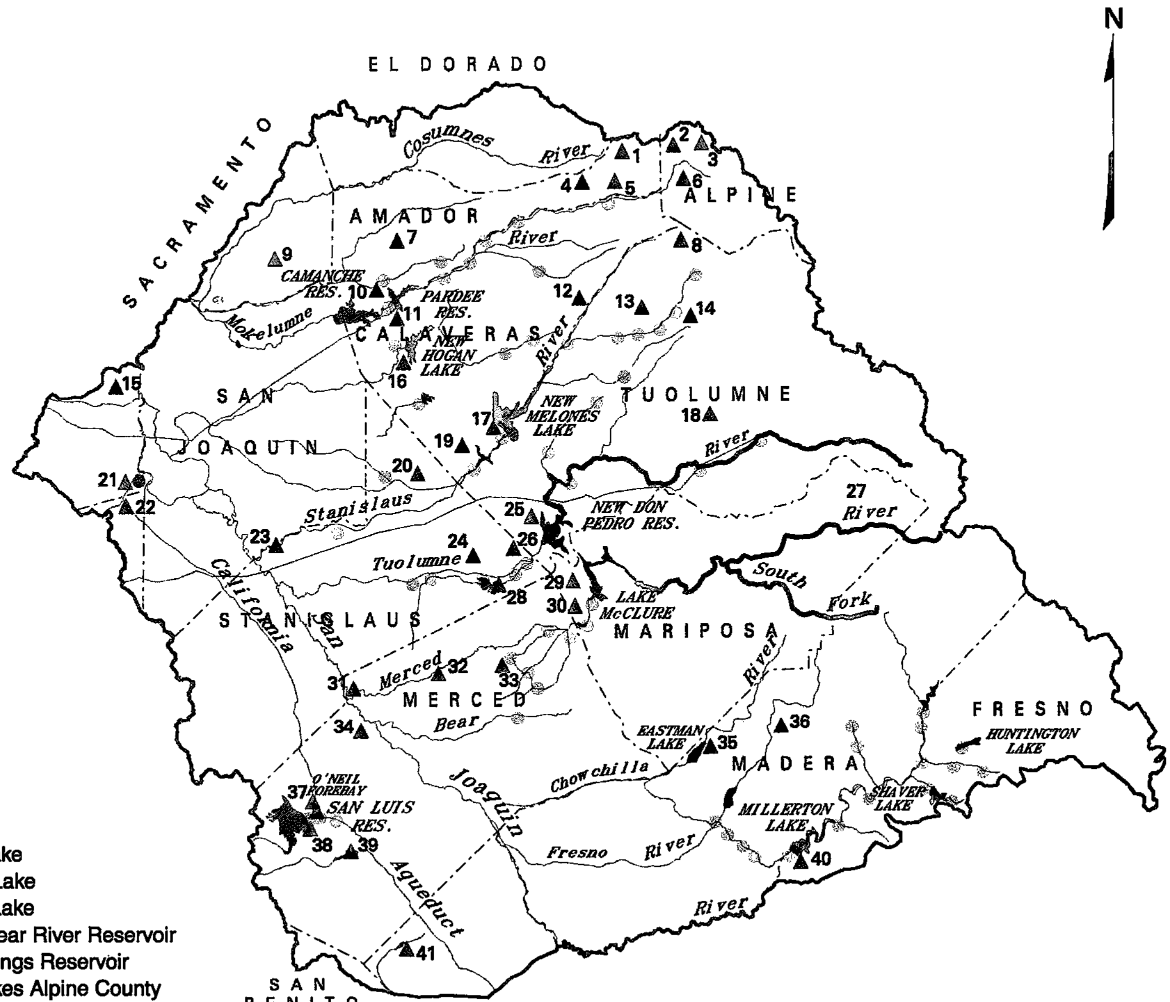
Recreation in the national forests and Yosemite National Park includes camping, hiking, snow skiing, white water rafting, hunting, bike riding, rock climbing, and spelunking, to name only a few. An estimated 4 million visitors from all over the world toured Yosemite in 1992.

San Luis, New Melones, and New Don Pedro reservoirs, and Lake McClure are just four of the region's many public access reservoirs that provide facilities for boating, swimming, water skiing, wind surfing, and fishing. Near the City of Los Banos, in western Merced County, is the Grasslands area where several public and private wildlife refuges provide areas for waterfowl hunting, fishing, and nature study. Figure SJ-6 shows water recreation areas in the San Joaquin River Region.

Water used in the region's recreation areas amounted to 4,500 af in 1990. Most of it was distributed to campgrounds for drinking water and sanitation. Other minor usage in the region includes water for power plant cooling, 20,000 af annually. Together these make up about 1 percent of the total regional demand. Table SJ-11 shows the total water demand for the region.

Figure SJ-6. San Joaquin River Region

Hydroelectric Power Plants, Wild and Scenic Rivers, and Water Recreation Areas



1. Silver Lake
2. Caples Lake
3. Woods Lake
4. Lower Bear River Reservoir
5. Salt Springs Reservoir
6. Blue Lakes Alpine County
7. Lake Amador
8. Highland Lake
9. Rancho Seco Park
10. Lake Camanche
11. Pardee Reservoir
12. Calaveras Big Trees
13. Hartley Lake
14. Pinecrest Lake
15. Franks Tract S.R.A.
16. New Hogan Reservoir
17. New Melones Reservoir
18. Cherry Lake
19. Lake Tulloch
20. Woodward Reservoir R.P.
21. Clifton Court Forebay R.A.
22. Bethany Reservoir S.R.A.
23. Caswell Memorial S.P.
24. Modesto Reservoir R.P.
25. New Don Pedro Reservoir
26. La Grange R.P.
27. Yosemite National Park
28. Turlock Lake S.R.A.
29. Lake McClure
30. Lake McSwain
31. George Hatfield S.R.A.
32. McConnell S.R.A.
33. Lake Yosemite
34. Fremont Ford S.R.A.
35. Eastman Lake
36. Bass Lake
37. O'Neill Forebay R.F.
38. San Luis Reservoir S.R.A.
39. Los Banos Reservoir R.F.
40. Millerton Lake S.R.A.
41. Little Panoche Reservoir R.F.

Legend

▲ Water Recreation Area

● Hydroelectric Power Plant*

— Federal Wild and Scenic River

0 10 20 30

SCALE IN MILES

*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

Table SJ-11. Total Water Demands
(thousands of acre-feet)

Category of Use	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Urban								
Applied water demand	495	507	663	684	839	867	1,029	1,063
Net water demand	353	366	468	490	587	616	717	752
Depletion	192	194	258	265	332	340	410	420
Agricultural								
Applied water demand	6,298	6,757	6,052	6,500	5,817	6,227	5,665	6,080
Net water demand	5,778	6,217	5,561	5,967	5,346	5,695	5,215	5,572
Depletion	4,719	5,064	4,605	4,909	4,490	4,777	4,383	4,678
Environmental								
Applied water demand	599	511	744	656	744	656	744	656
Net water demand	554	466	670	582	670	582	670	582
Depletion	190	190	306	306	306	306	306	306
Other[1]								
Applied water demand	24	24	36	36	48	48	48	48
Net water demand	141	141	148	148	161	162	161	162
Depletion	84	84	84	84	84	84	84	84
TOTAL								
Applied water demand	7,416	7,799	7,495	7,876	7,448	7,798	7,486	7,847
Net water demand	6,826	7,190	6,847	7,187	6,764	7,055	6,763	7,068
Depletion	5,185	5,532	5,253	5,564	5,212	5,507	5,183	5,488

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Issues Affecting Local Water Resource Management

Each area of the San Joaquin River Region has its own set of geographic and demographic conditions which present several water management issues. For example, during the 1987-92 drought, the Valley West Side planning subarea experienced severe shortages, primarily due to cutbacks in CVP water deliveries. This predominantly agricultural area receives about 95 percent of its total water supply from the CVP. The cutbacks prompted nine water-supplying agencies in the PSA to purchase a total of 2,630 af in 1992 from the State Drought Water Bank. For the most part, the municipal and industrial water demands are met by pumping ground water, and these demands have been met satisfactorily. However, meeting the demands during the drought increased pumping costs and accelerated ground water deterioration in some areas.

Legislation and Litigation

Statutes and court decisions have influenced water allocation and use in the San Joaquin River Region considerably. An overview of the major statutes and proceedings follows.

Bay-Delta Proceedings. In July 1978, the State Water Resources Control Board began hearings to adopt a water quality control plan and water rights decision for the Bay–Delta estuary. In addition, several other regulatory actions affecting the Bay-Delta have taken place, which are discussed in Volume I, Chapters 2 and 10.

South Delta Water Agency Lawsuit. In July 1982, SDWA filed a lawsuit claiming that SWP and CVP operations harmed their agricultural production by causing low water levels, poor water quality, and poor circulation. In October 1986, DWR, USBR, and SDWA signed an agreement solidifying a framework for settling the litigation. As a result of the agreement, during 1986 through 1993, DWR implemented operational criteria regarding Clifton Court gate openings, completed dredging and installed siphons in Tom Paine Slough, and constructed the Middle River barrier to improve water levels, circulation, and quality within parts of the SDWA area.

Continuing negotiations resulted in a draft long-term contract in 1990. The contract commits the three agencies to constructing and operating three permanent barriers—Middle River, Old River near Tracy, and Grant Line Canal—after a period of testing.

Other Litigation. Litigations affecting water resources management of the San Joaquin River Region include the following: (1) Stockton East Water District, Central San Joaquin Water Conservation District, the City of Stockton, San Joaquin County, and California Water Service Company have challenged the USBR's refusal to deliver water from the New Melones Project as well as implementation of the CVPIA by the United States; (2) Westlands Water District, San Benito County Water District, San Luis Water District, and Panoche Water District are raising similar challenges for implementation of the CVPIA by the USBR (*Westlands Water District v. United States*); and (3) the Natural Resources Defense Council has challenged the USBR that the Friant Project must make releases pursuant to Fish and Game Code Section 5937.

Delta Levees. More than 1,000 miles of levees act as the only barriers between land and water in the Delta. Behind these earthen walls lie over half a million acres of agricultural land and valuable wildlife habitat, many small communities, numerous roads, railroad lines, and utilities. With each passing year, the promise of protection provided by these levees grows weaker. The Delta islands, which commonly lie 10 to 15 feet below sea level and are composed mainly of highly organic (peat) soils, are constantly in danger of land subsidence and seepage.

The original levees were constructed in the late 1800s with heights of about 4 feet and founded on the soft, organic Delta soils. Due to continued subsidence of the levees and island interiors, it was necessary to continually add material to maintain freeboard and structural stability. Over the last century, the levees have significantly increased in size and are now between 15 and 25 feet high.

Several active faults, for example, the Antioch, Greenville, and Coast Range Sierra Nevada Boundary Zone faults, are west of the Delta and are capable of delivering moderate to large shaking. There has been ongoing concern about the potential for liquefaction of the Delta levees and of the foundation materials on some islands. However, there is no record of a levee failure resulting from earthquake shaking, meaning the levee system has not really been tested for earthquake shaking. Several studies indicate there would probably be levee damage or failure induced by earthquake shaking within the next 30 years. Further investigations are needed to better define the expected performance of the levees.

Delta levees are classified as either "project" or "nonproject." Project levees are part of the Sacramento River and San Joaquin River Flood Control Projects. Mostly found along the Sacramento and San Joaquin rivers, they are maintained to U.S. Army Corps of Engineers standards and generally provide dependable protection. Nonproject, or local, levees (65 percent of Delta levees) are those constructed and maintained to varying degrees by island landowners or local reclamation districts.

Most of these levees have not been brought up to federal standards and are less stable, increasing the area's chances of flooding.

The Delta Levee Subventions Program, originally known as the "Way Bill" program, began in 1973. The bill authorized funding, which grew from $200,000 annually in the 1970s to $2 million annually in the 1980s, for levee maintenance and rehabilitation costs with up to 50 percent reimbursement to local agencies.

Since 1980, 17 islands have been partially or completely flooded, costing roughly $100 million dollars for recovering property and completing repairs. As a result of 1986 floods, the Delta Flood Protection Act of 1988, Senate Bill 34, was enacted. It provides $12 million a year for 10 years for the long-standing Delta Levees Subventions Program and for developing special flood control programs to protect eight western Delta islands and the communities of Walnut Grove and Thornton.

Senate Bill 34 was enacted partly because of a commitment the State made in its 1983 Hazard Mitigation Plan for the Delta. (Hazard Mitigation Plans are required by the Federal Emergency Management Agency.) The plan recommended an increase in funding to the Subventions program to aid the districts in maintaining and upgrading their levees to minimum standards until a major federal levee rehabilitation project could be implemented. Through SB 34, legislative intent for funding the Delta Subventions program increased up to $6 million a year and allows up to 75-percent reimbursement to the local agencies for their levee work. The other $6 million is for implementing special flood control projects. Recent activities include planning and designing major levee rehabilitation projects on Twitchell Island and New Hope Tract, repairing threatened levee sites on Sherman Island, Twitchell Island, Bethel Island, and Webb Tract, and other special projects and studies to determine the causes of Delta land subsidence. On Twitchell Island, a five-mile reach of levees along the San Joaquin River has been significantly upgraded.

In 1991, the U.S. Army Corps of Engineers, DWR, and the Reclamation Board signed an agreement to work further toward solving Delta flood control and environmental problems. The agreement calls for a six-year special study that will define the extent of federal interest in implementing a long-term flood control plan for the Delta. The study will attempt to find long-term solutions to Delta problems after SB 34 lapses in 1999.

San Joaquin River Management Program. The San Joaquin River Management Program was created to address the needs of the San Joaquin River system. Existing conditions on the San Joaquin River do not fully satisfy present water supply, water quality, flood protection, fisheries, wildlife habitat, and recreational needs. Continuing present river management practices would further deteriorate the river system, adversely affecting all users. On September 18, 1990, the Governor signed Assembly Bill 3603 (Chapter 1068, 1990 statutes), which charges SJRMP with the following:

- Provide a forum where information can be developed and exchanged to provide for the orderly development and management of the water resources of the San Joaquin River system.
- Identify actions which can be taken to benefit legitimate uses of the San Joaquin River system.
- Develop compatible solutions to water supply, water quality, flood protection, fisheries, wildlife habitat, and recreation needs.

Regional Issues

West-Side Drainage Problem. On the west side of the region, over 100,000 acres of land are underlain by shallow, semi-impermeable clay layers that prevent water from percolating downward. Inadequate drainage and accumulating salts have been long-standing problems in this area of the valley. With the importation of irrigation water from northern California during the last 20 years, the problem has intensified. Where water tables are high, subsurface drainage is necessary to remove and dispose of the water.

In 1984, the San Joaquin Valley Drainage Program was established as a joint federal-State effort to investigate drainage and drainage-related problems. In 1990, the SJVDP published its recommended plan for managing the west side drainage problem, and at the end of 1991, a Memorandum of Understanding was executed that allows federal and State agencies to coordinate activities for implementing the plan. Work on this program is ongoing.

Ground Water Quality—Radon. Concentrations of radioactive elements in ground water vary widely throughout the Sierra Nevada. Radon is a radioactive gas generated by naturally occurring uranium deposits in the earth's crust. Radon is not a problem in surface water because the gas is released to the atmosphere. It can be found in outdoor air and can seep into homes through basements or foundations. Ground water can also release the odorless radon gas when residents wash dishes or the laundry, or when they shower. Inhalation of radon's decay products increases the risk of lung cancer.

According to the U.S. Environmental Protection Agency, radon is the second leading cause of lung cancer in the United States. In October 1990, DWR published *Natural Radioactivity in Ground Water of the Western Sierra Nevada*, which reported the quality of water sampled from 20 wells in the mountain and foothill areas of Mariposa and Madera counties. The highest concentrations of radon, uranium, and radium are found in wells drilled in granitic rock, while lower concentrations are associated with metamorphic rock formations. A notable radon and uranium "hot spot" in the region is near Bass Lake in Madera County. Granitic rock formations can be found in Alpine, Amador, Calaveras, El Dorado, and Tuolumne counties.

Water Balance

Water budgets were computed for each Planning Subarea in the San Joaquin River Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas, which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table SJ-12 presents water demands for the 1990 level and for future water demands to 2020 and compares them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management programs.

Table SJ-12. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	353	366	477	499	603	632	737	772
—reductions due to long-term conservation measures (Level I)	—	—	−9	−9	−16	−16	−20	−20
Agricultural—with 1990 level of conservation	5,778	6,217	5,571	5,977	5,365	5,714	5,245	5,602
—reductions due to long-term conservation measures (Level I)	—	—	−7	−7	−13	−13	−20	−20
—reductions due to land retirement in poor drainage areas of San Joaquin Valley (Level 1)	—	—	−3	−3	−6	−6	−10	−10
Environmental	554	466	670	582	670	582	670	582
Other[1]	141	141	148	148	161	162	161	162
TOTAL Net Demand	6,826	7,190	6,847	7,187	6,764	7,055	6,763	7,068
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	5,188	4,269	5,226	4,289	5,207	4,282	5,231	4,299
Ground Water	1,098	2,145	1,135	2,202	1,156	2,227	1,161	2,252
Ground Water Overdraft[3]	209	209	—	—	—	—	—	—
Subtotal	0	0	0	0	0	0	0	0
Dedicated Natural Flow	331	243	331	243	331	243	331	243
TOTAL Water Supplies	6,826	6,866	6,692	6,734	6,694	6,752	6,723	6,794
Demand/Supply Balance	0	−324	−155	−453	−70	−303	−40	−274
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed[5]	—	—	0	0	0	0	0	0
Local	—	—	2	1	2	1	2	1
Central Valley Project	—	—	0	0	0	0	0	0
State Water Project	—	—	1	1	1	0	1	0
***Subtotal* - Level I Water Management Programs**	0	0	3	2	3	1	3	1
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	−3	−2	7	9	−3	1
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	−324	−155	−453	−60	−293	−40	−272

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.
(5) Because of existing reuse within region, reclaimed water does not add supply to the region.

Regional net water demands for the 1990 level of development totaled 6,826,000 and 7,190,000 af for average and drought years, respectively. Those demands are forecasted to decrease slightly to 6,763,000 and 7,068,000 af, respectively, by the year 2020. This decrease accounts for a 20,000-af reduction in urban water demand resulting from implementing long-term conservation measures, a 20,000-af reduction in agricultural demand resulting from additional long-term agricultural water conservation measures, and a 10,000-af reduction due to land retirement in poor drainage areas.

Urban net water demand is forecasted to increase by about 364,000 af by 2020, due to expected increases in population. Agricultural net water demand is forecasted to decrease by about 563,000 af, primarily due to lands being taken out of production because of ubanization of irrigated lands and land retirement. Environmental net water demands, under existing rules and regulations, will increase 116,000 af over the next 30 years, reflecting increased supplies for managed wetlands resulting from implementing the CVPIA. However, there are several actions currently in progress, including further implementation of the CVPIA, that have proposed increases in instream flow for fisheries that will affect the availability of supplies for urban and agricultural use now and in the future.

Urban and environmental water demands will increase over the next 30 years, but the agricultural water demand will decrease significantly causing total net water demand for the region to decrease for both average and drought conditions. The majority of the decrease will come from the southern half of the region.

Future average annual supplies are not adequate to meet average net water demands in the San Joaquin Region, resulting in shortages of about 40,000 af by 2020. During drought conditions, substantial shortages occur at the 1990 level of development, as was evident during the 1987-92 drought. Drought year shortages are forecasted to decrease to about 272,000 af at the 2020 level of development due to reduced water demands and implementation of Level I water management programs.

In the Eastern Valley Floor PSA distribution and conveyance facilities to receive New Melones water are nearly completed; some segments which are completed could have received water in 1993 from New Melones Reservoir, but no deliveries were made. Two area water districts have contracts with USBR for 155,000 af, 106,000 af interim, and 49,000 af average and drought years, of New Melones Project water. If the districts receive additional surface supply, this PSA could rely less on ground water pumping, thereby reducing ground water overdraft. However, with the CVPIA requirements on New Melones supplies, it is unknown how much water is available to meet the 155,000-af contracts.

Total agricultural and urban net water demands in the Valley East Side PSA are expected to decrease 134,000 af by 2020. Existing surface and ground water supplies should meet future demands. Ground water overdraft could also be reduced or eliminated in this planning subarea.

The Valley West Side PSA supplies are mainly imported from the Delta by the CVP. Changes in CVP Delta supplies will affect the Valley West Side's ability to meet future demands.

The San Joaquin River Region depends on exports from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on D-1485 operating criteria for Delta supplies and do not take into account recent actions to protect aquatic species in the estuary. As such, regional water supply shortages are understated.

Year 2020 average and drought years shortages require both additional short-term drought management, water transfers and demand management programs, and future long-term Level II programs depending on the overall level of water service reliability deemed necessary. In the short-term, some areas of this region that rely on the Delta exports for all or a portion of their supplies face great uncertainty in terms of water supply reliability due to the uncertain outcome of actions undertaken to protect aquatic species in the Delta. For example, in 1993, an above normal runoff year, environmental restrictions limited CVP deliveries to 50 percent of contracted supply for federal water service contractors from Tracy to Kettleman City. Because ground water is used to replace much of the shortfall in surface water supplies, limitations on Delta exports will exacerbate ground water overdraft in this region.

This mature almond orchard is in Kern County. Almond and pistachio orchards typically use about 2.5 acre-feet of applied water per acre.

Tulare Lake Region

The Tulare Lake Region includes the southern San Joaquin Valley from the southern limit of the San Joaquin River watershed to the crest of the Tehachapi Mountains. It stretches from the Sierra Nevada Crest in the east to the Coast Range in the west. Many small agricultural communities dot the eastern side of the valley, and the rapidly growing cities of Fresno and Bakersfield anchor the region, which encompasses almost 10 percent of the State's total land area. (See Appendix C for maps of the planning subareas and land ownership in the region.)

Four main geographical areas make up this mostly agricultural region: the western side of the San Joaquin Valley floor, the Sierra Nevada foothills on the region's eastern side, the central San Joaquin Valley floor, and the Kern Valley floor. The major rivers in the region, the Kings, Kaweah, Tule, and Kern, begin in the Sierras and generally flow east to west into the San Joaquin Valley. They are sustained by snow melt from the upper mountain elevations. The Kern River follows a more north-south alignment for much of its path. All of the rivers terminate on the valley floor in lakes or sinks; water does not find its way to the ocean from the basin, as it once did under natural conditions, except in extremely wet years. There is also a considerably large drainage area on the west and south sides of the valley, but scant rainfall has not produced water development there.

The region's climate varies between valley and foothill areas. The valley areas experience mild springs and hot, dry summers. Winters are typically cold with some temperatures below freezing, but snowfall is rare. In some parts of the valley, thick tule fog is common at times during the winter. Climate in the foothills is typical of mountainous foothill areas where winters and springs are cold and where snowfall occurs at higher elevations.

Most of the region's winter and spring runoff is stored for later use in the summer for supplying the drier valley floor areas. In most years, imported water from northern California supplements local supplies to meet the region's large agricultural water demand.

Population

Population in the region increased substantially in the 1980s, led by 50- to 60-percent growth in the Fresno, Bakersfield, and Visalia-Tulare urban areas. Fresno's

Region Characteristics

Average Annual Precipitation: *14 inches* ***Average Annual Runoff:*** *3,313,500 af*

Land Area: *16,520 square miles* ***1990 Population:*** *1,554,000*

population, which had one of the highest growth rates among large metropolitan areas in the United States during the 1980s, grew by more than 60 percent—from 217,000 in 1980 to 354,000 in 1990. A high birth rate contributed to this growth and relatively low-cost housing encouraged immigration from out-of-state as well as from the San Francisco Bay and Los Angeles areas.

The region's population is projected to more than double in the next 30 years. Most of the future growth is expected in Fresno, the Visalia-Tulare area, and Bakersfield. Limited population growth is projected in the foothill communities. Little economic growth is expected there and limited ground water supplies will most likely restrict urban development. Table TL-1 shows population projections to 2020 for the Tulare Lake Region.

Table TL-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Uplands	55	81	117	158
Kings-Kaweah-Tule	1,022	1,411	1,827	2,327
San Luis West Side	39	52	60	68
Western Uplands	7	10	14	18
Kern Valley Floor	431	612	754	929
TOTAL	1,554	2,166	2,772	3,500

Land Use

The State and federal governments own about 3 percent of the land in the region, including 1.7 million acres of national forest, 0.8 million acres of national parks and recreation areas, and 0.5 million acres of land managed by the U.S. Bureau of Land Management. The region's foothills border Kings Canyon and Sequoia National Parks and Sierra National Forest. Privately owned land totals about 7.4 million acres. Irrigated agriculture accounts for more than 3 million acres of the private land, while urban areas take up 176,300 acres. Other agricultural lands and areas with native vegetation cover an additional 1,400,000 acres. The principal crops grown in the region are cotton, grapes, and deciduous fruits. Substantial acreages of almonds and pistachios are also grown, as well as increasing acreages of truck crops, such as tomatoes and corn.

In the eastern Sierra Nevada foothills, agriculture and timber production account for most of the land use. Deciduous and citrus trees are the main agricultural crops in the lower foothills, while timber harvesting occurs throughout many of the higher elevation areas. Figure TL-1 shows land use, along with imports and exports for the Tulare Lake Region.

Water Supply

The main local surface water supplies in the Tulare Lake Region come from Sierra Nevada rivers. Imported water is by way of the federal Central Valley Project's Delta-Mendota Canal and Friant-Kern Canal, and the State Water Project's California Aqueduct, which enters the region as part of the Joint-Use Facilities with the CVP's San Luis Unit. Ground water pumping meets the remaining water demands. Figure TL-2 shows the region's 1990 level sources of supply.

western side, smaller cities like Avenal, Huron, and Coalinga rely on imported surface water from the San Luis Canal for their municipal demands.

The SWP, through San Luis Reservoir and the California Aqueduct, provides an average of about 1,200,000 af of surface water yearly to the region. The U.S. Bureau of Reclamation supplies an average of 2,700,000 af during normal years from the CVP via Mendota Pool, the Friant-Kern Canal, and the San Luis Canal of the CVP/SWP San Luis Joint-Use Facilities. The Friant-Kern canal receives water from Millerton Lake on the San Joaquin River; Mendota Pool and the California Aqueduct receive water from the Sacramento-San Joaquin Delta.

Table TL-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Surface								
Local	2,398	1,239	2,398	1,240	2,398	1,240	2,398	1,240
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	2,705	1,288	2,705	1,288	2,705	1,288	2,705	1,288
Other federal	243	0	243	0	243	0	243	0
SWP	1,225	846	1,047	679	950	609	987	612
Ground water	915	3,773	918	3,758	921	3,726	926	3,758
Overdraft(1)	650	650	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	8,136	7,796	7,311	6,965	7,217	6,863	7,259	6,898

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

The valley floor overlies mostly one large ground water basin that consists of alluvial sediments. In the western half to three quarters, the Corcoran clay layer, which generally lies at depths of 300 to 900 feet, divides the ground water basin into two aquifers. South of the Kern River, the Corcoran horizon drops below well depths but other clay layers provide some confinement. On the eastern side of the valley, both north and south of the Kern County line, older formations are tapped by wells that usually exceed 2,000 feet in depth. A small ground water subbasin, with little hydraulic connection to the main aquifers, exists on the western side of Fresno, Kings, and Kern counties from Coalinga to Lost Hills. Two other small subbasins in Kern County are separated from the main basin by the White Wolf and Edison faults. Productive aquifers with good quality water are the general rule, except in the Tulare Lake area where lakebed clays yield little water, along the extreme eastern edge of the region where shallow depth to granite limits aquifer yields, and along the western side where water quality is poor.

The Kings-Kaweah-Tule River Planning Subarea accounts for just over 50 percent of net water demand of the Tulare Lake Region. Supplies for the KKT PSA are split three ways: local surface provides about 46 percent, imported water provides 25 percent, and ground water provides 29 percent. The San Luis West Side and Kern

Valley Floor PSAs will be heavily affected by reduced CVP and SWP deliveries. The SLWS meets over 90 percent of its demand with imported water, especially CVP water from the Delta. With future CVP deliveries unknown and limited available ground water and local surface supplies, the SLWS could have problems meeting future demand. Although ground water and local surface supplies are available, the KVF PSA could face similar problems as the SLWS PSA; more than 60 percent of its demand is met by imported water. Changes in SWP deliveries from the Delta would have the most effect in this PSA.

The City of Bakersfield operates a 2,800-acre recharge facility southwest of Bakersfield where the city and some local water agencies recharge surplus Kern River and occasionally, SWP and Friant-Kern Canal water; this water then is "banked" and withdrawn in drier years. The recharge facility is one of the largest single recharge areas in California, and during wet years, more than 100,000 af of water may be recharged.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Some of the water management options available to the region include increasing local reservoir storage by raising existing dam heights and encouraging more urban water conservation while protecting water quality in city wells.

Table TL-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	2,398	1,239	2,398	1,240	2,398	1,240	2,398	1,240
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	2,705	1,288	2,705	1,288	2,705	1,288	2,705	1,288
Other federal	243	0	243	0	243	0	243	0
SWP	1,225	846	1,111	704	1,235	749	1,237	741
Ground water	915	3,773	914	3,633	921	3,779	926	3,779
Overdraft(1)	650	650	—	—	—	—	—	—
Reclaimed	0	0	0	0	0	0	0	0
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	8,136	7,796	7,371	6,865	7,502	7,056	7,509	7,048

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Water Supply Reliability and Drought Water Management Strategies. During drought, as surface supplies dwindle and carryover storage in reservoirs is not replaced, ground water pumping increases tremendously. The number of new wells drilled during the recent drought (1987-92) more than doubled compared to normal periods.

Along the eastern side of the region, the ability to make up deficits by ground water pumping was crucial to sustaining agricultural production during the drought. Allotments from the Friant-Kern Canal, which delivers CVP water along the eastern side of the region from Fresno County to Kern County, were greatly decreased in the 1987–92 drought. Some growers who receive Friant-Kern Canal water along the eastern side of the region were not able to pump enough water to make up the deficiencies. In these cases, permanent crops did not receive full irrigations and yields suffered. State Water Project agricultural contractors received only 50 percent of their normal delivery in 1990 and then received no delivery in 1991, but 45 percent was available during 1992.

Although ground water pumping in western Fresno County reached all time highs during the 1987-92 drought, unprecedented since the arrival of CVP and SWP water, growers still could not afford to pump enough water to make up for the surface water deficiencies from reductions in CVP and SWP water. As a consequence, some acreage was fallowed. The situation was even worse in western Kern County, where ground water is not generally available. Some water was obtained from the State Drought Water Bank to ensure the survival of permanent crops in 1991. Still, over 125,000 acres were fallowed in 1991 due to lack of water.

Most communities enacted water use restriction ordinances during the recent drought, generally including time-of-day watering and odd-even-day watering, a prohibition of driveway or other paved surface washing, and water waste patrols. In addition, some well problems involving water quality have been experienced in the region's urban areas.

Water Management Options with Existing Facilities. Due to their hot climates, Fresno and Bakersfield have had relatively high per capita water use, when compared to statewide averages. As a result of continued urban growth and stricter federal drinking water standards, which have closed some wells with high contaminant levels, Fresno may have problems meeting its future urban water demand. The City of Fresno receives water allotments from the Kings River and the federal Friant-Kern Canal and uses some of this water to recharge its ground water basins. The city also makes use of its many flood control ponds throughout the metropolitan area for recharge.

DWR, in cooperation with the U.S. Bureau of Reclamation, is assisting local water agencies and districts in developing conservation plans that are required of all CVP water users because of the Reclamation Projects Authorization and Adjustment Act. With proper conservation planning, local agencies may better be able to deal with shortages of imported water during drought periods.

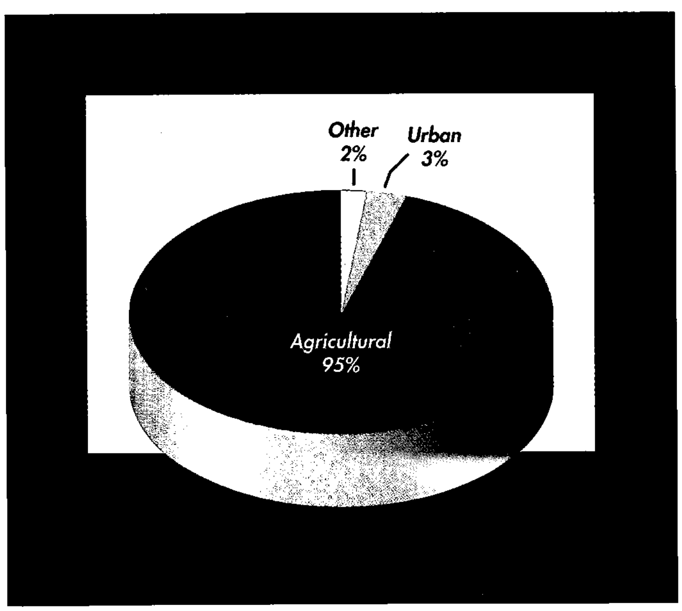
Water Management Options with Additional Facilities. To meet future agricultural water needs along the eastern half of the central San Joaquin Valley area, the Tule River Association wants to increase the reservoir capacity of Lake Success on the Tule River by 28,000 af. The extra capacity would be used for flood control and better irrigation scheduling during summer months. Construction would be completed by the year 2000, if approved by the U.S. Army Corps of Engineers. This project is in the planning stage.

The Kaweah-St. Johns Rivers Association also has a project in the planning stage that could raise the spillway of Terminus Dam on Lake Kaweah by 21 feet and add 43,000 af of flood control capacity and off-basin storage of Kaweah River water by 1999. Projects like the conservation program started by the Orange Cove Irrigation District will probably be more common in the future as area farmers look to cost-effective conservation rather than new and expensive water sources to alleviate shortages. OCID plans to replace 98 miles of 40-year-old pipelines to reduce leakage losses and add six regulating reservoirs and new metering equipment to make water delivery more precise.

Farmers on the Kern Valley floor will benefit from water transfers and banking of the Kern Water Bank Project when it is completed. Water districts and the SWP will be able to divert surplus water in wet years to recharge basins in the KWB project area, where the water will be stored in a vast underground aquifer. In dry years, users will be able to withdraw banked water from KWB to supplement SWP and other project deliveries.

Local supplies should remain at the1990 level since there are no firm plans to increase reservoir capacity in the region. As surplus SWP supplies decline and urban water demand increases, increased ground water pumping will probably continue to make up for reductions in surface water. Although the Central Valley Project Improvement Act could reduce agricultural water supplies to the region, its effects on future CVP deliveries are, as yet, unknown. Table TL-4 shows water supplies with additional Level I water management programs. Very little new agricultural land is expected to be brought into production, since most available productive agricultural land with a water supply is already in use.

Figure TL-3. Tulare Lake Region Net Water Demand (1990 Level Average Conditions)



Water Use

Water supplies in the Tulare Lake Region are mostly used for irrigated agriculture. In a normal year, irrigated agriculture uses 7,723,000 af, about 95 percent of the region's total water use; this is the largest agricultural demand for water of any hydrologic region in California. Municipal and industrial needs are about 214,000 af annually. Wildlife refuges and other nature areas account for one-third of one percent of the region's water needs. Agriculture will continue to be the major water user in the region in the future. However, as the population grows, municipal and industrial use will increase considerably. Figure TL-3 shows net demand for the 1990 level of development.

Municipal and industrial net water use is expected to increase 112 percent by 2020 due to large population increases throughout the region, while agricultural water use may decline by 554,000 af (7 percent) as farm irrigation efficiencies continue to increase and some agricultural land is converted to urban land. The total net water use for the region is projected to decrease by 292,000 af (or by 4 percent) by 2020.

Urban Water Use

In 1990, total urban applied water for the region was 523,000 af; urban net water use for the region was 214,000 af. The Sierra Nevada foothill area (Uplands planning subarea) had a net water use of about 6,000 af. Since 1980 per capita use has declined in most San Joaquin Valley communities. Table TL-5 shows urban applied and net water demand to 2020.

The average per capita daily water use within the Tulare Lake Region was about 301 gallons. Water use in the foothills was 202 gpcd, while that of the Kern Valley floor was 374 gpcd. The region has a fairly high urban water consumption rate primarily due to its hot summers, which cause greater demand for drinking, cooling, and landscaping water. Additionally, the per capita consumption rate in the Kern Valley area represents an average of many urban areas and water districts that serve high-water-use industries such as food processing and petroleum refining and production.

Municipal water use in valley cities represents up to 80 percent of total municipal and industrial net water use. About 60 percent of the total municipal and industrial net use occurs outdoors; landscaping accounts for 90 percent of this percentage and swimming pools the remaining 10 percent. Indoor water use (for drinking, washing, and cooking) accounts for 40 percent of total municipal and industrial net water use. Both Fresno and Bakersfield have a high per capita water use, about 280 and 330 gpcd, respectively. Both cities have water use regulations and water education programs to promote water conservation. Figure TL-4 shows the 1990 level applied urban water demands by sector.

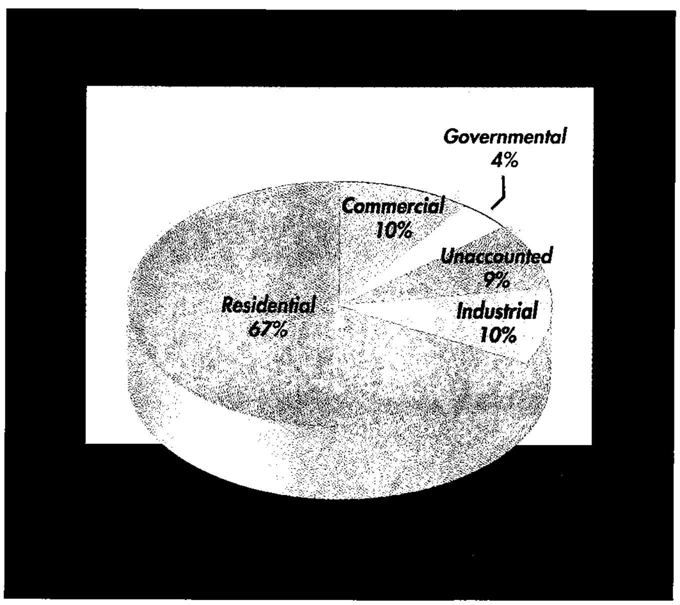


Figure TL-4. Tulare Lake Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

For the year 2020, municipal and industrial applied water is expected to increase in the Tulare Lake Region due to population increases in Fresno and other cities. The population for the valley and the foothills will more than double by 2020. Per capita water consumption in the central San Joaquin Valley floor area (Kings-Kaweah-Tule rivers planning subarea) is expected to decline because of implementation of additional water conservation measures. On the Kern Valley floor, per capita use should decrease, while use in the foothills should average about 190 gallons. Per capita water use on the western side of the valley floor should average about 225 gallons.

Table TL-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Uplands								
Applied water demand	12	12	18	18	26	26	35	35
Net water demand	5	5	7	7	10	10	14	14
Depletion	5	5	7	7	10	10	14	14
Kings-Kaweah-Tule								
Applied water demand	319	319	432	432	548	548	694	694
Net water demand	134	134	181	181	230	230	290	290
Depletion	134	134	181	181	230	230	290	290
San Luis West Side								
Applied water demand	10	10	14	14	16	16	18	18
Net water demand	4	4	6	6	7	7	7	7
Depletion	4	4	6	6	7	7	7	7
Western Uplands								
Applied water demand	2	2	2	2	3	3	4	4
Net water demand	1	1	1	1	1	1	2	2
Depletion	1	1	1	1	1	1	2	2
Kern Valley Floor								
Applied water demand	180	180	250	250	299	299	365	365
Net water demand	70	70	97	97	116	116	141	141
Depletion	70	70	97	97	116	116	141	141
TOTAL								
Applied water demand	523	523	716	716	892	892	1,116	1,116
Net water demand	214	214	292	292	364	364	454	454
Depletion	214	214	292	292	364	364	454	454

Agricultural Water Use

Irrigated agriculture accounts for more than 95 percent of the 1990 level water use in the Tulare Lake Region. Many different crops are grown throughout the region. In the future, however, urbanization, increasingly high costs for water, and the reliability of water supplies could reduce the variety and acreages of crops and thus, ultimately, agricultural water use. Figure TL-5 shows 1990 crop acreages, evapotranspiration, and applied water for major crops.

Climate, water supply, and salt buildup in the soils may limit the crops that can be grown profitably throughout the region. Most good irrigable land with access to dependable imported or local surface water has been developed. Crop acreages have generally declined in the region over the last decade, due to the limited availability of surface water and a drop in agricultural demand due to the sluggish economy. Cotton acreages, for example, declined from 1989 to 1992. Its price dropped from about 75 cents per pound in the late 1980s to about 50 cents per pound in 1992. In addition to decreased demand for cotton, the drought reduced SWP deliveries along the western side of the region. Table TL-6 shows irrigated crop acreage projections to 2020. Table TL-7 shows 1990 evapotranspiration of applied water by crop.

Table TL-8. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Uplands								
Applied water demand	29	29	29	29	29	29	29	29
Net water demand	20	20	20	20	20	20	20	20
Depletion	20	20	20	20	20	20	20	20
Kings-Kaweah-Tule								
Applied water demand	5,205	5,393	5,043	5,226	4,924	5,099	4,780	4,950
Net water demand	4,007	4,147	3,920	4,055	3,842	3,970	3,749	3,870
Depletion	3,988	4,128	3,901	4,036	3,823	3,951	3,730	3,851
San Luis West Side								
Applied water demand	1,695	1,721	1,636	1,646	1,590	1,600	1,547	1,559
Net water demand	1,514	1,532	1,454	1,472	1,403	1,419	1,357	1,374
Depletion	1,514	1,532	1,454	1,472	1,403	1,419	1,357	1,374
Western Uplands								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
Kern Valley Floor								
Applied water demand	2,684	2,706	2,598	2,617	2,532	2,553	2,477	2,500
Net water demand	2,182	2,196	2,124	2,138	2,082	2,096	2,043	2,056
Depletion	2,182	2,196	2,124	2,138	2,082	2,096	2,043	2,056
TOTAL								
Applied water demand	9,613	9,849	9,306	9,518	9,075	9,281	8,833	9,038
Net water demand	7,723	7,895	7,518	7,685	7,347	7,505	7,169	7,320
Depletion	7,704	7,876	7,499	7,666	7,328	7,486	7,150	7,301

Environmental Water Use

Wetlands in the region are mainly freshwater wetlands that provide habitat for migratory waterfowl. In Fresno County, the Mendota Wildlife Area has an applied water demand of 30,000 af for development of the refuge's 10,851 acres. The refuge has only received an average of 23,000 af. This supply of water for the Mendota Wildlife Area is fairly reliable, however, since the refuge is a regulating basin for the Delta-Mendota Canal.

In Kern County, the Kern National Wildlife Refuge, also a habitat for migratory waterfowl, needs an annual water supply of 25,000 af for management of its 2,800 acres of natural wetlands. However, the refuge has no firm supplies and usually relies on surplus SWP water and ground water. In an average water year, the refuge receives about 10,000 af of applied water.

In Tulare County, the Pixley National Wildlife Refuge has a water demand of 6,000 af for development of its 5,100 acres, used for migratory waterfowl. However, the refuge has no firm supplies and relies on flood flows from Deer Creek and ground water from recharge basins in the Pixley Irrigation District. Consequently, the refuge has received an average of about 1,000 af of water in recent years.

Besides these refuges, there are 2,879 acres of privately managed wetlands in the region, including duck clubs, nature preserves owned by nonprofit organizations, and rice lands. In average water years, an estimated 6,910 af is supplied to duck club properties. In the Tulare lakebed area, most of the original wetlands surrounding the old Tulare Lake have been drained for agriculture. However, evaporation ponds established to deal with agricultural drainage disposal in the area are potentially hazardous to migrating waterfowl. Table TL-9 shows wetland water needs to 2020.

Table TL-9. Wetland Water Needs
(thousands of acre-feet)

Wetland	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Kern NWR								
Applied water demand	10	10	25	25	25	25	25	25
Net water demand	8	8	21	21	21	21	21	21
Depletion	8	8	21	21	21	21	21	21
Pixley NWR								
Applied water demand	1	1	6	6	6	6	6	6
Net water demand	1	1	5	5	5	5	5	5
Depletion	1	1	5	5	5	5	5	5
Mendota WA								
Applied water demand	23	23	30	30	30	30	30	30
Net water demand	19	19	24	24	24	24	24	24
Depletion	19	19	24	24	24	24	24	24
Tulare Basin NWR								
Applied water demand	7	7	7	7	7	7	7	7
Net water demand	6	6	6	6	6	6	6	6
Depletion	6	6	6	6	6	6	6	6
TOTAL								
Applied water demand	41	41	68	68	68	68	68	68
Net water demand	34	34	56	56	56	56	56	56
Depletion	34	34	56	56	56	56	56	56

Another environmental water consideration involves the water conveyance facilities in the region. Certain endangered species, such as the San Joaquin kit fox and the blunt-nosed leopard lizard, are using the canal banks, flood control channels, and banks of the California Aqueduct for habitat as native vegetation grows around the facilities. DWR monitors these areas to prevent maintenance operations from disturbing these species and their habitat. DWR's Kern Water Bank in western Kern County will provide wetlands and refuges for endangered species as part of its overall program. Of the 20,000 acres that will be used for the Kern Water Bank, several thousand acres will be used for wildlife needs.

Other Water Use

Kings Canyon National Park and Sequoia National Park together use about 500 af of water annually for drinking water and other domestic uses. The parks obtain most of their water from ground water wells and local surface water diversions from the upper Kings River. During the 1987-92 drought, some campgrounds in Kings Canyon and Sequoia that relied on wells were closed for part of the camping season due to low ground water levels.

Some water use in recreation areas can be described as indirect usage. Along the California Aqueduct, there are many specially designated areas for fishing that include easy access from area roads and vehicle parking areas. In the Tulare Lake Region, there are five fishing access areas: Three Rocks, Huron, Kettleman City, Lost Hills, and Buttonwillow. In the foothills, three major lakes (Pine Lake, Lake Success, and Isabella Lake) have recreation areas that are used for fishing, boating, camping, and other recreational uses. Both the fishing access and the recreation areas show reduced use during drought periods and low-flow months.

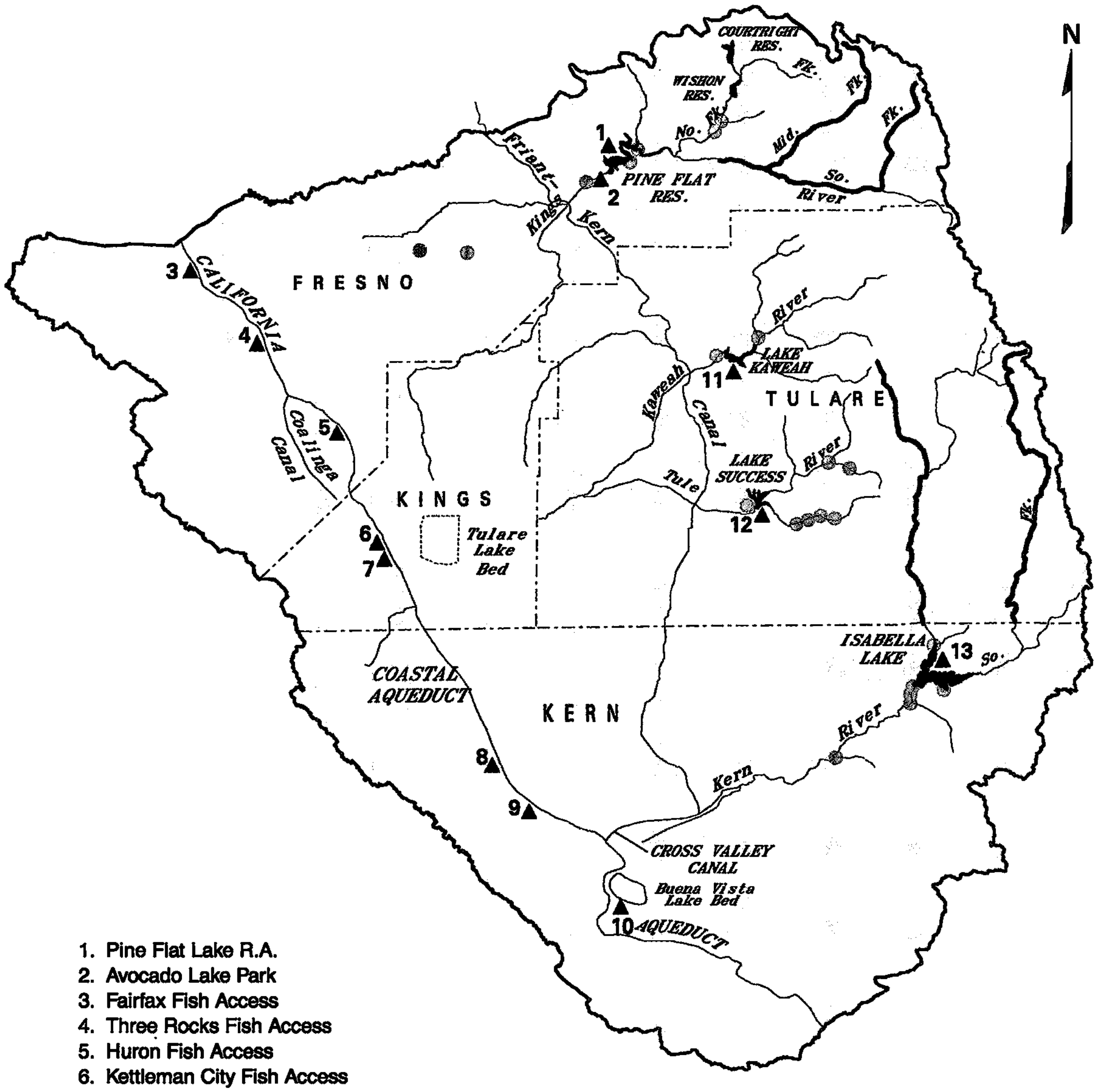
Table TL-10. Total Water Demands
(thousands of acre-feet)

Category of Use	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Urban								
Applied water demand	523	523	716	716	892	892	1,116	1,116
Net water demand	214	214	292	292	364	364	454	454
Depletion	214	214	292	292	364	364	454	454
Agricultural								
Applied water demand	9,613	9,849	9,306	9,518	9,075	9,281	8,833	9,038
Net water demand	7,723	7,895	7,518	7,685	7,347	7,505	7,169	7,320
Depletion	7,704	7,876	7,499	7,666	7,328	7,486	7,150	7,301
Environmental								
Applied water demand	41	41	68	68	68	68	68	68
Net water demand	34	34	56	56	56	56	56	56
Depletion	34	34	56	56	56	56	56	56
Other[1]								
Applied water demand	102	102	102	102	102	102	102	102
Net water demand	165	165	165	165	165	165	165	165
Depletion	165	165	165	165	165	165	165	165
TOTAL								
Applied water demand	10,279	10,515	10,192	10,404	10,137	10,343	10,119	10,324
Net water demand	8,136	8,308	8,031	8,198	7,932	8,090	7,844	7,995
Depletion	8,117	8,289	8,012	8,179	7,813	8,071	7,825	7,976

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Figure TL-6. Tulare Lake Region

Hydroelectric Power Plants, Wild and Scenic Rivers, and Water Recreation Areas



1. Pine Flat Lake R.A.
2. Avocado Lake Park
3. Fairfax Fish Access
4. Three Rocks Fish Access
5. Huron Fish Access
6. Kettleman City Fish Access
7. Kettleman City Aquatic S.R.A.
8. Lost Hills Fish Access
9. Buttonwillow Fish Access
10. Buena Vista Aquatic R.A.
11. Lake Kaweah R.A.
12. Success Lake R.A.
13. Isabella Lake R.A.

Legend

▲ Water Recreation Area
● Hydroelectric Power Plant*
— Federal Wild and Scenic River

0 10 20 30
SCALE IN MILES

*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

During normal years, white water rafting is a popular activity on the Kings and Kern rivers. The Kings River supports white water rafting above Pine Flat Reservoir for the experienced rafters while the river below the reservoir is satisfactory for beginners. The Kern River has expert-level white water rafting and kayaking above Isabella Lake while below the reservoir, beginners as well as experts can practice their white water rafting. Stretches of the upper Kings and Kern rivers have been declared wild and scenic by federal legislation. The Kings River is designated as such on both the middle and south fork of the upper portion above Mill Flat Creek. The Kern River is designated wild and scenic on both the north and south fork of the upper portion above Isabella Lake.

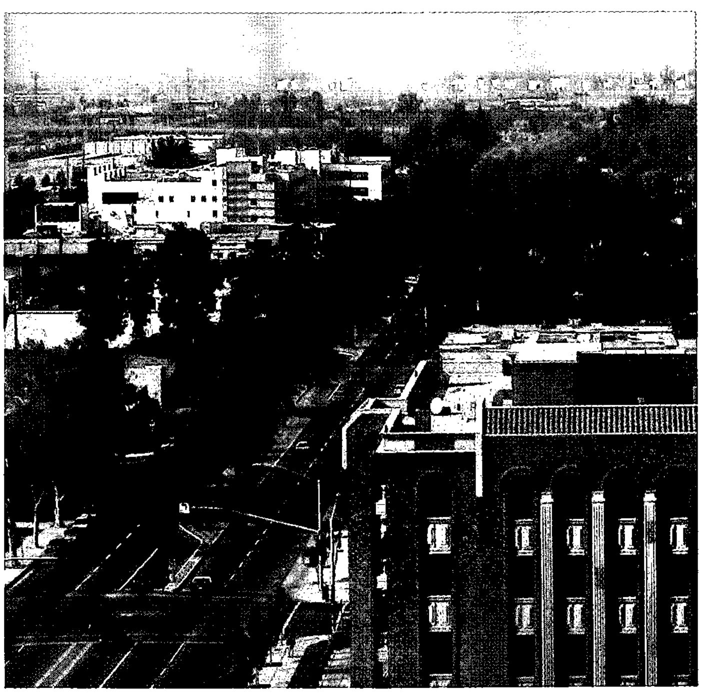
The many reservoirs and lakes throughout the Tulare Lake Region support recreational activities including fishing, camping, hiking, water skiing, and boating. Courtright and Wishon reservoirs on the Kings River have native trout fisheries, camping, and hiking on the trails of the John Muir and Dinkey Lakes wilderness areas. Also, Pine Flat Reservoir on the Kings, Isabella Lake on the Kern, Lake Kaweah on the Kaweah River, and Lake Success on Tule River are popular recreational areas in the region. Figure TL-6 shows water recreation areas in the region. Table TL-10 shows the total water demand for the region.

Issues Affecting Local Water Resource Management

Each area of the Tulare Lake Region has its own set of geographic and demographic conditions that have led to varied water supply circumstances. For example, the foothill cities along the eastern edge of the region experienced severe water shortages in the recent drought, while the Fresno area managed to meet most of its water needs. The following sections summarize major regional and local issues affecting water resources management.

Regional Issues

Population Growth. One of the most important issues in the Tulare Lake Region is whether to allow growth and development to continue at its current rate and location or restrict urban development to preserve prime agricultural land, wetlands, and other wildlife habitat. Although converting agricultural land to urban use can increase water use slightly, urban water use often requires higher water quality, and water supplies must be more reliable.



An aerial view of Bakersfield. Central Valley cities like Bakersfield are expected to grow substantially over the next few decades, causing more agricultural land to be converted to urban use.

For example, Fresno and surrounding towns draw ground water from the same basin. As

Fresno has expanded into former agricultural areas, it has encountered degraded ground water quality, in some places by pesticide contamination from DBCP and other farm chemicals used before the 1980s. This degraded water quality has shifted dependence to wells that produce good-quality water. Urban growth in Fresno is also occurring in outlying areas at higher elevations than many older portions of the city. These new suburbs have switched from the surface water supplies used by agriculture to new ground water wells. The urban ground water demand has created a fast drawdown of the aquifer, which has increased the depth to ground water, raised the cost of pumping, and decreased water quality.

Finally, converting agricultural land to urban use tends to diminish natural recharge and deep percolation of agricultural applied water to the ground water basins because of the nonporous nature of concrete and asphalt used in urban areas. While Fresno has existing recharge facilities, it may raise development taxes to finance more recharge basins to maintain current ground water levels underlying the city.

Ground Water Overdraft Problems. Agriculture, in areas with no surface water supply and good quality ground water, has overdrafted ground water basins where long-term replenishment is inadequate to maintain the water table. This in turn has induced subsurface flow from adjacent districts. Such an area exists along the valley trough from Madera to Kern counties and affects adjacent districts. Other overdrafted areas are in the subbasin around Coalinga and in Westlands Water District, where subsidence has occurred during droughts.

In western Fresno County and southern Kern County subsidence has stabilized, except during droughts. No subsidence data have been available for Madera, Kings, Kern, and Tulare counties since 1970. Subsidence can potentially compact the sediments and lower infiltration capabilities of a ground water aquifer and therefore has an undesired impact on conjunctive use programs in the region. Canals and wells have also required repair because of the effects of subsidence.

Reliability of Supplies in Foothill and Mountain Communities. In foothill and mountain areas, some urban water needs are met by ground water. However, the ground water is found in thin layers of alluvial sediments and in underlying hard rock fractures. Recharge to these underground reservoirs is very slow and during the recent drought, some foothill communities relied on imported surface water to supplement their supplies.

Orange Cove is a typical foothill community that relies on imported water delivered through the Friant-Kern Canal; it is the most economical alternative to limited ground water supplies, especially during drought periods. Ground water in the foothills can be scarce and expensive to extract. During severe drought conditions in 1990, Orange Cove allowed residents to use only 125 gpcd. A water transfer agreement enabled the city to relax this standard during 1991. Small foothill towns like Orange Cove will need to buy transfer water during droughts to prevent future severe rationing.

Water supply is often more limited in mountain communities than in valley or foothill cities of the region. Wofford Heights in eastern Kern County is a typical mountain community. Although Lake Isabella is nearby, the Arden Water Company would have to install almost 40 miles of pipeline to provide water service from that source, and it cannot afford the connection. During the recent drought, seven of Wofford Heights' 10 existing wells went dry and had to be abandoned. Arden Water Company was able to drill three new wells, but it had to drill them 450 to 500 feet deep. Previous wells had only been drilled to 300 feet. The sites for the new wells were carefully chosen to intersect two or more pockets of water, and Arden built new above-ground storage tanks to provide more dependable deliveries during droughts.

Reliability of Supplies for Wildlife. Many of the region's environmental needs, including maintenance of the Mendota Wildlife Area, the Kern National Wildlife Refuge, and various duck clubs and wetlands, require firm water supplies that are currently unavailable. The CVP water supplied to the Mendota area and the surplus water supplied to the Kern Refuge are usually the only water supplies available. The duck clubs and wetlands have relied partly on tail water from upstream sources.

Transfers and Exchanges. In western Kern County, 85 percent of the land related to SWP water entitlements of the Devil's Den Water District has been bought by the Castaic Lake Water Agency, which has transferred the water to the South Coast Region for urban use in the Santa Clarita urban area. The transfer resulted in the loss of some seasonal agricultural jobs and more than 20 full-time agricultural positions within the district. State planners in the future will be faced with this situation again, as metropolitan areas seek alternative water supplies. The needs of urban residents will have to be balanced against the potential loss of agricultural jobs and of agricultural production capacity brought on by the reallocation of water and its impacts on rural economies.

The final Environmental Impact Report for the Arvin-Edison Conjunctive Use Program, involving an agreement between MWDSC and the Arvin-Edison Water Storage District, is on hold until the program is reformulated under new Delta operating criteria. Arvin-Edison is a Central Valley Project contractor in southeastern Kern County. Its CVP water is delivered through the California Aqueduct by arrangement with the State. According to the proposed contract, MWDSC will help construct Arvin-Edison's partially completed distribution system and deliver a portion of its SWP water in wet years for use in Arvin-Edison's ground water replenishment programs. In return, MWDSC will receive some of Arvin-Edison's CVP water during dry years. Through this proposed agreement, MWDSC expects to store SWP water in the southern San Joaquin Valley during wet periods. In dry periods, the program could make up to 93,000 af per year available for MWDSC. In another exchange program, MWDSC negotiated with Kern County Water Agency to store SWP supplies in the Semitropic Water Storage District's ground water basin. (See Volume I, Chapter 11.)

Local Issues

Drinking Water in Fresno. As a result of continued urban growth and stricter federal drinking water standards, more than 40 wells have been shut down (closed) in the region. As mentioned earlier, these wells have a high level of dibromochloropropane or other contaminants, including trichloroethylene. Because of these well closings and future strict EPA requirements that the water be tested for a wide variety of chemical contaminants, the City of Fresno could have problems meeting its future urban water demand.

In addition, during past years, Fresno did not have to chlorinate its municipal supply because of its high-quality ground water in storage under the city. With recent EPA standards for coliform and other bacteria levels, Fresno has begun to chlorinate the municipal water supply at the wellheads. Although the city expects no problems with trihalomethanes, a byproduct of chlorination often found in chlorinated surface water, there have been some complaints about the taste and smell of the chlorinated water. As urban development continues, Fresno may attempt to supplement its ground water supply with surface water from the Friant-Kern Canal and the Kings River.

Arroyo Pasajero. DWR is currently seeking solutions to flood problems threatening the California Aqueduct near the intersection with a natural drainage channel called Arroyo Pasajero. The aqueduct, completed in 1967, formed a barrier to arroyo water and sediment flow. By design, arroyo runoff was retained in a 1,900-acre ponding basin and periodically discharged into the aqueduct through four inlet gates. Unfortunately, the runoff for the arroyo was found to be greater than anticipated. After a 1980 investigation determined that arroyo runoff was also raising asbestos levels in aqueduct water, concerns were voiced over possible health risks associated with consuming water containing high levels of asbestos. DWR has been studying methods of managing arroyo runoff without discharging it into the aqueduct. A nonstructural method of routing arroyo discharge is being considered and environmental studies are under way.

Agricultural Drainage. On the western side of the valley, where ground water quality is marginal to unusable for agriculture, farmers use good quality surface water to irrigate crops. This irrigation causes the shallow aquifer to fill, and this results in drainage problems. The high water table is exacerbated by clay-rich soils that slow drainage in some areas. Poor-quality ground water in the unconfined aquifer in Westlands Water District is increasing by about 110,000 af per year. In Kern County, west of the California Aqueduct, the few available wells also show rising water levels. This marginal to poor quality ground water has reached plant root zones in many areas along the western side and must be removed by drains if agriculture is to continue in these areas.

Nearly one-third of the Tulare Lake Region's total irrigated crop acreage is planted in cotton.

Ground Water Quality. Most naturally occurring, poor-quality ground water is found along the region's western side. Total dissolved solids, sulfate, boron, chloride, and selenium limit the usefulness of ground water in this area. Several contaminants are present, including pesticides, petroleum products, and industrial solvents. One of the pesticides, dibromochloropropane, is also found over large areas on the eastern side of the valley. Concentrations of DBCP (which the U.S. Environmental Protection Agency banned in 1977) are declining but are still above acceptable limits in many areas. Rising levels of nitrates have been found in numerous wells in rural areas. Many of them contain nitrate levels above the maximum contaminant level for nitrates in drinking water.

Water Balance

Water budgets were computed for each Planning Subarea in the Tulare Lake Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary to the sustained economic health of the region. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table TL-11 presents water demands for the 1990 level and for future water demands to 2020 and balances them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options.

Regional net water demands for the 1990 level of development totaled 8,136,000 and 8,308,000 af for average and drought years, respectively. Those demands are forecasted to decrease to 7,844,000 and 7,995,000 af, respectively, by the year 2020, after accounting for a 20,000-af reduction in urban water demand resulting from implementation of long-term conservation measures, a 90,000-af reduction in agricultural demand resulting from additional long-term agricultural water conservation measures, and a 120,000-af reduction due to land retirement on the west side of the region.

Urban net water demand is expected to increase by about 112 percent by 2020, due to expected increases in population, while agricultural net water demand is projected to decrease by about 7 percent, primarily due to lands being taken out of production because of poor drainage conditions on the west side of the San Joaquin Valley, urbanization, and increases in irrigation efficiency. Environmental net water demand, under existing rules and regulations, will increase by 22,000 af. However, there are several actions currently in progress, including implementation of the Central Valley Improvement Act, that have proposed increases in instream flow for fisheries that will affect the availability of supplies for urban and agricultural use.

Average annual supplies, including about 650,000 af overdraft, were generally adequate to meet average net water demands in 1990 for this region. However, during drought, present supplies are insufficient to meet present demands, resulting in shortages of about 512,000 af in 1990. Without additional water management programs, drought year annual shortages are expected to be about 1,097,000 af by 2020.

With planned Level I programs, overall ground water use could be reduced. Reduction in ground water use will reduce ground water overdraft. Therefore, the net effect of improved surface water deliveries would be to reduce long-term ground water overdraft in this region, as well as reduce shortages.

The remaining shortages of about 335,000 and 947,000 af in average and drought years, respectively, by 2020 requires both additional short-term drought management (water transfers and demand management programs) and other future long-term Level II programs depending on the overall level of water service reliability

Table TL-11. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	214	214	301	301	380	380	474	474
—reductions due to long-term conservation measures (Level I)	—	—	-9	-9	-16	-16	-20	-20
Agricultural—with 1990 level of conservation	7,723	7,895	7,588	7,755	7,487	7,645	7,379	7,530
—reductions due to long-term conservation measures (Level I)	—	—	-30	-30	-60	-60	-90	-90
—reductions due to land retirement in poor drainage areas of San Joaquin Valley (Level I)	—	—	-40	-40	-80	-80	-120	-120
Environmental	34	34	56	56	56	56	56	56
Other[1]	165	165	165	165	165	165	165	165
TOTAL Net Demand	8,136	8,308	8,031	8,198	7,932	8,090	7,844	7,995
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	6,571	3,373	6,393	3,207	6,296	3,137	6,333	3,140
Ground Water	915	3,773	918	3,758	921	3,726	926	3,758
Ground Water Overdraft[3]	650	650	—	—	—	—	—	—
Subtotal	8,136	7,796	7,311	6,965	7,217	6,863	7,259	6,898
Dedicated Natural Flow	0	0	0	0	0	0	0	0
TOTAL Water Supplies	8,136	7,796	7,311	6,965	7,217	6,863	7,259	6,898
Demand/Supply Balance	0	-512	-720	-1,233	-715	-1,227	-585	-1,097
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed[5]	—	—	0	0	0	0	0	0
Local	—	—	0	0	0	0	0	0
Central Valley Project	—	—	0	0	0	0	0	0
State Water Project	—	—	64	25	285	140	250	129
***Subtotal* - Level I Water Management Programs**	0	0	64	25	285	140	250	129
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	-4	-125	0	53	0	21
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	-512	-660	-1,333	-430	-1,034	-335	-947

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.
(5) Because of existing reuse within region, reclaimed water does not add supply to the region.

deemed necessary by local agencies to sustain the economic health of the region. This region depends on exports from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on D-1485 operating criteria for Delta supplies and do not take into account reduction of supplies due to recent actions to protect aquatic species in the Bay-Delta estuary. As such, regional water supply shortages are understated. In the short-term, some areas of this region that rely on the Delta exports for all or a portion of their supplies face great uncertainty in terms of water supply reliability. For example, in 1993, an above-normal runoff year, environmental restrictions limited CVP deliveries to 50 percent of contracted supply for federal water service contractors from Tracy to Kettleman City. Because ground water is used to replace much of the shortfall in surface water supplies, limitations on Delta exports will exacerbate ground water overdraft in this region.

The waters of the Carson River and its tributaries support a variety of uses such as serving agricultural users, providing urban water supplies, and sustaining fish and wildlife habitat.

North Lahontan Region

The eastern drainages of the Cascade Range and the eastern Sierra Nevada, north of the Mono Lake drainage, make up the North Lahontan Region. The region forms part of the western fringe of the Great Basin (a large landlocked drainage that includes most of Nevada and northern Utah) and stretches about 270 miles from the Oregon border to the southern boundary of the Walker River drainage in Mono County. At its widest part, the region measures about 60 miles across; it narrows to scarcely 5 miles in Sierra County. Its land area represents less than 3 percent of the State's total land area. The topography is generally mountainous and rugged with large desert valleys between mountain ranges in the north and narrow alpine valleys in the south. The mountain crests forming the western boundary of the region range up to 11,000 feet in elevation. (See Appendix C for maps of the planning subareas and land ownership in the region.)

The region comprises two planning subareas: the northernmost is the Lassen Group PSA, which includes the Modoc and Lassen county portions of the region, plus a small corner of northeastern Sierra County that drains to Honey Lake. The southern PSA is the Alpine Group from mid-Sierra County to near Mono Lake, which includes Lake Tahoe and the Truckee, Carson, and Walker river drainages.

Annual precipitation is as much as 70 inches at the crest of the Sierra Nevada, closest to Lake Tahoe, and as little as 4 inches at the Nevada boundary in Surprise Valley and in the Honey Lake Basin. The region's streams flow either to Nevada or to intermittent lakes in California. Natural runoff of the streams and rivers averages around 1,842,000 af per year; about three-quarters comes from the region's southern portion.

Population

Almost 65 percent of the 78,000 residents in the North Lahontan Region live in the Truckee-Tahoe Basin, where the largest community is the City of South Lake Tahoe with a 1990 population of 21,600. The main population center of the Lassen subarea is Susanville, the county seat of Lassen County, with 7,300 residents. Also in the region are Bridgeport, the county seat of Mono County, and Markleeville, the county seat of Alpine County. Population is quite sparse between these towns, consisting of ranches and tourist and service centers primarily along Highway 395.

Region Characteristics

Average Annual Precipitation: *32 inches* ***Average Annual Runoff:*** *1,842,000 af*

Land Area: *3,890 square miles* ***Population:*** *78,000*

Only about one-fourth of one percent of California's people live in the region. Table NL-1 shows population projections to 2020 for the North Lahontan Region.

Table NL-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Lassen Group	25	32	36	39
Alpine Group	53	63	71	79
TOTAL	78	95	107	118

Land Use

Much of the North Lahontan Region is either national forest land or under the jurisdiction of the Bureau of Land Management. The major privately owned lands are in the valley areas of Modoc and Lassen counties. Relatively small portions of the Truckee-Tahoe area and the Carson and Walker river basins are in private ownership, but those small areas are of considerable economic significance.

Cattle raising is the principal agricultural activity in the region, although the acreage of irrigated land is relatively small (less than 4 percent of the region's land area).Commercial crop production is limited because of the short growing season. Although growing seasons vary from year to year, the mountain valleys are usually frost-free from late May to mid-September, or about 120 days. Pasture and alfalfa are the dominant irrigated crops. About 75 percent of the irrigated land is in Modoc and Lassen counties, and most of the remainder is in the Carson and Walker river valleys in Alpine and Mono counties. The irrigated land in the Carson and Walker river valleys is almost exclusively pasture at elevations above 5,000 feet.

Tourism and recreation are the principal economic activities in the Truckee-Tahoe area and the surrounding mountains. On a typical summer day, the number of recreationists within the Tahoe Basin may equal the number of full-time residents. A similar but smaller peak in the number of recreationists visiting the basin occurs during the winter. Figure NL-1 shows land use, along with water imports and exports for the North Lahontan Region.

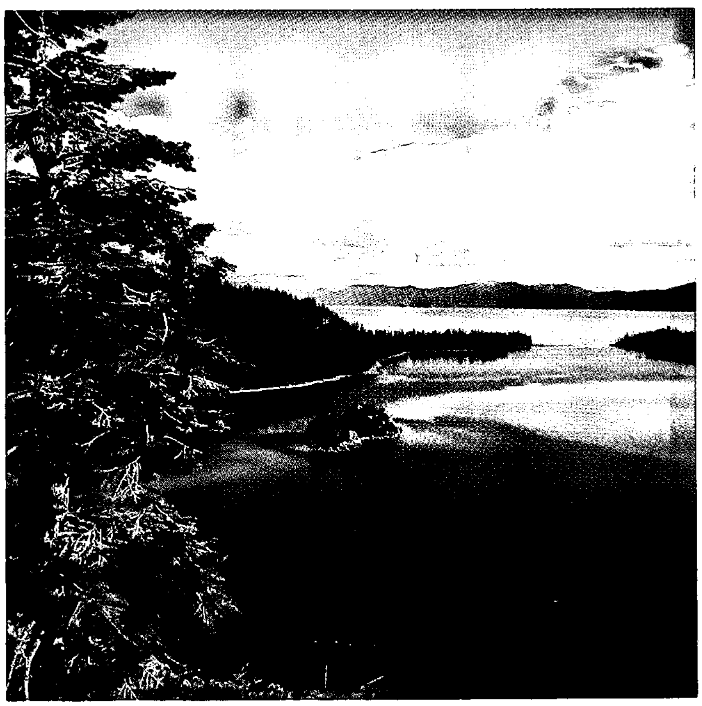
Water Supply

About 75 percent of the region's 1990 level water supply comes from surface sources. Ground water supply amounts to 23 percent. Throughout most of the North Lahontan Region, water development has been carried out on a modest scale by local interests, with many projects built in the late 1800s. In the northern portion of the region, these developments include numerous small reservoirs which store winter runoff for summer irrigation. The Lassen Irrigation District developed three small reservoirs in the Susan River drainage beginning in 1891—McCoy Flat Reservoir, Hog Flat Reservoir, and Lake Leavitt. About 3,000 af per year is imported through the Moon Lake project from the South Fork Pit River for irrigation in the Madeline Plains area. Figure NL-2 shows the region's 1990 level sources of supply.

River Basin of Sacramento River Region). Much of the supply from the Truckee, Carson, and Walker rivers is reserved for use by Nevada interests under various water rights settlements and agreements.

The major ground water basins in the Lassen Group PSA are Long, Honey Lake, Willow Creek, and Surprise valleys and the Madeline Plains. Interbasin ground water flow is limited by geologic structures between basins. Of the 109,000 af of net ground water used in this area, about 96,000 af are for irrigation and the remaining 13,000 af are for municipal and industrial purposes. Well yields are greatest in alluvial sand and gravel deposits around the margins of the valleys and from buried basalt flows. Some wells yield greater than 3,000 gallons per minute. Yields from hard rock wells are usually low but are generally sufficient for domestic uses.

Ground water quality in the Lassen Group PSA ranges from excellent to poor. Wells that obtain their supply from lake deposits can have high levels of boron, arsenic, and fluoride and high adjusted sodium absorption ratio. Some domestic wells in the Standish area of Honey Lake Valley have arsenic levels above safe drinking water standards. The total ground water in storage within this group is estimated to be 5,000,000 af.



Emerald Bay at Lake Tahoe. Lake Tahoe supplies water to communities surrounding the lake and for urban and agricultural uses downstream in Nevada.

The major ground water basins in the Alpine Group PSA include the Bridgeport, Antelope, Carson, and Martis valleys as well as the Tahoe Basin. Ground water recharge occurs primarily from infiltration of snowmelt and precipitation, while discharge from the basins occurs mainly from streams flowing east into Nevada. The estimated total net ground water use from these basins is 12,000 af annually. There is some agricultural ground water pumping in Antelope Valley; however, most occurs on the Nevada side of the basin. Ground water pumping in the hard rock area occurs at scattered locations throughout the subarea but is most heavily relied on in the area east of Martis Valley. Yields from these hard rock wells are usually low but sufficient to provide domestic or livestock supplies. Although pumping and ground water level information within the subarea is limited, there are no reported instances of basin overdraft, so current pumping is probably within the perennial yield. The total ground water in storage is estimated at 1,800,000 af. Although water quality in the Alpine Group PSA is usually good, some areas do have problems with water quality.

Some municipal wells in the Lake Tahoe Basin produce water high in uranium, radon, or radionuclides. Because of the granitic rocks and sediments from which ground water is produced, elevated levels of uranium or radon, or both, may occur in ground water in other areas of the PSA. Some test wells on the west side of the Lake Tahoe Basin produce poor-quality water that contains high concentrations of arsenic.

Table NL-3 shows water supplies with existing facilities and water management programs.

Table NL-3. Water Supplies with Existing Facilities and Programs

(thousands of acre-feet)

Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Surface								
Local	382	338	379	340	371	340	379	344
Local imports	3	3	3	3	3	3	3	3
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	0	0	0	0	0	0	0	0
Ground water	121	146	128	154	138	165	147	173
Overdraft(1)	0	0	—	—	—	—	—	—
Reclaimed	8	8	8	8	8	8	8	8
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	514	495	518	505	520	516	537	528

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Water supplies are not expected to change in the North Lahontan Region through the year 2020. Irrigated agriculture is already constrained by economically available water supplies; only a small amount of agricultural expansion is expected in areas that can support some additional ground water development. Similarly, the modest needs for additional municipal and industrial supplies can be met by minor expansion of present surface systems or by increased use of ground water. No significant additional Level I or Level II surface water development in the region is anticipated. The following sections summarize water management programs under active consideration in the region.

Table NL-4 shows water supplies with additional Level I water management programs. Since there are no planned Level I water management programs, the table is identical to Table NL-3.

About 5,500 af of recycled waste water is exported out of the Tahoe Basin by South Tahoe Public Utility District for agricultural use in the Carson River watershed. Truckee Tahoe Sanitation Agency treats waste water from the Tahoe Basin and returns about 4,000 af (which is used downstream in Nevada and does not contribute to California's supplies) to the Truckee River. The Susanville Sanitary District reclaims over 3,000 af of waste water for use on nearby irrigated pasture lands.

Table NL-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	382	338	379	340	371	340	379	344
Local imports	3	3	3	3	3	3	3	3
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	0	0	0	0	0	0	0	0
Ground water	121	146	128	154	138	165	147	173
Overdraft(1)	0	0	—	—	—	—	—	—
Reclaimed	8	8	8	8	8	8	8	8
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	514	495	518	505	520	516	537	528

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

In the northern portion of the region, drought is a way of life for agriculture; irrigators use the water available and then do without. In most irrigated areas there is little storage, and surface water runs out early in dry years. Drought water management consists mainly of making the best use of what water is available.

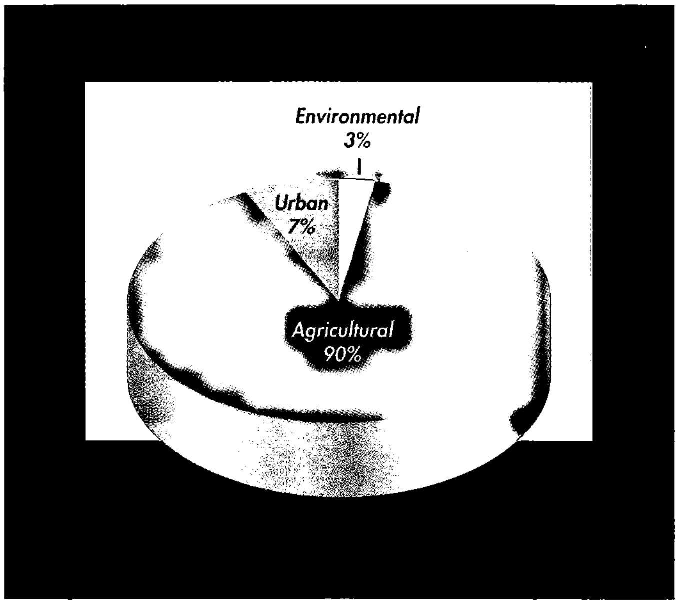
The Truckee River and Lake Tahoe Basin will be regulated by the Truckee River Operating Agreement if and when agreement is reached. The Carson and Walker rivers are controlled by federal watermasters according to federal court decrees. Further water development in these basins is unlikely. It is anticipated that water transfers will be used to meet changing or higher priority needs within the basins. In California, this has meant acquiring some agricultural land and water rights for both environmental needs throughout the basin and municipal needs downstream in Nevada.

In the Walker River basin, agricultural supplies may be supplemented by increasing use of ground water and conjunctive use in areas such as Antelope Valley. Water conservation for agricultural users (that is, ditch lining and soil moisture controlled irrigation scheduling) may become increasingly important as more water rights are sold or otherwise transferred to urban and environmental uses.

Water Use

The 1990 level annual net water use within the North Lahontan Region is about 514,000 af per year. About 90 percent is for irrigated agriculture. Most of the 37,000 af of municipal and industrial use takes place in the Susanville and Tahoe-Truckee areas. Despite the importance of recreation in the region's economy, the water needs of recreation are a small component of total water use. The principal environmental water needs are instream flows, and those of the State's Honey Lake and Willow Creek wildlife areas in southern Lassen County.

Figure NL-3. North Lahontan Region Net Water Demand (1990 Level Average Conditions)



The primary users of ground water in the Alpine subarea are the municipalities in the Lake Tahoe Basin and Martis Valley, and to a lesser extent in Bridgeport Valley. Figure NL-3 shows net water demand for the 1990 level of development.

Urban Water Use

Population projections indicate that by 2020, the region's population will increase by 51 percent over 1990 levels. Most people will still be in the Alpine subarea. Average water use is about 421 gallons per capita daily. In the two planning subareas, use ranges from 607 gpcd in the Lassen Group to 337 gpcd in the Alpine Group. The significantly larger per capita use in the northern PSA is due to high-water-use industry (mostly energy production—cogeneration and geothermal), which accounts for about half of the urban water use in this area. Per capita use values for areas such as the Tahoe Basin are distorted because they are based on permanent population, while a substantial share of the water use is by tourists and temporary residents. Figure NL-4 shows the 1990 level urban applied water use by sector.

Figure NL-4. North Lahontan Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

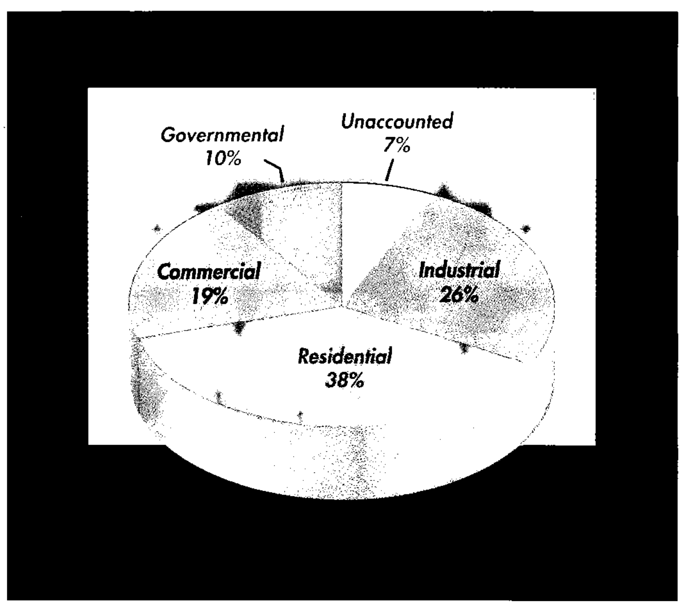


Table NL-5 shows applied water and net urban water demand through 2020. Urban water use is not expected to increase proportionately with population due to water-saving techniques employed with new construction and other water conservation measures.

The 17,000 af of urban water use within the Lassen Group is mostly from ground water. The 4,000 af of surface water used as an urban water supply is almost all used by the City of Susanville. Susanville, the largest city in the northern group, derives most of its municipal water from Cady and Bogwell Springs and some ground water wells. Increased population and the recent drought have forced Susanville to increase ground water pumping to supplement reduced surface water supplies.

The area's water demand is expected to increase. The State Department of Corrections is planning to expand the Susanville Correctional Center from 4,000 to a maximum of 8,000 inmates. The city also is requiring the developer of one large subdivision to produce a water supply for its project that is independent of existing city sources. Present plans are to meet this demand with ground water supplies.

In the Alpine Group there are 12,000 af of ground water and 8,000 af of surface water supplies for municipal use. Some systems divert directly from the lake, some from streams or springs, and some use wells. The Alpine Group has the largest population center in the region, the Lake Tahoe Basin. Municipal supplies in the Truckee Basin downstream of Lake Tahoe are almost entirely from ground water wells; the largest purveyor is the Truckee-Donner Public Utility District.

Table NL-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Lassen								
Applied water demand	17	17	19	19	20	20	21	21
Net water demand	17	17	19	19	20	20	21	21
Depletion	7	7	8	8	9	9	9	9
Alpine								
Applied water demand	20	21	24	25	26	28	30	31
Net water demand	20	21	24	25	26	28	30	31
Depletion	7	8	9	10	10	11	12	12
TOTAL								
Applied water demand	37	38	43	44	46	48	51	52
Net water demand	37	38	43	44	46	48	51	52
Depletion	14	15	17	18	19	20	21	21

Agricultural Water Use

Total irrigated land within the North Lahontan Region in 1990 was 161,000 acres, an increase of about 7 percent since 1980. Table NL-6 shows irrigated crop acreage for the region. The number of irrigated acres in the region is expected to increase slightly over the next three decades. Table NL-7 shows 1990 crop acreages and evapotranspiration of applied water. Figure NL-5 shows 1990 crop acreages, evapotranspiration, and applied water for major crops.

Table NL-6. Irrigated Crop Acreage
(thousands of acres)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Lassen Group	120	122	125	128
Alpine Group	41	41	41	41
TOTAL	161	163	166	169

Table NL-8 summarizes 1990 and forecasted agricultural water demand in the region. The applied water use values were derived by applying unit water use factors to the irrigated acreages in the region. Applied water amounts vary according to crop, soil type, cultural practices, and the quantity, timing, and availability of irrigation water. During drought years, there is an increased need for additional irrigations to replace water normally supplied by rainfall and to meet higher-than-normal evapotranspiration demands.

Table NL-7. 1990 Evapotranspiration of Applied Water by Crop

Irrigated Crop	*Total Acres (1,000)*	*Total ETAW (1,000 AF)*
Grain	6	10
Rice	1	2
Alfalfa	43	103
Pasture	110	233
Other truck	1	2
TOTAL	161	350

The majority of the area irrigated by surface water, particularly in the Lassen Group, has limited water storage facilities and is dependant on snowmelt and spring and summer rainfall. Since most of the surface water irrigation operates with a nonfirm water supply, irrigated acreage and the length of time irrigation water is available fluctuates annually. The crop most subject to these changes is irrigated pasture. Even though acreage in some areas can remain relatively stable, the length of the irrigation season is often shortened since runoff generally decreases as summer progresses. As in most situations when water is in short supply, water is used sparingly and irrigation efficiencies increase. There is no evidence that there will be significant changes in future irrigation efficiencies; however, some increase can be anticipated due to improved irrigation management and the water conservation ethic in the area. The agricultural economy and water users have adapted to the erratic water supply.

Land Conservancy, a private land trust organization, DFG has been acquiring lands and water rights at Heenan Lake in the upper watershed of the East Fork Carson River. This small reservoir, formerly used to supply irrigation water for lands in Nevada, is now being used by DFG to raise Lahontan cutthroat trout to stock in other locations throughout the Sierras. Parts of the upper Carson River are managed by DFG as wild trout waters, where stocking of hatchery fish is not allowed. Recreational trout fishing is a popular activity on both the upper Carson and Walker rivers.

The productive, highly alkaline waters of Eagle Lake near Susanville in Lassen County support a renowned trout fishery. The endemic Eagle Lake rainbow trout, a recognized subspecies, is a variety also suitable for widespread planting and has become an important hatchery strain. Eagle Lake is a fishing recreation center for Northern California and Nevada.

Bridgeport Reservoir on the East Walker River near the California-Nevada border was the site of a recent State Water Resources Control Board action regarding water requirements for the trout fishery. This reservoir supplies water to agricultural lands in Nevada. The operation of the reservoir during the recent drought caused a fishery resource to decline in the river downstream. As part of ensuing legal actions, instream flow releases and other conditions were imposed on reservoir operation. The SWRCB's modifications to the permits for Bridgeport Reservoir are being challenged in the U.S. District Court in Nevada.

Other Water Use

By far, the heaviest concentration of recreation use in the North Lahontan Region occurs within the Lake Tahoe Basin. Recreation development in other areas of the region is limited due to the relatively low population density and remoteness. Roughly half of the visitors to this region come from the San Francisco metropolitan area, about 30 percent from the Los Angeles metropolitan area, and 15 percent from out-of-state.

Public recreation areas include three national forest districts, 12 Bureau of Land Management recreation complexes, seven State parks, and six county parks. There are more than 30 major private recreation areas which include ski areas, golf courses, resorts, and marinas.

Several natural waterways in the region provide access for fishing, swimming, boating, hiking, and picnicking. River touring, a popular sport in California, is a common activity in the Truckee, Carson, East Fork Carson, West Walker, and East Walker rivers. Figure NL-6 shows water recreation areas in the region.

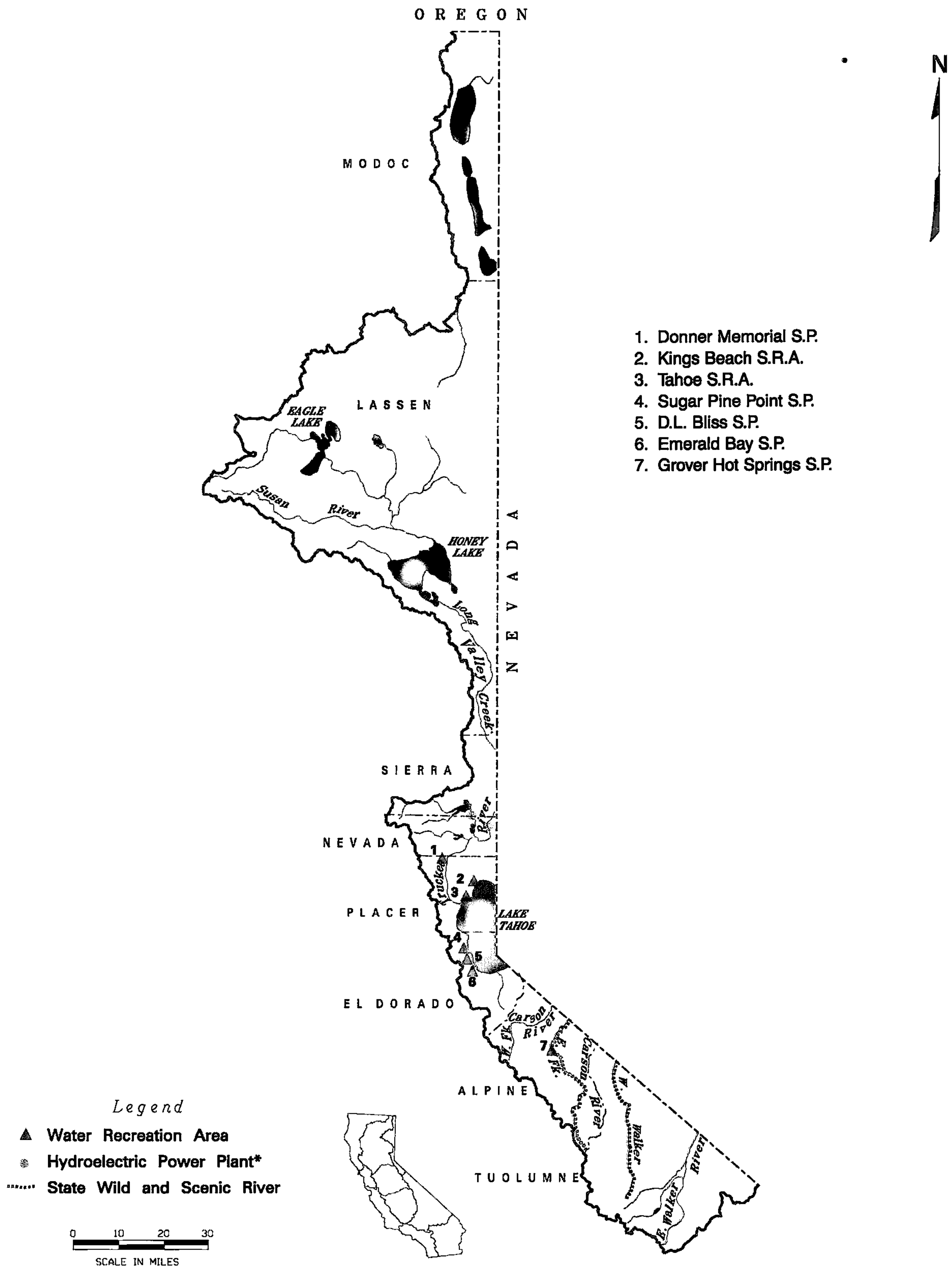
Table NL-10. Total Water Demands
(thousands of acre-feet)

Category of Use	**1990**		**2000**		**2010**		**2020**	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Urban								
Applied water demand	37	38	43	44	46	48	51	52
Net water demand	37	38	43	44	46	48	51	52
Depletion	14	15	17	18	19	20	21	21
Agricultural								
Applied water demand	522	587	523	589	525	591	536	602
Net water demand	460	511	458	510	457	508	469	521
Depletion	378	426	385	433	393	442	399	449
Environmental								
Applied water demand	17	17	17	17	17	17	17	17
Net water demand	17	17	17	17	17	17	17	17
Depletion	17	17	17	17	17	17	17	17
Other(1)								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	576	642	583	650	588	656	604	671
Net water demand	514	566	518	571	520	573	537	590
Depletion	409	458	419	468	429	479	437	487

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Figure NL-6. North Lahontan Region

Hydroelectric Power Plants, Wild and Scenic Rivers, and Water Recreation Areas



*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

Current visitor attendance to the region is estimated at 12 million visitor days annually. Total consumptive water use for recreation in the region is small. Table NL-10 shows the total water demands for this region.

Issues Affecting Local Water Resource Management

The principal water-related issues in the North Lahontan Region center around interstate water allocations, population growth, limitations of existing water supply systems, water quality protection, and ground water management.

Legislation and Litigation

Interstate River Issues. Years of disputes over the waters of the Truckee and Carson rivers finally led to congressional enactment of the Truckee-Carson-Pyramid Lake Water Rights Settlement Act in 1990. The act makes an interstate allocation of the waters between California and Nevada, provides for the settlement of certain Native American water rights claims, and provides for water supplies for specified environmental purposes in Nevada. The act allocates to California: 23,000 af annually in the Lake Tahoe Basin; 32,000 af annually in the Truckee River Basin below Lake Tahoe; and water corresponding to existing water uses in the Carson River Basin. Provisions of the Settlement Act, including the interstate water allocations, will not take effect until several conditions are met, including negotiation of the Truckee River Operating Agreement required in the act.

The Carson River in Alpine County. The Carson and Truckee rivers were the center of a years-long water rights dispute which was settled in 1990 in the congressional Truckee-Carson-Pyramid Lake Water Rights Settlement Act.

DWR and SWRCB staff have represented California interests in negotiating the Truckee River Operating Agreement. DWR is a lead agency, along with the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service, in developing the Environmental Impact Report/Statement for the agreement. A major purpose of the TROA is to establish detailed river operations procedures to meet the goals laid out in the act. It may also address some aspects of implementing California's water allocation. Issues of concern to California include implementation of surface and ground water allocations, including the amount of water allocated for snow-making at ski resorts, and allocations for operation of Truckee River storage facilities to protect lake and instream beneficial uses.

Present-day operations of the Truckee, Carson, and Walker rivers are governed in large part by existing federal court water rights decrees administered by court-appointed watermasters. The interstate nature of the rivers, combined with the long history of disputes over water rights, has created a complex system of river management criteria. On the Carson River for example, it took the federal court 55 years to sort out the water rights and issue the Alpine Decree, which governs operation of the river today.

Regional Issues

Population Growth. Growth has long been a major issue in the Tahoe Basin and strict controls have been adopted by local agencies under the leadership of the Tahoe Regional Planning Agency. These controls have been very effective. For example, the City of South Lake Tahoe grew by only 4 percent in the 1980s.

Population of the Lassen County portion of the region increased by nearly 30 percent over the past decade. A major contributor to this growth was the construction of the California Correctional Center at Susanville, which houses about 4,000 prisoners and employs a staff of about 1,000. This growth and the 1987-92 drought have revealed the limits of local surface water supplies. There is increasing interest in assuring that water will be available to meet urban needs without reducing agricultural supplies or overdrafting the ground water basin. State proposals to double the capacity of the correctional facility led to intense local debate in 1991. One of the principal issues was the growth-inducing impact of the proposal and the resulting increased pressure on existing water supplies. The question was eventually put on the ballot, and a substantial majority of the voters approved the expansion.

Reno Water Supplies. Although not strictly a California issue, local interests in the northern part of the region have been apprehensive about the Reno area's aggressive quest for additional water supplies. In the late 1980s, the *Silver State Plan* triggered concerns as far north as Modoc County (over 150 miles north of Reno). The plan envisioned constructing a pipeline north nearly to the Oregon border to tap ground water basins, some of which extend across the California-Nevada line. More recently, the proposed Truckee Meadows Project generated concerns about depletion of ground water supplies.

Ground water management is closely related to the issue of water supply for the Reno area. Concern over protecting local ground water resources has led to establishment of formal ground water management mechanisms in the Honey Lake and Long Valley basins in Lassen and Sierra counties. Similar arrangements are being considered in Surprise Valley and the pending interstate allocation establishes limits on ground water withdrawals in the Lake Tahoe and Truckee River basins. At present, neither the Honey Lake nor Long Valley ground water management districts is active, but either can be activated whenever a need is perceived.

Water Quality. There is a potential for future ground water pollution in those areas where single-family septic systems have been installed in high density subdivisions, especially in the hard rock areas. Water quality has also become a greater issue for many surface water systems around Lake Tahoe. The recent drought dropped lake levels to all-time lows and left some system intakes in shallow water. In addition, the 1986 amendments to the Safe Drinking Water Act are forcing many of the smaller private systems to consolidate or change ownership since they are unable to afford the new monitoring and treatment requirements of the amended act. South Tahoe Public Utility District, the largest water purveyor in the basin, is also experiencing some difficulty in planning to meet these requirements.

The Lahontan Regional Water Quality Control Board has been concerned about ground water contamination and eutrophication at Eagle Lake since 1982. Numerous studies, including one completed by DWR in October 1990, have shown widespread bacterial contamination in domestic wells in this area. Blooms of noxious species of algae appear to be increasing in frequency in the lake in response to nutrient enrichment, a suspected result of increased residential development in the basin. The regional board issued Cease and Desist Orders in 1991 requiring subdivision residents to abandon use of septic tanks. The State Water Resources Control Board was petitioned by residents of Spalding Tract and Stones-Bengard subdivisions for relief from these orders, and the SWRCB agreed to allow the formation of a septic system maintenance district in lieu of a regional waste water collection system. The regional board will be establishing guidelines for forming this district and monitoring requirements to ensure that ground water contamination does not continue.

A study of the potential contamination of Cady Springs by septic tank leachfield effluent from up-slope urban development is also being conducted. Cady Springs is the primary water supply for the City of Susanville. Until the completion of the study, further urban development of this area, west of Susanville, has been constrained by concerns expressed by the city and the Regional Water Quality Control Board.

Truckee Meadows Ground Water Transfer Project. In the mid-1980s, a plan for the Truckee Meadows Project was developed to export ground water from Nevada's portion of Honey Lake Valley ground water basin to the Reno area. Applications were filed with the Nevada State Engineer to transfer about 23,000 af per year. Concerns about the transfers and possible side effects resulted in a 1987 agreement between DWR, the State of Nevada, and the U.S. Geological Survey to jointly determine the ground water flow system in eastern Honey Lake Valley. When the USGS study was completed, the Nevada State Engineer opened hearings in the summer of 1990 regarding applications to transfer ground water from Honey Lake Valley to the Reno area. The Nevada State Engineer ruled that only about 13,000 af could be transferred from the basin. Currently, the Truckee Meadows Project developers are completing an Environmental Impact Statement for the 80-mile pipeline to transfer ground water. Lassen County and the Pyramid Lake Paiute Tribe have challenged the State Engineer's decision in a Nevada Court.

Long Valley Ground Water Transfers. In the late 1980s, there was a proposal to export about 3,000 af per year from Long Valley to the Reno area. The project developers were asked to submit an application to the Long Valley Ground Water Management District for a permit to export ground water from the district. To date, the project proponents have not filed an application.

Water Balance

Water budgets were computed for each planning subarea in the North Lahontan Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas, which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be less or more severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table NL-11. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	37	38	43	44	46	48	51	52
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Agricultural—with 1990 level of conservation.	460	511	458	510	457	508	469	521
—reductions due to long-term conservation measures (Level I)	—	—	0	0	0	0	0	0
Environmental	17	17	17	17	17	17	17	17
Other[1]	0	0	0	0	0	0	0	0
TOTAL Net Demand	514	566	518	571	520	573	537	590
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water	393	349	390	351	382	351	390	355
Ground Water	121	146	128	154	138	165	147	173
Ground Water Overdraft[2]	0	0	—	—	—	—	—	—
Subtotal	514	495	518	505	520	516	537	528
Dedicated Natural Flow	0	0	0	0	0	0	0	0
TOTAL Water Supplies	514	495	518	505	520	516	537	528
Demand/Supply Balance	0	–71	0	–66	0	–57	0	–62
Level I Water Management Programs								
Long-term Supply Augmentation								
Reclaimed	—	—	0	0	0	0	0	0
Local	—	—	0	0	0	0	0	0
Central Valley Project	—	—	0	0	0	0	0	0
State Water Project	—	—	0	0	0	0	0	0
***Subtotal* - Level I Water Management Programs**	0	0	0	0	0	0	0	0
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	0	0	0	0	0	0
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	–71	0	–66	0	–57	0	–62

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Table NL-11 presents water demands for the 1990 level and for future water demands to 2020 and balances them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options.

Regional net water demands for the 1990 level of development totaled 514,000 and 566,000 af for average and drought years, respectively. Those demands are forecasted to increase to 537,000 and 590,000 af, respectively, by the year 2020. Urban net water demand is forecasted to increase by about 14,000 af, primarily due to expected increases in population, while agricultural net water demand remains essentially level. Environmental net water demands are also expected to remain level out to 2020.

Average annual supplies are generally adequate to meet average water demands in this region to the year 2020. However, during drought, present supplies are insufficient to meet present and future demands without additional water management programs; annual drought year shortages are expected to be about 62,000 af by 2020.

The 1990 drought year shortage of about 71,000 af was reflected in reduced surface water supplies available for irrigation primarily in Alpine, Mono, Lassen, and Modoc counties. The shortages mentioned above for drought conditions are typically managed locally according to water availability. Specifically, available water supplies determine the amount of agricultural land in production in any given year. In most of these areas, supplies are delivered according to water rights or court decisions by local, state, and federal watermasters.

There are no major water management programs planned for this region. Plans for augmenting supplies for the Reno-Sparks area, such as ground water import from California, could affect future supplies in the region. The Truckee River operating agreement is currently being negotiated with Nevada interests but is not expected to limit supplies through 2020. Future water management programs depend on economic viability of such programs and the overall level of water service reliability deemed necessary by local agencies to sustain the economic health of the region.

Aerial view of the southern Sierra Nevada snow pack. Runoff from the eastern face of the Sierras is an integral part of the South Lahontan Region's water supply, part of which is exported to the South Coast Region.

South Lahontan Region

The South Lahontan Region accounts for about 18 percent of California's total land area. It encompasses the area from the mountain divide north of Mono Lake to the divide south of the Mojave River, which runs through the Mojave Desert. It is bordered on the east by the Nevada state line and on the west by the crest of of the Sierra Nevada.

The region is a closed basin with many desert valleys that contain central playas, or dry lakes, especially in the south. The northern portion is dominated by the Sierra Nevada and the White-Inyo Mountain Ranges. In the south are smaller mountain ranges with broad alluvial fans. Other prominent topographic features in the region include Mt. Whitney (the highest mountain in the contiguous 48 states, with an elevation of 14,495 feet), the Mono volcanic tableland, Death Valley (the lowest point at elevation 282 feet below mean sea level), and the Owens Valley. (See Appendix C for maps of the planning subareas and land ownership in the region.)

Average annual precipitation for the region's valleys generally ranges between 4 and 10 inches. Variations above and below this range do occur; for example, Death Valley receives only 1.9 inches annually. The Sierra Nevada Mountains 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.

Population

In 1990, the South Lahontan Region's population was almost 600,000, about 2 percent of California's total. Although not densely populated, the region contains some of the fastest growing urban areas in California, including the cities of Lancaster and Palmdale in the Antelope Valley of Los Angeles County and the Victor and Apple valleys of San Bernardino County. Many of the new residents in these valleys are workers who have accepted a long commute to the greater Los Angeles area in exchange for affordable new homes. Future population growth in the region will probably be concentrated in these vicinities. Major local employment includes the aerospace industry at Palmdale Airport and Edwards Air Force Base. Bishop, Ridgecrest, and Barstow are the other important centers in the region. The City of Ridgecrest's continued growth will be tied to the economic conditions of the nearby China Lake Naval Weapons Center and mining operations at Searles Lake.

Region Characteristics

Average Annual Precipitation: *8 inches* ***Average Annual Runoff:*** *1,334,000 af*

Land Area: *29,020 square miles* ***1990 Population:*** *599,900*

While the identified growth centers will probably continue to expand, there is little reason to expect much population growth elsewhere in the region. The Owens Valley and eastern Sierra area should remain sparsely populated, with the string of small communities serving recreationists and travelers along U.S. Highway 395. Barstow, a service center for railroads and travelers, is strongly tied to the U.S. Army's Fort Irwin, which has grown modestly in recent years. Most of the other towns and communities in this portion of the region are highway service centers or farm service centers. Table SL-1 shows population projections to 2020 for the South Lahontan Region.

Table SL-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Mono-Owens	25	29	35	43
Death Valley	1	1	1	1
Indian Wells	48	75	108	141
Antelope Valley	260	499	738	986
Mojave River	265	399	547	748
TOTAL	599	1,003	1,429	1,919

Land Use

Public lands constitute about 75 percent (14 million acres) of the region's area. Much of this land is national monument and scenic areas, national forests, and military reservations.

About 1 percent of the 18.6 million acres in the South Lahontan Region is used for urban and agricultural activities. In 1990, urban and suburban land uses occupied about 170,000 acres, a 21-percent increase from 1980. Over 80 percent of this increase was in urban acreage concentrated in the Antelope and Mojave River valleys. The only other area showing much urban growth was the Indian Wells Valley. Much of this increase was associated with construction of new single- and multiple-family dwellings. Modest increases are associated with new commercial services and light industry. Industries supporting the region's economy include the military, recreation and tourism, travelers' services, agriculture, and mining.

About 61,000 acres are irrigated crop land (less than 1 percent of the region's total land area). Multiple cropping is not generally practiced in the region. Most of the irrigated acreage is in the Mono-Owens planning subarea where roughly 30,000 acres are irrigated. This PSA includes the Owens Valley, the Lake Crowley area northwest of Bishop, and the Hammil and Fish Lake valleys. Alfalfa and pasture are the primary crops.

Moderate levels of irrigated agriculture subsist in the Mojave River, Antelope, and Indian Wells valleys. Most of the activity and acreage produces alfalfa, pasture, or deciduous fruit. Figure SL-1 shows land use, along with imports and exports for the South Lahontan Region.

Supply with Existing Facilities and Water Management Programs

Table SL-3 shows water supplies with existing facilities and water management programs. Ground water is the only source of domestic and agricultural water in the Death Valley and Indian Wells planning subareas. Very little, if any, of the surface water flow in these PSAs is used for other than natural ground water recharge. The Antelope Valley receives over 66 percent of its domestic and agricultural water supply from the State Water Project, with the remainder drawn from ground water and local surface supplies. The Mono-Owens and Mojave River PSAs rely on both surface and ground water supplies to meet demands.

Table SL-3. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	57	44	57	44	57	44	57	44
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	69	47	133	87	142	88	153	90
Ground water	221	252	220	237	226	271	258	271
Overdraft(1)	67	67	—	—	—	—	—	—
Reclaimed	13	13	13	13	13	13	13	13
Dedicated natural flow	128	122	128	122	128	122	128	122
TOTAL	555	545	551	503	566	538	609	540

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Ground water is extremely important in supplying water to the region. As many as 47 distinct ground water basins covering thousands of square miles have been identified in the South Lahontan Region. Storage capacities vary by basin. Ground water basin capacities in both the Mojave River and Antelope Valley PSAs, for example, total about 70,000,000 af each. Economically usable storage is significantly less but provides the major, if not the only, water source in many areas. Water quality also varies and this influences water supply. Basins are recharged through percolation from irrigation return flow, natural stream flow, and intermittent stream flow from snowmelt, depending on location.

Natural runoff, carried by numerous streams on the eastern slopes of the Sierras, is about 1,300,000 af annually in average years. Estimated projected average year deliveries to the City of Los Angeles are about 425,000 af a year for 2000 to 2020. Under drought conditions, deliveries are projected to be 208,000 af a year for 2000 to 2020.

Supply with Additional Facilities and Water Management Programs

Future water management options are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Table SL-4 shows water supplies with Level I water management programs.

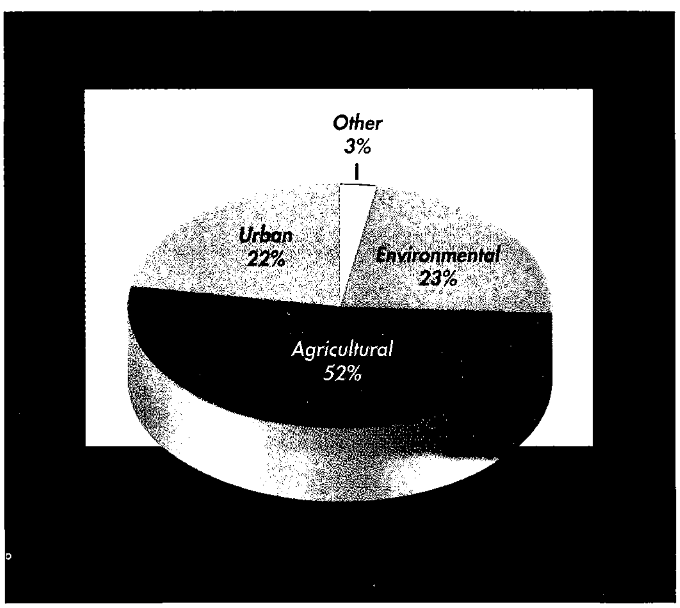
Table SL-4. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Surface								
Local	57	44	57	44	57	44	57	44
Local imports	0	0	0	0	0	0	0	0
Colorado River	0	0	0	0	0	0	0	0
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	69	47	143	107	164	141	185	142
Ground water	221	252	219	237	226	237	236	271
Overdraft(1)	67	67	—	—	—	—	—	—
Reclaimed	13	13	13	13	14	14	14	14
Dedicated natural flow	128	122	128	122	128	122	128	122
TOTAL	555	545	560	523	589	558	620	593

(1) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

The larger urban and agricultural areas of the South Lahontan Region—Owens Valley, Victorville, Hesperia, and Antelope Valley—have several water management options that can improve the reliability of supplies, including: formation of ground water management agencies or replenishment districts; reclamation of brackish ground water; desalination; water recycling; and institution of conjunctive use operations to make more efficient use of surface and ground water supplies.

Figure SL-3
South Lahontan Region
Net Water Demand
(1990 Level
Average Conditions)



Most of the water demands of the region are being met with ground water and local surface water. Several of the ground water basins are in overdraft. SWP water is being delivered to residents in the Antelope Valley and will be delivered to the Mojave Water Agency after the Morongo Pipeline is completed in 1994. Also, a feasibility study is being initiated for the Mojave Water Agency's proposed Mojave River Pipeline to the City of Barstow and the communities of Newberry Springs (Helendale, Hinkley, Lenwood, Daggett). More on this water management plan can be found in the *Legislation and Litigation* section later in this chapter.

Water Use

Estimated 1990 level annual net water use within the South Lahontan Region is about 555,000 af per year. Irrigated agriculture accounts for 52 percent of the region's 1990 level net water use, while urban use amounts to about 22 percent, and environmental and other water use account for 26 percent. Net water use for urban and agricultural purposes in the South Lahontan Region increased by almost 4 percent between 1980 and 1990. By 2020, net water demand for the region is forecasted to climb an additional 32 percent because of continued expansion of urban centers. Figure SL-3 show net water demand for the 1990 level of development.

Since the 1970s, population in some urban centers in Antelope, Mojave River, Apple, and Victor valleys has increased dramatically. Urban development alone in the Antelope and Mojave River valleys increased net water use by almost 125 percent since 1980.

Urban Water Use

Population projections indicate that from 1990 to 2020, the region's population will increase by over 200 percent. Medium-sized cities such as Lancaster, Palmdale, Apple Valley, Victorville, Hesperia, and Barstow will continue to expand; however, development in the rest of the region will be sporadic.

Total municipal and industrial applied water use in 1990 was about 187,000 af, an increase of about 97 percent from the 1980 level. The 1990 level urban net water demand was about 123,000 af and is forecasted to increase by almost 200 percent by 2020. Most of the increase in new water use will be in the residential category, while increases in industrial water use will be modest. Figure SL-4 shows the 1990 level urban applied water use by sector.

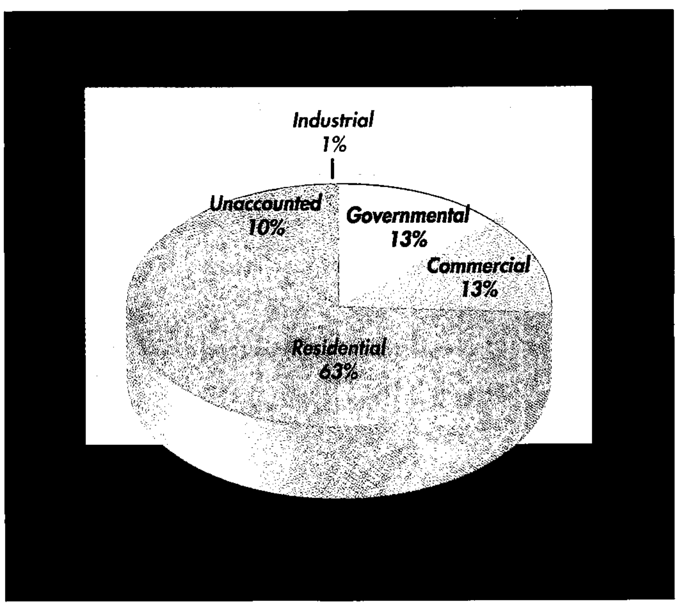


Figure SL-4. South Lahontan Region Urban Applied Water Use by Sector (1990 Level Average Conditions)

Normalized 1990 per capita water use for the region was 280 gallons daily. However, daily per capita use ranged from 124 gallons for the Death Valley PSA to 503 gallons for the Mono-Owens PSA. Possible reasons for the relatively high per capita values in the Mono-Owens area are the large numbers of tourists (greatly exceeding the residential population). In Death Valley, there is little outdoor residential water use, which accounts for the relatively low per capita use value for the area.

In 1990, the Antelope Valley and Mojave River PSAs combined accounted for about 86 percent of the region's total urban applied water, while the Mono-Owens and Indian Wells PSAs accounted for the remaining 14 percent. Regional applied water demands for urban use are forecasted to climb to almost 550,000 af by 2020, an increase of 194 percent over the 1990 level. Table SL-5 shows urban water demand to 2020.

Table SL-5. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Mono-Owens								
Applied water demand	14	15	16	17	19	20	24	24
Net water demand	8	8	9	9	11	11	13	14
Depletion	8	8	9	9	11	11	13	14
Death Valley								
Applied water demand	0	0	0	0	0	0	0	0
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
Indian Wells								
Applied water demand	12	12	18	19	27	28	36	37
Net water demand	7	7	10	11	15	16	20	21
Depletion	7	7	10	11	15	16	20	21
Antelope Valley								
Applied water demand	66	68	122	126	180	186	243	250
Net water demand	45	46	83	86	123	126	165	170
Depletion	45	46	83	86	123	126	165	170
Mojave River								
Applied water demand	95	98	136	140	183	189	247	254
Net water demand	63	64	89	92	120	124	162	167
Depletion	63	64	89	92	120	124	162	167
TOTAL								
Applied water demand	187	193	292	302	409	423	550	565
Net water demand	123	125	191	198	269	277	360	372
Depletion	123	125	191	198	269	277	360	372

those of the Los Angeles area is a vital concern in the region. This situation is discussed under *Issues Affecting Local Water Resource Management* later in this chapter. The Mono Lake and Owens River average annual instream water needs are about 73,000 and 55,000 af, respectively, and drought year water needs are 67,000 and 55,000 af, respectively. There are no measurable wetlands water needs in the South Lahontan Region. Table SL-9 shows environmental instream water needs for the region.

Other Water Use

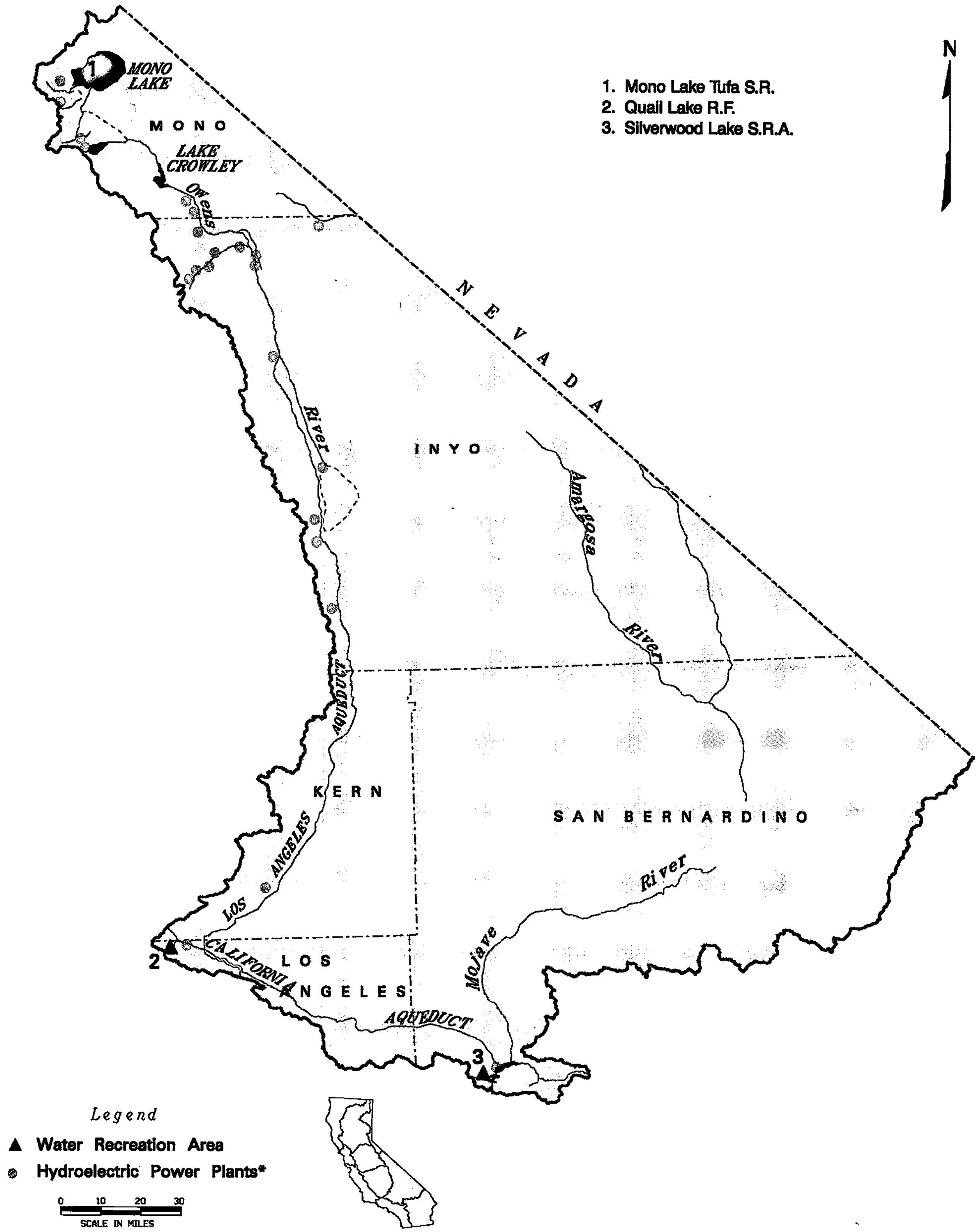
Other water uses in the region include energy production and water used at recreational facilities for public service, showers, toilets, and watering some limited landscaping. Power plant cooling water accounted for about 6,000 af of the regional water use in 1990; 4,000 af were used in the Mojave River PSA, and 1,000 af each in the Antelope Valley and Indian Wells PSAs. Water used at recreational facilities during 1990 was 3,000 af.

The East Branch of the State Water Project winds across sparsely vegetated hillsides past recently developed urban areas in the distance. Urban growth in the high desert area is expected to continue its rapid pace.

Table SL-9. Environmental Instream Water Needs
(thousands of acre-feet)

Stream	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Mono Lake								
Applied water demand	73	67	73	67	73	67	73	67
Net water demand	73	67	73	67	73	67	73	67
Depletion	73	67	73	67	73	67	73	67
Owens River								
Applied water demand	55	55	55	55	55	55	55	55
Net water demand	55	55	55	55	55	55	55	55
Depletion	0	0	0	0	0	0	0	0
TOTAL								
Applied water demand	128	122	128	122	128	122	128	122
Net water demand	128	122	128	122	128	122	128	122
Depletion	73	67	73	67	73	67	73	67

Figure SL-6. South Lahontan Region
Water Hydroelectric Power Plants and Recreation Areas



*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

Water-related recreation in the region includes fishing and skiing, and region recreational areas offer opportunities for camping and hiking. For instance, Lake Crowley, about 25 miles northwest of Bishop, is operated to provide optimum environmental and recreational benefits, as well as providing water and power to the Los Angeles Aqueduct system. Fishing, camping, water skiing, sailing, and water jet skiing are among the prevalent recreational activities. Figure SL-6 shows water recreation areas in the region. Table SL-10 shows the total water demands for this region.

Table SL-10. Total Water Demands
(thousands of acre-feet)

Category of Use	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Urban								
Applied water demand	187	193	292	302	409	423	550	565
Net water demand	123	125	191	198	269	277	360	372
Depletion	123	125	191	198	269	277	360	372
Agricultural								
Applied water demand	317	321	266	270	258	262	253	257
Net water demand	290	293	242	245	235	238	231	234
Depletion	290	293	242	245	235	238	231	234
Environmental								
Applied water demand	128	122	128	122	128	122	128	122
Net water demand	128	122	128	122	128	122	128	122
Depletion	73	67	73	67	73	67	73	67
Other(1)								
Applied water demand	9	9	9	9	9	9	9	9
Net water demand	14	14	16	16	16	16	16	16
Depletion	14	14	16	16	16	16	16	16
TOTAL								
Applied water demand	641	645	695	703	804	816	940	953
Net water demand	555	554	577	581	648	653	735	744
Depletion	500	499	522	526	593	598	680	689

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Issues Affecting Local Water Resource Management

The 1987-92 drought raised several water management issues in the South Lahontan Region. In 1991, retail urban water agencies in the region implemented ordinances requesting that their customers reduce their overall demand. Reductions ranged from 10 to 25 percent. Most agricultural operations were generally not hindered, as ground water supplies were generally adequate to meet demands. However, the City of Los Angeles cut back its deliveries to growers and ranchers in the Owens Valley, which resulted in a minor decline in planted and harvested acreage and yield. In addition, some alfalfa acreage in the Antelope Valley was fallowed so ground water supplies could be used to irrigate deciduous fruit orchards that were affected by reduced supplies from the State Water Project. (The ground water was pumped into the California Aqueduct and transported to the orchards.)

Legislation and Litigation

Of the many factors influencing water resource management, legislation and litigation have significantly changed water supply management in the South Lahontan Region. Several court cases have altered water diversions and ground water pumping in the region. A few of the landmark cases are described here.

Owens Valley Area. At the turn of the century, the City of Los Angeles faced a severe shortage of water due to a growing urban population. In 1913, the City of Los Angeles completed its first aqueduct from Owens Valley to the City of Los Angeles. This aqueduct has a carrying capacity of 480 cubic feet per second. Due to increased population and industries in Los Angeles, a second aqueduct was completed in 1970 with a capacity of 300 cfs. The Los Angeles Department of Water and Power diverts both surface and ground water from the Owens Valley and surface water from the Mono Basin.

In 1972, the County of Inyo filed suit against the City of Los Angeles, claiming that increased ground water pumping for the second aqueduct was harming the Owens Valley environment. The County of Inyo asked that LADWP's ground water pumping be analyzed in an Environmental Impact Report in accordance with the provisions of the California Environmental Quality Act.

Since 1984, the City of Los Angeles and Inyo County have spent about $5 million to determine the effects of ground water pumping on native vegetation. Together with the U.S. Geological Survey, the two parties gathered the data needed to formulate a long-term ground water management plan and develop an EIR. Within the scope of these studies, numerous enhancement and mitigation projects were implemented. Revegetation and irrigation of certain wildlife habitats and recreation areas constituted the bulk of these projects.

As of August 1, 1989, the parties reached agreement on the long-term ground water management plan for the Owens Valley. However, the EIR has been rejected by the Third District Court of Appeals in Sacramento, which required a more comprehensive environmental assessment of the agreement. The highlights of the agreement are:

- Formation of a technical group and a standing committee to oversee all operations pertaining to water and how its use affects the environment in the Owens Valley and adjacent areas.
- Formation of designated management areas.
- Development of a ground water pumping program including new wells and allowable production capacity.
- Construction of ground water recharge facilities including location and operation.
- Modification of Haiwee Reservoir operations.
- Provisions of financial assistance required by the City of Los Angeles.
- Release of city-owned lands.
- Development of projects and other provisions involving numerous enhancement and mitigation measures and transfer of ownership of the water systems of several towns.

Continued study of the Owens Valley appears to benefit all concerned.

Mono Basin. Mono Lake, which lies just east of Yosemite National Park at the base of the eastern Sierra Nevada, is the second largest lake completely within

California. It has long been recognized as a valuable environmental resource because of its rare scenic and biological characteristics. The area is famous for its tufa towers and spires, structures formed by years of mineral deposition in the lake's unique saline waters. The lake has no outlet, and 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 via five fresh-water creeks. Since 1941, the Los Angeles Department of Water and Power has diverted water from Lee Vining, Walker, Parker, and Rush creeks into tunnels and pipelines that carry the water to the Owens Valley drainage; it is eventually transferred, together with Owens River flows, to Los Angeles via the Los Angeles Aqueduct.

An aerial view of Mono Lake shows the island which is used as an avian nursery. Recent court decisions have set minimum water levels for the lake.

Diversions of in-stream flow from its tributaries lowered Mono Lake's water level to an historic low of 6,372 feet above sea level, reached in December 1981. With decreased inflow of fresh water, the lake's salinity has increased dramatically, which may eventually threaten local food chains. There is evidence that higher salinities reduce algal blooms, the food supply for the lake's abundant brine shrimp and brine flies. Such a change poses a threat to bird populations that feed on the shrimp and brine flies. In addition, when water levels drop to 6,375 feet or lower, a land bridge to Negit Island, one of the lake's two islands, is created, allowing predators to reach gull rookeries; this first happened in 1978 and again during the 1987-92 drought. Large areas of the lake bed have also become exposed, and the dust formed by dried alkali silt can cause air quality problems, especially during wind storms. The U.S. EPA, in November 1993, designated the Mono Basin as a nonattainment area under the Clean Air Act due to dust emissions from the dry lake bed.

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 a number of environmental groups since the late 1970s. (A more detailed discussion of key court cases is provided in Volume I, Chapter 2.) Los Angeles Department of Water and Power is now prohibited by court order from diverting the tributaries water until the lake level stabilizes at 6,377 feet above sea level, the level identified by state and federal agencies to protect the ecosystem and control air pollution. During the 1987-92 drought, Mono Lake remained near the target level, but the diversion limit resulted in an estimated loss of 100,000 af per year to Los Angeles' water supply by the end of 1992. In addition, releases into four of the lake's tributaries have been ordered by another court ruling to protect and restore once-thriving trout fisheries. Instream flow requirements for the tributaries have been set on an interim basis and will be reviewed once field studies are completed. SWRCB concluded Mono Lake water rights hearings in February 1994. A draft decision regarding lake levels and streamflows on the four tributaries is expected in late 1994. The final decision will be forwarded to the Alpine Superior Court for its approval. In the meantime, Los Angeles is making efforts to conserve water and has approved a mandatory conservation ordinance during the drought. Since 1989, annual water deliveries to the City of Los Angeles from the Mono-Owens system have decreased by an average of 39 percent from previous levels in the 1980s. The decrease is in part drought related. LADWP is also investigating potential alternative sources of water. The Mono Lake Committee recently signed a Memorandum of Understanding with LADWP. As a result of the MOU, an application is now being made for funds authorized by the Environmental Water Act to develop recycled water in Los Angeles to replace a portion of its lost supply. The CVPIA authorizes funds for replacing the water diverted from Mono Lake by a 25-percent contribution to develop recycled water.

Antelope Valley Area. In December 1991, the Palmdale Water District made public its intentions to create, through state legislation, a ground water management agency so that long-term overdrafting in the valley could be stopped. Several constituents within the Antelope Valley expressed their opposition. In the ensuing months, several local groups held meetings to reach a consensus on formation of the agency. The Antelope Valley-East Kern Water Agency suggests that a ground water management agency is "premature" and unnecessary. Due to public outcry over this issue, the Palmdale Water District Board of Directors has withdrawn its proposal. The Antelope Valley agencies have since formed an advisory board to discuss water issues, including ground water.

High Desert Area. Recent court cases involving, among others, the Cities of Barstow, Victorville, and Hesperia, have led to concerns over water rights in the Mojave River Basin. The Mojave Water Technical Advisory Committee reports that a preliminary estimate of overdraft for 1990 is between 65,000 and 75,000 af. Forecasted overdraft for the year 2015 amounts to 90,000 af, based on 2015 population forecasts. To help resolve the problem, the Mojave Water Agency completed a report for a 37-mile Mojave River Pipeline to convey State Water Project water to the City of Barstow and the community of Newberry Springs.

In addition, the SWP water will provide a supplemental supply for a district within the Mojave Water Agency, which now has only ground water available and whose extraction is exceeding replenishment. In June 1990, the district voted to approve issuing $66.5 million in general obligation bonds to finance the Morongo Pipeline. Construction of the 70-mile pipeline is expected to be completed in summer 1994. The Morongo Basin has an entitlement to 7,257 af of SWP water. The Board of Directors of the Mojave Water Agency decided to oversize the pipeline to provide capacity for water to recharge the Mojave River. Increasing the pipeline's first section from 30 inches in diameter to 54 inches gives it the capacity to put as much as 30,000 af a year into the river for ground water replenishment.

The City of Barstow filed a suit in 1990 against major Upper Basin water districts requesting that the Superior Court guarantee an annual supply of at least 30,000 af of Mojave River water at the USGS gaging station at Barstow. Barstow alleges that this was the natural river flow to the city in 1950, before Victor Valley's growth began to cause overdrafting of the Mojave River Basin's ground water. It further alleges that it now receives less than half the flow that it did 40 years ago. The Mojave Water Agency, after attempting a settlement, opted to expand the instream adjudication filed by Barstow to a "general stream" adjudication, encompassing the area both upstream and downstream of Barstow. A cross-complaint was filed by MWA to achieve this purpose in May 1991. The parties to the lawsuit, with the assistance of a facilitator, drafted a set of principles of adjudication and proceeded to draft a stipulated judgment for consideration by the court. In September 1993, the Riverside Superior Court issued an interim order basically binding those parties that had stipulated to the proposed judgment. This interim order has allowed a physical solution to the overdraft to proceed until the trial process is concluded with nonstipulating parties. A trial date has been set for February 1995.

In another suit, filed by Barstow regarding development proposed by the City of Hesperia, the court's ruling emphasized the necessity for Mojave Water Agency to exercise its authority as a key agent in settling the region's long-term water problems. Currently, Mojave Water Agency is developing a water management plan to address issues raised by the court.

Water Balance

Water budgets were computed for each Planning Subarea in the South Lahontan Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas, which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary to the sustained economic health of the region. Volume I, Chapter 11 presents a broader discussion of demand management options.

Table SL-11 presents water demands for the 1990 level and for future water demands to 2020 and balances them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management options.

Regional net water demands for the 1990 level of development totaled 555,000 and 554,000 af for average and drought years, respectively. Those demands are forecasted to increase to 735,000 and 744,000 af for average and drought years by the year 2020, after accounting for a 10,000-af reduction in urban water demand resulting from implementation of long-term conservation measures and a 10,000-af reduction in agricultural demand resulting from additional long-term agricultural water conservation measures.

Urban net water demand is forecasted to increase by about 237,000 af (193 percent) by 2020 from the 1990 level of 123,000 af, due to increases in population. Agricultural net water demand is forecasted to decrease by about 59,000 af by 2020, primarily due to lands being taken out of production as a result of the high cost of developed water supplies. Environmental net water demands, under existing rules and regulations, will remain essentially level out to 2020.

Average annual supplies, including 67,000 af of ground water overdraft, were generally adequate to meet average net water demands in 1990 for this region.

However, during drought, 1990 supplies were insufficient to meet the demands, resulting in a shortage of about 9,000 af. Without additional water management programs, annual average and drought year shortages are expected to increase to nearly 126,000 and 204,000 af by 2020, respectively.

With planned Level I programs, average and drought year shortages could be reduced to about 115,000 and 151,000 af, respectively. This remaining shortage requires both additional short-term drought management, water transfers and demand management programs, and other future long-term Level II programs depending on the overall level of water service reliability deemed necessary, by local agencies, to sustain the economic health of the region. In the short-term, some areas of this region will experience more frequent and severe water shortages. This region depends on exports from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on D-1485 operating criteria for Delta supplies and do not take into account recent actions to protect aquatic species in the estuary. As such, regional water supply shortages are understated.

Table SL-11. Water Budget
(thousands of acre-feet)

Water Demand/Supply	*1990* average	*1990* drought	*2000* average	*2000* drought	*2010* average	*2010* drought	*2020* average	*2020* drought
Net Demand								
Urban—with 1990 level of conservation	123	125	195	202	277	285	370	382
—reductions due to long-term conservation measures (Level I)	—	—	-4	-4	-8	-8	-10	-10
Agricultural—with 1990 level of conservation	290	293	245	248	242	245	241	244
—reductions due to long-term conservation measures (Level I)	—	—	-3	-3	-7	-7	-10	-10
Environmental	128	122	128	122	128	122	128	122
Other[1]	14	14	16	16	16	16	16	16
TOTAL Net Demand	555	554	577	581	648	653	735	744
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	139	104	203	144	212	145	223	147
Ground Water	221	252	220	237	226	271	258	271
Ground Water Overdraft[3]	67	67	—	—	—	—	—	—
Subtotal	427	423	423	381	438	416	481	418
Dedicated Natural Flow	128	122	128	122	128	122	128	122
TOTAL Water Supplies	555	545	551	503	566	538	609	540
Demand/Supply Balance	0	-9	-26	-78	-82	-115	-126	-204
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed	—	—	0	0	1	1	1	1
Local	—	—	0	0	0	0	0	0
Central Valley Project/ Other Federal	—	—	0	0	0	0	0	0
State Water Project	—	—	10	20	22	53	32	52
***Subtotal* - Level I Water Management Programs**	0	0	10	20	23	54	33	53
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	-1	0	0	-34	-22	0
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	-9	-17	-58	-59	-95	-115	-151

(1) Includes major conveyance facility losses, recreation uses, and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: proposed environmental water demands of 1 to 3 MAF are included in the California water budget).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

These Joshua trees cast shadows on the desert floor.
The Joshua Tree National Monument is in the Colorado River Region.

Colorado River Region

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 state line. 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 (which include the Laguna Mountains). The Nevada state line and the Colorado River (the boundary with Arizona) delineate the region's eastern boundary.

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 the Joshua tree, alkali scrub, and cholla communities; and elevated river terraces. Despite its dry climate and rugged terrain, the region contains some of the State's most productive agricultural areas and vacation resorts. (See Appendix C for maps of the planning subareas and land ownership in the region.)

Much of the region's topography consists of flat plains punctuated by numerous hills and mountain ranges. Faulting and volcanic activities are partially responsible for the presence of many abrupt mountain ranges. The San Andreas fault slices through portions of the Coachella and Imperial valleys.

A prominent topographic feature is the Salton Trough in the south-central part of the region. Oriented in a northwest-southeast direction, the trough extends from San Gorgonio Pass in the north to the Mexican border and beyond to the Gulf of California. It includes the Coachella Valley in the north and Imperial Valley in the south. The low point of the trough is the Salton Sea, which was created between 1905 and 1907 when the headworks of an irrigation canal conveying Colorado River water to Imperial Valley broke. Large volumes of water flowed into the Salton Sink, resulting in the sea that exists today. In September 1993, the Salton Sea's water surface level was about 227 feet below sea level.

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

Region Characteristics

Average Annual Precipitation: *5.5 inches* ***Average Annual Runoff:*** *178,700 af*

Land Area: *19,730 square miles* ***1990 Population:*** *464,200*

levels during winter. Most of the precipitation in the region falls during the winter; however, summer thunderstorms can produce rain and local flooding in many areas.

Drainage in the region is internal except for the eastern portion, which drains into the Colorado River. Portions of the Coachella Valley are drained by the Whitewater River, which terminates in the Salton Sea. The Imperial Valley is drained by the Alamo and New rivers, which originate in Mexico and terminate in the Salton Sea.

Population

The Colorado River Region's population increased 48 percent from 313,000 in 1980 to 464,200 in 1990. Most of the population is concentrated in the Coachella and Imperial valleys. Major cities in the Coachella Valley include Palm Springs, Indio, Cathedral City, and Palm Desert. Other urban centers in the region include the Cities of El Centro, Brawley, Yucca Valley, 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. Table CR-1 shows the population projections for this region.

Table CR-1. Population Projections
(thousands)

Planning Subarea	*1990*	*2000*	*2010*	*2020*
Twenty-Nine Palms	61	78	102	124
Chuckwalla	2	3	3	3
Colorado River	28	31	35	38
Coachella	263	375	496	619
Borrego	6	8	9	11
Imperial Valley	104	144	173	208
TOTAL	464	639	818	1,003

Less than 2 percent of California's population resides in the region. Urban development in the Coachella Valley is proceeding at a rapid pace due to affordable housing and the area's aesthetic appeal. Much of the growth is attributed to retirees and others who find the climate and real estate settings attractive.

Land Use

Federal and state government-owned lands account for about 14,270 square miles, or 72 percent, of the total land area of the region. There are several military training and testing grounds, including the large U.S. Marine Corps Military Training Center at Twenty-Nine Palms and the gunnery range in the Chocolate Mountains. Major parks include Joshua Tree National Monument and Anza-Borrego Desert State Park. The U.S. Bureau of Land Management oversees use of much of the desert lands.

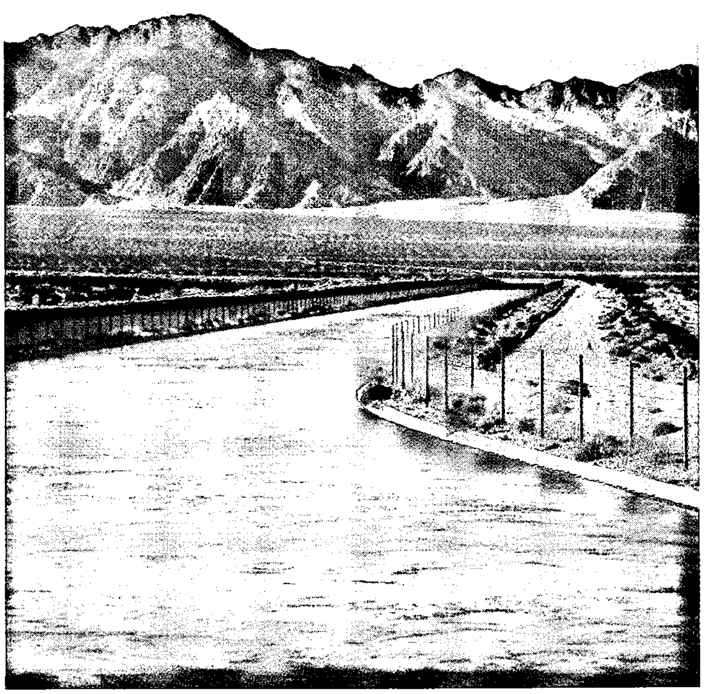
The number one industry and most important source of income for the region is agriculture. Almost 90 percent (647,000 acres) of the developed private land is used for agriculture, most of which is in the Imperial Valley. Because of a lack of significant rainfall, all crops planted and harvested in these areas receive irrigation water, mostly from the Colorado River. Some ground water supplies are used as well. Some of the more prominent crops include alfalfa, winter vegetables, spring melons, table grapes, dates, Sudan grass, and wheat. Figure CR-1 shows land use, along with imports and exports, for the Colorado River Region.

Table CR-2. Water Supplies with Existing Facilities and Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Surface								
Local	6	4	6	4	6	4	6	4
Local imports	0	0	0	0	0	0	0	0
Colorado River[1]	3,898	3,898	3,744	3,744	3,744	3,744	3,744	3,744
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	58	40	65	42	61	39	61	39
Ground water	80	80	79	79	80	80	79	79
Overdraft[2]	75	75	—	—	—	—	—	—
Reclaimed	7	7	7	7	7	7	7	7
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	4,124	4,104	3,901	3,876	3,898	3,874	3,897	3,873

(1) Colorado River supplies for the year 2000 and beyond reflect elimination of surplus and unused Colorado River supplies, and the availability of 106,000 AF of water to the South Coast region as a result of a currently agreed-upon conservation program being implemented by the Imperial Irrigation District and MWDSC.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

The Colorado River also supplies water to areas served by the Colorado River Aqueduct, owned by the Metropolitan Water District of Southern California. The California apportionment of Colorado River water is 4,400,000 af annually plus any unused Arizona and Nevada water and one-half of any surplus made available by the Secretary of the Interior. California consumptively used over 5,200,000 af of Colorado River water in 1990, of which 3,900,000 af was used in the Colorado River Region. Water from the Colorado River makes up about 95 percent of the region's total supply.



The Colorado River Aqueduct makes its way across the valley floor, with Iron Mountain providing the backdrop. This aqueduct has been providing about 1,000,000 af annually to the South Coast Region.

Four State Water Project contractors are located in the region: Desert Water Agency, Coachella Valley Water District, Mojave Water Agency and San Gorgonio Pass Water Agency. The SWP does not extend into the region at this time. (The Morongo Basin Pipeline will bring SWP water into the Colorado Region in 1994.) MWDSC has an exchange agreement with Desert Water Agency and Coachella Valley Water District that allows MWDSC to take the two agencies' SWP entitlement water. In return, MWDSC releases water from its Colorado River Aqueduct for ground water recharge in the Coachella Valley. Local surface water supply in the Coachella subarea amounted to about 6,000 af in 1990. This supply is derived from the Whitewater River; however, the supply is not dependable in times of drought.

About 7,000 af of fresh water was produced by water recycling in 1990. About 2,000 af of the water recycling occurred in the Coachella. Most of the recycled water was applied to golf courses and resort hotel common areas.

Total ground water supplies for 1990 were about 155,000 af, almost 4 percent of the region's total supply. The Coachella PSA accounted for about 85,000 af of the ground water use in the region, 52,000 af of which was overdraft. Streamflow percolation, subsurface inflow, periodic Colorado River flooding, and canal leakage all provide ground water basin recharge at various locations in the region.

Supply with Additional Facilities and Water Management Programs

Future water management programs are presented in two levels to better reflect the status of investigations required to implement them.

- Level I options are those programs that have undergone extensive investigation and environmental analyses and are judged to have a high likelihood of being implemented by 2020.
- Level II options are those programs that could fill the remaining gap between water supply and demand. These options require more investigation and alternative analyses.

Table CR-3. Water Supplies with Level I Water Management Programs
(Decision 1485 Operating Criteria for Delta Supplies)
(thousands of acre-feet)

Supply	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Surface								
Local	6	4	6	4	6	4	6	4
Local imports	0	0	0	0	0	0	0	0
Colorado River(1)	3,898	3,898	3,676	3,676	3,676	3,676	3,676	3,676
CVP	0	0	0	0	0	0	0	0
Other federal	0	0	0	0	0	0	0	0
SWP	58	40	70	42	71	59	71	60
Ground water	80	80	79	79	81	81	80	80
Overdraft(2)	75	75	—	—	—	—	—	—
Reclaimed	7	7	9	9	12	12	13	13
Dedicated natural flow	0	0	0	0	0	0	0	0
TOTAL	4,124	4,104	3,840	3,810	3,846	3,832	3,846	3,833

(1) Colorado River supplies for the year 2000 and beyond reflect elimination of surplus and unused Colorado River supplies, the availability of 106,000 AF of water to the South Coast region as a result of a currently agreed-upon conservation program being implemented by the Imperial Irrigation District and MWDSC, and an additional 68,000 AF of water made available from the Colorado River region as a result of an IID/MWDSC agreement negotiated, but not yet implemented relating to the lining of a portion of the All American Canal, a Level I conservation program.
(2) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.

Table CR-4. Urban Water Demand
(thousands of acre-feet)

Planning Subarea	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Twenty-Nine Palms								
Applied water demand	11	11	14	14	18	18	22	22
Net water demand	6	6	8	8	11	11	13	13
Depletion	6	6	8	8	11	11	13	13
Chuckwalla								
Applied water demand	0	0	0	0	1	1	1	1
Net water demand	0	0	0	0	0	0	0	0
Depletion	0	0	0	0	0	0	0	0
Colorado River								
Applied water demand	11	11	12	12	14	14	15	15
Net water demand	6	6	7	7	8	8	9	9
Depletion	6	6	7	7	8	8	9	9
Coachella								
Applied water demand	251	251	335	335	431	431	524	524
Net water demand	165	165	220	220	283	283	344	344
Depletion	165	165	220	220	283	283	344	344
Borrego								
Applied water demand	2	2	2	2	3	3	3	3
Net water demand	1	1	1	1	2	2	2	2
Depletion	1	1	1	1	2	2	2	2
Imperial Valley								
Applied water demand	26	26	36	36	45	45	56	56
Net water demand	26	26	36	36	45	45	56	56
Depletion	26	26	36	36	45	45	56	56
TOTAL								
Applied water demand	301	301	399	399	512	512	621	621
Net water demand	204	204	272	272	349	349	424	424
Depletion	204	204	272	272	349	349	424	424

Agricultural Water Use

The 1990 level irrigated crop acreage for the Colorado River Region amounted to 749,000 acres. Table CR-5 shows irrigated crop acreage forecasts to 2020. Most of the major agricultural operations in the region are in the Imperial Valley, Colorado River, and Coachella PSAs. Minor reductions of about three percent in total irrigated crop acres are forecasted to occur between 1990 and 2020. However, increases will occur in the planted and harvested acres for certain high-market-value crops, such as fresh market vegetables. Demand by both international and domestic markets for fresh vegetables will probably encourage growers to maintain current levels of crop production and, if possible, plant and harvest additional acres. Other crops expected to show minor to moderate increases are grains, citrus and subtropical fruit, sugar beets, and cotton. For cotton, current boll worm problems could be rectified and additional acres planted, mainly in Imperial Valley. The silverleaf whitefly infestation, primarily in Imperial Valley, has caused temporary minor reductions in the recent planted and harvested acreage. Eradication and management efforts should mitigate the problems caused by these pests and allow crop acreage to return to normal levels. Table CR-6 shows the 1990 level evapotranspiration of applied water for the region.

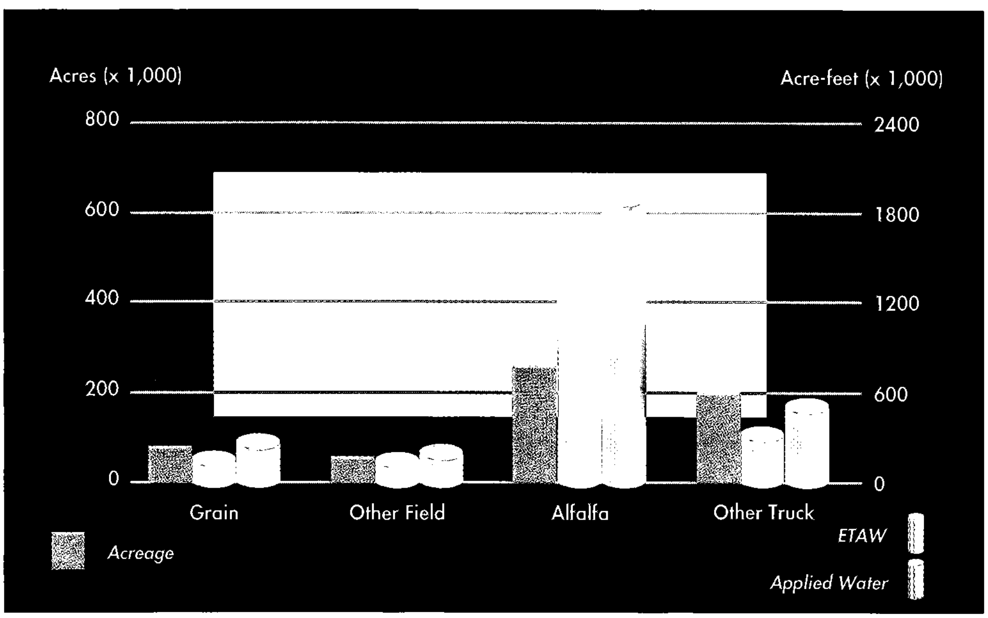
The four major crops in terms of acreage and total applied water use are alfalfa, truck (vegetables and nursery), grains, and miscellaneous field. In 1990, alfalfa used roughly 50 percent of the total applied agricultural water. Figure CR-5 compares 1990 crop acreages, evapotranspiration, and applied water for major crops.

Table CR-5. Irrigated Crop Acreage
(thousands of acres)

Planning Subarea	1990	2000	2010	2020
Twenty-Nine Palms	4	6	7	7
Chuckwalla	6	3	3	3
Colorado River	130	131	132	132
Coachella	74	64	48	37
Borrego	10	12	13	13
Imperial Valley	525	530	534	534
TOTAL	749	746	737	726

Reductions in irrigated acres are expected for crops or crop categories with low or fluctuating market values, such as alfalfa, corn, and miscellaneous field crops. Market competition (international and domestic) and the pressures from urban encroachment may cause decreases in acres planted with table grapes in the Coachella Valley. Total 1990 agricultural applied water demand was about 3,705,000 af and net water demand was about 3,439,000 af. Table CR-7 summarizes the 1990 and forecasted agricultural water demand in the region.

Figure CR-5. Colorado River Region 1990 Acreage, ETAW, and Applied Water for Major Crops



Minor reductions in crop acreage and applied water use are expected for the region. Forecasts indicate that the region's total applied agricultural water use will decrease by about 9 percent between 1990 and 2020. Improvements in on-farm irrigation operations and irrigation system technologies, the loss of irrigated land caused by urbanization, and minor shifts in crop type will contribute to the decrease. Table CR-7 shows increases of about 12,000 and 14,000 af in applied agricultural water use between 1990 and 2020 in the Twenty-Nine Palms and Borrego PSAs, respectively. During the same period, decreases of about 15,000 and 191,000 af are forecasted for both the Chuckwalla and Coachella PSAs, respectively.

Table CR-6. 1990 Evapotranspiration of Applied Water by Crop
(thousands of acres)

Irrigated Crop	*Total Acres (1,000)*	*Total ETAW (1,000 AF)*
Grain	76	152
Cotton	37	121
Sugar beets	35	134
Corn	8	20
Other field	55	146
Alfalfa	256	1,594
Pasture	32	176
Tomatoes	13	32
Other truck	187	310
Other deciduous	1	5
Vineyard	20	65
Citrus/olives	29	123
TOTAL	*749*	2,878

Since the late 1970s, major efforts have been undertaken by local governments, water agencies, and growers to improve agricultural irrigation efficiency in the region. The most observable improvements have been made in the Imperial and Coachella valleys. Agricultural conservation in the region can be placed into two categories: (1) on-farm irrigation system management and operation improvements, and (2) conveyance system improvements. Examples of current on-farm improvements include: carefully managing and designing furrows, basin and sprinkler systems to minimize excessive tailwater runoff from the ends of fields into drains and to evenly irrigate the entire field; laser leveling of fields to improve irrigation water movement in furrows and basin systems; implementing micro-irrigation technology (drip emitters and micro-jet sprinklers) for permanent crops; using different irrigation and cultivation techniques (hand-moved sprinklers for pre-irrigation of fields and seed germination); reusing tailwater to supplement delivered water for the irrigation of other fields; and irrigation scheduling. Subsurface irrigation systems are also being tested on certain crops in the region.

Conveyance system improvements have come in the form of: constructing regulatory reservoirs to enhance system delivery and storage capabilities; lining canals and laterals with concrete to minimize supply losses due to seepage; automating the system with telemetry for improved control over the delivery of water; and installing seepage recovery and operational spill interceptor systems.

Table CR-7. Agricultural Water Demand
(thousands of acre-feet)

Planning Subarea	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Twenty-Nine Palms								
Applied water demand	22	22	28	28	32	32	34	34
Net water demand	20	20	24	24	28	28	30	30
Depletion	20	20	24	24	28	28	30	30
Chuckwalla								
Applied water demand	30	30	17	17	13	13	15	15
Net water demand	27	27	16	16	12	12	13	13
Depletion	27	27	16	16	12	12	13	13
Colorado River								
Applied water demand	785	785	751	751	705	705	698	698
Net water demand	606	606	588	588	566	566	559	559
Depletion	606	606	588	588	566	566	559	559
Coachella								
Applied water demand	393	393	342	342	260	260	202	202
Net water demand	313	313	277	277	215	215	168	168
Depletion	313	313	277	277	215	215	168	168
Borrego								
Applied water demand	37	37	45	45	48	48	51	51
Net water demand	35	35	42	42	46	46	48	48
Depletion	35	35	42	42	46	46	48	48
Imperial Valley								
Applied water demand	2,438	2,438	2,415	2,415	2,395	2,395	2,363	2,363
Net water demand	2,438	2,438	2,415	2,415	2,395	2,395	2,363	2,363
Depletion	2,438	2,438	2,415	2,415	2,395	2,395	2,363	2,363
TOTAL								
Applied water demand	3,705	3,705	3,598	3,598	3,453	3,453	3,363	3,363
Net water demand	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
Depletion	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181

Environmental Water Use

Total 1990 environmental water use for the Colorado River Region amounts to nearly 39,000 af. Demands are forecasted to increase 13 percent by 2000 and remain at 44,000 af through 2020. Colorado River water supplies most of this use. Currently, 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. Table CR-8 shows wetlands water needs in the Colorado River Region.

The Salton Sea National Wildlife Refuge was established in 1930 by federal executive order. Originally the refuge contained 23,425 acres, but due to inflow of agricultural drain water and a rise in the sea level, most of the refuge is now inundated. About 2,500 acres of manageable habitat remain, with about 1,068 acres managed as marsh land. In 1990, the refuge used about 4,900 af of freshwater. Forecasts indicate the refuge will require about 10,000 af of freshwater by the year 2000.

The Imperial Wildlife Area is operated and managed by the State Department of Fish and Game. The area is comprised of two units. The Finney-Ramer unit has a total water surface area of about 2,050 acres, with total annual water use estimated at 7,600 af. The Wister unit has a total water surface area of about 5,500 acres and total annual water use of almost 21,000 af. Demands are forecasted to remain level through 2020.

Private wetlands in the Colorado River Region occupy about 2,225 acres and consumptively use roughly 5,330 af of freshwater annually. These wetlands, scattered throughout Imperial and Riverside Counties, are primarily used for duck hunting.

Table CR-8. Wetland Water Needs
(thousands of acre-feet)

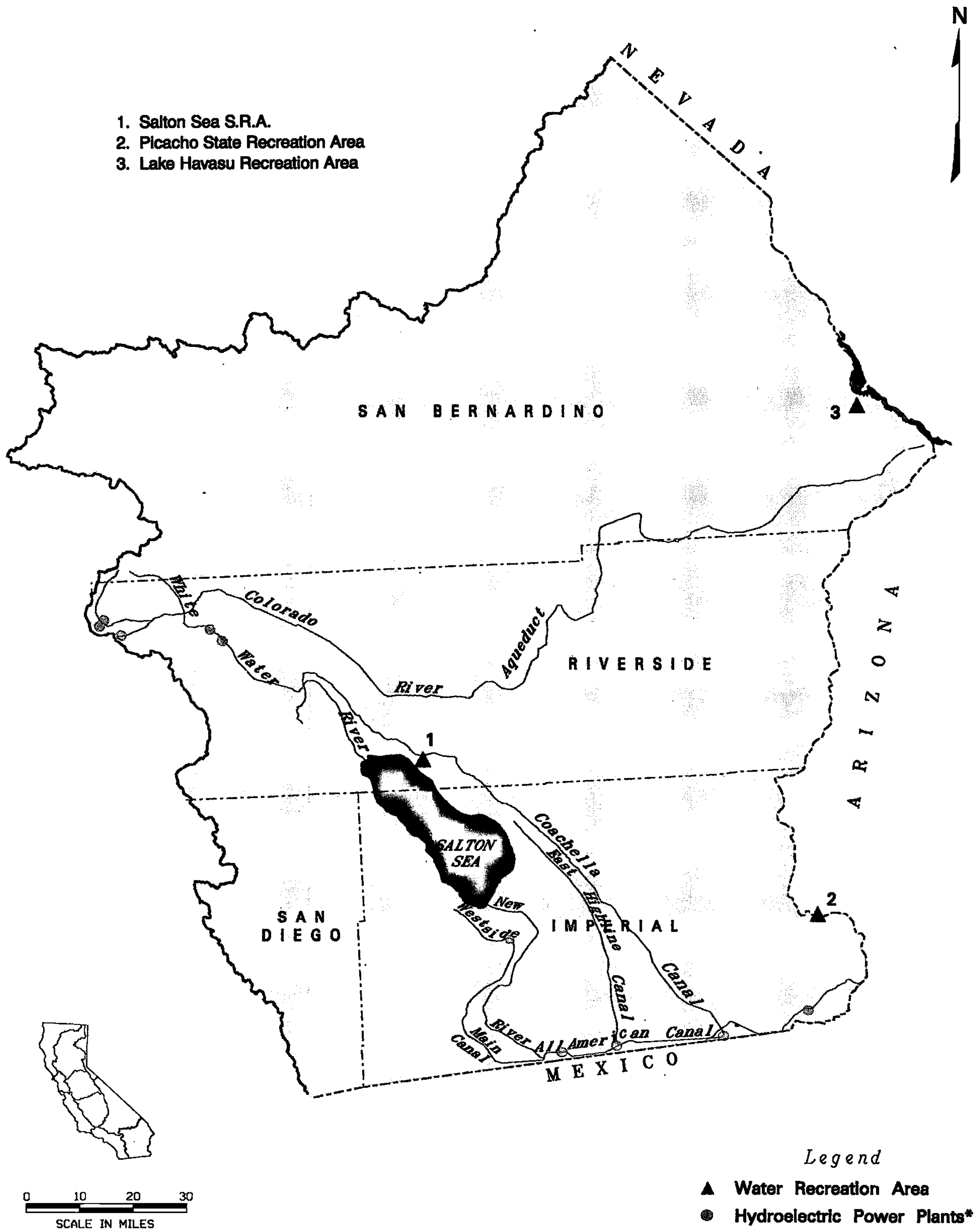
Wetland	*1990*		*2000*		*2010*		*2020*	
	average	*drought*	*average*	*drought*	*average*	*drought*	*average*	*drought*
Salton Sea NWR								
Applied water demand	5	5	10	10	10	10	10	10
Net water demand	5	5	10	10	10	10	10	10
Depletion	5	5	10	10	10	10	10	10
Imperial WA								
Applied water demand	29	29	29	29	29	29	29	29
Net water demand	29	29	29	29	29	29	29	29
Depletion	29	29	29	29	29	29	29	29
Private Refuges								
Applied water demand	5	5	5	5	5	5	5	5
Net water demand	5	5	5	5	5	5	5	5
Depletion	5	5	5	5	5	5	5	5
TOTAL								
Applied water demand	39	39	44	44	44	44	44	44
Net water demand	39	39	44	44	44	44	44	44
Depletion	39	39	44	44	44	44	44	44

Other Water Use

Conveyance losses in the All-American, Coachella, and intermediate canals averaged about 360,000 af in 1990. Both the Imperial Irrigation District and Coachella Valley Water District conveyance losses are calculated as the acre-feet of water diverted minus the amount of water actually delivered to users by the districts. Conservation measures could reduce conveyance losses by 100,000 af per year. Geothermal power plants in Imperial Valley PSA produce about 379 megawatts per year and use about 74,200 af of cooling water annually in their operation. Table CR-9 shows the total water demand for this region.

Recreational facilities are found in all PSAs; most consist of campgrounds and parks where water is used for drinking, landscape, toilets, showers, and facility maintenance. Total water use in these areas amounted to almost 5,000 af in 1990. The Colorado River PSA accounted for about 3,000 af of that use. Recreation includes water skiing, boating, fishing, and swimming. Figure CR-6 shows water recreation areas in the Colorado River Region.

Figure CR-6. Colorado River Region
Hydroelectric Power Plants and Water Recreation Areas



*From 1992 California Energy Commission Maps. See Table D-3 in Appendix D for plant information.

Table CR-9. Total Water Demands
(thousands of acre-feet)

Category of Use	1990		2000		2010		2020	
	average	drought	average	drought	average	drought	average	drought
Urban								
Applied water demand	301	301	399	399	512	512	621	621
Net water demand	204	204	272	272	349	349	424	424
Depletion	204	204	272	272	349	349	424	424
Agricultural								
Applied water demand	3,705	3,705	3,598	3,598	3,453	3,453	3,363	3,363
Net water demand	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
Depletion	3,439	3,439	3,362	3,362	3,262	3,262	3,181	3,181
Environmental								
Applied water demand	39	39	44	44	44	44	44	44
Net water demand	39	39	44	44	44	44	44	44
Depletion	39	39	44	44	44	44	44	44
Other(1)								
Applied water demand	82	82	83	83	83	83	83	83
Net water demand	442	442	363	363	363	363	363	363
Depletion	442	442	363	363	363	363	363	363
TOTAL								
Applied water demand	4,127	4,127	4,124	4,124	4,092	4,092	4,111	4,111
Net water demand	4,124	4,124	4,041	4,041	4,018	4,018	4,012	4,012
Depletion	4,124	4,124	4,041	4,041	4,018	4,018	4,012	4,012

(1) Includes major conveyance facility losses, recreation uses, and energy production.

Issues Affecting Local Water Resource Management

Legislation and Litigation

Colorado River Water Allocations. As a result of the 1964 U.S. Supreme Court decree in *Arizona v. California*, California's allocation of Colorado River water was quantified and five Lower Colorado River Indian tribes were awarded 905,496 acre-feet of annual diversions, 131,400 af of which were allocated for use 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 United States failed to claim a sufficient amount of irrigable acreage, called "omitted" lands, in the earlier litigation. The tribes also raised claims for more water based on allegedly larger reservation boundaries than had been assumed by the court in its initial award, called "boundary" lands. 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 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 Mohave Indian Tribe, Quechan Indian Tribe, and Colorado River Indian Tribe—are pursuing additional water rights related to the boundary lands claims. A settlement may be reached soon on the Fort Mohave claim. 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. The Colorado River Indian Tribe case was presented to the special master in early 1993. As with all claims to water from the main stem of the Colorado River and any determination by the special master, only the U.S. Supreme Court itself can make the final ruling.

Any Colorado River or Fort Mohave tribal claims granted for additional water rights would reduce the amount of water available to satisfy the fourth priority demands of MWDSC under the 1931 California Seven Party Agreement, which established priorities for use of California's entitlement. Any Quechan tribal claims granted for additional water rights would reduce the amount of water available to satisfy the third priority demands of the Coachella Valley Water District under this agreement because the Quechan Tribe receives Colorado River water under the Yuma Project Reservation Division's second priority. If all additional water rights claims were granted to the three Indian tribes, MWDSC could effectively lose up to 22,600 af and Coachella up to 45,200 af of their Colorado River supplies. The actual amounts to be granted, if any, are yet to be determined.

The Lower Colorado Water Supply Act. On November 14, 1986, the President signed the *Lower Colorado Water Supply Act*, Public Law 99-655, authorizing the U.S. Secretary of the Interior to construct, operate, and maintain a project consisting of a series of wells along the All-American Canal. The project would be capable of providing up to 10,000 af of water annually from ground water storage to indirectly benefit the City of Needles, the community of Winterhaven, the U.S. Bureau of Land Management, and other municipal, industrial, and recreational users in California with no or insufficient rights to Colorado River water. Under PL 99-655, the Imperial Irrigation District, the Coachella Valley Water District, or both, would exchange a portion of their Colorado River water for an equivalent quantity and quality of ground water pumped into the All-American Canal during years that unused apportioned water supplies are not available. The Lower Colorado Water Supply Project is now under construction and is scheduled for operation in 1994.

Effects of the Central Arizona Project on Colorado River Allocations. The Central Arizona Project, with an annual diversion capacity of 2,100,000 af, started delivering water in December 1985. All aqueduct facilities were completed in 1992 and about 1,034,000 af of water were diverted for municipal, industrial, and agricultural uses in Central Arizona in 1993. Deliveries are expected to increase to 1,500,000 af annually under full development, with the capability of up to 2,100,000 af when it is available and needed in the future.

When the Central Arizona Project begins diverting its full allocation of Colorado River water, California will be limited to its basic annual apportionment of 4,400,000 af when the Secretary of the Interior declares that a normal condition exists. Additional water can be and has been made available when the Secretary determines a surplus condition exists, or when one or both of the other Lower Division states (Arizona and Nevada) are not fully using their apportioned water. Since 1985, neither Arizona nor Nevada has used its full basic apportionment, and the Secretary of the Interior has allowed California to use surplus water or Arizona's and Nevada's apportioned but unused Colorado River water. These factors have allowed California to divert and consumptively use from 4,500,000 af to 5,200,000 af annually since 1985.

The availability of Colorado River water to California in 1993 was determined in the annual operating plan issued by the Secretary of the Interior in October 1992. The 1993 annual operating plan makes sufficient water available to supply all of

California's reasonable beneficial consumptive use demands, but the plan contains a proviso that if the total mainstream consumptive use in the Lower Division states exceeds 7,500,000 af, the entity or entities responsible for the overuse will be required to compensate for such overuse by 1996.

Lining of the All-American Canal. The Secretary of the Interior (under PL 100-675 enacted in 1988) is authorized to line portions of the All-American Canal and the Coachella Canal, using funds provided by MWDSC, Coachella Valley Water District, and Imperial Irrigation District. As of December 1993, the U.S. Bureau of Reclamation was preparing a final Environmental Impact Statement/Report regarding lining a portion of the All-American Canal. Lining the canal or constructing a parallel canal from Pilot Knob to Drop Number 3, about 25 miles east of Calexico, would save roughly 67,700 af annually.

The draft EIS/EIR for the project identified a parallel concrete-lined canal as the preferred alternative. The final EIS/EIR is scheduled to be filed in 1994 and construction could begin in 1995. In addition, the U.S. Bureau of Reclamation released a draft EIR/EIS in January 1994 regarding lining another section of the Coachella Canal to reduce seepage by about 30,900 af per year. Thus, if both canals were lined, as much as 98,600 af of water could be made available for other uses.

Salinity Concentrations in the Colorado River. Salinity in the Colorado River varies from year to year because the river is subject to highly variable flows. As a result of high river flows from 1983 to 1986, releases from reservoir storage into the lower Colorado River were greatly in excess of the releases required for beneficial uses. These record high flows reduced salinity in the lower river. However, since 1987, with below-normal water supply conditions and fewer reservoir releases, salinity levels have again increased.

Like most western rivers, the Colorado increases in salinity from its headwaters to its mouth, carrying a salt load of about 9 million tons annually (measured at Hoover Dam). Roughly 50 percent of the river's salinity results naturally from salt in saline springs, ground water discharge into the river, erosion and dissolution of sediments, and evaporation and transpiration. About 37 percent of the salt load comes from agricultural return flows, which carry dissolved salts from underlying saline soils and geologic formations. The remainder of the salt load results from out-of-basin exports, reservoir evaporation, development of energy resources in the Upper Colorado River Basin, and other municipal and industrial uses.

In 1972, the seven Colorado River Basin states adopted a policy that while they would continue to develop the Colorado River water apportioned to each of them, they would work with each other to maintain salinity concentrations in the lower main stem of the Colorado River at or below the flow-weighted average annual salinity of 1972. Later that year, amendments to the Federal Water Pollution Control Act required that standards for salinity in the Colorado River be established. In 1973, the seven basin states created the Colorado River Basin Salinity Control Forum to establish criteria and develop a plan for implementing a salinity control program.

In 1975, all the basin states adopted the salinity standards set forth in the report *Water Quality Standards for Salinity, Including Criteria, and Plan of Implementation for Salinity Control, Colorado River System*, as recommended by the forum. The state-adopted and EPA-approved numeric criteria call for maintenance of average annual flow-weighted salinity concentrations of 723 milligrams per liter below Hoover Dam, 747 mg/L below Parker Dam, and 879 mg/L at Imperial Dam.

Because of changes in hydrologic conditions and water use within the Colorado River Basin, the forum reviews its implementation plan every three years. The most recent recommended revisions to the plan appear in the 1993 *Review, Water Quality Standards for Salinity, Colorado River System.* The revised implementation plan is designed to control enough salt to maintain the salinity criteria adopted in 1975 under a long-term mean water supply of 15,000,000 af per year. The 1993 proposed implementation plan includes:

- Completion of U.S. Bureau of Reclamation, Bureau of Land Management, and Department of Agriculture salinity control measures. The plan's current remaining federal construction cost for USBR and Department of Agriculture activities are about $483 million.
- Imposition of effluent limitations, principally under the National Pollutant Discharge Elimination System permit program for industrial and municipal discharges.
- Implementation of various Forum-recommended policies on such subjects as use of brackish or saline waters for industrial purposes, NPDES standards for intercepted ground water, and fish hatcheries.
- Implementation of nonpoint source management plans developed by the states and approved by EPA.

The forum reported that average salinity concentrations for 1992 were 657 mg/L below Hoover Dam, 688 mg/L below Parker Dam, and 781 mg/L at Imperial Dam, which were all below the Forum's numeric criteria. It also reported that there was no reason to believe the criteria would be exceeded during the next three years. In fact, forecasts appearing in the 1993 review state, "The plan will control salinity levels so that, with long-term mean water supply conditions, salinity levels below Hoover Dam will be about 25 mg/L below the numeric criteria."

Salton Sea. The Salton Sea is a 35-mile-long, 12-mile-wide, 40-foot-deep, saline body of water. In 1924, the federal government, recognizing the sea as a depository for agricultural drainage waters, placed lands lying 220 below sea level in and around the sea in a public water reserve.

In 1968, California enacted a statute declaring that the primary use of the Salton Sea is for collection of agricultural drainage water, seepage, leachate, and control waters. In 1980, a local farmer wrote a letter to the State Water Resources Control Board alleging that the Imperial Irrigation District was wasting water to the sea and causing his land to be flooded. After an investigation by DWR and several hearings by the SWRCB, the board, in 1988, ordered IID to develop a plan to conserve 100,000 af of water per year by 1994. The order required IID to make water delivery and irrigation practices more efficient and included a reservation of jurisdiction regarding the possible future conservation of up to 368,000 af annually.

The order caused concerns that conservation measures would lower the sea's surface level and increase salinity concentrations at a slightly faster rate. The Salton Sea became increasingly saline between 1907 and 1934, largely because of high evaporation and reduced inflow of freshwater. Since 1934 the salinity has varied from 33,000 mg/L to 45,000 mg/L. Inflow from Imperial, Coachella, and Mexicali valleys for 1989, 1990, and 1991 was 977,000 af, 108,000 af, and 141,000 af, respectively. Irrigation return flows, precipitation (which averages less than 3 inches per year), and local runoff are the only fresh water supplies to the sea. As is common in arid environments, the equivalent of several years' rain may arrive in a single storm. With a watershed exceeding 8,000 square miles, a large storm can elevate the sea by one foot or more.

Agricultural drainage carries with it varying amounts of nutrients, mainly compounds of nitrogen and phosphorus, which encourage the growth of algae. Although algae are very productive and support the higher trophic levels, algae blooms in the upper water levels discolor the water and, upon death and decomposition, often cause temporary local anoxic conditions and produce obnoxious odors. Fish are occasionally killed by the temporary lack of oxygen. These conditions reduce the sea's aesthetic appeal and, to some extent, depress water-related recreation.

Recent attention has been focused on the source of the selenium found in the Salton Sea. The selenium content in the Colorado River water delivered to the Imperial and Coachella Valleys has been found to be about 2 parts per billion and reflects selenium contributions from tributaries to the main stem of the Colorado River in the Upper Colorado River Basin. The concentration of selenium in the sea water is about 2.5 ppb. As the result of a concentration of leachates from the soils irrigated with Colorado River water, higher levels of selenium concentrations in agricultural drains have been found. Although drainage water consists of components (for example, tile water, tail water, and seepage) carrying different concentrations of selenium, the mixing that occurs in the drain channels results in a selenium concentration of about 8 ppb.

The SWRCB has adopted a California Inland Surface Waters Plan with a performance goal of 5 ppb for selenium concentrations in agricultural drain channels. In an earlier action, the California Department of Health Services, concerned over the concentration of selenium in the tissue of fish in the sea, issued a health advisory that fish consumption by humans be limited to avoid any adverse health effects.

Four bird species residing in the Salton Sea area are potentially adversely affected by organochlorine pesticides. Such pesticides are mobilized from farm fields and transported to drains by tail water runoff. Resuspension of bottom sediments in the New and Alamo rivers and drains is another source of these pesticides. Twenty-three different organochlorine pesticides have been found in various types of biota in the Imperial Valley.

The average salt loading of inflow to the sea over the past 30 years has been 4.9 million tons per year. Since 1980, salinity concentrations have increased at a rate of 500 to 600 parts per million per year. As of December 1993, salinity levels in the Salton Sea were 45,000 parts of salt per million parts of water—saltier than ocean water, which averages 35,000 ppm.

Further increases in salinity could harm fish and wildlife and the recreational resources in the area. Salinity concentrations in the sea are forecasted to reach 50,000 ppm in the next 10 years, even without further conservation measures being implemented, which would increase the rate. It is not likely, even under the most favorable hydrologic conditions, that the salinity of the sea will return to concentrations below 40,000 ppm. On the other hand, occasional flooding has also adversely affected shoreline developments and recreation. The sea has maintained relatively stable water elevations for the past decade.

Since 1987, the Salton Sea Task Force, chaired by the State Resources Agency, has been studying these problems. This intergovernmental group's objective is to find a way to conserve water in the Salton Sea area while stabilizing the sea's salinity and water levels. Several plans have been proposed; however, all plans would incur substantial costs. The task force is continuing to explore various means of improving the financial feasibility of the plans and to seek some form of regional organization as a sponsoring entity to carry out and provide funding for preservation measures.

Contracts and Agreements

MWDSC Water Conservation Agreements. To compensate for the loss of Colorado River water under the Supreme Court decree in *Arizona v. California*, MWDSC is pursuing a number of programs to augment its supplies. In December 1988, MWDSC and Imperial Irrigation District signed the first of two agreements expected to make 106,110 af of conserved water available to MWDSC annually, except under certain limited circumstances, by implementing structural and nonstructural water conservation projects within IID's service area. The conservation measures to be used are: (1) concrete lining of existing earthen canals, (2) construction of reservoirs and canal spill interceptors, (3) installation of non-leak gates and distribution system automation equipment, and (4) on-farm management of irrigation water. MWDSC will furnish an estimated $222 million (1988 dollars) for the conservation projects. Increased conservation in the IID would reduce surface and subsurface fresh water inflow to the Salton Sea, thus shortening the time it takes for the sea's salinity concentration to increase. Of the funds provided by MWDSC, $23 million is for indirect costs including, among other items, environmental mitigation and litigation relating to the impact, if any, of the water conservation program on the water level or quality of the Salton Sea, the New and Alamo rivers, to the extent such costs are not reimbursable.

The Palo Verde Irrigation District signed an agreement with MWDSC for a two-year fallowing program involving 20,000 acres of land that could save 186,000 af of Colorado River water (93,000 af per year). The fallowing began August 1, 1992, and will end July 31, 1994. Program lands lying fallow in 1992 are required to lie fallow through July 31, 1994. MWDSC must use the water, which is being stored in Lake Mead, before the year 2000.

A farmer adjusts water flow from the main pipe to the sprinkler lines. Innovative water conservation agreements between several water agencies in the region allow agricultural water to be available for future use in urban areas.

IID and MWDSC have considered, but have not yet implemented, a test fallowing and modified irrigation practice program to save up to 200,000 af of Colorado River water over a two-year period for MWDSC's use. Fallowing and modified irrigation of alfalfa would be conducted by Imperial Valley farmers on a voluntary basis for monetary compensation.

Water Banking Proposal. The U.S. Bureau of Reclamation has formed a technical work group with representatives from California, Arizona, Nevada, and the Colorado River Indian tribes to explore the merits and feasibility of banking water in Lake Mead for use by California, Arizona, Nevada, and the tribes. A banking proposal is being considered as a provision of proposed regulations being prepared by USBR for administration of Colorado River entitlements in the Lower Basin.

Yuma Desalting Plant. The high salinity of Colorado River water in past years led to protests from the Republic of Mexico and an agreement between the United States and Mexico. To enable the U.S. to comply with the agreement without depriving Colorado River basin states of any of their apportioned water, the Yuma Desalting Plant was authorized under Title I of PL 93-320 in 1974. The purpose of the desalter is to remove sufficient salts from irrigation drainage water from the Wellton-Mohawk Irrigation and Drainage District in Arizona to meet the established salinity control standards at the Northerly International Boundary when the treated drainage water is released into the river. At the Yuma Desalting Plant, the brine discharge is disposed of in a channel leading to the Santa Clara Slough in Mexico, and the treated water is blended with the remaining untreated drainage water and returned to the river. The Yuma Desalting Plant began operation at one-third capacity in May 1992. Due to high flows in the Gila River early in 1993, the plant was shut down in January 1993.

Under full operation, the desalter will be able to take about 98,000 af of drainage water and produce 68,500 af of water; this will be blended with about 10,000 af of untreated drainage water, so that a total of 78,500 af will be returned to the river.

Water Balance

Water budgets were computed for each planning subarea in the Colorado River Region by comparing existing and future water demand forecasts with the forecasted availability of supply. The region total was computed by summing the demand and supply totals for all the planning subareas. This method does not reflect the severity of drought year shortages in some local areas which can be hidden when planning subareas are combined within the region. Thus, there could be substantial shortages in some areas during drought periods. Local and regional shortages could also be more or less severe than the shortage shown, depending on how supplies are allocated within the region, a particular water agency's ability to participate in water transfers or demand management programs (including land fallowing or emergency allocation programs), and the overall level of reliability deemed necessary to the sustained economic health of the region. Volume I, Chapter 11, presents a broader discussion of demand management options.

Table CR-10 presents water demands for the 1990 level and for future water demands to 2020 and compares them with: (1) supplies from existing facilities and water management programs, and (2) future demand management and water supply management programs. Regional net water demands for the 1990 level of development totaled 4,124,000 af for average and drought years. Those demands are forecasted to decrease to 4,012,000 af by the year 2020, after accounting for a 35,000 af reduction in urban water demand resulting from implementation of long-term conservation measures and a 273,000 af reduction in agricultural demand resulting from additional long-term agricultural water conservation measures.

Urban net water demand is expected to increase by about 220,000 af by 2020, due to increases in population, while agricultural net water demand is expected to decrease by about 258,000 af. Environmental net water demands, under existing rules and regulations, will increase from 39,000 to 44,000 af annually as a result of increased allocation of water to wildlife refuges.

Average annual supplies, including 75,000 af of ground water overdraft, were generally adequate to meet average net water demands in 1990 for this region. However, during drought, present supplies are insufficient to meet present demands and, without additional water management programs, annual average and drought year shortages are expected to be about 115,000 and 139,000 af by 2020, respectively.

With planned Level I programs, average and drought year shortages could be reduced to about 56,000 and 69,000 af, respectively. This remaining shortage requires both additional short-term drought management and future long-term Level II programs depending on the overall level of water service reliability deemed necessary. Because of high priority rights to Colorado River water by such areas in the Palo Verde Irrigation District, the Coachella Valley, and the Imperial Valley, any future shortages in these areas are expected to be limited. However, this region also depends on exports from the Sacramento-San Joaquin Delta for a portion of its supplies. Shortages stated above are based on Decision 1485 operating criteria for Delta supplies and do not take into account recent actions to protect aquatic species in the estuary. As such, water supply shortages are understated for the areas which depend on Delta supplies.

Table CR-10. Water Budget
(thousands of acre-feet)

Water Demand/Supply	1990 average	1990 drought	2000 average	2000 drought	2010 average	2010 drought	2020 average	2020 drought
Net Demand								
Urban—with 1990 level of conservation	204	204	288	288	376	376	459	459
—reductions due to long-term conservation measures (Level I)	—	—	–16	–16	–27	–27	–35	–35
Agricultural—with 1990 level of conservation	3,439	3,439	3,499	3,499	3,465	3,465	3,454	3,454
—reductions due to long-term conservation measures (Level I)	—	—	–137	–137	–203	–203	–273	–273
Environmental	39	39	44	44	44	44	44	44
Other[1]	442	442	363	363	363	363	363	363
TOTAL Net Demand	4,124	4,124	4,041	4,041	4,018	4,018	4,012	4,012
Water Supplies w/Existing Facilities Under D-1485 for Delta Supplies								
Developed Supplies								
Surface Water[2]	3,969	3,949	3,822	3,797	3,818	3,794	3,818	3,794
Ground Water	80	80	79	79	80	80	79	79
Ground Water Overdraft[3]	75	75	—	—	—	—	—	—
Subtotal	4,124	4,104	3,901	3,876	3,898	3,874	3,897	3,873
Dedicated Natural Flow	0	0	0	0	0	0	0	0
TOTAL Water Supplies	4,124	4,104	3,901	3,876	3,898	3,874	3,897	3,873
Demand/Supply Balance	0	–20	–140	–165	–120	–144	–115	–139
Level I Water Management Programs[4]								
Long-term Supply Augmentation								
Reclaimed	—	—	2	2	5	5	6	6
Local	—	—	0	0	0	0	0	0
Colorado River	—	—	–68	–68	–68	–68	–68	–68
State Water Project	—	—	5	0	10	20	10	21
***Subtotal* - Level I Water Management Programs**	0	0	–61	–66	–53	–43	–52	–41
Net Ground Water or Surface Water Use Reduction Resulting from Level I Programs	—	—	70	70	71	71	111	111
Remaining Demand/Supply Balance Requiring Short-term Drought Management and/or Level II Options	0	–20	–131	–161	–102	–116	–56	–69

(1) Includes major conveyance facility losses, recreation uses and energy production.
(2) Existing and future imported supplies that depend on Delta export capabilities are based on SWRCB D-1485 and do not take into account recent actions to protect aquatic species. As such, regional water supply shortages are understated (note: *proposed environmental water demands of 1 to 3 MAF are included in the California water budget*).
(3) The degree future shortages are met by increased overdraft is unknown. Since overdraft is not sustainable, it is not included as a future supply.
(4) Protection of fish and wildlife and a long-term solution to complex Delta problems will determine the feasibility of several water supply augmentation proposals and their water supply benefits.

Appendix C

Planning Subareas and Land Ownership

Each hydrologic region is divided into several planning subareas, which, in turn, are divided into detailed analysis units. Data collected at the DAU level is aggregated to the PSA level and then to the hydrologic region level. DWR districts have data for each DAU, and specific requests or questions about the DAU data or the aggregations should be directed to the appropriate district. For your convenience, the addresses and phone numbers of the four district offices are listed below, and a map showing district boundaries is shown on the next page.

Northern District

2440 Main Street
Redding, CA 96080-2398
(916) 529-7300

Central District

3251 S Street
Sacramento, CA 95816-7017
(916) 445-683

San Joaquin District

3374 East Shields Avenue
Fresno, CA 93726-6990
(209) 445-5443

Southern District

770 Fairmount Avenue
Glendale, CA 91203-1035
(818) 543-4600

Appendix D

Hydroelectric Resources of California

This appendix condenses information from the following sources:

- The California Energy Commission, *California Power Plant Maps*, July 1992.
- The Federal Energy Regulatory Agency, *Hydroelectric Power Resources of the United States, Developed and Undeveloped*, January 1988.
- The Federal Energy Regulatory Agency, *SFRO Project Assignments by Project Number*, September 16, 1992 (unpublished).

The proposed developments in Tables D-1 and D-3 are only those that have a Federal Energy Regulatory Commission number or are listed by the California Energy Commission.

There are 416 operating hydroelectric plants in California with an installed capacity of 11.4 million kilowatts. Another 76 planned developments are in the regulatory process. Table D-1 shows the distribution of developed and planned projects among the hydrologic regions, and Table D-2 further breaks down this distribution into river basins or planning subareas. Finally, Table D-3 presents a more detailed inventory of hydroelectric resources in California. The data sources differ as to hydroelectric plant names, owners, and capacities. FERC was generally the preferred source for the information in Table D-3, except when information was secured directly from the owner. The CEC designation is supplied when it is significantly different from that of FERC's or is not the owner's name.

Table D-1. Developed and Undeveloped Hydroelectric Plant Sites

Hydrologic Region	Developed Capacity KW	Developed Capacity Number	Proposed Developments Number	Total
North Coast	210,766	32	9	41
San Francisco Bay	1,087	3	3	6
Central Coast	7,425	10	3	13
South Coast	812,975	79	4	83
Sacramento River	4,890,855	151	30	181
San Joaquin River	3,217,435	75	8	83
Tulare	1,853,688	23	3	26
North Lahontan	6,450	2	1	3
South Lahontan	201,302	27	9	36
Colorado River	209,395	14	4	18
TOTAL	11,410,858	416	76	492

Table D-2. Developed and Planned Development of Hydroelectric Resources Summary

Hydrographic Region River Basin or PSA	*Developed Sites* KW	*Developed Sites* Number	*Undeveloped Sites* Number	*Total*
North Coast				
Klamath River	49,532	9	4	13
Trinity River	114,526	9	4	13
Mad River	4,240	3	0	3
Eel River	25,968	5	0	5
Russian River	16,500	6	1	7
TOTAL North Coast	210,766	32	9	41
San Francisco Bay				
North Bay	287	2	1	3
South Bay	800	1	2	3
TOTAL San Francisco Bay	1,087	3	3	6
Central Coast				
Northern	90	1	1	2
Southern	7,335	9	2	11
TOTAL Central Coast	7,425	10	3	13
South Coast				
Santa Clara	212,500	12	1	13
Metro Los Angeles	259,791	24	2	26
Santa Ana	326,344	32	2	34
San Diego	13,820	10	0	10
TOTAL South Coast	812,455	78	5	83
Sacramento				
Sacramento River	959,640	7	2	9
Pit and McCloud Rivers	817,227	22	5	27
West Side	28,143	10	1	11
East Side	79,460	28	3	31
Feather River	1,223,285	25	5	30
Yuba and Bear Rivers	708,366	35	7	42
American River	1,074,734	25	8	33
TOTAL Sacramento	4,890,855	152	31	183

Table D-2. Developed and Planned Development of Hydroelectric Resources Summary (Continued)

Hydrographic Region River Basin or PSA	*Developed Sites* KW	*Developed Sites* Number	*Undeveloped Sites* Number	*Total*
San Joaquin				
Mokelumne River	246,590	9	1	10
Calaveras River	3,940	3	0	3
Stanislaus River	778,250	14	1	15
Tuolumne River	483,631	15	2	17
Merced River	107,000	6	0	6
San Joaquin River	1,598,024	28	4	32
TOTAL San Joaquin	3,217,435	75	8	83
Tulare				
Kings River	1,713,000	7	3	10
Kawea River	23,850	4	0	4
Tule River	11,388	6	0	6
Kern River	105,450	6	0	6
TOTAL Tulare	1,853,688	23	3	26
North Lahontan	6,450	2	1	3
South Lahontan	201,302	27	9	36
Colorado River	209,395	14	4	18
STATEWIDE TOTAL	11,410,858	416	76	492

DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES

1 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
North Coast Region		**Smith River**							
Boulder Cr	Moore, CN	Boulder Cr, SFS	Del Norte	8153					75
North Coast Region		**Klamath River**							
Bluff Creek	Eckert, David & Penelope	Bluff Cr, Slate Cr	Humboldt	6454				1	
Fall Creek*	Pacific Power & Light Co	Jenny Cr	Siskiyou	2082	1903	2,200	12,800		730
Copco 2*	Pacific Power & Light Co	Klamath R	Siskiyou	2082	1925	27,000	141,200		152
Copco 1*	Pacific Power & Light Co	Klamath R	Siskiyou	2082	1918	2,000	120,000		125
Iron Gate*	Pacific Power & Light Co	Klamath R	Siskiyou	2082	1961	18,000	153,500	158	158
Lower Cold Springs	Foster, Harold et al	Cold Cr, Bogus Cr	Siskiyou	7059		95	660		245
Upper Cold Springs	Foster, Harold et al	Cold Cr, Bogus Cr	Siskiyou	7279				50	230
Luckey	Luckey, Haward Paul	Cold Cr, Bogus Cr	Siskiyou	7279				50	230
Prather Ranch	T K O Power	Prather Cr, L Shasta	Siskiyou	6634		100	680		517
Cornwell	Cornwell, M H & J V	Trib to Merrill	Siskiyou	2987		12	35		
Drager-Jones-Timmons	Drager, Tery et al	Clark Cr Scott R	Siskiyou			25	208		150
Shasta R	Difanics	Shasta River	Siskiyou			100	600		21
Shasta R	Smith, Dewey D.	Shasta River	Siskiyou	7400				480	35
North Coast Region		**Trinity River**							
Mill Sulpher Crs*	North Coast Hydro	Miller	Humboldt	6154		990			
Hawkins Cr*			Humboldt					400	
Willow Cr*			Humboldt					1,700	
Big Cr*	Xenaphon Enterprises	Big Cr, S Fk T	Trinity	7010	1987	4,800			
Eltapom Cr	Rulofson, R	Eltapom Cr S Fk	Trinity	6167				1,490	400
Cedar Flat*	Mega, Renewables	Cedar Flat Cr	Trinity	6168		1,500	5,900		869
Biber Spellenburg*	Spellenburg, S	Bidden Cr	Trinity	6550		30	152		320
Lewiston*	Bureau of Reclamation	Trinity R	Trinity			350	2,600		60
Trinity*	Bureau of Reclamation	Trinity R	Trinity			105,556	409,000	214,000	469
Trinity Alps Creek	Mallett, F & B	Trinity Alps Cr	Trinity	4737		500	1,900		10
Bell (Upper)	Bell Enterprises	Battle Cr, Coffee	Trinity	4478		50	264		
Bell (Lower)	Bell Enterprises	Battle Cr, Coffee	Trinity	4478				550	900
Weber Flat	Pan-Pacific Hydro Inc	W Fk Trinity	Trinity	6959		750	3,000		510

** On California Energy Commission Map and List*

DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

2 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
North Coast Region		**Mad River**							
Schatz Tree Farm*			Humboldt			100			
Davis Creek	General Plastics Mfg Co	Davis Cr	Humboldt	6633		140	477		520
R W Matthews*	Humboldt Bay MUD	Mad R	Trinity	3430	1983	4,000	14,210		100
North Coast Region		**Eel River**							
Redwood Trails	Redwood Trails	McBrindle Cr	Humboldt			160	2,500		48
Baker Creek*	Hunt, A R & B F	Baker Cr, Van D	Humboldt	4627	1987	1,500	5,580		916
Burgess Creek	Burgess, Edward et al	Burgess Cr	Trinity	5955		25	100		10
Bluford Creek*	Burgess, M & N	Bluford Cr	Trinity	6062	1984	1,250	3,585		858
Three Forks	Burgess, NR	Bluford Cr	Trinity	10882					
Kekawaka Creek*	Kekawaka Kilowatts Inc	Kekawaka Cr	Trinity	7120	1989	4,950	14,200		1,008
North Coast Region		**Russian River**							
Mendocino	Ukiah, City of	E Fk Russian R	Mendocino	2841		3,500	17,660		100
McFadden Farms*	McFadden, Eugene J M	E Fk Russian R	Mendocino	4658		380	1,870		15
Power Canal*	BES Hydro Co	PH Disch Cnl	Mendocino	8936		400			18
Hammeken	Hammeken, WH et al	PH Disch Cnl	Mendocino	9647				300	16
Potter Valley*	Pacific Gas & Electric Co	E Fk Russian R	Mendocino	77		9,200	61,000		476
Warm Springs*	Sonoma Co Water Agency	Dry Cr	Sonoma	3351	1988	3,000	18,210		200
California Fish*	Ca Fish Growers, Inc	Ocean Trib	Sonoma			20			
San Francisco Bay Region		**North Bay PSA**							
Yellowjacket*	Neerhout, John Jr	Yellowjacket Cr	Napa				70		600
Stony Brook	Webster, John A	Unn Str, Murphy C	Napa			2	10		100
Fleming Hill	Vallejo, City of	Fleming Hill WS P	Solano	5593		285	1,850		190
San Francisco Bay Region		**South Bay PSA**							
WTP No. 2	Alameda Co. WD		Alameda	10833					
Anderson Dam*	Santa Clara Valley WD	Coyote Creek	Santa Clara	5737		800	4,177		215
High Line Cnl	Santa Clara, City of		Santa Clara	7252					215

* *On California Energy Commission Map and List*

DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

3 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Central Coast Region									
San Antonio	Monterey Co. FC & WCD	San Antonio R, Salinas	Monterey	10618				6,000	160
Nacimiento*	Monterey Co. FC & WCD	Nacimiento R, Sal	San Luis Obispo	6378	1987	3,750	9,500		115
San Luis Obispo WTP*	Energy Partners	Wtr Sup Pl	San Luis Obispo			130			110
Whale Rock*	Whale Rock Commission	Old Cr	San Luis Obispo	5890		75	650		176
San Luis Obispo	San Luis Obispo, City of	San Luis Obispo	San Luis Obispo	5218				620	650
Stenner Cyn*			San Luis Obispo			780			
CSL-WT-PP	San Luis Obispo, City of	San Luis Obispo	San Luis Obispo	9261					
Lopez WTP	San Luis Obispo Co FC & WCD	Wtr Sup Pl Arroyo	San Luis Obispo	4804		120			
Gibraltar	Santa Barbara, City of	Santa Ynez R	Santa Barbara			1,500	4,200		142
Picay*	Montecito WD & Howard JE	Doulton Tunnel	Santa Barbara	8210	1989	130			663
Goleta*	Goleta WD		Santa Barbara		1986	150			
Cater*	Santa Barbara, City of		Santa Barbara		1985	700			
Graham Hill*		Graham Hill WTP	Santa Cruz			90			
South Coast Region		**Santa Clara PSA**							
W E Warne*	Ca Dept of Wtr Resour	W Br Ca Aque Piru	Los Angeles	2426	1983	75,000	394,200		739
Castaic 3*	Ca Dpt W R & L A W P	W Br Ca Aque	Los Angeles	2426	1972	56,000	60,000		1,048
Chatsworth*	Calleguas MWD		Los Angeles	6868	1984	1,250			
West Coast Basin Bar*	Los Angeles Co FCD	G.W Inj (Col Ag)	Los Angeles	8434	1985	930			225
WB-28*	El Segundo, City of	MWD H Coast FDR	Los Angeles	8310	1989	520			196
Alamitos*	Los Angeles Co. FCD	Alamitos PL	Los Angeles	9008	1986	250	1,850		358
MWD Recovery I*	Metro W Dist S Ca		Los Angeles		1980	29,000			
MWD Recovery II-IV*	Metro W Dist S Ca		Los Angeles		1982	47,200			
Santa Felicia*	United Wtr Cons Dist	Piru Cr, Santa Cl	Ventura	2153	1987	1,200	1,985		194
Conejo Pump Sta*	Calleguas MWD	Conejo Pump Sta	Ventura	4611	1982	750	3,200		145
Santa Rosa Val*	Calleguas MWD	Pressure Red Sta.	Ventura	9071	1986	250			
Woodcreek Rd*	Camrosa CWD	W.S. P.L.	Ventura	9879	1987	150			215
Springville	Calleguas MWD		Ventura	11094					

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

4 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
South Coast Region		**Metro Los Angeles**							
Sepulveda Can*	Metro Wtr Dist of So Ca	Sepulveda Fdr	Los Angeles		1982	8,600	53,200		300
Santa Monica	Santa Monica, City of	Sepulveda Fdr	Los Angeles	7190			800	150	203
Venice*	Metro Wtr Dist of So Ca	Sepulveda Fdr	Los Angeles	5197	1982	10,100	60,000		280
Dominguez Gap*	Los Angeles Co FCD	Dom. Gap P1	Los Angeles	9007	1986	275	2,200		325
Greg Avenue*	Metro Wtr Dist of So Ca	E. Valley Fdr Cnl	Los Angeles		1979	1,000	7,260		
Franklin Canyon*	Los Angeles Dept W & P	Franklin Can	Los Angeles		1921	2,000	8,800		283
East Portal	Calleguas Mn Wtr Dist	Santa Susana Cnl	Los Angeles	6868		1,000	6,000		86
San Fernando*	L A Dept W & P	La Aque	Los Angeles		1922	5,600	30,000		250
Foothill*	L A Dept W & P	La Aque	Los Angeles		1971	11,000	60,450		548
S Francisquito 1*	L A Dept W & P	La Aque	Los Angeles		1928	64,375	273,000		895
S Francisquito 2*	L A Dept W & P	La Aque (Santa Cl)	Los Angeles		1932	42,000	15,000		540
Foothill Feeder	Metro Wtr Dist So Ca	Foothill Fdr Cnl	Los Angeles		1981	9,032	23,000		
Sawtelle	L A Dept W & P		Los Angeles		1986	81,000			
Fulton Station	Three Valleys Mun Wrt Dist	Laverne Conn Tre	Los Angeles	10264	1987	300	976		188
Williams Station	Three Valleys Mun Wrt Dist	Laverne Conn Tre	Los Angeles	10265	1987	350	2,210		288
Miramar Treatment	Three Valleys Mun Wrt Dist	Miramar Ave 1Rea	Los Angeles	10263	1987			520	227
Verdugo	Glendale, City of	Metro Wtr Dist Pl	Los Angeles	6352		400	1,300		
Rio Hondo	Metro Wtr Dist of So Ca	Middle Feeder Pl	Los Angeles	6093		1,910	12,300		220
San Dimas*	Metro Wtr Dist of So Ca	Foothill Cnl Dal	Los Angeles	2896	1981	9,924	42,000		
S Dimas Wash Turn	San Gabriel V MWD	Devil Canyon/Azus	Los Angeles	5648	1986	1,200			425
Ontario 1*	So Ca Edison Co	San Antonio Cr, W	Los Angeles		1902	600	4,800		700
Sierra*	So Ca Edison Co	San Antonio Cr, W	Los Angeles		1922	480	4,000		628
Ontario 2*	So Ca Edison Co	San Antonio Cr, W	Los Angeles		1963	320	1,100		314
Azusa*	Pasadena, City of	San Gabriel R	Los Angeles	1250	1948	3,000	11,525		401
San Gabriel*	San Gabriel Hydro Ptnsp	San Gabriel R	Los Angeles		1987	4,980			280
Dist Terminal Sto*	Walnut V WD	Southern Cr, San	Los Angeles	8764	1984	195	600		123

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

5 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Undeveloped Proposed Capacity KW	Gross Stat Head (FT)
South Coast Region		**Santa Ana PSA**							
MWD F-8	Fullerton, City of	MWD P1 F-8 Col R	Orange	9735	1986	400			260
OC-17 Turnout*	Buena Park, City of	W Orange Fdr LA A9	Orange	7297	1985	120	870		240
Lambert Road*	La Habra, City of	Colorado R Aque	Orange	3797	1982	87	565		170
Yorba Linda*	Metro Wtr Dist of So Ca	Yorba Linda Cnl	Orange	2896	1981	5,100	39,000		
Valley View*	Metro Wtr Dist of So Ca	MWD Valley View	Orange	8828	1985	4,100	13,600		421
Coyote Creek*	Metro Wtr Dist of So Ca	Lower FDR Coyo	Orange	6174	1984	3,125	19,600		218
Santa Ana Pres Red S*	Mesa Consolidated WD	OC-44 ID Pl	Orange	10742	1991	50			221
Santa Ana*	Santa Ana, City of		Orange		1986	200			
Zone I Reservoir*	Irvine Ranch WD	Sand Canyon Pl	Orange	9186	1984	130			180
Turtle Rock-Quail Hi	Energy Res & Appl	MWD Feeder Pl	Orange	7401	1984	187	1,416		196
Snow Creek*	Desert Water Agency	Snow Cr, Santa An	Riverside	6819	1988	300			760
Corona*	Metro Wtr Dist So Ca	MWD L Fdr Pl	Riverside	6010	1983	2,850	18,000		135
Temescal*	Metro Wtr Dist So Ca	MWD L Fdr Pl	Riverside	5938	1983	2,850	18,000		135
Lake Mathews*	Metro Wtr Dist So Ca	Lake Mathews Cnl	Riverside	2896	1980	4,900	39,000		250
Perris*	Metro Wtr Dist So Ca	Perris Bypass Pl	Riverside	6056	1983	7,900	40,000		
Oakcliff*	Lake Hemet Muni Wtr Dist	WD Pl San Jacint	Riverside	5714	1982	100	360		220
North Fork*	Lake Hemet Muni Wtr Dist	San Jacinto R	Riverside	7426		255	1,148		270
Lytle Creek*	So Ca Edison Co	Lytle Cr, Santa A	San Bernardino	1932	1904	450	3,900		483
Lytle Creek	San Bernardino V Mun Wtr	Lytle Cr, Santa A	San Bernardino	2889				1,300	
Site 1720*	San Bernardino, City of	Muni Pl Carjein C	San Bernardino	6155	1983	207	450		169
Site 1895*	San Bernardino, City of	Muni Pl Carjein C	San Bernardino	6155	1984	70	220		169
Site 2100*	San Bernardino, City of	Muni Pl Carjein C	San Bernardino	6155	1987	83	260		169
Mill Creek 1*	So Ca Edison Co	Hill Cr, Santa An	San Bernardino	1934	1904	800	4,700		510
Mill Creek 2*	So Ca Edison Co	Mill Cr, Santa An	San Bernardino	1934	1904	250	1,500		620
Mill Creek 3*	So Ca Edison Co	Mill Cr, Santa An	San Bernardino	1934	1904	3,000	14,000		1911
Upland*	Upland Wtr Dept	Upland FDR	San Bernardino	6688	1984	90	403		220
Cucamonga*	Cucamonga Co WD		San Bernardino		1981	20			
Devils Canyon*	Ca Dpt Wtr Resource	E Br Ca Aque	San Bernardino	2426	1976	279,700	1,510,000		1406
R-4 Station*	Monte Vista Wtr Dist	Muni Wtr Pl Ca A	San Bernardino	10484	1990	870			363
Fontana*	So Ca Edison Co	Lytle Cr, Santa A	San Bernardino		1917	2,950	8,800		658
Santa Ana 3*	So Ca Edison Co	Santa Ana R	San Bernardino	2198	1947	1,200	7,000		354
Santa Ana 2*	So Ca Edison Co	Santa Ana R	San Bernardino	1933	1905	800	5,000		310
Santa Ana 1*	So Ca Edison Co	Santa Ana R	San Bernardino	1933	1899	3,200	18,000		726
Lucerne Val	Big Bear ARWA		San Bernardino	9186					

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

6 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed				Undeveloped	
				FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Proposed Capacity KW	Gross Stat Head (FT)
South Coast Region		**San Diego PSA**							
San Francisco Peak*	Oceanside, City of	Tri-Agencies Pl (M)	San Diego	7147	1985	90	532		350
Squires Dam*	Costa Real Muni WD	Muni WS Pl Diego	San Diego	9902	1988	40			325
Roger Miller*	Olivernhain Mun WD	Gaty Res Pl San	San Diego	9888	1988	450			270
Rincon*	Escondido Mutual Water Co	San Luis Rey R	San Diego	176	1983	300	1,200		824
Bear Valley*	Escondido Mutual Water Co	Escondido Cr, Pac	San Diego		1986	1,400	5,600		400
Alvarado*	San Diego Co Water Auth	Second Aque Pl (Fl)	San Diego	5670	1985	2,000	7,816		190
Badger Filt Plt*	San Diego Wtr Dist	Aliso Canyon (San)	San Diego	5397	1987	1,490			350
Red Mountain*	Metro Water Dist of So Ca	SD Pl	San Diego	8552	1985	5,900	37,900		232
Miramar*	San Diego Co Water Auth	Second Aque Pl (F)	San Diego	5669	1985	800	3,995		72
Point Loma	San Diego, City of	WWT Outfall (San D)	San Diego	7510		1,350	3,300		89
Sacramento Region		**Sacramento River**							
Slate Creek	Slate Cr Hydro Assoc	Slate Cr, Sacramento	Shasta	3908		2,710	14,200		150
Shasta*	Bureau of Reclamation	Sacramento R	Shasta			539,000	2,788,590		492
Keswick*	Bureau of Reclamation	Sacramento R	Shasta			75,000	477,500		87
Spring Creek*	Bureau of Reclamation	Spring Cr, Sac	Shasta		1964	180,000	603,000		625
Spring Creek*	Iron Mtn Mines*	Spring Cr	Shasta					5,000	
Judge Francis Carr*	Bureau of Reclamation	Clear Cr Tnl	Shasta		1963	154,400	531,232		695
Whiskeytown*	Redding, City of	Clear Cr, Sac	Shasta	2688	1986	3,530	8,658		240
Spring Creek	Redding, City of	Spring Cr, Sac	Shasta	9470					
Lake Siskiyou	Siskiyou Co FC & WCD	Little Sacramento	Siskiyou	2796		5,000	21,900		191
Sacramento Region		**Pit and McCloud Rivers**							
Turner Cr	Turner Cr. Power Co	Turner Cr	Modoc	10048					
Pit 4*	Pacific Gas & Electric Co	Pit R	Shasta	233	1955	95,000	479,000		382
Pit 3*	Pacific Gas & Electric Co	Pit R	Shasta	233	1925	70,000	385,400		315
Montgomery Cr Falls*	Deyl, C	Montgomery Cr	Shasta					500	67
Montgomery Cr*	Northern Resources, Inc	Montgomery Cr	Shasta	3590	1987	2,400	10,800		24
Silver Springs*	Bosetti, Rick M	Silver Springs	Shasta	8975	1982	600	4,000		555
Grasshopper Flat	Nelson Creek Power Inc	Nelson Cr	Shasta	9029				1035	370
Burney Creek	Mega Renewables	Burney Cr	Shasta	8671				3000	630
Muck Valley	Malacha Pwr Project Inc	Pit R	Shasta	8296		29,900	90,000		666
Goose Valley*	Mega Hydro Inc	Goose Cr, Burney	Shasta	6548		280			251
Hat Cr 2*	Pacific Gas & Electric Co	Hat Cr	Shasta	2661	1921	8,500	39,300		198
Hat Cr 1*	Pacific Gas & Electric Co	Hat Cr	Shasta	2661	1921	8,500	19,300		213

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

7 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**Pit and McCloud Rivers (Continued)**							
Hat Cr Hereford R*	Thompson, Robert	Hat Cr	Shasta	4794	1982	100	900		16
Bidwell Ditch*	Bidwell, Floyd N	Lost Cr, Hat Cr	Shasta	9334	1987	2,000			150
Lost Cr 2*	Highland Hydro Const	Lost Cr., Hat Cr	Shasta	5130	1985	500			85
Lost Cr 1*	Bidwell, Floyd N	Lost Cr, Hat Cr	Shasta	3863	1989	1,400			363
Pit 1*	Pacific Gas & Electric Co	Pit R	Shasta	2687	1965	61,000	264,100		455
Fruit Growers*		Burney Cr	Shasta		1990	3,000			
Hatchet Cr*	Roseburg Lumber Co	Hatchet Cr	Shasta	5931	1987	6,890	21,270		1,210
Roaring Cr*	Roaring Cr Ranch	Roaring Cr	Shasta	7282	1986	2,000	3,750		315
Coldwater*	Coldwater Pwr Proj	Roaring Cr	Shasta		1990	5,000			760
Pit 7*	Pacific Gas & Electric Co	Pit R	Shasta	2106	1965	112,000	495,100		205
Pit 6*	Pacific Gas & Electric Co	Pit R	Shasta	2106	1965	80,000	334,600		155
James B. Black*	Pacific Gas & Electric Co	Pit R	Shasta	2106		172,000	539,700		1,226
Baker-Kosk Cr*	Pfeiffer, Dr Harold W	Kosk Cr	Shasta	4826	1985	207	1,410		185
Pit 5*	Pacific Gas & Electric Co	Pit R	Shasta	233	1944	156,000	920,000		615
Sacramento Region		**West Side**							
Stovall 1	Glenn-Colusa ID	Glenn-Colusa Cnl	Colusa	6805		120	433		14
Stovall 2*	Glenn-Colusa ID	Glenn-Colusa Cnl	Colusa	6546		30	170		20
Mile 41.1*	Glenn-Colusa Irrig Dist	Glenn-Colusa Cnl	Colusa	9045		93	200		41
High Line Canal*	Santa Clara, City of	Highline Cnl	Glenn		1989	500			29
Stony Gorge*	Santa Clara, City of	Stony Cr, Sac	Glenn	3193	1991	3,900	13,220		105
Indian Valley*	Yolo Co FC & WCD	N Fk Cache Cr	Lake	4066	1983	2,900	7,190		152
Clear Lake*	Yolo Co FC & WCD	Cache Cr	Lake	4063	1985	2,500			40
Monticello*	Solano ID	Putah Cr	Napa	2780	1983	11,500	52,000		210
Arbuckle Mtn*	Arbuckle Mtn Hydro Pnsp	MF Cottonwood Cr	Shasta			400	950		50
Monticello Tap	Pacific Gas & Electric Co	Putah Cr	Solano	5828					
Black Butte*	Santa Clara, City of	Stony Cr	Tehama	3190	1989	6,200	16,900		78

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

8 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**East Side**							
Centerville*	Pacific Gas & Elec Co	Butte Cr	Butte	803	1900	6,400	43,800		557
De Sabla*	Pacific Gas & Elec Co	Butte Cr	Butte	803	1963	18,500	120,100		1545
Forks of Butte*	Energy Growth Group et al	Butte Cr	Butte	6896			11,600		720
Toadtown*	Pacific Gas & Elec Co	Hendricks Cnl	Butte	803	1986	1,700	8,430		185
Hamlin Canyon	Crow, Oliver M & Gail M	Hamlin Canyon	Butte	7466		5	9		17
Paradise Project C*	Beckwith, Sterling	Paradise Supply	Butte	6274		40			115
Paradise Project D*	Beckwith, Sterling		Butte			40			
Mud Creek*	Perry Logging Co	Mud Cr	Butte	6330		300	1,300		176
Bailey Creek*	Bailey Creek Ranch	Bailey Cr, Battle	Shasta	3948	1982	630	5,000		100
Viola Church Camp*	No Valley Baptist Church	Armstrong Dth	Shasta			50			
Coleman*	Pacific Gas & Electric Co	Battle Cr	Shasta	1121	1911	13,000	63,481		482
Ponderosa Bailey*	Forward, Al	Bailey Cr, Battle	Shasta	8357	1990	1,100			300
Volta 2*	Pacific Gas & Electric Co	Cross Country Chl	Shasta	1121	1981	900	5,040		125
Volta 1*	Pacific Gas & Electric Co	Millseat Cr, N Fk	Shasta	1121	1981	9,000	57,000		1264
Sutters Mill*	Sutter, Fred N Jr	Millseat Cr, N Fk	Shasta	4283		150			60
Nichols*	Nichols, Frank B	S Fk Bear Cr	Shasta	5766	1986	3,000			650
McMillan*	McMillan Hydro Co	N Fk Little Cow Cr	Shasta	6952		950			590
McMillian Power 2	McMillian Hydro Co	Cow Cr	Shasta	8676				75	471
T & G Hydro*	T & G Hydro	Canyon Cr, Old Cow	Shasta	6905		350	845		551
Mega Hydro 1*	Mega Hydro Inc	Clover Cr	Shasta	5306	1986	1,000	4,300		437
Clover Leaf Ranch*	Mega Hydro Inc	Clover Cr	Shasta	7057	1985	200	882		148
Olsen*	Olsen Power Partners	Old Cow Cr	Shasta	8361	1990	5,000			596
Kilarc*	Pacific Gas & Electric Co	Old Cow	Shasta	606	1903	3,200	22,000		1192
Poulton*	Poulton, W R	S Cow Cr	Shasta		1982	100	350		40
Cow Creek*	Pacific Gas & Electric Co	S Cow Cr	Shasta	606	1907	1,800	12,000		715
Inskip*	Pacific Gas & Electric Co	S Fk Battle Cr	Tehama	1121	1910	8,000	60,645		383
South*	Pacific Gas & Electric Co	S Fk Battle Cr	Tehama	1121	1979	7,000	44,000		516
Fire Mountain	Townsend, D E	Fern Spr Cr	Tehama			45	130		6
Nikola 1	Lassen Research Co	Lower Booledth Pl	Tehama	5697				30	10
Digger Cr*	Forward Pwr & Engy Co, Inc	S Digger Cr	Tehama	4714		750	5,300		465

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9 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**Feather River**							
Lime Saddle*	Pacific Gas & Elec Co	W Br N Fk	Butte			2,000	11,000		462
French Cr	Oroville Wyandotte ID	French Cr N Fk	Butte	5601				10,000	978
Poe*	Pacific Gas & Elec Co	N Fk Feather R	Butte	2107	1958	120,000	600,670		477
Cresta*	Pacific Gas & Elec Co	N Fk Feather R	Butte	1962	1949	70,000	330,500		290
Camp Creek	Lassen Sta. Hydro LP	Camp Cr, N Fk	Butte	6120		990	4,778		500
Coal Canyon*	Pacific Gas & Elec Co	Miocene Cn 1	Butte		1907	900	7,500		481
Kanaka*	Television Comm In	Sucker Run Cr, S	Butte	7242	1989	1,100			324
Forbestown*	Oroville-Wyandotte Irrig Dist	S Fk Feather R	Butte	2088	1963	28,800	183,100		835
Woodleaf *	Oroville-Wyandotte Irrig Dist	S Fk Feather R	Butte	2088	1963	52,200	297,100		1,495
Sly Creek*	Oroville-Wyandotte Irrig Dist	Lost Cr, S Fk	Butte	2088	1984	13,200	48,200		225
Feather River Hatch	Ca Dept of Water Resource	Feather R	Butte	2100				4,770	18
Thermalito*	Ca Dept of Water Resource	Off Stream	Butte	2100	1968	32,600	270,000		102
Thermalito Diversion*	Ca Dept of Water Resource	Feather R	Butte	2100	1987	3,000	19,700		74
Kelly Ridge*	Oroville-Wyandotte Irrig Dist	Kelly Ridge Cnl	Butte	2088	1963	10,000	7,900		668
Edward G Hyatt*	Ca Dept of Water Resource	Feather R	Butte	2100	1969	351,000	1,934,000		675
Gansner Creek*	Austin, L & K	Gansner Cr, E Br N	Plumas	7919		250	844		300
Gansner Bar*			Plumas			280			
Peter Ranch	Peter, James B	Peters Cr, Lights	Plumas	6919		15	83		161
Five Bears*	Ditt Inc	Ward Cr, Indian Cr	Plumas	6281		990			1,000
Belden*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	2105	1969	125,000	245,300		770
Oak Flat*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	2105	1985	1,300	6,600		137
Caribou 2*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	2105	1958	120,000	210,900		1,149
Caribou 1*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	2105	1958	75,000	145,000		1,149
Butt Valley*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	2105	1958	40,000	84,200		358
Hamilton Branch*	Pacific Gas & Elec Co	Hamilton Cr, N Fk	Plumas		1921	4,800	15,800		410
Graeagle	Henwood Assoc Inc	Gray Eagle Cr, M	Plumas	3247		360	2,800		460
Graeagle Golf C	Graeagle L & W Co	Frazier Cr M Fk	Plumas	10505				90	255
Rock Creek*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	1962	1950	112,000	482,500		535
Bucks Creek*	Pacific Gas & Elec Co	N Fk Feather R	Plumas	619		57,500	241,300		2,558
Rock Cr 2	Oroville-Wyandotte ID	Rock Cr	Sierra	3479					

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

10 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed				Undeveloped	
				FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**Yuba-Bear Rivers**							
Drum 2*	Pacific Gas & Electric Co	Drum Cnl (Bear R)	Nevada	2310	1965	49,500	35,000		1,370
Drum 1*	Pacific Gas & Electric Co	Drum Cnl (Bear R)	Nevada	2310	1965	54,000	245,000		1,373
Deer Creek	Pacific Gas & Electric Co	S Yuba Cnl	Nevada	2310	1908	5,700	30,600		837
Scotts Flat*	Nevada I D	Deer Cr	Nevada	5930	1984	1,000	3,500		140
Miners Tunnel	Haypress Hydroelectric Inc	S Yuba R	Nevada	6727				2,500	48
Excelsior	Northwest & Power Co	S Yuba R	Nevada	9086				14,000	155
Bowman*	Nevada I D	Canyon Cr, S Yuba	Nevada	2266	1986	3,600	16,000		162
Haypress-Bowman	Haypress Hydro, Inc		Nevada	8255					
Spaulding 2*	Pacific Gas & Electric Co	S Yuba Cnl S Yuba	Nevada	2310	1929	4,400	20,000		344
Spaulding 1*	Pacific Gas & Electric Co	Drum Cnl S Yuba	Nevada	2310	1929	7,000	38,000		197
Spaulding 3*	Pacific Gas & Electric Co	Bow-SP Cnl S Yuba	Nevada	2310	1929	5,800	25,100		318
Jackson Meadows	Nevada I D	N Yuba R	Nevada	2981				3,500	184
Haemmig	Haemmig, Adrian & Janice	N Fk Wolf Cr, Bear	Nevada	6253		14	94		15
Combie N*	Nevada I D	Combie N Aqueduct	Nevada	7731		350	2,500		40
Lake Combie*	Nevada I D	Bear R	Nevada	2981	1984	1,500	4,500		70
Halsey*	Pacific Gas & Electric Co	S Fk Dry Cr	Placer	2310	1916	11,000	66,600		327
Bell*	Swiss American Co	Fiddler Green Cn	Placer		1981	100			80
Wise 1 & 2*	Pacific Gas & Electric Co	Auburn Ravine	Placer	2310	1986	14,700	87,400		519
Garden Bar*	Garden Bar Farms, Inc	Camp Far W Dth	Placer	7745		84	427		40
Garden Bar	South Sutter W D	Bear R	Placer	5222					
Vanjop 1*	South Sutter W D	Conv Cnl, Bear	Placer			350	1,233		13
Camp Far West*	South Sutter W D	Bear R	Placer	2997	1985	6,800	26,900		165
Rollins	Nevada I D	Bear R	Placer	2981	1980	12,200	77,000		215
Chicago Park*	Nevada I D	Chicago Park Flm	Placer	2981	1966	41,500	140,000		481
Dutch Flat 2*	Nevada I D	Dutch Flat Cnl (B)	Placer	2981	1966	26,000	120,000		591
Dutch Flat 1*	Pacific Gas & Electric Co	Dutch Flat Cnl	Placer	2310	1943	22,000	54,800		643
Alta*	Pacific Gas & Electric Co	Towle Cnl Bear	Placer	2310	1902	2,000	6,400		648
Little Bear Cr	Irvine, Robert	Little Bear Cr	Placer	6942		10	50		25
Newcastle	Pacific Gas & Electric Co	South Cnl	Placer	2310		11,500	49,000		419
North Yuba R	Gallery, D F	N Yuba R	Sierra	5841				7,500	700
Wright Ranch	Bertillion, Bertha W	Rock Cr, N Yuba	Sierra	7893				20	138
Salmon Creek*	Henwood Associates Inc	Salmon Cr, N Yuba	Sierra	3730		600	5,100		460

** On California Energy Commission Map and List*

DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

11 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed FERC Project No.	Developed Year Installed	Developed Installed Capacity KW	Developed Average Annual Generation 1,000 KWH	Undeveloped Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**Yuba-Bear Rivers (Continued)**							
Charcoal Ravine*	Neocene Exploration Inc	Charcoal Ravine	Sierra	7006		58	375		240
Middle Haypress Cr*	Mac Hydro-Power Co Inc	Haypress Cr, N Yuba	Sierra	6061	1989	8,700			320
East Fork Cr	Haypress Hydroelectric Inc	Haypress Cr, N Yuba	Sierra	9072					
Lower Haypress Cr*	Haypress Hydroelectric Inc	Haypress Cr, N Yuba	Sierra	6028	1989	6,100			400
Fish Power*	Corps of Engineers	Yuba R	Yuba			150			
Virginia Ranch Dam*	Browns Valley I D	Dry Cr	Yuba	3075	1984	1,000	4,030		125
Narrows*	Pacific Gas & Electric Co	N Yuba R	Yuba	1403	1991	12,000	72,000		240
New Narrows*	Yuba County Water Agcy	N Yuba R	Yuba	2246	1970	55,500	210,000		240
New Colgate*	Yuba County Water Agcy	Yuba R	Yuba	2246	1970	341,000	2,160,000		1390
Bullards Bar	Yuba County Water Agcy	N Yuba R	Yuba	2246		150	1,130		560
Deadwood Cr*	Enviro Hydro Inc	Deadwood Cr, N Yuba	Yuba	6780	1989	2,000			925
Sacramento Region		**American River**							
Akin	Akin, R E	Hangtown Cr, Weber	El Dorado	5055		127	380		173
Akin/Cola*	Akin, R E	EID Main Cnl	El Dorado	8010	1984	250	1,100		387
Weber Dam*	El Dorado Irrig Dist	N Fk Weber Cr	El Dorado	7454		175	680		74
Chili Bar*	Pacific Gas & Electric Co	S Fk American R	El Dorado	2155	1965	7,020	37,000		60
White Rock*	Sacramento M U D	S Fk American R	El Dorado	2101	1968	190,000	618,000		852
Upper Rock Cr	Lind Adssoc	Rock Cr, S Fk Am	El Dorado	5192					
Rock Creek*	Keating, Joseph M	Rock Cr, S Fk Am	El Dorado	3189	1986	3,000	7,000		212
Slab Creek	Sacramento M U D	Slab Cr, S Fk Am	El Dorado	2101		482	2,950		
Camino*	Sacramento M U D	S Fk American R	El Dorado	2101	1968	142,500	441,600		1061
El Dorado*	Pacific Gas & Electric Co	S Fk American R	El Dorado	184	1924	21,000	97,900		1910
Jaybird*	Sacramento M U D	Silver Cr, S Fk Am	El Dorado	2101	1961	133,000	575,000		1530
Union Valley*	Sacramento M U D	Silver Cr, S Fk Am	El Dorado	2101	1963	33,250	115,000		430
Jones Fork*	Sacramento M U D	S Fk Silver Cr	El Dorado	2101	1985	10,000	40,570		610
Robbs Peak*	Sacramento M U D	Tells Cr, Silver	El Dorado	2101	1965	23,750	55,000		400
29 Mile Creek	Hensley, Larry	UNN Str, S Fk Am	El Dorado	7931				30	550
Foottrail	Keating, J M	Silver Fk S Fk Am	El Dorado	3194				3,300	285
Sayles Flat	Keating, Joseph M	S Fk Amer R	El Dorado	3195				3,250	485
Canyon Creek*	Eagle Hydro Ptns	Canyon Cr, M Fk Am	El Dorado	7192		480			980
Long Canyon Cr	Enviro Hydro Inc	Long Canyon Cr	El Dorado	7722				2,400	560
Buckeye*			El Dorado			380			
Grizzley Canyon Cr	Enviro Hydro Inc	Big Grizzley Can Cr	El Dorado	7723				4,000	1,580

* *On California Energy Commission Map and List*

DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

12 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Sacramento Region		**American River (Continued)**							
Georgetown Divide*	Georgetown Divide P U D	Georgetown Condui	El Dorado	4303		600			208
Grizzley Cr	Enviro Hydro Inc	Grizzley Cr	El Dorado	6781					
Loon Lake*	Sacramento M U D	Gerle Cr, S Fk Ru	El Dorado	2101	1971	74,100	117,000		1,140
Ralston*	Placer Co Water Agency	Rubicon R	Placer	2079	1966	79,200	476,300		1,250
Hell Hole*	Placer Co Water Agency	Rubicon R	Placer	2079		725	2,930		359
French Meadows*	Placer Co Water Agency	Rubicon R	Placer	2079	1966	15,300	75,300		654
L J Stephenson*	Placer Co Water Agency	M Fk American R	Placer	2079		109,800	650,000		2101
Newcastle*	Pacific Gas & Electric Co	South Cnl N Fk Am	Placer	2310	1986	10,800	49,000		419
Oxbow*	Placer Co Water Agency	M Fk Amer R	Placer	2079	1966	6,570	36,500		89
Big Mosquito Cr	Nugget Hydro Electric	B Mosquito Cr MF Am	Placer	6488					
Bell	Suter, R T	Dardanells Cr	Placer	9032				100	80
Dardanells Pond*	Suter, R T	Dardanells Cr	Placer	6142				200	950
Nimbus*	Bureau of Reclamation	American River	Sacramento		1955	13,500	91,100		43
Folsom*	Bureau of Reclamation	American River	Sacramento		1955	198,720	702,700		333
San Joaquin Region		**Cosumnes River**							
Landis-Harde	Harde, D D	Perry Cr, M F	El Dorado	8722				100	101
San Joaquin Region		**Mokelumne River**							
Jackson Creek*	Jackson Valley I D	Jackson Cr	Amador	5388		460			152
Camanche*	East Bay M U D	Mokelumne R	Amador	5536	1983	10,800	40,208		107
Pardee*	East Bay M U D	Mokelumne R	Amador	2916	1930	26,600	200,779		327
Electra*	Pacific Gas & Electric Co	Mokelumne R	Amador	137	1948	92,000	347,200		1272
Devils Nose	Amador Co N F	Mokelumne R	Amador	8144				30,600	
West Point*	Pacific Gas & Electric Co	N Fk Mokelumne R	Amador	137	1931	14,500	87,600		312
Tiger Creek*	Pacific Gas & Electric Co	N Fk Mokelumne R	Amador	137	1931	58,000	353,200		1219
Salt Springs 1	Pacific Gas & Electric Co	N Fk Mokelumne R	Amador	137	1931	11,000	50,000		257
Salt Springs 2*	Pacific Gas & Electric Co	N Fk Mokelumne R	Amador	137	1931	33,000	125,600		2113
Middle Fork Dam*	Calaveras P U D	M Fk Mokelumne R	Calaveras	7506		230			80
San Joaquin Region		**Calaveras River**							
CPUD Pipeline 1,2,3	Calaveras P U D	Calaveras R	Calaveras	7283		270			
New Hogan*	Calaveras Co Wtr Dist	Calaveras R	Calaveras	2903	1988	2,970	10,110		195
Rock Creek*	Rock Creek W D	Rock Cr	Calaveras	8533		700	3,000		600

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

13 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed FERC Project No.	Developed Year Installed	Developed Installed Capacity KW	Developed Average Annual Generation 1,000 KWH	Undeveloped Proposed Capacity KW	Gross Stat Head (FT)
San Joaquin Region		**Stanislaus River**							
Tulloch*	Oakdale & S San Joaquin I Ds	Stanislaus R	Calaveras	2067	1958	19,000	70,200		157
Colliervile*	Calaveras Co Wtr Dist	Stanislaus R	Calaveras	2409	1990	254,300			872
Angels*	Pacific Gas & Electric Co	Angels Cr	Calaveras	2699	1940	1,000	6,200		444
Murphys*	Pacific Gas & Electric Co	Angels Cr	Calaveras	2019	1954	4,000	16,000		684
Woodward*	S San Joaquin I D	Simmons Cr	Stanislaus	3056	1982	2,300	7,000		41
Frankenheimer*	S San Joaquin I D	Main Cnl	Stanislaus	3113	1982	4,700	18,700		78
Columbia Dth (Yankee)	Tuolumne, County of	Columbia Dth	Tuolumne	8930		118	1,041		450
Columbia Dth (Old Oak)	Toulumne, County of	Columbia Dth	Tuolumne	8930		32	281		36
New Melones*	Bureau of Reclamation	Stanislaus R	Tuolumne		1979	300,000	385,000		583
Stanislaus*	Pacific Gas & Electric Co	M Fk Stanislaus R	Tuolumne	2130	1963	91,000	406,200		1,525
Sand Bar*	Oakdale & S San Joaquin I Ds	M Fk Stanislaus R	Tuolumne	2975		16,200	84,000		389
Spring Gap*	Pacific Gas & Electric Co	Philadelphia Dth	Tuolumne	2130	1921	7,000	48,500		1,865
Beardsley*	Oakdale & S San Joaquin I Ds	M Fk Stanislaus R	Tuolumne	2005	1958	11,100	51,500		264
Donnells*	Oakdale & S San Joaquin I Ds	M Fk Stanislaus R	Tuolumne	2005	1958	67,500	279,000		1,484
New Spicer Meadow	Calaveras Co Wtr Dist	Highland Cr	Tuolumne	2409				5,200	839
San Joaquin Region		**Tuolumne River**							
Hickman*	Turlock I D	Main Cnl	Stanislaus	2878	1979	1,110	3,940		18
Turlock Drop Lake*	Turlock I D	Main Cnl	Stanislaus	2871	1980	3,300	13,056		32
Stone Drop*	Modesto I D	L Main Cnl	Stanislaus	6147	1985	600	1,872		13
Upper Dawson*	Turlock I D	Main Cnl	Stanislaus	3136	1983	4,427	23,980		25
La Grange*	Turlock I D	Tuolumne R	Stanislaus		1924	3,900	16,036		119
Don Pedro*	Turlock & Modesto I D's	Tuolumne R	Tuolumne	2299	1971	199,000	676,675		530
Phoenix*	Pacific Gas & Electric Co	Sullivan Cr (S Fk)	Tuolumne	1061	1940	2,000	10,000		1,190
Phoenix Lake Bypass	Tuolumne, County of	Sullivan Cr (S Fk)	Tuolumne	10480		31	255		37
Eureka Dth	Tuolumne, County of	Eureka DTH, N Fk	Tuolumne	8931		109	956		560
Shadybrook P Sta*	Tuolumne C W D 1	TCWD Sec 4 DTH	Tuolumne	7908		27	19		278
Moccasin*	Hetch Hetchy Wtr & Pwr	Hetch Hetchy Aque	Tuolumne		1969	90,000	548,000		1,257
Moccasin L H*	San Francisco, City & Co	L Moccasin Cr	Tuolumne	5295	1987	2,400	10,000		76
Clavey	Tuolumne Co & T I D	Clavey R	Tuolumne	10081				148,600	2,933
R Kirkwood*	Hetch Hetchy Wtr & Pwr	Tuolumne R	Tuolumne		1967	104,022	433,000		1,450
D R Holm*	Hetch Hetchy Wtr & Pwr	Cherry Cr	Tuolumne		1960	135,000	772,000		2,481
Piute Creek	Hi-Head Hdro Inc	Piute Cr	Tuolumne	3580				371	

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

14 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed				Undeveloped	
				FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Proposed Capacity KW	Gross Stat Head (FT)
San Joaquin Region		**Merced River**							
McSwain*	Merced I D	Merced R	Mariposa	2179	1967	10,000	45,000		56
Exchequer*	Merced I D	Merced R	Mariposa	2179	1989	89,000	316,100		464
Merced Falls*	Pacific Gas & Electric Co	Merced R	Merced	2467	1930	3,500	19,100		26
Parker, R B*	Merced I D	Merced M Cnl	Merced	3055	1982	2,700	9,750		22
Upper Gorge	Merced I D	Merced M Cnl	Merced			900	3,600		30
Canal Creek*	Merced I D	Merced M Cnl	Merced	3114	1983	900	3,600		30
San Joaquin Region		**San Joaquin River**							
Friant Fish Release*	Friant Power Auth	San Joaquin R	Fresno	2892		450			
Friant Transmission	Pacific Gas & Electric Co		Fresno	7009					
Kerckhoff 2*	Pacific Gas & Electric Co	San Joaquin R	Fresno	96		155,000	264,000		442
Kerckhoff 1*	Pacific Gas & Electric Co	San Joaquin R	Fresno	96	1983	38,000	290,000		350
Big Creek 4*	Southern Ca Edison Co	San Joaquin R	Fresno	2017	1951	92,000	428,000		416
Big Creek 3*	Southern Ca Edison Co	San Joaquin R	Fresno	120	1980	147,450	1,275,040		827
John Eastwood*	Southern Ca Edison Co	San Joaquin R	Fresno		1987	207,000			
Big Creek 8*	Southern Ca Edison Co	San Joaquin R	Fresno	67	1929	58,500	337,000		713
Big Creek 2A*	Southern Ca Edison Co	Big Cr	Fresno	67	1928	95,000	391,000		2,418
Big Creek 2*	Southern Ca Edison Co	Big Cr	Fresno	2175	1925	63,000	451,000		1875
Big Creek 1*	Southern Ca Edison Co	Big Cr	Fresno	2175	1925	70,000	655,560		2131
Portal*	Southern Ca Edison Co	Rancheria Cr, Big	Fresno	2174	1956	10,000	51,000		230
Vermillion Val	Southern Ca Edison Co	Mono Cr	Fresno	2086				7,770	
Kings River Siphon*	Orange Cove Irr Dist	Friant-Kern Cnl	Fresno	9399	1990	1,000			11
Lewis Fk Cr	Lucas, Dale L R	Lewis Fk, Fresno R	Madera	8160				3,749	720
Madera Canal M24	Madera Chowchilla Pwr	Madera Cnl Fresno	Madera	5765		440	333		50
Friant Dam	Friant Power Auth	San Joaquin R	Madera	2892	1985	25,000			87
Madera Canal*	Madera-Chowchilla Pwr	Madera Cnl (SJ)	Madera	2958		3,275	11,120		31
Madera Lat 104-10	Madera I D	Madera Cnl (SJ)	Madera			150	850		10
San Joaquin IA*	Pacific Gas & Electric Co	Willow Cr, SJ	Madera	1354	1923	400	1,700		42
Wishon A G*	Pacific Gas & Electric Co	N Fk Willow Cr	Madera	1354	1910	20,000	94,200		1,412
San Joaquin 2*	Pacific Gas & Electric Co	Ditch 1 Willow Cr	Madera	1354	1923	3,200	22,000		307
San Joaquin 3*	Pacific Gas & Electric Co	Willow Cr	Madera	1354	1923	4,200	17,500		405
Crane Valley*	Pacific Gas & Electric Co	Willow Cr	Madera	1354	1919	900	5,100		128
Mammoth Pool*	Southern Ca Edison Co	San Joaquin R	Madera	2085	1960	148,960	546,000		1,100
Rock Creek*	Mega Renewables	Rock Cr	Madera	5756				1,750	699
Papazian*	Merced I D		Merced		1982	900			
RETA*	Merced I D		Merced			900			

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

				Developed				Undeveloped	
15 Hydrologic Region Plant or Site	***Owner***	***River Basin or PSA and Stream***	***County***	***FERC Project No.***	***Year Installed***	***Installed Capacity KW***	***Average Annual Generation 1,000 KWH***	***Proposed Capacity KW***	***Gross Stat Head (FT)***
San Joaquin Region		**San Joaquin River (Continued)**							
Wolfsen By-Pass*	Central Ca I D	CCID Outside Cnl	Merced	5129	1985	705	3,900		23
Fairfield*	Merced I D	Fairfield Cnl	Merced	3116	1983	900	3,600		30
San Luis By-Pass*	Central Ca I D	CCID Outside Cnl	Merced	5128		494	2,300		27
O'Neill*	Bureau of Reclamation	San Luis Cr	Merced		1968	25,200			
San Luis*	Bureau of Reclamation	San Luis Cr	Merced		1969	426,000			
Tulare Region		**Kings River**							
Fishwater Release	Orange Cove I D	Kings R	Fresno	11068					
Pine Flat*	Kings River Cons D	Kings R	Fresno	2741	1983	165,000	418,920		386
Kings River*	Pacific Gas & Electric Co	N Fk Kings R	Fresno	1988	1962	52,000	207,900		798
Balch 1*	Pacific Gas & Electric Co	N Fk Kings R	Fresno	175	1958	34,000	61,400		2379
Balch 2*	Pacific Gas & Electric Co	N Fk Kings R	Fresno	175	1958	105,000	552,200		2389
Haas*	Pacific Gas & Electric Co	N Fk Kings R	Fresno	1988	1958	144,000	517,500		2444
Helms*	Pacific Gas & Electric Co	N Fk Kings R	Fresno	2735	1984	1,212,000	64,000		1744
Tenmile Cr	Evans, L D	Tenmile Cr	Fresno	6017				4,950	1,345
Hume Lake	Evans, D	Tenmile Cr	Fresno	3208				3,500	1,450
Tulare Region		**Kawea River**							
Terminus*	Tulare Hydro Assoc	Kawea R	Tulare	3947	1990	17,000			174
Kawea 2*	Southern Ca Edison Co	M Fk Kawea R	Tulare	298	1929	1,800	13,000		367
Kawea 1*	Southern Ca Edison Co	E Fk Kawea R	Tulare	298	1929	2,250	16,000		1,326
Deer Cr	Bates, D M	E Fk Kawea R	Tulare	7981					
Kawea 3*	Southern Ca Edison Co	Kawea R	Tulare	298	1913	2,800	25,000		775
Tulare Region		**Tule River**							
Success*	Lower Tule River I D	Tule R	Tulare	3038	1989	1,400	4,870		90
Old Oak Ranch*	Portwood, O & R	N Fk Tule R	Tulare	6136	1983	374	1,061		100
Tule R*	Pacific Gas & Electric Co	N Fk M Fk Tule R	Tulare	1333	1914	6,400	26,500		1,544
Sequoia Ranch*	Sequoia L & P Co	M Fk Tule R	Tulare	8679	1994	1,090			169
Lower Tule*	Southern Ca Edison Co	M Fk Tule R	Tulare	372	1909	2,000	16,200		1,140
Tule R Indian*	Tule R Indian Res.	S Fk Tule R	Tulare	5067	1984	124	1,000		487

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

16 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed: FERC Project No.	Developed: Year Installed	Developed: Installed Capacity KW	Developed: Average Annual Generation 1,000 KWH	Undeveloped: Proposed Capacity KW	Gross Stat Head (FT)
Tulare Region		**Kern River**							
Rio Bravo*	Olcese Water Dist	Kern R	Kern	4129	1989	16,000			105
Kern Canyon*	Pacific Gas & Electric Co	Kern R	Kern	178	1921	11,500	47,200		264
Kern River*	Southern Ca Edison Co	Kern R	Kern	1930	1907	24,800	214,240		877
Isabella*	Isabella Partners	Kern R	Kern	8377	1990	11,950			132
Borel*	Southern Ca Edison Co	Borel Cnl	Kern	382	1932	9,200	59,900		261
Kern River 3*	Southern Ca Edison Co	N Fk Kern R	Kern	2290	1921	32,000	197,500		821
North Lahontan Region		**Alpine Group PSA**							
Sonora Peak	Silver Star Hydro Ltd	Silver Cr, W Walker R	Mono	9156					
Dynamo Pond*	Henwood Associates Inc	Green Cr, E Walker R	Mono	8142				700	
Farad*	Sierra Pacific Power Co	Truckee R	Nevada		1933	2,800	13,300		82
Stampede*	Bureau of Reclamation	L Truckee R	Sierra		1987	3,650	12,000		183
South Lahontan Region									
Piute Creek*	Hi-Head Hydro Inc	Piute Cr	Inyo	3580	1982	371	2,800		
Millner Creek No 1*	Henwood Associates Inc	Millner Cr	Inyo	4009	1983	400	2,600		1,100
Cinnamon Ranch	Moss, Richard	Ditch Middle Cr	Inyo	6885		175	815		625
Cottonwood 1*	Los Angeles W & P	Cottonwood Cr, Owens	Inyo		1989	800			
Cottonwood 2*	Los Angeles W & P	Cottonwood Cr, Owens	Inyo		1909	800			
Cottonwood 3	Los Angeles Dept EW& P	Cottonwood Cr	Inyo		1909	1,500	6,000		1,267
Tungstar	Keating, J M	Morgan Cr, Pine Cr	Inyo	7267				990	470
Pine Creek 2	Umetco Mini Co	Morgan Cr, Pine Cr	Inyo	8418				170	110
Pine Creek 1	Umetco Mini Co	Morgan Cr, Pine Cr	Inyo	8418				80	111
Deep Springs	Deep Springs College	Irrig Pl Wyman	Inyo	8319				90	380
Independence Cr.	Inyo Co WD	Independence Cr	Inyo	6158					
Division Creek*	Los Angeles Dept W & P	Division Cr, Owen	Inyo		1909	600	3,000		1,250
Big Pine 3	Los Angeles, City of	Big Pine Cr, Owen	Inyo		1925	3,200	14,000		1,243
Tinnemaha/Red Mtn.	Sierra Hydro Inc	Tinnimaha Cr	Inyo	6188					
Rancho Riata*	Symons, John L	Bishop Cr, Owens	Inyo	4669				400	190
Bishop Creek 6*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1913	1,600	12,000		260
Bishop Creek 5*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1991	3,500	18,000		420
Bishop Creek 4*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1909	7,250	59,900		1,112
Bishop Creek 3*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1913	7,150	34,000		809
Bishop Creek 2*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1911	7,320	39,000		953
Bishop Creek 1*	So Ca Edison Co	Bishop Cr, Owens	Inyo	1394	1908	5,000			

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DEVELOPED AND PLANNED DEVELOPMENT OF HYDROELECTRIC RESOURCES (Continued)

17 Hydrologic Region Plant or Site	Owner	River Basin or PSA and Stream	County	Developed				Undeveloped	
				FERC Project No.	Year Installed	Installed Capacity KW	Average Annual Generation 1,000 KWH	Proposed Capacity KW	Gross Stat Head (FT)
South Lahontan Region (Continued)									
Pleasant Valley*	Los Angeles Dept W & P	Owens R	Inyo		1958	3,200	11,000		76
Pine Creek	Keating Assoc	Pine Cr	Inyo	3258				4,150	995
Control Gorge*	Los Angeles Dept W & P	Owens R	Inyo		1952	37,500	133,000		780
Desert Power*	Desert Power Co	Cottonwood Cyn	Inyo		1983	950			
Cottonwood Canyon	Cruz, Edward S et al	Lone Tree Cr	Inyo	3525		840	3,870		1,410
Haiwee	Los Angeles W & P	LA Aqueduct	Inyo		1927	5,600	35,000		193
Power Recovery	Tehachapi-Cummings WD	TCC WD Pl	Kern	7330	1989	46	150		50
Palmdale*	Palmdale Water Dist	Lake Palmdale	Los Angeles	8734	1987	100	745		120
Alamo (Cottonwood)*	Ca Dept Water Resources	E Br Ca Aque	Los Angeles	2426		17,000	115,000		140
Middle Gorge*	Los Angeles Dept W & P	Owens R	Mono		1952	37,500	133,000		795
Upper Gorge*	Los Angeles Dept W & P	Owens R	Mono		1953	37,500	133,000		872
Rush Creek*	June Lake P U D	Rush Cr	Mono	1389	1916	8,400	49,000		1,807
Poole*	So Ca Edison Co	Lee Vining Cr	Mono	1388	1963	10,000	29,000		1,671
Leggett	Keating, J M	Lee Vining Cr	Mono	3272				2,200	332
Paoha	Keating Assoc	Wilson Cr	Mono	3259				370	98
Lundy*	So Ca Edison Co	Mill Cr	Mono	1390	1912	3,000	9,300		785
Las Flores	Ca Dept of Water Resources	Mojave Siphon	San Bernardino	2426				190	220
Colorado River Region									
Double Weir*	Imperial Irrig Dist	Cent M Cnl New R	Imperial		1961	560	2,000		11
Turnip*	Imperial Irrig Dist	W Side M Cnl New R	Imperial		1964	420	1,200		17
Drop 5*	Imperial Irrig Dist	All Amer Cnl New R	Imperial		1984	4,000	18,500		24
Drop 4*	Imperial Irrig Dist	All Amer Cnl New R	Imperial		1984	19,600	89,400		51
Drop 3*	Imperial Irrig Dist	All Amer Cnl New R	Imperial		1984	9,800	43,000		26
Drop 2*	Imperial Irrig Dist	All Amer Cnl New R	Imperial		1984	10,000	50,000		26
Drop 1*	Imperial Irrig Dist	All Amer Cnl	Imperial		1984	5,850	28,900		14
Pilot Knob*	Imperial Irrig Dist	All Amer Cnl New R	Imperial		1966	33,000	145,000		55
East Highline*	Imperial I D	E Highline Cnl	Imperial		1984	2,415	8,400		
Whitewater*	Desert Water Agency	Whitewater R	Riverside	4292	1986	1,000			
San Gorgonio 2*	So Ca Edison Co	San Gorgonio Cr	Riverside	344	1923	750	800		898
San Gorgonio 1*	So Ca Edison Co	San Gorgonio Cr	Riverside	344	1923	1,500	1,600		1,775
San Gorgonio Lower*	Banning, City of	San Gorgonio Cr	Riverside	9994	1989	500			390
San Gorgonio Middle	Banning, City of	San Gorgonio Cr	Riverside	10085				249	420
Cabzon Lower	Cross Flow Hydro Elec Inc	WS Pl	Riverside	9820				375	560
Cabzon Upper	Cross Flow Hydro Elec Inc	WS Pl	Riverside	9820				550	920
Parker	Bureau of Reclamation	Colorado R	San Bernardino			120,000	659,600		78

** On California Energy Commission Map and List*