The California Water Plan

Outlook in 1974

November 1974

State of California
The Resources Agency

Department of
Water Resources
Bulletin No. 160-74

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Water Resources

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Resources Agency

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Secretary for Resources

State of California

Ronald Reagan
Governor

Department of
Water Resources

John R. Teerink
Director

Satellite "photograph" of California
ERTS "photo" (See page x)

FOREWORD

Water development has done more to enhance the economy and environment of California than any of man's other activities. From a hostile climate has come the livelihood of 20.9 million people and a major portion of the nation's food supply. California today is the result of the planning and management of its water resources by local, state, and federal agencies. California tomorrow will also depend on continued wise resource management but is challenged by increasingly complex issues that will affect the quality of life. Water development is a part of these interrelated issues and must be viewed in a broader context than in the past. An affluent society with its water demands satiated can afford to consider a larger value system.

Momentous events and trends have occurred during the past four years since our last statewide water resource assessment was made. Some of these events and trends have already affected the water picture in definable ways, while the effects of others are yet to mature. Some major examples are the establishment of stringent goals for water quality improvement and waste management, the substantial new demands for cooling water for thermal electric power plants, the reservation of one-fourth of the State's surface water resources in a Wild and Scenic River System, the increasing worldwide demand for agricultural products, widespread litigation seeking delay or curtailment of water development programs, and the escalating costs of energy.

While these and additional events have occurred, other significant trends have continued that also affect the State's water resources. Population has continued to increase, but at a rate less than during the 1960s, reflecting the national trend, and thereby stretching our presently developed water supplies. Irrigated agriculture has continued to increase at about the same rate as during the previous reporting period.

On a statewide basis, the California water outlook is favorable. There are, however, areas facing distress and some uncertainties in the future that will require corrective action. The continued increase of salinity in many of the local ground water basins and in water from the Colorado River will be detrimental to many water users. The continued overdraft, currently over one and one-half million acre-feet per year, in the San Joaquin Valley will have a permanent adverse economic effect on the user and will deplete some portions of the basin. Conveyance facilities are necessary to bring developed water supplies to the areas of need in the valley.

The inland siting of thermal electric power plants will impose a significant water requirement on water deficient areas of the State. To meet this requirement every effort should be made to use our poorer quality water supplies such as agricultural drainage and other waste water to the extent feasible. Where agricultural waste water can be used, the drainage disposal problem could be reduced.

Current litigation, if successful, will have a serious adverse effect on several areas of the State. Alternatives to projects in contention are limited and costly. The full ramifications of these law suits cannot be determined at this time.

Thorough study needs to be given to alternatives that would continue to stretch our water supplies. The reclamation of waste water, including demineralization of brackish water, appears to be the most promising today. While research and development of alternatives continues, it is incumbent on all users to achieve more efficient use of the water supplies now available. Several significant policy issues relating to water resource management need careful and thoughtful public and legislative consideration if we are to most effectively meet our future water needs.

John R. Teerink

John R. Teerink, *Director*
Department of Water Resources
The Resources Agency
State of California

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FRONTISPIECE

This "photograph" of the State was produced from imagery collected by the Earth Resources Technology Satellite (ERTS-1) orbiting at a distance of about 570 miles above the earth. The electronic instruments in the satellite scanned the terrain and recorded light reflected back from the earth in four spectral bands (2 visible, 2 infrared). This data was then telemetered to a data-processing facility and reconstructed into four separate black and white "photographs" each covering the same 100 x 100 mile area. The Department used three of the four "photographs" of each area and a color additive process to create the thirty-four color "photographs" used to make this mosaic of the State of California, which has been reduced from its original 1:1,000,000-scale for presentation in this report. In this format, green vegetation appears red. The advantage of the infrared bands are that they enhance the presence of green, growing vegetation compared to other land features.

The sharpest, most cloud-free images available were selected, therefore, the dates of the individual images vary. This is the principal reason for the color tone differences between neighboring photos in the mosaic.

The resolution obtainable with these images is approximately 200 feet, which is sufficient for reconnaissance level interpretation of certain aspects of vegetation and other land-related conditions considered in water resource planning. The Department of Water Resources is investigating potential uses, which include determining irrigated land use change, extent of double cropping, urban land use change, change in vegetation cover of watersheds, and areal extent of snow cover.

INTRODUCTION

Bulletin No. 160-74 is the third in a series of reports updating the California Water Plan, originally published in 1957 as Department of Water Resources Bulletin No. 3. The California Water Plan is a comprehensive master plan to guide and coordinate the use of California's water resources for all beneficial purposes to meet present and future needs in all parts of the state. The plane is not a specific blueprint for construction but is, rather, a flexible pattern which can provide information and guidance relating to the use of the state's water resources, its future water requirements, and sources of water supply for California.

In this bulletin, the Department of Water Resources has departed from the previous practice of developing a single forecast of future water requirements, and has used for the first time a concept of "alternative futures". Under this concept, four different estimates of future water requirements are developed, each relating to different scenarios as to future conditions and events that affect water use and demands.

Data collected by the Department of Water Resources since publication of Bulletin No. 160-70 four years ago show that water use in California between 1967 and 1972 has increased a moderate 1.4 million acre-feet, or some 4 percent, corresponding generally to a moderate population increase of 1.4 million people, or 7 percent, and an increase in irrigated area of 300,000 acres or 4 percent. Analysis of present and past conditions, together with studies and estimates of future conditions—using the alternative futures approach—indicates the following outlook for water resources management in California.

The Outlook in 1974

General

1. The status of developed and available water supplies compared to present demands for water is still favorable—the situation affords time for consideration of all alternative sources for future water supply, including techniques for more efficient use of water to reduce demands. This outlook is premised on completion of Auburn Dam on the American River, New Melones Dam on the Stanislaus River, and Warm Springs Dam on Dry Creek in the Russian River Basin, and the Peripheral Canal being constructed and in operation by 1980.

2. How far into the future this condition will extend depends on the completion of additional conveyance facilities needed to deliver already regulated supplies to various service areas in the State.

3. The extent to which available supplies will cover future requirements is considerably less certain in 1974 than it appeared to be in 1970 because of highly significant events and trends that have occurred during the last four years—major factors being the establishment of additional water requirements for water quality improvement and salinity control; the movement toward siting of power plants at inland locations rather than on the coast, also leading to a substantial additional water requirement; and the worldwide leap in demand for agricultural products.

4. In addition, no new water projects that would develop additional supplies of any significance have been authorized, either by state, federal, or local agencies in California during the past four years, and virtually every attempt to begin construction of previously authorized projects or units of such projects has met with litigation seeking to delay or stop such construction—a condition which, along with the wild river legislation and the coastal zone initiative, clearly reflects a widespread public interest and concern with protection and preservation of the natural environment.

5. The quality of the State's water supply is generally quite satisfactory, with the significant exception of the Colorado River and some localized ground water problems, and may be expected to be maintained and improved as the result of the basin plans for water quality management currently being developed by the State Water Resources Control Board.

6. While the urban areas of the State should experience no significant or extensive water shortages during the next 20 years, the prospects of providing water for any large expansion of irrigated agriculture in California to meet increased demands for food and fiber worldwide are not considered optimistic under the general conditions prevailing at the present time.

Concerning Growth

1. In 1974 the population of California was 20.9 million people, reflecting a continued slowing in growth rates, and it may range from a low of 23.6 to a high of 27.4 million by 1990, or an increase of 13 to 31 percent. By 2020, the population may range from 26.5 to 43.3 million, or an increase of 27 to 107 percent.

2. Of the total state area of 100 million acres, urban development currently occupies 2.6 million acres and may increase to between 2.9 and 3.3 million by 1990. Urban land use in 2020 may range from 3.2 to 4.4 million acres—still less than 5 percent of the total area of the State.

3. Irrigated agriculture increased at an average rate of 60,000 acres per year from about 8.5 million acres in 1967 to about 8.8 million in 1972. Irrigated area may range between 9.2 and 10.2 million acres by 1990, an increase of 5 to 16 percent. In 2020, irrigated land may ranage from 9.4 million to 11.4 million acres, an increase from 7 to 29 percent. The Department of Water Resources' land classification surveys show 22 million acres of irrigabl land in California.

Concerning Water Demands

1. Urban water use is now about 5 million acre-feet annually, and future demands are expected to range from 6.2 to 7.1 million acre-feet in 1990, an increase of 22 to 41 percent. By 2020, urban use may range from 7.2 to 11.4 million acre-feet. Urban water use today accounts for about 13 percent of total water use in the State.

2. Present agricultural water use is 32 million acre-feet of applied water annually, or about 85 percent of total water use in the State. Demands for agricultural water in 1990 are expected to range from 34 million to 38 million acre-feet, an increase of from 7 to 19 percent. By 2020, agricultural water demands may range from 35 to 42 million acre-feet annually.

3. If two-thirds of the projected increase in thermal electrical generation is located at inland sites, up to 400,000 acre-feet of cooling water will be required by 1990, and as much as 1.1 million acre-feet could be required by 2020.

4. Total annual applied water demands for all purposes in California are projected to increase from the present 37 million acre-feet, and may range from 41 to 46 million acre-feet in 1990, an increase from 10 to 24 percent annually. By 2020, the total applied water demands may range from 43 to 55 million acre-feet annually.

5. Net water demands in California, which reflect the opportunities to reuse return flows, are projected to increase from the 1972 level of 31 million acre-feet annually, and may range from 34 to 38 million acre-feet by 1990, an increase of 11 to 23 percent. By 2020, total net water demands may range from 36 to 46 million acre-feet annually.

6. With full use of presently foreseen supplies, the supplemental water requirements are expected to range from 1.6 million to 3.8 million acre-feet annually by 1990, and from 2.6 to 9.6 million acre-feet annually by 2020.

Concerning Present Water Supplies

1. California's present water needs are being met by existing state, federal, and local projects, and in some areas, especially the San Joaquin Valley, by overdrafting ground water supplies. More water is available from the existing projects than is being used now, and this reserve can be used to satisfy increasing demands for a number of years, providing necessary conveyance facilities are constructed in a timely manner. One such facility is the Peripheral Canal which will provide conveyance of water for several regions. Other facilities are mentioned in the regional outlooks later in this section.

2. Supplemental water requirements currently average 2.4 million acre-feet per year and are being met primarily through ground water overdraft. The major overdrafted areas are in the San Joaquin Valley, the Central Coast, and Southern California.

3. Total overdraft of ground water basins has decreased in the past four years by about 500,000 acre-feet per year, due to new water brought into the western San Joaquin Valley by the State Water Project and the San Luis Division of the Central Valley Project, thus replacing to some extent previous ground water use. Remaining overdrafts, of which the largest is 1.4 million acre-feet on the east side of the San Joaquin Valley, are not considered permanent sources of water supply. The Cross Valley Canal, under construction by the Kern County Water Agency, will alleviate some of the overdraft in the San Joaquin Valley. Further, a possible mid-valley canal, being studied by the Department of Water Resources and the Bureau of Reclamation, could provide additional alleviation of part of the remaining San Joaquin Valley overdraft.

4. Intentionally reclaimed waste water furnished about 180,000 acre-feet of usable water supply in 1972, most of which was for agricultural irrigation. An additional 530,000 acre-feet of waste water was indirectly reclaimed, returned to the surface and ground water supply and reused.

5. In 1974, virtually no water supply from desalting plants was being used in California, and none at all was furnished from geothermal sources.

Concerning New Water Supplies

1. The location, character of streamflow, and present stage of development of California's surface water resources are such that the only areas in the State where there is any substantial physical potential for development of additional water supplies are in the north coastal area and the Sacramento River Basin. More than 25 percent (18 million acre-feet) of the total stream runoff in California is set aside and not available for water supply development under existing law for wild and scenic rivers in the north coastal area (although the law does require the Department of Water Resources to report in 1985 on the need for water supply and flood control projects on the Eel River and its tributaries). There is a potential for additional development of water in the Sacramento Basin, although such development will be costly because the more economical sites have already been developed.

2. Conjunctive use of ground water basins and surface supplies can achieve more effective use of existing surface water supplies and would help conserve water that would otherwise spill from surface reservoirs during periods of high water. Additional study and exploration of the State's ground water basins are needed to adequately assess the potential for conserving additional surface water resources through conjunctive operation.

3. The California Aqueduct will have access capacity for several years that could be used to convey surplus water from Northern California for recharge of overdrawn ground water basins in Southern California.

4. Reclamation of waste water, including highly saline agricultural waste water, may provide an important source of industrial water, particularly for cooling in power plants. Reservations regarding the safety of reclaimed water from a health standpoint greatly limit its use for human consumption and restrict projecting future use for municipal water supply purposes. To adequately evaluate the role of waste water reclamation in meeting the supplemental demands, the Department of Water Resources is participating in projects of applied research.

5. Desalting of sea water on a large scale does not currently appear practical due to high costs and extremely large energy requirements. Desalting may be used for a variety of smaller applications, however, over the next 10 to 30 years, particularly to treat brackish waste water for use as cooling water in power plants. In coastal communities requiring supplemental water supplies, there may be limited possibilities for desalting sea water by distillation. Inland communities with brackish ground water supplies may find the membrane processes (reverse osmosis and electrodialysis) practical.

6. Geothermal resources in the Imperial Valley could provide California with additional energy, and possibly water supplies. These could help meet local municipal and industrial water demands or might be blended with Colorado River water to reduce the salinity of water supplies from the river. To this date however, it has not been demonstrated that development of geothermal water supplies is feasible, either from an economic or environmental point of view.

7. There are several operational weather modification programs in California and in other states. It has not been possible to determine the extent to which a consistent increase in precipitation and streamflow can be attained. Several studies and pilot projects are underway but their success is problematical. Consequently, it is not prudent at this time to rely on weather modification as a feasible source of future water supply. In addition, there are as yet unresolved problems of environmental effects and legal questions.

Concerning Regional Water Supply and Demand

1. *North Coastal.* Overall water supplies are abundant, amounting to nearly 40 percent of the total water resources of the State. However, there are scattered local shortages during the dry season when streams are low. In the interior (upper Klamath River Basin including the Shasta and Scott Rivers) present supplies are nearly completely used and significant expansion would require additional water development.

Only minor increases from present water demands are projected for the region in 1990, most of which is expected to be met from increased ground water pumping and remaining surface supplies. The minor increase in supplemental demand is mostly due to increases in wildlife requirements.

2. *San Francisco Bay.* This region presently has enough water to take care of its requirements, except for a few scattered areas in the North Bay and Russian River basins. Overall water supplies appear adequate for 1990, but the distribution of supplies does not correspond with the pattern of projected demand. Therefore, a supplemental demand of from 30,000 to 80,000 acre-feet per year is indicated, primarily in Santa Clara, Marin, and Napa Counties. The near future supply assumes completion of Warm Springs Dam and Reservoir. If that water supply of 115,000 acre-feet is not available, major shortages in Sonoma County also would be expected by 1990. Completion of the North Bay Aqueduct of the State Water Project will provide capacity for an additional 12,500 acre-feet annually for Napa County.

3. *Central Coastal.* Water demands in this region presently exceed dependable supplies by about 140,000 acre-feet, per year, with the difference showing up as ground water overdraft. This has resulted in salinity intrusion in certain coastal aquifers. The quality of ground water is poor in the area around the City of Santa Barbara and some locations along the Santa Maria River. New supplies to Santa Barbara and San Luis Obispo Counties from the Coastal Aqueduct of the State Water Project will help meet demands, but projected increases in 1990 water demands would leave a shortage between 200,000 to 280,000 acre-feet per year. The bulk of the shortage would be in the northern portion of the region, including the Salinas Valley and the service area of the authorized San Felipe Division of the Central Valley Project.

4. *South Coastal.* Water demands in 1972 had begun to outstrip the supplies available from sources other than the State Water Project. New supplies from the State Water Project should be more than adequate to meet 1990 water demands, even with the projected reduction of about 780,000 acre-feet per year in Colorado River supplies including some reallocations for power plant cooling in the desert areas. The increase in State Water Project supply and its

substitution in part for Colorado River water should markedly lower the dissolved salts content of Southern California water supplies. Indicated annual 1990 demands range from 650,000 to 1,030,000 acre-feet less than 1990 total water supplies assuming the full contractual commitments of the State Water Project are available to the region.

5. *Sacramento Basin.* Although overall supplies in this region appear adequate, not all locations have sufficient dependable water supplies at present. The indicated current annual deficit is estimated to be 240,000 acre-feet and could increase to as much as 500,000 acre-feet by 1990 for the highest demand projection, or could be slightly less than current levels for the lowest demand projection. Most of the projected supplemental demand in 1990 is expected to occur on the west side of the Sacramento Valley and in several upland basins.

Significant additions to present water facilities include completion of the Tehama-Colusa Canal in the Sacramento Valley and Indian Valley Reservoir on Cache Creek, both currently under construction.

6. *Delta-Central Sierra.* Estimated 1972 supplemental demand was about 120,000 acre-feet per year, mostly in the Folsom South Canal service area in Sacramento and San Joaquin Counties. Completion of the Folsom-South Canal and possibly a Hood-Clay intertie from the Sacramento River will meet this demand. Other supplemental demands ranging from 80,000 to 220,000 acre-feet would remain. Completion of the North Bay Aqueduct of the State Water Project will enable 43,000 acre-feet annually to be supplied Solano County from the Delta.

7. *San Joaquin Basin.* The estimated present ground water overdraft in this region is about 250,000 acre-feet per year, mainly in Madera, southeastern Merced, and eastern Stanislaus Counties. The assumed additional Central Valley Project supply of New Melones Reservoir, plus some additional use of other sources, is not expected to completely end the overdraft. Supplemental demands ranging from 130,000 to 670,000 acre-feet are projected for 1990.

8. *Tulare Basin.* Estimated 1972 ground water overdraft was slightly over 1,300,000 acre-feet per year, significantly less than the 1,800,000 acre-feet amount in 1967. The improvement is due to new water supplies from the Central Valley Project and the State Water Project to service areas on the west side of the basin, with some 1,500,000 acre-feet provided in 1972. By 1990 projected deliveries would be increased by about another 1,300,000 acre-feet per year, but increases in demand and continued overdraft in areas not served by state and federal facilities would still leave supplemental demands or continuing ground water overdrafts ranging from 920,000 to 1,920,000 acre-feet per year. A possible mid-valley canal could convey surplus water to the east side of the basin to partially alleviate overdrafted ground water conditions.

9. *North Lahontan.* Water demands by 1990 could range from a slight decrease to a minor increase over the present net demands of 430,000 acre-feet per year. Some of the current deficiency in firm water supply, about 40,000 acre-feet, is expected to be met by continuing ground water development. There is a projected 1990 supplemental irrigation demand of about 20,000 acre-feet per year. The high cost of water development, however, will make it difficult to meet this requirement.

10. *South Lahontan.* Estimated present annual ground water overdraft amounts to about 120,000 acre-feet. Projected State Water Project entitlement supplies, if delivered in 1990, could completely eliminate the current overdraft and could add from 70,000 to 100,000 acre-feet per year to underground storage in the Antelope Valley-Mojave River areas.

11. *Colorado Desert.* Only modest increases of 130,000 to 150,000 acre-feet per year in agricultural and urban applied water demands are projected for this region in 1990. The estimated 1972 annual ground water overdraft of almost 40,000 acre-feet could be mostly eliminated by use of State Water Project supplies. The only significant new type of demand would be that for power plant cooling which could range from 40,000 to 130,000 acre-feet per year in 1990, part of which is expected to be served from the Colorado River entitlement of the Metropolitan Water District of Southern California.

Concerning Alternative Futures

1. None of the four alternative futures presented in this bulletin was designed to represent a most probable future. If such a projection were to be developed, it would most likely result in a statewide water demand somewhere within the range of alternative futures II and III.

2. Selection of a future(s) as a basis for making a decision should reflect the degree of flexibility to change a decision. In other words, as long as it is not necessary to make a final decision, alternative futures should be examined and, when it becomes necessary to adopt a course of action, a single future must be selected.

3. In evaluating actions to meet the short range 1990 needs, the Department of Water Resources concludes that alternative future II is a reasonable basis since it would be unwise to risk water shortages due to unplanned rates of growth. In evaluating actions to meet 2020 needs the Department concludes that alternative future III provides flexibility yet is a reasonable basis as use of this alternative future minimizes the likelihood of oversizing facilities and overcommitment of resources.

California's Water Resources

California's natural water supplies are derived from an average annual precipitation of 200 million acre-feet—the equivalent of more than 65 trillion gallons. About 65 percent of this precipitation is consumed through evaporation and transpiration by trees, plants, and other vegetation (Figure 1). The remaining 35 percent comprises the State's average annual runoff of 71 million acre-feet.

Water information compiled by the Department of Water Resources and presented in this report is shown by 11 hydrologic study areas covering California, Figure 2. Average runoff in the hydrologic areas is shown in Figure 3. The wide disparity in runoff, both from year to year and between major drainage areas, creates the need for the storage and conveyance of surface water and the extensive use of ground water. As shown in Figure 3, the greatest amounts of runoff are available in areas with the fewest people, i.e., the North Coastal area and the Sacramento Basin. As California has grown, its surface water systems have been expanded to large-scale transfer systems, involving the storage and transportation of water almost the entire length of the State.

A continuing major water problem today is the maintenance of a proper balance between the use of the State's water resources and protection and enhancement of the natural environment. Prior to the 1960s, environmental benefits for the preservation of cultural resources and aesthetic areas, including open and green space, wild rivers, and wilderness regions, were not usually included in water project planning. Many such benefits were difficult to identify and are still difficult to measure because they cannot be assigned a value, and the technique of cost and benefit analysis to determine relative value of a proposed project is no longer adequate. Accordingly, to reflect today's widespread concern for the natural environment, water resources planning has been broadened to include consideration of aesthetic and ecological effects.

State Responsibility for Water Development

California's responsibility for the development and wise use of her water resources is set forth in various sections of the California Water Code. The Department of Water Resources and the State Water Resources Control Board each are assigned specific duties in the Code. The Board regulates activities that affect quality and rights to use of the waters of the State. Water Code Section 10005, in addition to establishing the California Water Plan, assigns the Department of Water Resources the responsibility for updating and

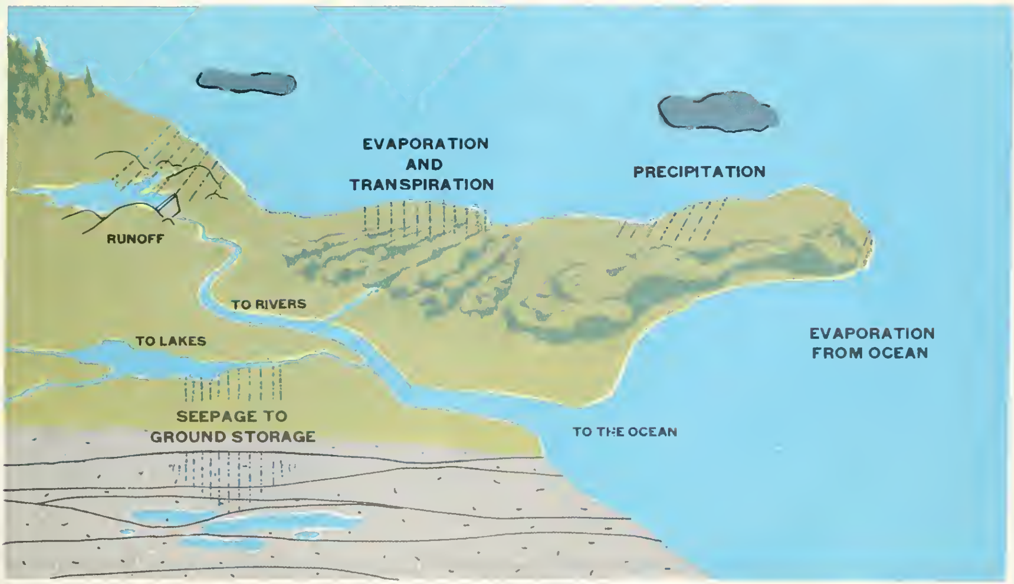


Figure 1. Hydrologic Cycle

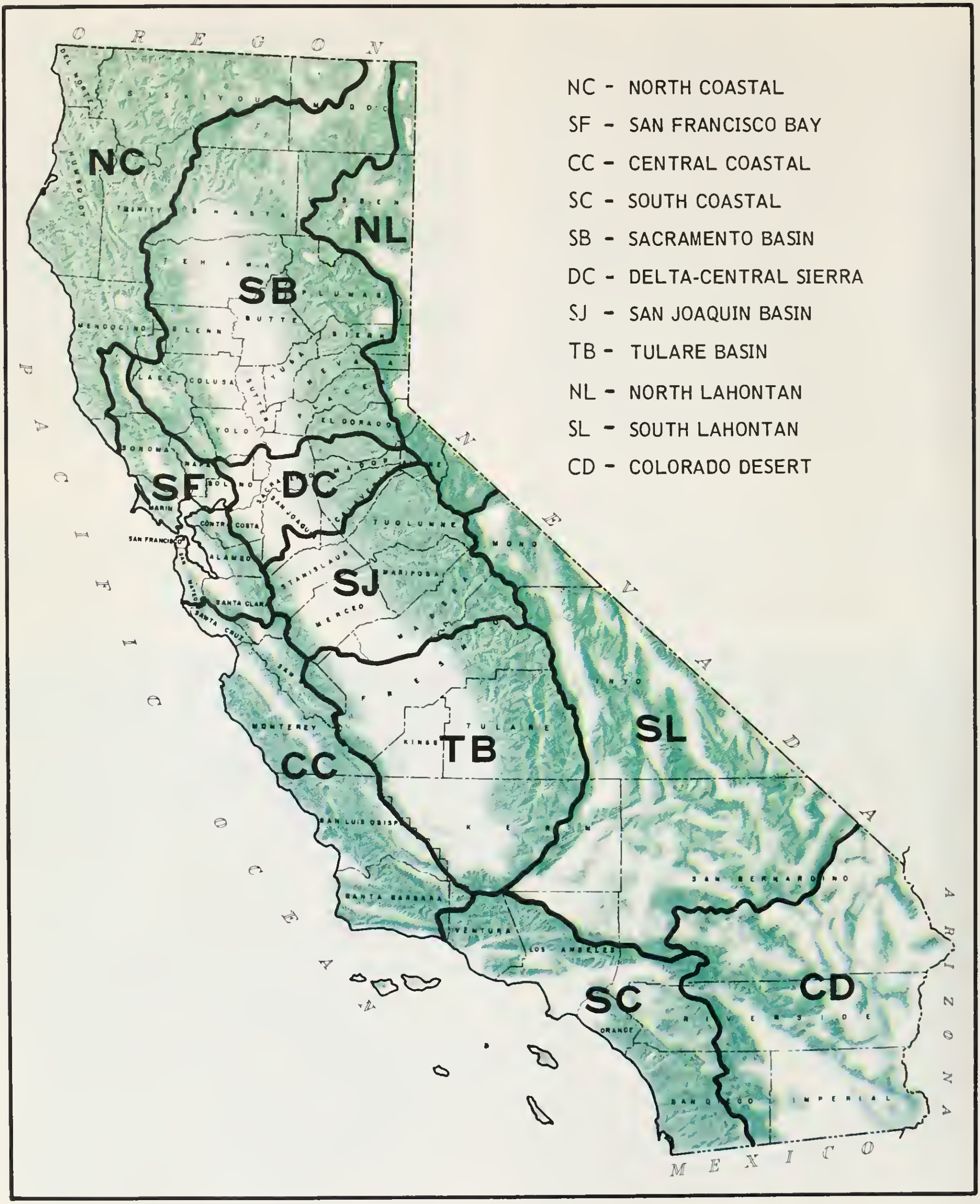


Figure 2. Hydrologic Study Areas of California

supplementing the Plan. The Department carries out this responsibility through a statewide planning program, which guides the selection of the most favorable pattern for use of the State's water resources, considering all reasonable alternative courses of action. Such alternatives are evaluated on the basis of technical feasibility and economic, social, and institutional factors. The program comprises:

- Periodic reassessment of existing and future demands for water for all uses in each of the hydrologic study areas of California.

- Periodic reassessment of local water resources, water uses, and the magnitude and timing of the need for additional water supplies that cannot be provided locally.

- Appraisal of various alternative sources of water —ground water, surface water, reclaimed waste water, desalting, goethermal resources, etc.—to meet future demands in areas of water deficiency.

- Determination of the need for protection and preservation of water resources in keeping with protection and enhancement of the environment.

- Evaluation of water development plans.

Figure 3. Average Annual Runoff in Million Acre-feet

Organization of Bulletin 160-74

Bulletin No. 160-74 and its summary report have the same format, which consists of six chapters. Chapter 1 discusses historic and recent events in water resources planning and development in California, including recent environmental planning, measures to enhance water quality, and the recent interest and close involvement of the public in environmental enhancement. Chapter 1 also touches on a recent National Water Commission report, which indicates possible forthcoming changes in U. S. water policies. Finally, the chapter reports on California's cooperative activities with federal water agencies and other western states, and briefly describes recent trends in land use planning and controls.

Chapter 2 presents a discussion of important water-policy issues for consideration by legislators, administrators and the public. Chapter 3 presents alternative future projections—of population, agriculture, and electrical energy. In addition, Chapter 3 discusses the trends and influences that affect other water-related needs, such as (a) recreation, fish, and wildlife, (b) environmental quality, (c) water quality, and (d) flood control.

In Chapter 4, the alternative future projections presented in Chapter 3 are discussed in terms of future water demands.

Chapter 5 discusses potential supplemental sources of water supply and water quality planning. Chapter 6 relates the alternative future projections of water demand presented in Chapter 4 to existing developed supplies and gives estimates of future supplemental water demands.

CHAPTER I

HISTORIC AND RECENT EVENTS

Water resources development in California during the last century has progressed through the efforts of numerous private individuals and companies and public agencies at the local, state, and federal levels. Although many of the resulting water projects and programs have been large in compass and purpose, initial efforts were primarily directed toward solution of localized water requirement problems. The aggregate expenditure by local agencies exceeds the state and federal costs.

The first irrigation supplies were diverted from nearby streams, without storage, and agricultural lands irrigated were limited to those that could be watered from available low summer flows. However, the need for storage reservoirs to capture the winter runoff and hold it until the summer irrigation season was soon recognized and construction on several important dams was started in the 1880s. Later, the large metropolitan areas of the State, under pressure of increasing requirements and diminishing resources of local water, found it necessary to develop remote sources of water supply and construct extensive conveyance systems across mountains and deserts to satisfy their needs.

The need to plan for the development of the State's water resources on a broad scale was recognized over a century ago, and the first broad investigation of the irrigation problems of California was made by a board of commissioners appointed by the President. The commission's report, published in 1874, outlined a hypothetical irrigation system for the San Joaquin and Sacramento Valleys. Other investigations by federal and state agencies followed during the next several decades. Reports on these investigations contain meteorological and streamflow data, with notes on irrigation, drainage, and flood control, all of which proved of great value in planning for water development in the years that followed.

Comprehensive investigations of the water resources of California were first made by the State Engineer in the 1920s. Initial reports of these investigations were presented in a series of bulletins by the State Division of Engineering and Irrigation and later by the State Division of Water Resources. A report giving results of investigations, and outlining revised proposals, was published in 1930 as Division of Water Resources Bulletin No. 25, entitled, "Report to Legislature of 1931 on State Water Plan." It outlined a coordinated plan for conservation, development, and utilization of the water resources of California. In 1941 the plan was adopted by the Legislature and designated the "State Water Plan". In a series of bulletins following Bulletin No. 25, the Division of Water Resources outlined in greater detail plans for coordinated development of the water resources of the Central Valley which formed the basis for the Central Valley Project.

California Water Plan

In 1947, the Statewide Water Resources Investigation was initiated by the Division of Water Resources for the State Water Resources Board in response to legislation enacted in 1945 and 1947. This investigation entailed a three-fold program of study to evaluate the water resources of California, to determine present and probable ultimate water requirements, and to formulate plans for the orderly development of the State's water resources to meet its ultimate water requirements.

The first phase of the statewide investigation comprised an inventory of data on sources, quantities, and characteristics of water in California. The results are available in a bulletin "Water Resources of California"*, published in 1951. This bulletin comprises a concise compilation of data on precipitation, runoff of streams, floodflows and frequencies, and quality of water throughout the State. The Bulletin showed the average annual supply from the State's streams to be about 71 million acre-feet. In addition California uses water from the Colorado River.

The second phase dealt with present and ultimate requirements for water. The associated bulletin, "Water Utilization and Requirements of California"†, was published in 1955. This report comprises determinations of the 1950 level of water use throughout the State for all consumptive purposes, and forecasts of ultimate water requirements based, in general, on the capabilities of the land to support further balanced development.

The final phase of the Statewide Water Resources Investigation was presnted in 1957 as "The California Water Plan".‡ The report describes a comprehensive master plan to guide and coordinate the planning and construction of works required for the control, protection, conservation, and distribution of the water of California, to meet present and future needs for all beneficial uses and purposes in all areas of the State. The Plan is designed to include or supplement, rather than to supersede, existing water resource development works, and does not interfere with existing rights to the use of water.

* Bulletin No. 1, "Water Resources of California," State Water Resources Board, 1951.

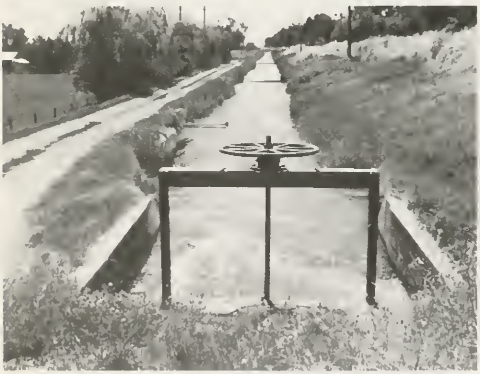
† Bulletin No. 2, "Water Utilization and Requirements of California," State Water Resources Board, 1955.

‡ Bulletin No. 3, "The California Water Plan," Department of Water Resources, 1957.

The urgency of California's water problems was illustrated at the time by citing the rapid growth of the State. In 1940, just before the beginning of World War II, California had a population of about 6,900,000. By 1950 the population had increased to about 10,600,000, and by 1955 it had increasd to more than 13,000,000. Industrial expansion during the war years was needed to supply the United States and her allies with vast amounts of food, arms and other material. After the war, industry continued to expand in order to provide Americans and others with goods and services they had foregone. Concurrently, the demand for water increased significantly.

Another result of this growth was the need for larger quantities of agricultural products, and California had the land and climate to fulfill this demand. The State also needed water to irrigate the additional acreage, and this represented a dramatic increase in water requirements. The total requirement for water in California for all consumptive purposes in 1950 was about 21 million acre-feet, and it was forecast in Bulletin No. 2 that this would ultimately increase to over 51 million acre-feet.

The California Water Plan includes many facts and forecasts. It presents an evaluation of the water supply available to the State, and an estimate of water requirements, both present and future, for all purposes that could then be foreseen. The plan identifies watersheds where studies indicated that surplus water existed and others where a deficiency in supply was projected. It identifies existing and prospective water problems and it contains suggestions as to the manner in which the waters of the State should be distributed for the benefit and use of all areas. The plan proposes objectives toward which future development of water resources should be directed and defines objectives in terms of potential physical accomplishments which could be used to measure the merits of projects proposed by any agency. It also took cognizance of other



Natomas Ditch in Sacramento County

possibilities for augmenting the State's water supplies. It discussed and evaluated the potentialities of sea water conversion, waste water reclamation, artificial increase of precipitation and waste water management. Finally, it demonstrated that the water available to the State is adequate for full development of the land resources of the State.

The very magnitude of the task involved in the formulation of the California Water Plan was such that detailed surveys and economic and financial analysis could not be undertaken. The plan was regarded as a broad and flexible pattern into which future definite projects could be integrated in an orderly fashion when needed. It was also anticipated that the plan would be altered and improved as more detailed studies were undertaken in the light of future events.

The completion of the California Water Plan and the publication of Bulletin No. 3 completed the Statewide Water Resources Investigation; it by no means signified the termination of planning activities by the Department of Water Resources. It marked only the beginning of an intensive and continuing program of study of the needs for specific, local, and statewide water programs, analysis of their economic justification and financial feasibility, and determination of the recommended priority of their implementation. It was envisioned that the study program would enable the planning endeavor to keep pace with the needs of a rapidly growing state.

The State, in 1951, selected the California State Water Project, first known as the Feather River Project, as a feature of the California Water Plan to be constructed by the State.

Transition to the Present

In the decade following publication of the California Water Plan, rapid population growth in California continued, and with it the demand for development of additional water supplies for all purposes. The Department of Water Resources published a report, "Implementation of the California Water Plan",* in 1966. It assessed the changes which had occurred during the 10-year period since the formulation of the California Water Plan.

During this period all areas of economic activity, including employment, personal income, construction, retail sales, corporate profits, and farm receipts advanced to higher levels.

The growth in population of nearly 5,750,000 people during that decade represented an increase of almost 45 percent over the 1955 population of 13,000,000. California, with 18,750,000 people in 1965, was becoming the most populous state in the nation. Continued growth at this rate would increase future pop-

* Bulletin No. 160-66, "Implementation of the California Water Plan," Department of Water Resources, 1966.

ulations to more than 35,000,000 by 1990 and 54,-000,000 in 2020.

The second report in the Bulletin 160 series,* was released 4 years later. In the period between 1966 and 1970 California experienced a dynamic era, not only in water project implementation, but also in the consideration of water resource development within the framework of the overall environment.

The rapid rate of growth of California's population that had occurred during the 1940s and 1950s decreased sharply in the mid-1960s as a result of both reduction in births and immigration. By 1970, the trend indicated that California's population would probably increase to about 29,000,000 in 1990 and 45,000,000 in 2020, instead of 35,000,000 and 54,000,-000 respectively, as projected in 1966.

Bulletin 160-70 reported that applied and net water requirements for 1967 were 36,000,000 and 28,000,000 acre-feet respectively. Applied water requirements are quantities needed annually at all farm headgates and urban distribution system intakes. Net water requirements reflect the allowance for probable reuse of water within each area. The bulletin also reported that projected applied water demands for California in 1990 and 2020 were expected to be 42,000,000 and 48,000,000 acre-feet respectively. The projected net water demands for 1990 and 2020 were given as 35,-000,000 and 40,000,000 acre-feet, respectively.

A significant conclusion in Bulletin 160-70, resulting from the projections of a reduced rate of population growth, was that projected future water demands in California would also grow at a slower rate. As a result it was postulated that more time would be available to develop new water supplies than had been thought in 1966, and that additional conservation facilities of the State Water Project would not be needed until possibly the mid-1990s. It was pointed out, however, that additional conveyance facilities to deliver conserved water to areas of need were required.

The temporary adequacy of developed water supplies was received with loud applause by some and with reserved dismay by others. The record of the public hearings on Bulletin 160-70 held during 1971 shows that many Californians were pleased to hear that population growth was slowing down significantly and that this would reduce the demands on water resources. Others, however, saw this as possibly a hasty conclusion and sought to remind the Department of Water Resources that California still had numerous water problems for which solutions were required.

A number of significant events have occurred in the last four years, some of which have tended to place an increased burden on the State's water resources and some of which have directed more attention to those factors affecting the future use of water resources. At the federal level, the National Water Commission has published probably the most comprehensive report ever seen on water management; a National Environmental Policy Act has been adopted; Congress has given considerable attention to a National Land Use Policy; and principles and standards have been established by the Water Resources Council and adopted by the President that add environmental quality as an objective for planning.

At the state level California has adopted a Wild and Scenic Rivers Act which dedicates about one-fourth of the State's surface water flow to scenic and recreational use; an Environmental Quality Act similar to the federal legislation has been adopted; and several major administrative decisions concerning water rights have focused attention on natural environmental and esthetic uses of water.

National Water Commission Report

The National Water Commission's report, "Water Policies for the Future", published in June 1973, is probably the most comprehensive analysis of federal water policies and practices ever seen. It is also the most far-reaching in its recommendations.

The Commission, composed of seven members appointed by the President, was established for a 5-year term by an act of Congress in September 1968. Duties of the Commission were stated in the act to be:

> "The Commission shall (1) review present and anticipated national water resource problems, making such projections of water requirements as may be necessary and identifying alternative ways of meeting these requirements—giving consideration, among other things, to conservation and more efficient use of existing supplies, increased usability by reduction of pollution, innovations to encourage the highest economic use of water, interbasin transfers, and technological advances including, but not limited to, desalting, weather modification, and waste water purification and reuse; (2) consider economic and social consequences of water resource development, including, for example, the impact of water resource development on regional economic growth, on institutional arrangements, and on esthetic values affecting the quality of life of the American people; and (3) advise on such specific water resource matters as may be referred to it by the President and the Water Resources Council."

Commissioners served on a part-time basis and were forbidden to hold any other position as officers or employees of the United States. Five million dollars was authorized for the five years of work. The Commission's final report consists of approximately 600 pages and its 17 chapters cover all the items in the foregoing statement of duties.

* Bulletin No. 160-70, "Water for California, the California Water Plan, Outlook in 1970," Department of Water Resources, 1970.

The Commission in its summary stated that a relatively small number of themes emerge in the report.

> "First, the report emphasizes that the level of future demands for water is not inevitable but derives in large part from policy decisions within the control of society."
>
> "A second recurring theme of the Commission's report is that it sees a shift in national priorities from development of water resources to restoration and enhancement of water quality."
>
> "Third, the Commission believes that water resource planning must be tied more closely to land use planning."
>
> "Fourth, the Commission recommends policies which will lead to the conservation of water—policies which will motivate better use of water and reduce water losses by improved efficiency."
>
> "Fifth, the Commission believes that sound economic principles should be applied to decisions on whether to build water projects."
>
> "Sixth, the Commission believes that laws and legal institutions should be reexamined in the light of contemporary water problems."
>
> "Seventh, the Commission believes that development, management, and protection of water resources should be controlled by that level of government nearest the problem and most capable of effectively representing the vital interests involved."

The report devotes considerable attention to planning for water resources development and control. In general, it advocates an increased level of planning at local or regional levels supported by federal funding.

In its consideration of agricultural matters, the report relied heavily on a number of alternative future models of agricultural development prepared for the Commission by professors at Iowa State University. The alternatives involved different assumptions for farm policy, population, water price, exports and technology. In addition, the report discussed the projection of past trends in agriculture including the OBERS * projections.

Concluding their discussion of this topic, the Commission's report states on page 141:

> ". . . there appears to be adequate productive capacity in the Nation's agriculture to meet food and fiber demand under various alternative futures at least until the year 2000. In such case there would be no need in the next 30 years to continue federally subsidized water resource development programs to increase the agricultural land base of the country, but where the Federal Government has executed contracts to complete water projects already begun, such projects should of course be completed.
>
> "Even if none of the alternative futures assumed in the Iowa State University studies adequately project the actual supply and demand for food and fiber for the year 2000, there is still no justification for subsidizing reclamation projects. If, for example, export demand for food and fiber greatly exceeds the amount contemplated in any of the alternative futures considered, that demand should nevertheless be satisfied in the most efficient way."

In leading to this conclusion, the Commission did note that the OBERS projections used by federal agencies contemplated a much larger need for irrigated agriculture than the Iowa State model but it expressed the belief that the Iowa State assumptions were reasonable.

The State of California in its comments on the report noted the Iowa State models were "what if" models but had been used to set the tone of the report. This was believed unrealistic and to have led to some erroneous conclusions. The State in its comments also termed unrealistic:

a) Use of a constant level of foreign export in all but one model

b) Assumption of greatly increased water prices

c) Assumed shifts of agricultural production from irrigated to nonirrigated lands.

The effect of the Commission's recommendations would probably be to reduce the number and scope of future irrigation projects, except those in areas where long-growing seasons provide sufficient repayment capacity to pay the full costs of extensive water projects.

The report dealt in detail with financing, construction, and repayment of federal water projects. Its principal recommendations concerned repayment. It advocated that, in addition to elimination of subsidies for irrigation, water supply, flood control and navigation, project costs also be repaid in full by the direct beneficiaries. While one could suppose that financing and construction by federal agencies would continue, it would certainly follow that without historic federal nonreimbursable capital expenditures for these types of projects, the number of such projects would rapidly decrease. The present program of grants for water quality control facilities would be continued under the Commission's recommendations for about 10 years.

The Commission made a number of recommendations regarding interbasin transfers of water. The economic criteria for justifying such projects and the amount to be paid by beneficiaries of such projects, including the principle that areas of origin should receive monetary compensation for net losses occurring as a result of the transfer, appear to be overly restrictive and would undoubtedly preclude any interbasin transfers whatsoever.

The Commission recommended the definition and quantification of Indian water rights. It also recom-

* Office of Business Economics and the Economic Research Service. Term is still in use although OBE was reorganized in 1972 and renamed Bureau of Economic Analysis.

mended that Congress make available financial assistance to Indian tribes. This would enable those tribes, which lack the funds, to make economic use of the water.

The Commission made other recommendations too numerous to list in detail. However, a few are summarized here. In its recommendations regarding use of water projects to promote regional economic development it stated that,

> ". . . under certain conditions, water development may be helpful as one of the several ingredients necessary to encourage regional economic development and population growth, or to preserve existing development. However, water developments differ widely in the effects they induce. Congress, in making judgments as to whether water development should be used to aid regional growth, should require evaluations of certain critical growth factors in order to enhance the effectiveness of developments and reduce offsetting losses in other regions. These factors include: market demands, availability of substitutes for water services, competitive advantage of the region, and the potential for capitalizing on growth opportunities."

It commented on population distribution by saying that,

> ". . . federal water programs can be easily adjusted to support whatever population distribution policy the nation adopts. However, water programs are not, in and of themselves, adequate to effectuate a national policy concerning where people will live."

The Commission recommended that the Principles and Standards that were then being recommended by the Water Resources Council in regard to Planning Water and Related Land Resources be adopted except that the discount rate should be the interest rate on long-term federal securities rather than the opportunity cost of money that had then been included in the recommended Principles and Standards. The Principles and Standards were later put in force by the President. Subsequently, Congress directed, in a flood control bill (P.L. 93-251), use of a discount rate equal to the interest rate on long-term federal securities.

The report recommended a close relationship between land use and water and other planning as indicated in its seven key issues noted at the outset. It spoke in favor of water pollution control but recommended that the Federal Water Pollution Control Act Amendments of 1972 should be revised to restore the policies that (1) water is polluted when its quality has been altered by the activities of man to such a degree that reasonable present and prospective uses as designated by public authorities are impaired, and that (2) the objective of pollution control should be to protect the designated uses. This and other recommendations in regard to this subject will undoubtedly be given much consideration in studies by the National Commission on Water Quality and by the committees of the Congress who are engaged in oversight activities regarding Public Law 92-500 at the present time.

Finally, the report touched on basic data and research for future progress. It recommended that the Water Resources Council direct that planning studies include an assessment of research needed to support planning objectives. It also recommended organizational changes in the agencies in Federal Government that deal with water resources research.

The State of California, in commenting on the review draft, agreed with most of the recommendations on water resources planning. The State, however, disagreed with many of the conclusions regarding the future of irrigated agriculture that were expressed by the National Water Commission.

The State observed that the substitution of floodplain management for structural remedies for flood control has definite limitations in California due to the extensive areas flooded in the Central Valley prior to construction of levees. In Southern California much development is necessarily located on alluvial cones which were built by streams that wandered over the surface of the cones in recent geologic time and if not restrained will continue to do so.

The State also disagreed with economic criteria proposed for interbasin transfers of water. The Commission's recommendation that an interbasin transfer should be the least cost source of water supply for a given purpose is contrary to the concepts of multiobjective planning wherein all needs, purposes and uses are considered in an integrated planning process.

It is difficult to predict the degree to which the Commission's recommendations will be implemented. The budgetary programs of the present administration and some attitudes of Congress seem to be considerably in tune with some of the Commission's recommendations in regard to water supply, flood control and navigation. Few new starts have been authorized and funding of construction has been substantially reduced. This is probably due in part to the Commission's reflecting current public expressions of priorities and in part to the Administration and Congress recognizing the independent views expressed by the Commission.

It seems unlikely that congressional approval of the repayment policies recommended by the Commission will occur in the near future if at all.

The report is worth careful review by anyone with serious concern for federal water policies and, in fact, for water policies in general.

Environmental Considerations in Water Management

The term "environment" has more than one meaning. To many people, it is the surroundings in which they live or work. To others, it is more closely associated with natural conditions and the land and resources that have not yet been significantly affected by man's activities.

Under the first usage, much of the desirable environment of California has been created by development and use of the State's water resources. This environment includes lawns, shade trees, and ornamental shrubbery around homes and in cities; orchards and green fields that make up several million acres of irrigated lands; and the many reservoirs that provide recreation activity for millions of the State's residents.

For decades in California multiple-purpose water projects have been designed and constructed to provide for environmental, as well as many other, uses. However, in the last few years, many additional environmental factors, largely natural, have been introduced.

The Porter-Cologne Water Quality Control Act, adopted by California in 1969, reflected a tough new attitude toward water pollution problems. At both the national and state levels sweeping legislation was enacted to protect environmental quality: the National Environmental Policy Act (NEPA) of 1969 and the (California) Environmental Quality Act (CEQA) of 1970. In addition much litigation has been introduced in the federal and state courts with respect to environmental considerations in the area of water resources development and management.

A new planning thrust at both state and local levels toward the development of supplemental sources of water through waste water reclamation and the more efficient use of water is also indicative of the emphasis on environmental protection. There is a growing awareness that water is a finite renewable resource which must be protected—both now and for generations to come.

Public Involvement

Most of the legislation protecting the environment can be traced to firm public support. Public opinion polls taken in the late 1960s and early 1970s showed strong sentiment toward natural environmental protection.

Governing bodies at all levels—Congress, the California Legislature, local boards and commissions—reflected the concern of their constituents in approving CEQA, NEPA, the California Wild and Scenic Rivers Act, the Federal Water Pollution Control Act Amendments of 1972, and resolutions supporting "no growth".

In California, citizens also voiced their concern directly by passing the California Coastal Zone Conservation Act of 1972, an initiative. That same year, Colorado voters rejected a bid to hold the Winter Olympics in their State, largely on an argument that the environment would be harmed.

Individual members of the public, and various organizations, have also attempted to achieve environmental goals through litigation. Public appeal to the courts began in the mid-60s. It is generally believed that these early cases spawned the federal and state environmental laws which became effective in 1970.

Since 1972, newer considerations have begun to weigh heavily on the public mind such as the energy crisis and inflation. The environment is still a major concern, however. Environmental considerations are now a part of the public conscience—and they are likely to remain so.

Water Rights Decisions

The State Water Resources Control Board (SWRCB) in 1971, 1972, and 1973 rendered three decisions which imposed conditions on water development in California of far greater consequences than ever before. These decisions could influence water project planning far into the future. At this time, the three decisions are under review in the federal or state courts.

Decision 1379 would require greater outflows from the Sacramento-San Joaquin Delta into San Francisco Bay and the Pacific Ocean than had been considered in previous planning and operation studies and would reduce the quantities of water available for delivery to homes, farms and industries served by the Central Valley Project and the State Water Project. Decision 1400 would require increased flows in the American River below the diversion for the Folsom-South Canal and thus reduce the quantities of water available for a direct gravity diversion to users in the service area. Decision 1422 would limit the amount of water that could be stored in New Melones Reservoir on the Stanislaus River until water is needed for users in service areas in other parts of the San Joaquin Valley.

In issuing Decision 1379, the State Water Resources Control Board set water quality standards in the Sacramento-San Joaquin Delta to protect agricultural, municipal, industrial, and fishery uses; as well as for the maintenance of neomysis awatschensis, the opossum shrimp, which is a principal food of juvenile striped bass. Salinity standards were also set for Suisun Marsh for wildlife maintenance.

Decision 1379, in effect, establishes standards and directs the Bureau of Reclamation and the Department of Water Resources to operate their valley water projects to maintain water quality in the channels of the Delta equal to or better than those set out in the standards, doing so, either by discontinuance of proj-

Waterways of the Sacramento-San Joaquin Delta

ect diversions or by release of stored water. A further provision of the Decision would require increased Delta surveillance and water quality monitoring that would measure environmental factors and enable the correlation of the physical parameters to the key resources of the area.

The many ramifications and secondary effects of Decision 1379 on water development in California are a continuing subject for discussion by water interests and environmentalists. The SWRCB will reopen this decision not later than July 1, 1978, to consider possible modifications of the decision.

Decision 1400 affects plans of the Bureau of Reclamation to divert much of the flow of the American River to users in service areas in Sacramento and San Joaquin Counties. In 1957, the Bureau agreed* to fish releases of 250 cubic feet per second (cfs) from January 1 to September 14, and 500 cfs from September 5 to December 31, below Nimbus Dam. Additional releases also are made to meet the existing water rights and water supply contracts and agreements with downstream users.

Decision 1400, which was applied to Auburn Reservoir by the State Water Resources Control Board, calls for greatly increased flows for fishery and recreation purposes in the American River from Nimbus Dam to its junction with the Sacramento River. The required flows range from 1,250 to 1,500 cfs in normal water years.

For nearly two decades water stored in Folsom Reservoir was released to the American River because the Folsom-South Canal had not been constructed. This resulted in providing larger summer flows than had occurred before Folsom Dam was built. During this period an extensive fishery developed in the river, and local residents developed plans for and began using the new recreational potential of the river area during the summer months. Decision 1400 would allow the fishery and recreational benefits to continue to a greater extent than contemplated for conditions authorized by the Congress. The water could flow down the American River into the Sacramento River and be diverted from that river near Hood. A pumping plant and canal would then be used to put the water into the Folsom-South Canal near Clay at increased cost.

Decision 1422 restricts storage in the federal New Melones Reservoir to less than half of the total reservoir capacity. The restriction will be reconsidered by the State Water Resources Control Board when the

* State Water Rights Decision D-893, March 18, 1958.


White water rafting on the Eel River

Bureau of Reclamation demonstrates a specific need for the water that can be obtained from the capacity of the upper part of the reservoir. The storage limitations will preserve a popular "whitewater" area (which exists because of releases from headwater reservoirs for power generation) and will protect some limestone caves and, possibly, some archeological and historical sites. D-1422 provides for a project yield that will satisfy adjacent service area demands for irrigation, water quality control, and fish and wildlife preservation and enhancement—and the use of the same waters for power generation but with much less output. It defers significant impairment of upstream recreational values until a need for the additonal water can be demonstrated. The reservoir available at the lower water level would provide very limited recreation opportunity as compared to recreation on the reservoir at the higher level.

California Wild and Scenic Rivers Act

During the four year period since publication of Bulletin 160-70, the citizens of California have expressed a strong interest in preserving certain free-flowing rivers in their natural condition and appearance. These expressions have resulted in two acts by the California Legislature.

In 1971, the Legislature passed SB-1285 (Chapter 761, Statutes of 1971) which directed the Resources Agency to prepare waterway management plans for 20 rivers and tributaries in Northwestern California. These rivers include essentially all of the coastal stream systems from the Smith River on the north to the Russian River on the south. The Big Sur and Little Sur Rivers in the central coastal region were later added to this study list.

The management plans being prepared pursuant to Chapter 761 are to include provisions for necessary and desirable flood control, water conservation, recreation, fish and wildlife preservation and enhancement, water quality preservation and enhancement, streamflow augmentation and free-flowing rivers.

In the following year, the Legislature passed and the Governor signed into law SB-107 (Chapter 1259, Statutes of 1972) known as the California Wild and Scenic Rivers Act. This act added provisions to the Public Resources Code which established a State Wild, Scenic and Recreational Rivers System. The California Act is similar in concept to that established at the Federal level through passage of the Federal Wild and Scenic Rivers Act of 1968 (P.L. 90-542).

Eight rivers were designated for inclusion in the State system. These are the entire Smith River and major portions of the Klamath, Trinity, Scott, Salmon, Eel, and Van Duzen Rivers and the American River (north fork and lower main stem).

The Secretary for Resources is required to administer the system in accordance with management plans to be prepared by the Resources Agency and approved by the Legislature. These plans are presently under preparation with the Smith River plan scheduled as the first for completion.

Each river component of the system is to be administered by the Secretary so as to protect and enhance the scenic, recreational and related values for which it was included. This is to be done without unreasonably limiting the other resource values, such as lumbering and grazing, where the extent and nature of such uses do not conflict with public use and enjoyment of these values.

Except for the Eel River, the Wild and Scenic Rivers Act precludes state agency participation in planning and construction of projects, such as dams and reservoirs, which would directly affect the free-flowing natural condition of the rivers. In the case of the Eel, the Department of Water Resources is required to report to the Legislature in 1985 on the results of authorized studies as to the need for flood control and water conservation facilities. That report will form the basis for legislative hearings to determine if segments of the Eel River should be deleted from the system.

Preparation of the management plans required under both Chapter 761 of 1971 and the Wild and Scenic Rivers Act is being accomplished by a task committee within the Office of the Secretary for Resources, comprised of members from the Departments of Water Resources, Fish and Game, Conservation, and Parks and Recreation. The studies in progress are discussed in subsequent chapters of this bulletin.

NEPA and CEQA

The National Environmental Policy Act of 1969 (NEPA) was signed into law on New Year's Day 1970. In California, the Environmental Quality Act of 1970—which is more commonly known as the California Environmental Quality Act (CEQA)—became effective on November 23, 1970. These two legislative acts clearly set forth a national policy and a state pol-

North Fork of the Smith River, a designated wild river icy which requires all public agencies to give full consideration to environmental effects in planning their programs. Both acts emphasize the need to achieve a productive harmony between man and nature.

The broad scope and general language of both laws have made their implementation by public agencies difficult. Since their enactment, there has been a process of legal challenge, court ruling, and legislation or public agency accommodation and implementation. While this process is probably far from complete, the basic outlines of procedures for implementation of the two acts are now becoming apparent.

NEPA requires that all agencies of the federal government include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment a detailed statement by the responsible agency of the environmental impact of the proposal. The statement is known as an Environmental Impact Statement (EIS). Federal agencies must prepare EISs for their own proposals and for others' proposals which require approval or funding by a federal agency. It is in this latter way that many state and local proposals come under the provisions of NEPA.

CEQA, on the other hand, applies to all public agencies in the State of California except federal units. CEQA requires all public agencies to consider the environmental consequences of all of their activities. Under CEQA, Environmental Impact Reports (EIRs) are to be prepared, generally, for projects which may have a significant effect on the environment. They do not have to be prepared for projects which fall within exempted categories, which are specifically excepted by law, or which will not have a significant effect on the environment. "Significant effect" is defined in the State Guidelines for Implementation of CEQA as a "substantial adverse impact on the environment". Under CEQA, then, the requirement for preparation of EIRs is applicable to a project which may have a significant effect on the environment. The activities of nongovernmental entities come under the provisions of CEQA whenever those activities require approval or funding by a public agency in California.

It is probable that the full impact of the passage of NEPA and CEQA in 1970 will not be known for many years, but it is reasonable to assume that these laws will continue to have a profound influence on water management. It is difficult to accommodate the requirements of these laws in projects now underway that were planned and authorized prior to enactment of the laws. The longer term effect of the laws should be to improve planning, and it is probable that fifteen years from now, planners will recognize them as a valuable part of the water management process.

Litigation

The courts have played an increased role in water resources development during the last several years. Most litigation that has been instituted against agencies planning or constructing water projects has been brought by individuals or groups who believed that the projects would have important adverse effects on the environment or that insufficient attention had been given to environmental considerations in planning the projects. Many of the suits were brought under the National Environmental Policy Act (NEPA) or the California Environmental Quality Act (CEQA).

In California, lawsuits have delayed some projects but to date no water projects have been totally abandoned due to litigation alone. Many of the lawsuits, however, are still in various stages of trial or pretrial or have been appealed to higher courts. Some of these will not be decided for several years.

Many of the uncertainties of the federal and state environmental protection acts have now been resolved and the degree of compliance with these acts by project constructors is increasing. There will still be disagreements, however, between those seeking to avoid changing the environment through the prevention of further development and those planning and constructing water projects who may have a different assessment of the balance between environmental benefits and detriments. Significant cases interpreting the National Environmental Policy Act, the California Environmental Quality Act or otherwise involving water projects are summarized briefly below.

The right of a court to review an agency's environmental impact report (EIR) after that agency has found its own work satisfactory was established in the case of *Environmental Defense Fund, Inc.* v. *Coastside County Water District*, 27 Cal.App.3d 695 [104 Cal. Rptr. 197] (1972).

The premiere CEQA case is *Friends of Mammoth* v. *Board of Supervisors of Mono County*, 8 Cal.3d 247 [104 Cal.Rptr. 761] (1972) which held that private activities subject to the discretionary approval or cooperation of a public agency must include an environmental analysis by the public agency. That analysis must be written in an environmental impact report if the activity may have a significant adverse impact on the environment.

The court in *County of Inyo* v. *Yorty*, 32 Cal.App. 3d 795 [108 Cal.Rptr. 377] (1973) held that an EIR was required for projects begun before the enactment of CEQA if that on-going project had not progressed to the point of no return or if substantial changes were proposed after the Act became law.

The *Environmental Defense Fund* v. *Armstrong* case involved a challenge to the adequacy of the Corps of Engineers environmental impact statement (EIS) on the New Melones Dam prepared pursuant to the requirements of NEPA. The Corps revised its EIS, which was then found legally sufficient by the Ninth Circuit Court of Appeals and the Corps is proceeding with construction.

Another group of cases are at trial or on appeal. In the *Sierra Club* v. *Morton* case in the federal district court in San Francisco, the Sierra Club has sued the Department of Water Resources to stop or limit the export of water from the Delta through the California Aqueduct of the State Water Project. The Sierra Club also seeks to stop or delay the proposed Peripheral Canal.

In *Bowker* v. *Morton*, also in the federal district court in San Francisco, the plaintiffs are attempting to force the Department to limit the delivery of project water to land holdings of 160 acres or less. That acreage limitation exists under federal reclamation laws and the plaintiffs believe that because the State Water Project has benefited from the operation of the San Luis joint use facilities, the federal limitations should be applied to the entire State Water Project.

Two cases, *Friends of the Earth* v. *Brinegar* in federal court in San Francisco and *Friends of the Earth* v. *Walton*, in state superior court in San Francisco, have challenged the use of the Peripheral Canal alignment as a borrow site for land fill in the Interstate 5 highway project. The suits charge that the digging involved would constitute the beginning of the canal before an EIR on the canal had been approved.

There have been several cases involving numerous parties which seek to set aside the State Water Resources Control Board's Decision 1379, concerning Delta Water Quality, and Decision 1400, concerning American River flows. A closely related case, *United States* v. *State of California* in federal district court in Sacramento, was brought by the U. S. Bureau of Reclamation seeking a declaration that its water rights are not subject to State Water Resources Control Board regulations.

A suit to halt the U.S. Corps of Engineers' Warm Springs Dam has been brought in federal court in San Francisco. The *Warm Springs Task Force* v. *Corps of Engineers* case challenges the adequacy of the Corps' environmental impact statement prepared pursuant to the requirements of NEPA. Also, Auburn Dam, and the Auburn-Folsom South Canal, which are U. S. Bureau of Reclamation projects, have been challenged in federal court in Sacramento in *National Resources Defense Counsel, Inc.* v. *Stamm* case on the grounds that the Bureau's EIS was not adequate.

Another case involving the Auburn-Folsom South Canal is the *Environmental Defense Fund* v. *East Bay Municipal Utility District* in federal court in San Francisco. That suit seeks to compel the East Bay Municipal Utility District to abandon its agreement with the U.S. Bureau of Reclamation for Auburn-Folsom South Water and to reclaim waste water instead.

Comprehensive Water Quality Control Planning

In 1970, the Porter-Cologne Water Quality Act replaced the former Division 7 of the Water Code. This Act required the implementation of a statewide program for the control of the quality of all water of the State. To implement the Act, the people of California in 1970 approved the Clean Water Bond Law, which made the proceeds from the sale of $250 million of state general obligation bonds available for assisting local governmental agencies to correct and avoid pollution of water of the State. Over $6 million from these funds were allocated for the development of plans for water quality control within 16 planning basins covering the State. These basins depicted on Figure 4, are essentially the same areas or further divisions of the planning areas used by the Department of Water Resources for this report and shown in Figure 2.

Section 303(e) of the Federal Water Pollution Control Act Amendments of 1972 ordered each state to have a continuing planning process for water quality control of interstate water. Over $2 million in federal funds were allocated to the State Water Resources Control Board (SWRCB) Study.

The Board contracted with seven basin contractors in 1971. The contractors prepared a basin plan for each of the 16 planning areas, working in coordination with the State and Regional Boards and other interested parties through public workshops. The com-

Figure 4. Water Quality Control Planning Basins

prehensive basinwide plans give consideration to interrelationships of quantity and quality of water. Under provisions of the Porter-Cologne Act, water quality control plans adopted by a regional water quality control board and approved by the SWRCB become a part of California Water Plan, effective when such plans are reported to the Legislature.

The Department of Water Resources participated in this planning effort by furnishing water resources data and information for each of the 16 planning basins and acting as the basin contractor in developing the comprehensive water quality control plans for each of 4 planning basins which are shown on Figure 4. Each plan consists of identified beneficial water uses, water quality objectives, plan implementation program for meeting these objectives, an environmental assessment of the recommended plan, and a surveillance program to monitor the effectiveness of the plan. Each plan is intended to provide a definite program of actions within the planning area designed to preserve and enhance quality and protect beneficial uses in a manner which will result in maximum benefit to the people of the State for the next 25 to 30 years.

Although the intent of this comprehensive planning effort is to provide positive and firm direction for water quality control for many years, it is also recognized that adequate provisions must be made for changing conditions and technology. Thus, a major premise in the development of the basin plans is that they will be updated periodically to maintain pace with technology, policies and physical changes in the basin. This planning effort is discussed in some detail in Chapter V.

State-Federal and Interstate Activities

The satisfaction of future water needs in consonance with environmental goals depends to an important degree upon relations with Federal agencies. In a number of respects, coordination of objectives and actions with neighboring states and with other states in the West is also an important factor. Activities in the areas of state-federal relations and interstate matters, particularly in regard to events that have occurred since the publication of Bulletin No. 160–70, are discussed in the following paragraphs.

Cooperation With U.S. Water Resources Council

The Water Resources Council was established by the Water Resources Planning Act of 1965. It consists of the cabinet secretaries of federal departments and other top federal officials who have some responsibilities for water and related land resources.

The most significant aspect of the Council's activities to California was its sponsorship of the comprehensive framework studies, including one for the California Region, which encompassed California and a small part of Southern Oregon. These were very broad studies covering estimates of needs for water and related land resources, ways of meeting such needs and, in some cases, the consequences of doing so or not doing so. The study for the California Region commenced in 1967 under the direction of the California State-Federal Interagency Group, representing the States of Nevada and Oregon, 9 California agencies and 22 federal agencies. Field drafts of a Main Report and 18 appendixes were completed in mid-1971 and forwarded to the Water Resources Council for their use in preparing a final report. State and federal comments on these field drafts were received and published in January 1972, and a revised Main Report was forwarded to the Council in May 1972. To date, the Council's final report has not been completed for transmittal to the President and Congress.

Concurrent with this study of the California Region, similar investigations were progressing in three other portions of the Southwest, including the Upper and Lower Colorado Regions and the Great Basin Region. Finally, the report "Pacific Southwest Analytical Summary Report on Water and Land Resources", based on the framework studies of the four regions, was published in November 1971.

The major limitation of the framework studies, as far as California is concerned, is its emphasis on the needs for water and related land resources with Series C projections of population and resulting food and fiber requirements, which the California investigators considered too high in view of the lower growth rates measured in 1970.

The Water Resources Planning Act of 1965 also provides that the Water Resources Council shall establish "principles, standards, and procedures for Federal participants in the preparation of comprehensive regional or river basin plans and for the formulation and evaluation of Federal water and related land resources projects". After producing several drafts, the Council published in the Federal Register on December 21, 1971, "Proposed Principles and Standards for Planning Water and Related Land Resources". When approved, these were to supersede the "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources" approved by President Kennedy on May 15, 1962, and printed as Senate Document 97. They would apply not only to federal projects but also to many regulatory activities and all federal water resources grants to the states except those by the Environmental Protection Agency.

The proposed criteria provided for addition of the planning objectives "environmental quality" and "regional development" to the former single objective of "national economic development" in Senate Document 97. They provided further for the display of beneficial and adverse effects of projects or measures being considered according to four accounts, including three corresponding to the planning objectives just mentioned and one designated "social well-being". One of the more controversial aspects was a discount rate for evaluation of federal projects to be set at 7 percent for 5 years. Thereafter the rate would be the "opportunity cost", estimated to be approximately 10 percent.

Hearings on the proposed Principles and Standards were held early in 1972. The Department of Water Resources and many others presented testimony. Following the evaluation of these comments and consideration of other factors, the Principles and Standards were again revised and were approved by the President on September 5, 1973. As adopted, the criteria retained only the planning objectives of "national economic development" and "environmental quality" but included all four of the evaluation accounts noted above. The planning discount rate was changed to the average interest cost to the United States of both short-term and long-term securities. It was established initially at 6⅞ percent.

The latest development relating to the Principles and Standards is contained in the Omnibus Appropriation Act for fiscal year 1974 entitled "Water Resources Development Act of 1974". In Section 80 of this Act the Congress amended the planning interest rate to the rate on federal long-term securities only, a criterion which had been adopted by the Water Resources Council in 1968 and which was in effect prior to the latest presidential approval. This section of the Act also requested the President to study further the matters of the discount rate and the objectives and evaluation criteria to be used in planning water resources projects.

Under the Water Resources Planning Act, the Water Resources Council is required periodically to assess the adequacy of the nation's water resources. The first National Assessment was prepared in 1968, and preparations are being made for the second. The originally announced plan for this new effort was to conduct both regional assessments and a national assessment using similar approaches. The regional assessments would have been compiled independently by regional teams to present different viewpoints from the National Assessment which would have been based on a nationally consistent analysis. Because of a reduction in alloted funds, only the national assessment is now scheduled for preparation.

Western U.S. Water Plan Study

The Colorado River Basin Project Act (P.L. 90-537) which authorized the Central Arizona Project and several projects in the Upper Basin, also authorized investigations which became known as the Western U.S. Water Plan Study. Title 1 of the Act contemplated a regional water plan "to serve as the framework under which projects in the Colorado River Basin may be coordinated and constructed with proper timing to the end that an adequate supply of water may be made available for such projects . . . ." Title II provided that "the Secretary of the Interior shall conduct full and complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States. Such investigations shall include the long-range water supply available and the long-range water requirements in each water resource region of the Western United States." A final report was to be completed not later than June 30, 1977. A proviso stated that for a period of ten years or until September 30, 1978, "the Secretary shall not undertake reconnaissance studies of any plan for the importation of water into the Colorado River Basin from any other natural river drainage basin lying outside the states of Arizona, California, Colorado, New Mexico, and those portions of Nevada, Utah, and Wyoming, which are in the natural drainage basin of the Colorado River". This moratorium was intended to exclude the study of importations from the Pacific Northwest.

The Bureau of Reclamation on behalf of the Secretary of the Interior started these studies in 1970. Early in 1973 the Office of Management and Budget directed the Department of the Interior to reduce the scope of the investigation from that originally laid out in the plan of study and to shorten the study period so as to complete the final report by June 30, 1974. The Bureau of Reclamation prepared an abbreviated plan of study, which consisted mainly of identifying major problems in the West relating to water resources and recommending further investigations to find solutions therefor. Since the scope of studies was largely limited to review and summarization of other work, there will not be any major new findings regarding water supplies for California.

Salinity of Colorado River

The Colorado River is now and will continue to be an important source of water for the coastal and desert areas of Southern California. The primary agricultural service areas are in the Blythe and Yuma areas along the River and in Imperial and Coachella Valleys. The principal municipal and industrial service in the coastal drainage area from Ventura County to San Diego County is by the Metropolitan Water District of Southern California. By the time the full capacity of the State Water Project is being used to import water to Southern California, the Colorado River supply will still amount to more than half of the total for that area. Thus, it is to California's economic interest that the quality of the Colorado River be maintained as high as possible.

The Colorado River has always had a substantial load of dissolved salts as well as its burden of sediment. The natural salinity comes from salt springs and from the widely diffuse leaching of salt from marine sediments by precipitation, surface runoff and ground water flow. Additional quantities of salt have been introduced by agricultural, domestic, industrial and other uses of water. Further, the export of good quality water originating in the high mountains of Colorado and New Mexico for use outside the Colorado River Basin and the evaporation or transpiration of water from reservoirs and irrigated areas has caused the concentration of salt to increase.

The combination of the above factors has, for example, caused salinity to increase substantially in the vicinity of Imperial Dam, the diversion point for the All-American Canal near the Mexican Border. Since the beginning of salinity records in 1941, salinity has increased from an average of about 700 milligrams of salt per liter of water to 870 milligrams per liter (mg/l) in 1972. Recent projections by the Colorado River Board of California forecast about 1,300 mg/l at Imperial Dam in the year 2000 if control measures as planned are not undertaken. For the same year at Lake Havasu, the point of Metropolitan Water District's diversions, the Board has predicted about 1,100 mg/l compared with about 750 mg/l at the present time.

Several steps have been taken in the last decade toward the planning and implementation of measures to control the increase of salinity in the Lower Colorado River and to improve the quality of water reaching Mexico. The first was publication of the report entitled, "Need for Controlling Salinity of the Colorado River" by the Colorado River Board of California in August 1970. This report combined information on the probable rate of development and use of water in the basin and its effect on the salinity of the lower river if mitigation measures are not taken.

In 1971, the U. S. Environmental Protection Agency published the result of studies begun in 1963 in a report titled, "The Mineral Quality Problem in the Colorado River Basin—Summary Report". This report projected future salinity levels without control projects, suggested specific projects to control salinity, and compared the costs of these projects with the detriments that would be caused by using the water of higher salinity without control measures. The Summary Report recommended a policy of maintaining salinity concentrations at or below levels then found in the lower main stem of the River; the adoption of water quality standards at key points; and the implementation of a basinwide salinity control program as future water development in the Basin occurs.

The Environmental Protection Agency report was used as a basis for meetings among the seven states and the Environmental Protection Agency in February and April 1972. These meetings together comprised the "Seventh Session of Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries—Colorado, New Mexico, Arizona, California, Nevada, Wyoming, Utah". The conferees agreed to defer the establishment of numerical criteria but to adopt and accelerate the salinity control program outlined in the 1971 Environmental Protection Agency report as modified by further studies of the Bureau of Reclamation. In this connection, the Bureau prepared a report in February 1972 entitled, "Colorado River Water Quality Improvement Program".

Also during the 1960s and early 1970s, the Department of State was negotiating with Mexico toward solution of the problem of salinity in the water delivered to that country under the 1944 water treaty. On August 30, 1973, after agreement had been reached by U. S. Ambassador Herbert Brownell and Mexico's Foreign Secretary Rebassa, the Presidents of the two countries signed the agreement, which was recorded as Minute 242 of the International Boundary and Water Commission. The minute specified that annual average salinity concentrations at Morelos Dam, the Mexican diversion point, would be no more than 115 mg/l (plus or minus 30 mg/l) greater than at Imperial Dam, the lowest diversion point in the United States. This provision was conditioned on the authorization by Congress of certain facilities and measures required to effectuate the agreement. While not specified in the agreement, these would include a desalter on the Wellton-Mohawk Drain in the vicinity of Yuma, Arizona; lining or reconstruction of the Coachella Canal to control seepage losses and thereby provide an interim water supply for dilution; and other related facilities.

The congressional delegation of the Colorado River Basin states introduced legislation into both houses of the Congress in February 1974, to combine authorization of facilities of the upstream salinity control program under study by the U. S. Bureau of Reclamation and of the downstream works to effectuate Minute 242. This legislation was passed and signed by the President on June 24, 1974.

In a parallel action of September 10, 1973, the Environmental Protection Agency notified the states of the Lower Colorado River Basin that, pursuant to the Water Pollution Control Act Amendments of 1972 (PL 92-500), the states would be required to establish numerical criteria for salinity control and a plan of implementation to achieve the criteria. Representatives of the seven states established the Colorado River Basin Salinity Control Forum through which they plan to comply with the proposed Environmental Protection Agency regulation.

A probable major component of the Forum's plan will be implementation of feasible components of the Bureau of Reclamation's salinity control program. In addition, the plan will undoubtedly include actions to be taken by the states, local governmental agencies, and private industry. The latter, in particular, will likely include measures to limit the increase of salinity from mining and processing of oil shale and coal for petroleum or synthetic gas or for combustion in thermal power plants in the Basin. The plan will also cover estimates of the degree to which salinity can be controlled in the lower main stem of the Colorado by measures such as those that have been identified, and economic evaluations relating costs and benefits of the measures. The plan may allow for salinity to increase temporarily while the Upper Basin continues to develop and before full control measures are instituted. However, the objective will be to reduce the salinity to 1972 levels within a specific period of time.

Western States Water Council

In 1965, the Western Governors' Conference, composed of 11 states lying wholly or partially west of the continental divide, created the Western States Water Council. The purpose of the Council is to provide effective cooperation among the western states in planning for programs leading to the integrated development of water resources by state, federal, and other agencies. Its "Principles, Standards, and Guidelines" contemplate a high degree of cooperation in planning to meet water needs.

While the Council itself has not entered into a planning program as such, it has fostered communication and mutual understanding among water leaders throughout the West. There have been a number of positions taken by the Council on legislative and policy matters that have affected the western states. Even though unanimous consent was not obtained on all issues considered, as is required by its Rules of Organization for adoption of any external position, the thorough exploration of issues has been beneficial in clarifying the interests and desires of the states.

California State-Federal Interagency Group

In an effort to coordinate water planning, development and management activities in California by the

Pine Flat Reservoir, constructed by the U.S. Army Corps of Engineers. *U.S. Army Corps of Engineers photo* major water development and management agencies, the California State-Federal Interagency Group was established in 1958 as a forum for information exchange and resolution of mutual interest issues. It consists of the director of the State Department of Water Resources and the equivalent officers in California for the U. S. Army Corps of Engineers, the U. S. Bureau of Reclamation, and the U. S. Soil Conservation Service.

The Group includes a Task Force for Planning Coordination, which is composed of the planning chiefs of the parent organizations and also of the U. S. Fish and Wildlife Service, the California Department of Fish and Game, and the State Water Resources Control Board. This is the major coordinating group at the subpolicy level. In addition, staff representing these organizations and others as circumstances warrant make up work groups and supporting subgroups that report to the Task Force. Representatives of the State of California are the Chairmen of both the Interagency Group and the Task Force for Planning Coordination.

The Interagency Group meets quarterly and has been a useful organization to consider and find solutions to problems of coordination, needs for new studies and similar matters. The emphasis has been on water resource planning.

Interstate Water Compacts

Under terms of the Klamath River Basin Compact, California cooperates with Oregon in the administration and use of water common to the two states within the Upper Klamath River Basin. The compact allocates sufficient water to each of the two states to provide for all foreseeable uses within the area. At present, both states are operating well within their water allocations and are expected to continue to do so for some time into the future because of the relatively slow rate of growth of agriculture and other developments within the compact area.

A California-Nevada Interstate Compact relates to the distribution and use of interstate water resources. The compact allocates the water supplies of the Lake Tahoe Basin and the Truckee, Carson, and Walker River Basins. This agreement has been approved by both California and Nevada, but has not yet received the necessary consent of the United States. Pending this consent, each state is administering the use of water covered by the compact as if it were in effect.

The compact makes an equitable apportionment between the states of the available water of the respective stream systems, but the limited supplies does not provide sufficient water to either state to provide for the full development of the available land.

The need for a compact to distribute the water is emphasized by two lawsuits which the United States has instituted. In one case, the United States is attempting to define water rights for the Newlands Reclamation Project in Nevada by bringing suit against all water users on the Carson River upstream from the project, both in California and Nevada. In the other case, the United States is seeking to define its rights and those of the Pyramid Lake Tribe of Paiute Indians to water from the Truckee River by suing all diverters of water from the Truckee River in Nevada upstream from Pyramid Lake.

In May 1974 the Nevada State Supreme Court issued a writ of mandamus requiring the Nevada State Engineer and the Director of the Bureau of Environmental Health to approve a subdivision map for a development along the crest of the Lake Tahoe Basin. The two state officials had refused approval on the ground that the water supply for the subdivision came from the Lake Tahoe Basin and some of the lands in the subdivision were outside the Basin. They cited the California-Nevada Interstate Compact, which prohibits additional out-of-basin diversion of water from the Lake Tahoe Basin, as expressing the intent of the State of Nevada in this matter even though the Compact has not yet been approved by the Congress.

Significant recent events on the Colorado River from which water supplies are allocated under a compact written in 1922, are described in an earlier section on Salinity of the Colorado River.

Land Use Planning and Controls

In recent years increasing emphasis has been given at both state and federal levels to fashioning legislation aimed at controlling land use. Although many different concerns are reflected in this movement, the catalyst that is bring numerous interests together has been concern for the environment. Many people believe there is a need for a rational, carefully thought-out plan for land use to provide organization to the current situation which sometimes seems near chaotic due to the multiplicity of agencies independently applying environment-related controls.

Land use policies, planning, and controls would have direct impact on all resource management, including water resources. They could provide better insight as to the location and nature of future water management problems. Similarly, they might assist in identification of possible solutions to these problems.

The Department of Water Resources' interest goes beyond questions of possible impact, however. In the arid west, land use and water use management are intimately tied together.

In this section, some of the proposed land use legislation will be reviewed as well as some of the history of land use control.

Land Use Policy and Control Legislation

Congress gave extensive consideration to two land use bills in 1974. Both bills were defeated, but pos-

Change in Contra Costa County land use—1946, 1954 and 1974 sibly will be introduced again in the next Congress. Various provisions of the bills would have had state government responsible for (1) establishing a statewide land use planning process within 3 years of passage, (2) developing an adequate state land use program within 5 years of passage, and (3) establishing an intergovernmental advisory council composed of officials of local governments. The state process would have been required to have the power to regulate development around key major facilities (airports, major freeway interchanges, etc.) and to regulate real estate development of 50 lots or more 10 miles beyond the boundaries of a Standard Metropolitan Statistical Area (as defined by the U.S. Bureau of Census). The legislation included the concept of "areas of critical concern" which has been adopted in California as a basis for policy statements by the State Administration and for pending state legislation. Generally, these are lands of more than local importance in regard to agricultural use, unique flora or fauna, natural or historic character, etc., and those lands having a hazardous nature for certain kinds of development.

The American Law Institute has said that 90 percent of decisions regarding land use are of only local significance. If this is correct, then the "areas of critical state concern" should be expected to be impacted by only 10 percent of the cases of proposed actions. However, precisely defining "areas of state critical concern" will require considerable deliberation to limit the scope so that a much larger portion of decision making does not become unduly relegated to other than the local level. At the same time these definitions must be broad enough to meet the social, economic, and environmental land-related objectives being sought.

At the state government level, the major legislative considerations, to the time of this writing, have been directed toward establishing a responsible agency in state government to designate areas of critical state concern and establish rules and regulations for land development within these areas.

The proposed federal and state legislation briefly described above is addressed directly to areawide land use planning and control. Many administrative and legislative actions in the past have dealt with the subject in a more indirect or more limited manner. Their total effect has been increasingly apparent, and they have contributed to the steadily broadening and deepening of public control of land use.

The "Quiet Revolution"

Land use control is by no means a new concept in California. Federal, state, and local government as well as public initiative action have all contributed a variety of control mechanisms. In recent years, principally in response to environmental concerns, there has been a rapid increase in land use controls, many indirect, but some quite specifically directed toward limiting or shaping the nature of land utilization. The National Environmental Policy Act of 1969 (NEPA), among other things, established the Council of Environmental Quality. Its report on land use and associated environmental issues spoke of this proliferation of controls as the "quiet revolution".

The following presents some of these legislative, administrative, and public land use control actions that have taken place through the years.

Federal. The Federal Water Pollution Control Act Amendments of 1972 include the goal that the discharge of pollutants into navigable waters be eliminated by 1985. The Clean Air Act of 1970 grants land use controls to agencies regulating air pollution under the 1965 Housing Act. The Housing and Urban Development Agency requires that there is a "certified" regional planning activity in every metropolitan area in order to qualify communities for receipt of grants for a variety of urban-related purposes. The 1966 Demonstration Cities and Metropolitan Development Act empowered the regional planning agencies to review application for federal grants from both public and private bodies. The Federal Flood Insurance Program requires local government to zone and otherwise control land use in flood prone areas.

Probably most significant at the federal level was the establishment of the Environmental Protection Agency (EPA) in 1970. This consolidated some of the above programs and others dealing with air pollution, water pollution, solid waste disposal, pesticide regulation and atomic radiation in the environment. EPA has some authority to use land use controls to accomplish the objectives of these programs. The limited use it has made of this power reflects the somewhat disaggregated character of its statutory authority.

In addition to the above, Federal Government influences on land use are often quite significant as a result of congressional and federal administrative decisions regarding location of key federal facilities, the awarding of contracts, and other major federal financial investments.

State. The 1949 water quality control legislation and the Porter-Cologne Water Quality Act as well as the establishment of the Solid Waste Management Board and the Air Resources Board created state government agencies designed to formulate and enforce provisions for control of pollution.

The Porter-Cologne Water Quality Act enables regional water quality control boards to place a freeze on new sewer connections until waste treatment problems are solved. The Air Resources Board has the power of land use control through provisions of the federal Clean Air Act of 1970.

The Cobey-Alquist Flood Plain Management Act prescribes the manner of cooperation between the Department of Water Resources or the State Reclamation Board and local government in developing regulations to control land use within flood-prone areas.

The Agricultural Land Conservation Act (Williamson Act) passed in 1965 was a major step toward preserving agricultural lands from urbanization. Although there is current debate over how successfully it accomplishes this purpose, without question, it has had some positive effects on the agricultural industry. The act allows agreements to be entered into by private land owners and county government whereby the land is retained for agricultural uses in exchange for tax assessment based on value of agricultural production, rather than on the traditional "comparative" sales basis. The act was amended in 1967 to allow these agreements to be drawn in land use cases other than agricultural, i.e., scenic highway corridors, wildlife habitat, wet lands, submerged lands, salt ponds, recreation lands, and open space.

The Legislature created the San Francisco Bay Conservation and Development Commission in 1965, and in 1967, the Tahoe Regional Planning Agency was formed. In 1972, through initiative action and by direct public election, the California Coastal Zone Commission was established. All three entities are looked upon as representing the most direct and significant involvement by state government in areas of land use control formerly under the exclusive jurisdiction of local government. The nature of the problems and the degree of success experienced by these agencies undoubtedly will have impact on future statewide land use planning and control legislation.

Pending state land use policy and control legislation might be considered to be potentially the most significant state action impacting land use decision-making to date. From the sense of direct consideration and control of land use this may be true. However, legislation already enacted probably has had equally as broad an influence, albeit more indirect, on land use decision-making. The California Environmental Quality Act, passed in 1970, required government agencies to prepare environmental impact documents covering activities they intend to carry out. The Friends of Mammoth decision by the California Supreme court expanded this responsibility to include environmental impact analysis by public agencies having discretionary or financial responsibilities over proposed private activities.

The Environmental Impact Reports constitute an important tool for the decision makers (and their constituents). The requirement to include all pertinent basic data and the descriptions of possible direct and peripheral impacts makes much more of the available knowledge readily accessible to the decision makers than has traditionally been the case.

In 1970 the Legislature declared that future growth of the State should be guided by an effective planning process, which includes a framework of "officially approved statewide goals and policies directed to land use, population growth and distribution, urban expansion and other relevant physical, social, and economic development factors".* To carry out this process, the Legislature created the Office of Planning and Research and placed it within the Governor's Office.

The Office of Planning and Research produced a state Environmental Goals and Policy Report † which was approved by the Governor in June 1973. It contains general goals and policies on such subjects as water, noise, air quality, transportation, population, pesticides, land use, environmental resources and hazardous areas. The report lists potential areas of statewide critical concern, plus eleven basic principles which provide a framework for assessing the intent of the goals and policies and the government's role.

The report looks to the State to exert leadership in areas classified as of statewide critical concern and, through its departments and political subdivisions, to undertake measures to minimize those activities which will have a detrimental effect on such resources. The report also states that programs are encouraged which will enhance the quality of the areas of concern or at least optimize their use without destroying their inherent value. Activities, such as providing water and other governmental services, which support development of areas identified as of hazardous concern (fault zones, fire hazard, flood-prone areas, etc.) should be avoided.

Local. Traditionally, control of land use has resided in the hands of local government. Zoning ordinances have been based on many considerations, such as separation of industry from residential development, ability of soils to adequately handle septic tank leachate, stability of hillsides relative to erosion and sedimentation potential if disturbed, building height limitation, and others. This traditional approach to land use control has received much criticism for its apparent lack of strength in the face of development pressures. More importance is being placed on the preparation of sound County General Plans to provide the framework for decision making.

The State Planning Act in 1929 required counties to adopt master plans. In 1947, this Act was replaced by the Planning and Conservation Act that require cities also to prepare such plans. During the period 1967 through 1971, state legislation was enacted that added separate and specific elements to the require-

* Chapter 1534, Statutes of 1970.
† "Environmental Goals and Policy", State of California, June 1973.

High altitude photograph taken over the lower Sacramento Valley from a U-2 plane during the summer of 1974. Water-using areas (green fields) stand out as red in the picture. The Sacramento River winds through the right side of the picture. The cities of Woodland (upper left), Davis (lower left), and part of Sacramento (mid-to-lower right) can be seen. Note the light colored areas which are plots of unirrigated land in an intensely developed agricultural area. *NASA photo* ments for the general plan (i.e., master plan). These were the housing element, the conservation element, the open space plan, and the seismic safety, noise, scenic highway, fire protection, and geological hazards elements. Although much work remains to be done in most counties even to assemble the necessary data for satisfactory analysis of these subjects, the requirements have forced consideration of many aspects of land development not covered to any obvious degree in earlier cases.

Recent dramatic land use controls at the local level precipitated by citizen action have occurred in the communities of Palo Alto, San Diego, and San Jose, and in Marin County. These have ranged from initiative action to freeze or slow growth pending specific studies or other action, to the disapproval of bond proposal for financing utility development. The extent of future impact of this type of action is uncertain, as some have been overturned in the courts.

Questions of personal property rights, of alternatives to property taxes as the principal local funding instrument, of how to achieve a balance between social, economic, and environmental objectives, and other difficult questions remain to be adequately answered.

Land Use Planning and the Department of Water Resources

The Department of Water Resources does not engage in land use planning, but it does make land use studies. In planning of water projects and coordinating the plans of other agencies, the Department's procedures are reactive rather than proactive. It projects what it believes will be the most likely land use under existing public policies. Since the major consumptive use of water in California is by irrigated agriculture, it goes into considerable detail, projecting areas and types of cropping. It works with population projection and distribution. The planning takes into account current trends and considers probable future trends.

The Department has made major contributions to recent deliberations in the State administration on land use planning. Its data files on present and past land use are extensive and widely used. Plans for water management will be an essential and integral part of comprehensive land use plans. The Department will be able to contribute in numerous additional ways to any land use management program that may be adopted by the State.

CHAPTER II

KEY WATER POLICY ISSUES

A significant aspect of the greatly expanded public concern for natural environmental conditions is the need for greater consideration of interrelationships of actions, "trade-offs", and secondary effects. The need to evaluate the interrelationships, and frequently even their existence, is not always recognized. The complex interrelationships need to be understood to avoid simplistic or partial solutions to water problems.

The following discussions outline some of the current water policy issues that need thorough consideration. In some cases adequate data are not available to make complete assessments of the interrelationships currently considered important. Awareness of these and the likely direction of the effects is, however, very important to sound decisions. Every effort should be made to avoid actions that produce unexpected and adverse results. All of the issues relate to changing public attitudes that affect or are affected by water development and management. The principal cause for the changes relates to revised views on protection and enhancement of the natural environment.

Over the past quarter century, the technology of economic analysis as applied in the planning, formulation, and design of government-sponsored water resources development has reached a high level of sophistication, particularly as compared with the analysis of other government-sponsored programs. This technology, based largely on economic criteria, has its critics and its difficulties. When properly and conscientiously applied it provided a tangible basis for decision making in connection with implementation of major water resources development and the allocation of the costs among beneficiaries.

Within recent years, however, this approach to the decision making process has been seriously challenged by those who contend that preservation and enhancement of the natural environment, and social considerations, are of primary concern in connection with any development-oriented undertaking. These considerations are highly qualitative, judgment oriented, and not readily adaptable to quantitative expression or economic dimensioning. When included in water project development they result in benefits and costs which may significantly affect the cost of other products and services.

In an expanding economy under conditions of increasing population, maintenance of the status quo, or the "no project alternative", usually represents a cost in itself, since the products and services which society demands must be supplied from a more costly alternative. Indeed, the "environmental movement" and the increasing awareness and concern on the part of the general public for the natural environment and esthetics appear to be side effects or results of increasing economic affluence in a large sector of society.

Although environmental and esthetic goals involve economic aspects, it is not necessary that these considerations be forced into a rigorous economic framework. Care must be taken, however, to adopt a reasonable balance between economic factors and subjective factors to provide opportunity for the economically handicapped portion of society to increase its level of economic affluence to a point where it can participate in the natural environmental and esthetic amenities of California. Such an approach would recognize the impact of water management actions on the environment as well as recognize the economic and social impact of development. There is need for a straightforward, workable basis for formulating and evaluating water resources development, and for allocating the costs of such development among all beneficiaries, including those for whom the natural environmental and esthetic considerations are enhanced.

The issues presented in this chapter have significant potential impact on the public and most have received public attention. Most have been extensively reviewed and discussed in various forums including the workshops held by the Department of Water Resources in the preparation of this bulletin. While the subjects have received wide attention, the ramifications of the courses of action have not always received the attention necessary to develop public policy and decisions.

Cooling Water for Electric Energy Production

The cooling water policy issue arises because limitations on locating power plants on the coast are creating a substantial previously unplanned-for demand on inland water resources. Significant resource trade-offs and costs result from the coastal limitations.

In recent decades most of the increased demand for electric energy in California has been met by constructing thermal electric plants. Although the remaining hydroelectric potential is significant, pollution-free, and nonconsumptive of fuels (as pointed out in Department of Water Resources' Bulletin No. 194, "Hydroelectric Energy Potential in California") the majority of future energy requirements must still be met by thermal generating plants. Thermal plants require some high quality water for steam generation, which is frequently obtained by distillation, and much larger quantities of cooling water to recondense the steam and to remove approximately 50 to 60 percent of the heat which cannot be converted to electricity due to natural heat exchange limitations. This cooling water is either passed through the plant and discharged back into its source or recycled through cooling towers where heat is removed by evaporation.

Thermal electric plants located along the Pacific Ocean or its bays and estuaries take advantage of the large volume of cold water available and use once-through cooling systems. Concerns about the marine environment, the esthetics of coastal plants, and the safety of structures against earthquakes, however, have greatly restricted further construction of new plants along the coast during the past few years. The present trend is toward location of new thermal plants at inland sites. Plants in these areas will require recirculation of the cooling water, most of which must come from fresh water resources. The number of new plants which will be constructed at inland sites will depend on many factors but it is possible that the cooling water demands may range between 300,000 and 400,000 acre-feet annually by the year 1990. Even more water might be required in later years, although technological advances may improve cooling methods and energy conservation programs may slow the rate of growth in demand. The U.S. Environmental Protection Agency is currently proposing that all existing plants stop using ocean water for cooling and switch to other sources. To do so would require by 1977 about 200,000 acre-feet of fresh water annually. The Department of Water Resources, State Water Resources Control Board, and the electric utilities have expressed concern to the Environmental Protection Agency that such a requirement is impractical and unnecessary.

Many of the natural environmental concerns about coastal sites apply equally well to inland sites. While there are impacts on marine resources from use of ocean water for cooling, the development of additional surface water supplies for inland plants will also have environmental impacts on fresh water fish and wildlife resources. Similarly, concern with the esthetics and scenery on the coast will be translated to analogous concerns at inland locations. Plants at coastal locations using once-through cooling are not as large and imposing as ones located inland with their large cooling towers, which typically are several hundred feet tall if natural draft is used. An alternative to cooling towers would be construction of large ponds, which could be esthetically pleasing but require large areas of land. Consideration is currently being given to using air cooling, in which the cooling water is recirculated through a radiator system similar to that used in an automobile. These costly systems, however, would require very large installations covering large areas in order to provide enough cooling surface, and they also require energy for pumping.

Water for cooling at inland locations, however, can in part be obtained from waste water discharges which may be too brackish to use for other purposes. Waste water that would otherwise be discharged to the ocean that could be used for power plant cooling could result in an overall economic benefit. The cost of electric generation may be somewhat greater than if fresh water is used due to the cost of pretreatment of the water. The cost of disposing of the waste water, however, could be much lower because the volume may be only about one-tenth the initial volume due to the concentrating effect of the evaporative process.

Ocean water cooling at Diablo Canyon nuclear power plant

In the Central Valley there will be signficant quantities of waste water which must otherwise be discharged to the ocean. This water must be collected, treated, and stored for cooling. Some discharges into the Salton Sea may also offer potential for power plant cooling. The level of the Salton Sea would, however, be lowered and the salinity increased. This would have an impact on the fishery resources and the recreation use of the Salton Sea.

A major untapped source of waste water would be the urban discharges to the ocean and its estuaries. Due to safety and environmental considerations, it has been difficult to locate power plants near the metropolitan areas, and the use of urban waste water for cooling would involve extensive collection and transmission facilities.

An additional factor involved in the source of cooling water is the physical advantage of the cold Pacific Ocean over inland water supplies. The ocean water in Northern California is generally 20–25 degrees colder than inland supplies and therefore is a more efficient coolant. The difference in Southern California may be around 10–15 degrees. The increased efficiency of power plants using colder sea water when compared to plants operated inland with warmer waters and evaporative coolers would be equivalent to between 15 and 20 million barrels of oil annually for the additional plants needed by 1990.

Boards and agencies responsible for developing coastal zone and control plans, the Legislature, and the public should be aware of the trade-offs which are involved. The esthetic impact on the coastline should be compared to the trade-off of a highly visible inland site with its massive cooling towers. Waste water in the San Joaquin Valley used for cooling at inland sites might be some of the water now used for Delta salinity control and would have to be offset by fresh water outflow. Until waste water can be collected and adequately treated, it may be necessary in some areas of the state to use fresh water for cooling thus imposing additional stress on the state's water supplies. The coastal site limitations on power plants will create very similar inland problems.

Water Deficiencies

The size and scheduling of future water conservation facilities, particularly for the State Water Project and the Central Valley Project, depend to some degree on the certainty of meeting contractual delivery schedules. If it is not necessary to fully meet the contractual commitments during dry years, the water supply available during "normal" or wet years can be spread out to more users, or the date by which additional conservation facilities are needed for a given service area can be deferred. This latter concept is the basis for suggestions for increasing the yield of the State Water Project and the Central Valley Project by simply expanding the degree of risk in meeting water delivery commitments. The policy issue is whether an increased degree of risk should be borne by water users in order to defer or avoid additional water development. Equitable consideration of any increased risk would involve all water uses, including municipal and industrial users, agriculture, fish and wildlife, recreation, and hydroelectric generation.

The dependable or firm yield of each water project traditionally has been based on the capabilities of that project to furnish water service on some prescribed pattern or schedule during the most severe drought of record. Built into this approach are tempering allowances for reduction of water deliveries in critically dry years. For example, State Water Project contracts with agricultural customers provide for maximum deficiency of up to 50 percent of contractual amounts in any one year and up to 100 percent cumulative deficiency over a seven-year period after which municipal and agricultural users jointly share any further shortages. The practical effect of these deficiency allowances in project planning and design is to build in some degree of risk, but the amount of risk is usually not statistically determined.

For water projects using Northern California water supplies such as the Central Valley Project and the State Water Project, the historic drought which occurred during the six water seasons 1929 through 1934 is the critical period for project water yield studies. This period was the worst sustained drought in the Sacramento River Basin in the 120 years of record in terms of length and severity. The driest single runoff year in the past 100 years was 1924 (1864 was probably slightly drier, based on very limited rainfall records).

The recurrence interval of a six-year drought comparable in severity to the 1929–1934 critical dry period is not known. Estimates range from between 100 and 400 years, and the best estimate at this time is that a similar drought could be expected about once every 200 years on the average. It could occur twice in successive decades, however.

Critics of the traditional "historic critical period" method have suggested that probability methods be used for determining the design size and water yield accomplishment of water resource projects. With the advent of the electronic computer, this approach is possible, but the matter of risk remains. Three aspects need to be evaluated somewhere in this process: (1) assessment of the level of risk built into the traditional approach, an extremely important point to those holding existing contracts for firm yield; (2) the economic effect of water shortages on various types of use; and (3) the degree of risk of water and hydroelectric power shortage which the public is able or willing to accept and the equitable distribution of such risks.

The same water development system might be able to provide more water on the average than the calculated dry period safe yield, if sufficient conveyance capacity existed. Operating in this manner would tend to use all or much of the reservoir carryover reserves during the current year rather than a longer and more conservative carryover as assumed in conventional studies; therefore, the shortages which occur would generally be greater. The average water supply would be increased, but the lack of dependability would also be increased, causing dry year hardships for some water users whose investments may require a firm or dependable supply. Hydroelectric power production would also be reduced in dry years due to lower water levels in reservoirs. This would require additional installed capacity in new thermal electric plants.

The sharing of water deficiencies between agencies under drought conditions would be constrained by institutional and legal considerations. Water rights are property rights and there is no legal basis for sharing between users of different basins.

Cost Sharing of Environmental Enhancement

As a general principle of equity, the cost of mitigation, due to the loss of a public resource, such as fish, have been borne by water project beneficiaries. Considerable efforts have been made to compensate for certain unavoidable losses. For example fish hatcheries have been constructed to replace the loss of fish spawning areas due to dam construction. These have been accepted as project costs. There has not, however, been a corresponding degree of concern with cost sharing for the benefits received when enhancement occurs.

In large federal water projects, such as those on the American River, there are generally many years between the time of authorization of a plan of accomplishments with its corresponding cost-sharing formula and the time the project is completed and in operation. Public pressures for changes in plan or operation to enhance the natural environment are common but generally do not include any proposals for changing the cost-sharing formulas. In some cases large segments of the public can be benefited by project changes, while in other cases only limited numbers of people enjoy the benefits. Frequently, significant benefits incidental to the main purpose of project operation, such as a live summer stream with enough flow to produce "white water" rapids favored for recreation or an esthetically pleasing stream flow, are taken for granted. Intensive public pressures are applied to retain the windfall benefits but little or no indication is made as to what project costs should be assigned to those benefits or how they should be paid for. The result is often long delays in carrying out the water program.

In the Water Rights Decision 1379 of the State Water Resources Control Board provision was made for fishery enhancement. This decision, which calls for mitigation as well as enhancement, establishes certain water quality conditions in the Sacramento-San Joaquin Delta which would in part be dependent on release of stored water. It would require about 500,000 acre-feet annually of stored water from the State Water Project and the federal Central Valley Project to achieve the prescribed conditions for enhancement.

Release of stored water to the lower American River enhances recreation

To make up the loss of water resulting from the decision would require the construction of a new water storage project in the Upper Sacramento Valley or the North Coast.

Among public works projects, water development undertakings are in the forefront on economic justification, that is, benefits versus costs, and on cost allocations. Over the years legislative acts have identified certain types of project accomplishments which are sufficiently widespread to warrant repayment from general taxes. This was the purpose of the Davis-Dolwig Act which applies only to the State Water Project. For federal water projects provision for enhancement may be included at time of authorization, but great difficulty has arisen when these benefits have been added ex post facto. As the type and scope of environmental amenities expand, public policy on cost sharing has not kept pace, and financing and repayment obligations have been assigned by default. There is a pressing need for further conscious consideration of the degree of general public benefit which could be paid by general taxes, and the extent of direct user repayment by the specific beneficiaries. The process of evaluating public interest in paying for various environmental benefits would identify the relation between benefits and costs and may indicate the need to revise some goals.

Water Quality Improvement

Concern for the quality of the rivers and lakes of the nation has become a major public issue in the last decade. The state and national programs for water quality improvement involve large sums of money and material and human resources, as well as releases of stored fresh water in some cases. The United States is now planning to spend billions of dollars over the next few years for clean water. Grants of up to 75 percent of the cost of waste treatment facilities are available to local communities. In California an additional 12.5 percent can be obtained from the State. These programs are designed to treat wastes from municipalities. They call for secondary treatment of all wastes by 1977, the best practicable treatment by 1983, and elimination of all pollutant discharges to navigable waterways by 1985. There are also requirements for major improvements in industrial waste discharges. Increasing attention is being directed to agricultural return flows. Concern is also being expressed with the loads of pollution which run off from streets and urban areas during storm periods, and means of controlling these wastes are being considered.

Benefits from the quality improvements have generally not been assessed in quantitative terms and compared to the costs, particularly the incremental benefits and costs resulting from varying levels of treatment. The issue of cost effectiveness was raised by the National Water Commission in its report of 1973. The Federal Water Pollution Control Act calls for a high degree of uniformity in requirements throughout the country. The water supplies, seasonal precipitation patterns, present quality of rivers and lakes, and historic pollution control vary widely, however, and many of the requirements for humid and industrialized eastern states do not fit the California case. Strong water quality control has been in effect in California since the late 1940s, and in 1969 this control was further strengthened with enactment of the Porter-Cologne Water Quality Control Act. This Act establishes as state policy that the quality of the water resources of the State shall be protected for the use and enjoyment of people and that activities which affect quality shall be regulated to attain the highest water quality which is reasonable considering all uses of the water and all values involved. These qualified policies call for a balance between various water uses. The general public in its support for better water quality or waste treatment may not take into account the tradeoffs that such a program imposes. This could be in the form of higher taxes or prices for goods and services.

Practically all of the attention has been directed toward the reduction of discharged pollutants. Less attention has been directel toward desirable degrees of water quality in the rivers, lakes, and ground water bodies for beneficial uses. Since these are the sources of water supply for other users, there is a relationship between the quality of the supply and the benefits derived by the subsequent user. In most cases there is a wide range of qualities which are fully satisfactory to meet consumptive urban, industrial, and agricultural needs as well as fish, wildlife, and recreation needs. The incremental savings which may result from providing better quality water within that range may be far less than the costs of providing the incremental improvement. As the quality of the water supply deteriorates, the incremental costs to the user become increasingly greater, and in this range there may be justification for larger expenditures on water treatment.

In addition to the overall question on the appropriate level of water quality achievement, there is the consideration of the payment of costs. Where there is widespread public benefit, it is generally satisfactory to use public taxes. Where identifiable commercial interests are involved, the costs are generally assigned to those interests but these increased costs of production are, in turn, passed on to the product consumers.

Some proposals and requirements for water quality improvement involve releases of stored water from existing or future water projects. Dedication of the yield of projects to this end may mean construction of additional and more costly facilities if other water requirements are to be met. The additional costs would be passed on to a different group of beneficiaries unless special provisions are made for repayment. There may also be environmental costs with additional water development which would be an offset to the environmental enhancement achieved by use of stored water.

It is reasonable that additional consideration be given to all types of benefits of water quality improvement to be certain that benefits equal or exceed costs or offsets. Congress has recognized the need for methods of evaluation and the federal program is being evaluated by the National Commission on Water Quality. The Commission report is due in October 1976 and guidelines from this effort are anticipated.

Water Supplies as a Growth Regulator

There has been increasing activity in recent years to limit population growth by restriciting water supplies. Most of these efforts have been at the local community level, but there are those who suggest that the denial of additional water would stop population growth in Southern California and thereby alleviate air quality problems, further congestion, and so on. Water is necessary to support growth as well as the status quo, but it is equally true that the factors influencing growth are many.

In California, a State of over 20 million people, much of the pressures of growth are related directly to natural population increase. Decisions regarding numbers of children are matters of individual family planning and are based on considerations other than the availability of water. There is no evidence that decisions to migrate to or from California or to other areas within the State are made on the basis of an assured water supply. Such movement has been induced principally by climatic, social, or economic reasons. Environmental quality is also becoming a motivating factor and is affecting some growth patterns.

When considering the growth issue recognition should be given that curtailing services such as water supplies may not, in fact, limit growth but induce health hazards, environmental degradation, and other complications. Further, in most California urban areas growth would still be possible where water is in short supply by taking water conservation, reclamation, and reuse measures. Finally, localized moves to control population expansion, if successful, might simply transfer the growth and associated problems to another area.

Government at all levels has mechanisms at its disposal to influence population growth patterns. A broad policy to do so, however, does not exist. When and if such should occur, the State's water resources can be adjusted to accommodate growth patterns. The more significant hurdles may be legal and institutional. Aside from recent court decisions confirming the right to move, significant changes in water law would be necessary. Government can largely control further development of surface water simply by withholding funds for building projects. The surface water supplies remaining to be developed require large projects to be economically feasible and are generally beyond the means of private individuals or the smaller public agencies. Ground water in California is another matter, however. In all but the adjudicated ground water basins of the State, any local public agency or an individual can construct a well and obtain water for a variety of purposes. Under existing law, the state or federal government has little influence on use of ground water except in those few areas where the basin has been so severely overdrawn that the courts through the adjudicatory process have placed limits on the further withdrawal of ground water. A whole new body of ground water law would be required for the State to be able to designate areas that could not use available ground water to support further development.

Another factor to be considered in limiting growth would be the payment of costs incurred and obligated in existing water projects that have been sized and constructed to support future growth.

Role of Water Exchanges in Water Management

As California's water supplies become more fully used or reserved for natural environmental uses, such as wild and scenic rivers, it becomes increasingly important to review water rights and management policies. Many changes would involve revised laws, but frequently much can be done within existing laws or with minor modifications. Significant policies, such as water rights, water pricing, water quality, and flexibility of operations, are almost always involved.

There are opportunities for water exchanges which could be considered to reduce the expenditure of resources to meet future needs and to make more effective use of available resources. Each case will have its own particular problems. It will almost always be necessary to make some financial arrangements, and in many cases there would be water quality considerations. Two key ingredients to agreements appear to be earnest desire by water users to improve the service of their agencies, and mutual economic advantage for each agency. Public interest in the concept would stimulate dormant opportunities. Some past exchanges and potential opportunities that have had some attention are described in the following paragraphs.

Each additional increment of water supply is generally more expensive than previous increments, and frequently long distances between source and area of use are involved. Water supplies are sometimes conveyed through areas which already have adequate supplies or which only received a small additional supply from the system passing through the area. In other cases, areas which have been slow to develop are faced with high costs because supplies originating in or nearby the developing areas have already been appropriated by a downstream or distant area. In some places,

Growth in Southern California—1954 to 1974. *(Spence Photo—UCLA and DWR)* water of excellent quality is used once and discharged to a marine water body and lost. If an alternative and available supply of adequate but lower quality water would suffice, the water of excellent quality might be made available for more than one use.

Possibilities for water exchanges are enhanced when they can be combined with major regional transfer works such as the California Aqueduct of the State Water Project and the Central Valley Project. For example, the Desert Water Agency and the Coachella Valley County Water District have arranged with The Metropolitan Water District of Southern California to take Colorado River water for a few years from the Colorado Aqueduct which goes through their area and, in turn, assign to the Metropolitan Water District their water supply from the State Water Project. This exchange permits the two desert districts to defer a major outlay of funds for a conveyance system to connect with the California Aqueduct until later when demands are greater and the financial base of the districts is larger.

In terms of the quantity of water, the largest exchange in the State involves the Central Valley Project. Water from the Sacramento Valley is conveyed through the Delta-Mendota Canal to Mendota Pool on the San Joaquin River to replace supplies in the river which are diverted at Friant Dam and conveyed southward through the Friant-Kern Canal as far as the Bakersfield area.

Study is being given by the state and federal agencies and the Pacific Gas and Electric Company to increasing dry season in-stream flows in the Eel River below Van Arsdale Dam by using some of the water stored in Lake Pillsbury and diverted by Pacific Gas and Electric to a power plant on the East Fork Russian River. This trade would result in a reduction in power output and some reduction in water supply to the Russian River Basin. Primary benefits would be enhancement of Eel River fisheries and recreation in northern Mendocino and southern Humboldt Counties, plus a possible supplemental irrigation supply in the Eel River Delta.

Where a ground water basin has been adjudicated, as, for example the West Coast Basin in Los Angeles County, exchange of water may occur when surface water is also available. Operation of the basin to reduce sea water intrusion is possible by the reduction in pumping of some overlying owners in exchange for surface water importation. Such exchange also factors in any cost and quality differences between the two sources.

Proposals have also been made to use Los Angeles' Owens Valley Aqueduct Water in communities adjacent to the aqueduct, such as China Lake-Inyokern, in exchange for Northern California water delivered to the City of Los Angeles via the State Water Project and Metropolitan Water District's facilities.

Although the opportunities for exchanges exist, such factors as cost, quality differences, and legal and institutional constraints will often present formidable problems. In the final analysis such exchanges may save conveyance costs but do not obviate the need to develop dependable water supplies.

Public Interest in Agricultural Drainage

Agricultural drainage in the San Joaquin Valley is a problem which could have a major impact on the State's agricultural economy and consequently, upon the economic well-being of a significant portion of the State's population. Some 150,000 acres of presently productive land will become seriously degraded within the next decade unless some corrective measure to remove salt and reduce water tables is developed. An additional 800,000 acres are in jeopardy of a similar fate unless corrected within the next two to five decades. With increasing demands for food, losses of agricultural production in this magnitude would have significant impacts on the economy of the State.

The fundamental problem involves "salt balance" in the San Joaquin Valley where only a part of the salt residue resulting from the consumptive use of local and imported water supplies is discharged from the Valley. The greater portion is simply accumulating in the ground, water and soil. If the productivity of the San Joaquin Valley is to be maintained, this salination process must be stopped and reversed.

The general approach to maintenance of salt balance is to remove the salts from the area in the form of concentrated saline waste water collected as natural drainage or from subsurface drainage systems installed by the irrigators. The San Joaquin River now serves as a conduit for the removal of such waste water in the northern or San Joaquin Basin portion of the Valley. The river also is a source of irrigation water and, at times, the quality is only marginally adequate and further degradation cannot be tolerated. The larger Tulare Lake Basin portion of the San Joaquin Valley is essentially a closed basin with no outlet, and the problem of salt balance in this area is particularly threatening since none of the salts are leaving the basin.

A master drain system for the San Joaquin Valley is an authorized part of the State Water Project, and the Department of Water Resources has made extensive studies of the drainage problem in the Valley and has developed a plan for a master drain system. Difficulties in obtaining repayment contracts with beneficiaries have so far prevented implementation of the plan. The major problem has been that, though a large portion of the San Joaquin Valley contributes to the problem, only those areas which actually suffer damage have thus far been called upon to repay the costs of implementing the drainage plan. Some means is needed to finance and assign responsibility for repayment of the costs of such a system on an expanded repayment base. Benefits to the State in maintaining its number one industry—agriculture, are threatened unless some repayment means are found. The costs would be partially borne by electric power users if thermal electric plants located in the San Joaquin Valley use agricultural drainage water for cooling.

A closely related and significant environmental problem is the manner of disposing of the saline drainage water. Drainage conveyed to the Sacramento-San Joaquin Delta may require removal of the nutrients to avoid undesirable algae conditions in the Delta channels. The water would, however, provide a portion of the outflow needed to control intrusion of salinity from the bay system which would otherwise have to be provided from fresh water sources. If the drainage water is ponded in the valley and removed by evaporation, large land areas would be required. Concentrated brine blowdown from power plant cooling would require much less land area. Any inland storage areas would need to be sealed to prevent percolation to ground water and any such plan may only defer an ultimate solution of salt removal. If the water or the salt cannot finally be disposed of at inland facilities or to the ocean through the Delta, it will have to be conveyed by conduit and discharged directly into the ocean at an offshore location. Environmental concerns will be involved in any disposal alternative, and some impact is unavoidable for continuation of the agricultural economy of the State.

Flood Damage Prevention

There are basically two means to prevent flood damages. They are (1) stay out of the way of floods, or (2) keep the flood flows in defined channels either with or without upstream regulatory storage. Both methods have been used throughout the history of California with the greatest emphasis being placed on controlling floods. Although a great deal of money has been spent on structural control measures, such as reservoirs and leveed channels, annual flood damages continue in many unprotected areas. More attention to staying out of the way of floods—flood plain management is being urged.

Significant amounts of public funds and natural resources, as well as control of land use decisions, are involved, and it is increasingly important to give thoughtful consideration to the various aspects of flood damage prevention alternatives.

The nature of California's topography is a major factor in considering this issue. Most of the mountains are geologically young and quite steep. The valleys and plains are composed of the sediments washed down from the mountains. Most of the easily habitable land is a flood plain. Stream channels are naturally inclined to extensive changes in course as sediments build up. Levees and channel works are necessary to keep the floods within reasonable limits, if the flood plain is inhabited.

Staying fully out of the way of floods in California is probably not practical as a complete solution. In some of the mountainous northern California counties, practically all of the "flat" land is in a flood plain and further economic development would be severely limited if it could not take place in the flood plain, but structural control measures would be required. The desire to maintain streams in their natural state for wildlife or scenic values, particularly in urban areas, will necessitate strong land use controls.

Major flood control reservoirs can adequately reduce most flood peaks, but in all cases they are designed to operate with high release rates to accommodate large inflows from a major storm when the reservoir is nearly full. These high release rates, even though far smaller than the natural flood flows, generally are so infrequent that the public does not recognize that they may occur. Consequently, the flood channel becomes encroached upon by downstream development in the absence of adequate zoning protection. The Sacramento River below Shasta Dam, particularly in the Redding area, and the Santa Ana River in Orange County below Prado Dam are two examples.

Land use control—and flood plain management is a major form of land use control—is, under existing state law, the responsibility of local agencies. Failure to adequately zone, and regulate in accordance therewith, at the local level tends to create laws and programs administered by state and federal governments. To prevent development in floodways in which the State financially assists local agencies to provide rights of way for federal flood control agencies to construct flood control projects, the State has since 1965 under the Cobey-Alquist Act required that the local agency zone and regulate the channel area. For areas identified by the U. S. Department of Housing and Urban Development as having special flood hazards, flood insurance is a requirement to obtain a new or additional loan from a federally insured financial institution, if such insurance is available. After July 1, 1975, loans cannot be made unless the community is participating in the national flood insurance program and insurance is purchased.

In addition to changing public attitudes regarding flood control structures in favor of greater emphasis on flood plain management, the record of unusual flood events continues to lengthen. It indicates that extreme events like the 1964 flood on the Eel River, the new 1974 peak inflow to Shasta Reservoir, or even the 1-in-500-year flood as occurred in Rapid City, South Dakota, in 1972, are possible and it is necessary to plan for increasingly intense storms.

As the State's growth continues, the potential for loss of life and economic investment also grows. The trade-offs between large investment of public funds, flood risk, and the environmental desires to maintain natural channels and wild rivers should be considered in future public policy decisions.

Water Pricing Policy and Its Effect on Demand

To reduce the future quantity of water used by urban areas and irrigated agriculture, suggestions have been made that water prices be raised. Urban users generally pay for water at a flat rate or a decreasing block rate under which the unit costs of successive blocks of water are priced at lower rates, similar to most electric power rates. Irrigation water in federal reclamation projects is priced at less than full costs. Price increases may reduce demand for future irrigation water. Some industries may also be encouraged to use less water or to reuse waste water. There would be related effects which must also be considered in any discussion of the price/demand relationship.

In the development of the State Water Project, an initial determination was made of the overall market for urban and agricultural water, and direct negotiations were undertaken with water agencies acting on behalf of individual customers. Contracts were signed that obligated the water agencies to pay full cost of providing the water, including interest. The aqueduct system was sized and built to convey the contracted for quantities of water. Repayment for the system is the obligation of the agencies. The additional costs of conserving and pumping the water is fixed by contract to the actual costs to the State.

To effect a significant change in agricultural water demands would require a governmental pricing policy for all irrigated area which would result in sufficiently high costs as to eliminate some farming enterprises. Such a governmental policy could not be extended across the agricultural sector under existing laws. Water is diverted or pumped by individuals and many public districts and, therefore, pricing is not subject to state or federal intervention. Since existing federal reclamation contracts have fixed the price of water, any increase could be effected only when those contracts come up for renewal or for future projects.

The California Aqueduct conveys contracted for quantities of water

In the case of urban water demands, the evidence is mixed but there are examples where a switch from flat rates to metered rates has resulted in decisive and permanent reductions in water use. This follows the usual expectation that an increase in price results in a decrease in demand, and the greater the price increase the greater change in demand. Behavioral patterns are oftentimes affected, which results in conservation practices including reductions in wastage from over-irrigation, lawn watering, and leaky plumbing fixtures. The duration of these practices will depend, in part, upon the costs of water relative to personal income and other expenditures. This applies to industry as well, but as long as the price of water is sufficiently high to be a concern, a reduction in water demand could be expected.

A significant question involved in increasing municipal water rates is who is affected and what may be the results. Most probably the low income group would be most seriously affected, as the more affluent families would be able to more easily absorb a cost increase. Environmental amenities such as lawns, trees, fountains, and parks would likely be reduced. The U. S. Forest Service has found that well-watered trees can reduce air temperatures on a hot, dry day as much as five degrees. They also found that a single city tree provides a cooling effect equivalent to five average-sized room air conditioners running about 20 hours per day.

In summary there is a relationship between water price and demand. From a practical standpoint the ability of federal and state pricing policies would have limited effect. The tradeoffs of local environmental amenities, economic and social well-being vis-a-vis the environmental benefits of leaving more natural stream flow or some streams undeveloped require thoughtful consideration.

Water Use Efficiency and Its Effect on Demand

A great deal of attention is currently being directed toward improvements in the efficiency of use of resources as a means of decreasing expanding demands and stretching available supplies. Possibilities for more efficient use of water, range from flush toilets that use less water to desert type landscaping or applying irrigation by controlled dripping at each tree. These and various other methods can reduce the amount of water used in homes and industry, and to irrigate crops. The degree to which they would reduce the overall requirement for water supplies, however, depends on several factors.

In evaluating the effects of improving the methods of using water, consideration must also be given to

Small sprinklers provide for efficient use of water

the disposal of waste water. Where the waste water is discharged to saline water, any reduction in the amount of water originally applied will provide an equivalent reduction in demand for developed water supplies. It will also reduce the size of the waste treatment facilities. This case generally applies to coastal urban areas but only to a very limited degree to agriculture. The principal areas where agricultural returns mix with brackish water are in the Coachella and Imperial Valleys which drain to the Salton Sea.

Throughout practically all other irrigated areas and at inland urban locations, almost all excess irrigation water or urban waste water becomes part of the supply for downstream users. Any reduction in the amount of applied water will result in approximately the same reduction in return flow and therefore require a comparable amount of water from an alternative sources for downstream users. With the exception of some savings in unavoidable losses, there will not be any overall savings in total water demand by improving the efficiency of application or use of water in such cases. There will, however, be other advantages and some disadvantages.

If less water is used, the costs of handling it, in particular energy for pumping, will be less. With less applied water there will generally be less leaching from irrigation, and the quantity of dissolved salts which need to be removed from the area will be less. The concentration of salts in the return flows, however, will be greater due to the reduced volume of water. Reduction in the waste water from urban areas will involve higher concentrations of salts unless there are also changes in the home and industrial practices which reduce the quantity of waste minerals.

Reduction in the amount of irrigation runoff from fields will be adverse to trees, brush, and native grasses, and the wildlife which depends on this vegetation. In most cases, and particularly the flat Central Valley, there would be scenic detriments from the loss of vegetation.

While the overall water savings from more efficient use probably will be relatively small in comparison to total usage, the advantages warrant thorough study. As water supplies become increasingly scarce improved use methods become more important.

Economic Efficiency as a Basis for Water Management

As California's supplies of undeveloped water have decreased, suggestions have been made that certain presently developed supplies could be diverted from uses having low economic returns to uses with higher economic returns. Generally this would involve a shift from agricultural production to industrial use, as well as a change in geographic location. It also suggests the shifting of water from one crop to another that might use less water and produce more economic return. Advocates of this view point out that there would be greater employment and wealth for a given quantity of water and there would not be need for as much, if any, additional water development. This concept also includes the purchase or shifting of water during periods of drought from one use such as irrigation of an annual crop to a use of greater significance to the State's economy. Such a concept has great ramifications and raises major policy issues. State law does not provide for administrative reassignment of water supplies being beneficially used.

A change in use would involve water rights as well as financial considerations. A major factor in buying out the water supply of an agricultural area is the relocation and social impact and change of life style on the people of the area. Payment for water and land values will not necessarily provide for relocation and/or gainful employment elsewhere, although some agricultural workers may retrain for industrial work if it is in the same general area. There may be increased costs in social welfare programs. It would be necessary to reimburse owners more than market values to obtain comparable relocated conditions and to assist in relocation.

Three generations have passed since the City of Los Angeles purchased the lands and acquired the water rights in the Owens Valley. The transfer of water from irrigation use to urban use was made and one of the world's major cities developed. This experience has shown, however, that long lasting social problems remain even though there was an increase in economic effciency.

Supplemental Water Through Waste Water Reclamation

Waste water reclamation is generally acclaimed as the primary alternative to further surface water development for meeting California's future water needs. This alternative, while probably the major potential supplement to surface water development, must also be viewed from the perspective of some limitations. The following discussion outlines some key considerations, such as dissolved mineral levels, health concerns, costs, and institutional conflicts, which strongly affect policy decisions by local agencies in pursuing waste water reclamation.

Waste water reclamation, as considered in this bulletin, is the planned renovation of waste water with the intent of producing usable water for a specific beneficial purpose. Biological treatment and/or demineralization may be involved.

It is important to distinguish between reclamation which results in improvement of the existing supply and reclamation which actually results in creation of a "new" supply. Both facets are important, but the creation of a "new" supply as supplemental water is the thrust of this policy issue.

Only when waste water would otherwise be discharged to saline water—or when water has been so degraded that it cannot be discharged to fresh water—does reclamation create a water supply which can be considered "new". Much of the water used in California is returned to the freshwater cycle, either directly after its use or following treatment. This includes 90 percent of the irrigation return water from nearly 9 million acres of irrigated land and the treated wastes from inland cities, particularly in the Central Valley. Although reclamation of this water would tend to enhance water quality, it would not create a new supply.

There are two main sources of water which can be reclaimed for new supplies. These are (1) the brackish agricultural drainage water which must be removed from the Central Valley and in particular the San Joaquin Valley, and (2) the urban wastes from coastal areas which are discharged to the ocean and its estuaries. It is anticipated that much of the agricultural drainage could be reclaimed for power plant cooling. The role for reclaimed coastal urban wastes is not, however, as apparent.

To undertake waste water reclamation there needs to be a supply of fresh water of good quality to begin with. Not all of this fresh water supply can be reclaimed, however. Up to 50 percent of an urban supply is used consumptively or incidentally lost. Another 20–30 percent of the initial supply is needed to carry off concentrated wastes and prevent accumulation of salts in gardens, parks, etc. Accordingly, only 20–30 percent of the original supply may be available for possible reclamation.

The mineral quality of the initial supply is important in evaluating reclamation. A single cycle of water use in an urban area normally adds about 300 milligrams of salts per liter of water. The recommended limit for salts in municipal supplies is 500 milligrams per liter (mg/l) but up to 1,000 mg/l is acceptable. A large share of the urban water supply in the coastal area of Southern California is from the Colorado River and has a salt content of around 750 mg/l. A single use would cause the salt to exceed the acceptable limit, and reclaimed water would require blending with less saline water. With an increasingly greater share of water from the State Water Project used in Southern California, the widespread mineral limitation on waste water reclamation would be reduced. At the other end of the scale, the Sierra Nevada water supplies delivered to the San Francisco Bay area through the Hetch Hetchy and Mokelumne Aqueducts are of excellent mineral quality with generally less than 100 mg/l. Water delivered by the State Water Project would average less than 220 mg/l.

At this time there are significant health concerns which greatly limit urban use of reclaimed water. Development and use of a wide range of organic compounds for industrial, agricultural, and household uses, which find their way into public water supplies, are causing concern regarding effects on public health. Many of the complex compounds are stable, that is, they do not break down into simpler forms, and persist for a long time. The long-term effect of ingesting even minute amounts of some stable organic compounds is unknown and, therefore, efforts are made to avoid use of water containing the compounds. Similar concerns exist regarding viruses which may not be fully eliminated in waste water treatment and reclamation processes.

Concern about viruses has caused health officials to reject direct distribution and use of reclaimed water for human consumption. Concern regarding effects of stable organic compounds has caused health officials to greatly restrict the use of reclaimed water for ground water recharge where the ground water basin is a source of water for human consumption. Since ground water moves very slowly and does not mix very well, reclaimed water would generally move as a unit away from the point of recharge and could remain in the basin for many years.

Until the uncertainties regarding health are resolved, plans for using reclaimed water are being directed toward nonpotable uses such as irrigation and industrial, especially power plant cooling. Efforts are being launched by local and state agencies to develop research programs on these health concerns. The Department of Water Resources, in cooperation with the State Water Resources Control Board with help from the University of California, is initiating work leading to specific and coordinated studies of the stable organic and virus problems.

General industrial use of reclaimed water would require separate distribution systems and in-plant modifications. The costs are generally not competitive with fresh water, although as the requirements for treatment of waste water increase, industry will find it more advantageous to recirculate its water. Thermal electric power plant cooling could be a major use of reclaimed water, but the plants cannot usually be located near urban centers for environmental and safety reasons. Consequently, the reclaimed water from urban areas would need to be conveyed long distances with considerable expense and use of energy.

In addition to the costs directly associated with reclamation, consideration must be given to costs already invested in facility capacity for future needs. These sunk costs are frequently quite great since many water projects and distribution systems are constructed with capacity for the future to take advantage of economies of scale. Economic evaluation of waste water reclamation must take into account the sunk costs in existing facilities.

Generally separate local agencies have been organized to handle water supply and waste. Full consideration of the reclamation of waste water may be inhibited due to institutional constraints. The appropriate agencies to pursue this potential is one of the policy issues needing attention.

CHAPTER III

ALTERNATIVE FUTURES FOR CALIFORNIA

This chapter presents the first phase of a two part approach to determining water requirements. It does so by focusing attention on the needs of people—needs that have an impact on the State's water resources—needs for goods and services, security, social well-being and the quality of life. Historical trends and forces that influence change are given special attention since an understanding of trends and influences is prerequisite to forecasting possible future growth. In addition emphasis is given to the possible variability of projected needs and their relationship with the factors that cause variation. The second part is accomplished in Chapter IV where the needs discussed in this chapter are converted to water requirements.

In previous reports the Department has made a single projection of growth which was representative of a "most probable" future based upon an extension of past trends and the public attitudes of the time. This report contains projections of "alternative futures" any one of which might occur under various assumptions regarding factors that influence change. While trend analysis remains a valid description of one possible occurrence and serves to indicate what may happen if no significant change occurs, it should not be presumed that the resulting projection is necessarily the most probable description of the future. An important justification for presenting alternative futures is recognition of the fact that there are a variety of possible events and outcomes which can bring about changes that do not mirror the past.

The importance of studying and evaluating a range of water management and demand alternatives and maintaining as much flexibility as possible becomes more evident when considering the uncertainties involved in projections of the nature, location, and timing of future events. Some of the factors which are particularly difficult to assess are the recent downward trend in the birth rate, the opening of China and Russia agricultural market, air and water quality standards, and future land use policies. Recognition also must be given to the need to identify environmental preservation or enhancement goals, assess their impact on demands for water, and establish their relationship with economic and social objectives.

Because of the rapid changes occurring in society, including its outlook and values, planning on the basis of alternative futures is extremely relevant. If properly presented, alternative futures do not presume what the choices should be but rather define the issues, the assumptions, possibilities, and consequences of certain actions and events taking place. The process recognizes that several futures are possible and that technological developments, unforeseeable events, changing public attitudes, and future policy decisions can affect the outcome.

Projected Needs

Alternative future levels for three of the major water using fuctions were developed for the outlook presented in this bulletin—urban, agriculture, and electric power plant cooling. Insufficient information regarding alternative outlooks for fish, wildlife and recreation, made it impracticable to present more than a single projection for these needs.

Future population will have a direct effect on urban water use in California. The U. S. population will have a direct impact on California agriculture since much of the State's production of food and fiber is used by the rest of the nation.

Production of food and fiber in California is by far the most significant single enterprise affecting use of the State's land and water resources. Future amounts of irrigated agriculture in the State will have a major impact on water resources management and planning.

Fresh water use for cooling thermal electric power plants has historically not been significant. Most of the major thermal electrical generation plants in California are located near the ocean or saline estuaries and use salt water for cooling. Current trends and environmental policies indicate that much of the future power generation facilities may be located in inland areas where fresh water resources would be the major cooling water source available.

Since water plays such an important part in human life and activity, a large number of factors influence the future uses and needs for this resource. Water management plans must necessarily therefore include functions such as flood control, environmental enhancement, and water quality maintenance. These needs are also discussed in this chapter but in qualitative rather than quantitative terms.

Population

California's population has increased each year for the past 150 years. During that span the growth rate has varied, but has exceeded comparable rates for the U. S. as a whole. Table 1 summarizes growth in California and the United States by decades since 1920.

Trends and Influences

In California, population growth is a product of natural increase and net migration. Until a few years ago, the latter was the principal contributor to the State's growth, but now with a population of nearly 21 million, natural increase is the predominant factor.

Table 1. California and U. S. Population and Percent Increase by Decades, 1920–1974

Year	Decade	California Population[a] (Millions)	California Population[a] (Percent increase)	United States Population[b] (Millions)	United States Population[b] (Percent increase)
1920	1920–1930	3.4	68	107	16
1930	1930–1940	5.7	21	123	8
1940	1940–1950	6.9	54	132	15
1950	1950–1960	10.6	50	152	19
1960	1960–1970	15.9	26	180	14
1970		20.0		205	
1972		20.5		209	
1974		20.9		212	

[a] Includes armed forces stationed in area.
[b] Total resident population. Prior to 1940 excludes Alaska and Hawaii.
Source: U.S. Bureau of the Census, "Current Population Reports", Series P-25, Nos. 139, 250, 469, 481 and 502.

Both influences have shown significant decreases since the mid 1960s, reducing the annual growth rate from about four percent in the 1950s to the present one percent. Had the earlier rate continued to the present and into the future, California could expect a population of about 56,000,000 in 50 years, or 20 million more than expected if present trends continue. This difference becomes especially meaningful when one considers that meeting the needs of 20 million people amounts to planning and providing for another California of the present size.

Attempting to anticipate future levels of migration and birth rates is fraught with uncertainties. Although voices have been raised for population policies of some sort, direct intervention by government to control population is not expected. Having or not having children will continue to be an individual decision, but the increasing availability, effectiveness, and acceptance of birth control measures make the realization of these decisions more a certainty. Since there is a larger number of women of childbearing age than ever before, the implication of this "personal" control could be drastic as suggested by the difference in population projections mentioned above. Similarly, governmental action to prohibit migration is not anticipated but the factors that stimulated an average annual 200,000 to 300,000 immigration for nearly 20 years after World War II are not expected to recur during the present planning period. Population estimates appearing in this bulletin are based upon immigration ranging from 0 to 150,000 annually.

Alternative Population Projections

Four alternative future population projections are presented in this report as shown in Table 2. It will be noted from the table that each of the four projections is characterized by a different combination of fertility rates and assumed net migration levels. The U. S. Bureau of the Census uses the letters A through G to identify population series ranging from high to low. This bulletin considers only the series designated C, D, and E, which are derived from fertility rates of 2.8, 2.5, and 2.1. The 2.1 rate or Series E is commonly termed zero population growth. Fertility rates indicate the average number of children a woman will have during her childbearing years.

Table 2. Population Factors

Alternative projections	Population series	Fertility rates	Net migration
I	C	2.8	150,000
II	D	2.5	150,000
III	D	2.5	100,000
IV	E	2.1	0

Each projection results in a different population total for the State (Table 3) and a different distribution among hydrologic areas (Table 4). The latter is essentially an aggregation of county projections appearing in a Department of Finance report,* which is the basis for the alternative projections presented here. The report contains a discussion of those considerations involved in making the estimates. The alternatives are plausible possibilities. They reflect trends in births, deaths, and migration that, for the most part, have occurred in California at one time or another. As noted in the Department of Finance report, the projections "are designed to provide the planner and decision-maker with the dimensions of his problem as they are affected by population".

Table 3. California and United States Populations (in millions)

Alternative Future Projections	1972	1980	1990	2000	2010	2020
I (C-150)	20.5	23.0	27.4	31.9	37.2	43.3
II (D-150)	20.5	22.8	26.7	30.5	34.6	39.1
III (D-100)	20.5	22.7	26.1	29.3	32.8	36.6
IV (E-O)	20.5	21.9	23.6	24.7	25.7	26.5
U.S. Population Series[1]						
C	209	231	266	300	344	392
D	209	229	259	286	318	351
E	209	224	247	264	282	298

[1] U.S. Bureau of the Census, 1972.

Figure 5 shows the historic growth of California's population from 1920 to 1973 and the four alternative projections. Figure 6 shows the United States population from 1920 to 1973 and three of the alternative growth projections used nationally.

* "Population Projections for California Counties 1975-2020," Report 74, P-2, June 1974.

Table 4. Population in California—1972, 1990 and 2020
(In Thousands)

Hydrologic study area	1972	Alternative future projection							
		I (Series C-150)		II (Series D-150)		III (Series D-100)		IV (Series E-0)	
		1990	2020	1990	2020	1990	2020	1990	2020
North Coastal	180	250	390	240	350	230	310	210	230
San Francisco Bay	4,630	5,940	8,670	5,800	7,920	5,680	7,350	5,270	5,700
Central Coastal	840	1,370	2,430	1,340	2,200	1,290	2,030	1,130	1,370
South Coastal	11,240	14,620	22,510	14,260	20,300	13,930	19,140	12,510	13,790
Sacramento Basin	1,210	1,700	2,600	1,670	2,400	1,630	2,230	1,470	1,620
Delta Central Sierra	470	760	1,730	730	1,550	710	1,420	640	930
San Joaquin Basin	440	650	1,140	640	1,010	620	940	560	660
Tulare Basin	980	1,280	2,030	1,250	1,820	1,240	1,730	1,160	1,360
North Lahontan	40	70	110	70	100	70	90	60	60
South Lahontan	240	410	1,040	370	870	370	820	290	380
Colorado Desert	230	350	650	330	580	330	540	300	400
Totals	20,500	27,400	43,300	26,700	39,100	26,100	36,600	23,600	26,500

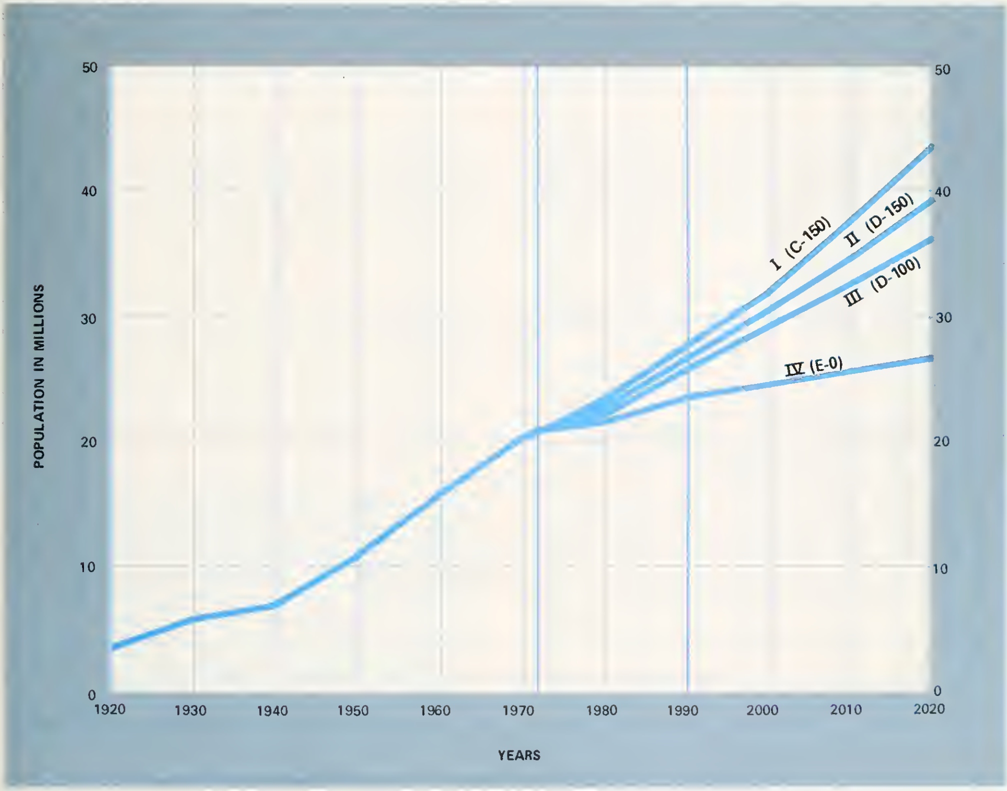


Figure 5. California Historical and Projected Population Growth

Population change in California

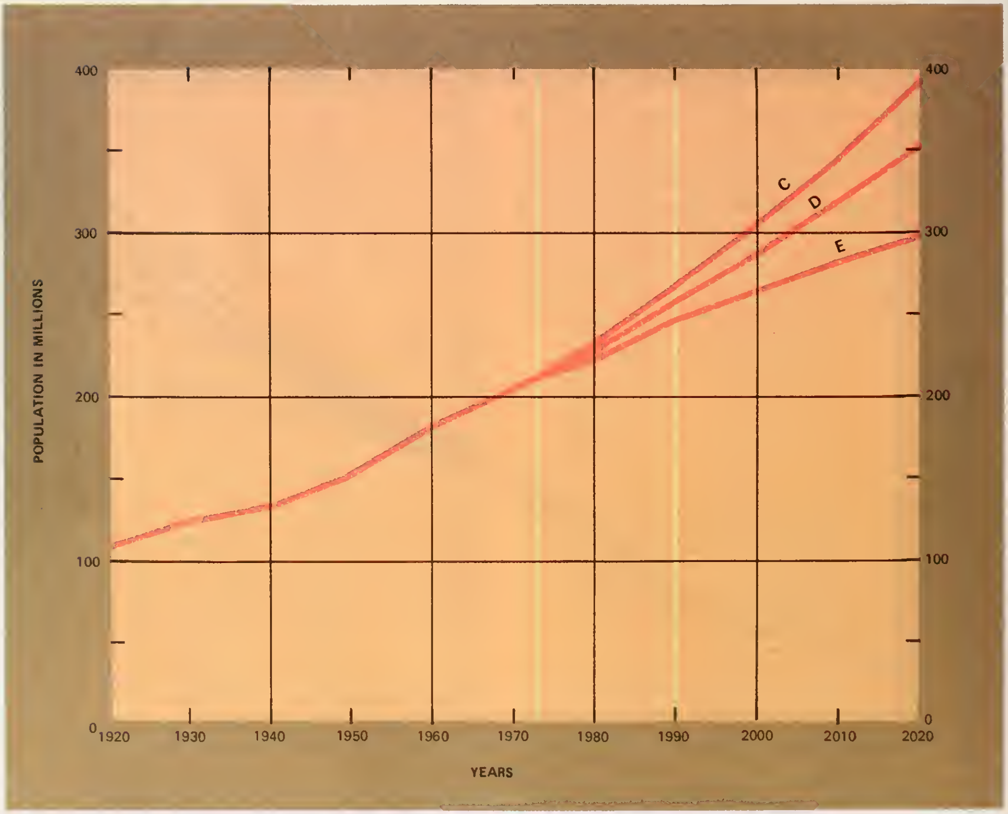


Figure 6. United States Historical and Projected Population Growth

Agricultural Production

California is blessed with the climate, land, and water resources which give it the capability of producing large amounts of a great number of crops, currently over 200 on a commercial scale. The State is the nation's leading producer of about 50 crops and is among the top five in the production of another 20. In addition, it ranks second in milk and cream production and fifth in cattle production. California continues to be the nation's number one farm state in terms of cash receipts from farming. According to the California Crop and Livestock Reporting Service, the total receipts from farm marketing in 1972 was $5.5 billion. The sharp increase in prices contributed to a rise to $7.5 billion in 1973.

Trends and Influences

The industry in this State is vexed by many of the same problems facing agriculture throughout the country, but does not have anywhere near the problem that many of the other major producing areas have with annual fluctuations in weather. Certainly there are occasions when late frost or unseasonable rain cause a drop in yields for some crops. But the impact on the total agricultural production in the State is rarely significant compared to the impact weather often has on crop production in many other states. The relatively predictable weather in California, the State's reliance on irrigation rather than growing season precipitation, and the wide variety of crops are the principal reasons for the industry's freedom from weather-borne catastrophes.

The importance of California in regard to satisfying the food and fiber needs of the nation is highly significant. The importance of agriculture to the California economy is apparent upon considering that California farms and other agriculture-related industries and activities such as food processing, financing of farm production, and sales of equipment and supplies to farms, generate income estimated to be at least 20 billion dollars annually.

Exporting California's agricultural production
Port of Sacramento photo

Irrigated corn field in California

Because it enjoys so many climatic and soil advantages, California has a major role to play in producing food and fiber for both national and foreign markets. The future size of these markets is the key question. Population growth and consumptive patterns are important variables, but the market is also influenced by policy decisions involving acreage allotments and foreign trade. The latter is especially difficult to anticipate in view of balance of payment considerations, world food production, and changes in international relationships which may open new markets (China) or shut others off. Because of this uncertainty, care should be taken to see that agriculture retains a capability that is flexible and responsive. This means that decisions and policy relative to land and water use must be concerned with the availability of productive agricultural land and necessary water supplies to irrigate those lands.

Although many factors will influence the future demands for California produced food and fiber, most are directly or indirectly accounted for when attention is focused on national population growth, possible changes in per capita consumption, changes in crop yields, foreign trade, and California's probable share of national production considering the relative ability of other areas to meet the needs. In order to provide a basis for examining the capability of available water supplies to meet the needs of a wide range of possible levels of agricultural activities and to give examples of the impact on calculated water demand of different assumptions regarding each of these five factors, the Department conducted the study of future crop production described in this section.

Various specialists from the University of California were sought out as data sources and for comments on what appears likely for agriculture's future. The California Department of Food and Agriculture was

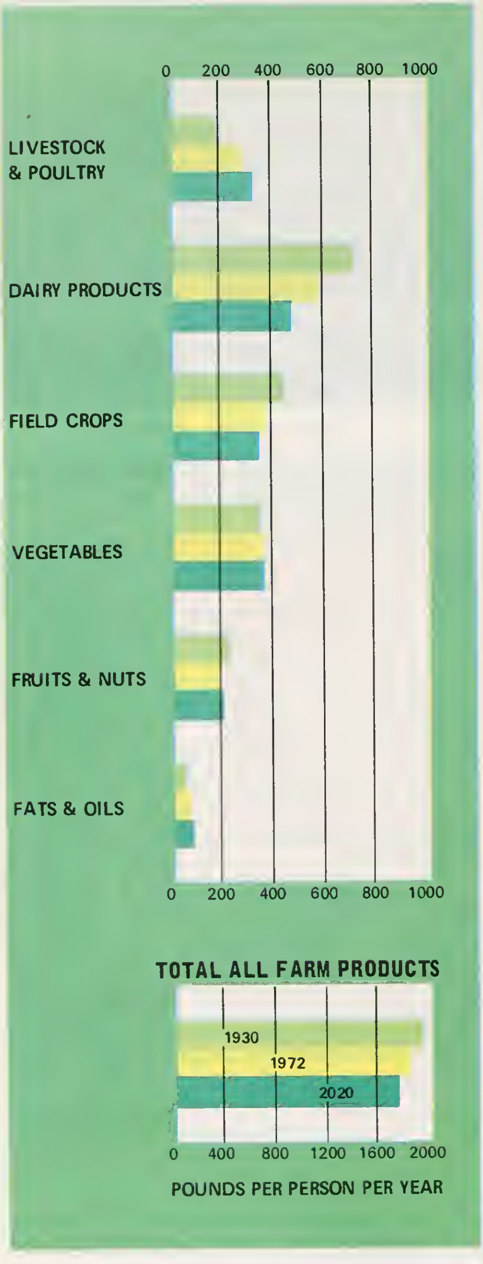


Figure 7. Per Capita Consumption of Form Products in the United Stotes

brought into the studies at an early stage, and, in addition to the valuable data provided by that agency, its review and comments on the various phases of the work as it progressed were very helpful.

Each subject—national population, per capita consumption, foreign trade, state share of national production, and crop yields—was studied to determine if there were more than one projected level (i.e., value) for the years 1990 and 2020 appropriate to consider at this time, considering current trends and events. Alternative assumptions were identified and four projections of future crop acreage were calculated based on selected combinations of some of these assumptions.

The results of this study are presented in the following pages.

National Population. In the last 50 years, United States population has doubled. The 1920 and 1970 Census of Population showed 107 million and 205 million people, respectively. According to the U. S. Bureau of Census, basing calculations on the E fertility series results in a 2020 population projection of 298 million; the D Series gives 351 million. As discussed later, Series C was not used in estimating future crop production. Series D and E were used.

Per Capita Consumption. The principal basis for per capita consumption estimates is contained in the 1972 OBERS Projections.* This work was primarily based on data available through 1970.

Figure 7 shows the past, present, and projected average per capita consumption of major groups of farm products in the United States as determined by the OBERS studies. The national average for total quantity of food and fiber used per person has declined over the years, principally as a result of less consumption of cereals, potatoes, and dairy products.

The types of food eaten have changed over time and changes are expected in the future. The OBERS study projected a decline in per capita consumption of dairy products and field crops. Dry beans, wheat, rice, and other food grains are included in the field crop category. They expect the consumption of vegetables to remain about level. Projections of livestock and poultry consumption indicate the quantity of animal feed and forage required. OBERS projection of a substantial increase in livestock and poultry consumption includes a large (40%) increase in per capita consumption of beef. Although the total for fruits and nuts is projected to increase slightly, per capita consumption of nuts and noncitrus fruit is projected to decrease 15% while consumption of citrus fruits will increase 100%. These estimates prepared by OBERS were used in calculating future crop acreages for this bulletin.

The projections of future crop acreages contained in Bulletin Nos. 160–66 and 160–70 were based on as-

* "1972 OBERS Projections, Regional Economic Activity in the U.S.", OBERS, 1972. OBERS stands for the Federal Bureau of Economic Analysis (formerly Office of Business Economics) and the Economic Research Service.

sumptions of a lesser increase in beef consumption and increased consumption of nuts, noncitrus fruits, and vegetables. These were the conclusions of earlier studies conducted by the Department of Water Resources and, separately, by the Economic Research Service of the U. S. Department of Agriculture.

The impact on California's agricultural production of a change toward greater use of nuts, fruits, and vegetables would likely be quite significant considering the State's large share of current national production of these crops.

Foreign Trade. In looking at recent developments in international agricultural trade, a number of profound changes can be seen. These include an apparent revolution in world dietary patterns, and major changes in agricultural trade flows and trade policies.

Per capita incomes around the world are growing and promise to continue to grow at a pace never experienced before in human history. As incomes rise, more people will be able to afford an improved quality of life. Among the first areas where improvement is usually seen is in upgraded diets. This coupled with increasing population, not only increases total food consumption, but also creates a demand for a wider variety of foods.

As the nations of the world increase their use of more agricultural commodities, they are buying more in the world market, and more of what they buy is coming from the United States. American agriculture has conducted an extensive sales and advertising campaign over the past decade which has enabled the United States to secure a greater share of the international market. To the extent that this country's long term production can be managed to reduce the impact of periodic droughts in the nonirrigated, rain-fed regions of central and southern United States, the growth in foreign exports should continue in the future.

A review of U. S. agricultural exports to foreign countries since 1960 gives some idea of the magnitude of food demand increase over time. In 1960 all agricultural commodities exported were slightly in excess of $4.5 billion; by 1970 exports had increased to $6.7 billion, and in 1973, the level of U. S. exports was $12.9 billion. California's share of U. S. agriculture exports includes 54% of the U. S. foreign sale of fruit, 27% of the vegetables, 22% of the rice, 11% of the cotton, and 94% of the nuts.

Two levels of foreign trade were given consideration in the Department of Water Resources' studies of future crop production in California. The 1972 OBERS projections of foreign trade were used as one level. These were prepared prior to the substantial increases in foreign trade that occurred in 1972, 1973, and 1974. Certainly there were aspects of these recent increases, such as the availability of dollars for payment that raise questions as to whether foreign export will continue to increase at this rate, or for that

Ripping hardpan soils to a depth of 5 to 7 feet
Collin Company photo

matter, remain this large. However, studies conducted by the Department of Water Resources in 1974, based on United States Department of Agriculture publications, indicated that the future export demand for California farm products could be greater than the projections contained in the 1972 OBERS report, which were based on data available through 1970, if some of the more substantial world market opportunities unfolding in recent years continue to materialize. Based on assumptions resulting from the Department's study, an alternative set of values for foreign trade of specific commodities was developed.

California's Share of U. S. Production. The 1972 OBERS report figures were used for the crops that had been studied on an individual basis. In those cases where values were prepared for groups of crops, the State share of production for each individual crop was projected from historical trends with modifications which reflect recent national and international market opportunities and changes. In general, OBERS projections showed a small overall increase in California's share of the market for all crops. The agricultural industry in California has demonstrated considerable success in competing for greater shares of U. S. production

Crop Yields. Two sets of crop yields were derived. One set was the values used in preparing Bulletin 160-70 estimates of crop acreages. These were based principally on the advice of agricultural specialists of the University of California, and were developed in 1968, prior to the energy crisis and prior to development of some of the possible limitations on agricultural chemical use as a result of concern for environmental protection.

For this study, a modified set of crop yields has been developed which reflect a more conservative outlook regarding increased yields. The advice of various agricultural experts was considered in developing these estimates, including crop specialists from the University of California and County Farm Advisor Offices. Figure 8 illustrates the magnitude of revisions which were made to the previous crop yield estimates for

Dry farmed wheat with irrigated almonds in the background

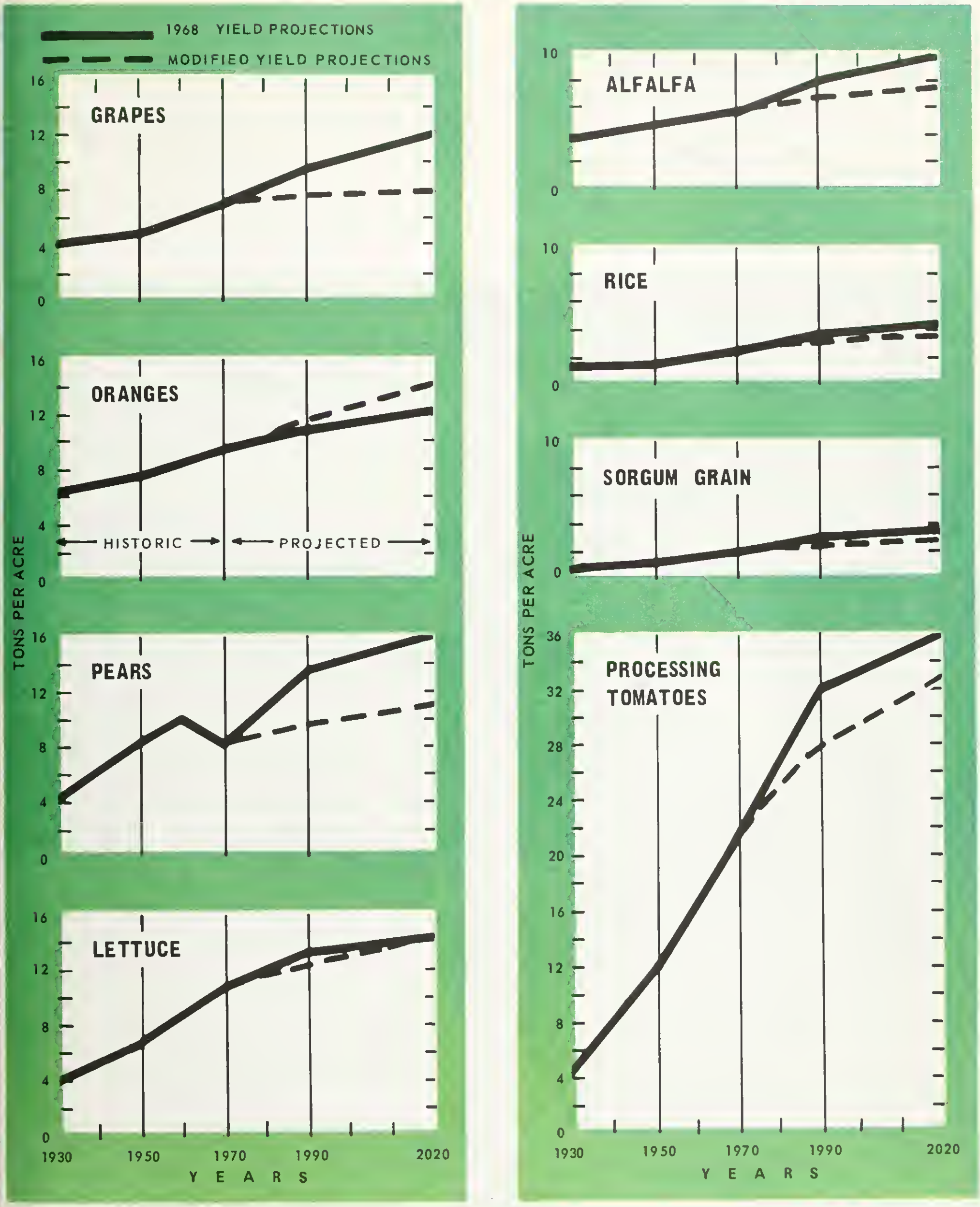


Figure 8. Average Yields of Selected Farm Crops in California

eight of the forty-five crops studied. These eight crops were selected as being fairly representative of the trend of all crops. They account for 30 percent of the total state irrigated acreage and 25 percent of the dollar value of total state crop production.

Alternative Projections of Irrigated Crop and Land Acreage

The study of the five principal factors which govern agricultural growth resulted in the identification and quantification of three possible levels of national population, two levels of foreign trade and two sets of future crop yields. Only one set of values for per capita consumption and the State's share of U. S. production was prepared.

The crop acreage for any combination of assumptions for the five growth regulating factors is calculated as follows:

$$\text{Crop acreage} = \frac{\left(\begin{array}{c}\text{National}\\\text{population}\end{array} \times \begin{array}{c}\text{Per capita}\\\text{consumption}\end{array} + \begin{array}{c}\text{Net}\\\text{foreign}\\\text{trade}\end{array}\right) \times \begin{array}{c}\text{State share}\\\text{of U.S.}\\\text{production}\end{array}}{\text{Crop yield}}$$

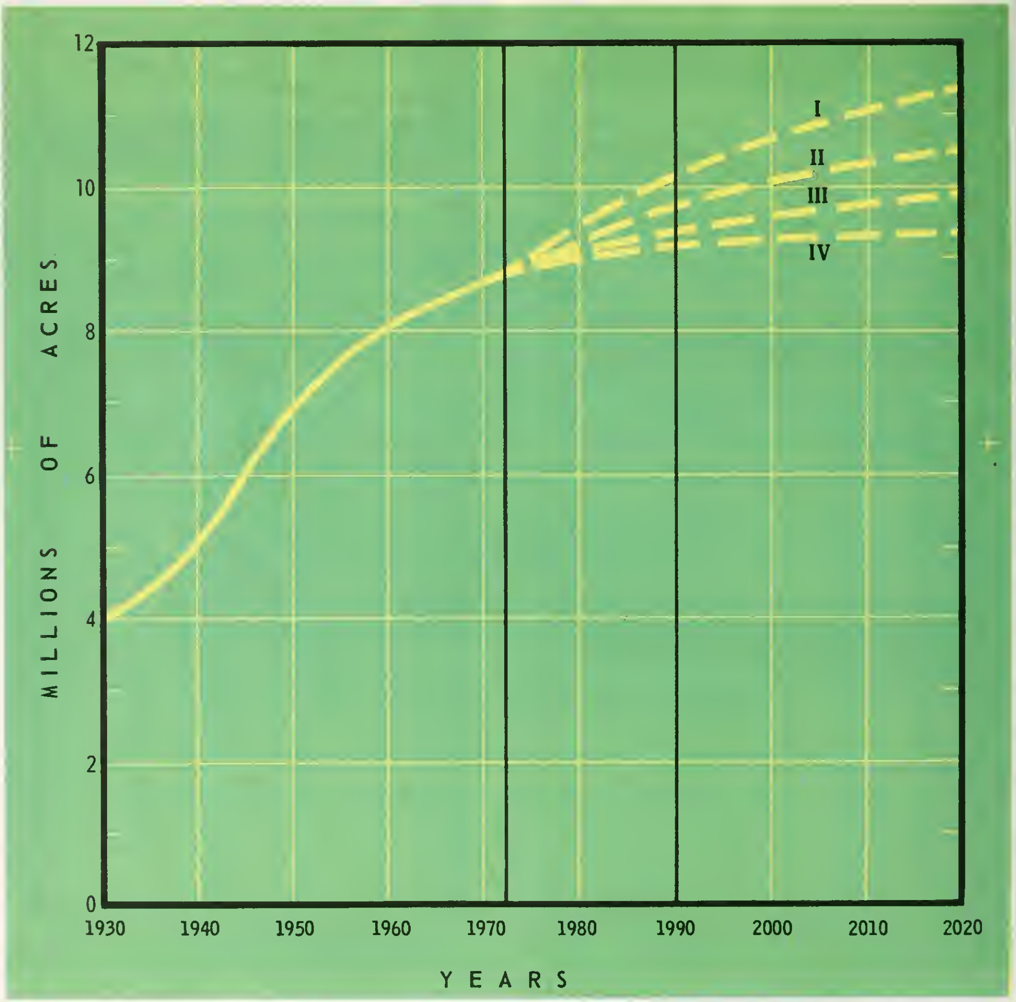


Figure 9. Historical and Projected Irrigated Land Area

There are numerous possible combinations of the alternative values derived for the five factors. In order to provide a basis for examining water use for a wide range of possible levels of agricultural activities and to give examples of the result of different combinations of assumptions, four alternative crop acreage projections were prepared based on essentially an arbitrary selection of groups of assumptions. For simplification, only two alternative population levels, two foreign trade levels, and two sets of crops yields were used in combination with the single projection of state share of U. S. production and the projection of per capita consumption.

The combinations of assumptions for national population, net foreign trade and crop yields used in calculating alternative crop acreages were as follows:

Alternative	U.S. Population		Net Foreign Trade		Crops Yields	
	Series D	Series E	Higher estimate	Lower estimate	1968 estimate	Modified estimate
I	x		x			x
II	x			x		x
III	x			x	x	
IV		x		x		x

These combinations of assumptions resulted in the projected irrigated land acreages shown in Figure 9. All other combinations but two would fall within the extremes shown. Combining Series C national population with the higher foreign trade estimate and the modified crop yields would give a higher acreage projection, while combining the Series E population with the lower foreign trade estimate and the 1968 estimate of yields would give a lower projection. In the judgment of the Department, both of these combinations resulted in projections of crop acreages which appeared to be unreasonable in light of current knowledge and trends.

The projections of total irrigated land shown in Figure 9 were obtained by adjusting the calculated harvested crop acreage value for each set of assumptions to account for land planted but not harvested, the acreage of dry-farmed crops and double cropping (i.e., more than one crop during the year on the same parcel of land).

The State total irrigated land acreage and total crop acreage were distributed to hydrologic study areas, Table 5, considering the availability of suitable land and historic agricultural land use in each area.

The location of irrigated, irrigable, and urban lands throughout the State is shown in Plate II. The small scale of this map does not allow completely accurate depiction of land use. The three enlarged township areas are typical examples of the actual pattern of land use which exist within areas shown to be solidly developed on the map.

A discussion of available land and recent trends in irrigated agriculture is presented in the following sections.

Land Availability. The Department has mapped the location, nature and extent of lands physically suited to production of irrigated crops throughout the State. The classifications provide a basis for determining both the physical suitability of the land for specific crop production under various farm management programs and the influence of soil factors on the rate of water use by each crop.

Table 5. 1972 and Projected Irrigated Land Area and Irrigated Double Crop Acreage
(1,000 acres)

	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Totals
1972 Irrigated land	240	110	420	390	1,520	800	1,350	3,100	140	80	630	8,780
Double crop	0	--	50	40	10	20	10	70	0	0	90	290
Alternative I												
1990 Irrigated land	240	130	500	290	1,950	990	1,690	3,560	140	80	630	10,200
Double crop	0	0	50	50	10	20	20	200	0	0	90	440
2020 Irrigated land	260	150	530	220	2,250	1,130	1,920	4,040	140	70	650	11,360
Double crop	0	0	80	60	20	30	50	420	0	0	110	770
Alternative II												
1990 Irrigated land	240	120	480	290	1,850	930	1,610	3,370	140	80	630	9,740
Double crop	0	0	50	40	10	20	20	180	0	0	90	410
2020 Irrigated land	260	140	520	220	2,060	1,060	1,690	3,730	140	70	630	10,520
Double crop	0	0	70	50	10	20	40	340	0	0	100	630
Alternative III												
1990 Irrigated land	240	120	480	290	1,740	880	1,530	3,250	140	80	630	9,380
Double crop	0	0	50	40	10	20	10	120	0	0	90	340
2020 Irrigated land	250	140	520	220	1,890	980	1,580	3,430	140	70	630	9,850
Double crop	0	0	60	50	10	20	30	220	0	0	90	480
Alternative IV												
1990 Irrigated land	240	120	480	300	1,680	850	1,480	3,190	130	80	630	9,180
Double crop	0	0	50	40	10	20	10	110	0	0	90	330
2020 Irrigated land	250	120	510	220	1,760	920	1,490	3,260	130	70	630	9,360
Double crop	0	0	60	50	10	20	20	190	0	0	90	440

The total statewide acreage determined to be suited to some kind of irrigated crop production is 22,000,000 acres, including 8,780,000 acres of currently irrigated lands. With the advice of local agricultural experts, including County Farm Advisors, and considering present day practices, it has been determined that one million acres occur where climate is suitable for the production of citrus and other subtropicals. Three million acres have deep, well-drained soils, are relatively flat and where the climate is right, are suited to deciduous orchards. Grapes and many truck crops are suited to much of the above land as well as to an additional six million acres. Field crops and pasture are adaptable to practically all irrigable land and slightly over 12 million acres are best suited to their production under current practices.

Recent Trends in Irrigated Land Use. Agriculture in California is characteristically an ever-changing enterprise. New lands continue to be put into production and changes in the proportion of each crop occur constantly throughout the State.

The nonirrigated crops account for less than 15 percent of the State's total crop acreage. Most of this is comprised of small grains and grain hay. A large portion is raised as a rotation crop on land which otherwise is irrigated. The total acreage of cropped land without developed irrigation systems is constantly decreasing as a result of urbanization and new irrigation development.

Figure 10 illustrates the changes in irrigated and urban land in the State from 1920 to 1950 and to 1972. In the latter part of this period, the acreage of irrigated land increased from the 1960 level of 8,085,000 to 8,480,000 in 1967 and to 8,780,000 in 1972. The actual amount of new land developed to irrigation during this period is greater than the differences in these totals due to replacement of land lost to urban encroachment. The rate of urbanization of irrigated land in recent times has been between 20,000 and 25,000 acres per year.

Some of the recent changes in irrigated land and cropping practices around the State are shown on Figure 11.

Figure 10. Irrigated and Urban Areas

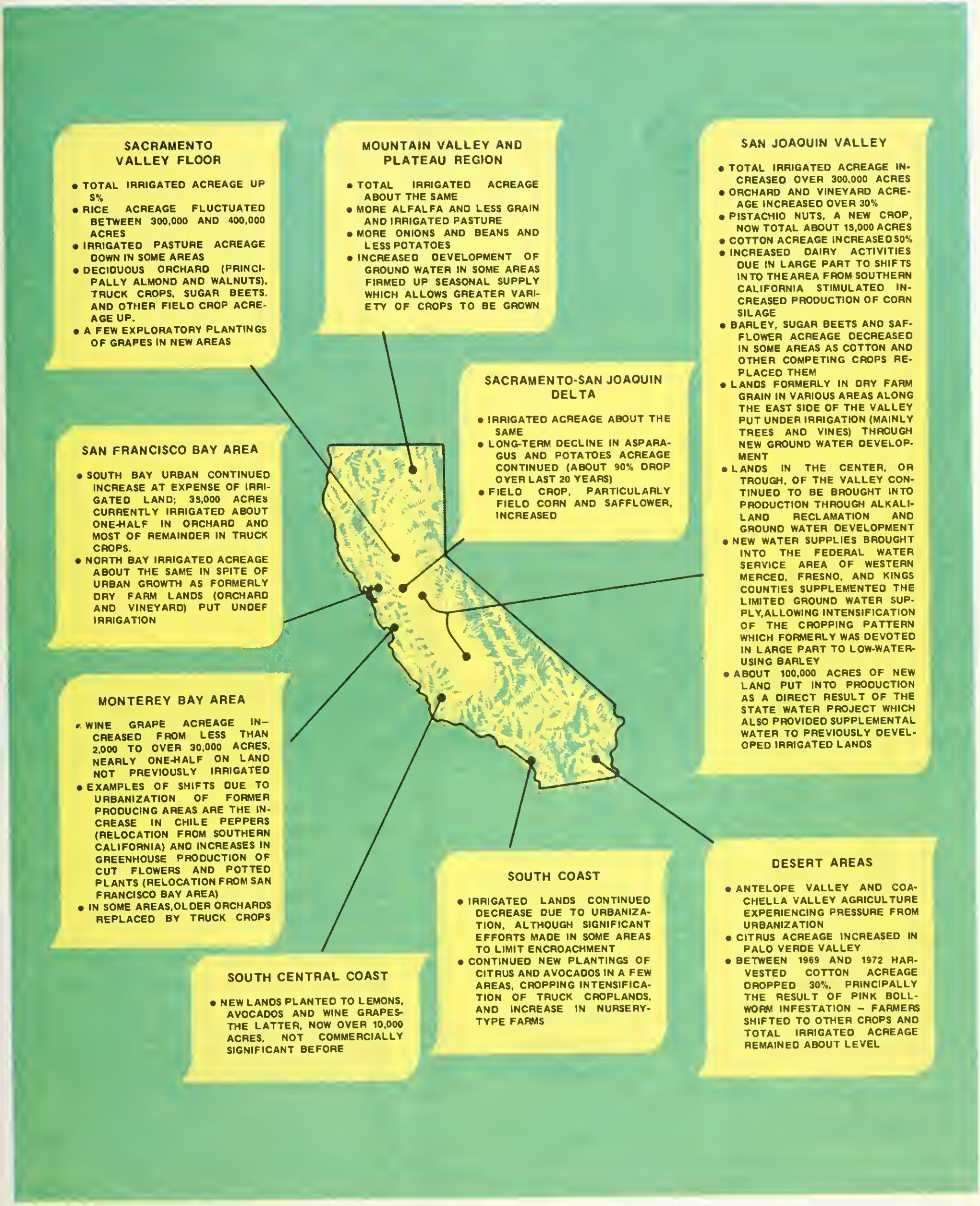


Figure 11. Highlights of Changes in Irrigated Land Use, 1967–1972

Electrical Energy

"Energy" has had an emotional impact on the United States second only to "war" or "riot". The effect of a shortage of energy on water projects would be as severe as the impacts on travel, heating, or industry. Many water projects and related services depend on large blocks of electrical energy for pumping, and the cost of the energy is a major, and sometimes the largest, operating cost for water supply projects.

The direct concern for this report is the water requirement for cooling thermal generating plants. At present, most of the plants in California are cooled with ocean or brackish water. Several factors are now leading to use of fresh water at inland thermal power plant sites. This is a large potential new fresh water requirement.

Trends and Influences

There is more known about the trend of increased use of electrical energy than the reasons for the trend. Studies by the Rand Corporation * of increases in energy consumptions have been prepared for residential, commercial, and manufacturing sectors in California. Residential use of energy has increased in recent years and is projected to continue to increase primarily for environmental control and personal comfort. Air conditioning and heating continue to use increasing amounts of electrical energy on a per capita basis. In addition, numerous small personal electrical consuming items are being added to homes. While the electric stove has maintained the same level of electrical consumption in the home for many years, the average size of refrigerators has increased and most of the newer models are frost-free and include freezers.

Commercial use of electrical energy is the fastest growing of the three sectors. Most of the increases relate to air conditioning and heating, but in addition there has been a trend for more floor space per employee. It is more difficult to identify a general pattern for manufacturing and industrial increases except that many industries are decreasing the amount of labor per unit of product and, for the most part, substituting electrical devices and increased electrical energy for the labor.

Electrical energy usage increased at a high rate for about 20 years after World War II. The average annual compound rate of increase was 9.2% from 1950 to 1966 and 6.7% from 1966 to 1972. During this period the price of electricity did not increase in the same magnitude as other prices. New power plants have been more efficient, and the unit cost of adding generating capacity decreased. The annual rate of increase in electrical energy use thus had begun to taper off in the late 1960s before such limiting factors as power plant siting and price increases added their effect. Now that energy prices have begun to increase and are expected to increase even more, demand should respond in an elastic manner. It should also be pointed out that concurrent with the reduction in growth rate of energy sales there was a similar reduction in the rate of increase in population.

Until recently, energy has been taken for granted in California. In the evaluation of water projects, energy considerations have been limited to pumping costs and the value of hydroelectric generation. The cost of energy for pumping has been and will be of primary concern to the Department of Water Resources because payment for power required by pumping plants is the major cost in the operation of the State Water Project. It is also an important factor in other water projects and in ground water management.

In the last two years the energy situation and public awareness have brought a period of change and uncertainty. Assumptions about future power requirements need to be reexamined. Some of the factors which affect future demand of electricity in a qualitative way are listed in the following two groups.

Factors which cause continued increase in electricity consumption:

- Population growth
- Extension of existing uses of electricity
  - Resistance heating
  - Refrigeration cooling
  - Transportation—trains, mass transit
- New uses for electricity
  - Transportation—autos
  - Conversion of alternative forms of energy
  - Desalting

Factors which contribute to a lower rate of increase in electricity consumption:

- Decline in birthrate and net in-migration
- Rising energy costs
- More efficient use of energy
  - Conservation measures to reduce waste
  - Better appliances
  - Beneficial uses of waste heat
- Substitution of alternative forms of energy

Some of the factors in the first group have exerted a dominant influence during most of the period since 1945. In the future, factors in the second group are expected to become dominant. Population growth is slowing down. Although per capita energy use grew very rapidly for about 20 years, its growth is now slowing down. Energy costs have increased significantly and are expected to continue to increase. Projection of some of the other factors, however, is more uncertain. How soon technology may advance new and alternative forms of energy is very speculative.

* "California's Electricity Quandary: 1. Estimating Future Demand," Rand Corporation, September 1972.

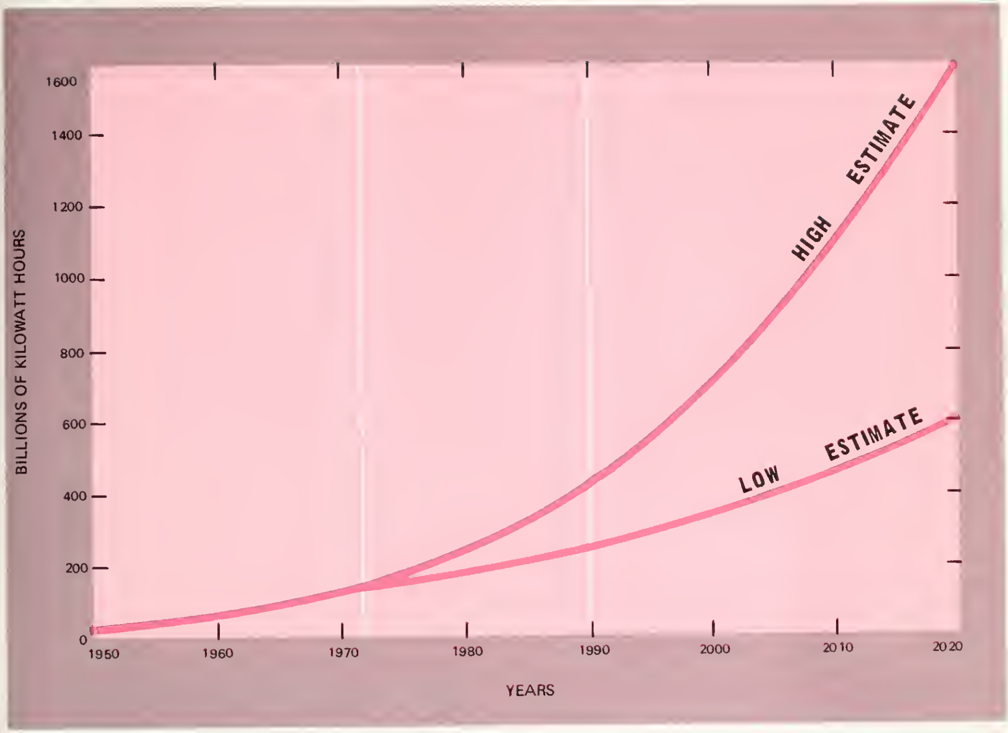


Figure 12. Historic and Projected Electric Energy Requirements

Alternative Future Projections

Consideration of projections of future electrical energy requirements was the subject of the September 1972 report by the Rand Corporation, and it included a detailed study of five different projections or cases. The base case projection, Case 1, is a generally accepted view of the future which tends to be a statistical extension of the past. The other cases were combinations of high or low growth of population and the economy with or without relative increases of price of energy. Case 3, the low growth case, gave a rate of growth of 3.4% per year for the period 1970–2000.

The Energy Dilemma Report * contains a comparison of the 1972 California Public Utilities Commission (CPUC) projection of annual peak demand in the year 1991 with the Rand Case 1 electrical energy projections, converted by the CPUC staff to peak demand, and found the difference to be less than one year's growth.

A current assessment of the foregoing factors resulted in the selection of a high and a low projection, neither of which is considered an extreme or limiting condition. The high alternative was obtained by using the projection from the Energy Dilemma Report to 1991, the Rand base case projection up to the year 2000 and assuming a 4.4 percent annual growth rate from 2001 to 2020. The low alternative was obtained by using the Rand low growth case projection up to the year 2000 and assuming a 3.0 percent annual growth rate from 2001 to 2020.

A graph of the historical electrical energy sales from 1950 to 1972 and the high and low estimates of future energy use is shown on Figure 12. Quantities of pro-

* "Energy Dilemma" California's 20-Year Power Plant Siting Plan, State of California, The Resources Agency, June 1973.

jected electrical energy sales and generation are given in Table 6. Estimates of the generation of energy by plants that require cooling are given in Table 7.

Table 6. Projected Requirements for Electrical Energy (billion kilowatt hours per year)

Year	Electrical energy sales		Electric energy generation[c]	
	High estimate	Low estimate	High estimate	Low estimate
1972	140	140	155	155
1990	420	247	466	274
2020	1600[a]	600[b]	1780	670

[a] Estimated by projecting 4.4 percent rate of growth from 2000.
[b] Estimated by projecting 3.0 percent rate of growth from 2000.
[c] Electric energy generation differs from sales by 10 percent losses.

Table 7. Projected Additional Generation Requiring Cooling Water (in billion kilowatt hours)

Type	1972	1990		2020	
		High	Low	High	Low
Nuclear	3	220	83	1,184	387
Oil and gas	90	26	13	26	13
Total thermal	93	246	96	1,210	400

Thermal Power Plant Siting

Most of the electrical energy generated in California to satisfy energy needs will probably be produced using oil and nuclear fuel. While there may be a slight increase in electric energy production using oil, most of the increase is expected to be developed from nuclear energy. However, projections for 2020 are fraught with uncertainties especially where fairly rapidly changing technology, such as in the production of electricity, is involved. It is not known if fusion will be the leading form of energy generation by 2020, but it is considered likely. With the application of magnetohydrodynamics (MHD) one can envision efficiencies of 60 percent or better. Gas turbines discharging waste heat directly to the atmosphere coupled with nuclear reactors are expected for commercial application in the 1990s. Higher efficiencies and direct discharge of waste heat to the atmosphere will reduce the need for cooling water for power plants by 2020.

Solar energy or other novel energy sources by today's standards could be utilized in central stations for generation of electrical energy. On the other hand, individual use of solar energy could substantially reduce central station demand. Individual units would no doubt discharge waste heat directly to air, thereby not requiring water for cooling.

Nevertheless, a very substantial portion of our thermal generating plants will require cooling water for operation. Therefore, projections of thermal power plants needing water for cooling and the siting of the plants is a major concern in considering California's future water needs. The location of future thermal power plants (taking into consideration load center, safety, aesthetics, technological changes, and economics and the amount of energy generated) are the major ingredients of alternative futures for electrical energy.

Location of power plants along California's 1,072-mile coastline with its access to an unlimited supply of sea water, usable for once-through cooling, has provided an economic solution to the current cooling water requirements related with thermal energy production. About 90 percent of the thermal power plants in California are presently located along the coast to take advantage of cooling with saline or brackish water.

Since the coastal zone is in such great demand for so many uses, i.e., commercial, industrial, residential, recreation, aquatic and wildlife habitat, and preservation as natural areas, it is not surprising that there is a conflict for above ground power plant siting.

Active and potentially active seismic areas in the coastal area are a serious restraint for siting nuclear plants.

Several estimates have been made of the length of coastline that might be suitable for power plant siting based largely on population centers and seismic hazards. In the Holmes and Narver report, "California Power Plant Siting Study", 17 siting variations were studied. The amount of suitable coastline varied from 2 to 855 miles depending upon the type of installation considered. The criteria in that report were generally

Most California thermal power plants are along the ocean more lenient than those used in the report by the California Institute of Technology in 1973, entitled "Siting Nuclear Power Plants in California, the Near-Term Alternatives", which found only 52 miles of the 1,072-mile coastline suitable for power plant siting consideration.

The difficulty in finding suitable coastal sites for power plants has caused power companies to look inland for sites. Studies of power plant siting criteria reveal that the most favorable inland locations are the Central Valley and the eastern portion of the Colorado Desert area. These locations are discussed in the Resources Agency's report, "Energy Dilemma, California 20-Year Power Plant Siting Plan". The studies of inland siting which have been made thus far have not been detailed enough to determine whether other parts of the State might yet be found suitable for power plant siting.

In view of the uncertainties about power plant siting, two alternatives for thermal power plant location were considered. The assumption was made for planning purposes in this report that either one-third or two-thirds of the future additional thermal power plants would use closed cycle evaporative cooling which would have to be supplied from inland sources of fresh water. The remaining plants would be located on the coast for cooling with ocean water. This assumption on plant location could not be followed completely for the low alternatives because more than ⅓ of the plants needed are already under construction or planned to be located at inland sites.

Compounding these two assumptions of future thermal power plant location with the aforementioned two levels of electric energy requirements results in four alternative futures for thermal power plants in California. The energy to be generated by plants requiring inland sources of cooling water is given in Table 8.

Table 8. Additional Inland Thermal Power Generation (in billion kilowatt hours)

Alternative future	Energy demand	Fresh water cooling[a]	Generation requiring cooling	
			1990	2020
I	High	⅔	158	790
II	High	⅓	88	420
III	Low	⅔	52	250
IV	Low	⅓	44	150

[a] Fraction shown indicates that portion of additional thermal generation using fresh water for cooling purposes. The remaining portion of cooling need would be met by ocean water.

Trends and Influences on Other Water-related Needs

There are several other water-related needs that must be included in the formulation of water resource management plans. The earlier portion of this chapter covered population, agriculture and energy which in Chapter IV will be translated into alternative levels of water needs for municipal and industrial purposes, irrigation of crops, and power plant cooling. While these include the primary consumptive needs for which water supplies are developed they do not provide information on the other purposes of water resource management plans.

Items such as recreation, fish, and wildlife, flood control, water quality, and environmental quality are important values. Past trends and present attitudes of society indicate that there are presently unmet needs and that additional needs can be projected into the future. However, since most of such needs do not directly affect the water supply-use balance of a specific area it has not been necessary in water management planning to directly quantify projected future levels of need. The usual procedure has been to recognize the importance of damage prevention and quality enhancement, incorporate protection of existing values to the maximum extent possible, and enhance those benefits where there is an opportunity in the formulation of water resources management plans.

The following discussions of recreation, fish and wildlife, flood control, water quality, and environmental quality cover the trends and influences that affect these water-related benefits.

Recreation, Fish and Wildlife

The long-range trend of public participation in outdoor recreation activities is upward. Throughout the Nation, and especially in the West, recreation area use data reveal a greater per capita participation for most types of recreation as compared with past years. As an indication of this, Figure 13 shows the growth in California State Park System attendance since 1950 which is increasing much more rapidly than population. Other outdoor recreation activities reveal a similar trend.

Most observers of recreation use patterns and trends attribute a large part of the increase to more leisure time, more income, and greater mobility. Another factor—less often mentioned—that has doubtless had a major influence on recreation activity has been an innovative recreation industry. Improved services, facilities, and equipment have proved attractive to a larger segment of the population.

In addition to these factors, it has been true in California and elsewhere in the West that resources have generally been available for expanding recreation activities. Land, water, fisheries, etc. have generally been adequate to support the increased activity. Unfortunately, these resources frequently are not near the large concentration of people in the urban centers.

As a result of the growth factors, a large recreation industry has developed in California and has grown without significant interruption in the almost 30 years since World War II.

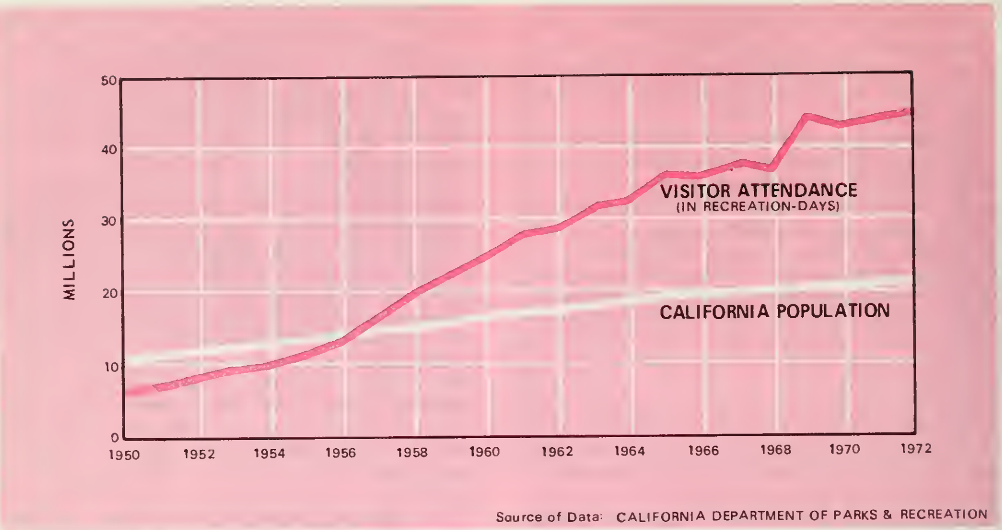


Figure 13. California Population and State Park System Attendance

Like most other human activities, outdoor recreation participation is dynamic and changing. When looking to the future and attempting to develop a basis for forecasting future recreation activity, the usual procedure is to look at past trends and present influences. On this basis it would be logical to project a continuation of the upward trends. The energy crisis, however, demonstrated the vulnerability of recreation activities to external influences including public confidence in the economy and their own economic security.

There is no doubt that gasoline shortages and price increases starting in the last half of 1973 reduced recreation travel. There is also no doubt that there was a decrease in the purchase of recreation vehicles, trailers, motor homes, boats, and other energy using items at the same time. However, it is impossible to find uniformity in forecasts of the duration and severity of the energy shortage, and therefore difficult to predict with any certainty the effect of that shortage on outdoor recreation.

Two major types of outdoor recreation that are dependent upon fish and wildlife resources are fresh water fishing and water fowl hunting. The present level and the projected levels of these two recreation activities (as shown in Table 9) demonstrate their popularity and also indicate the importance of fish and wildlife resources.

Fish and wildlife resources must be protected and enhanced where possible to preserve and expand recreational opportunity. These resources include a number of limited and endangered species of fish and wildlife. Water resource management plans must also include measures for their protection and survival.

Table 9. Existing and Projected Fishing and Hunting Uses of California's Fresh Water Fish and Water Fowl Resources (in 1,000 of user days)

Hydrologic Study Area	Fresh Water Fishing		Water Fowl Hunting	
	1970	2000	1970	2000
North Coastal	983	1,435	213	277
San Francisco Bay	812	1,262	60	84
Central Coastal	988	1,403	8	11
South Coastal	2,195	2,837	34	63
Sacramento Basin	4,617	6,940	625	928
Delta-Central Sierra	3,100	4,916	110	193
San Joaquin Basin	1,819	3,038	234	403
Tulare Basin	1,704	2,486	168	218
North Lahontan	1,180	2,392	41	53
South Lahontan	1,759	3,421	46	160
Colorado Desert	1,286	2,351	126	260
Totals	20,443	32,481	1,665	2,650

Source: "Present and Future Human Demands for Fish and Wildlife", California Department of Fish and Game, August 1972.

Some species of wildlife need habitat protection to survive while others need additional protected habitat to maintain populations that will be beneficial to society. Riparian habitat adjacent to rivers, lakes and other waterways is particularly important to many species. Mountain valley habitats are limited for many deer and the few remaining elk herds and competitive uses of these valleys for cattle grazing, intensive recreation use, and reservoir sites places additional strain on the animal populations.

The Pacific Flyway for water fowl passes through the entire length of California from the Mexican to the Oregon borders. Marsh areas which provide resting, nesting, and feeding areas are essential to maintain the present populations of these birds. To maintain these important habitats requires water and protection from encroachment of competing uses. Several state and federal water fowl management areas are now in operation and additional areas are needed. Opportunities for providing such areas should be evaluated in the preparation of water resource management plans.

The fresh water and anadromous fisheries are important to the recreational and economic welfare of the State. Good spawning areas for anadromous fish are limited and in many natural streams dry season flow are not sufficient to maintain optimum fish populations. Water resource planning must include evaluation of the fishery resources and explore opportunities to enhance the fisheries through riverflow augmentation and protection or replacement of spawning areas.

California Wildlife habitat

Wetland habitat for waterfowl
Department of Fish and Game photo

Flood Control

Every few years some of California's winter storms occur in such rapid succession that there are severe floodflows over extensive areas. Prior to settlement by migration from the eastern states, these floodflows covered the terraces along streams and the Sacramento and San Joaquin Valleys became lakes over much of their areas. Alluvial cones in Southern California were covered by water and debris.

Flood control works in California now prevent inundation of many of these areas and have made a significant contribution to the State's productive capacity and social well-being. Without these facilities, California would be unable to sustain its high level of agricultural production and industrial output; its municipal and industrial communities would be so scattered as to render them ineffective.

In the early days of California there was little choice but to settle in areas prone to flood damage. Provision of flood control structures has been a gradual process, but with numerous projects completed since World War II, major portions of the State are now relatively secure from flood damage. As flood protection works have been expanded, often initially to protect large areas of agricultural land, the pressures of urban expansion caused further invasion of the floodplain and greater levels of flood protection became necessary. The clearest discernable trend has been a decline in new starts for structural works in the past few years. Factors contributing to this trend include a decrease in federal spending, a 4-year period to work out a new basis for sharing of nonfederal costs of federal projects between the State and local agencies and concern for possible detrimental environmental effects of projects.

Both social concerns and legislative actions are contributing to increased use of floodplain zoning. Environmental concerns of people in some flood control districts has resulted in strong objections to concrete or rock-lined flood control channels and searches for alternative solutions.

Flood damage in the Delta

The Federal Flood Insurance Program was not well received for its first four years, but additional legislation following severe floods at several locations in the United States has stimulated widespread interest in extension of the program in flood-prone areas. A requirement of the program is local agency implementation of suitable zoning of floodplains.

Until recently, the State reimbursed local flood control agencies for nearly all the local share of the capital costs of federal flood control projects. State legislation adopted in 1973 reduced reimbursement by the State thus requiring local agencies to assume a significant part of the nonfederal share of first costs of projects. This is in addition to the operation and maintenance costs local agencies have borne in the past and will continue to pay. This too can be expected to shift flood management toward greater use of floodplain zoning.

The State in 1974 adopted legislation providing that it will pay part of the maintenance cost of eligible levees. In the Sacramento-San Joaquin Delta, for nonfederal project levees, the State will pay annually up to 50 percent of the maintenance costs after the local agencies have assumed the first $500 per mile of levee. For all project levees in the State, authorized under the State Water Resources law of 1945, the State will also pay 50 percent of additional costs attributed to planting or retention of controlled vegetative cover for wildlife, recreational, scenic and aesthetic purposes.

Land use planning and zoning can be used to keep incompatible urban development out of flood-prone areas and at the same time allow for suitable uses of the land resources.

To insure that man's needs for protection and security are satisfied, protection from floods is essential. Furthermore, to maintain adequate production of agricultural produce, goods, and other services, adequate land resources must be made available. Flood damage prevention is an economic cost which must be considered in the development of California's land and water resources to satisfy the needs of people.

Environmental Quality

Water, either running or standing, is often the central environmental attraction of an area regardless of whether the area is used for recreation, residential or other purposes. Whatever the recreational activity, the setting with a stream or lake seems to be preferred to a setting without water. It also is apparent that land with a lakeview or a stream nearby is higher in value for residential use than other land. The development of stream parkways such as along Los Gatos Creek in Santa Clara County and the American River in Sacramento is further evidence of the high regard placed on streams.

Other examples of concern for environmental quality are the California Wild and Scenic Rivers Act, which followed by a few years federal legislation in this field, and the current Resources Agency program for the development of waterway management plans. Californians for years have developed lakes and reservoirs for recreation and their scenic attributes. Streams now seem to offer the kinds of environmental quality and recreation potentials that excite communities to action.

Up through the 1950s concern about comprehensive long-range environmental goals for an area such as California was minimal. During the 1960s there was increasing concern about what was happening and what might happen to the environment in California and elsewhere. By the end of the 1960s there appeared to be an informal concensus on the part of the people of California and the United States that we should achieve and maintain a high quality of liveability for ourselves, our children, and grandchildren.

This informal consensus was translated into law by the Congress of the United States in 1969 and the California State Legislature in 1970. Those laws established a formal statutory base which will "create and maintain conditions under which man and nature can exist in productive harmony".*

There is little understanding of the long-term effects that different rates and kinds of growth would have on the quality of life. There does not appear to be agreement on what the mix of material goods for social well-being should be with the intangibles needed for the highest attainable quality of life. Each person, each corporation, each governmental unit, each citizen organization historically has pursued his or its own ends. The result, through the 1960s, generally has been unplanned, uncoordinated, and uncontrolled growth. This kind of growth, historically, has produced in the United States and in California a high material standard of living. It also increasingly is yielding some undesirable natural environmental results and conflict.

These problems are considered in the report entitled "Summary Report: Environmental Goals and Policy", issued by the Governor in 1973. The report is discussed in Chapter I of this bulletin.

During the next few years, it is anticipated that a more specific body of information will be developed to better define some of the relationships between man and nature. At the present time, the interrelationships of water management and environmental concerns require institutional, economic and operational studies to develop alternative courses of action that may result in solution. In the interim, water management programs must be aware of and respond to issues that relate environmental quality and water resources.

Water Quality

The quality of water provides a measure of the utility of water for its many beneficial uses. In gen-

* National Environmental Policy Act of 1969 (NEPA), Public Law 91-190.

eral, the better the quality of the water the wider the variety of uses that can be met. In recognition of this the public at large and the legislature's attitudes are to protect the quality of the State's water resources and to enhance water quality in those instances where a better quality would facilitate more beneficial uses or esthetic enjoyment.

California since 1950 has had an aggressive program to prevent water pollution resulting from municipal and industrial waste discharges. This program was expanded in 1970 by the Porter-Cologne Water Quality Control Act which added many provisions to provide stricter water quality control management, particularly through new enforcement provisions. Additional emphasis was placed on control of water quality by the passage of the 1972 amendments to the Federal Water Pollution Control Act (PL 92-500). PL 92-500 provided funds to assist the local agencies of every state in construction of treatment facilities to improve the quality of waste water discharges. The goal of PL 92-500 is to have by 1983 a national water resource of sufficient quality to provide for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water. The State Water Resources Control Board has further emphasized protection of water quality by the adoption of a policy to prevent degradation of the existing quality of all water of the State by any of man's activities to the maximum feasible extent.

The State Water Quality Control Board is currently completing a massive water quality management planning program which is mentioned in Chapter I and is discussed in detail in Chapter V of this bulletin.

The basic water quality assumption for water resources management planning is that overall improvements in water quality can be expected in spite of increased population levels and economic activities. Achieving the established water quality standards may affect the need for future water supply development, reclamation of waste water, and agricultural waste water drainage systems.

Environmental quality is improved by summer releases from storage to the American River

CHAPTER IV

DEMANDS FOR WATER

This chapter discusses demands for water—water supplies to meet out-of-stream consumptive uses, water for instream flow maintenance and enhancement, water quality for protection of beneficial purposes, and control of water to reduce damage from floods. "Water demands" as used in this report means "quantity of water use".

The quantity of water for irrigated agriculture, urban uses, and for power plant cooling has been calculated for several alternative levels of future development. Only one estimate of future water demand for recreation, fish and wildlife was made. Water management requirements for other purposes such as flood control, energy generation, quality protection, environmental enhancement, and navigation are discussed only qualitatively—in terms of their relation to the future.

Urban Water Use

California currently requires more than five million acre-feet of water each year for municipal and industrial purposes. The uses are many and varied but fall broadly into four general groups: domestic (residential), industrial, commercial, and governmental. Domestic uses require about 68 percent of the total, industrial about 18 percent, commercial 10 percent, and governmental and institutional uses the remaining 4 percent.

These four components are treated in this bulletin as a single combined entity, "urban water use". The projected quantities presented in this chapter are derived as the product of per capita water use and the population projections presented in Chapter III. By way of review, the four levels of future population are shown in the following tabulation:

Alternative Future Population
(millions)

	I	II	III	IV
1972	20.5	20.5	20.5	20.5
1990	27.4	26.7	26.1	23.6
2020	43.3	39.1	36.6	26.5

Urban rates of water use were determined on a per capita basis. The total quantity of water used by a community each day was divided by its population. The quantity of water used is the net result of a number of variables, some of which tend to increase unit use while others cause decreases. Each area has a unique combination of these variables which result in a per capita value specific to that area.

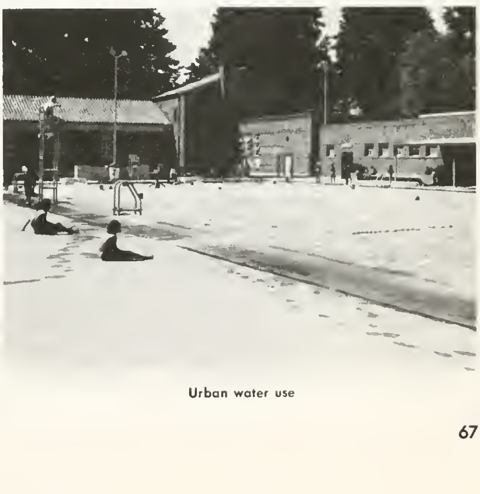
The variability in per capita water use between communities is demonstrated by the examples in Table 10.

Table 10. Per Capita Water Use in Selected Communities

Agency	Service area population	Per capita water use (gallons per capita per day)
San Francisco Bay Area		
Palo Alto Water Department	59,300	255
Marin Municipal Water District	160,000	164
San Francisco Water Department	712,000	144
Hayward Water Department	91,460	134
North County Water District (Pacifica)	34,200	98
South Coastal Area		
Pasadena Water Department	116,749	223
Orange Water Department	72,427	171
Los Angeles Department of Water & Power (City and habor area)	1,877,736	163
San Diego Water Department	657,036	154

Industrial use of fresh water constitutes about one-fifth of the total urban water demand. The State's 1972 industrial use amounted to about 920,000 acre-feet. Considerable effort has been devoted to canvassing industry to obtain data on water use and related production information. The results are summarized in Department of Water Resources Bulletin No. 124, "Water Use by Manufacturing Industries in California". For purposes of this Bulletin 160-74, the detailed information was adapted to permit industrial water use and all other urban uses to be expressed as a direct function of population, that is, as per capita water use.

Temperature has significant influence on residential use, especially where lawns and gardens are extensive. In these areas, summer use often will vary from winter use by several hundred percent. Precipitation most



Urban water use

markedly reduces water requirements when it occurs during late spring and early fall while vegetation is actively growing.

Other factors which influence per capita water use include personal income, cost of water, degree of industrialization, family size, type of community, metering water delivered to individual users, and system losses. In addition, many cities are undergoing a change in unit water use trends as their residential development patterns change. An example is the replacement of older single family dwellings with high-rise apartment complexes; this usually results in lower per capita water use.

Historic rates of urban water use are determined by sampling as many individual water service agencies as can be found with reliable water production data. The per capita value derived for each agency is weighted according to population served to determine the proper value for each geographic area under investigation.

Trends in per capita water use rates provide a useful guide in predicting future unit water values, although the reliability of this technique diminishes the further ahead one looks. The 1990 unit values derived for calculating the total urban water demand presented in this report are principally the result of extrapolation of historic trends. Consideration is given to possible future industrial activity and the character or type of future residential development to modify the extrapolated trends for estimating year 2020 unit values.

The populous San Francisco Bay and South Coastal areas have established rates of use which are not apt to change greatly in the foreseeable future due to the relatively small impact changes in new residential development and new industry will have on total use. Unit use in the San Francisco Bay area is still increasing somewhat but data from the South Coastal area reveal a leveling off.

Sacramento Basin, Delta-Central Sierra, San Joaquin Basin, and Tulare Basin have a high per capita water use due to high summertime residential requirements, high water-using industries, and mostly flat-rate residential services. Considering the current high use and the likelihood of more extensive recycling of industrial waste water, the average unit use should remain relatively constant. Average unit use in Delta-Central Sierra will probably show a decline beyond the present because increase of large water consuming industries is not keeping pace with population growth.

Average North Coastal per capital use will probably decline as the high water use in pulp and paper manufacturing remains level and population continues to grow.

A substantial increase in average unit use is predicted for North Lahontan area as a reflection of recreational growth. Per capita water use is calculated based on resident population but includes the water used by tourists. Tourism is treated similarly to industry in computing unit use.

As would be expected, the desert areas have a high unit rate of use because of hot and dry climatic conditions throughout the year.

A detailed discussion and analysis of historic unit municipal and industrial water use is presented in the Department of Water Resources Bulletin No. 166 series. Bulletin No. 166-1, "Municipal and Industrial Water Use", was published in 1968, but an updated edition is being prepared and will be published soon. That bulletin should be referred to for data on water deliveries by specific agencies, unit rates of use for specific communities and other geographic areas, and other urban-related water use information.

Urban applied water demands projected for 1990 and 2020 under the four levels of alternative population are presented by major hydrologic areas in Table 11, along with 1972 demands. The term "applied water" refers to the total quantity produced by a water service agency and delivered to its customers, plus all losses inherent in the system such as conveyance leakage, back-flushing of the filter system, fire protection, etc.

Table 11. 1972 and Projected Urban Applied Water Demand
(1,000 acre-feet)

	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta-Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Total
1972	93	990	181	2,370	470	173	192	363	23	89	99	5,040
Alternative I												
1990	104	1,480	308	3,130	700	251	295	493	40	154	148	7,100
2020	126	2,240	569	4,830	1,040	537	548	798	68	387	275	11,400
Alternative II												
1990	102	1,460	300	3,050	687	247	287	479	40	139	142	6,930
2020	120	2,070	516	4,360	968	490	485	718	59	326	246	10,400
Alternative III												
1990	101	1,430	289	2,980	674	239	279	471	39	136	139	6,770
2020	114	1,940	473	4,120	908	451	451	679	54	306	230	9,730
Alternative IV												
1990	97	1,340	252	2,670	621	219	249	441	32	108	126	6,160
2020	100	1,570	318	2,980	702	323	307	530	35	143	173	7,170

Lake Merced Golf Course in San Francisco

Agricultural Water Demands

At the present time, nearly 9 million of the 10.5 million acres of cultivated lands in California are irrigated. The remaining 1.5 million acres are dry-farmed, planted primarily to small grains and hay which derive their water solely from rainfall. The 1972 total applied water for irrigation is some 31.7 million acre-feet. The estimates of future agricultural applied water demands presented in this bulletin are the product of the projected acreage of each irrigated crop and the appropriate unit values of applied water.

By way of review, the four alternative levels of future agriculture development presented in Chapter III were premised on two different rates of national population growth, two projections of foreign trade, two sets of projected crop yields, a single projection of per capita consumption of food and fiber, and a single projection of the state's share of national production.

Alternative Future Irrigated Crop Acreages
(1,000 acres)

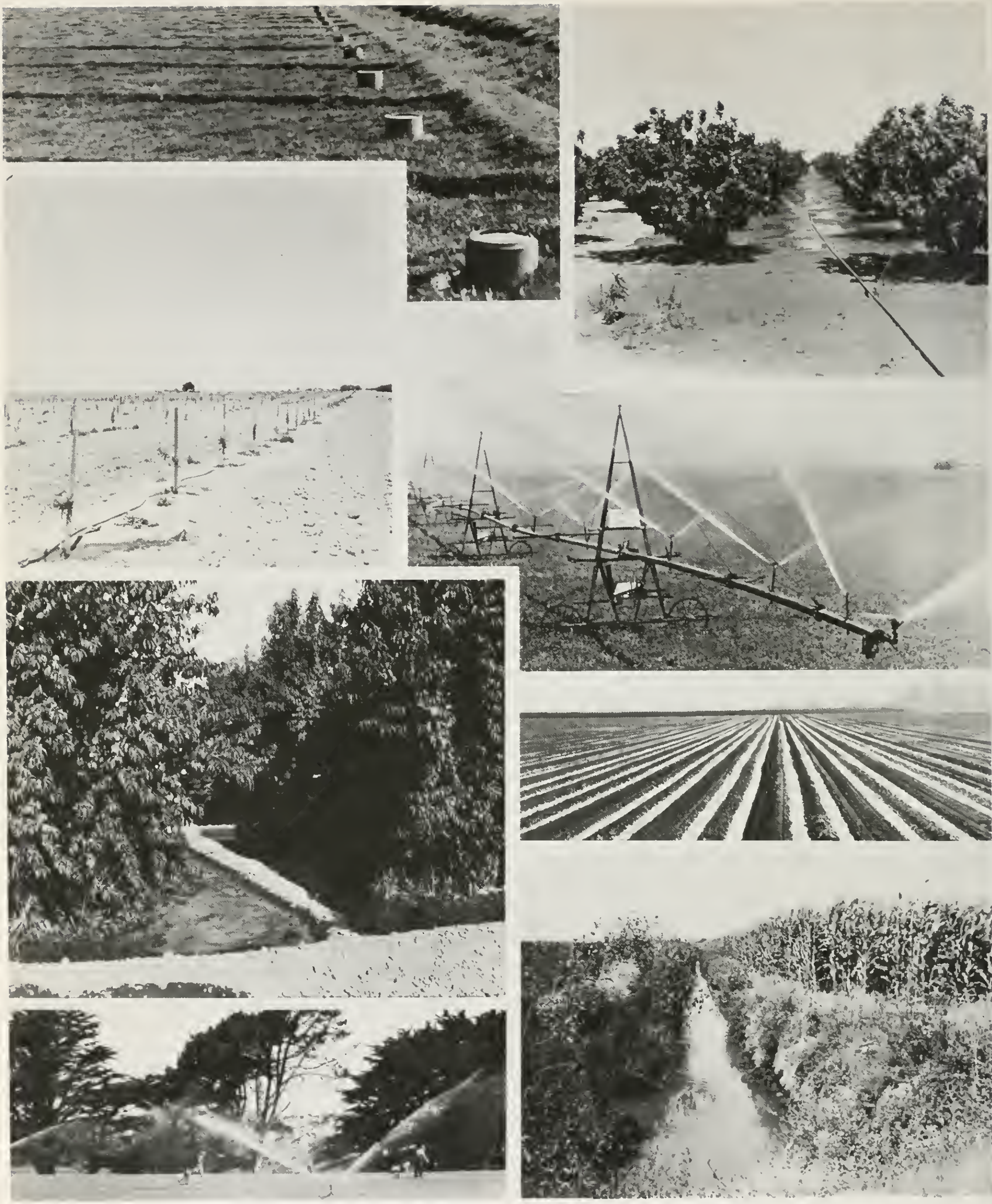
	I	II	III	IV
1972	9,070	9,070	9,070	9,070
1990	10,640	10,150	9,720	9,510
2020	12,130	11,150	10,330	9,800

While the actual use of water (evapotranspiration) is primarily a physiological function of the crop, the rate of water application (irrigation) is a function of many variables, some unrelated to the specific crop in question. In order to determine the amount of applied water required per acre of each crop within an investigation area, it is necessary to know not only the methods of irrigation but also those factors which affect irrigation practices. This is important because crop culture, soils, climate, water availability, and other factors vary substantially from place to place within California, often over short distances. Some examples of the wide range of water application rates are given below:

Crop	Weighted Average Annual Unit Applied Water (AF/A)	
	Tehama County	Kern County
Alfalfa	3.6	5.4
Sugar beets	3.1	4.2
Deciduous orchard	2.7	3.7

Within each of these areas the rates vary considerably.

Results of in-depth studies of water use rates and much of the collected data are presented in the Department's Bulletin No. 113 series, the most recent edition being Bulletin No. 113-3, "Vegetative Water Use in California, 1974". The crop unit water use values used in calculating agricultural water demands were based on data presented in Bulletin No. 113-3. That report should be referred to for more detailed information on the quantity of water transpired by



Several irrigation methods used in California plants or evaporated from soil and plant surfaces as a result of irrigation and current rates of water application for specific crops in the various geographic areas of the State.

In California, irrigation systems range from wild flooding to the most advanced found anywhere in the world. The wild-flooding technique, i.e., letting water flow randomly downslope from a network of distribution ditches, is still used today in some of the mountainous areas where pasture and the associated livestock production remain the principal agricultural enterprise. The other extreme can be found in such places as San Diego County, where high income producing truck, nursery, and semitropical fruit crops are irrigated with expensive water by highly sophisticated and expensive systems, including drip irrigation. At the present time, about 2 percent of the State's total irrigated lands are irrigated by wild flooding, about 17 percent by sprinklers, and most of the remainder by border, basin, or furrow systems.

However, as is true for nearly all phases of farm management in California, there are significant changes taking place in irrigation practices throughout the State, even in some of the long-established agricultural areas such as the pasture-livestock producing mountainous areas mentioned in the previous paragraph. The need to increase production to offset ever-increasing costs has encouraged efforts to spread limited water supplies to the maximum extent possible. Even where water availability and price are not constraints, irrigation techniques are changing, principally as a result of increased labor costs. The change is mainly to sprinkler systems and this trend seems likely to continue.

The water application efficiency of sprinkler systems is generally greater than with other systems. Sprinklers are also used for frost control, principally on grapes and deciduous orchard, but also on certain truck crops. The heat provided by the relatively warm water and the heat energy released as it changes from the liquid state to ice often can provide just enough protection. The same system can provide a few degrees of cooling during periods of extreme heat which can be important in preserving the quality of some varieties of wine grapes.

A new "drip" method of irrigation has recently been initiated with encouraging results. Drip irrigation has potential for significant reduction in total water application requirements for some crops. It has been defined as the application of water to the soil at a rate sufficiently slow so that all water immediately enters the soil, with the result that the root zone is filled but only a minimum area of the soil surface is wetted. In practice, small amounts of water are applied every day or so, depending on the weather and stage of plant development, through one to six emitters around each tree or vine, or along the full length of a porous hose in the case of truck crops.

It has been estimated that about 40,000 acres are presently irrigated with drippers in California. Much of this is in San Diego County; however, the system is being tried in other locations throughout the State. The initial system cost is high; although, as with many sprinkler systems, operational labor costs can be kept fairly low. How widespread the future use of this system will be cannot be forecast with any degree of confidence at this time. Increased use should reduce applied water requirements, at least for young trees and vines and many truck crops. The effects of salt buildup in the soil as water is used and the leaching requirements need careful evaluation to reach conclusions regarding the overall water requirements.

In selecting the unit applied water values for this study, consideration was given to those crops that could be expected to be grown on new irrigated land, the changes in cropping pattern that would likely take place on existing irrigated land, and the changes in

Drip irrigation of young pistachio nut tree farm management which might take place in the future. While drip irrigation may become more widely accepted, it is concluded that the major change in the foreseeable future will be toward a greater use of sprinklers, with much of the new land and more of the presently irrigated land under sprinkler irrigation by year 2020.

Agricultural applied water demands projected for 1990 and 2020 under the four levels of alternative future development are presented by major hydrologic areas in Table 12, along with 1972 demands. The term "applied water" refers to the quantities of water that must be delivered to the place of use, such as a farm headgate, to satisfy the irrigated crop requirements.

Table 12. 1972 and Projected Agricultural Applied Water Demand (1,000 acre-feet)

	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta-Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Totals
1972	710	250	1,030	920	6,020	2,470	5,450	10,890	420	310	3,220	31,700
Alternative I												
1990	720	290	1,240	730	7,940	3,220	6,620	13,070	430	300	3,320	37,900
2020	740	330	1,310	530	9,080	3,700	7,320	14,870	430	250	3,320	41,900
Alternative II												
1990	720	280	1,200	720	7,540	3,010	6,390	12,510	430	300	3,320	36,400
2020	740	320	1,270	510	8,350	3,540	6,600	13,720	430	250	3,320	39,000
Alternative III												
1990	710	290	1,190	720	7,050	2,810	6,040	11,750	430	300	3,320	34,600
2020	730	310	1,240	520	7,540	3,250	6,180	12,360	430	250	3,320	36,100
Alternative IV												
1990	710	280	1,200	750	6,960	2,710	5,750	11,580	400	300	3,320	34,000
2020	730	280	1,220	520	7,410	3,020	5,750	11,750	400	250	3,320	34,600

Water for Power

Water resources are developed and managed in many ways to produce energy and power. Hydroelectric plants use the force of falling water to spin turbines and generators to produce electricity. Thermal plants, both fossil fuel and nuclear, use water for cooling. Geothermal plants may either produce water from deep extractions or may use water for injection into deep heated strata. The consumptive use of water for power plant cooling is discussed in this section, while nonconsumptive uses of water for power are discussed later in this chapter.

About 90 percent of thermal power plants in California presently use once-through cooling with saline or brackish water. In 1972, there were about a dozen plants using an estimated 25,000 acre-feet of fresh water for cooling in recirculating systems. In addition, an estimated 13,000 acre-feet of evaporation is caused by two plants that take fresh water from Sacramento-San Joaquin Delta channels for once-through cooling.

A number of assumptions are necessary in calculating the quantity of cooling water needed in the future by thermal power plants. A simplified heat flow is illustrated in Figure 14, "Heat Balance Diagram". This diagram shows a modern fossil fuel power plant with an efficiency of over 37 percent. As illustrated by this diagram, when the plant is in operation, it requires about 20 cubic feet per second (cfs) to provide sufficient water for cooling and drift loss. Five cubic feet per second is an average value for blowdown which can vary considerably depending upon the quality of the makeup water. These plants, however, do not operate continuously or always at full rated output. In 1972 in California, the average capacity factor for thermal plants was about 56 percent.

Cooling water requirements must include an allowance for blowdown. Blowdown is the continuous or intermittent wasting of a small amount of the circulating cooling water to limit the increase in the concentration of solids in the water due to evaporation. A blowdown of 15 percent was assumed for the calculations of cooling water requirements. The following factors and additional assumptions were used:

Nuclear plants	AF/Million KWH
1990	2.4
2020	1.4
Gas and Oil Plants	
Existing	1.42
1990	1.27
2020	1.27

As presented in Chapter III, an assumption was made that either one-third or two-thirds of the cooling water demand will be supplied from inland water sources. Combining these two alternative inland siting assumptions with high and low projections of electricity used,

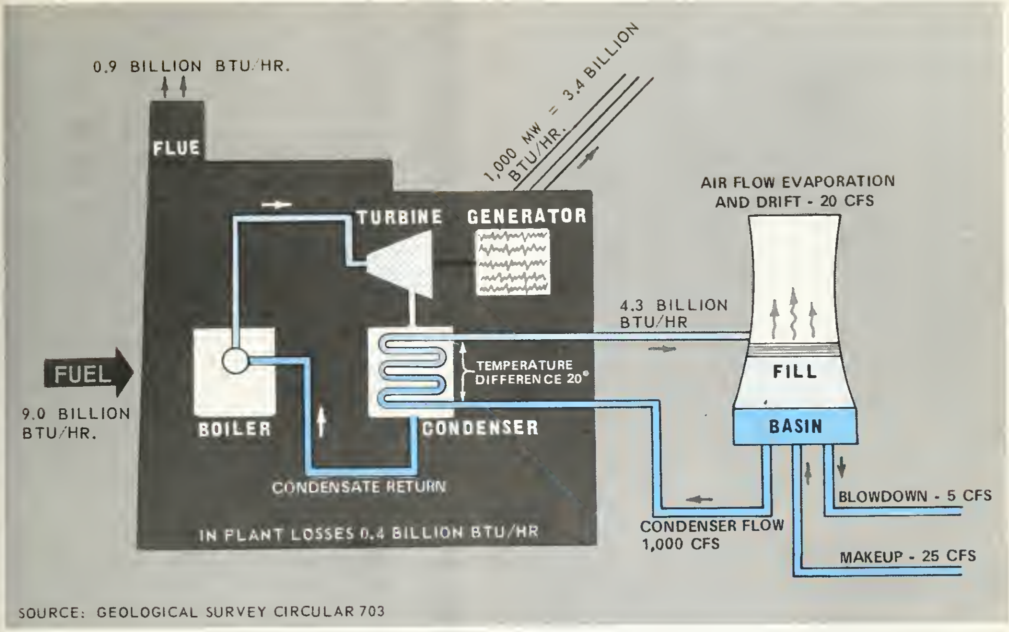


Figure 14. Heat Balance Diagram

Rancho Seco nuclear power plant uses fresh water for cooling

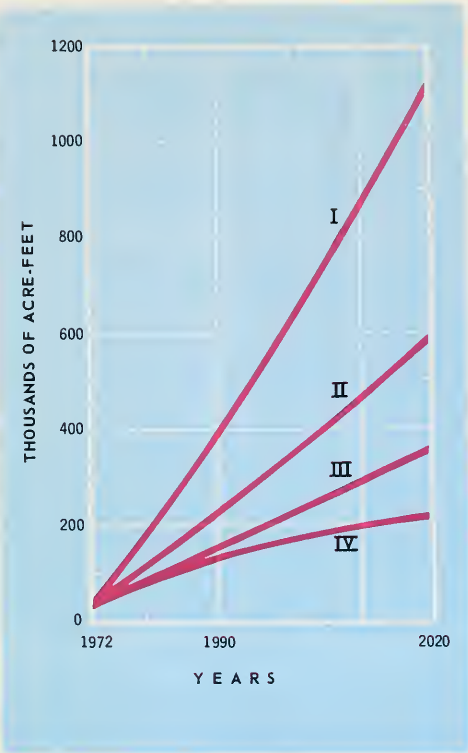


Figure 15. Projected Demands for Fresh Cooling Water

Figure 12, gives four levels of cooling water demand. These demands are presented in Figure 15.

The projected cooling water requirements for the State were calculated for the four alternatives using the above factors and the generation given in Table 8. The results distributed to hydrologic study areas are shown in Table 13.

Power plant cooling water demands will not necessarily all be met with new supplies of inland fresh water. Reclaimed waste water is a prime potential source of fresh water for power plant cooling. Also, as discussed in Chapter III, advancement in technology may have a significant impact on the actual water demand. Some factors such as geothermal and possibly solar energy may increase the demand. On the other hand, air cooling, use of gas-cooled nuclear plants with gas turbines and higher efficiency, are more likely to reduce the overall demand. While little effect is likely by 1990, one can envisage perhaps one-third of the heat being discharged directly to the atmosphere by 2020, with an attendant reduction of one-third in the amount of cooling water required from that shown in Table 13.

Another aspect to consider in estimating cooling water demand is that there are beneficial uses of warm cooling water which are quite likely to become more common as the cost of energy increases. The tremendous amounts of waste heat produced by power plants may become too valuable to be wasted. Warm cooling water is being used beneficially in other areas of the world. Future uses of warm cooling water which might become economical in this country include agricultural uses such as greenhouse or soil heating, aquaculture, and mariculture.

Table 13. Power Plant Fresh Water Cooling Requirements (1,000 acre-feet)

		Alternative futures							
		1990				2020			
Hydrologic study area	1972	I	II	III	IV	I	II	III	IV
South Coastal	18	30	30	30	30	80	40	0	0
Sacramento Basin	0	50	0	0	0	140	60	50	0
Delta-Central Sierra	20	100	75	50	40	150	100	110	70
San Joaquin Basin	0	0	0	0	0	140	70	0	0
Tulare Lake Basin	0	70	35	20	20	240	130	60	60
South Lahontan	0	10	10	10	0	100	50	0	0
Colorado Desert	0*	130	70	40	40	250	130	130	80
Entire state	38	390	220	150	130	1,100	580	350	210

* Less than 2,000 acre-feet (included with industrial).

Recreation, Fish and Wildlife

The policy of the State recognizes concern for recreation, fish, and wildlife as primary purposes in the formulation and review of water projects. The California Water Code sets forth clear directives that facilities be provided for public recreational purposes and that fisheries and wildlife be preserved and enhanced to the maximum justifiable extent. Federal policy, likewise, places emphasis on recreation, fish and wildlife. The policy has been demonstrated in the passage of both state and federal legislation on wild and scenic rivers and environmental quality, and in recent decisions by the State Water Resources Control Board.

In some parts of the State, especially the North Coastal area, the greatest local need for water will be for the purposes of recreation, and enhancement of fisheries and wildlife. Consequently, much of the future planning efforts, especially for Northern California rivers, would be directed toward developing water supplies to meet these needs. Recreation and commercial fishing presently comprise the second and fourth largest income producing industries in the North Coastal area. The anadromous fishery resources are extremely significant to both of these industries.

In other areas of the State, such as the northeastern counties and the Sacramento-San Joaquin Valleys, water is nedeed to replace depleted wetlands for waterfowl.

Streamflow Maintenance

The ability of a stream to support fish populations or to attract and support recreation activities is a function of its flow more than any other variable. Other factors, however, are important; the water must be of satisfactory quality and temperature, and the surrounding terrain and vegetation must be sufficiently attractive to provide a pleasing environment.

Dams and reservoirs, properly operated, can provide for recreation and support fisheries by storing water during periods of high runoff and releasing it during the summer and fall seasons of low flow. This provides benefits downstream in addition to the benefits of the man-made lake itself.

In the 1930s, an ambitious program was conducted in the high Sierra by the U. S. Forest Service and sportsmens organizations to build a number of dams at the outlet of mountain lakes to maintain flows in the streams below them to support trout fisheries. The Department of Fish and Game and the Wildlife Conservation Board continued this program into more recent years. This State program, by the 1960s, had provided about 50 dams in the central and southern Sierra Nevadas storing snowmelt and sending more than 10,000 acre-feet of water annually into more than 400 miles of trout streams during late summer and fall when they would otherwise be dry or nearly so.

There are numerous agreements between water developers and other parties (often the State Department of Fish and Game) that specify conditions requiring maintenance of downstream flows. Often such requirements are made a part of water rights and other agreements. Table 14 lists current streamflow amounts by hydrologic area to indicate the extent of this important phase of water project operations. The flows covered by agreements and by the terms of permits and licenses are as varied as the watersheds they cover. Often, it is intended that they preserve, or mitigate damage to, existing resources. In other cases, the flows released provide enhanced fisheries and recreational opportunities downstream.

Table 14. Summary of Flow Maintenance Agreements (normal year flows)

Hydrologic study area and river	Annual water allocations for streamflow maintenance (1,000 acre-feet)
North Coastal	
Klamath River below Iron Gate Dam	514
Mad River below Ruth Dam	46
Trinity River below Lewiston Dam	120
San Francisco Bay	
Russian River below Coyote Dam	108
Nicasio Creek, Marin Co.	4
Scotty Creek, Sonoma Co.	3
Central Coastal	
San Lorenzo River, Santa Cruz Co.	11
Uvas Creek, Santa Clara Co.	10
Chorro Creek, San Luis Obispo Co.	1
Sacramento Basin	
Pit-McCloud Rivers above Shasta Lake	149
Clear Creek below Whiskeytown Dam	25
Sacramento River below Box Canyon Dam	62
Sacramento River below Keswick Dam	2,006
Feather River tributaries above Lake Oroville	59
Feather River below Thermalito Afterbay	978
Yuba and Bear Rivers System	236
Upper American River and tributaries	158
American River below Nimbus Dam	234
Delta-Central Sierra	
Mokelumne River below Camanche Dam	13
San Joaquin Basin	
San Joaquin River	31
San Joaquin River tributaries	11
Merced River below Exchequer Dam	44
Stanislaus River above Melones Reservoir	36
Tuolumne River below New Don Pedro Dam	123
Tulare Basin	
Kern River below Fairview Diversion	50
Kern River Hatchery Supply	14
Salmon and Corral Creek Diversions in Tulare County	2
Kings River below Pine Flat Dam	47
North Lahontan	
Truckee River	33
South Lahontan	
Owens River	54

Some of the kinds of uses of water in stream and out of stream are illustrated in Figure 16.

Wildlife Habitat Protection

Water projects affect wildlife populations by inundating habitat in the reservoir area and by changing downstream river habitat as a result of the changed flow regime. The downstream effect can be either positive or negative depending on whether the regulated flows tend to increase or decrease the amount and types of vegetation, but the effect of reservoir inundation is almost always detrimental to deer and other terrestrial animals.

Wildlife habitat losses can sometimes be mitigated through special habitat management of lands near the project area. However, often there is no way to adequately compensate for lost habitat "on site". Therefore, it is necessary either to experience a loss or accept some type of a trade off, such as development of equivalent habitat at some site remote from the project (off-site mitigation).

Riparian areas are an important wildlife habitat, and a significant consideration in water project planning. Riparian habitat consists of native vegetation that occurs along permanent and intermittent watercourses, sloughs, floodplains, overflow channels, drainage ditches, and lakes. These areas are dependent upon periodic flooding for their existence. According to the California Fish and Wildlife Plan*, published in 1966, there were an estimated 350,000 acres of riparian habitat in California. This is less than one-half of one percent of the total land area in the State, but the importance of this habitat to wildlife far exceeds this proportion.

Refuges and marsh lands are also extremely important to the maintenance of many decreasing wildlife species in California. There are presently 20 waterfowl management refuges in California operated by state or federal agencies, and numerous wetland hunting areas managed by private organizations. Some of these refuges and marshlands are located in water deficient areas. For example, the Kern and Pixley National Wildlife Refuges are under-developed because of the low availability and high cost of water.

In California, which is the main wintering ground for waterfowl in the Pacific Flyway, marsh habitat has dwindled from an estimated original 3.5 million acres to about 400,000 acres presently. The demand for waterfowl hunting, and nonhunting activities such as birdwatching, photography, and sightseeing, continues to increase. It is quite evident that the continual loss of living space for wildlife and the loss of ready access to public lands for hunting and other uses are major problems facing wildlife management agencies.

* "California Fish and Wildlife Plan", Department of Fish and Game, 1966.

Water and people just naturally go together

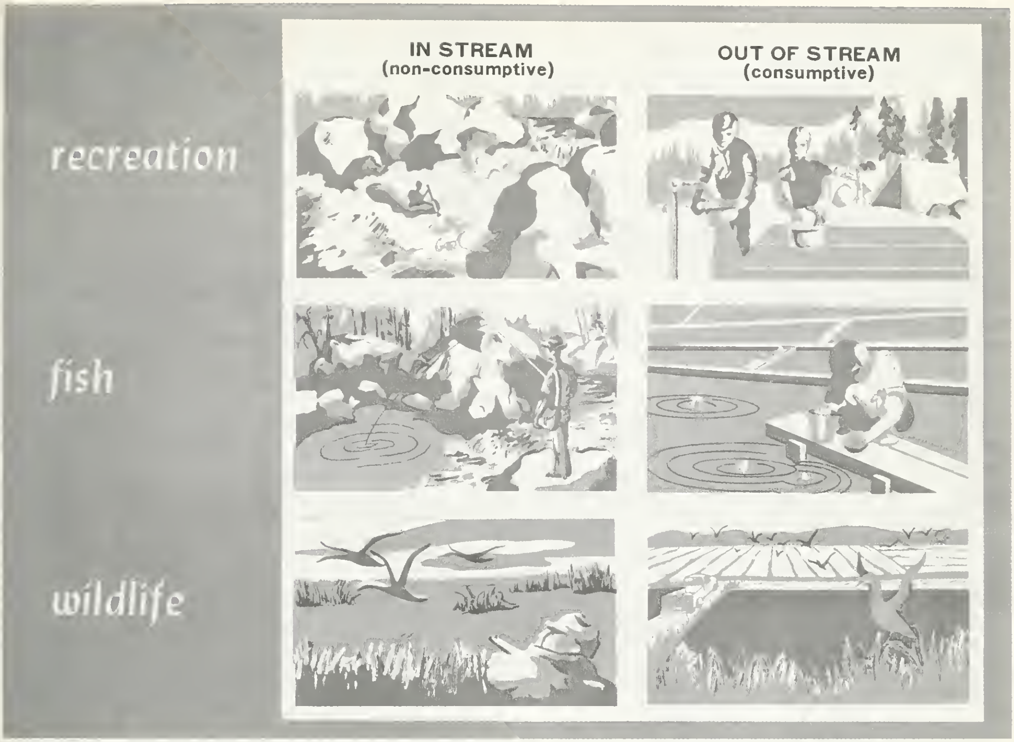


Figure 16. Water Use for Recreation, Fish and Wildlife

Some areas of the State have marshland for which the available water is inadequate for effective management for wildlife. Future water resources planning in these areas should consider the possibility of providing additional water supplies for wildlife habitat enhancement on these marshlands. Unlike fish spawning habitat and deer habitat, marshland habitat can be created on almost any flat land within the Pacific Flyway if an adequate water supply is available. The water can even be of relatively poor quality. Therefore, the possible creation of additional marshland habitat should also be given consideration in future water resource management.

Fishery Mitigation and Enhancement

Maintenance and enhancement of fisheries in the streams below water projects is of primary importance as is mitigation for lost fishery habitat above the project. Several fishery mitigation and enhancement techniques have been developed. Some have proved effective while others have not. Following is a brief description of some of the more noteworthy techniques that have been tried.

Fish hatcheries are the oldest and perhaps most successful means of increasing the numbers of fish in a stream. Experience has shown that most hatcheries must undergo an extended shakedown period of operation before they become highly productive. Among the more successful hatcheries are the State Water Project Hatchery at Oroville on the Feather River, the Nimbus Hatchery on the American River, and the Coleman Hatchery on Butte Creek, a tributary of the Sacramento River. It appears that the best way of maintaining adequate salmon and steelhead runs is to construct modern fish hatcheries either at project sites or at other suitable locations having water of proper quantity, temperature, and quality.

Rearing ponds offer a significant potential for increasing production of silver salmon and steelhead at reasonable costs, provided volunteers can be found to operate and maintain them. Otherwise, their costs approach that of a hatchery. Rearing ponds are basically areas into which hatchery reared fingerling salmonids

Steelhead fishing on the lower American River

are introduced, fed, and protected until they are ready to migrate to the ocean. The Humboldt Bay Fish Action Council is operating a rearing pond on Cochran Creek, a tributary to Humboldt Bay. A run of silver salmon has been reestablished in Freshwater Creek by planting fish reared in these ponds.

Artificial spawning channels, another method of fishery enhancement, are man-made water courses, usually paralleling a natural stream, designed specifically to provide spawning habitat for fish. Although they do not provide a habitat suitable for juvenile steelhead or silver salmon which remain in fresh water for at least one year, their potential for enhancing king salmon runs is considered quite good.

There are four spawning channels in California that raise king salmon. They are located on the Merced, Mokelumne, Sacramento, and Feather Rivers. The largest of these facilities is the $20 million spawning channel of the Bureau of Reclamation on the Sacramento River at Red Bluff, which was completed in 1971 as part of the Tehama-Colusa Canal of the Central Valley Project. About 5,000 adult king salmon were used to produce the initial brood stock. The spawning channel is expected to reach its ultimate capacity of 40,000 adults annually by 1982.

Applied Water Demands

The 1972 and projected 1990 and 2020 applied water demands for recreation, fish, and wildlife are shown in Table 15. The values represent water used in fish and wildlife management areas and refuges, and

Table 15. Applied Water Demands for Fish, Wildlife and Nonurban Area Recreation
(1,000 acre-feet)

Hydrologic area	1972	Estimated 1990	Estimated 2020
North Coastal	323	359	362
San Francisco Bay	24	37	46
Central Coastal	2	3	6
South Coastal	6	19	23
Sacramento Basin	125	170	174
Delta-Central Sierra	6	7	9
San Joaquin Basin	91	94	95
Tulare Basin	43	68	70
North Lahontan	11	11	13
South Lahontan	4	16	22
Colorado Desert	20	22	26
Total	655	806	846

the out-of-stream use by recreationists in park areas removed from population centers. In total, the consumptive uses of water for these purposes amounts to only about two percent of the State's projected 2020 total water demands. However, in the specific management areas this water is essential to maintenance of the present fish and wildlife populations. Not included in the projections is the water required for fish or wildlife enhancement, and instream requirements for fish, wildlife, and recreation.

Farm ditches can be good habitat for wildlife

Other Water Demand Considerations

This section discusses those aspects of water management for which demands cannot be evaluated quantitatively. This is not to say that these considerations (environmental enhancement, water quality control, flood control, and navigation) are not important—for, indeed, they are important. However, their water use cannot be identified separately, does not involve consumption of water, and can be satisfied generally by water controlled, conserved, and put to use for the other beneficial purposes described earlier in this chapter.

Environmental Enhancement

Environment and environmental concern are at the forefront in the public conscience. While the word "environment" is all-embracing, being the total complex of social and cultural conditions affecting an individual or community, its consideration in this chapter is limited to its relation to water and water management.

In a large sense, water *is* environment. People have an inherent affinity for nearness to water in pursuing their various outdoor recreational and aesthetic endeavors. More than half of the total outdoors recreation in California is water associated, and the majority of this recreation is enjoyed on or near manmade lakes (reservoirs) and streams whose flows are augmented by releases from upstream reservoirs.

Experience has demonstrated that water projects, including both reservoirs and streams with augmented flows from reservoir releases, have provided and continue to provide substantial environmental quality, even though the facilities were not necessarily planned with that purpose in mind. The reason is that environmental enjoyment is compatible with many other project purposes.

Environmental quality at existing projects can be enhanced by changes in policy of use. For example, measures are being taken to open up terminal storage reservoirs for public use, a move made possible by increasing the degree of treatment of the water supplies before delivery to users. The East Bay Municipal Utility District has recently opened some of its water storage areas to at least limited public use and plans to open other areas in the future. Similar measures are underway by the Metropolitan Water District of Southern California. With sufficient public interest and support, other existing water resource reservoirs in the vicinity of major metropolitan areas could probably also be opened up to full or limited public use.

The reservoirs of the State Water Project in Southern California have been planned to maximize public use. This provides fishing and recreational lakes near large population concentrations in areas that previously were deficient in fresh water recreation opportunity. Oroville and San Luis Reservoirs, primary storage facilities of the State Water Project in northern and central California, were planned and constructed with recreation as a primary purpose. A number of fishing access areas have been provided along the California Aqueduct. The Peripheral Canal is being planned with environmental quality as an important purpose.

Current trends in the public demand for stream parkways are demonstrated by the local development and preservation of the scenic attributes of Los Gatos Creek in Santa Clara County, Big Chico Creek in the city of Chico and the American River in Sacramento County. Such demands have also resulted in studies currently in progress to find ways to preserve the flood control integrity of the levee systems of the Sacramento-San Joaquin Delta and the Sacramento and American Rivers while preserving as much vegetation as possible.

Stream channels used for water supply conveyance, such as Sacramento River and the lower Feather and American Rivers, can be a scenic attraction, as well as providing benefits for fisheries and recreation.

It has been necessary to revise the concept of proposed stream channelization flood control projects as the public appears to be willing to accept the consequence of occasional flooding to the alternative of altering the character of the natural waterway and removing the native vegetation. An example of this occurred in Ross Valley, Marin County, where opposition of the local residents to construction of a stream channelization project has delayed its completion.

The current controversy regarding New Melones Dam on the Stanislaus River is another interesting example. Part of the river is recognized as an outstanding white water stream and New Melones Dam has been strongly oppposed because the reservoir would inundate the white water reach. Two major reservoirs, Donnels, and Beardsley, and several smaller storage facilities provide summer flows in the white water reach, and are almost solely responsible for the existence of those flows.

The Eel River as a wild and scenic river contrasts sharply with the Stanislaus, in that there is essentially no storage on the Eel, other than Lake Pillsbury water which is diverted out of the Eel River watershed. Accordingly, the Eel has extremely high flows in the winter and very low flows during the summer. A most vivid example of such streamflow extremes occurred on the Eel River in the late summer and early winter of 1964. The mean daily flow of the Eel River at Alderpoint was at an historical low of 10 cubic feet per second in September of that year, but just three months later during the December 1964 flood, the flow of the river at this location reached the record instantaneous peak of over 560,000 cfs with the mean daily flow at 434,000 cfs. While this is indeed an "extreme" among streamflow extremes, it does serve to illustrate the wide fluctuations in seasonal flows in this essentially unregulated river.

At just about the time the summer water-oriented recreational season commences, i.e., from the first week in June and through mid-September, a rapid recession in streamflow occurs for most of California's rivers. Potentially enjoyable in-stream recreational uses during the peak summer recreational season are out of phase with natural streamflow conditions for many leisure time pursuits as well as for the sustenance of fish.

Prudent water resources management may prove it desirable in the future to enhance the human and natural environment associated with many rivers. This may require new or additional measures for attenuation of damaging high flows and for augmentation of inhibiting low flows or both. On the other hand, some streams may be best left alone, consistent with the well-being of the people residing in their localities.

Wild and scenic rivers are considered of high natural environmental value by many people. The value of wild and scenic rivers is clearly evident, as nearly everyone derives enjoyment from such streams, whether it be camping, boating, rafting, hiking, picnicking, or merely contemplating their beauty.

The recent and current move toward wild and scenic rivers is manifested in enactment of the California Wild and Scenic Rivers Act, a number of lawsuits, and an initiative to include the Stanislaus River within the wild and scenic rivers system. All of these actions have been undertaken on the basic premise that dams are destructive of the natural environment. Yet, the fact is that the "premium" wild and scenic rivers which are most popular are generally those with reservoirs upstream, from which water releases create the premium conditions.

The Tuolumne River is a good example of a premium white water stream where upstream storage contributes substantially to the unique white water condition. In an appendix to the Resources Agency report, "California's Protected Waterways Plan", February 1971, the Sierra Club describes the 18-mile reach of the Tuolumne from Lumsden Campground to Wards Ferry Bridge as

> ". . . having received the distinction of being considered the finest and longest stretch of white water in the State, and probably in the world." (pg. F-53)

Percolation ponds along Los Gatos Creek

Cherry Valley and O'Shaunessy Reservoirs and Lake Eleanor are located upstream of that reach and release summer flows to be re-regulated in downstream New Don Pedro Reservoir. Without those facilities there would be few days of white water rafting on the Tuolumne River.

Water Quality Control

Water quality and water quantity are inseparable, and together, determine the suitability of water for beneficial uses, the objective toward which water quality control or protection is directed.

The intensified and competing uses of the Nation's water resources, both as a source of supply and as a conveyance system for disposal of wastes, has properly caused the Federal Government and a number of state governments to identify existing and potential problems and to take action toward their correction or prevention. Water quality occupies center stage at the present time. The need for protection of the quality of water to enable full and proper use of the water resources is receiving more and more public attention.

Goals, Policies, and Programs. At the federal level PL 92-500, administered by the Environmental Protection Agency, establishes national goals and policy, sets forth comprehensive programs for water pollution control, provides grants for construction of treatment works, sets standards and provides for enforcement.

At the state level, policy and programs are promulgated by the State Water Resources Control Board and implemented with the assistance of the regional water quality control boards. The basic water quality authority for the State Board is set forth in the Porter-Cologne Water Quality Control Act. The policy clearly indicates the need to relate water quality to water uses and to reflect all values in regulations designed to attain the highest reasonable quality.

Federal and state goals and policies are discussed in more detail in Chapter V.

Demands for Water Quality Control. The demand for water quality can be demonstrated by the extent of the State Water Resources Control Board's planning program for water quality control which is discussed in some detail in Chapter V. This discussion also covers the major water quality problems in each of the 16

Water quality protection through evaporation of toxic waste *Dow Chemical Co. photo*

basins, Figure 4. Another indication of the demand is the amount of funds involved. PL 92-500 includes authorization for 18 billion dollars for the period July 1, 1972, to June 30, 1975 for treatment works for municipal and industrial waste waters. The State of California through two separate referendums in 1970 and 1974 has made available $500 million from bonds under the Clean Water Grant Program. For the 1974–75 fiscal year the State Water Resources Control Board's list of clean water grant priorities covers projects that total over $2½ billion. The cost sharing formula for these grants for control of pollution from municipal wastes is 75 percent federal, 12½ percent state and 12½ percent local.

Water supplies for improvement and maintenance of water quality are to be provided from the New Melones Project for the lower Stanislaus River and San Joaquin River. These specific releases will be available for downstream use in the Delta. Decision 1379 of the State Water Resources Control Board calls for certain water quality conditions in the Sacramento-San Joaquin Delta which require release of stored water during periods of natural low inflow to the Delta. These demands are reflected in computations of the water supplies available for diversion from the Delta.

Flood Control

One purpose of this chapter is to translate trends discussed in the previous chapter into projected demands for water service. Quantified demands for future state and federal flood control services cannot easily be calculated. The basis for payment for these services is changing, leading to uncertainty as to availability of funds for construction. In the past, the direct user of flood control service has not been required to pay a significant part of the construction cost since national and state policy provided flood control in the interest of the economy and health and welfare of the people. It can be expected that damages to future development will increase at a slower rate if the recent measures to keep damage-prone development out of floodplains continue and ordinances are rigorously enforced.

Residual Damages and Flood Categories. Residual flood damages are the damages that occur despite the extensive flood control measures that have been taken by federal, state, and local agencies. In the last 20 years, they have occurred in the State at an average yearly amount in excess of $50 million.

Residual flood damages have been classified into six categories for this report as to the physical situation that propagates the occurrences. They are: (1) narrow floodplains in mountains and foothills—particularly Northern California, the eastern side of the southern San Joaquin Valley and the south coastal area; (2) areas "protected" by substandard levees—or receiving less than an acceptable standard of protection befitting the situation; (3) water-course encroachments downstream from reservoirs which prohibit design operation for flood control without damage occurring—examples are Shasta Reservoir on Sacramento River, Success Reservoir on Tule River, and Prado Dam on Santa Ana River; (4) areas subject to flash floods such as the southern deserts; (5) small urban areas; and (6) foothill and mountain canyon alluvial cones below areas subject to wild fires and subsequent heavy rains —principally in the south coastal area.

Major Problem Areas. It is beyond the intent of this report to discuss all the many flood problems facing Californians. However, five problems have been included as representing such a potential magnitude of damages and/or threat to life that they must be considered significant.

The Santa Ana River Basin floodplain in Orange County has experienced rapid transformation from a predominantly agricultural area to a highly urbanized area. The flood problem to this area stems principally from category 2 above but also relates to a lesser degree to category 3 as indicated above.

Western Riverside and San Bernardino counties, upstream from Orange County, have undergone urbanization at an unprecedented rate. This has caused an increase in rapidity and quantities of runoff from the upper watershed and has thus decreased the degree of protection afforded by Prado Reservoir—the major component of the Orange County flood control works. Consequently, what was thought, in the 1930s, would provide protection from a flood reasonably expected to occur under anticipated future devleopment of the watershed, now provides protection from the 70-year return frequency flood. With a flood of this magnitude project design releases will cause damages estimated at $15 million due to downstream encroachments. Based on today's hydrology criteria, the standard design storm against which protection would be provided for this area would cause about $3 billion damages and 100,000 acres would be inundated.

There is need for structural measures to provide a high standard of protection. Flood insurance can help defray personal losses in an interim period, but it would accomplish nothing toward preventing physical damages.

At the other end of the State in the North Coast lies the Eel River Basin. This is a rural area of 3,600 square miles. The economy is based principally on logging, recreation and limited agriculture. Because of the steep topography and the nature of the area's economy, development is primarily in the narrow floodplains, which characteristically experience rapid rising, high velocity floods of major consequences every few years. Such floods not only exert a disproportionate impact on the economy but create a very real and high risk to human life. This type of consequence relates to category 1 areas.

Structures such as levees would be the only solution to allow maximum use of the floodplain. But levees alone cannot be justified under present economic design criteria and state statutes prohibit flood control storage projects that could be coordinated with levee protection. The only choices available are seasonal occupancy in some reaches, flood proofing where hydraulic conditions permit in others, and continual use of the existing flood warning procedures throughout the river system. These would minimize but not eliminate damages.

The Sacramento-San Joaquin Delta has a flood problem of category 2. The problem stems from the area's genesis—an area of some 50 islands reclaiming an aggregated 700,000 acres of intensely farmed, rich, organic peat soil. Much of the area lying at or below sea level is protected by levees, many constructed with local material and on unstable foundations. A large percentage of these levees are substandard. The islands are compacting, oxidizing, and eroding, causing increasing hydraulic pressure on the subsiding land. This coupled with wave wash when certain wind conditions prevail, especially during high tides, poses a constant flood threat to the Delta.

Average annual flood damages total $4.5 million. To protect and preserve the Delta will require an improved levee system and the initiation of certain flood proofing techniques for any additional urban development.

The Sacramento River is the principal stream in California, accounting for 30 percent of the runoff in the State. It is an alluvial stream with meandering characteristics. In the reaches between Shasta Dam and the start of the Sacramento River Project levees near Ord Ferry, significant bank undercutting and erosion are occurring.

Besides destroying valuable land and causing other costly property losses, the erosion threatens to cut off oxbows in the river which disrupts the hydraulic energy balance. A chain reaction then occurs both up and down stream. Although not occurring in any one flood or any one year, this chain reaction will eventually cause additional problems if left unattended.

Local interests claim that the regulated flows from upstream reservoirs are responsible for more serious erosion problems than would occur under natural conditions and that the cost to provide suitable bank protection is beyond their capability.

Another factor in recent years is the increased boat use by recreationists. The boats' wave wash adds to the bank sloughing problem.

Bank erosion—a continuing problem

The erosion and sloughing will require bank stabilization measures. These measures could conflict with the characteristics of the river that make it a scenic attraction, a haven for wildlife and a popular boating and recreation stream.

The last problem to be discussed lies in Santa Clara County. It results from a phenomenal growth in the floodplain and a local self-help flood control program that lacked the financial capabilities to provide the high degree of protection urban development demands or zoning regulations to limit growth in threatened areas.

Santa Clara County was a predominantly agricultural area in 1950. Its population doubled between 1950 and 1960 and has nearly doubled again. The Santa Clara Valley floodplain is transversed by two principal water courses. Guadalupe River and Coyote Creek flow from south to north into the southern tip of San Francisco Bay. Should the Valley experience a standard project flood, an estimated $100 million in damages would result and about 38,000 acres would be inundated. The principal urban area—City of San Jose—would be particularly vulnerable to this flood.

To provide protection against the 100-year flood which is compatible with the National Flood Insurance Act, $61 million would be required. It is estimated damages for this frequency flood would be about $50 million.

The local people in attempting to alleviate the more frequent flood problems with project works have essentially painted themselves into a corner. By providing limited protection with the higher and more frequent economic benefits, the area has been cut off from federal funds. Under federal criteria, an improved level of protection could not be justified in the studies that have been completed. Yet flood protection is needed now. At the present tax rate, on a pay-as-you-go basis, it will require 40 more years to complete the flood control works to provide 100 year flood protection.

In Chapter V present ongoing activities and future flood control activities are considered in regard to satisfying unmet needs such as the problems just discussed.

Energy Generation

An earlier section in this chapter, titled "Water for Power", discussed the demands for consumptive use of water for cooling thermal power plants. This section on energy discusses other nonconsumptive aspects of water use and energy generation.

Hydroelectric Energy. Conventional hydroelectric energy developments use the force of falling water to spin turbines and generators to produce electric energy. Pumped storage type hydroelectric developments use a power plant situated between an upper

Figure 17. Pumped Storage Sites Under Consideration

Figure 18. Geothermal Resource Areas

and a lower reservoir. A pump-turbine turns a generator to generate electricity during daily peak periods of demand as water is released from the upper reservoir to the lower reservoir. The pump turbine is then reversed for pumping water back to the upper reservoir, using energy from thermal power plants when it is not needed by consumers. The addition of pumped storage to a conventional hydroelectric development creates the ability to produce more power on peak when it is most valuable.

In March 1974, the Department of Water Resources published Bulletin No. 194, a report of "Hydroelectric Energy Potential in California". This report presented an inventory of existing and potential hydroelectric developments in California. Its purpose was to provide an overview of hydroelectric energy potential remaining in California and to identify those developments where additional analysis may be warranted. The report indicates that prompt action could increase the hydroelectric energy output of California about 30 percent by 1990. An additional significant amount of potential exists but its development may never be realized because of major engineering problems, wild and scenic river systems, and adverse effects on fisheries. Even if this 30 percent expansion is achieved most of the expected future growth in electrical energy requirements will have to be met by other sources, such as nuclear and fossil fueled steam plants. Bulletin No. 194 did not consider pumped storage developments.

Thermal plants supply low-cost base load energy, but they are not well suited to meeting peaking requirements. With the future emphasis on nuclear power plants and their associated lower fuel costs, the capability of meeting the daily peak power demands from hydroelectric installations will tend to favor pumped storage developments. A pumped storage installation will increase the installed capacity of an electrical supply system, and its quick response and generally superior operating flexibility make it ideal for operation during peak load periods and for system reserve service. Some of the more notable sites currently under consideration for pumped storage installations are shown on Figure 17.

An important factor for single-purpose pumped storage projects is their overall energy loss. Losses of energy due to friction inevitably occur during both the pumping and generating operations. The result is that pumped storage projects consume more energy during off-peak periods than they generate on-peak, and therefore do not add energy to an electrical system. Their primary value is the provision of additional generating capacity and energy to a system during periods of peak demand. If the current delays in developing large nuclear power plants are overcome and these nuclear power plants begin to predominate the overall electric power system, there will probably follow a trend towards pumped storage developments to meet peaking requirements.

While the generation of hydroelectric energy does not consume water except for associated reservoir evaporation, use of available water resources to generate smog-free electrical energy will continue to be an important function of water projects. The demand for energy could have significant influence on which projects are built and when they are built.

Geothermal Energy. Geothermal resources are defined as the natural heat of the earth and all minerals and solutions obtained from naturally heated fluids, (brines, associated gases, and steam) found beneath the surface of the earth. Oil, hydrocarbon gas, and other hydrocarbon substances are excluded from this definition. Geothermal energy occurs in three principal forms: (1) superheated steam, (2) superheated water, and (3) rock heat at depth.

Geothermal energy has been used to generate electricity for many years. In California, three locations shown on Figure 18 have been identified as either proven or potential geothermal power sites. They are The Geysers, near Cloverdale in Sonoma County; the Mono Lake area in Mono County; and the southern Imperial Valley.

At The Geysers, superheated steam has been produced from wells to generate electricity commercially since 1960. From the first unit, with a capacity of 12,500 kilowatts (KW), energy production has been progressively increased to the present capacity of 396,000 KW. Current plans are to install additional equipment to increase the capacity by 110,000 KW each year until the field reaches an estimated maximum capacity of over one million KW. This would be the largest geothermal power development in the world.

The Mono Lake area is recognized as a geothermal area from which superheated water may be produced at some future date. The wells most recently drilled in this area yielded water that was too cool for effective power development and were abandoned. However, the U. S. Geological Survey is continuing to conduct field studies in the area.

Attempts to develop geothermal resources in the Imperial Valley began in the mid-1920s. Recently, considerable new interest has been aroused by preliminary assessments of the overall availability of geothermal resources in the Valley. Various private and public entities are investigating the area. The Magma Power Company, the Magma Energy Company, the

The Geysers—electricity from geothermal steam

San Diego Gas and Electric Company, Southern California Edison, Southern Pacific Land Company, Phillips Petroleum Company, and the Getty Oil Company have ongoing programs to explore the area and develop techniques for making use of its geothermal resources.

Public entities active in the development of geothermal resources including the U. S. Bureau of Reclamation, the federal Office of Water Research and Technology which includes the former Office of Saline Water, the U. S. Geological Survey, the Lawrence Laboratory of the Atomic Energy Commission at Livermore, the University of California, and the California Department of Water Resources.

The intensive ongoing private and public efforts in California will eventually provide enough knowledge to enable the Department of Water Resources to assess the overall potential of geothermal resources and to predict its impact on future water development.

Navigation

Navigation can exert specific demands for water in order to maintain suitable depths for safe passage. Due to the shallow draft of most boats used for recreation on the State's inland waters, water depth has rarely been identified as a recreation boating problem. Therefore, this discussion is limited to fresh water commercial navigation.

The only significant commercial navigation on fresh water within the State extends from San Francisco Bay and the Sacramento-San Joaquin Delta upstream to the Port of Stockton via the Stockton Deep Water Channel, to the Port of Sacramento via the Sacramento Deep Water Channel, and upstream on the Sacramento River to Colusa.

Most of the fresh water channels used for commercial navigation are within the zone of tidal influence so that minimum depths do not depend entirely upon the rates of flow. The exception is the reach of the Sacramento River from Sacramento to Colusa. Under the Sacramento River Shallow Draft Channel Project Act, a 145 mile channel, up to 200 feet wide, was excavated from Suisun Bay to Colusa. Downstream from Sacramento, the minimum depth of channel is 10 feet; upstream the minimum depth is 6 feet.

Ocean going vessels now reach the Port of Sacramento through the deep water channel, and it is also used by barges that come as far as Sacramento. The principal commercial barge traffic on the Sacramento River involves delivery of petroleum products and rock for bank protection and export of rice and other grains. Total annual grain exports by barge are on the order of 50,000 tons, a small proportion of the total quantity of farm products shipped from the Sacramento Valley.

Very low river flows can result in below-minimum depths within the Sacramento River Shallow Draft Channel Project. The authorizing document for Shasta Dam provided for minimum releases of 5,000 cubic feet per second to maintain navigation depth. Releases for other Central Valley Project purposes generally exceed the minimum requirement, but releases specifically for navigation are occasionally needed.

There is concern that the planned deepening of the John F. Baldwin and Stockton ship channels from the Golden Gate into Suisun Bay and then on into Stockton may increase the amount of fresh water outflow from the Delta needed for salinity control. Results to date from available model tests by the U. S. Army Corps of Engineers on this effect of deepening are inconclusive.

Summary of Water Demands

Table 16 summarizes by major hydrologic areas of the State, 1972 and projected 1990 and 2020 applied water demands under four levels of alternative future development described in Chapter III. As a review, the following tabulation lists the variables used for each alternative future. Other factors affecting projections of future growth are not shown in the tabulation but were discussed in Chapter III.

Variable	Alternative Future I	II	III	IV
Population Growth				
Fertility series[1]	C	D	D	E
Immigration	150,000	150,000	100,000	0
Agricultural Production				
National population	D	D	D	E
Foreign trade[2]	High	Low	Low	Low
Crop yields[3]	Modified	Modified	1968	Modified
Power Plant Cooling				
Energy demand[4]	High	High	Low	Low
Inland plants[5]	⅔	⅓	⅔	⅓

Notes: [1] Average number of children born per woman of child-bearing age.
[2] Low estimate based on pre-1970 data; high estimate reflects 1972–74 events.
[3] 1968 estimates used in Bulletin No. 160-70.
[4] High estimate based on California Public Utilities Commission projection and low estimate on Rand Corporation Case 3.
[5] Portion of new thermal plants requiring fresh cooling water.

Table 16 includes only those demands for which quantitative determinations could be made, including urban, agricultural, power plant cooling, and recreation, fish, and wildlife. It will be noted that only one future projection for recreation, fish and wildlife water demand is shown in the table. The reason, as explained at the outset of Chapter III, is that insufficient knowledge is available now to discuss variations in demand.

As defined earlier in the chapter, applied water demands are the quantities required to be delivered to the point of use, such as a municipal system, factory, or farm headgate. Net water demands are used in the next chapter of this bulletin to evaluate the water demand-water supply relationship. Net demand is determined for each study area, after accounting for the

Table 16. 1972 and Projected Applied Water Demands by Alternative Futures
(1,000 acre-feet)

Hydrologic study area	Urban				Agricultural				Power plant cooling				Fish, wildlife and recreation	Totals			
	I	II	III	IV	I	II	III	IV	I	II	III	IV		I	II	III	IV
North Coastal																	
1972	93	93	93	93	710	710	710	710	--	--	--	--	323	1,120	1,120	1,120	1,120
1990	104	102	101	97	720	720	710	710	--	--	--	--	359	1,180	1,180	1,170	1,170
2020	126	120	114	100	740	740	730	730	--	--	--	--	362	1,230	1,220	1,210	1,190
San Francisco Bay																	
1972	990	990	990	990	250	250	250	250	--	--	--	--	24	1,260	1,260	1,260	1,260
1990	1,480	1,460	1,430	1,340	290	280	290	280	--	--	--	--	37	1,810	1,770	1,750	1,660
2020	2,240	2,070	1,940	1,570	330	320	310	280	--	--	--	--	46	2,620	2,440	2,300	1,890
Central Coastal																	
1972	181	181	181	181	1,030	1,030	1,030	1,030	--	--	--	--	2	1,210	1,210	1,210	1,210
1990	308	300	289	252	1,240	1,200	1,190	1,200	--	--	--	--	3	1,550	1,500	1,480	1,460
2020	569	516	473	318	1,310	1,270	1,240	1,220	--	--	--	--	6	1,890	1,790	1,720	1,540
South Coastal																	
1972	2,370	2,370	2,370	2,370	920	920	920	920	18	18	18	18	6	3,320	3,320	3,320	3,320
1990	3,130	3,050	2,980	2,670	730	720	720	750	30	30	30	30	19	3,900	3,820	3,750	3,470
2020	4,830	4,360	4,120	2,980	530	510	520	520	80	40	0	0	23	5,470	4,940	4,660	3,520
Sacramento Basin																	
1972	470	470	470	470	6,020	6,020	6,020	6,020	0	0	0	0	125	6,610	6,610	6,610	6,610
1990	700	687	674	621	7,940	7,540	7,050	6,960	50	0	0	0	170	8,860	8,400	7,900	7,750
2020	1,040	968	908	702	9,080	8,350	7,540	7,410	140	60	50	0	174	10,400	9,550	8,670	8,290
Delta-Central Sierra																	
1972	173	173	173	173	2,470	2,470	2,470	2,470	20	20	20	20	6	2,670	2,670	2,670	2,670
1990	251	247	239	219	3,220	3,010	2,810	2,710	100	75	50	40	7	3,570	3,340	3,110	2,970
2020	537	490	451	323	3,700	3,540	3,250	3,020	150	100	110	70	9	4,400	4,140	3,820	3,420
San Joaquin Basin																	
1972	192	192	192	192	5,450	5,450	5,450	5,450	0	0	0	0	91	5,730	5,730	5,730	5,730
1990	295	287	279	249	6,620	6,390	6,040	5,750	0	0	0	0	94	7,010	6,770	6,410	6,090
2020	548	485	451	307	7,320	6,600	6,180	5,750	140	70	0	0	95	8,100	7,250	6,730	6,150
Tulare Basin																	
1972	363	363	363	363	10,890	10,890	10,890	10,890	0	0	0	0	43	11,300	11,300	11,300	11,300
1990	493	479	471	441	13,070	12,510	11,750	11,580	70	35	20	20	68	13,700	13,100	12,300	12,100
2020	798	718	679	530	14,870	13,720	12,360	11,750	240	130	60	60	70	16,000	14,600	13,200	12,400
North Lahontan																	
1972	23	23	23	23	420	420	420	420	--	--	--	--	11	454	454	454	454
1990	40	40	39	32	430	430	430	400	--	--	--	--	11	479	479	478	441
2020	68	59	54	35	430	430	430	400	--	--	--	--	13	507	498	493	444
South Lahontan																	
1972	89	89	89	89	310	310	310	310	0	0	0	0	4	399	399	399	399
1990	154	139	136	108	300	300	300	300	10	10	10	0	16	478	463	460	422
2020	387	326	306	143	250	250	250	250	100	50	0	0	22	762	651	581	418
Colorado Desert																	
1972	99	99	99	99	3,220	3,220	3,220	3,220	0	0	0	0	20	3,340	3,340	3,340	3,340
1990	148	142	139	126	3,320	3,320	3,320	3,320	130	70	40	40	22	3,620	3,560	3,530	3,510
2020	275	246	230	173	3,320	3,320	3,320	3,320	250	130	130	80	26	3,880	3,730	3,710	3,600
State Total																	
1972	5,040	5,040	5,040	5,040	31,700	31,700	31,700	31,700	38	38	38	38	655	37,400	37,400	37,400	37,400
1990	7,100	6,930	6,770	6,160	37,900	36,400	34,600	34,000	390	220	150	130	806	46,200	44,400	42,400	41,100
2020	11,400	10,400	9,730	7,170	41,900	39,000	36,100	34,600	1,100	580	350	210	846	55,300	50,800	47,000	42,900

internal reuse of water and the losses associated with conveying water from the source to the user. As an example of reuse, return flows or drainage from a farm field may be used directly in an adjacent field or may be returned to the water supply distribution system for reuse in a more distant field. Other examples inclue percolation of excess applied irrigation water to ground water storage where it may be recovered by pumping, and percolation or runoff from urban yard watering which may also be recoverable. Reuse of municipal and industrial applied water occurs where sewerage systems discharge to surface or underground fresh water bodies which also serve as supply sources. Not all surplus surface and percolating water supplies are susceptible to recovery. For example, water discharging to the ocean or percolating to saline water bodies is lost to the freshwater supply. Return flows leaving the study area are also lost for reuse by that area but may serve as a supply to another downstream area.

Table 17. 1972 and Projected Net Water Demands by Alternative Futures
(1,000 acre-feet)

Hydrologic study area	Present 1972	Alternative 1990 future				Alternative 2020 future			
		I	II	III	IV	I	II	III	IV
North Coastal	940	990	990	980	980	1,040	1,030	1,010	1,000
Sao Francisco Bay	1,270	1,820	1,780	1,760	1,660	2,630	2,450	2,310	1,900
Central Coastal	950	1,240	1,200	1,180	1,150	1,560	1,480	1,410	1,250
South Coastal	3,030	3,770	3,700	3,640	3,390	5,200	4,720	4,480	3,460
Sacramento Basin	5,780	7,610	7,200	6,800	6,630	9,030	8,240	7,530	7,080
Delta-Central Sierra	2,270	3,110	2,900	2,700	2,580	3,860	3,630	3,360	3,010
San Joaquin Basin	4,650	5,510	5,350	5,120	4,960	6,280	5,710	5,320	5,030
Tulare Basin	7,300	9,200	8,800	8,290	8,180	11,000	10,110	9,160	8,700
North Lahontan	430	450	450	450	420	480	470	470	420
South Lahontan	280	330	330	320	300	510	430	370	290
Colorado Desert	4,070	4,240	4,180	4,150	4,140	4,430	4,300	4,290	4,210
State Total	31,000	38,300	36,900	35,400	34,400	46,000	42,600	39,700	36,400

Hydrologic study area demands met by imports from distant sources were increased to account for the losses occurring en route to the hydrologic study area and therefore represent the total water demand at the primary source, that is, at the initial diversion point in the case of a surface water supply project. This is in contrast with Bulletin No. 160-70 where import supply requirements were specified at the hydrologic study area without inclusion of conveyance losses occurring outside the area.

The summary of net water demands by hydrologic study area are shown for each alternative future in Table 17.

CHAPTER V

SOURCES OF WATER AND WATER MANAGEMENT

California's water requirements are being met in the traditional manner, primarily by regulation of surface water and by drawing on water in underground storage. However, most of the best damsites have been developed or are under contention for competing uses or environmental considerations. Similarly, ground water use now exceeds the natural replenishment capability of the basins in many areas.

Recent developments in technology give promise of a number of potential water sources which may serve as supplements to conventional water supplies. Future water management activities will include the integration of these water sources into the overall water supply system.

This chapter discusses the sources of water which at this time appear to offer the greatest potential for meeting the State's water demands in the future. In addition to the traditional surface conservation and ground water pumping methods, these include waste water reclamation, desalination, geothermal development, weather modification, more efficient use of water and water management practices.

Surface Water Regulation

About 60 percent of California's present water supply is derived from regulation and diversions of the natural runoff from surface streams. Natural flows in streams vary from as little as zero in late summer to many thousands of cubic feet per second during winter or spring floods. A wide variation in the total quantity of annual runoff among wet, normal, and dry years can also be expected. Total runoff during a wet year may be more than 10 times the quantity of runoff in a dry year. However, relatively uniform and firm water supplies can be obtained from such streams through regulation in reservoirs.

An extensive network of local, state, and federal storage reservoirs provides a significant degree of control of the runoff of most streams in the more highly developed areas of the State. At present there are 1,090 reservoirs in California operated by state and local agencies and by individuals which are under state jurisdiction as to safety and 150 federal reservoirs. Of these 1,240 reservoirs, 141 have storage capacity between 10,000 and 100,000 acre-feet, 45 between 100,000 and 1,000,000 acre-feet, and 10 have capacity greater than 1,000,000, acre-feet. Most of the larger projects are located on streams in the Central Valley. Major surface water supply and conveyance facilities are shown on Figure 19. Total storage capacity in California is about 39,000,000 acre-feet.

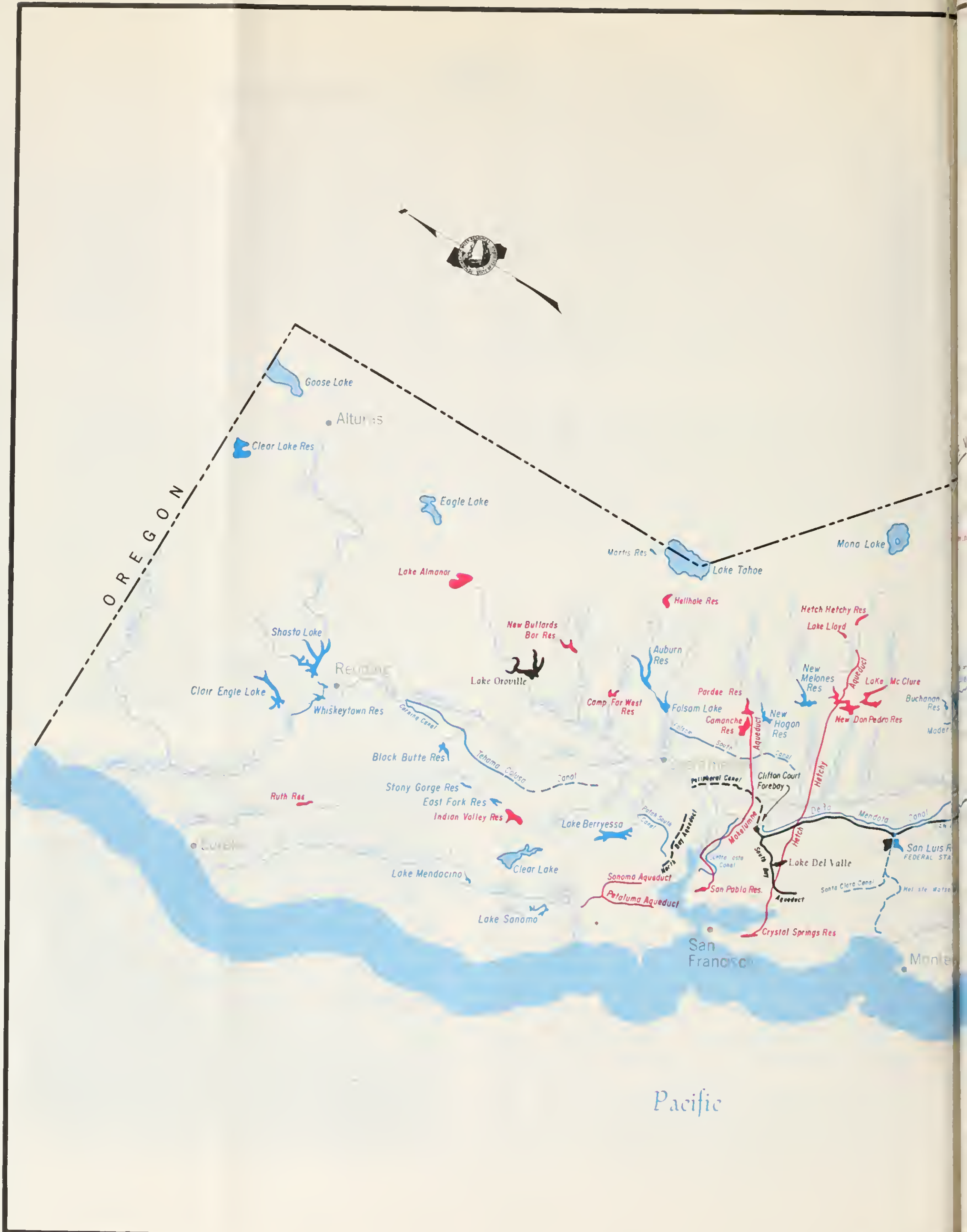
Recent Water Projects

Completion of construction of the initial phase of the California State Water Project stands out as the State's most significant event in water resource development during the past four years. In 1973 one million acre-feet were delivered to water supply contractors through State Water Project facilities and the contractors have ordered deliveries of about 1.5 million acre-feet in 1974. Other major events in water resource development which have occurred in California since publication of Bulletin 160-70 are described below.

Major developments by *local water agencies* include construction of additional storage, conveyance and treatment facilities by the Metropolitan Water District of Southern California. Completed works include (1) portions of the tunnel and pipeline system which make up the Foothill Feeder, (2) Joseph Jenson Filtration Plant, (3) second Lower Feeder, (4) Sepulveda Feeder, (5) Lake Skinner (formerly Auld Valley) and (6) a portion of San Diego Pipeline No. 4. The District is currently administering construction contracts for additional distribution and treatment facilities amounting to almost $100 million.

Kern County Water Agency has initiated construction of the Cross Valley Canal to transfer water from the California Aqueduct of the State Water Project to the vicinity of Bakersfield. Other water agencies in the western San Joaquin Valley have been expanding distribution works in State Water Project and Central Valley Project service areas.

Rollins Dam on Bear River


OREGON
Goose Lake
Clear Lake Res
Eagle Lake
Lake Almanor
Lake Tahoe
Mono Lake
Hellhole Res
Hetch Hetchy Res
Lake Lloyd
New Bullards Bar Res
Shasta Lake
Auburn Res
Lake Oroville
Clair Engle Lake
Whiskeytown Res
Camp Far West Res
Folsom Lake
Pardee Res
Camanche Res
New Melones Res
New Hogan Res
Lake Mc Clure
New Don Pedro Res
Aqueduct
Hetchy
Black Butte Res
Tehama Colusa Canal
Stony Gorge Res
East Fork Res
Indian Valley Res
Ruth Res
Lake Berryessa
Clifton Court Forebay
Peripheral Canal
Mokelumne
Hetch
Delta Mendota Canal
Lake Del Valle
San Luis R
Clear Lake
Lake Mendocino
Sonoma Aqueduct
Petaluma Aqueduct
San Pablo Res.
Lake Sonoma
Crystal Springs Res
San Francisco
Pacific

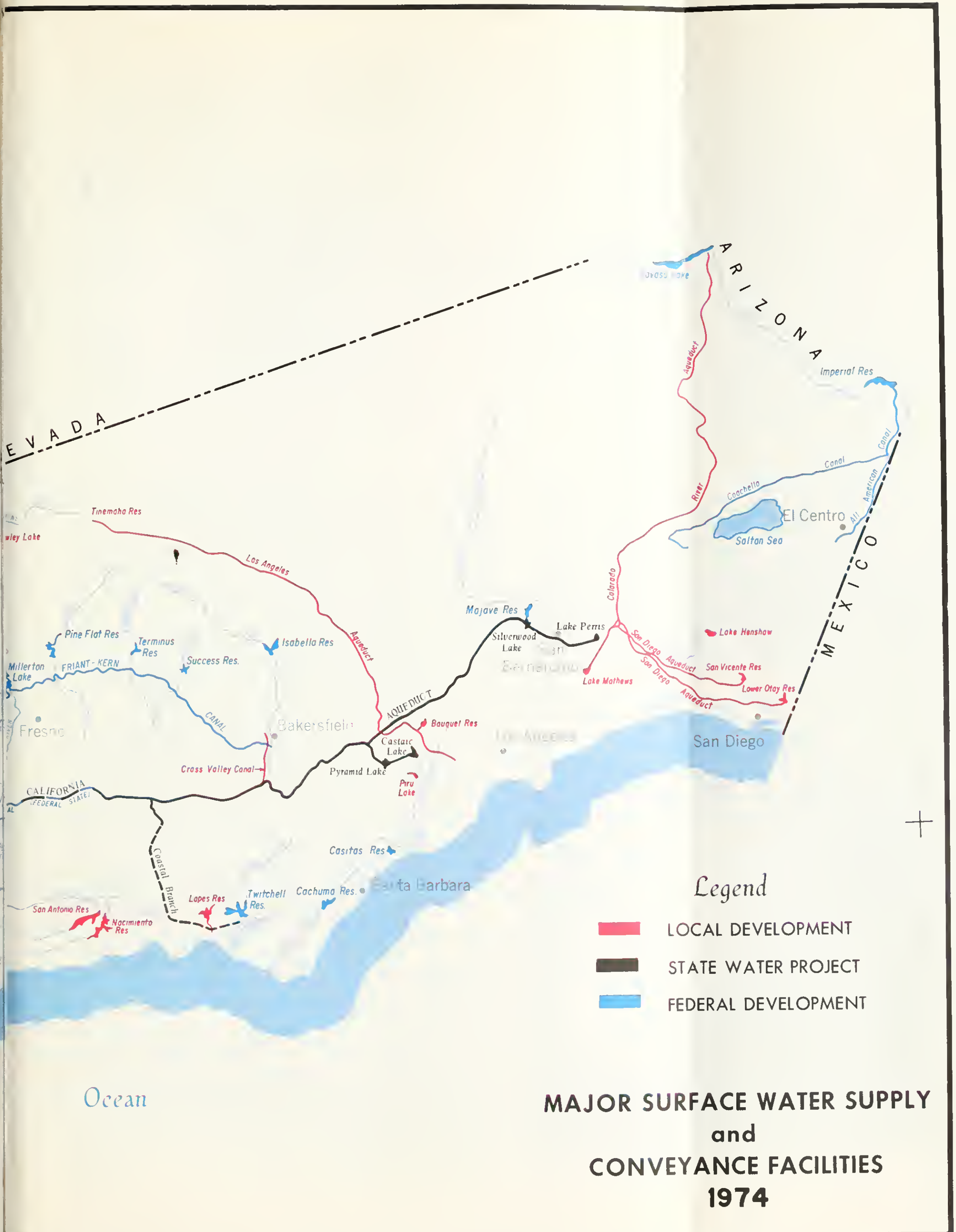


Figure 19. Major Surface Water Supply and Conveyance Facilities, 1974

Table 18. Projects Completed by Local Agencies 1971–1974

Agency	Name and/or Project Facilities	Project Purposes	Hydrologic Study Area	Capital Cost
Avenal Community Services District*	Distribution System	Mun. Water Supply	Tulare Basin	1,100,000
Coalinga, City of*	Distribution System	Mun. Water Supply	Tulare Basin	6,146,000
Crestline-Lake Arrowhead Water Agency	Pumping Plants, Pipelines, and Reservoirs	Mun. Water Supply	South Lahontan	4,300,000
Dudley Ridge Water District	Distribution System	Irr. Water Supply	Tulare Basin	652,900
Empire Westside Irrigation District	Distribution System	Irr. Water Supply	Tulare Basin	48,100
Hacienda Water District	Distribution System	Irr. Water Supply	Tulare Basin	98,700
Member Units of Kern County Water Agency	Distribution Systems	Irr. Water Supply	Tulare Basin	76,196,400
Los Angeles Department of Water and Power	Water Wells in San Fernando Valley	Mun. Water Supply	South Coastal	450,000
	Kittridge Tanks & Associated Pipelines	Mun. Water Supply		5,000,000
	Bouquet Canyon Emergency Storage Pumps	Mun. Water Supply		500,000
	South Haiwee Reservoir Bypass Channel	Mun. Water Supply		2,300,000
Poway Municipal Water District*	Poway Dam and Reservoir	Water Storage, Recreation, and Fish enhancement	South Coastal	3,733,100
San Bernardino Valley Municipal Water District	Distribution System	Mun. Water Supply	South Coastal	11,000,000
San Diego County Water Authority	Pipeline #4†	Mun. Water Supply	South Coastal	33,400,000
	Pomerado Pipeline	Mun. Water Supply		1,800,000
San Gabriel Valley Municipal Water District	Devil Canyon-Azusa Pipeline	Mun. Water Supply	South Coastal	17,100,000
Tulare Lake Basin Water Storage District	Distribution System	Irrigation	Tulare Basin	2,221,000

* These Projects received partial Davis-Grunsky financing.
† Northern portion being constructed by Metropolitan Water District of Southern California.

Construction is underway on Indian Valley Dam and Reservoir on North Fork Cache Creek by the Yolo County Flood Control and Water Conservation District. The project is scheduled for completion late in 1974.

Figure 20. Projects Completed Under the Davis-Grunsky Act 1971–1974

Figure 20 shows the projects completed by local agencies since the publication of Bulletin 160-70 which were financed under the Davis-Grunsky Act*. Of the 29 projects shown, eight were partially financed by grants for the recreation and fish enhancement features of the projects. The remaining 21 were financed by construction loans.

Table 18 lists additional major projects completed by local agencies since the publication of Bulletin 160-70. Most of these projects were constructed to utilize water from the State Water Project.

The *Bureau of Reclamation* has four projects underway. Tehama-Colusa Canal has been completed from the Red Bluff Diversion Dam to Stony Creek. Folsom-South Canal has been completed from Lake Nimbus to Rancho Seco Nuclear Power Plant. San Luis Drain has been completed for approximately 84 miles of the total 188-mile conduit.

Under a federal court ruling the Bureau of Reclamation can proceed with construction of Auburn Dam on the American River for 180 days from April 15, 1974. Construction is enjoined thereafter, however, pending approval of an amended environmental impact statement. Work has been completed on the Auburn-Foresthill Bridge. No construction is underway on the authorized San Felipe Division of the Central Valley Project.

Projects by the *Corps of Engineers* which have advanced in the last few years include completion of Martis Creek Dam in the Truckee River Basin and Mojave Dam on the Mojave River near Victorville. Both projects provide flood control, recreation and some water supply.

* Sections 12880 through 12893, California Water Code.

The U.S. Supreme Court has refused to intervene in the controversy over construction of New Melones Dam on the Stanislaus River. It has thus left standing a lower court ruling that the project, which is under construction, meets the requirements of the National Environmental Policy Act of 1969.

Highway relocation and preconstruction work has progressed at the Warm Springs Dam and Reservoir site in the Russian River Basin. A contract for construction of Warm Springs Dam, however, is currently held up as the result of litigation in the federal court system between the Corps of Engineers and plaintiffs who represent organizations opposed to the project.

Construction was started on Buchanan Dam on Chowchilla River and Hidden Dam on Fresno River in 1971; both projects are for water supply, flood control, recreation, and fish and wildlife enhancement purposes. The main dam contracts were awarded the following year, and project completions, including future downstream channel improvement and recreation facilities, are scheduled for 1976.

The locations of these major projects, both existing and under construction, are shown on Plate 1 (inside back cover).

Central Valley Area Water Projects

Some of the remaining potential water projects in the Central Valley are described in the following paragraphs. Many of the projects are alternatives to each other so not all of them would be constructed. It should be recognized that estimates of amount of water supply from most of the projects are affected by criteria regarding (1) releases to meet Delta outflow requirements, prior downstream water rights, and navigation flow requirements (2) streamflow releases for fish preservation or enhancement, (3) reservoir space to be reserved for flood control, (4) maintenance of reservoir storage levels for recreation, and (5) releases for generation of hydroelectric power.

The Cottonwood Creek Project was authorized by the Federal Government in 1970 for construction and operation by the Corps of Engineers. Thus far, funds have not been provided for detailed planning and design. This project consists of Dutch Gulch Reservoir at a capacity of 1,100,000 acre-feet and Tehama Reservoir at a capacity of 900,000 acre-feet. Dutch Gulch damsite is located on the mainstem of Cottonwood Creek below its junction with the middle fork. Tehama damsite is located on the South Fork of Cottonwood Creek. Total runoff at the two damsites averages 522,000 acre-feet per year. The Interim Survey Report for Cottonwood Creek issued by the Corps of Engineers indicates that the project would have multiple purposes which include development of new water supplies totaling 275,000 acre-feet per year. Other project purposes would be flood control, recreation, and fish enhancement.

Millville Project on South Cow Creek and Wing Project on Inks Creek are currently under study by the Corps of Engineers. These multiple purpose reservoirs could provide a combined yield of about 40,000 acre-feet per year of new water supplies and would aid in reducing flood peaks on the Sacramento River.

Schoenfield Reservoir on Red Bank Creek and Gallatin Reservoir on Elder Creek are under study by the Department of Water Resources. The two multiple purpose reservoirs could provide a total of about 70,000 acre-feet per year of new water supplies.

The Glenn Reservoir-Sacramento River Diversion Plan is presently under preliminary study by the Department of Water Resources. This project would consist of Newville and Rancheria Reservoirs on Stony Creek, a gravity diversion from Thomes Creek into Newville Reservoir and a 5,000 cfs conduit-pumping system to transport winter flows from the Sacramento River to the reservoir and diversion system would provide a project with a yield capability of about 900,000 acre-feet per year if operated in conjunction with the State Water Project. This multiple purpose development could also include a large hydroelectric pumped-storage development between Newville Reservoir and Black Butte Reservoir.

Marysville Project on the Yuba River was authorized by Congress in 1966. Funds for construction have not been provided although Congress has appropriated some monies for post authorization studies. This project would consist of a 1,000,000 acre-foot Marysville Reservoir and a 150-megawatt power plant. The Yuba River, a major tributary of the Feather River, has a runoff approaching two million acre-feet per year. It is partially controlled at present by New Bullards Bar Reservoir on the north fork plus several other relatively small reservoirs. The project planned at the Marysville site would provide full regulation of the river near its mouth. Its purposes include flood control, hydroelectric power, recreation, and water supply. New water yield is estimated to be 150,000 acre-feet per year if operated as part of the Central Valley Project.

Los Banos Reservoir would provide additional offstream storage capacity in the western San Joaquin Valley to supplement that of the existing San Luis Reservoir. The reservoir site on Los Banos Creek has potential storage capacity in excess of 3 million acre-feet. It would be filled with water from the Sacramento River Delta during winter and spring seasons. Water would be transported to O'Neill Forebay through the California Aqueduct and pumped into Los Banos Reservoir. If sized with active storage capacity of 2 million acre-feet, Los Banos Reservoir would add a firm new yield of about 200,000 acre-feet per year to the State Water Project. Since Los Banos Reservoir would be near, but higher in elevation than both San Luis Reservoir and Los Banos Creek Detention Reservoir, it has a potential for pumped storage power generation if operated in combination with either of the other two reservoirs.

The Cosumnes River Division of the Central Valley Project would regulate the Cosumnes River to provide a new water supply. A development under consideration by the Bureau of Reclamation includes Nashville Reservoir, with a capacity of 900,000 acre-feet, on the lower main stream and Pi Pi Reservoir, with a capacity of 70,000 acre-feet, on the middle fork, and Aukum Reservoir, with a capacity of 120,-000 acre-feet, on the south fork. The federal feasibility report on the Cosumnes River Division indicates that it would have multiple accomplishments which include provision of flood control, recreation, fish enhancement, and water yield of 145,000 acre-feet per year. The project has not been authorized for construction.

The East Side Division of the Central Valley Project, as planned by the Bureau of Reclamation, would be primarily an aqueduct system extending from the Delta to the Kern River along the east side of the San Joaquin Valley. Its maximum capacity where it would have joint use with the Folsom South service area would be 7,000 cubic feet per second. Water supply for the East Side Division would be provided from Central Valley Project supplies allocated for that purpose and from yield of offstream storage reservoirs at the Yokohl and Hungry Hollow sites in Tulare County. Federal plans call for initial delivery capability of 1,500,000 acre-feet per year and ultimate delivery capability of up to 4,000,000 acre-feet annually. The aqueduct would serve areas in the eastern San Joaquin Valley where ground water is being overdrafted. The project has not been authorized by the Federal Government.

Study is also being given jointly by the Department of Water Resources and the Bureau of Reclamation to a mid-valley canal that could provide water to some of the ground water overdraft areas in the eastern San Joaquin Valley. A mid-valley canal could also provide a connection from the California Aqueduct to the Friant-Kern Canal, facilitating coordinated operation of the two aqueduct systems.

Additional surface water projects which have been studied at the reconnaissance level as possible future developments in the Central Valley include (1) enlargement of Lake Berryessa, (2) enlargement of Shasta Lake, (3) extension of the Bureau of Reclamation Tehama-Colusa Canal to provide service in Yolo and Solano Counties, and (4) construction of offstream storage reservoirs at the Los Vaqueros site on Kellogg Creek in Contra Costa County and at the Sunflower site, located on the Kings-Kern County line in the western San Joaquin Valley. These project locations, except Los Vaqueros, are also shown on Plate 1.

North Coast Area Water Projects

The Smith, Klamath, and Trinity and Eel Rivers are excluded from consideration for further development by the California Wild and Scenic Rivers Act. These rivers produce about 20,000,000 acre-feet of mean annual natural runoff, or over 25 percent of California's total runoff.

In the case of the Eel River, however, the Act provides for legislative consideration of possible removal of wild river status for the Eel in 1985. Two reservoir and conveyance systems previously studied on the Eel River, the Dos Rios and English Ridge projects, could be used to regulate the headwaters of the Eel River for export to the Sacramento Valley and to provide flood peak reductions on the Eel River. The combined water yield of these two reservoirs could vary from about 500,000 to 1,000,000 acre-feet per year for various size reservoirs and plans of operation.

Butler Valley Dam and Reservoir Project on the Mad River, which is authorized for construction by the Corps of Engineers, has been deferred indefinitely. The deferment is primarily due to the decision by voters of Humboldt County not to participate in the project. The reservoir, with a capacity of 460,000 acre-feet, could control floods on the Mad River and yield about 120,000 acre-feet annually after meeting downstream flow requirements.

Ground Water

Ground water occurs in California primarily in unconsolidated sedimentary deposits which underlie much of the agricultural lands and large portions of the State's urban areas. Its development and use has been second only to that of the surface water sources. Relative freedom from contamination has made it especially suitable for municipal use where protection of the public health is a prime consideration. Occurrence of ground water in areas where surface water is in short supply and its availability to the users on demand has led to widespread use for irrigation on overlying lands. Ground water currently furnishes about 40 percent of total water use in California.

In those areas requiring supplemental water to meet future requirements and which overlie usable ground water basins, the basin characteristics, hydrology, and water quality must be examined to estimate the amounts and qualities of ground water which may be utilized. The four methods of basin operation generally in use are: (a) safe yield operation based on natural replenishment, (b) temporary overdraft, or mining, of ground water pending development of a supplemental surface water supply; (c) court ordered regulation of withdrawals; and (d) sustained yield using natural replenishment and planned or incidental recharge with imported water.

In areas where the ground water has already been put to extensive use, available data from well logs, measurements of water levels in wells, chemical analyses of water in wells, and other knowledge gained in development of the basin provide the basis for further study of the basin characteristics and determination of more efficient operational procedures. On the other hand, in areas where the basin has been little developed, there is often little data on the basin characteristics which can be obtained short of an extensive and costly investigative program. Thus, projections of future yields from development of unused ground water basins are subject to considerably more uncertainty than from the presently developed basins.

Development of most sustained new yields from ground water, as with surface reservoirs, requires surplus surface water to provide the required annual recharge of the basin. Exceptions include cases where pumping lowers ground water levels and reduces losses such as consumptive use by nonproductive vegetation, or subsurface outflow to saline water bodies or to salt sinks. New yields on an interim basis from overdrafting (mining) the ground water reservoir may be a feasible alternative supply. However, consideration must be given to the effects which may result from the resultant decline in water levels, such as pumping costs, land subsidence, and change in water quality. The limiting effects of these factors will vary with the local conditions, both physical and economic.

Empty storage space in ground water basins may be used by importation of water from distant watersheds for recharge and subsequent withdrawal — either on a "one-time" basis where surplus water or conveyance capacity are limited in time; or on a cyclic basis where recurring surplus water and conveyance capacity are available.

Some idea of the effects of the variation in the ground water conditions with change in surface water can be gained from Figures 21 and 22. Figure 21 shows the change in ground water levels in the San Joaquin Valley during a 5-year dry period, 1960-1965, when average annual surface water supply was only about 75% of normal. The changes shown in Figure 22 are for a wet period, 1965-1970, when water supply was about 125% of normal. In general, the areas served by ground water tend to have ground water level changes which follow the trend of runoff of tributary streams. However, areas served by the Friant-Kern and Madera Canals on the east side of the valley and by the Delta-Mendota Canal on west side show rising water levels even during the dry period as a result of continued full import supplies during the local drought period. During the above-normal period, there still remain many areas where heavy pumping draughts which are in excess of recharge capability are causing water tables to decline. Increasing deliveries from the California Aqueduct replaced considerable ground water pumping and resulted in a substantial decrease in the overdraft by 1972. This effect was just beginning to show in the data presented in the two figures.

Activities by the Department of Water Resources

In planning to meet future water requirements of the State, the Department has given ground water equal consideration with other alternative sources. The previously discussed general planning concepts illustrate some of the considerations which are a part of studies of future ground water development and management.

A specific example of a current investigation by the Department of Water Resources is that of the potential recharge of Northern California surplus water in areas south of the Tehachapi Mountains for subsequent withdrawal, either to offset water supply deficiencies during periods of possible aqueduct shutdown or to defer capital expenditures for construction of additional conservation facilities required in the event of critical dry period water supply conditions as the State Water Project approaches full delivery operation. Investigation of this possibility is being conducted jointly by the Department of Water Resources and the members of the Southern California Water Conference.

In another study currently underway, a cooperative effort by the United States Bureau of Reclamation and the Department of Water Resources, consideration is being given to alignments of a mid-valley canal located at the approximate latitude of the City of Fresno and running from the California Aqueduct on the west side of the San Joaquin Valley to the eastern areas of the San Joaquin Valley. Its purpose would be to convey federal water through state and federal facilities to areas of long-standing overdraft in the eastern portions of the Tulare Lake Basin. Included in the operational aspects of this investigation will be the possibilities of ground water recharge and the direct delivery of water through distribution systems to areas presently relying totally or partially upon ground water overdraft for irrigation supplies.

Additionally, the Department, in cooperation with federal agencies such as the United States Geological Survey, Water Resources Division, and local water service agencies, has and is continuing to conduct hydrologic, geologic, and water quality investigations to determine the availability of ground water resources in all areas of the State.

Examples of these types of investigations are those being conducted in Northern California, in the South San Francisco Bay area, in Sacramento and Sonoma Counties, and in Livermore Valley. Also, the Department and the Kern County Water Agency are conducting a cooperative investigation, with the objective of assisting the Agency, through use of a mathematical model of the ground water basin, to determine means of managing the basin to make the best use of supplemental water obtained through the

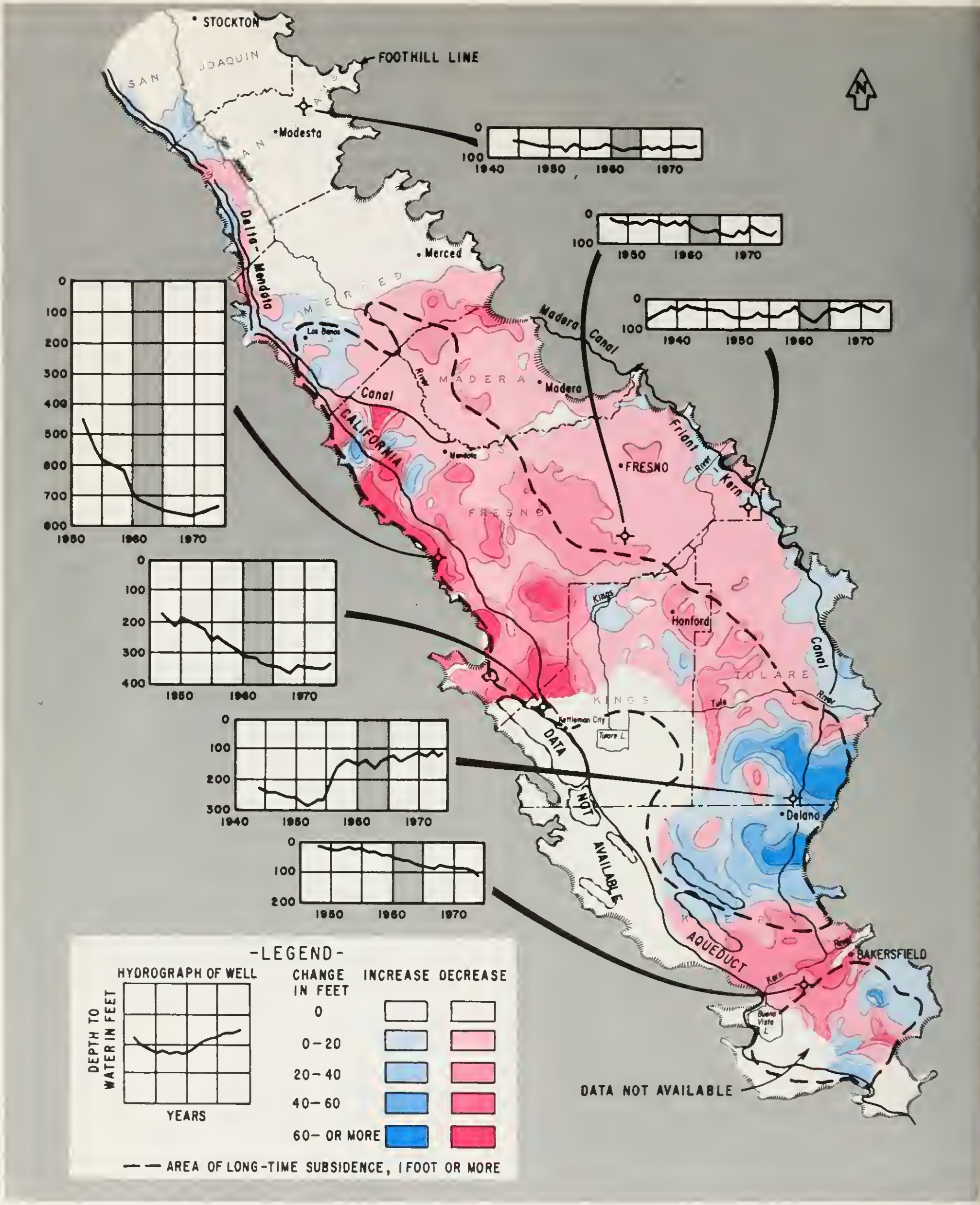


Figure 21. Ground Water Change During Dry Period, 1960–1965

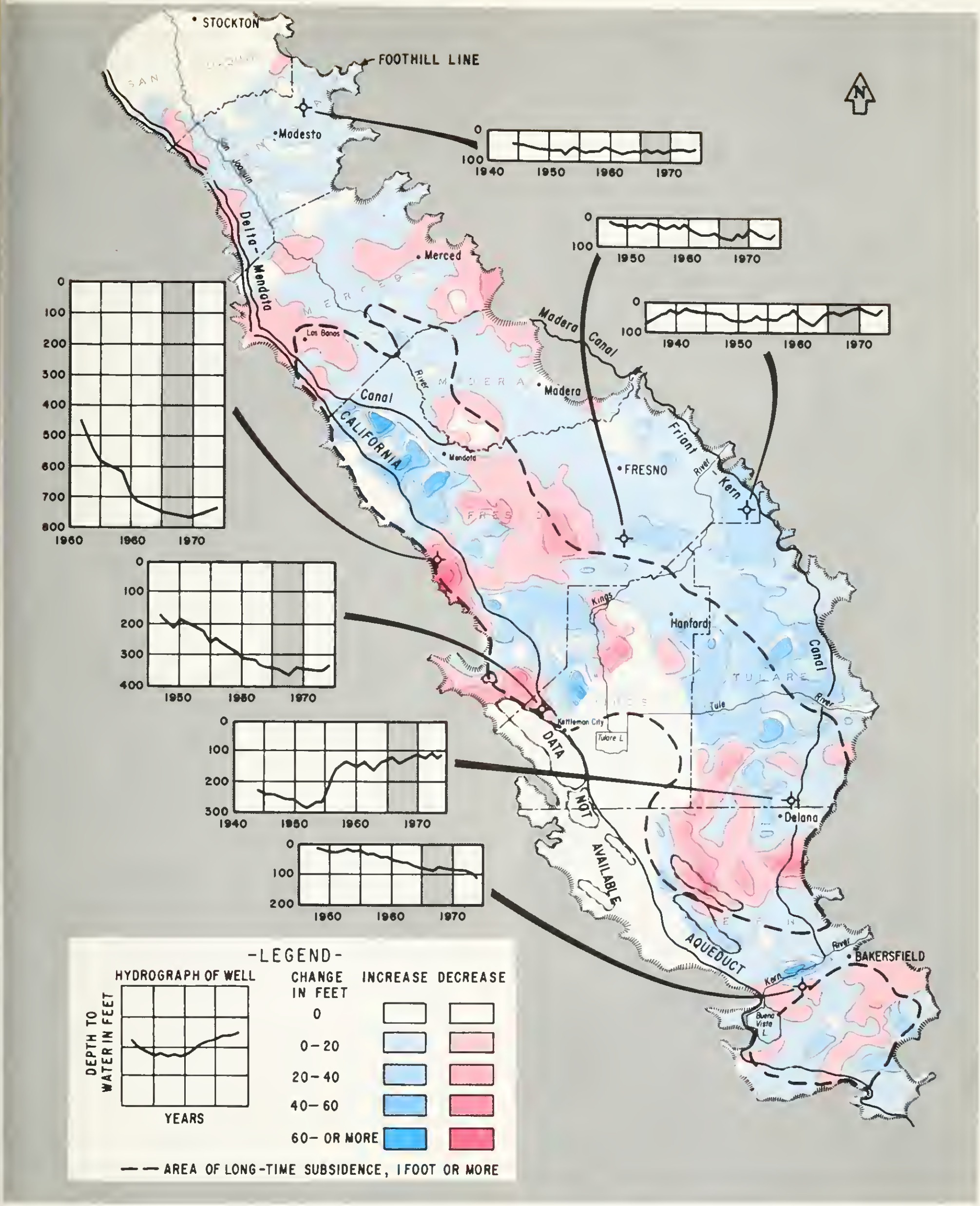


Figure 22. Ground Water Change During Wet Period, 1965–1970

facilities of the California Aqueduct. Similarly, in Southern California, investigations of operational modes and economic factors have been conducted for most of the major local water service agencies as a part of their programs to augment and better manage the water resources available to their areas. Areas presently under investigation are in Ventura County, San Jacinto Valley, Antelope Valley, Upper San Diego Area, and Arroyo Grande-Paso Robles Area.

Another field of study by the Department consists of a preliminary evaluation of the probability of obtaining producing wells (primarily domestic) in fractured rock of the mountain areas of California.

The maintenance of a good quality ground water resource is dependent on its protection from degradation from various possible sources. To this end, the Department of Water Resources has formulated a Ground Water Basin Protection program. Current studies include design of sea water intrusion barriers and sanitary landfills to protect related ground water bodies, determination of the effects of deep injection of oil field and industrial wastes on ground water, evaluation of well construction practices as related to hydrologic and geologic conditions in order to formulate recommendations for water well standards, and surveillance of land subsidence as it relates to extraction of ground water. The components of this program are varied from time to time as required to counter possible threats to the integrity of the ground water resource.

Ground water supply *California Farmer photo*

Among some of the major issues surrounding use of ground water are those of sustained or long-term overdraft and land subsidence due to compaction of deep confining clay beds such as have occurred extensively in the San Joaquin Valley.

The problems of overdraft on a long-term basis are those of diminishing ground water resources in storage and increasing costs of pumping and of deepening existing wells or drilling replacement wells due to declining ground water levels. However, in areas where alternative water supplies are relatively expensive, continued overdraft operation for a considerable period of time may still be the most economic management plan.

The problems associated with deep subsidence are primarily physical in that surface structures are disturbed by the lowering of land surface elevations caused by compaction of the underlying clay and silt layers under decreased pressures in the deeper-lying confined aquifers. Basins with extensive underground clay structures will evidence correspondingly greater subsidence effects than basins with minimal compressible material. In the latter case, subsidence may be only a minor problem.

The above-cited issues have specific problems; however, they are not without some offsetting benefits to the areas affected. For example the condition of long-term sustained overdraft is mostly evident in the eastern portions of the Tulare Lake Basin where an agricultural economy has developed in which Fresno, Kings, Tulare, and Kern Counties rank among the top dollar-producing agricultural counties in the United States. Without use of the ground water in storage by overdraft pumping, and imported water, such development would not have occurred. The capability to pay for imported water was significantly increased by the economy built upon ground water.

Deep subsidence, although capable of being arrested by reducing the extraction rates of water from the underlying confined aquifers, cannot be reversed by presently known technology. However, in areas where deep subsidence has already occurred, there may be future as well as past benefits related to operation of the ground water basin.* For example, future increased recharge to the forebay areas easterly from the subsiding San Joaquin Valley area, even though it exceeds extraction from the westerly confined aquifers, will not result in vertical upward movement or return of the ground surface to original conditions, but it will reduce or eliminate further downward subsidence of land surfaces already affecred. Future operation of the ground water reservoir over a range of pressure variations which do not exceed the new equilibrium conditions will cause little if any additional subsidence. Additionally, the water released by consolidation of compressible sediments in underlying confined aquifers may be considered as a one-time-only water supply which would not otherwise have been available. Total water derived from this source in the San Joaquin Valley was estimated by the U. S. Geological Survey to be 15,600,000 acre-feet during the period 1926–1970 *. Over one-half this amount was withdrawn in the last 20 years. The area of subsidence in excess of one foot resulting from this ground water extraction is shown in Figures 21 and 22.

Ground Water Conditions

A brief summary of the present knowledge of ground water conditions in each hydrologic study area (Figure 2) is presented in the following discussion which is based in part on a report by the U. S. Geological Survey.*

The computations of useable storage do not reflect potential problems such as deep subsidence, or poor quality water that might be induced by pumping if water in these basins is lowered to the depths indicated.

North Coastal Hydrologic Area. Within the predominantly mountainous North Coast Hydrologic Area ground water occurs in 13 alluvial-filled valleys, comprising a total area of about 1,300 square miles. Some of these alluvial valleys in the northeastern part of the area also contain extensive water-bearing volcanic formations. Water-bearing deposits in these valleys range in thickness from about 50 to 2,000 feet.

Total storage capacity of the basins for which determinations have been made is nearly 1,000,000 acre-feet. The usable storage capacity, where determined, totals 700,000 acre-feet; the limiting factors are the possibility of sea-water intrusion and aquifer materials of low permeability which do not readily yield water. Generally, the quality of ground water is excellent; however, in isolated areas there are poor quality waters with total dissolved solids of more than 4,800 milligrams per liter (mg/l).

Properly constructed wells in many areas can yield as much as 1,000 gallons per minute. Wells in the Butte Valley basalt formation of volcanic origin yield larger quantities of flow, ranging from 2,000 to 4,000 gallons per minute. So far, ground water levels do not indicate an overdraft. However, pumping in Butte Valley does exceed earlier cursory estimates of the safe yield of that basin. Water levels have remained fairly constant over the past several years.

San Francisco Bay Hydrologic Area. Most usable ground warer in the San Francisco Bay Hydrologic Area is found in the Santa Clara Valley and in six smaller alluvium-filled valleys, all of which are adjacent to and partially underlie the San Francisco Bay. These seven areas, together with eleven other scattered basins which have been identified as significant sources of ground water, have a total area of about 2,000 square miles. Water-bearing deposits range in in thickness from 100 to 2,000 feet.

The ground water basins of the area are estimated to have a capacity of at least 10,000,000 acre-feet and a usable capacity of at least 5,000,000 acre-feet.

Although much of the area is served by imported water, ground water still is pumped extensively from Livermore Valley, Santa Clara Valley, and other

* J. T. Poland, B. E. Lofgren, R. S. Ireland, and R. G. Pugh, "Land Subsidence in the San Joaquin Valley, California, as of 1972," U.S. Geological Survey open-file report, 1973.

* U.S. Geological Survey, Water Resources Division, Open-File Report, "Summary of Ground Water Data as of 1967, California Region," July 24, 1969.

South Bay areas. Most of this ground water is of excellent quality, although the intrusion of saline water from the San Francisco Bay system has caused significant problems in the past. Also, in the Santa Clara Valley area, ground water withdrawals have caused subsidence of the ground surface. One effect of this subsidence has been to cause levees along the bayshore to be overtopped during periods of high tides.

After completion of the South Bay Aqueduct of the State Water Project in 1962, deliveries of imported water from this source were begun in Alameda and Santa Clara Counties. This water has been used to recharge the ground water basin, and subsequently subsidence and much of the intrusion of saline water has ceased. Water levels in Santa Clara and Livermore Valleys have shown marked recoveries to historic levels.

Water levels in North Bay areas have shown little change over the years, an indication that these ground water basins may be able to yield larger quantities of ground water than at present.

Central Coastal Hydrologic Area. With a predominant mountainous terrain, the Central Coastal area's usable ground water occurs in alluvium-filled valleys and coastal plains and in deeper lying aquifers. Significant sources of ground water have been identified in 24 basins with a total area of about 3,500 square miles. Water-bearing deposits range from 200 to 4,000 feet in thickness.

The gross storage capacity in the Central Coastal area is 20,000,000 acre-feet, of which 7,600,000 acre-feet are usable. The limiting factor is sea water intrusion. The dissolved solids content of the water is generally less than 800 mg/l, but locally is more than 11,000 mg/l.

Ground water is the main source of supply in the Central Coastal area, and present use exceeds the average supply by about 140,000 acre-feet per year. In the northern region of the Central Coastal area the major problem is in the lower Salinas Valley where ground water use in excess of recharge capability has lowered water levels below sea level and has caused sea water intrusion in the bayshore area. Long associated with the upper aquifer, sea water intrusion now threatens the lower aquifer as well. Monterey County is considering a plan to convey Salinas River water to the area for surface application to alleviate the problem. The authorized San Felipe Project of the Bureau of Reclamation could also provide surface supplies to this area as well as to smaller overdraft areas in the lower Pajaro Valley, where sea water intrusion is also a threat, and in the Hollister area.

In the southern region, there is a current overdraft of about 50,000 acre-feet per year, mainly in Santa Barbara County, but including inland areas of San Luis Obispo County. Completion of the Coastal Aqueduct of the California State Water Project could help reduce this overdraft.

South Coastal Hydrologic Area. The south coastal area is comprised of coastal valleys separated by mountainous areas. Significant ground water sources have been identified in 44 basins with a total area of about 3,000 square miles. Included are four large basins, the Los Angeles coastal plain, the San Gabriel Valley, the Orange County coastal plain and the upper Santa Ana River Basin; and three major smaller basins, the Oxnard Plain, Fillmore, and San Jacinto Basins. Water-bearing deposits range from 50 to 2,500 feet in thickness.

The storage capacity of the basins is about 100,000,000 acre-feet of which 7,000,000 is estimated to be usable. Limiting factors are possible sea water intrusion, thin alluvial material, and locally, high pumping lifts. The dissolved solids content of the water is generally less than 1,000 mg/l, but locally is more than 36,000 mg/l.

There is a current annual overdraft of 160,000 acre-feet, mainly in Ventura County, the Upper Santa Ana River Basin, and Coastal Orange County. Additional imported water from the State Water Project should eliminate this overdraft by 1990.

Sacramento Basin Hydrologic Area. In this hydrologic area, 21 valley areas have been identified as significant sources of ground water, and they have a total area of about 6,150 square miles, of which 5,000 square miles are in the Sacramento Valley. The water-bearing deposits range in thickness from about 100 to 3,000 feet.

The storage capacity, as determined for 17 of the basins, is nearly 55,000,000 acre-feet, of which more than 33,000,000 acre-feet are in the Sacramento Valley. This estimate is based on a depth of 20–200 feet for the Sacramento Valley, and does not include the deeper aquifers. The usable storage capacity in the Sacramento Valley is estimated at 22,000,000 acre-feet; the limiting factors are economic considerations, aquifer materials of low permeability, potential land subsidence, and quality of water. The dissolved-solids content of the ground water is generally less than 500 mg/l, but locally is as much as 2,800 mg/l.

Ground water is used extensively for irrigation purposes in the Sacramento Valley, and some ground water is pumped for irrigation use in the Upper Pit River region.

In 1972, 1,500,000 acre-feet of ground water was pumped to meet applied water demands for irrigation and domestic use in the Sacramento Basin hydrologic unit. While in general the basin has an adequate supply of ground water for present demands, there are several local areas along the west side of the Sacramento Valley that have incurred overdraft problems during dry periods when pumping drafts were heavy. Annual overdraft in these areas totals about 90,000 acre-feet.

Delta Central Sierra Hydrologic Area. It is estimated that the Sacramento Valley portion of the

Delta-Central Sierra Unit contains a total of about 64,000,000 acre-feet of ground water. Certain portions of this unit, notably the central Delta area, contain quantities of nonusable saline ground water. In some of the surrounding area, ground water levels in recent years were at markedly lower elevations than at present. In Solano County, this was the case prior to the completion of the Bureau of Reclamation Solano Project; now, with surface water deliveries, water levels have shown a significant recovery to historic levels.

Water levels are still declining in San Joaquin County, where overdraft of the basin is estimated to be on the order of 120,000 acre-feet per year. Water levels in this area decline at an average rate of about 5 feet per year, caused by pumpage which exceeds recharge. This decline has caused the eastward migration of saline ground water from the central Delta area.

San Joaquin Hydrologic Area. Ground water provides a substantial portion of the water supply necessary to meet the water demands of the San Joaquin Basin. For the entire basin about 35 percent of the agricultural applied water demand and, with the exception of the foothill and mountain areas, nearly all of the municipal and industrial requirements are met by ground water. During the period 1962 through 1966, an average of almost two million acre-feet annually was extracted for agricultural use and 119,000 acre-feet annually for municipal and industrial use.*

The water-bearing sediments which underlie the valley floor portion of the San Joaquin Basin contain large amounts of fresh water of suitable mineral quality for agricultural and urban use. The Department of Water Resources has estimated the storage capacity and the amount of water in storage by analyzing thousands of well drillers logs.† The following tabulation presents an example of the magnitude of the ground water resource.

Depth Range (Feet)	Storage Capacity (Acre-feet)	Water in Storage as of Spring 1961 (Acre-feet)
0–200	43,400,000	36,000,000
0–500	95,800,000	85,400,000

Ground water withdrawal in excess of replenishment since the spring of 1961 has reduced the amount of ground water in storage by about 2,000,000 acre-feet.

During the 10-year period 1958 through 1967, there was an average annual overdraft of ground water in storage of 154,000 acre-feet, of which 140,000 acre-feet was yielded by dewatering aquifers and 14,000 acre-feet was yielded by squeezing water from saturated clays due to declining piezometric levels. This later yield is sometimes referred to as "deep subsidence yield from ground water withdrawal" and is evidenced by a lowering of the land surface. The yield from this source is considered to be equal to the land subsidence volume. Figure 21 shows the areal extent of land subsidence in the San Joaquin Valley caused by ground water withdrawal.

The 1972 overdraft of ground water is estimated at 250,000 acre-feet annually. The principal areas of overdraft are the areas east of the San Joaquin River that lie to the southwest of Merced Irrigation District and to the west of Chowchilla Water District and Madera Irrigation District. Other areas being overdrafted are the lands developed to irrigated agriculture just west of the Sierra foothills in Stanislaus, Merced, and Madera Counties. In general, the areas of overdraft are outside the boundaries of organized agricultural water agencies and have inadequate surface water supplies.

Except for the scattered overdraft areas, the basin has adequate surface supplies and shallow depths to ground water. Some of the ground water pumping in the northeastern portion of the valley floor is necessary to prevent excessively high water levels. In the overdrafted areas there is a significant amount of recharge to the ground water basin from natural streamflow and subsurface inflows.

Tulare Basin Hydrologic Area. Ground water is a major source of water supply in the Tulare Basin. About 65 percent of the agricultural applied water demand and virtually all of the municipal and industrial applied water demands are met by ground water pumping. During the period 1962 through 1966, gross ground water withdrawals averaged 6,800,000 acre-feet per year for agricultural use and 300,000 acre-feet per year for municipal and industrial use.*

The water-bearing sediments under the valley floor portion of Tulare Basin contain vast amounts of water of suitable quality for agricultural and urban uses. The Department of Water Resources has estimated the storage capacity and the amount of fresh water in storage by analyzing thousands of well drillers logs.† The following tabulation presents an example of the magnitude of the ground water resource.

Depth Range (Feet)	Storage Capacity (Acre-feet)	Water in Storage as of Spring 1957 (Acre-feet)
0–200	88,000,000	48,000,000
0–500	187,000,000	134,000,000

* U.S. Geological Survey open-file reports on ground water pumping in the San Joaquin Valley, California, and unpublished reports of ground water pumping by Turlock, Modesto, and Oakdale Irrigation Districts.

† Department of Water Resources unpublished report entitled "San Joaquin River Basin Storage Capacity Values", August 1961.

* U.S. Geological Survey open-file reports on ground water pumping in the San Joaquin Valley, California.

† Department of Water Resources unpublished report entitled "Ground Water Geology of the Tulare Basin", May 1963.

Ground water withdrawal in excess of replenishment since spring of 1957 has reduced the amount of ground water in storage by about 20,000,000 acre-feet.

During the 10-year period 1958 through 1967, there was an average annual overdraft of ground water in storage of 1,470,000 acre-feet, of which 910,000 acre-feet was yielded by dewatering the sands and gravels of the aquifer system and 560,000 acre-feet was yielded by squeezing water from the saturated clays of the aquitards caused by declining subsurface water pressures induced by ground water withdrawals.

The increase in water demands since the period 1958 through 1967 has more than been offset by recent imports from the State Water Project and the San Luis Division of the Central Valley Projects. Nevertheless, the 1972 overdraft of ground water in storage is estimated at 1,300,000 acre-feet annually. The major portion of the recently expanded imports has been to the worst subsidence areas and has reduced ground water withdrawal and land subsidence rates.

The rate of overdraft varies widely throughout the basin. In fact, some areas are experiencing stable or even rising water levels. In other areas the rate of overdraft is moderate, and ground water could continue to be mined for years without any adverse effect other than increased pumping costs and energy usage. In still other areas, the overdraft is severe and the ground water in storage is being rapidly depleted.

Recent water deliveries from the Central Valley Project and the State Water Project have slightly increased the maximum sustained pumpage because of recharge to usable ground water through seepage losses from conveyance facilities and application of water to agricultural lands in excess of evapotranspiration. Part of the water is delivered to land which does not overlie usable ground water and is therefore not a source of recharge.

North Lahontan Hydrologic Area. Most of the usable ground water in the predominantly mountainous North Lahontan Hydrologic Area occurs in the scattered valleys that are filled with alluvium and material of volcanic origin. The area contains eight valley fill areas which have been identified as significant sources of ground water. The total area of the eight valleys is about 1,300 square miles. The water-bearing deposits range in thickness from about 250 to 1,000 feet. The total storage capacity has been estimated for seven of the basins and is nearly 23,000,000 acre-feet. However, the usable storage capacity has not been determined; the limiting factor is the quality of water. The dissolved solids contents of the water is generally less than 500 mg/l, but locally is as much as 2,000 mg/l.

Ground water is used for irrigation primarily in Surprise Valley and Honey Lake Valley. In recent years many wells have been drilled in the Surprise Valley area to augment water supplies. In 1972 an estimated 56,000 acre-feet of ground water was pumped for irrigation in the hydrologic area, mostly in the northern part. There are no indications of ground water overdraft in the area.

South Lahontan Hydrologic Area. Most usable ground water in this predominantly mountainous area occurs in alluvium-filled valleys, of which 50 have been identified as significant sources of water and which have an area of more than 13,000 square miles. The water-bearing deposits range in thickness from 30 to about 2,000 feet.

The total storage capacity of the area's basins is presently estimated at about 194,000,000 acre-feet of which about 700,000 acre-feet are known to be usable in Indian Wells Valley, the only basin where a determination has been made. Water quality is variable; most valleys have some ground water with less than 800 mg/l, dissolved solids but many also have water with several thousand mg/l.

Most of the ground water use is in the Antelope Valley and the Mojave River Basins, both of which are in an overdraft condition totaling about 120,000 acre-feet per year. State Water Project imports are expected to eliminate the overdraft by 1990.

Colorado Desert Hydrologic Area. This desert area lies between the Colorado River and mountain ranges located about 50 miles inland from the Pacific Ocean. Significant ground water resources have been identified in 45 alluvium-filled valleys covering an area of about 12,800 square miles. Thickness of water-bearing deposits ranges from 50 to 2,800 feet.

Total storage capacity of the hydrologic area is about 158,000,000 acre-feet; and usable capacity, determined only for the Coachella Valley, is 3,600,000 acre-feet. Water quality varies from basin to basin; most valleys have some ground water with less than 600 mg/l dissolved solids, but some have as much as several thousand mg/l. The quality of the large volume of ground water in the Imperial Valley is so poor that its use is very limited.

Ground water is used mainly for agriculture in the Coachella Valley where a current overdraft is estimated to be about 33,000 acre-feet annually. The overdraft could be reduced to 15,000 acre-feet or less before 1990 by increased imports from the State Water Project. There is also an overdraft of about 5,000 acre-feet per year in Lucerne Valley.

Waste Water Reclamation

~~In the public mind~~ During the last decade, waste water treatment has probably been most closely associated with the movement to reduce the pollution of streams and other water bodies. While this effort has been motivated largely by aesthetic and ecological concerns, the result has been to require more complete treatment of wastes before they are disposed to water bodies and so to make them more suitable for reclamation and reuse. Also, the added treatment and cost induced by these requirements reduces the incremental cost of treatment for reclamation purposes and improves waste water reclamation's competitive position when compared with alternative water sources. Of course, the increasing demands for all purposes which are being placed on the limited water supplies in some areas have also been a prime motivation for seeking the available in-area sources of new water which waste water reclamation can provide.

As California's urban areas have grown, larger quantities of waste water have been collected and conveyed to central points for treatment and have become more readily available for reclamation. About 2.5 million acre-feet of municipal waste water is presently processed each year and represents a significant potential for reclamation to meet demands for various purposes.

Waste water reclamation is sometimes implemented as a means of waste disposal, i.e., the primary purpose of the reclamation is to dispose of treated effluent while the beneficial use derived from the effluent so discharged is incidental. However, the Department considers the term "waste water reclamation" to mean the planned renovation of waste water with the intent of producing usable water for a specific beneficial purpose. The California Water Code defines reclaimed water as ". . . water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur.*

Municipal and industrial waste water discharged to inland fresh water bodies is subject to rediversion and incidental or unplanned reuse. Reclamation of this water will improve the quality but will not increase the quantity of water—will not add "new water" to the system. This is also true of most of the agricultural water used in the San Joaquin Valley and other inland areas where return flows from farm applications are returned to the supply system and are reused until the progressive accumulation of salts renders the water detrimental to plant growth. Reclamation of the resultant saline drainage flow does constitute "new water", but the flows are only a small fraction of the total applied water. The same is true of municipal and industrial wastes in inland areas which are disposed of by evaporation, by percolation to saline ground water bodies, or by other methods where the effluents are not readily reusable. In coastal areas where municipal and industrial wastes are discharged to saline waters of the ocean, bays, or estuaries and are lost to the freshwater cycle, the reclamation of wastes also constitutes a "new supply". Since most of California's population is concentrated in the coastal cities, these areas offer the greatest opportunity for economic reclamation of waste water. About 50 percent of the water supplied for municipal purposes will be discharged as waste water. Of this amount approximately 60 percent can be reclaimed and the remainder must be used to convey residual salts and solids to disposal sites.

Table 19 shows the disposition of treated municipal and industrial waste water discharged in 1972. As shown, 1.7 million acre-feet of treated waste effluent produced during 1972 was discharged into the ocean and into saline bays and estuaries. It is the reclamation of this waste water that offers the primary potential as a "new" source of water. As shown in Table 19, the sum of the intentional and incidental reclamation in the inland hydrologic areas is a very large percentage of total waste water production, being well over 90 percent in the Sacramento, Delta-Central Sierra, and San Joaquin areas.

* Section 13050(n) California Water Code.

Table 19. Summary of Urban Waste Water Production Disposal, and Reclamation Practices in 1972

			Waste water reclaimed						Waste water discharge			
			Intentional		Incidental		Total		Net[a]		To saline waters[b]	
Hydrologic study area	Estimated population served (1,000's)	Waste water produced (1,000 AF)	Quantity (1,000 AF)	Percent[c]	Quantity (1,000 AF)	Percent[c]	Quantity (1,000 AF)	Percent[c]	Quantity (1,000 AF)	Percent[c]	(1,000 AF)	Percent[c]
North Coastal	85	73	1	1	6	8	7	10	72	99	66	90
San Francisco Bay	4,578	583	8	1	32	6	40	7	575	99	540	93
Central Coastal	718	114	5	4	35	31	40	35	109	96	62	54
South Coastal	11,021	1,287	57	4	152	12	209	16	1,230	96	1,066	83
Sacramento Basin	618	106	12	11	86	81	98	92	94	89	0	0
Delta-Central Sierra	902	131	8	6	121	92	129	98	123	94	0	0
San Joaquin Basin	356	60	26	43	32	53	58	97	34	57	0	0
Tulare Basin	719	116	45	39	45	39	90	78	71	61	0	0
North Lahontan	56	11	6	55	3	27	9	82	5	45	0	0
South Lahontan	176	20	7	35	8	40	15	75	13	65	0	0
Colorado Desert	162	22	6	27	12	55	18	82	16	73	1[d]	5
Total	19,391	2,523	181	7	532	21	713	28	2,342	93	1,735	69

[a] The amount of waste water produced less the amount used in intentional reclamation.
[b] Ocean, bays, and estuaries.
[c] Of the amount of waste water produced.
[d] Discharges to Salton Sea and Colorado River.

Source: DWR Bulletin No. 68-72, "Inventory of Waste Water Production and Waste Water Reclamation Practices in California", 1972 (corrected).

Use of Reclaimed Waste Water

The feasibility of reclamation and reuse of waste water will vary with each individual situation. However, some of the obvious parameters which will affect reclamation are:

1. Quality of the waste water.
2. Cost of treatment.
3. Cost of conveyance and distribution in the area where it will be used.
4. Price that users are willing and able to pay.
5. Public acceptance of the use proposed.

Various public health, physical, aesthetic, economic, and other restraints will determine how each of the above factors affects the feasibility of any given reclamation project. For example, the direct use of reclaimed water for domestic needs is not practiced in California because public health authorities are uncertain that stable organics * and virus and other disease-producing agents can be removed from waste water. Also, such use has not yet gained public acceptance. The results of recent public-opinion surveys on the use of reclaimed water indicate that the majority of those questioned opposed the use of reclaimed water for personal use, e.g., drinking, cooking, bathing, and laundering. In one particular statewide survey,† only 0.8 percent of 972 persons questioned opposed the use of reclaimed water in road construction; however, 56.4 percent of the same group opposed its use as drinking water.

At present, reclaimed water is used chiefly for agricultural, industrial, municipal irrigation, recreational, and ground water recharge purposes.

Agricultural uses include irrigation of (1) pasture, (2) fodder, fiber, and seed crops, (3) crops that are grown well above the ground, such as fruits, nuts, and grapes, provided they are not harvested after they have fallen, and (4) crops that are processed so that pathogenic organisms are destroyed prior to human consumption.

* Stable organics are those organic materials which are not removed from waste water as a result of treatment using conventional primary and secondary sewage treatment processes.

† William H. Bruvold and Henry J. Ongerth, "Public Use and Evaluation of Reclaimed Water," Journal of American Water Works Association, May 1974.

Industrial uses of reclaimed water include cooling water, process wash water, boiler feed water, quenching spray water, fire protection, and secondary product recovery. These are carried out chiefly at metallurgical manufacturing and fabrication plants, electric-power generation plants, oil refineries and petro-chemical plants, and in mining and quarrying.

The direct use of reclaimed water for municipal irrigation and recreational pursuits includes (1) irrigation of parks, freeway landscapes, golf courses, and athletic fields, (2) creation of scenic and ornamental lakes and ponds, (3) the maintenance of recreational lakes—for picnicking, boating, swimming, etc., and (4) irrigation at thermal power plants and industrial plants.

The use made of water resulting from intentional reclamation of municipal and industrial wastes in 1972 as reported by municipal, federal, and private agencies is shown in Table 20. The locations of these reclamation operations are shown in Figure 23. Of the total 181,000 acre-feet of intentional reclamation shown in Table 20, an estimated 50,000 acre-feet, or 28 percent, represents a "new" water supply; that is, had this amount not been reclaimed, it would have been discharged to saline waters and lost to the usable fresh-water supply. The remaining 131,000 acre-feet would have been available for incidental reuse through disposal to land or to streams.

Potential Future of Waste Water Reclamation

Of the waste waters from which reclamation could provide a "new" supply, only a portion will normally be reclaimed. High total dissolved solids or specific constituents may make about 15 percent of the waters uneconomic for the possible uses in the area. Also, a portion of the water will be required to convey concentrated wastes to points of disposal or to prevent

Table 20. Intentional Use of Reclaimed Water in 1972
(acre-feet)

Hydrologic area	Industrial	Irrigation			Ground water recharge	Recreation	Log deck sprinkling	Wildlife habitat	Total
		Crops	Landscape	Golf course					
North Coastal	100	500	--	--	--	--	--	--	600
San Francisco Bay	--	3,200	1,000	200	--	3,800	--	--	8,200
Central Coastal	--	5,400	--	--	100	--	--	--	5,500
South Coastal	2,800	20,200	9,600	2,700	21,200	700	--	--	57,200
Sacramento Basin	--	5,000	--	--	--	--	4,900	1,700	11,600
Delta-Central Sierra	--	8,400	--	--	--	--	--	--	8,400
San Joaquin Basin	--	25,300	200	200	--	--	--	--	25,700
Tulare Basin	--	44,100	200	200	900	--	--	--	45,400
North Lahontan	--	3,600	--	--	--	--	2,800	--	6,400
South Lahontan	--	2,600	--	3,600	400	--	--	--	6,600
Colorado Desert	900	3,600	--	1,600	200	--	--	--	6,300
Totals	3,800	121,900	11,000	8,500	22,800	4,500	7,700	1,700	181,900

accumulation of salts in the soil, and this use may account for from 20 to 30 percent of the waste water which is available for reclamation. Therefore, an average of about 60 percent of available waste water could ultimately be reclaimed.

Table 19 shows that in 1972, intentional reclamation amounted to 7 percent of waste water produced; however, the sum of the intentional and the incidental reclamation amounted to nearly 30 percent of production, or about one-half the potential reclaimable water.

Five Hydrologic Study Areas that appear to offer especially favorable conditions for reclamation and reuse of waste water include:

1. San Francisco Bay
2. Central Coastal
3. South Coastal
4. San Joaquin
5. Tulare Basin

These areas are considered particularly suitable for reclamation and reuse of waste water to alleviate problems associated with (1) present and projected demands for supplemental water, (2) relatively high salinity of much of the basic water supplies, (3) sea water intrusion in the coastal areas, or (4) high costs of alternative supplemental supplies.

In the three large coastal metropolitan areas, i.e., San Francisco Bay, Los Angeles Metropolitan, and San Diego Metropolitan, reclamation of waste water offers particular potential as an alternative water supply. These basins depend to some extent now, and will depend to a greater extent in the future, on good quality water imports, and much of the waste water produced in these basins is of reusable quality. However, the average mineral quality of the waste water potentially available in the South Coastal Hydrologic Study Area is about 1,000 parts per million, and its use for municipal purposes would be limited unless desalting or blending with better quality water were practiced.

Table 21 provides projections from a recent Department report *, by urban area, of (1) total municipal and industrial waste production, and (2) the

Table 21. Municipal and Industrial Waste Water Production in Coastal Metropolitan Areas (1,000 acre-feet)

Area	Total waste produced			Suitable for reclamation		
	1970	1990	2000	1970	1990	2000
San Francisco Bay	607	1,140	1,360	560	950	1,140
Monterey Bay	50	140	180	50	140	180
Santa Barbara-Ventura	70	230	340	60	190	290
Los Angeles Metropolitan	1,070	1,730	2,160	890	1,450	1,800
San Diego Metropolitan	110	260	390	80	200	300

* Department of Water Resources Bulletin No. 189, "Waste Water Reclamation, State of the Art," March 1973.

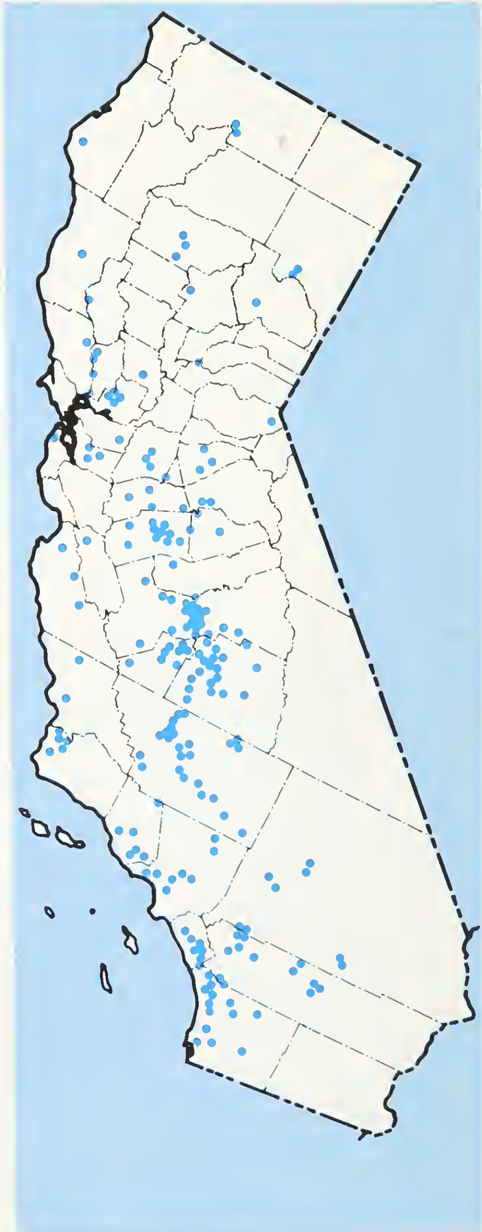


Figure 23. Waste Water Reclamation Facilities

amount of discharged wastes that, considering present and planned water supplies, would be chemically suitable for reclamation. Much of the waste water from these areas, if reclaimed, would represent a "new" water supply in lieu of discharge to saline waters. The amount of water that may be reclaimed in each area will depend on various factors, including costs, suitability of the water for various uses, and marketing factors.

Both the San Joaquin and Tulare Lake Basins offer potential for reclamation of agricultural waste water. Recent estimates indicate that, at the 1970 level of development, some 87,000 acre-feet of agricultural waste water which could no longer be recycled were generated each year in these two basins. The amount is expected to increase to 400,000 acre-feet by 1990.

Some means of disposal or reclamation of these waste waters is fast becoming a necessity. In the San Joaquin Valley, the Bureau of Reclamation is constructing the first phase of the San Luis Drain to remove agricultural wastes from the San Luis Project service area. As an interim measure the agricultural waste water will be conveyed to Kesterson Reservoir and used for wildlife management.

At the present time, the average salt concentration of this agricultural waste water is about 6,800 milligrams per liter (mg/l). For most purposes, this exceeds the maximum practicable limit for reuse without desalting treatment. However, as salts are leached from the soil and removed from the basin, the average mineral concentration is expected to decline to about 3,000 mg/l by the year 2000. The lower concentrations in later years will increase the utility of waste water use from an economic standpoint.

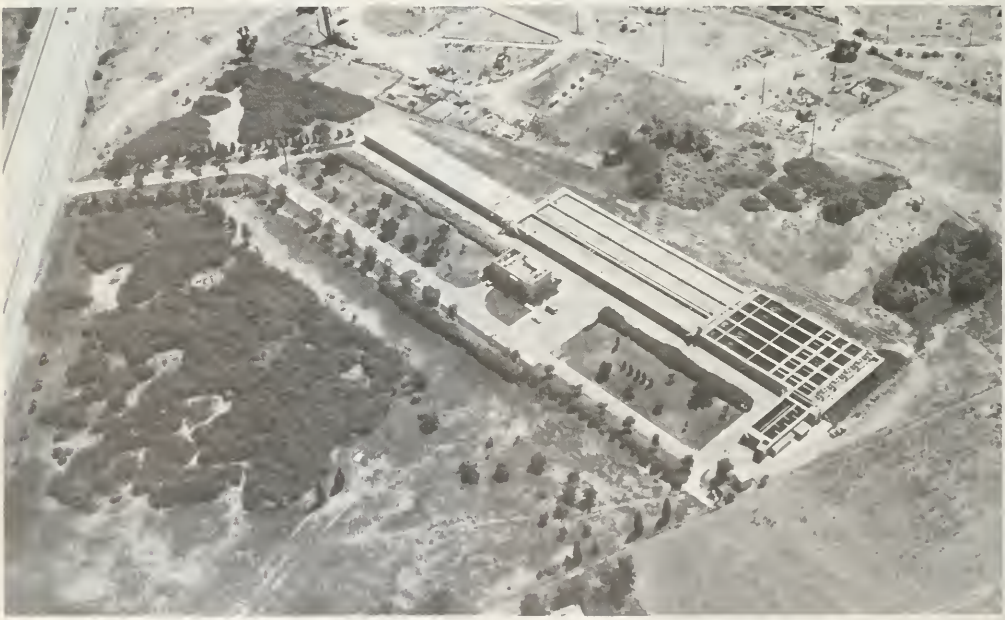
Two possible alternatives exist for the use of this highly saline waste water:

1. It could be desalted to provide additional local water supplies.
2. It could be softened and used for power plant cooling.

Cost of Waste Water Reclamation

Since state and federal regulatory agencies will require at least the equivalent of secondary treatment for all wastes discharged into surface water, including the ocean, by 1977, costs for additional steps for waste water reclamation will be lower in the future. The costs of outfall lines and any associated pumping for disposal of treated sewage effluent would also be less. Costs allocated to sewage treatment and to waste water reclamation should reflect equitable sharing of savings through multipurpose projects.

The costs of reclaimed water vary widely, depending on the quantity and quality of the waste water, disposal requirements, treatment requirements, in-



Whittier Narrows waste water reclamation plant tended uses, and the transportation requirement to the site of use. Present costs range from:

1. Two to five dollars per acre-foot in areas where reclaimed water can be used for irrigation near the treatment plants;
2. Twenty to forty dollars per acre-foot where expensive treatment, storage, transportation and disposal are required; and
3. More than $100 per acre-foot where more extensive treatment, such as desalting, is required.

Activities by the Department of Water Resources

The Department of Water Resources has for many years had statutory responsibilities to study and promote waste water reclamation. These responsibilities were reiterated and brought up to date by the 1973–74 Legislature in AB 3815 which is called Waste Water Reuse Law of 1974. In addition to re-expressing state policy that there should be maximum reuse of waste water for satisfying beneficial water needs, the Department is directed to consider use of waste water for power plant cooling as well as for other purposes, and is authorized to study the technology of the reuse of waste water and further the development of the technology of reclamation of waste water. The Department of Water Resources' current reclamation activities include:

1. An annual statewide inventory of waste water production and reclamation practices and technology, published in the Bulletin No. 68 Series.

2. Studies in specific areas to (a) report on the current status of waste water reclamation practice and update the state of the art, (b) determine the possibility of using reclamed water to both meet future water demands and solve water quality problems, (c) define specific waste water reclamation possibilities, and (d) determine the environmental and ecological effects from the use of reclaimed water. The results of these studies are published in the Bulletin No. 80 Series.

3. Investigations and studies leading to (a) the implementation of waste water reclamation projects, or (b) a determination of the potential of reclaiming water from a specific waste or for a specific use.

The scope of present and future planning investigations of waste water reclamation potential is, perhaps, typified by the Department's recent participation in and preparation of a report for the San Francisco Bay Area Interagency Waste Water Reclamation Study. Participants included 16 federal, state, and local water agencies and several local sanitation districts. The report presents a summary of information on waste water discharges in the Bay area, identifies possible markets for reclaimed water, and discusses the aggregation, conveyance, treatment, and storage systems necessary to connect waste water sources to reclaimed water markets. The study focused on the possibility of using the reclaimed waste water for augmentation of delta outflow; and, in addition to direct use for that purpose, indirect means were investigated. These included substituting reclaimed water for irrigation and ground water recharge demands in the Bay area and for irrigation in the adjacent Hollister area and in the Delta-Mendota and San Luis service areas in the San Joaquin Valley. Also, the possibility of using reclaimed water as a cooling supply for power plants was considered. A number of alternative projects were investigated, and costs were estimated to range from $90 to $130 per acre-foot of delivered water. The Department is engaged in further study of reclamation of this waste water.

A listing of reports by the Department of Water Resources for the years 1950 through 1972 and brief descriptions of the activities of the Department are given in Bulletin No. 189.*

Legal Requirements and Public Acceptance

Regulations and requirements for the quality of water from all sources that can be used by the public are set by federal, state, and local authorities to protect both the public health and the environment. Regulations and requirements for the use of reclaimed waste water are prescribed in accordance with the Water Reclamation Law (Division 7, Chapter 7 of the State Water Code). Statewide waste water reclamation criteria are set by the Department of Health for those uses of reclaimed waste water which affect the public health. The regional water quality control boards then set requirements in relationship with these waste water reclamation criteria upon either the producer of the reclaimed water or the user, or both.

Currently, the Department of Health has established waste water reclamation criteria for irrigation of fodder, fiber, seed, and some food crops. Generally, the food crops eaten raw which will not come in contact with the reclaimed waste water or those which are cooked in a controlled environment, such as in a cannery, may be irrigated with reclaimed water. Also, criteria to protect the public health have been established for recreation impoundments and landscape irrigation. While the Department of Health has not as yet established waste water criteria for ground water recharge, it has issued a position paper as it pertains to the development of basin plans for the State Water Resources Control Board. The Department of Health states that direct injection to ground water is prohibited and that surface spreading will be considered on a case-by-case basis. It further states that it would be its position to recommend against waste water reuse in small ground water basins or where the quantity to be reused would be a large amount with respect to the quantity of water in the basin. The Department of Health would also require the abandoment of any projects where reclaimed waste water appeared in a local water supply well.

* Department of Water Resources Bulletin No. 189, "Waste Water Reclamation, State of the Art," March 1973.

The public is conscious of the need for conserving water resources, and many feel that the reuse of reclaimed waste water, except for domestic purposes, is acceptable provided the necessary precautions to protect the public health are taken. The health authorities feel that the reuse of reclaimed waste water for domestic and municipal water supplies should be banned until such time as the effects of stable organics upon the public health are fully understood, until reasonable methods of identification and measurement of stable organics and viruses have been developed, and until fail-safe treatment processes for the total removal of stable organics and viruses have been perfected.

The reuse of waste water in the past, and currently, has been controlled by the requirements set by the Department of Health. Future knowledge and technology will probably permit the criteria for use of reclaimed waste water to be more easily met and allow a higher degree of recycling and more direct municipal and industrial reuse.

Desalting

Established desalting processes are in operation in a number of arid areas in the world which are in proximity to the ocean or other saline water bodies and where the relatively high cost is competitive with available alternatives. The distillation process is highly developed and, for small and medium capacity applications, has been in use for many years, during which time single-unit capacity has risen to several million gallons per day. The electrodialysis and reverse osmosis processes have also been applied to commercial production of fresh water.

In California thus far, there has been limited incentive for applying existing desalting technology for water resources development due to the high costs and to the highly developed surface and ground water systems which have made large quantities of water available at reasonable cost. However, a number of industries in California use desalting to provide process water and for production of bottled water. Also, most of the power plants sited adjacent to the ocean have sea water distillation facilities for producing boiler feed water and, in some cases, for other in-plant uses. Output of the desalters ranges from about 30,000 to 400,000 gallons per day. Total state production is probably not more than 2 to 3 thousand acre-feet per year.

There are no municipal applications of desalting in California today; however, studies by the Department of Water Resources indicate that desalting could benefit a number of small and medium-size communities that have poor quality water. For the most part, these communities are isolated from developed water systems and local water supplies are highly mineralized. Desalting has been used in only a few California communities, such as the electrodialysis plant and the reverse osmosis test unit which were operated for a number of years at Coalinga, and the standby sea water distillation unit on Catalina Island. The Coalinga plants were used to desalt ground water until good quality surface water was imported.

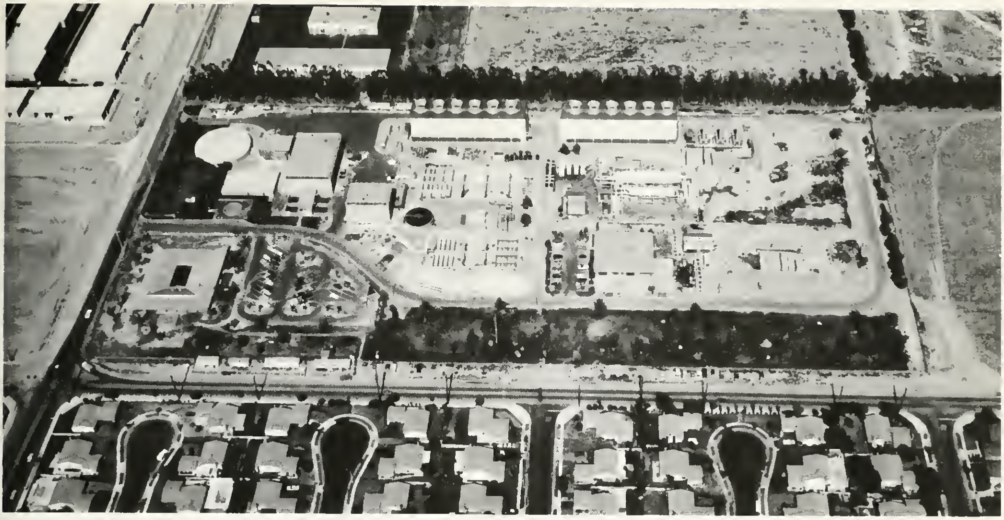
Costs of Desalting

Inflation and the energy crisis have delivered some heavy blows to the economics of saline water conversion. Advances in technology were unable to keep up with rising inflation from about 1970. Until that year, advances in technology were steadily decreasing the cost of desalted water in small-capacity plants from about $6 per 1,000 gallons ($1950 per acre-foot) a decade before to about $1 per 1,000 gallons ($325 per acre-foot) in 1970. Capital costs were about $1 per gallon per day of plant capacity.

The trend in capital cost reduction was reversed in the early 1970s when escalation increased costs more rapidly than advances in technological improvements reduced them. The estimated capital cost for the proposed 40,000,000 gallon per day Diablo Canyon distillation sea water desalter was about $66,000,000 or $1.65 per gallon per day of plant capacity at 1971 prices. These costs were substantially greater than would have been estimated for a large-capacity plant in the late 1960s. The at-site cost of desalted water was estimated to be about $240 per acre-foot. Delivery into the San Luis Obispo-Santa Barbara Counties service area brought the cost up to about $300 per acre-foot.

One of the major means for the control of salinity of Colorado River water delivered to Mexico under the agreement reached by the United States and Mexico is to blend river water with desalted water from a proposed very large capacity desalting complex. About 100,000 acre-feet per year of desalted water will be produced by reverse-osmosis or possibly electrodialysis equipment capable of producing 100,000,000 gallons per day, making this facility by far the largest desalter in the world. The saline feed to the desalter will be brackish agricultural return water from the Wellton-Mohawk Drain in Arizona. The waste water desalting plant and facilities are estimated to cost about $62,000,000 or about 62 cents per gallon per day of plant capacity. The unit cost of producing the desalted water from the 100,000 acre-feet per year plant is estimated to be about $136 per acre-foot.

For several of the California communities investigated by the Department of Water Resources where desalting could be used to improve the quality of the brackish ground water supply, the estimated capital cost for reverse osmosis plants ranges from 75 cents to $5.00 per gallon per day of plant capacity. The plant capacities varied from 20,000 to 1,000,000 gallons per day. The water production costs ranged from about 70 cents to $4.50 per 1,000 gallons ($230 to $1,460 per acre-foot).



Water Factory 21, Orange County

Energy Required

Various forms of energy are used for desalting, depending on the desalting process and the source of energy available. Steam is used to heat water for the distillation processes. Pumps are used to create pressure in the feed water in the reverse osmosis process and electricity is used in the electrodialysis process.

Energy is expended to create the steam and drive the pumps. The heat generated by burning natural gas or oil, or nuclear fission can be used to generate the steam. The pumps are usually driven by electric motors.

The amount of energy used for desalting can vary with the concentration of salt in the water to be desalted, the amount of salt to be removed, and the amount of water to be treated. For desalting sea water, a small vapor compression distillation desalter uses nearly 100 kilowatt-hours of electricity for every 1,000 gallons (33,000 kilowatt-hours per acre-foot) of fresh water produced. A large-capacity multistage flash distillation plant would use about 50 kilowatt-hours per 1,000 gallons of water produced. For the desalting of brackish ground water with small-capacity membrane desalters, about 10 kilowatt-hours would be used per 1,000 gallons. For comparison, 10 kilowatt-hours would also be required to pump 1,000 gallons of water a vertical distance of 2,700 feet, the equivalent of the combined lift of the three southernmost San Joaquin Valley pumping plants of the State Water Project, Wheeler Ridge, Wind Gap, and A. D. Edmonston Pumping Plants.

Activities by the Department

The Saline Water Conversion Program was initiared in the Department of Water Resources in 1957, and since that time several cooperative efforts with the federal Office of Saline Water * have been undertaken. After participating in financing and the operation of the Point Loma sea water conversion plant and the San Diego Saline Water Test Facility, the Department in 1969 intensified its cooperative efforts in the development of potential desalting applications and sites, and in the development of a large-capacity prototype desalter.

A study was made to select a site for a prototype desalting plant that would be a full-size, first-of-a-kind plant. A reconnaissance-level survey identified potential markets for desalted water in water service areas along the California coast and possible sites for obtaining a steam supply from a power plant. The Diablo Canyon nuclear power plant on the coast near San Luis Obispo was selected for the protoype study. The Diablo Canyon protoype desalter study included a 40 million gallon per day sea water desalter that would use some of the steam produced by the nuclear generating plant now under construction at Diablo Canyon by the Pacific Gas and Electric Company. The desalter consisted of two units of 20 mgd capacity which was more than three times the capacity of any individual units in the world at that time. Also pro-

* Office of Saline Water (OSW) and the Office of Water Resources Research have been combined within the new Office of Water Research and Technology. References to OSW in this report concern past activities of that office and the previous name is therefore used.

posed was a 62-mile pipeline to convey desalted water into parts of San Luis Obispo County and Santa Barbara County.

As a result of this study the Department of Water Resources issued a feasibility report * which recommended that the U. S. Congress and State Legislature authorize the project as described in the report and provide the means to finance the construction and operation of the project. However, the Office of Saline Water reported to the 1972 Session of Congress that a large-scale prototype desalting project had not been satisfactorily identified that would meet all of its requirements. Since the prototype project would not be feasible without federal participation in funding, no further action has been taken on this project.

The present on-going desalting program includes the assessment of membrane desalting processes for selected types of brackish and waste waters and an assessment of possible desalting applications in the State.

In 1971 an experimental reverse osmosis desalting unit to desalt agricultural waste water was installed at the Firebaugh Test Station, 40 miles west of Fresno, under an agreement with the University of California which has provided technical guidance in the testing program. Also, the Office of Saline Water joined the Department of Water Resources in a cooperative agreement in 1972 for testing at Firebaugh by furnishing two reverse osmosis test units in operation at Firebaugh to determine the technical feasibility of desalting agricultural waste water. Desalting of the waste water could provide a quantity of water for reuse and at the same time serve to concentrate the waste into a much smaller volume.

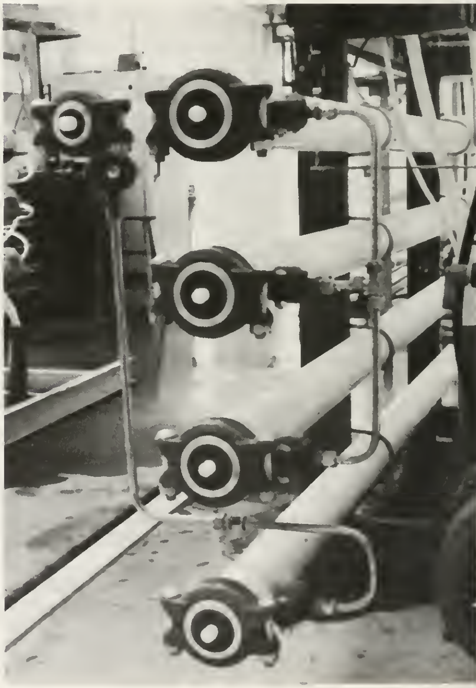
The Department's participation in this effort at Firebaugh has led to a discovery that by adding an ion exchange water softening unit in series with the reverse osmosis desalters it is possible to attain an efficiency of 90 percent recovery of the treated feed water. Previous efforts had attained 70 percent efficiency.

Under another cooperative agreement with the University of California in 1973, the University produced a reverse osmosis unit which the Department provided to the Metropolitan Water District of Southern California to operate at the F. E. Weymouth Memorial Softening and Filtration Plant. The Department's unit is being operated by the Metropolitan Water District, along with four other types of reverse osmosis units owned by the District, to determine the feasibility of desalting Colorado River Water for quality improvement.

In 1973, the Department joined in an ongoing program of the City of San Diego for the desalting of untreated municipal waste water. The City has made some successful inroads into this area of desalting, and the Department will provide studies on, among other things, the determination of the concentration of virus in the product water.

To assess the potential for small desalting installations for improvement of local water supplies the Department made an inventory of 111 small and medium size communities in California where water quality problems exist in the municipal water supply. The communities included in the inventory are located in various parts of the State, although the majority are in Southern California. In each community excessive concentration of salts occurs in existing municipal water supplies, potential supplemental municipal water supplies, or municipal waste waters. The communities are isolated from existing and proposed water project facilities that could feasibly provide a better water supply. All facilities required for a desalting application were assessed for each community and estimated capital costs, annual costs, and unit costs were determined for each system.

Desalting may play a role in the operation of future electric generating plants at inland sites by enabling operators to use brackish agricultural waste water for cooling and also to meet the requirements of the Environmental Protection Agency for disposal of brines resulting from the evaporative cooling process. The



Experimental tubular reverse osmosis desalting unit

* State of California, Department of Water Resources and United States Department of the Interior, Office of Saline Water, "Feasibility Report, Diablo Canyon Desalting Project", March 1972.

agricultural waste water generally contains concentrations of scale-producing constituents that must be reduced by ion exchange softening before the water can be economically used for cooling. It is desirable to concentrate the blowdown waste from the evaporative cooling process to facilitate its disposal. The distillation desalting process may be used for this purpose, and the concentrated waste from the distillation process could provide an economic source of brine to regenerate the ion exchange resins used in the softening process. There is a need to develop design and cost data for both of these systems before the potential of either can be fully evaluated. To meet this need, the Department is planning a development and testing program with technical assistance from the University of California.

Future Potential of Desalination

In the future, desalting can play a role in specialized applications to improve management and conservation of California's water resources. It is visualized that metropolitan areas will more intensively manage their existing water supplies. There will be a need to provide salt balance in ground water basins, to improve water quality, to reuse water, and to meet regulatory requirements for waste water discharges. In some cases, these management processes will require desalting. Hence, it is anticipated that desalting in California will find relatively small, but wide-spread use in the next 10 to 30 years. The membrane desalting processes (reverse osmosis and electrodialysis) are likely to play a major role in desalting brackish waters. For coastal communities that need additional quantities of fresh water there may be limited applications for sea water desalting, using the distillation process.

Geothermal Water Potential

Since the late 1960s, considerable attention has been focused on the possibility of utilizing geothermal heat to produce fresh water from the saline ground water that sometimes occurs in geothermal regions.

Necessary conditions for geothermal fresh water production include a geothermal heat source, an adequate supply of brine, and a market for fresh water. The most economic development of geothermal resources is believed to result from a facility which combines the production of power and water and possibly mineral by-products. Disposal of waste products will also require a method which is economical and which protects the environment.

Of the three major geothermal areas in California (Figure 18) which have been investigated for commercial exploitation, the Geysers in Sonoma County, the Mono-Long Valley-Casa Diablo area, and the Southern Imperial Valley, only Imperial Valley appears at this time to have the quantities of hot subsurface brine sufficient to support large scale production of water. At least nine anomalies—areas beneath the surface where ground temperatures are above normal as a result of near-surface penetration of heat from the hot magma of the earth's core—have been identified between the Salton Sea and the Mexican Border. Figure 24 shows the location of the anomalies where temperature gradients have been investigated.* Other areas have been identified on the basis of favorable geologic conditions as potential areas for further investigation. Estimates of the amount of hot brine in the basin range from 1 to 5 billion acre-feet. Assuming the lower value for brine in storage, usable quantities at temperatures of 300° F or more have been estimated at 200 million acre-feet. Perhaps an additional 100 million acre-feet may also be usable at lower temperatures.

It is probable that in addition to reinjection of concentrated brines from the desalting process, it will be necessary to replace the water withdrawn from the underlying sediments to maintain subsurface pressures and to prevent land subsidence. Limited amounts of this recharge water might be obtained from the Salton Sea or other local drainage sources, but large-scale development would probably require importation of seawater from the Pacific Ocean or from the Gulf of California.

The Bureau of Reclamation has been conducting a freshwater-production research project in cooperation with the Office of Saline Water at the Mesa Anomaly in the Imperial Valley. In 1972, the Bureau of Reclamation drilled and completed a geothermal well to a depth of 8,000 feet where a temperature of 400°F was measured. Pressure and temperature were adequate to produce steam and a brine with a salinity of about 17,000 milligrams per liter (mg/l) (sea water has 34,000 mg/l). In 1973, two experimental desalination units, each capable of 20,000 to 50,000 gpd, were erected near the well to test the operation of both multistage flash distillation and vertical tube evaporation processes. Production of fresh water has been intermittent in line with the project's purpose of identifying and solving the problems unique to desalination of brines by use of geothermal heat. In 1973, a second well was drilled to a depth of 6,000 feet, where the temperature is about 370°F and the liquid salinity is about 2,400 mg/l. Three additional wells were completed to a depth of about 6,000 feet in 1974. These wells are still being tested, but present plans call for use of one well to develop injection techniques and the four remaining wells to develop water production methods.

The Department of Water Resources is monitoring the programs conducted by private and public entities with the objective of establishing the physical and

* Data from report by the Bureau of Reclamation, "Geothermal Resources Investigations, Imperial Valley, California, Developmental Concepts", January 1972.

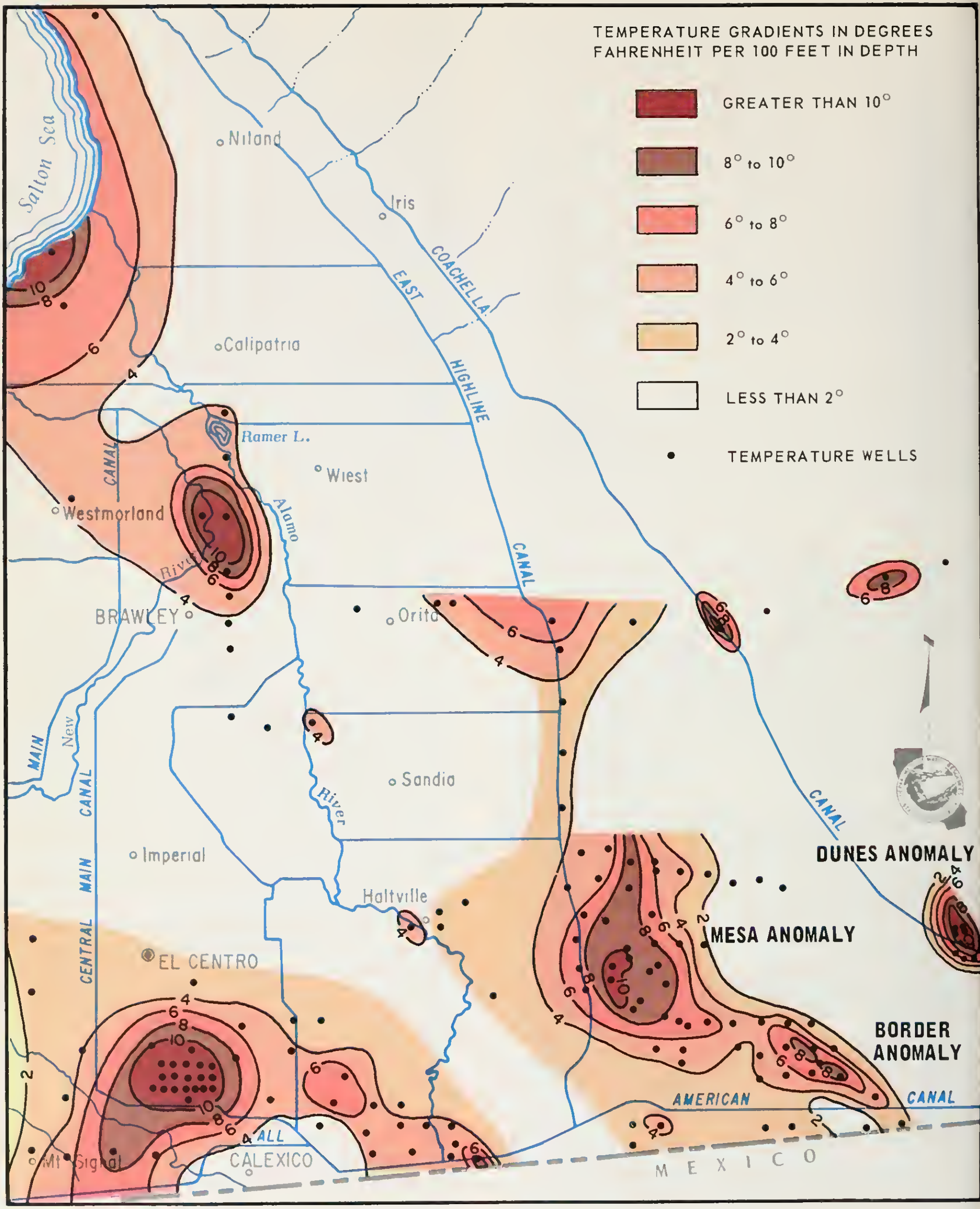


Figure 24. Thermal Anomalies in the Imperial Valley Area

economic feasibility of geothermal resources development in the Imperial Valley as soon as possible. Also, to further define conditions at the Dunes anomaly, the Department drilled a 2,000 foot test hole in 1972. Maximum temperature encountered in the test hole was 218°F. Cores, fluid samples and logs for this well were collected and analyzed and preliminary results were published in a joint report by the Department and the University of California, Riverside.*

As with the production of power by use of geothermal fluids, economic development of fresh water will depend on solutions of technical problems, many of which result from the high mineral content of the subsurface brines. The scaling and waste disposal problems may prove to be the most difficult. Land subsidence and potential for induced seismic activity are very important environmental questions that need study. Odor and noise problems can be solved but need special treatment. Information currently available is not adequate to permit a reliable projection as to the amount of water that can be produced competitively with alternative sources of water.

Geothermal power is not expected to make a relatively large contribution to power production in the next decade or two. Without the economic advantages of the combined power-water production process, and considering the relative difficulty of desalting geothermal fluids as compared with other available saline sources, geothermal water production appears to have limited potential for immediate commercial exploitation as a source of significant quantities of additional water.

Further investigation is required to establish the feasibility of any large, new, geothermal operation. More geologic and engineering knowledge is needed to (1) refine estimates of the amount of brines and of the utility of the heat contents, (2) solve the scaling, corrosion and environmental problems, (3) develop acceptable methods of disposing of geothermal pollutants, (4) determine costs of fresh water production, and (5) establish the economic feasibility and justification of such production.

If geothermal fluids in the Imperial Valley prove to be an economical source of water, they might augment the Colorado River supplies now used in Southern California and alleviate the increasing water quality problems there. Fresh water could be (1) added to the Colorado River, (2) used as a direct supply to meet municipal and industrial demand in the Imperial Valley, or (3) blended with Colorado River water in the All-American Canal system.

Although not oriented specifically to the production of fresh water from geothermal brines, many governmental and private entities are engaged in investigations and research programs related to the recovery of minerals and the production of power. Knowledge obtained from these programs will add to the data needed for early findings as to the practicality of fresh water production from the valley's geothermal resources.

* California Department of Water Resources and University of California, Riverside. The Institute of Geophysics and Planetary Physics, a Joint Study by Coplen, Tyler B.; Combs, Jim; Rex, Robert W.; Burchalter, George; and Laird, Robert. "Preliminary Findings of an Investigation of the Dunes Thermal Anomaly, Imperial Valley, California, 1973".

Weather Modification

The weather is both man's friend and foe, and its control has long been a dream which is just now beginning to show a glimmer of promise of realization. However, the very nature of weather—its vagaries, its unpredictable swings from plenty to paucity, the complex nature of its processes—makes evaluation of the effects of weather modification operations difficult. While the procedures for seeding clouds in California to increase precipitation has been developed to a fair degree in recent years, the processes for evaluating the effects of seeding have been slower in development and acceptance as assured indicators of incremental water production. Changes in precipitation fall within the range of natural variation and are difficult to identify. Therefore, statistical analyses are used in attempts to evaluate the effects of cloud seeding operations, a process which can be improved mainly by accumulation of additional operating experience and data and by a better understanding of the precipitation process.

During the 1971–72 year there were 12 weather modification projects conducted in California. Three of the projects were research and development oriented, three were primarily to increase hydro-power production, and the balance were to increase the availability of water supply. The locations of the project target areas are shown in Figure 25.

Research activities were primarily sponsored by the U. S. Department of the Interior as part of its nationwide Project Skywater. The California Department of Water Resources founded several activities of the California State University, Fresno Foundation, in conjunction with the Project Skywater effort. Results from state participation included:

1. Classification of Sierra Nevada winter storms by types.
2. Evaluation of a quantitative precipitation model—assessment of winter precipitation factors.
3. Establishment of requirements for a winter-time cloud-seeding operation in the Feather River and North Yuba River basins.

During 1972 the Bureau of Reclamation sponsored three field trials in California. Activities were conducted by the Desert Research Institute, University of Nevada, as part of the Pyramid Lake Pilot Project to increase water supply. In this program, efforts are oriented toward determining whether increased precipitation can be promoted on the lee side of the Sierra Nevada crest. Results of the first season's operation indicated a possible 14 percent increase in precipitation.*

In the CENSARE (*CEN*tral Sierr*A RE*search) project the Fresno Foundation accumulated additional evidence of precipitation increase. A supplemental final report † was published August 31, 1973, which includes the following observations:

1. Precipitation enhancement of 5 to 10 percent occurred as a result of cloud seeding.
2. Some potential exists for summer-time cumulus seeding in the CENSARE target area.

The third project, conducted by Aerometric Research, Inc., in the Santa Barbara region, studied the downwind effect and precipitation duration of various seeding efforts. Results indicate that aerial seeding at very heavy rates produces decreased precipitation in primary target areas and large increases 50 to 100 miles downwind.

Another aspect of precipitation modification activities is the assessment of the ecological-environmental effect of such activities. A study, supported by the Bureau of Reclamation and the Department of Water Resources, was made by the Center for Regional Environmental Studies, California State University, San Diego, of such items as: effects of seeding agents, physical effects, ecosystem effects, and social effects. Preliminary results indicate the following general conclusions:

1. The insolubility of silver iodide, the principal seeding agent, and the small quantity used, make any immediate danger to the environment unlikely—monitoring should continue to allow evaluation of any long-term effect.
2. Research on effect of seeding agents is not areally unique, and research results could be transferred to other areas—study of the cumulative effect of long-time seeding is desirable.
3. Effect of an ecosystem of 5–10% increase in precipitation is not likely to be significant—some redistribution of plant and animal species may take place, but with little detrimental effect.
4. Some aggravation of summer fire hazard may occur if plant vegetative growth is significantly increased.
5. The effect on transportation facilities may be the greatest social effect, with a negative impact if the duration of storms is increased.
6. Effects of increased precipitation would fall within natural year-to-year variations—cumulative effect for a given year could be a problem if natural late season precipitation is large.

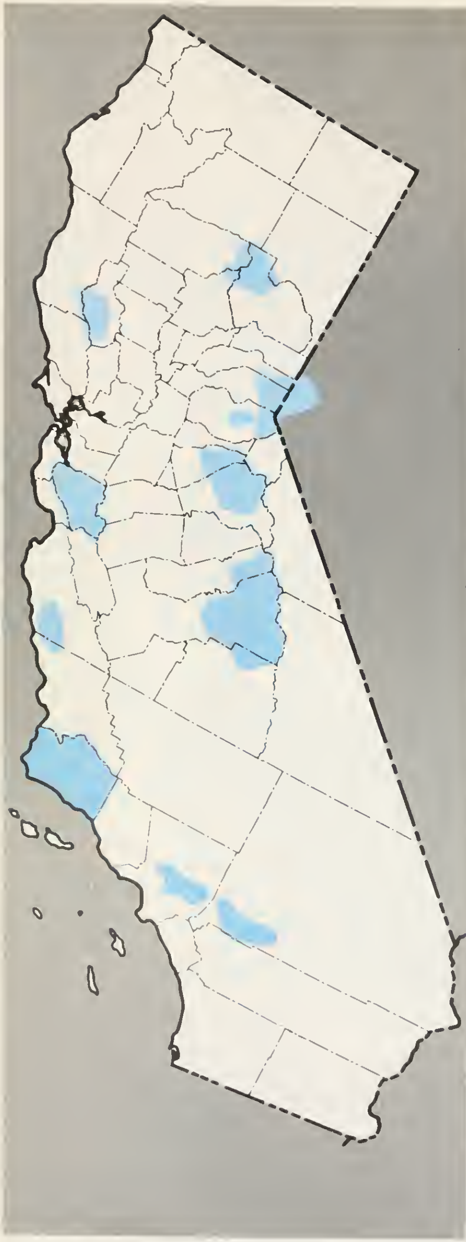


Figure 25. Weather Modification Target Areas in 1971–1972

* Bureau of Reclamation, Division of Atmospheric Water Resources Management, "Project Skywater, 1972 Annual Report," November 1973.

† California State University, Fresno Foundation, Atmospheric Water Resources Research, "Supplemental Final Report—Volume I, Summary of Accomplishments", August 31, 1973, prepared under Bureau of Reclamation Contract No. 14-06-D-6592.

7. Public response to a survey regarding attitude toward the precipitation modification program is essentially noncommittal at this time.

A recent analysis has been completed by North American Weather Consultants, for the Bureau of Reclamation, of potential increases in precipitation and streamflow resulting from modification of winter orographic storms. Included in the first report* on the analysis is a study of the Sacramento Basin which indicates significant increases may be possible from precipitation modification activities. Actual estimated increases were based on unregulated runoff without elimination of incremental precipitation which might tend to increase the severity of winter flood runoff. Thus, while the values cited in the report give a somewhat high estimate of increase, they do indicate that the Feather, Yuba-Bear, and American Rivers subbasins have a good potential for significantly increased runoff. Future activities in the field of precipitation management will be concerned with continuation of several ongoing pilot projects, completion of programs for evaluating the ecological-environmental effects, and the development of additional pilot projects to determine factors for consideration in assessing the feasibility of developing additional water supplies from operational precipitation management projects.

The Department of Water Resources is currently planning for a pilot project in the Feather River Basin. Subject to satisfactory completion of an Environmental Impact Report, seeding of a portion of productive storms is expected to commence in the fall of 1975. Active participation by other agencies is desired to provide a coordinated effort which would result in areawide conclusions on full operation feasibility.

Weather modification involves uncertainties regarding downwind impacts beyond target areas, particularly as they relate to claims of decreased potential precipitation, claims for increased costs due to floods and snow removal, and other possible litigation. These matters require careful study and work with the public and organizations who would be affected.

The estimated costs of producing incremental amounts of runoff are generally very low. The cost of associated activities for environmental protection and insurance or facilities to protect against uncertainties and claims cannot be reasonably estimated on the basis of current knowledge.

Management Concepts and Practices

Future large-scale surface water development, control, and conveyance projects in California face significant obstacles, both economic and institutional. The number of desirable storage development sites is rapidly diminishing, and those that do remain are often far removed from the areas of need. Yet demands for water in California continue to increase.

A significant possibility for meeting at least some part of these growing water requirements lies in more effective water management practices.

Water is managed in California by individuals, private companies, local agencies, municipalities, and the state and federal governments. Management traditionally has been performed at the lowest practical level, by individuals and local agencies when possible; and local entities have guarded against infringement of this management right by large government agencies. Joint exercise of powers authority, given many local agencies by state law, has been used by two or more local agencies to manage water resources where one agency alone could not effectively do so. When there has been a need for a large importation project whose cost exceeded the financial capability of the local agencies, the project has usually been constructed, operated and managed by a larger agency, with the local agencies acting as contractors who then manage the local distribution and use of the water.

This section discusses water management practices as they relate to more effective use of water, more effective use of facilities, ground water modeling, flood control, and waterways management.

More Effective Use of Water

Making more effective use of the water supplies currently available is popularly considered a prime method to help satisfy a portion of the increased demands for water. Since many of the methods for improving use of water are so inexpensive, and some may even save money too, it is important that all reasonable steps be undertaken. The extent of overall water saving and reduction in need for additional water supplies is, however, much less than generally believed because there is already a high degree of reuse of excess water from inefficient operations. With the exception of waste water discharged to the ocean and that which is so brackish it must be discarded, nearly all of the excess now returns to the water supply system for reuse. There will, however, be water quality advantages in reducing water use, as well as some water savings, and improved methods should be pursued.

In this context, more effective use includes more efficient use. Efficiency can be defined as "doing things right" whereas effectiveness is defined as "doing the right things". Some general approaches toward more effective use of present water supplies include:

(1) application of farming and irrigation practices which result in the least waste of water, (2) elimination of wasteful practices in the use of urban water supplies, and (3) utilization of poor quality water when feasible.

* Robert D. Elliott, Jack F. Hannaford, Russell W. Shaffer, North American Weather Consultants, "Twelve Basin Investigation, Volume 1, Report No. 15-18", May 15, 1973.

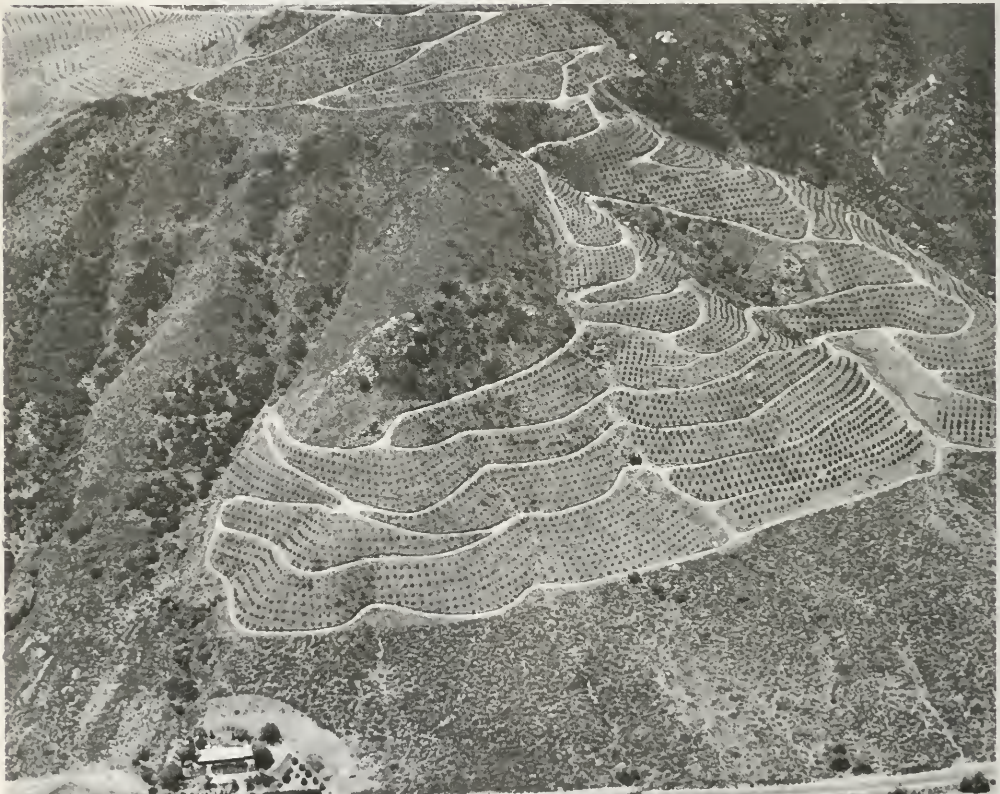
Practices which might extend the effective use of irrigation water are listed below:

1. Utilize water distribution systems which provide uniform application of irrigation water and which allow controlled application to wet only the root zone. The increasing use of sprinkler irrigation is an example of this. New drip irrigation techniques also demonstrates some promise on selected crops in areas where water is very expensive. Drip irrigation is discussed more fully in Chapter IV under "Agricultural Water Use".
2. Improve timing of water applications to reduce nonrecoverable runoff and deep percolation.
3. Eliminate nonbeneficial water-consuming ground cover in orchards.
4. Improve soil structure to increase its water intake rate.
5. Line farm ditches to reduce seepage loss.

The cost of water is a principal influencing factor in urban water use. Cost consciousness on the part of the user can effectively be created by metering water use. However, most of the high use, unmetered cities are in the Central Valley where water not consumptively used returns to the water cycle. Most coastal cities which discharge sewage effluent to the ocean are now metered.

In general about half of the water supply to urban homes is used outside of the home and the other half is used inside. Use of landscaping which does not require much water can yield significant savings. Most of the savings in homes would be dependent on being water conscious and continually making efforts to save water in using appliances.

Water resources which are not usable for normal agricultural or domestic use because of quality considerations can be used in some circumstances for specialized purposes within a service area and thereby



Avocados drip irrigated on a steep hillside in San Diego County extend the effective use of the area's good quality water. Examples of this practice are listed below.

1. Cooling water for thermal power plants and other industrial purposes.
2. Application for esthetic purposes in municipal areas or for irrigation of golf courses and city parks.
3. Blending with a suitable volume of high quality water to obtain an increased supply of water of satisfactory quality.
4. Creation of wetlands and wildlife refuges.

More Effective Use of Facilities

There are many individual water projects and systems in California, and at the present time, most are operated on an independent basis. Opportunities exist in cetrain areas for joint operation of surface water facilities with ground water basins. In the Central Valley, the state and federal water projects are operated through coordination to make effective use of the water supply available in the Sacramento-San Joaquin Delta.

The Department of Water Resources and other leading water agencies in California are pursuing studies directed toward full development of the potential capability of existing water supply facilities. For example, agreement was recently reached with power companies contracting for purchases of Oroville power which will allow operation of the facility at levels below that of the maximum flood control reservation during the flood season in an effort to reduce the amount of spill which bypasses the power plant.

The transportation facilities of the State Water Project will continue to have additional capacity during the nonirrigation seasons of each year for conveying water that is excess to the contractors' projected needs. During years of above-normal inflow to the Sacramento-San Joaquin Delta, additional volumes of water will be available for delivery to offstream storage sites—either on the surface or in ground water basins. This stored water would then be available to lessen the impact of dry-year deficiencies and reduce ground water pumping lifts. The Bureau of Reclamation has carryover storage—except in dry years—which is utilized as a nonfirm supply in some of its service areas.

An example of what can be accomplished in the area of more effective use of facilities is embodied in a cross-valley canal under construction by the Kern County Water Agency. This facility was originally intended to transport normal year deliveries of water from the State Water Project to an area near Bakersfield. Negotiations have been successfully concluded which provide for an increase in capacity of this aqueduct to facilitate the delivery of Bureau of Reclamation water, available in the Delta, through the excess capacity of the State Water Project, including the joint state-federal San Luis canal, and through the Kern County Water Agency canal to water-deficient areas on the east side of the San Joaquin Valley.

There are many potential opportunities for surface water exchanges among water agencies. Use of surface water instead of ground water in coastal areas can reduce the threat of sea water intrusion into ground water basins. In some cases ground water basins can effectively be used for water distribution in lieu of constructing surface distribution systems. The rapidly increasing cost of energy may make some water exchanges feasible if pumping can be decreased thereby.

Ground Water Modeling

Availability of large capacity electronic computers has made possible a new approach to management of ground water basins to increase water supplies, reduce costs and improve operational flexibility. Management of a ground water basin involves the planned use of ground water storage in conjunction with local and imported surface water storage and use of subsurface aquifers in conjunction with pipelines and canals for movement of water. Such management may, depending on the management objective, require deliberate augmentation of natural recharge to place necessary quantities of water underground, and planned extraction patterns and facilities to control both removal of ground water and its movement through the basin's aquifers. It may also involve measures to prevent degradation of the ground water.

Ground water management objectives for a basin may include one or any number of the following:

1. Utilize all sources of water to obtain the lowest cost water supply.
2. "Mine" previously stored ground water supplies to delay construction of water importation facilities or distribution systems.
3. Control location and movement of degraded water already in the ground water system.
4. Control sea water intrusion into a ground water system.
5. Prevent adverse salt buildup in a ground water resource.
6. Predict the expected life and yield of a ground water resource in an overdraft situation or mining operation.
7. Utilize the ground water basin reservoir to store excess surface water for later use and thereby increase the total available supply.
8. Operate the ground water reservoir at levels below those causing drainage problems and above those causing subsidence or quality problems or necessitating deepening of large numbers of wells.

In developing ways in which ground water can be used to help meet water demands, the collection, analysis and verification of a large amount of geologic, hydrologic, and water quality information is necessary.

The relations between the physical properties of a ground water basin can be approximately expressed by equations; therefore, a mathematical model can be used to verify the analysis and to test alternative ways of utilizing the ground water basin in conjunction with surface supplies, facilities, and storage. The model programmed on a high-speed electronic computer can then be verified. The process is essentially one of trial and error and is too laborious to do by hand. The verified model can be used to test alternative plans so that a wide variety of alternatives can be tested in a short time and at a reasonable cost.

The results of both basic ground water resource studies and more advanced studies evaluating alternative operational plans have been used beneficially by both the Department of Water Resources and local agencies. On a statewide basis, they provide additional knowledge on the role ground water can play in satisfying demands for future water supply and storage. To ensure that the study results will be realistic, the information is developed for local areas that use or have in storage significant amounts of ground water and in cooperation with local agencies responsible for operation of the ground water basin. This method of conducting ground water studies provides a better understanding of local institutional and economic restraints on the full utilization of ground water supplies as well as the full consequences of overdraft, sea water intrusion, and water quality degradation.

Local agencies have benefitted mainly by being able to make decisions on ground water management based on fact instead of speculation. Decisions on how much imported water to purchase, when to purchase it, and where to apply it have been influenced by model studies in many areas of the State. Because there are a number of other factors involved, a local agency may not always select the least expensive alternative, but will review the range of alternatives and select the one best suited to their area. Examples of uses of model studies developed cooperatively with the Department of Water Resources are: (1) Metropolitan Water District of Southern California used financial information extensively in its pricing-policy studies; (2) San Bernardino Valley Municipal Water District used the study information to plan and operate its water distribution system and to keep the local voters apprised of water planning in the area with the result that it has been able to pass necessary water bond issues; (3) City of Pasadena has used the mathematical model of Raymond Basin to evaluate the effects of shifting recharge and extraction locations, under a "safe-yield" operation condition, on water level elevations, water quality, and the cost of water resources management in the basin; and (4) Sacramento County water purveyors are using model studies in developing a countywide plan to integrate ground and surface water supplies.

Other agencies, although they have not used the results of the investigations directly, have increased substantially their understanding of water management options. Their interest in considering the use of ground water basins for regulation of surplus State Water Project water is considered to be a consequence of their participation in the ground water modeling program.

Ground water basins for which models were developed by the Department of Water Resources in cooperation with other agencies are:

North Santa Clara County
Fremont Study Area (Niles Cone)
Livermore Valley
Coyote Basin (Santa Clara County)
Sacramento County
Kern County
Coastal Plain of Los Angeles County
San Gabriel Valley
Chino-Riverside Area
Bunker Hill-San Timoteo Area
Ventura County
Raymond Basin

Waterway Management Plans

Waterway management planning is a subdivision within the more universal field of water management. Waterway management concerns primarily those factors related directly to the rivers and streams and to their immediately adjacent land areas, whereas water management involves matters of basin-wide and even trans-basin scope.

In 1971, the Legislature directed the Resources Agency to prepare detailed waterway management plans for specified streams in the North Coastal and northern San Francisco Bay Hydrologic Study Areas.* In the following year, the Administrator of the Resources Agency was further directed to prepare and administer river management plans under legislation establishing the State Wild, Scenic, and Recreational System.**

The objectives of the Resources Agency's WaterWay Management Program are:

1. To protect and enhance scenic, recreational, geologic, fish and wildlife, historic, archaelogical and similar values associated with riverine environments, without unreasonably limiting other resource uses, where the extent and nature of such uses do not conflict with the public use and enjoyment of these values.
2. To assist in maintaining or enhancing water quality.
3. To provide opportunities for river-oriented recreation which is consistent with protection of the quality values associated with the rivers.

* Senate Bill No. 1285, Chapter 761, Statutes of 1971.
** Senate Bill No. 107, Chapter 1259, Statutes of 1972. Also, see Chapter 1 of this report.

4. To maintain those rivers included in the State Wild and Scenic Rivers System in natural and free-flowing conditions for the benefit and enjoyment of the people of the State.
5. To identify measures for flood control and streamflow augmentation which may be necessary and desirable to enhance the riverine environments where such measures do not conflict with natural, free-flowing and other requirements of the rivers included in the system.

Waterway management plans are currently under preparation for the Smith and Klamath Rivers. Program activities in progress include:

1. Identification of actions presently in effect or required to insure safeguarding of scenic, fishery, wildlife and recreational values;
2. Preparation of information on flood control, inbasin water conservation and streamflow augmentation needs and possible measures required exclusive of permanent mainstream dams or other facilities which would adversely affect the natural and free-flowing character of the rivers;
3. Preparation of estimates of recreational developments necessary, river access and controls desired, possible adjacent land use, and associated costs to achieve greater human enjoyment of these rivers.

The above work is carried out by the Resources Agency in cooperation with local government entities and the appropriate federal agencies where federal lands are involved, and it is coordinated closely with the related studies of the State Water Resources Control Board in its preparation of Comprehensive Water Quality Control Plans for the Smith and Klamath Rivers. Similar coordination is maintained with the State Board of Forestry in its development and implementation of new Forest Practice Act rules and regulations.

Subsequent to public hearings, it is anticipated that the Smith River Waterway Management Plan Report will be submitted to the California Legislature for its consideration early during the 1975 Session.

Smith River at the junction of the North Fork and Middle Fork

Flood Control

Flood control management is discussed in this chapter in regard to processes that are available or being considered for preventing flood damage, programs and projects that are underway that prevent flood damage and studies by various agencies that will lead to future programs or projects for floodplain management.

Methods of Preventing Flood Damage. There are two general categories of flood control measures to be considered in planning for damage control—structural and nonstructural. The two differ in function. Structural measures are designed to control water. Nonstructural measures are intended to control people's actions. In the structural category are such features as reservoirs and detention basins, floodways and bypasses, levees, and channel improvements. Nonstructural measures include floodplain regulation, flood forecasting and warning procedures, flood proofing, watershed land treatment, and flood insurance.

Theoretically, structural measures could provide the maximum reduction in damages to existing land use development while allowing the most intensive use of flood-prone lands. Realistically, structural measures are not an absolute protection from flood damage. Project design capacity which governs the degree of protection from the return frequency of floods is limited by economics. Projects are usually sized according to estimated damages prevented over an assigned life of the project that at least equal the cost of the project calculated with an interest rate. A greater degree of protection is usually provided where a high threat to life exists. Protection from flooding may be further diminished by change in land use in the upstream basin after project completion. Projects lure development by providing a sense of security. Consequently, projects designed with a limited capacity pose the greatest threat to man's encroachment on floodplains by setting the stage for greater disaster than would occur without an existing project. Unless economics will allow a very high degree of protection for urban development, no "project only" alternative should be considered. It should be mandatory to incorporate nonstructural measures such as regulatory land use controls and flood proofing and flood warning procedures.

Notwithstanding the limitations, there are some flood problems where only structural measures will protect a desired land use. Structures are required to train and contain stream channels on sediment debris cones found below mountain canyons and to protect agricultural development on valley floors.

Nonstructural measures are an important aspect in any overall flood control plan. Nonstructural measures attempt to regulate development within a floodplain to that which can withstand flooding or be capable of evacuation.

The success of nonstructural measures depends on several factors, not least important, human attitudes. The cooperation and coordination of various levels of governmental service agencies are required to establish reasonable building codes and zoning regulations. These regulations must be hard and fast with respect to future amendments that would relax them, mindful of individual's property rights, enforceable, and *be* enforced in the future. Paramount for success is the attitude of the private citizens who must initiate actions requiring personal expenditures and time, sometimes before the need has actually been demonstrated to them.

Zoning and building codes hold the greatest promise for those areas not yet developed, but potentially vulnerable to future development pressure. Floodplain zoning can be used as an interim solution, prior to future structural measures if it is clear that there is a lack of safe alternative land available for regulated growth. For those areas where other lands are available, floodplain zoning would allow uses compatible with flooding or provide open spaces for future generations to enjoy. Nonstructural floodplain management would also reduce the trend of increasing flood damage in developing areas where existing projects afford a low degree of protection from floods.

Flood forecasting is a tool that can help reduce flood damages. It may be employed by itself or in conjunction with other available measures. Flood forecasting is essential in the successful operation and maintenance of flood control projects. It is prerequisite to successful floodplain evacuation and to implementing certain types of flood proofing procedures. Flood forecasting success in reducing damages is dependent on several factors. There must be enough time for people to act after the initial warning. There must be a local organization geared to receive warnings and disseminate pertinent information to the floodplain dwellers. And, the forecasts must be reliable enough to create confidence in the users so they will take the necessary actions in subsequent events.

Flood proofing embodies permanent and temporary structural changes and adjustments to property in the flood hazard area. Two common practices are grading ordinances that require the ground level for streets and buildings to be above flood stages and construction of buildings so the first floor can be inundated without much damage. Flood proofing is particularly suited for areas where flood stages and velocities are low and adequate advanced warning time is available. The cost to provide flood proofing measures must be borne by the local property owners.

Watershed treatment involves treating the land to retard runoff and reduce erosion. Land treatment is most applicable to small upstream portions of basins. In general, such measures are ineffective toward reducing flood damages in areas much removed from the lands where the treatment has been applied. In steep mountainous areas adjacent to urban development where wild fires occur, seeding of ground cover after a fire is done as soon as possible prior to the rainy season. The purpose is to retard rapid erosion and ensuing mud and debris flows that disrupt downstream project operation and may inflict other costly damages, too. Success depends on adequate germination and growing time before heavy rains begin.

Flood insurance is available to eligible communities as a result of the National Flood Insurance Act of 1968. The act as amended in 1973, will provide strong incentives for local communities to regulate land use and will require the floodplain dweller to share more fully in the costs to mitigate damages in the future.

Present Flood Control Activities. This discussion primarily reports state and federal flood damage reduction programs. Many smaller projects are being constructed by local flood control agencies. However, there is no systematic compilation of information on the work in flood control accomplished by local agencies.

The tabulation below lists major structural projects currently underway. Those projects, where construction started since 1970, are indicated with an "x".

Project Name	Constr. Begun Since 1970	River Basin and/or County	Hydrologic Study Area
Dams[1]			
Hidden	x	Fresno River	San Joaquin
Buchanan	x	Chowchilla River	San Joaquin
New Melones	x	Stanislaus River	San Joaquin
Auburn	x	American River	Sacramento
Warm Springs	x	Dry Creek (Russian River)	San Francisco
Local Projects[1,2]			
Los Angeles River		Los Angeles Co.	South Coastal
Lyle & Warm Creeks	x	Santa Ana River	South Coastal
Santa Paula Creek	x	Santa Clara River	South Coastal
Sweetwater River	x	San Diego Co.	South Coastal
Walnut Creek		Contra Costa Co.	San Francisco
Watershed Projects[2,3]			
Carpinteria Valley	x	Santa Barbara Co.	Central Coastal
Central Sonoma		Sonoma Co.	San Francisco
Main Street Canyon	x	Riverside Co.	South Coastal
Mustang Creek	x	Merced Co.	San Joaquin
Napa River		Napa Co.	San Francisco
Revolon Slough		Ventura Co.	South Coastal

[1] U.S. Army Corps of Engineers is constructing agency—See Plate 1 for location of dams and reservoirs.
[2] Projects for which the State has a financial obligation.
[3] U.S. Department of Agriculture, Soil Conservation Service is the funding agency.

The State has not been as active in construction or planning projects to alleviate flood problems as have the federal and local agencies. Two of the dams the State built for the California State Water Project provide flood control. They are Oroville Dam on the Feather River and Del Valle Dam in Livermore Valley. The Department of Water Resources also designed and constructed the lower San Joaquin River Flood Control Project. The State's principal involvement has been as a financial partner in eligible local projects and in nonstructural implementation programs directed toward reducing flood losses.

The United States Army Corps of Engineers has a Flood Plain Information Service Program underway. A floodplain information report typically includes maps, flood profiles, and other display and narrative material on the extent, depth, and duration of past floods, and similar data on floods that may reasonably be expected in the future. To date 91 reports have been completed; 15 are ongoing and 35 others planned for completion over the next several years. This information is essential for analysis of nonstructural measures. Similar studies are conducted by the Department of Water Resources in cooperation with local agencies.

The State requires local agencies to zone floodplains to be protected by authorized federal flood control projects to prevent incompatible development. The State Reclamation Board, which has jurisdiction over flood control projects in the Central Valley of California, is establishing "designated floodways" to prevent incompatible development in flood channels under its jurisdiction.

The National Flood Insurance Program is just get-

Urban development below debris control structure

ting underway. It shows great promise of correcting many floodplain encroachment problems that do not justify structural remedies. Additional federal staff is needed to keep pace with increasing public desire to participate in the program.

The Department of Water Resources expends approximately $725,000 annually on the following activities: in cooperation with the National Weather Service to provide timely flood warnings and forecasts for river basins greater than 200 square miles in area; to administer the Cobey-Alquist Flood Plain Management Act to regulate floodplains prior to construction starts of authorized projects; by establishing priorities among the requesting local agencies for floodplain information studies by the Corps of Engineers; to assist local communities in qualifying for federal flood insurance; and to provide engineering services to the Reclamation Board on its Designated Floodway Program —a program to prevent encroachments in Central Valley water courses to preserve adequate floodways. The Department expends an additional $4,200,000 annually on other flood control activities including maintenance of Central Valley flood control systems.

The Corps of Engineers has 23 major and minor general investigations underway at a cost of $1,900,000 annually.

The U. S. Department of Agriculture, Soil Conservation Service is currently spending about $450,000 per year on 5 watershed works plans and 3 river basin planning studies in California.

The flood problem in the Delta, discussed in Chapter IV, was studied by the Department of Water Resources and several alternative solutions presented * for public discussion. The opinion shared by most suggests structural protection from a flood-return interval commensurate with agricultural lands should be provided. The cost should be allocated to all levels of government and among the different purposes that stand to gain from such protection.

The Corps of Engineers has been requested by the State Legislature to study the existing levees and render a report by the fall of 1976. The Corps has stated the investigation would require more time because of the many diverse problems involved. No investigative work is underway at present as federal funds have not been made available.

Cognizant of the need for more state participation in flood management, the Department of Water Resources initiated a 3-year study in July 1974 to evaluate flood damage prevention. The study, at a cost of about $500,000, in consultation with local government and flood control agencies will review existing and proposed flood control works, estimate the degree of protection from flooding, identify residual flood problems, and examine and evaluate flood management concepts as they might resolve existing problems.

* "Delta Levees, What is their Future?" Department of Water Resources, September 1973.

Water Quality Control Planning

(This section of the report was prepared by the State Water Resources Control Board)

Introduction

It is the responsibility of the State Water Resources Control Board to regulate the activities and factors which affect or may affect the quality of the waters of the State in order to attain the highest water quality which is reasonable considering all demands being made and to be made on those waters and the total values involved.* Quality and quantity are so interrelated that they must be considered together, a fact recognized by the Legislature which has placed the responsibility for both quantity allocation (water rights administration) and control of quality upon the Board.

The State's Porter-Cologne Water Quality Control Act of 1969 established the present control mechanism. The Act requires the formulation and adoption of water quality control plans by each of the nine Regional Water Quality Control Boards "for all areas within the region".† The plans become effective upon approval by the State Board. The Act also provides that the approved water quality control plans shall become a part of the California Water Plan when "reported to the Legislature".‡

Federal requirements for water pollution control plans did not appear until the issuing of the federal regulation 18CFR 601.32–33 on July 2, 1970, which specified that no grant for waste treatment works can be made unless the project is included in an effective, current basinwide plan for pollution abatement consistent with approved water quality standards.

The Porter-Cologne Act requires that "each Regional Board shall establish such water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance; . . ." § Further, the plan shall contain a program of implementation for achieving water quality objectives which includes a description of the nature of actions to be taken, a time schedule and a description of surveillance to be undertaken to determine compliance with objectives. The federal regulation in effect at the start of the comprehensive planning program required the plan to take into account sources of pollution, volume of discharge, character of effluent, present treatment, the effect of the discharge on the water quality in the basin and establish a detailed program of abatement. These regulations emphasized facilities for the abatement of municipal and industrial pollution problems.

* S 13000, California Water Code.
† S 13240, California Water Code.
‡ S 13141, California Water Code.
§ S 13241, California Water Code.

The Federal Water Pollution Control Act Amendments of 1972, which were enacted after the comprehensive planning program was well underway, imposed a number of additional requirements. Under the 1972 Amendments the plan must include at least effluent limitations and schedules of compliance with established degrees of treatment, compatability with all elements of applicable areawide wastewater management plans, a statement of total maximum daily pollutant loads, procedures for revision, authority for intergovernmental cooperation, an adequate program for implementation, controls over disposition of wastewater treatment residuals and an inventory and ranking of needs for construction of waste treatment works.

The comprehensive plans will be an extension of the Interim Water Quality Control Plans adopted and approved by the Regional Boards and the State Board in June 1971. The Interim Plans will serve as a guide for water quality management until the comprehensive plans are completed, adopted and approved.

The comprehensive plans for each of the sixteen basins comprising the State have been under preparation since May 1972, and will be completed by December 1974. The plans will be published as reports. Adoption and approval are anticipated to be accomplished within a few months after completion. The plans will be assessed and revised as necessary to reflect current conditions and technology.

Purposes of the Plans

The purposes of the comprehensive Water Quality Control Plans are to: (1) establish beneficial uses to be protected and the water quality objectives which will ensure the reasonable protection of established beneficial uses; (2) describe the optimum conceptual basinwide strategy to achieve the water quality objectives and management goals; (3) delineate and evaluate the viable alternatives for treatment and control of point and nonpoint sources to meet established water quality objectives; (4) select from the alternatives by a process which considers costs, flexibility to adapt to future changes in conditions, resources commitment, environmental impacts and socio-economic aspects to obtain a recommended control plan; and (5) provide information which allows the State to establish priorities for construction grants and issuance of waste discharge permits.

The goals of the State in water quality management are implied in Section 13000 of the Water Code (Porter-Cologne Act) by the words ". . . The quality of all waters of the State shall be protected for use and enjoyment by the people of the State." The goals of the Federal Act are more specifically stated in Section 101 of PL 92-500 as follows:

(1) The objective of the Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters.

(2) It is the national goal to eliminate discharge of pollutants to navigable waters by 1985.

(3) It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish and wildlife, and provides for recreation in and on the water be achieved by July 1, 1983.

(4) It is a national policy that the discharge of toxic pollutants in toxic amounts be prohibited.

(5) It is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works.

(6) It is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of the sources of pollutants, and

(7) It is the national policy to develop technology necessary to eliminate the discharge of pollutants to navigable waters, waters of the contiguous zone and the oceans.

The above Federal goals were extended and provided a time element in Section 301, PL 92-500, wherein the effluent limitations establish minimum, or mandatory, degrees of treatment to be afforded by publicly owned and other than publicly owned treatment works. The effluent limitations are set forth in Table 22. Definitions of "secondary treatment", "best practicable control technology currently available", "best practicable waste treatment technology", and "best available technology economically achievable" by the U. S. Environmental Protection Agency establish limiting values for certain pollutant parameters.

Table 22. Mandatory Waste Treatment Requirements
Public Law 92-500

	Publicly Owned Plants	Plants Not Publicly Owned
By July 1, 1977	Secondary Treatment	Best Practicable Waste Treatment Technology
By July 1, 1983	Best Practicable Control Technology Currently Available	Best Available Technology Economically Achievable

The plans have been developed to comply with the planning requirements of the Porter-Cologne Act and Sections 106, 201, 208, and 303 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500).

Plan Preparation

The basin planning program is managed by the Division of Planning and Research of the State Board in conjunction with the staff of the Regional Boards. In order to fully utilize planning data contained in the files of various state and regional agencies, the State Board contracted with these agencies to prepare reports of planning information related to their areas of interest.

The Department of Water Resources prepared reports on land and water use, economic, employment and land use projections, population distribution, water quality modeling, present and historical water quality and, in addition, prepared maps of hydrologic subunits.

The Department of Fish and Game prepared reports on water quality and quantity data, present and future water use and waste loads for DF&G installations, present and future demands for fish and wildlife, water quality and quantity problems related to fish and wildlife, and development of water quality objectives for waters having beneficial uses related to fish and wildlife. DF&G also provided input for preparation of environmental impact assessments for the basin plans.

The Department of Health provided information on beneficial uses of water and water supply quality problems, present and projected domestic water use, and identification and evaluation of existing wastewater reclamation projects.

The Department of Parks and Recreation reported upon existing and potential public and private recreational areas, estimates of present and projected park attendance, present and future water and wastewater requirements for parks and recreational areas, and present and future recreational area waste management practices.

The Department of Conservation provided an inventory of mines and mine pollution, data related to soil and vegetation conditions and their affect on the production of sediment, information on current and projected operations of the timber industry, forest management practices, problems of and procedures for control of water pollution related to oil, gas, and geothermal operations, and opportunities for utilizing wastewaters in the oil and gas industry.

These state agencies were retained under contract to provide assistance to the planners during plan preparation on an as-needed basis.

The State Board also entered into contracts with local and regional planning agencies to provide planning data and assistance. These agencies include the Association of Bay Area Governments, Sacramento Regional Area Planning Commission, Southern California Association of Governments, Comprehensive Planning Organization (San Diego), Association of Monterey Bay Area Governments, San Luis Rey-Santa Margarita Joint Committee, Ventura Regional County Sanitation District and Lompoc Valley Region.

Development of the basin plans was performed under contracts between the State Board and public agencies and private consulting organizations. These organizations and the respective basins are identified in Table 23.

The Board contracted with the consulting joint venture of CDM/Banks Consultants to serve as the Office of Technical Coordination (OTC) which furnished administrative and technical advice and assistance to the Board in matters relating to the preparation of the basin plans.

Table 23. Basin Planning Organizations

Contractor	Basin
Department of Water Resources	1A, 6B, 7A, 7B
Brown & Caldwell, Water Resources Engineers, Inc., Yoder-Trotter-Orlob & Associates	1B, 2, 3
Daniel, Mann, Johnson & Mendenhall/Koebig & Koebig, Inc.	4A, 4B, 5D
Bay-Valley Consultants (Bechtel Corp., Consoer-Townsend & Associates, CH_2M-Hill, Hydroscience)	5A, 5B, 5C
Kaiser Engineers	6A
Santa Ana Watershed Planning Agency	8
James M. Montgomery, Consulting Engineers, Inc.	9

Planning Criteria and Constraints

The basin plans were prepared within a framework of criteria, policies, base conditions and environmental constraints. The first objective was to meet the requirements of the laws, regulations and policies which provide basic legal control. Further the intent was to develop a set of basin plans which address the water quality management problems of each of the basins individually while considering the inter-basin and statewide problems so that the basin plans, considered together, will provide a consistent and continuous overall statewide plan. Interface problems among the basins are formidable in California where major inter-basin transfers of water occur.

Although planning was already well under way, changes, some of which were rather drastic, were made to comply with PL 92-500 which became effective on October 18, 1972. The problem was further complicated by the considerable array of specific new regulations that began to emerge from the U. S. Environmental Protection Agency shortly after passage of the Act and are still being promulgated as this planning effort nears completion. Every attempt has been made to comply with these regulations.

The several policies and plans of the State Water Resources Control Board which affect basin planning are described briefly below. These policies and plans provide the added details needed to carry out the intent and general provisions of the laws. One objective of the comprehensive study was to look at the impact of these plans and policies on the water resources, and upon the people, to determine if changes are advisable.

Four State Board policies and plans provided policy guidance in this comprehensive planning program. They are the (1) State Policy for Water Quality Control (State Policy); (2) Statement of Policy with Respect to Maintaining High Quality of Waters in California (Nondegradation Policy); (3) Water Quality

Control Plan for Ocean Waters of California (Ocean Plan); and (4) Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California (Thermal Plan). The State Policy stresses that control decisions must assure protection of water resources for maximum beneficial use; that municipal, agricultural and industrial wastewaters must be considered an integral part of the total fresh water resource; that wastewater management is dependent upon a balanced program of source control, treatment of wastewaters, reuse of reclaimed water, and proper disposal of effluents and residuals; and that wastewater reclamation and reuse shall be encouraged.

The Nondegradation Policy essentially provides that wherever existing quality of water is better than need be to adequately support existing or potential beneficial uses or to comply with established policy, the existing high quality will be maintained. Exception is allowed only if any change will be consistent with the maximum benefit to the people, will not unreasonably affect beneficial uses and will not result in quality lower than that prescribed by other policies.

The Ocean Plan sets forth limits or levels of water quality for ocean waters to ensure protection of beneficial uses and prevention of nuisance, and states that the discharge of wastes shall not cause violation of these quality objectives. The plan describes acceptable bacteriological, physical, chemical, biological, toxicity and radioactive limits in both numerical and descriptive terms. The plan prohibits the discharge of hazardous substances and sludge, bypassing of untreated wastes, and requires that waste discharges not alter natural water quality in areas designated as having special biological significance.

The Thermal Plan imposes limits on the temperature of waste materials discharged to waters of the state classified as cold interstate waters, warm interstate waters, coastal waters, enclosed bays, and estuaries. In general, existing elevated temperature discharges are required to be at such a temperature as to assure protection of beneficial uses and areas of special biological significance. New elevated temperature discharges are assigned specific limits on the temperature of the discharge as well as the resulting temperature of the mixed receiving and wastewaters.

The basin plans have been prepared to encompass a planning period from the present through the year 2000. Projections of population, employment, water use, land use, industrial output, and agricultural production were used to estimate the situations that are most likely to occur in the planning period. The plans were prepared according to base line projections and because projections are only informed guesses, sensitivity of the plans to projections other than base line were assessed.

Population projections prepared by the California Departments of Finance and Water Resources were used: the Base Plan or D-150, and Alternate E-O. The letter designates the fertility rate, or births per female of 2.45 for Series D, and 2.11 for Series E. The number designates the annual net in-migration to the State in thousands. Common to all three projections was the "benchmark" population data provided by the Nineteenth Decennial Census of Population of the United States, April 1, 1970.

The D-150 projection was used as base line except that for areas designated as "air-critical" because of air pollution problem, the E-O projection must be base line. State grant fund regulations place limitations upon grant eligibility for excess or future capacity to be built into collection and treatment facilities by limiting eligible project costs. Capacity in excess of present needs to handle projected municipal and commercial growth for 10 years is grant eligible for treatment plants, and for 20 years for sewers, interceptors and outfalls. Capacity in excess of this must be funded locally. No capacity for industrial growth is grant eligible. In the planning program, latitude was allowed in selection of alternative projections for sensitivity studies to account for local opinions.

Certain other basic considerations in planning were established as "base conditions" to assure that the various basin plans were basically consistent and uniform statewide. Planning was carried out according to these stipulated "base conditions" but the effects on the basic plan of possible changes in these base conditions were investigated. The established base conditions for the planning program are listed in Table 24.

Planning program guidelines were developed by the State Board staff and Office of Technical Coordination to establish consistent planning conditions for use by the various basin contractors. Twenty-six such planning management memoranda were issued encompassing a wide range of subjects. In addition, standardized information on design parameters, facility performance, construction costs, interest and escalation rates, and energy requirements for facilities, was developed and distributed for use in the program. Uniformity and consistency in planning for all basins was achieved by the use of these management memoranda and standardized information items.

Planning Strategy

A planning strategy was developed for the preparation of the basin water quality control plans. The strategy meets the requirements of the Porter-Cologne Act in that it begins with the establishment of beneficial uses, establishes water quality objectives to protect those beneficial uses, evaluates alternative means to meet these objectives, selects a recommended plan, and provides a plan and program for implementation all within a framework of the water quality control policies of the State Board. The strategy also provides for the classification of segments into water quality or effluent limitation classes, the allocation of assimilative capacity, consideration of nonpoint sources and development of water quality management plans as required by the Federal Water Pollution Control Act Amendments of 1972.

Figure 26 is a graphic representation of this planning strategy. The strategy applies to both surface and groundwaters even though the federal requirements, strictly interpreted, applies only to navigable waters. For purposes of these plans, the State Board considers that navigable waters are defined as all surface waters of the State.

The planning strategy is carried out for each water body, surface or groundwater, classified as a segment. A segment is a water body having common hydrologic characteristics (or flow regulation patterns) and common natural physical, chemical and biological processes, including reactions to external stresses. Two classes of segments are defined. An effluent limitation class segment is one in which water quality objectives will be met with the implementation of mandatory treatment processes called for in PL 92-500 (Table 22) for point waste sources. A water quality class segment, conversely, is one in which established water quality objectives will not be met upon implementation of mandatory treatment processes for point waste sources. The designation of a segment as water quality class means that higher degrees of treatment will be required for point waste sources and/or control measures must be imposed to decrease nonpoint waste loadings.

Table 24. Base Conditions for Planning

Project	Base Condition Status
1. Western Delta Overland Water Supply System	Joint construction and operation by SWP and CVP. Operative by 1985.
2. Kellogg Unit, Federal CVP	Not constructed within planning period.
3. Folsom-South Canal	Facility to be completed to its originally planned southern terminous by 1985.
4. Hood-Clay Connection	Facility to be constructed and operative when demands exceed Folsom-South Canal supply available at Nimbus under SWRCB Decision D-1400.
5. Eastside Division, Federal CVP	Facility will not be built within planning period. DWR-Kern Co. Cross Valley Canal to be considered an alternative.
6. Export from North Coast Streams	No additional diversions from North Coast Streams within planning period.
7. San Felipe Division, Federal CVP	Evaluate as one alternative for meeting future water demands in service area.
8. East Bay MUD American River Project	Evaluate as one alternative for meeting future demands. Value of quality to be considered.
9. Extension of Coastal Aqueduct to San Luis Obispo and Santa Barbara	Coastal Aqueduct will be completed at such time water demands indicate need.
10. New Melones Project	Construction as planned will take place.
11. Baldwin Ship Channel	Evaluate quantity and quality effects of proposed facility on the Delta.
12. Colorado River Quality	Present TDS at Imperial Dam is 850 mg/l with uniform degradation to 1,250 mg/l by year 2000. California diversions limited to 4.4×10^6 afa except in surplus years.
13. Peripheral Canal	Two cases to be considered: (a) Joint federal and state construction and operation. (b) State construction and operation with federal continuation of cross-Delta flow.
14. SWP Diversions	Will meet SWP Schedule A contract commitments.

Abbreviations:
SWP — State Water Project
CVP — Central Valley Project
SWRCB — State Water Resources Control Board
DWR — Department of Water Resources
MUD — Municipal Utility District
TDS — Total disolved solids
mg/l — Milligrams per liter
afa — Acre feet per annum

The planning strategy may be divided into four distinct steps each of which must be completed before starting the next. The first step in the planning process, selection of beneficial uses for a segment, is made by the Regional Board with input from the other public agencies, the public and the basin contractor.

In the second step, the most strict of the three water quality constraints; i.e., state policy, nondegradation policy, or quality to protect the beneficial use, is then selected as the basis for the water quality objectives for that segment. Water quality objectives are determined early in the planning process and remain fixed throughout the process except for two situations in which a change may be considered. The first is a change to a better water quality through enhancement which will be described later. The second is a change to lower water quality objectives to be considered only as a last resort, and only in a situation where uncontrollable waste loads make it impossible to meet the recommended water quality objectives. The latter situation is not shown on Figure 26.

The third step, the classification of surface water segments into either the effluent limitation class or the water quality class, involves the determination of the magnitude and location of waste loads in the segment that will be discharged into the segment waters. Nonpoint waste loads heretofore uncontrolled and uncontrollable loads are included as well as all point source waste loads. All loads are projected to future conditions expected to occur at the point in time for which the plan is being developed.

For point source waste loads, the estimated untreated loads are first determined and then reduced by the amount of treatment afforded by mandatory treatment levels. For nonpoint loads, consideration is given to sources, magnitudes and reasonable means of control. The estimated future nonpoint loads are reduced by whatever degree of control is to be applied under the selected management strategy. The remaining loads are combined with the point source loads which remain after mandatory treatment. To obtain the residual segment loading, a judgment factor is added

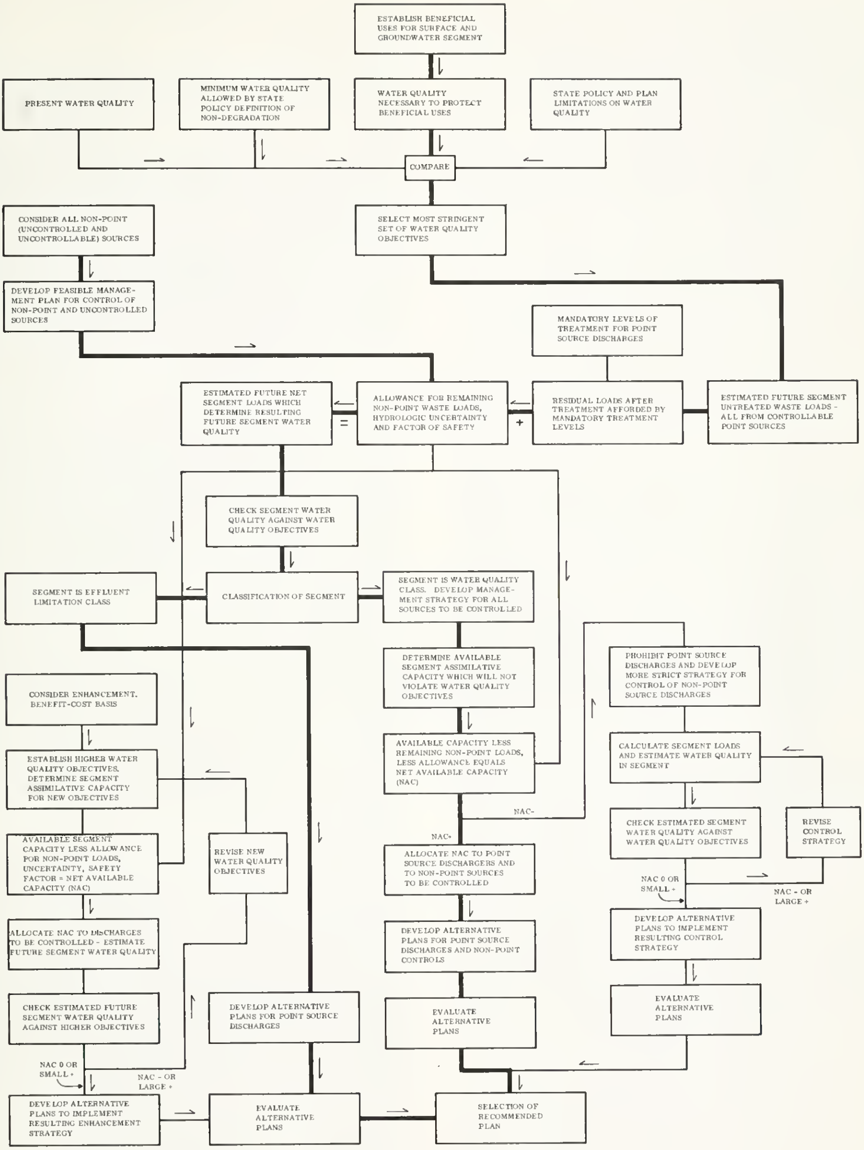


Figure 26. Statewide Planning Strategy for Water Quality Management

to account for hydrologic uncertainty and a factor of safety. This residual segment loading is applied under selected critical flow conditions and the estimated future water quality in the segment determined. Some of the available assimilative capacity within the established water quality objectives may be reserved for possible new loadings in the future. Estimated future quality is checked against the established water quality objectives. If the estimated segment water quality is better than or equal to the objectives, the segment is an effluent limitation class and, if not, the segment is a water quality class.

The fourth step is to develop, in detail and with full consideration and evaluation of all reasonable alternarives, the recommended management plan, including facilities. For effluent limitation class segments, this involves the development of alternative plans using the mandatory treatment levels for point source pollutant control and any nonpoint source control measures considered in the computations which led to the classification.

For water quality class segments, the net available assimilative capacity of the segment within the established water quality objectives under selected critical flow conditions is allocated among the point and nonpoint waste load sources. Due allowance is made for natural background loading, loadings from upstream, hydrologic uncertainty, any reserve to be made for the possibility of new loadings in the future and a factor of safety. Progressively higher degrees of treatment are applied to the point sources and more stringent control measures to the nonpoint sources until a balance is obtained between projected residual waste loadings on the segment and the estimated assimilative capacity available for rhose loadings. It may be found necessary to prohibit some or all point source waste discharges to the segment, particularly in cases where the residual uncontrollable nonpoint waste discharges are large, in order to meet the water quality objectives.

There may be water quality class segments for which it is clearly unreasonable or even impossible to meet the water quality objectives established in the second step of the planning process because of excessive costs or inability to control nonpoint waste sources sufficiently. In such cases, it may be necessary to revise the water quality objectives downward. However, the justification for accepting lower water quality must be clearly demonstrated.

In developing alternative plans, consideration is given to the possibilities of regionalization and integration of facilities for municipal and industrial wastes. These alternative plans are evaluated, along with any alternatives developed through consideration of enhancement. Selection of the recommended plan from among the alternatives is made considering cost-effectiveness, environmental impacts and functional effectiveness, reliability, flexibility, program acceptability and amenability to implementation. The institutional and financial arrangements necessary for implementation of the recommended plan are set forth and made a part of the plan.

Enhancement is defined as an improvement of the water quality of a segment over the water quality objectives as determined in the second planning step. Enhancement is a viable alternative in situations where there is a demonstrable economic or environmental advantage to be gained by having higher quality water or where higher water quality can be achieved at low incremental cost.

If enhancement appears to be possible, trial higher quality objectives are established, the net assimilation capacity (see Figure 26) of the segment is determined, allocations are made and the resulting segment quality is estimated. This may take several trials to arrive at an acceptable and cost-effective set of objectives.

Plan Reports

Each of the basin plans will be published in a report, entitled Comprehensive Water Quality Control Plan. The report is prepared in two parts. Part I, Water Quality Control Plan, contains a statement of the plan and its environmental assessment and includes those portions to be adopted and approved by the Boards. Part II, Supporting Information, contains information which supports the development of the plan.

Each plan contains an assessment of the expected effects the plan will have on the environment including the socio-economic effects it will have on people. In addition, each plan includes a surveillance and monitoring program designed to gather and store information relating to background quality, discharger compliance and control plan effectiveness.

The Water Quality Control Plans will be reviewed from time to time and revised as deemed necessary.

Public Participation

Participation by the public, organizations and individuals, has been encouraged throughout the planning process. The Porter-Cologne Act requires that "the Regional Boards shall not adopt any water quality control plan unless a public hearing is first held, . . . ".* In this planning program, more public participation was sought, not only to obtain input of information from the public, but to prepare the way for smoother adoption proceedings. Early in the program, guidelines for public participation were established which called for at least four public meetings scheduled at specific points in the planning process. The purpose of each meeting is described as follows:

Meeting 1. Introduction of the scope and purpose of the basin planning program; presentation of the planning schedule; introduction of the planning personnel; description in general terms of the basic elements of the plan; details on population and land use

* Section 13244, California Water Code.

projections discussed; the public urged to express its views.

Meeting 2. Display of beneficial uses and water quality objectives for public scrutiny and comment; beneficial uses and water quality objectives not adopted at this meeting but public concurrence with the thrust of the plan sought.

Meeting 3. Presentation of the alternative plans with a discussion of the legal, policy and institutional aspects; public expression sought as to acceptance and indication of preferred plan among the alternatives.

Meeting 4. In the form of a Regional Board hearing; the final recommended plan presented with justification for its selection; the public provided the opportunity and encouraged to comment upon the recommended plan.

Federal guidelines for public participation, developed as required by PL 92-500, are much the same as the state guidelines set forth above.

During the planning period, meetings were held as required by the guidelines, and in several basins additional meetings were held. The participation by the public is documented in the ancillary portions of the plan report. Public participation, for the most part, has been beneficial and gratifying.

Basin Problems

Following is a brief description of each of the sixteen basins and a general discussion of the major water quality and quantity problems in each basin. At the time of this writing, none of the water quality control plans have been adopted or approved by the Regional and State Boards. Accordingly, it would be premature and perhaps misleading to describe the action portion of these plans at this time. The plans are expected to be adopted and approved by the Regional and State Boards by December 1974. Individual plans should be consulted after adoption to obtain details on the recommended plan.

The water quality class segments are particularly significant in view of the focus of attention that must be directed to them to conform to PL 92–500. Each water quality class segment is identified, and the nature and seriousness of the problem, as well as planned alleviation measures, is discussed. Thirty-one such segments have been designated in the State.

Basin 1A, Klamath River Basin. The Klamath River, a relatively large Northern California river, rises in the Oregon plateau swamps and flows through the Northern California lava plateau region and mountainous area of Northwestern California to the sea. The Trinity River is the major tributary. Most of the 12.5 million acre-feet per year runoff from the basin originates in the mountain region. In Oregon, considerable use is made of the rather limited flow for irrigation causing some degradation in the quality of the water reaching California. Water supplies in the California lava plateau region are derived largely from groundwater in relatively small amount (104,000 acre-feet per year at present) for agriculture, municipal and industrial supplies. Regulation of the river and its tributaries in California is relatively minor with much of the runoff flowing unregulated to the sea during the winter months: the only significant regulation is that provided by Clair Engle Lake on the Trinity River from which about 900,000 acre-feet of water per year are exported to the Sacramento Valley. A much smaller river, the Smith, drains a 719 square mile area in the northwestern corner of the State. All rivers and streams in the basin support important fish resources.

Water quality problems are not serious at the present time. Avian botulism is a problem in the Pacific Flyway haven of Tule Lake due to organic loading, shallow water and poor circulation. Algae growths occur in the impoundments in the lower flow regions above the mouth of the Trinity River. Population centers are few and small and have relied heavily upon individual waste disposal systems which are generally not satisfactory. A major problem is the sediment developed by erosion in the forest areas, due in part to lumbering and construction. Tremendous quantities of silt are transported to the sea during high runoff periods. Another problem, sedimentation in the Trinity River channel downstream of Lewiston Dam is due to the decreased flows resulting from regulation and diversion to the Sacramento Valley and natural high erosion rates present within the watershed. There are no water quality class segments in Basin 1A.

Basin 1B, North Coastal Basin. The North Coastal Basin includes those drainages which originate on the western slopes of the Coastal Range and flow to the sea. The basin extends from the Klamath River drainage basin on the north to the Marin-Sonoma area on the south. The basin area is rugged and mountainous, and sparsely populated except for the two centers of population in the Eureka-Humboldt Bay and Santa Rosa areas. Agriculture in the basin area is limited to a few narrow valleys and is relatively unimportant. Lumbering and paper industries and tourism are the economic bases in the Humboldt Bay area. Santa Rosa is a business city on the northern fringe of the urban San Francisco Bay area.

Precipitation in the basin area is relatively heavy and seasonal, giving rise to considerable variation of flows in the rivers. Regulation of the flows is not extensive. Except for erosion, siltation and dairy and cattle confinement areas, the problems of water quality are due to municipal and industrial wastes discharges threatening shellfish utilization in Humboldt Bay. Water quality problems in other areas are related to poor land use practices including improper logging, road building and farming.

Basin 2, San Francisco Bay Basin. The San Francisco Bay Basin includes the drainage area tributary to San Francisco Bay and west of the Sacramento-San Joaquin Delta as well as the watersheds of minor streams draining into the sea between the Marin-Sonoma County line and Pescadero Point. The basin is primarily urban although intensive agriculture is practiced in the Napa, Petaluma, Sonoma and lower Santa Clara Valleys and eastern Contra Costa County. Heavy industry is concentrated along the Bay from Richmond to the Pittsbury-Antioch area.

The primary hydrologic feature of the basin is the San Francisco Bay system. The inflow of large quantities of fresh water from the Sacramento and San Joaquin Rivers into the northern portion of the Bay system form one of the world's major estuaries. In addition, there is considerable tidal exchange through the Golden Gate. The latter provides the primary means by which conservative pollutants are moved out of the Bay.

The inflow of inadequately controlled and treated waste materials has been the cause of the principal water quality problems in the basin that exist at present. These problems tend to be most severe in the shallow extremities of the Bay system where dispersion and dilution characteristics are not sufficient to maintain water quality objectives with current waste loadings. Such areas include the South Bay, the Napa, Petaluma and Sonoma Rivers, and many of the shallow dead end sloughs around the Bay; all of these experience low dissolved oxygen and high nutrient levels.

Six of the State's 31 water quality class segments are located in Basin 2, namely: (1) South San Francisco Bay south of Dumbarton Bridge, where dissolved oxygen objectives are violated for substantial periods due to incompletely treated municipal wastewaters and urban runoff; (2) Richardson Bay, where bacteriological objectives are not met during wet-weather overflow periods; (3) Livermore Valley, Alameda Creek, Arroyo Las Positas and Arroyo de le Laguna, where total dissolved solids in treated wastewaters exceed objectives for downstream groundwater recharge and reuse; (4) Napa River, Calistoga to San Pablo Bay, where low dissolved oxygen and high nutrient concentrations are often experienced; (5) Petaluma River, Penngrove to San Pablo Bay, where dissolved oxygen and nutrient problems occur; and (6) Tomales Bay, where coliform concentrations exceed water quality objectives for shellfish.

Other major water quality problems in the basin are high bacterial levels resulting from wet weather sewer bypassing and combined sewer overflows and saline water intrusion due to overdrafting in the Niles Cone and northern Santa Clara County groundwater basins.

Potential water quality problems are associated with either increasing waste loads to those portions of the basins which cannot assimilate, dilute, disperse or otherwise neutralize pollutants to acceptable levels, or with the diversion of Delta waters from the Delta and its tributaries which may significantly modify the present hydraulic regime and physical-chemical characteristics of the estuarine portion of San Francisco Bay system.

Basin 3, Central Coastal Basin. This basin extends along the coast from Pescadero Point to the Ventura County line south of Santa Barbara and inland to the ridge of the Coast Range. It contains a wide variety of land forms including Monterey Bay, the Big Sur Coast, fertile Salinas Valley, the enclosed desert Carrizo Plain and alternate mountains, valleys and coastal plains in the southern portion. In general, rainfall is limited and seasonal. Streams, with the exception of those in the Salinas Valley, flow rather directly to the Pacific Ocean. Future imports of water are planned for the areas east of Monterey Bay and along the south coast from San Luis Obispo to Santa Barbara.

Water quality problems in Basin 3 are varied. Short outfalls into shallow and poorly circulating ocean waters are causing problems along the north and south shores of Monterey Bay and at Santa Barbara. Agricultural drainage, nutrients and pesticides are problem sources in the Salinas River; septic tank system problems exist in the San Lorenzo subbasin and at smaller communities along the coast such as Cambria; and salt balance and groundwater quality problems exist in the Lower Salinas Valley, Hollister-Tres Pinos, Soda Lake and Carmel River areas due to extractions and return flows. Groundwater quality is not suitable in portions of the Santa Maria and Santa Ynez subbasins due in part to naturally occurring hard and high TDS waters and in part due to municipal wastewater disposal on land areas as well as irrigation return flows. TDS and nitrate concentrations are high in the latter case. There is one water quality class segment in the basin; the lower portion of the Salinas River from the Spreckles gage to Monterey Bay. TDS, dissolved oxygen, turbidity and nutrient water quality objectives are violated.

Basin 4A, Santa Clara River Basin. The Santa Clara River Basin includes the drainage from the Ventura and Santa Clara Rivers, and their tributaries, and the Calleguas-Conejo system of creeks and arroyos. It also includes the off-shore islands of Anacapa and San Nicolas. Much of the basin is rugged, mountainous and undeveloped. The valleys and coastal plain around Oxnard are important agricultural areas and are beginning to urbanize due to overflow from nearby Los Angeles. The basin contains about 40 miles of ocean shore line from Rincon Point on the north to the Ventura-Los Angeles county line on the south. A major portion of the basin area is contained in the Los Padres and Angeles National Forests.

The major water problems in the Santa Clara River Basin are mineralization of groundwaters and dry weather flows and the overdraft in the Oxnard Plain. Mineralization is a result of localized recycling (mostly from irrigation practices), highly mineralized inflows and addition of salts as fertilizers. Boron deposits in the basin cause boron concentrations which often exceed limits for irrigation. During wet weather flows, erosion and siltation are problems in the streams. Biologic overproduction is a problem in Lake Casitas. Also, algae blooms in Castaic Lake have forced suspension of its operation for short periods in 1973 as a part of the State Water Project but presently such algae blooms are controlled through chemical applications. The Oxnard Plain overdraft, estimated at 40,000 acre-feet per year, has lowered the groundwater level as much as 55 feet below sea level allowing sea water to intrude. Groundwater degradation due to wastewater discharges is relatively minor and is confined locally. Agricultural return flows from tile drainage and the disposal of water softener regeneration brines from individual home systems are also problems in the basin. Water quality problems in ocean waters are minor.

Basin 4B, Los Angeles River Basin. This basin comprises that portion of Los Angeles County which lies south of the ridge line of the San Gabriel Mountains and the western Santa Monica Mountains, and includes a small portion of the south corner of Ventura County. The planning area includes the offshore islands of San Clemente, Santa Barbara and Santa Catalina. Excluding the islands, the basin is about 33 percent urban land, 40 percent unusable land and 27 percent agricultural or vacant land. The unusable land is mountainous, too steep to build upon or lies in the flood plain of a stream. However, development is extensive in the coastal plain, San Fernando Valley, San Gabriel Valley and adjoining foothills. Considerable industrial development is centered around the harbor area and the Burbank-Glendale area.

This basin has relied upon imports of water for more than 60 years from the Owens River, since 1941 from the Colorado River and for the past few years from the State Water Project. Although imports meet much of the demands for water, the local supplies from the ground and runoff from surface streams are important to the basin and must be protected. In general, facilities for water supply and wastewater collection, treatment and disposal have been adequate or have been provided as needed to take care of growth areas. Two enormous wastewater systems, the City of Los Angeles system and the Los Angeles County system provide sewerage services for most of the basin. These systems include treatment plants offering less than secondary treatment and disposal through long, deep-water diffusers to the ocean. Sludge, some of which is digested, is also disposed of now through long outfalls into ocean waters. A portion of the wastewaters in both systems is removed from the sewer at inland wastewater treatment plants for secondary treatment and disposal by groundwater recharge, with the sludge being returned to the sewer. This relieves the hydraulic loading on the downstream sewers and provides water for replenishment of groundwaters. Well injection is practiced along the coast to halt sea water intrusion into overdrafted coastal plain groundwater basins. Maintenance of low groundwater levels in the Los Angeles Coastal basin is intentional to increase the flow of water recharged in the Montebellow Forebay for increased system yield.

A major problem in the basin is pollution in Dominguez Channel and Los Angeles-Long Beach harbor. The completion of the Terminal Island Treatment Plant in 1975 to provide secondary treatment for large volumes of municipal and industrial wastewaters heretofore receiving only primary treatment or less, is expected to halt the degradation of harbor waters effectively. Accumulations of organic matter from decades of discharge of municipal and industrial wastes add to the water quality problems in the harbor.

There are other relatively minor water quality problems in the basin. These are: (1) a "wave" of poor quality groundwater traveling northeasterly across the San Fernando Valley due to well-pumping patterns in the valley; (2) high concentrations of nitrates in the groundwater in the La Crescenta area due to septic tank-leach field systems; and (3) an unacceptable surface pollution from septic tank-leach field systems in the Malibu Beach area.

Basin 5A, Sacramento River Basin. The Sacramento River Basin extends from the Oregon border and Goose Lake on the north and includes the American River and Cache Creek drainages on the south. The east and west boundaries are the ridge lines of the Sierra Nevada Mountains and the Coastal Range and Klamath River drainage, respectively. The basin is one of water surplus, derived from rain and snowfall occurring mainly during the months between October and May. The principal river of the basin is the Sacramento. The rivers and creeks of the basin are highly regulated for flood control, hydroelectric power and water supply. About 900,000 acre-feet per year are diverted from the Trinity River in Basin 1A to the Sacramento River Basin. Extensive groundwater resources exist in the alluvial valley floors. The Goose Lake area is a closed basin.

Generally, the quality of the waters in the basin is excellent. There are water quality problems, however, caused mainly by local concentrations of used water. The greatest single cause of degradation of the surface waters in the basin is the return of waters used for irrigated agriculture.

There are three water quality class segments identified in the basin. Of these segments, two are caused by drainage through the tailings from abandoned mines.

The first is Spring Creek, a tributary to the Sacramento River within the Keswick Reservoir upstream of Redding, which is polluted by acid waters and heavy metals primarily from copper mine drainage. The second is Little Grizzly Creek, a tributary to Indian Creek at Genessee which is in turn tributary to the North Fork, Feather River, which is polluted by acid drainage from Walker Mine. The third water quality segment is Clear Lake which is shallow and contains bottom deposits rich in nutrients. The problem is excessive algae growths that cause nuisance conditions.

Basin 5B, Sacramento-San Joaquin Delta. The Delta basin is the hub of the Central Valley drainage system. Rivers entering the Delta are the Sacramento from the north, the Cosumnes, Mokelumne and Calaveras from the east and the San Joaquin from the south. An intricate set of channels conveys the water westward across the Delta for discharge into San Francisco Bay. Interbasin exports by the Federal Central Valley Project and the State Water Project originate in this basin by diversion of surplus unregulated inflows and by rediversion of portions of the regulated releases from upstream project reservoirs, as does the Mokelumne River export by East Bay Municipal Utility District to its San Francisco Bay service area. The quality of the waters entering the Delta is generally good except for that entering from the San Joaquin River during low flow periods which contains concentrations of dissolved salts and nutrients derived from agricultural return flows. Diverson from the Mokelumne River also results in poor quality in its lower reaches during dry weather periods. Flow into the Delta is highly regulated by upstream facilities on the principal tributaries, thus affecting salt water intrusion from San Francisco Bay.

The major water quality problems in the Delta are twofold, namely: (a) maintenance of proper quality conditions within the Delta for municipal, industrial and agricultural supplies, for the very important fish and wildlife resources, and for recreation, and (b) maintenance of proper quality conditions for export at the Tracy Pumping Plant of the Federal Central Valley Project and the Delta Pumping Plant of the State Water Project in the southern part of the Delta. Water must be conveyed across or around the Delta to the export pumps. A certain minimum rate of fresh water outflow from the Delta is needed to prevent salt water intrusion from the Bay system to preserve quality for Western Delta uses and the environment for fish and wildlife. Delta outflow is also beneficial in flushing pollutants from the Bay system. Nutrients in the Delta water, originating mainly from agricultural return flows, pose a potential algae problem in the Western Delta and Suisun Bay.

Six water quality class segments have been identified in Basin 5B. These are: (1) the San Joaquin River from the Merced County Line to Antioch where total dissolved solids and nutrient concentrations exceed objectives, and under certain local physical and chemical conditions, low dissolved oxygen levels occur; (2) Lower Sacramento River from the American River to Emmaton where nitrogn concentrations due to agricultural, municipal and industrial wastewaters are greater than established objectives; (3) the Mokelumne River from Penn Mine to Highway 99 where mine drainage causes pH and heavy metals pollution; (4) Fourteen-Mile Slough, from the City of Stockton Northwest Treatment Plant to the San Joaquin River, where low dissolved oxygen levels are experienced due to incomplete municipal wastewater treatment and sluggish flow; (5) Jackson Creek from the Jackson municipal plant outfall to Lake Amador where little dilution is afforded the inadequately treated municipal wastewater resulting in dissolved oxygen problems; and (6) Old River, from the Tracy plant outfall to the Clifton Court Forebay, where nitrogen and coliform concentrations exceed Delta objectives.

Basin 5C, San Joaquin River Basin. This third Central Valley basin lies south of the Delta Basin and encompasses the drainage of the San Joaquin River. Major rivers rising in the Sierra Nevada and tributary to the San Joaquin in the valley floor are the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno Rivers. The San Joaquin River also rises in the Sierra Nevada and flows to the valley before turning north down the valley floor. The Friant-Kern Canal system of the Federal Central Valley Project exports water from Millerton Lake, impounded by Friant Dam, south into Basin 5D to supply water along the Canal extending almost to Bakersfield. The Hetch Hetchy system of the City and County of San Francisco exports water from the Tuolumne River to Basin 2. Water is imported from Basin 5B by the Federal Central Valley Project. Natural runoff from the western side of the valley is almost nonexistent. The basin is primarily agricultural with population centers oriented mainly to farm supply and product handling. Recreational and second-home developments are increasing in number and extent in the foothill and lower mountain regions, however.

Water problems in the basin relate mainly to dissolved salts and nutrients from agricultural return flows and effluent seepage which constitute the major portion of the dry weather flow in the San Joaquin River and to the overdrafted condition in the groundwater basins. Low flows resulting from upstream diversions and regulation have virtually eliminated salmon runs in the basin streams and are endangering the marsh lands necessary for maintaining wildlife. Salt balance is adverse because of insufficient drainage facilities to convey salts from irrigated land in the basin. Three water quality class segments are identified in this basin. These are: (1) Woods Creek from Columbia to Don Pedro Reservoir due to inadequate dilution for the insufficiently treated wastewaters from several small foothill communities causing dissolved oxygen and nitrogen problems; (2) Tuolumne River from Hughson outfall to Santa Fe Avenue, Modesto, where nitrogen concentrations exceed objectives due to incomplete treatment of industrial wastes at the Hughson Treatment Plant; and (3) Stanislaus River from Tulloch Reservoir to the San Joaquin River where coliform concentrations from an unidentified source have caused counts exceeding objectives to the extent that Caswell State Park has been closed.

Basin 5D, Tulare Lake Basin. This southernmost of the four Central Valley Basins is essentially a closed basin in that, except in the very wet years, there is no natural drainage from the basin. The basin is in the shape of a "U" rimmed by the Sierra Nevada on the east, Tehachapi Mountains on the south and the Coastal Range on the west. The north boundary is the low drainage divide between the watersheds of the San Joaquin River on the north and the Kings River on the south.

Major surface streams are the Kings, Tule, Kaweah, and Kern Rivers. Water is imported via the California Aqueduct of the State Water Project and the Friant-Kern Canal and San Luis Unit of the Federal Central Valley Project. Service to the Federal San Luis service area in western Fresno and Kings Counties is from the joint federal-state facilities of the San Luis Division of the California Aqueduct. The basin economy is agriculture-oriented but there is a significant oil industry and other manufacturing in the basin. Population centers are Fresno and Bakersfield and several cities of smaller populations.

The major water problem in the basin is a demand for more water than can be supplied by existing sources. This has caused severe groundwater overdrafting and an adverse salt balance in this essentially closed basin. There are also problems of local degradation of groundwaters due to land disposal of municipal and industrial wastes, naturally poor quality in the western and southern areas of the basin, high groundwater levels near the valley trough and western areas caused by use of imported water as well as ground water for irrigation without providing adequate drainage, septic tank-leach system failures in the foothills areas, and oil-field, industrial, dairy and feedlot waste disposal practices. The western area high water table and overdraft situation in the basin is causing poor quality western water to flow eastward and degrade the waters in the aquifers there.

A problem associated with overdraft is deep subsidence. As an aquifer is overdrafted, the decrease in water pressure allows the soil comprising the aquifer to settle and compact resulting in a general settling of overlying soils. Subsidence on the order of 25 feet has been experienced in portions of the basin since 1935. The underground storage space lost because of subsidence is not usually fully recovered upon replenishment with water.

The major concern is that of salt balance. During the water quality control planning study several alternative plans for maintaining a favorable salt balance were considered.

Basin 6A, North Lahontan Basin. The North Lahontan Basin includes that portion of the State bordering Nevada lying east of the Sierra Nevada and Warner Mountain Ranges and extending from the Oregon State Line to and including the Walker River Watershed near Bridgeport. The principal geographic features are the mountains and Lake Tahoe. The northern third of the basin is a narrow inter-mountain valley having no drainage outlet. Runoff, consisting mainly of snowmelt, is limited and seasonal, with the excess evaporating from the alkali lakes which are dry much of the time. Economic activity is agriculture oriented. The middle third of the basin is a semi-arid, high-elevation plateau with scattered mountains, sparse settlement and limited areas supporting agriculture. Logging is a major economic activity although the region is becoming a popular second-home area. The lower third of the basin is a narrow, rugged area with drainage generally eastward into Nevada. The Truckee River system, which includes Lake Tahoe, is the major hydrologic feature. The Carson and Walker Rivers, forming the southern watersheds in the basin, have headwater areas in California and are used for recreation, and fish and wildlife habitat. Tourism and second-home development are intensive in the Tahoe-Truckee area and has resulted in the major population center in the basin.

The major problems in the basin are point and nonpoint sources of wastewater pollution in the Lake Tahoe-Truckee River system. Rigid objectives to protect the Lake and downstream beneficial uses require that all point source wastes be given tertiary treatment or exported. The South Lake Tahoe system, involving phosphorus and nitrogen removals, exports the treated wastewater out of the basin to protect the exceptional clarity of Lake Tahoe. This system has been in operation for several years. A similar system for the communities around the north end of the Lake is under design. It will convey all municipal wastewaters to a central location near Martis Creek for tertiary treatment and disposal to land. The Truckee River has been designated a water quality class segment because partially treated wastewaters cause the rigid nitrogen, chloride, coliform and dissolved solids objectives to be exceeded. Problems of insufficiently controlled nonpoint pollution from urban and nonurban runoff remain. Siltation along the Lake Tahoe shores is causing concern. Groundwater problems are relatively minor in the Tahoe-Truckee portion of the basin.

Water quality problems in Surprise Valley are minor. The lakes are highly saline but sources of good quality water are obtained upstream and from groundwaters in the edge of the valley. Septic tank-leach field problems that jeopardize groundwaters have been identified in the communities of Cedarville and Fort Bidwell. Similar septic tank-leach field problems were noted in Janesville, Doyle, Sage Valley Flat, and the fringe areas of Susanville. The City of Susanville treatment plant has inadequate capacity partially due to infiltration in a poor collection system. The growing enrichment of Honey Lake could result in its eutrophication and could contribute to avian botulism. Eagle Lake is naturally high alkaline.

Water quality problems in the southern part of the basin are minor except for mine drainage pollution in Leviathin Creek which eliminates fish and wildlife in that creek and degrades the East Fork Carson River. Pollution of Monitor Creek by an active mine has been stopped effectively by construction of control facilities.

Basin 6B, South Lahontan Basin. This is the desert basin encompassing Inyo County, most of Mono and San Bernardino Counties and the southeast and northeast corners of Kern and Los Angeles Counties, respectively. In general, rainfall occurs relatively infrequently and limited water supplies for most of the area are obtained from groundwater sources. Runoff, mainly snowmelt from the eastern slopes of the Sierra Nevada, provides a substantial water supply in the Owens Valley. Much of this water is exported to the City of Los Angeles in a system that has been in operation more than 60 years. The basin is characterized by an agriculture-oriented development in the Owens Valley and several population centers located where water supplies are found such as Barstow, Mojave, Victorville, Lancaster and Palmdale. The basin economy relies upon a substantial mining industry, military and space-industry installations and agriculture. Retirement communities are also becoming more numerous. Recreation is popular in the eastern Sierra and San Bernardino Mountains.

Water quality problems in the northern part of the basin relate to improper treatment of municipal and domestic wastewaters. Most of the larger communities are partially sewered and have primary treatment facilities and evaporation/percolation ponds for effluent disposal. Generally the individual systems function properly in the valley areas but a considerable proportion of failures have been experienced in the foothill and mountain areas. Poor quality groundwaters, caused locally by percolation of wastewaters from mining operations and more generally by downgradient subsurface flow, are prevalent in the Amargosa River area. Similar groundwater degradation occurs near Boron due to percolation of mine waters. Occurrences of overflow of the Lancaster oxidation ponds offer a potential public health hazard.

At Barstow inadequately treated municipal and industrial wastewaters have created a "tail" of poor quality groundwater downstream of the discharge point causing significant quality deterioration in local domestic well supplies.

Basin 7A, West Colorado River Basin. This basin consists of the areas which are tributary to the Salton Sea. The area northeast of the Sea is the southern end of the great California desert which is, like Basin 6B, sparsely settled and receives little rainfall. The Coachella Valley, which lies northwest of the Sea, and Imperial Valley, which lies south and southeast of the Sea are semi-arid agricultural lands supported by water for irrigation by import from the Colorado River. The Whitewater River, which flows intermittently, drains the Coachella Valley while the New and Alamo Rivers flow northward from Mexico through the Imperial Valley. The Salton Sea is a "sink" area having a surface elevation well below sea level. The basin is important to the State and nation because of the value of the winter truck crops grown there. Population centers are generally small except growth is notable in the Palm Springs area where people seeking the desert climate are settling or visiting in significant numbers. The basin relies heavily upon imported water from the Colorado River to supply its demands. Although the occurrence of groundwater in the basin is extensive much of it is unusable quality.

The major water quality problem in the basin is the high and increasing salinity of the Salton Sea. The Sea is somewhat saltier than the oceans and is approaching the salinity in which fish can no longer survive. Uses of the Sea include recreation, fishery, wildlife and esthetics. Water quality in the New and Alamo Rivers has been degraded by inadequately treated municipal discharges some of which originate in Mexico. Other problems are: (1) the limited amount and increasing salinity of the Colorado River supply; (2) nutrient contamination of the Salton Sea by inflows of the New, Alamo and Whitewater Rivers from agricultural, municipal and industrial wastewaters; and (3) overdraft of high quality groundwater in the Coachella Valley. Water quality class segments are: (1) the Salton Sea because of its high and increasing salinity; (2) New River because of high oxygen demands resulting in low dissolved oxygen concentration caused by untreated sewage discharged by the City of Mexicali; and (3) Alamo River because of low dissolved oxygen concentrations and high bacterial counts caused by improperly treated municipal discharges. Widespread use of pesticides in the basin poses a potential water quality problem.

Basin 7B, East Colorado River Basin. The East Colorado River Basin encompasses all areas in the State which lie in the Colorado River watershed. The basin is 30 to 40 miles wide and about 200 miles long. The river is the predominant feature of the basin; it provides water supply for municipalities and agriculture, recreation for basin inhabitants and many tourists, hydroelectric power and water for export both within

California and Arizona. The land area in the basin is mainly desert with mountains and valleys. Population centers are Blythe, supported by agriculture and tourism, and Needles, supported by tourism and transportation industries. The resident population in the basin was 22,200 in 1970 but recreation draws an estimated 500,000 visitors each year. The river provides a significant fishery and wildlife habitat. Two major water development projects have been completed within the basin; they are Lake Havasu, formed by Parker Dam, and Imperial Reservoir formed by Imperial Dam. The former is the diversion point for the Colorado River Aqueduct system which supplies about 1.2 million acre-feet per year to Southern California. About 3.4 million acre-feet of water for much of Basin 7A is diverted at Imperial Dam and conveyed by the All American Canal. Water for irrigation is also diverted to the Palo Verde Valley near Blythe.

The major water quality problem in the basin is the high and increasing salinity of the Colorado River which has been described previously. Municipal water supplies for Blythe, East Blythe Water District, Needles and Winterhaven, from local groundwater basins, are of poor quality not meeting drinking water standards because of high TDS, and manganese. Fluoride concentrations are high in several locations. Septic tank-leach field systems are failing in Winterhaven, at a resort complex in the Havasu Landing area and in areas around Blythe. The Needles treatment plant is adequate except for infrequent peak flows but poor dispersion into the river causes a localized coliform problem. High salinity blowdown waters are discharged to the river by gas compression industries located near Topock and Blythe. Agricultural return flows from Palo Verde and Bard Valleys add salinity, nutrients and pesticides to the river.

Basin 8, Santa Ana River Basin. This basin's widely varied physiography and development belies its size as it is one of the smallest basins. There are two distinct subbasins drained by the Santa Ana River and a third drained by the San Jacinto River. The Upper Santa Ana Subbasin is rimmed by the San Gabriel and San Bernardino Mountains and a series of low granitic hills and eroded uplands known as the San Timoteo Redlands. The valley is effectively blocked by the Santa Ana Mountains, except for the narrow Santa Ana Canyon through which the river passes. The Lower Santa Ana Subbasin is best characterized as a coastal plain. The Santa Ana River discharges through this subbasin into the Pacific Ocean near Newport Beach. The San Jacinto subbasin is adjacent to the upper subbasin and to the southeast of it. It is essentially a closed basin drained by the San Jacinto River which discharges into Lake Elsinore. Drainage from Lake Elsinore to the Santa Ana River occurs only rarely, through Temescal Wash.

The Upper Santa Ana Subbasin is a significant agricultural area; however, population centers such as Riverside, San Bernardino and Redlands are rapidly encroaching onto valley farmlands. The Lower Santa Ana Subbasin is primarily urban with open areas along the river and where steeper slopes occur.

The Santa Ana River is ephemeral in the upper subbasin, with surface flows only in wet weather. There is, however, extensive alluvium in the valley which carries a considerable underground flow. This underground flow normally emerges upstream of Prado Dam at the upper end of the Santa Ana Canyon. Below the dam, the river is perennial. The San Jacinto River is similarly ephemeral throughout most of its length.

Data from 1970 indicated an applied water requirement (demand in excess of direct precipitation) for the total basin of 1,135,000 acre-feet per year, of which only 451,000 acre-feet can be supplied by local initial-use sources. Of the remainder, 302,000 acre-feet were imported from the Colorado River system and the balance of the demand was met by reclaimed wastewater generated in the basin and obtained from the groundwater basin. The annual applied water requirement is expected to increase to 1,415,000 acre-feet by the year 2000. This situation will continue to aggravate an already adverse salt balance.

Surface water quality and quantity problems in the Upper Santa Ana Subbasin include: increasing concentrations of coliform bacteria, nutrients and toxic wastes which threaten the important recreational beneficial use in the segment from Riverside to Prado Dam; presently high and increasing concentrations of TDS and nutrients at Prado Dam in waters which are used to recharge the Lower Santa Ana Subbasin, and; inadequate wastewater treatment and disposal practices in the Big Bear Lake and Baldwin Lake areas which cause violations of water quality objectives for mountain streams and lakes. The middle segment of the Santa Ana River from Riverside to Anaheim is classified as a water quality class segment because concentrations of salts, coliforms and nutrients, as well as turbidity, exceed adopted objectives. Major nonpoint source problems in the basin are agricultural return flows and high nutrient and TDS concentrations due to percolation of wastewaters from dairies and feedlots.

In the San Jacinto subbasin, agriculture is the largest user of water. This use results in large consumptive losses and high concentrations of salt and nutrients which are carried by percolation to the groundwater. There are also local areas in the subbasin where the groundwater quality is naturally poor due to mineralized aquifers and to isolation by faults. Twenty percent of the applied water requirement of 137,700 acre-feet in 1970 was met from local sources, 29 percent from Colorado River imports, 46 percent from reclaimed water and the remaining 5 percent from groundwater overdrafts. The amount of overdraft varies with precipitation. Lake Elsinore, which receives wet weather surface runoff, varies in salinity (TDS) from 1,000 to 36,000 mg/l depending upon the amount of fresh water in storage.

Basin 9, San Diego Basin. The San Diego Basin includes the southern corner of Orange County, a considerable portion of southwestern Riverside County and all of San Diego County west of the ridge line of the Peninsular Range about 50 miles from the ocean shore. The climate is semi-arid and typical of the Pacific coastal plain, i.e., warm, wet winters and cool summers. The average rainfall is 15 inches per year. The basin can be characterized by three regions, a coastal plain area, a central mountain-valley area and an eastern mountain-valley area. There are eight principal stream systems or subbasins, the hydrology of which was treated individually in the study. Drainage is from east to west with discharge into the Ocean. The Pacific Ocean shoreline consists of beaches and lagoons with San Diego Bay, the largest of the lagoons, forming a substantial deep water harbor. Economic development consists of agriculture, ship building and maintenance, metal processing, electronics and sand and gravel mining. There is considerable military activity at Camp Pendleton and several naval installations centered mainly around San Diego. The basin is also a popular retirement area. The economic development is projected to increase with industry concentrating in the northern and southern portions and agriculture holding its own in the central portion of the basin. The basin population is expected to double the 1970 population by the year 2000.

The fundamental quantity/quality problem in the basin is an inadequate local supply of water. Expansion of the already considerable import facilities will be needed. All local surface and groundwater supplies have been developed and limited reuse is practiced. Local supplies satisfied only 28 percent of the demand in 1973. Water quality has been a problem due to the high TDS in the Colorado River water imported since 1947 and many poor quality local sources. Overdrafting in the coastal areas has caused some sea water intrusion. Surface streams are ephemeral but problems of nutrients and eutrophication exist in the lagoons and in ponds formed by gravel pits in the alluvium. The diversion of municipal and industrial wastewaters from San Diego Bay for treatment at the Point Loma Plant and ocean discharge has abated a pollution problem in the Bay without creating a measurable problem in the ocean. Although the Bay has recovered remarkably well in the few years since diversion, it is classified as a water quality segment because of thermal discharges and nutrient concentrations, the latter being derived from existing bottom deposits and urban runoff. High nutrient and TDS concentrations are experienced in the Lower San Diego River to cause that stream to be classed also as a water quality segment. Salt balance in the basin is presently adverse, due mainly to the relatively high salinity of the imported water. There are local areas where groundwater quality is poor.

CHAPTER VI

WATER SUPPLY AND SUPPLEMENTAL DEMANDS

On the average, the total natural surface water supply of 71 million acre-feet in California is adequate to meet foreseeable demands. But natural stream runoff does not always occur at the time when it is needed nor in the right place. Most of the State's runoff is in the northern portion where about 75 percent occurs north of Sacramento while about 75 percent of the demand for irrigation and urban water is south of Sacramento. Also, most of the rainfall and runoff occurs in the winter, while the peak demand for water supply occurs in the summer. Figure 27 shows the distribution of natural runoff among the 11 hydrologic study areas of California.

California experiences a considerable amount of natural regulation by which water from the wet season is held until the dry season. Winter snow in the high mountains of the Sierra Nevada and Cascade ranges and in the Klamath mountains gradually melts during the late spring and early summer to sustain dry season flows in many streams and rivers. The vast alluvial ground water basins also store percolating wet season rainfall and streamflow in underground reservoirs where it is available for pumping as required.

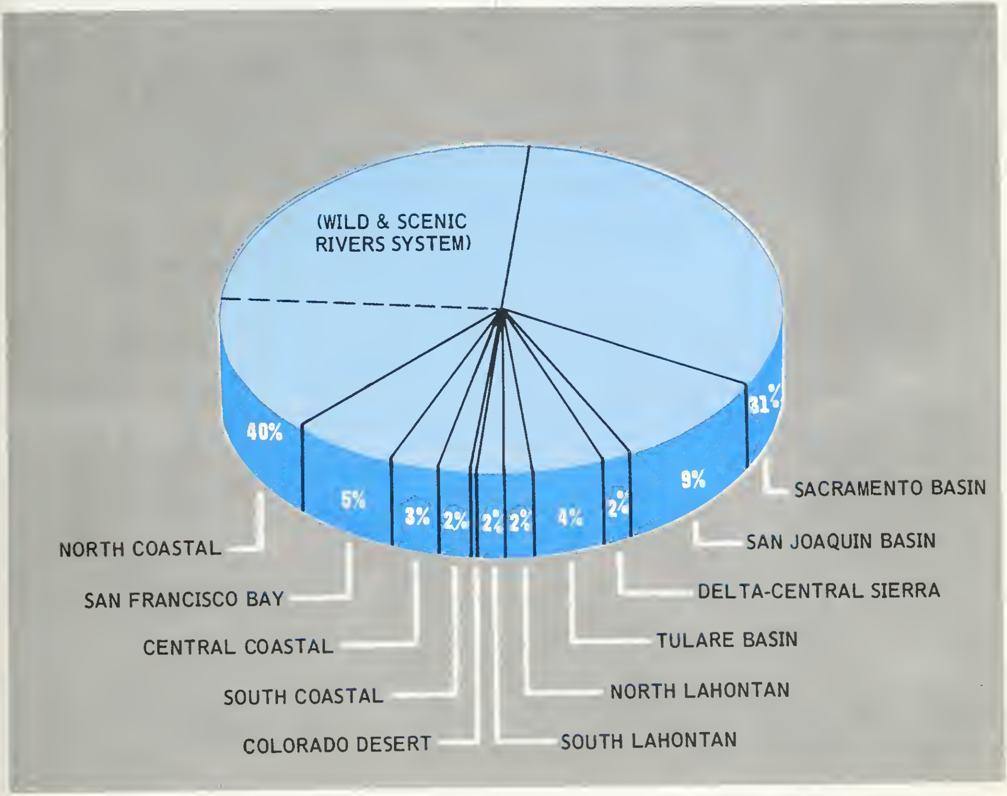
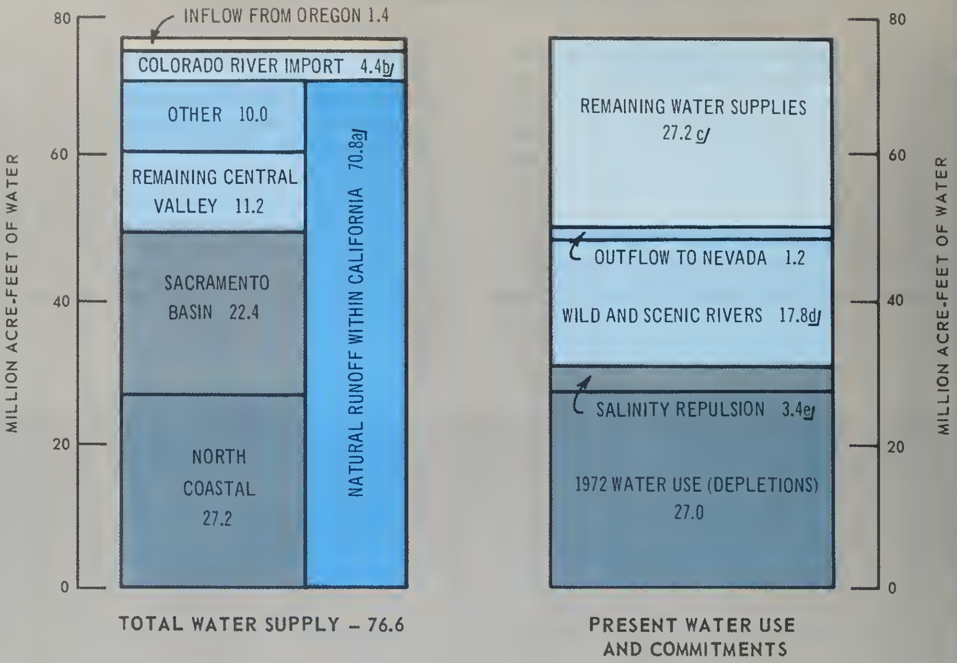


Figure 27. Distribution of Natural Runoff in California by Hydrologic Study Area



a/ WATER RESOURCES BOARD BULLETIN No. 1, 1951

b/ CALIFORNIA SHARE ACCORDING TO SUPREME COURT DECREE IN ARIZONA v.s. CALIFORNIA, WHEN CENTRAL ARIZONA PROJECT BECOMES OPERATIONAL.

c/ A SIGNIFICANT PORTION IS UNAVAILABLE FOR OUT-OF-STREAM USES.

d/ ESTIMATED NATURAL FLOW IN DESIGNATED REACHES OF THE SMITH, KLAMATH, TRINITY AND EEL RIVERS.

e/ 4,500 cfs, EXCEPT 5 WEEKS AT 6,700 cfs IN THE SPRING.

Figure 28. Total Surface Water Supply and Present Uses and Commitments

Figure 28 shows the average total water supply available and the present water commitments for the 1972 level of use including commitment of water for major in-stream uses. The long-term import supply of 4.4 million acre-feet from the Colorado River is a significant addition to the natural supply, particularly since the southeastern portion of the State has practically no natural surface supplies.

The estimate of 1972 level water use (depletion) consists of the evapotranspiration (consumptive use) of applied water plus related consumptive losses and waste water discharges to the ocean or other saline water bodies such as the Salton Sea. It does not include potentially usable return flow or waste discharges in noncoastal areas of the State.

The salinity repulsion estimate of 3.4 million acre-feet is based on 4,500 cfs of net Sacramento-San Joaquin Delta outflow except 5 weeks at 6,700 cfs in the spring for striped bass spawning which is a requirement of State Water Resources Control Board Decision 1379. The 4,500 cfs outflow is the current estimate of the amount necessary to meet the neomysis [1] requirement of not over 4,000 milligrams per liter chloride in the water at Chipps Island Strait.

The wild and scenic riverflow commitment represents the estimated full natural flow of the Eel River below Van Arsdale Dam, Klamath River below Iron Gate Dam, Trinity River below Lewiston Dam, and Smith River. The Eel River accounts for 5.8 million acre-feet of the 17.8 million acre-feet total commitment for wild and scenic riverflow. There is an additional 2.2 million acre-feet of annual runoff from the reaches of these streams excluded from the Wild and Scenic Rivers system.

The 1.2 million acre-foot outflow to Nevada represents the flow to Nevada of the Truckee, Walker, and Carson Rivers from the portions of their drainage basins which are in California.

Deducting current depletions, salinity repulsion, flow to Nevada, and the commitment of in-stream flow to wild and scenic rivers from the total supply of 76.6 million acre-feet leaves a remainder of 27.2 million acre-feet. Theoretically, the 27.2 million acre-feet represents the surface supply available for regulation to meet increases in future water demands. In a practical sense, half is probably unavailable for out-of-stream use because the runoff occurs in remote areas, small coastal watersheds where regulatory reservoir storage sites are lacking, interior desert areas where much of the runoff comes in flash floods, or because it occurs at infrequent intervals of short duration during large flood runoffs which are not physically possible to regulate or conserve.

[1] Neomysis is an opossum shrimp which is an important estuary fish food.

Available Water Supplies

The measure of regulated water supply used herein is dependable water supply. This is the amount of water which can be provided from the source to each water service area on a schedule matching the demands for water. The dependable supply contains an allowance for conveyance loss, if any, in transporting the water from its original source to the users.

Water supplies presented in this report for 1972 are an estimate for that level of development and are not necessarily the actual deliveries in that year. The 1972 water year (October 1971 through September 1972) was abnormal, being quite dry in all but the northern portion of the State.

Local Surface Water Projects

Surface water development in California has evolved over the last 200 years from a simple diversion of available stream flow at Mission San Diego to large and complex systems. Dams have been built to conserve and regulate the winter and spring runoff for use during the dry summer period. The stored waters have been conveyed by natural stream channels, canals, tunnels, and pipelines, often over long distances, to areas of use. Hydroelectric power plants have been installed along the conveyance conduits as they drop from the mountains to the valley. Many of these water supply systems have been financed and constructed by local agencies to serve areas located within a single hydrologic study area, both for municipal and industrial use and for agricultural purposes. It is these developments by local agencies which are designated in this report as local surface water supplies. Water supply projects of a local nature, but constructed by federal agencies are separately reported.

In Table 27 local project water supplies are shown in two categories: (1) local surface water developments and (2) imports by local water agencies. The first category denotes use of stream flow (including stored water) within the hydrologic study area; the second comprises water imported from outside the hydrologic area.

Local surface supplies, together with imports by local agencies, account for about 11.8 million acre-feet of present water supplies. This is about 38 percent of the present total net water supply.

Ground Water Safe Yield

Safe ground water yield is the measure of dependable ground water supply used in this bulletin. It comprises primary recharge to the underground storage aquifers from natural sources plus recharge from local surface reservoirs operated to augment natural stream channel percolation or to supply recharge basins. For example, about 100,000 acre-feet of water in the Salinas Valley of the Central Coastal Hydrologic Study Area is supplied by ground water which is percolated from releases from Nacimiento and San Antonio Reservoirs. The Monterey County Flood Control and Water Conservation District stores winter season runoff in the two reservoirs for later release to the Salinas River when the stream channel has unused percolation capacity for recharging the ground water basin. Statewide, ground water supplies presently provide about 5.2 million acre-feet of safe yield or about 17% of the present dependable water supplies. Some increases are projected, mostly from future use of available capacity of some northern California ground water basins.

Pumping in excess of safe yield is causing an estimated 2.2 million acre-foot average annual withdrawal of ground water storage (net overdraft) throughout the State. This overdraft and the safe yield, together, comprise about 7.4 million acre-feet or about 24 percent of present net water use. An additional 7.6 million acre-feet of annual ground water extraction constitutes reuse of water percolated from canals and distribution systems and from excess surface applications. In total, ground water pumping provides about 40% (15 million acre-feet per year) of the present applied water needs of the State.

The full extent of the State's ground water resource is not completely known. While the areas of water-bearing underground strata have been generally delineated on a statewide basis, detailed knowledge of storage capacity and other characteristics has been limited primarily to the basins most heavily used where the need is the most immediate and where a considerable body of factual data, such as well logs, is available for study. Further, many investigations conducted before the 1950s were limited to depths below the surface considered to represent a limit to economic pumping, even though usable water may extend to much greater depths. In some cases, actual pumping depths are now in excess of original projections. As the need for greater use of the ground water resource develops, so will the need for more definitive information on the underground reservoir characteristics. In most current investigations, this fact is recognized, and analysis is carried to the base of fresh water. As basins are operated over greater ranges of capacity, more information will become available for evaluating the extent and usefulness of the resource. At present, estimates of storage capacity are generally on the conservative side, especially in the less developed ground water areas.

The Central Valley Project

The Central Valley Project (CVP) was conceived as a plan to overcome the natural maldistribution of water supply and demand in the Great Central Valley of California. As early as the 1920s it was apparent that the natural water supply of the southern San Joaquin Valley was inadequate to meet the needs of this fertile area.

The initial units of the Central Valley Project consisted of Friant and Shasta Dams and the Contra Costa, Delta-Mendota, Friant-Kern, and Madera Canals. The first water deliveries for the Central Valley Project were made from the Contra Costa Canal in 1940. Current annual water deliveries, including that provided under water exchange contracts, amount to about 6 million acre-feet. (Actual 1972 deliveries were less because the dry year resulted in below average supplies at Millerton Lake.)

Major features of the Central Valley Project are shown on Figure 19. Table 25 gives a listing of major reservoirs and canals which are built or under construction. In addition, there are two authorized projects. Marysville Reservoir on the Yuba River would increase conservation of the water in the Sacramento Basin; and the San Felipe Division would serve water to the South San Francisco Bay and to the Pajaro River watershed in the Central Coastal Hydrologic Study Area.

Total reservoir storage capacity in the Central Valley Project is now 10.1 million acre-feet, including the Central Valley Project share of San Luis Reservoir.

Table 25. Major Features of the Central Valley Project

	Capacity (1,000 acre-feet)	First year of operation
Storage reservoirs		
Shasta Lake	4,552	1944
Clair Engle Lake (Trinity Dam)	2,448	1960
Lewiston Lake	15	1963
Whiskeytown Lake	241	1963
Spring Creek Debris	6	1963
Keswick	24	1948
Red Bluff Diversion	4	1966
Black Butte[1]	160	1963
Jenkinson Lake (Sly Park Dam)[2]	41	1955
Folsom Lake	1,010	1955
Lake Natoma (Nimbus)	9	1955
Contra Loma	2	1963
San Luis[3]	2,039	1967
O'Neill (San Luis Forebay)[3]	56	1966
Los Banos (Detention)[3]	35	1966
Little Panoche (Detention)[3]	13	1966
Millerton Lake (Friant Dam)	520	1944
Auburn	2,326	Under constr.
New Melones	2,400	Under constr.
Canals	(CFS)	
Corning	500	1961
Folsom South	3,500	1973[4]
Contra Costa[5]	350	1940
Delta Mendota	4,600	1951
San Luis[3]	13,100	1967
Madera	1,200	1944
Friant Kern	4,200	1949
Tehama Colusa	2,300	Under constr.

[1] Operated by the Corps of Engineers.
[2] Operated by El Dorado Irrigation District.
[3] Joint use with State Water Project; operated by State of California.
[4] Only first 26 miles complete out of a total of about 68 miles.
[5] Operated by Contra Costa County Water District.

Completion of the Auburn and New Melones projects would increase the capacity to 14.8 million acre-feet. The total installed hydroelectric capacity of the CVP is about 1,250 megawatts, excluding the San Luis plant. This is about 3 percent of the State's total electric power capacity. Auburn and New Melones, as planned, will add 600 megawatts of new capacity, less the existing 26 megawatt Melones power plant which will be inundated.

The estimated dependable water supply capability of the Central Valley Project upon the completion of Auburn and New Melones Reservoirs and with the Peripheral Canal will be about 9.2 million acre-feet annually under full operation and including reuse of some return flows. This yield assumes that State Water Resources Control Board Decision 1379 requirements will apply, except for relaxation in dry years. The supply includes 285,000 acre-feet from New Melones Reservoir (including downstream quality and new fishery releases) and 318,000 acre-feet from Auburn Reservoir. Marysville Reservoir is not included but could add about 150,000 acre-feet to the Central Valley Project yield at the Delta.

Included in the Central Valley Project water supply are exchange and water rights supplies provided by the Central Valley Project under various agreements. Technically, these supplies would be considered as local water supplies; however, in keeping with conventional practice these deliveries were placed in the Central Valley Project category herein. The 1972 Central Valley Project annual report shows that about 2.6 million acre-feet of exchange and water rights water was provided in that year.

Friant Dam—a key unit of the Central Valley Project *U.S. Bureau of Reclamation photo*

Other Federal Water Developments

This category of water supply consists of water projects constructed by the Army Corps of Engineers or by the Bureau of Reclamation, but which are not part of the Central Valley Project. Table 26 contains a list of the facilities included.

Table 26. Other Federal Water Projects in California

Storage reservoir	Capacity (1,000 AF)	Watershed	Hydrologic study area	Completion date
Clear Lake[a]	527	Lost River	NC	1910
Upper Klamath Lake[b]	525[c]	Klamath River	NC	1921
Lake Mendocino	122	Russian River	SF	1959
Warm Springs	281	Russian River	SF	U.C.[d]
Salinas	26	Salinas River	CC	1942
Twitchell	240	Santa Maria River	CC	1958
Cachuma	205	Santa Ynez River	CC	1953
Casitas	252	Ventura River	SC	1959
East Park	51	Stony Creek	SB	1910
Stony Gorge	50	Stony Creek	SB	1928
Lake Berryessa	1,602	Putah Creek	SB	1957
New Hogan	325	Calaveras River	DC	1964
Buchanan	150	Chowchilla River	SJ	U.C.[d]
Hidden	90	Fresno River	SJ	U.C.[d]
Pine Flat	1,000	Kings River	TB	1954
Terminus	150	Kaweah River	TB	1962
Success	85	Tule River	TB	1961
Isabella	570	Kern River	TB	1953
Lake Tahoe	732[c]	Truckee River	NL	1913
Boca	41	Truckee River	NL	1939
Prosser Creek	30	Truckee River	NL	1962
Stampede	226	Truckee River	NL	1970
Lake Mead[b]	28,537	Colorado River	-	1936
Lake Mohave[b]	1,818	Colorado River	--	1950
Lake Havasu	648	Colorado River	CD	1938
Senator Wash	14	Colorado River	CD	1966

[a] In Modoc County.
[b] Outside California.
[c] Active Capacity.
[d] Under construction.

Water deliveries from the Colorado River to the Colorado Desert Hydrologic Study Area have been included in the other federal category.

Included in the list on Table 26 are four federal reservoirs in the North Lahontan Hydrologic Study Area which regulate water supplies of the Truckee River watershed, but for use primarily in Nevada. Several more federal water supply projects have been authorized for construction in Northern California but their water supply has not been included. These are:

Reservoir	Capacity (1,000 acre-feet)	Watershed	Hydrologic study area
Butler Valley	460	Mad River	North Coastal
Knights Valley	233[a]	Russian River	San Francisco Bay
Dutch Gulch	1,100	Cottonwood Creek	Sacramento Basin
Tehama	900	Cottonwood Creek	Sacramento Basin
Lakeport	55	Cache Creek	Sacramento Basin

[a] First stage.

California State Water Project

The California State Water Project is a system of reservoirs and conveyance works which regulate water supplies from runoff in Northern California for use in Northern California, San Francisco Bay area, San Joaquin Valley, Central Coast, and Southern California. It also provides flood control, hydroelectric power generation, water-oriented recreation, salinity control in the Delta in coordination with the federal Central Valley Project, and enhancement of fisheries and wildlife habitat.

The Project extends from reservoirs on the upper Feather River in Plumas County to Lake Perris in Riverside County, with branch aqueducts to the north and south San Francisco Bay areas, to the Central Coastal area and the northwest portion of metropolitan Southern California. Water from Lake Perris is distributed by agencies of the Metropolitan Water District of Southern California throughout the South Coastal area to the vicinity of the Mexican border. Major physical facilities of the State Water Project, both completed and authorized, include 23 dams and reservoirs, 6 hydroelectric power plants, 22 pumping plants and 685 miles of conveyance facilities.

Features of the State Water Project are shown in Figure 19, and are described in detail in Department of Water Resources Bulletin No. 132-74, "The State Water Project in 1974".

Facilities which comprise the State Water Project are:

- Frenchman, Antelope, and Grizzly Valley Dams and the Grizzly Valley Pipeline, for recreation and water service to the Upper Feather River area.
- Oroville-Thermalito Facilities, the key source of project water supply, also for power generation, flood control, and recreation.
- Phase I of the North Bay Aqueduct, for delivery of water to the north San Francisco Bay area.
- The South Bay Aqueduct, for recreation, flood control, and water service to the South San Francisco Bay area.
- The California Aqueduct, extending 444 miles from the Sacramento-San Joaquin Delta to Lake Perris, for recreation, power generation, and water service to the western San Joaquin Valley and high desert and southern coastal plain of Southern California.
- The West Branch of the California Aqueduct, including Pyramid and Castaic Lakes and a 1250 megawatt pump storage power plant. The power plant was constructed by the Los Angeles Department of Water and Power. This system provides recreation, power generation, and water service to the northern coastal plain of Southern California.

- Phase I of the Coastal Branch of the California Aqueduct for project water service initially to the Antelope Plain on the central-western periphery of the San Joaquin Valley (and eventually to San Luis Obispo and Santa Barbara Counties).
- Storage and pumping-generating facilities at San Luis Reservoir which are utilized jointly with the federal Central Valley Project.

The Department of Water Resources has contracted to deliver state project water to 31 water service agencies located in 8 of the State's 11 hydrologic study areas. Maximum annual entitlements by the contractors for the water supply amount to 4,230,000 acre-feet per year. In addition, the project has the capability to provide 45,500 acre-feet per year for recreation purposes associated with the project. Finally, conveyances losses estimated at about 187,000 acre-feet per year are included in the net demand on the State Water Project. A tabulation of the entitlements to state project water within hydrologic study areas is shown below:

Hydrologic Study Area	Amount (acre-feet per year)
Sacramento Basin	39,800
San Francisco Bay	255,000
Central Coastal	82,700
San Joaquin Basin	5,700
Tulare Basin	1,349,300
South Coastal	2,204,400
South Lahontan	206,600
Colorado Desert	86,500
Total Entitlement of Contractors	4,230,000
Recreation	45,500
System Conveyances Losses (estimated)	187,000
Total Project Water Requirements (rounded)	4,462,000

The firm water yield of the conservation facilities of the State Water Project, when completed, will be 4.46 million acre-feet per year. This estimate envisions completion of the North Bay Aqueduct and Coastal Branch, and installation of the necessary final pump units at the Delta and Edmonston Pumping Plants. It also envisions the construction of additional conservation facilities as necessary to satisfy full contractual

Wind Gap Pumping Plant—California State Water Project entitlements. Currently, the project yield with the Peripheral Canal assumed to be in operation is estimated at 3.4 million acre-feet per year, based on the project being operated in accordance with State Water Resources Control Board Decision 1379 for outflow requirements in the Sacramento-San Joaquin Delta, except for relaxation in dry years.

Waste Water Reclamation

A considerable amount of municipal and industrial waste water has been reclaimed and has been used for years at inland locations for irrigation, mainly of fodder. In previous bulletins this water supply has usually been considered part of the reuse of net supplies and has not been identified separately. However, in this bulletin, the amounts of waste water reclaimed deliberately for a specific beneficial use have been included as an item of supply. The projected amounts in coastal hydrologic study areas include present amounts plus those new waste water reclamation projects which seem to be assured either by a start of construction or by a specific allocation of funds for construction. Until concerns regarding public health safety aspects of using reclaimed water are resolved it is not possible to plan for significant increases in waste water reclamation for municipal use. In the inland hydrologic study areas, present practices were assumed to continue, and future waste water reclamation was assumed to be about the same percentage of total municipal and industrial applied water as it is today. Exceptions were made in the case of military and some industrial facilities where waste water reclamation was projected at present levels.

Desalting

Desalination of brackish drainage water and sea water is a potential source of water in some areas. The only source of desalted water regarded firm enough to include in the projected net water supplies is 16,000 acre-feet per year from the Water Factory 21 installation being constructed in Orange County. The San Diego Saline Test Facility was producing about 500 acre-feet per year in 1972; the plant ceased operation in 1973 and has been dismantled.

Summary of Available Water Supplies

Table 27 presents the summary of water supplies available in each of the eleven hydrologic study areas. The water supply is presented in the eight supply categories just discussed.

TABLE 27

Summary of 1972 and Projected Water Supplies, Net Water Demands and Supplemental Demands by Hydrologic Study Areas

(1,000 acre-feet per year)

Items	North Coastal			San Francisco Bay			Central Coastal			South Coastal			Sacramento Basin			Delta-Central Sierra		
	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020
Dependable water supplies																		
Local surface water developments	390	390	400	170	170	170	54	54	54	90	90	90	2,480	2,610	2,790	1,330	1,370	1,420
Imports by local water agencies	2	2	2	700	700	700	--	--	--	1,720	940	940	9	9	9	--	--	--
Ground water safe yield	140	160	180	330	340	340	720	750	750	930	930	930	1,190	1,360	1,390	630	610	610
Central Valley Project[1]	-	--	--	80	140	270	--	--	--	--	--	--	2,700	3,170	3,380	130	800	760
Other federal water developments[1]	430	430	430	100	230	230	55	55	55	20	20	20	200	190	190	110	120	120
State water project[2]	--	--	--	130	230	260	0	87	87	190	2,340	2,340	1	38	40	--	--	--
Waste water reclamation	--	--	--	8	54	55	6	7	8	57	81	81	11	13	18	8	10	18
Desalting	--	--	--	--	--	--	--	--	--	0	16	16	--	--	--	--	--	--
Total dependable water supplies	960	980	1,010	1,520	1,860	2,030	830	950	950	3,010	4,420	4,420	6,590	7,390	7,820	2,210	2,910	2,930
Alternative Future I																		
Total net water demand	940	990	1,040	1,270	1,820	2,630	950	1,240	1,560	3,080	3,770	5,200	5,780	7,610	9,030	2,270	3,110	3,860
Supplemental demand	2	20	30	9	80	600	140	290	610	160	0	780	240	500	1,210	120	220	930
Reserve supply[3]	20	10	0	260	120	0	20	0	0	90	650	0	1,050	280	0	60	20	0
Alternative Future II																		
Total net water demand	940	990	1,030	1,270	1,780	2,450	950	1,200	1,480	3,080	3,700	4,720	5,780	7,200	8,240	2,270	2,900	3,630
Supplemental demand	2	20	30	9	70	480	140	250	530	160	0	300	240	360	730	120	120	710
Reserve supply[3]	20	10	10	260	150	60	20	0	0	90	720	0	1,050	550	310	60	130	10
Alternative Future III																		
Total net water demand	940	980	1,010	1,270	1,760	2,310	950	1,180	1,410	3,080	3,640	4,480	5,780	6,800	7,530	2,270	2,700	3,360
Supplemental demand	2	20	20	9	70	370	140	230	460	160	0	60	240	290	530	120	110	550
Reserve supply[3]	20	20	20	260	170	90	20	0	0	90	780	0	1,050	880	820	60	320	120
Alternative Future IV																		
Total net water demand	940	980	1,000	1,270	1,660	1,900	950	1,150	1,250	3,080	3,390	3,460	5,780	6,630	7,080	2,270	2,580	3,010
Supplemental demand	2	20	20	9	30	120	140	200	300	160	0	0	240	210	320	120	80	280
Reserve supply[3]	20	20	30	260	230	250	20	0	0	90	1,030	960	1,050	970	1,060	60	410	200

[1] Facilities existing or under construction; amounts include water rights and exchange supplies in the Central Valley furnished from CVP facilities.
[2] Facilities definitely planned for construction and additional conservation facilities authorized to meet contractual commitments.
[3] Potentially available to certain portions of the hydrologic study area to meet additional water demands; usually not available to other areas of supplemental demand because of a lack of physical facilities and/or institutional arrangements.

The supply for the State Water Project assumes that such works as necessary to meet contractual deliveries will be constructed. It should be noted that a significant portion of the present regulated water supply is in a reserve status. This means that: (1) the demands for water in certain areas are not large enough to utilize all of the available regulated water supply, (2) the areas of need cannot be served with the conveyance facilities available, or (3) no contractual arrangement exists for service to the area. The reserve supply is only valid at face value in its designated service area. Even if the necessary physical and institutional transfer means existed, some quantity adjustment would be needed if use of the reserve supply in another service area is contemplated. The adjustment would include the effect of return flows and differing monthly schedules of water demand.

A summary of the statewide water supply and demand picture for each alternative future is shown in Figure 29. Major sources of water are indicated and compared to total net demands for water. The difference between usable water supply and net water demand is the supplemental demand. About 90 percent of the estimated 1972 supplemental demand of 2,450,000 acre-feet is met from ground water overdraft. The Colorado River supply will decrease from about 5,150,000 acre-feet currently to 4,400,000 acre-feet by 1990, which is California's share of the Colorado River supply according to the Supreme Court allocation.

The bottom category on the figure is labeled "Local Water Projects". It includes local agency and federal surface water developments, except for Colorado River and Central Valley Project sources. It also includes waste water reclamation and desalting which are too small to show on the figure.

TABLE 27—Continued

Summary of 1972 and Projected Water Supplies, Net Water Demands and Supplemental Demands by Hydrologic Study Areas—Continued

(1,000 acre-feet per year)

Items	San Joaquin Basin			Tulare Basin			North Lahontan			South Lahontan			Colorado Desert			State totals		
	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020	1972	1990	2020
Dependable water supplies																		
Local surface water developments	2,230	2,280	2,280	2,220	2,220	2,220	330	330	330	30	40	50	--	--	--	9,310	9,560	9,810
Imports by local water agencies	--	--	--	--	--	--	11	11	11	--	--	--	--	--	--	2,450	1,660	1,660
Ground water safe yield	520	520	520	510	510	510	56	90	110	120	130	130	74	85	90	5,220	5,470	5,560
Central Valley Project[1]	1,720	1,940	1,940	2,660	2,890	2,890	--	--	--	--	--	--	--	--	--	7,290	8,930	9,230
Other federal water developments[1]	0	48	48	240	240	240	--	--	--	--	--	--	3,950	3,970	3,970	5,110	5,310	5,310
State water project[2]	9	9	9	790	1,410	1,410	--	--	--	34	220	220	14	85	91	1,160	4,420	4,460
Waste water reclamation	26	38	62	45	59	85	6	9	12	7	8	10	7	9	12	180	290	360
Desalting	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	16
Total dependable water supplies	4,510	4,840	4,860	6,470	7,330	7,360	400	440	460	190	400	410	4,040	4,150	4,160	30,700	35,700	36,400
Alternative Future I																		
Total net water demand	4,650	5,510	6,280	7,300	9,200	11,000	430	450	480	280	330	510	4,070	4,240	4,430	31,000	38,300	46,000
Supplemental demand	250	670	1,420	1,310	1,920	3,640	40	20	20	120	3	100	40	90	270	2,450	3,810	9,610
Reserve supply[3]	110	0	0	480	50	0	10	10	0	30	70	0	10	0	0	2,140	1,200	0
Alternative Future II																		
Total net water demand	4,650	5,350	5,710	7,300	8,800	10,110	430	450	470	280	330	430	4,070	4,180	4,300	31,000	36,900	42,600
Supplemental demand	250	510	850	1,310	1,500	2,750	40	20	10	120	3	70	40	30	140	2,450	2,880	6,600
Reserve supply[3]	110	0	0	480	30	0	10	10	0	30	70	50	10	0	0	2,140	1,670	430
Alternative Future III																		
Total net water demand	4,650	5,120	5,320	7,300	8,290	9,160	430	450	470	280	320	370	4,070	4,150	4,290	31,000	35,400	39,700
Supplemental demand	250	280	460	1,310	1,030	1,800	40	20	10	120	3	30	40	20	130	2,450	2,070	4,420
Reserve supply[3]	110	0	0	480	70	0	10	10	0	30	80	70	10	20	0	2,140	2,330	1,120
Alternative Future IV																		
Total net water demand	4,650	4,960	5,030	7,300	8,180	8,700	430	420	420	280	300	290	4,070	4,140	4,210	31,000	34,400	36,400
Supplemental demand	250	130	170	1,310	920	1,340	40	20	0	120	3	10	40	10	60	2,450	1,620	2,620
Reserve supply[3]	110	10	0	480	70	0	10	40	40	30	100	130	10	20	10	2,140	2,900	2,680

[1] Facilities existing or under construction; amounts include water rights and exchange supplies in the Central Valley furnished from CVP facilities.
[2] Facilities definitely planned for construction and additional conservation facilities authorized to meet contractual commitments.
[3] Potentially available to certain portions of the hydrologic study area to meet additional water demands; usually not available to other areas of supplemental demand because of a lack of physical facilities and/or institutional arrangements.

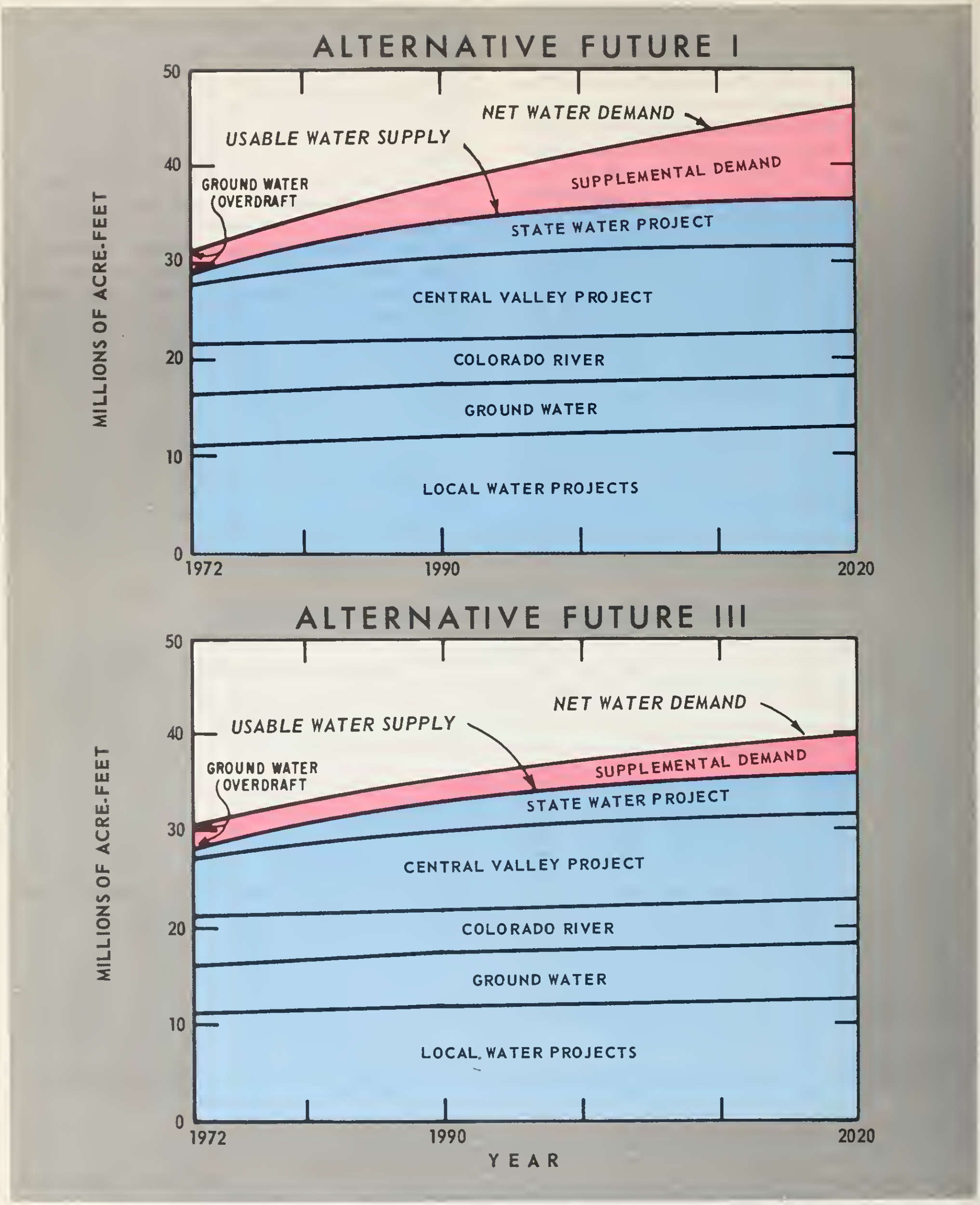


Figure 29. Statewide Water Demand and Usable Water Supply

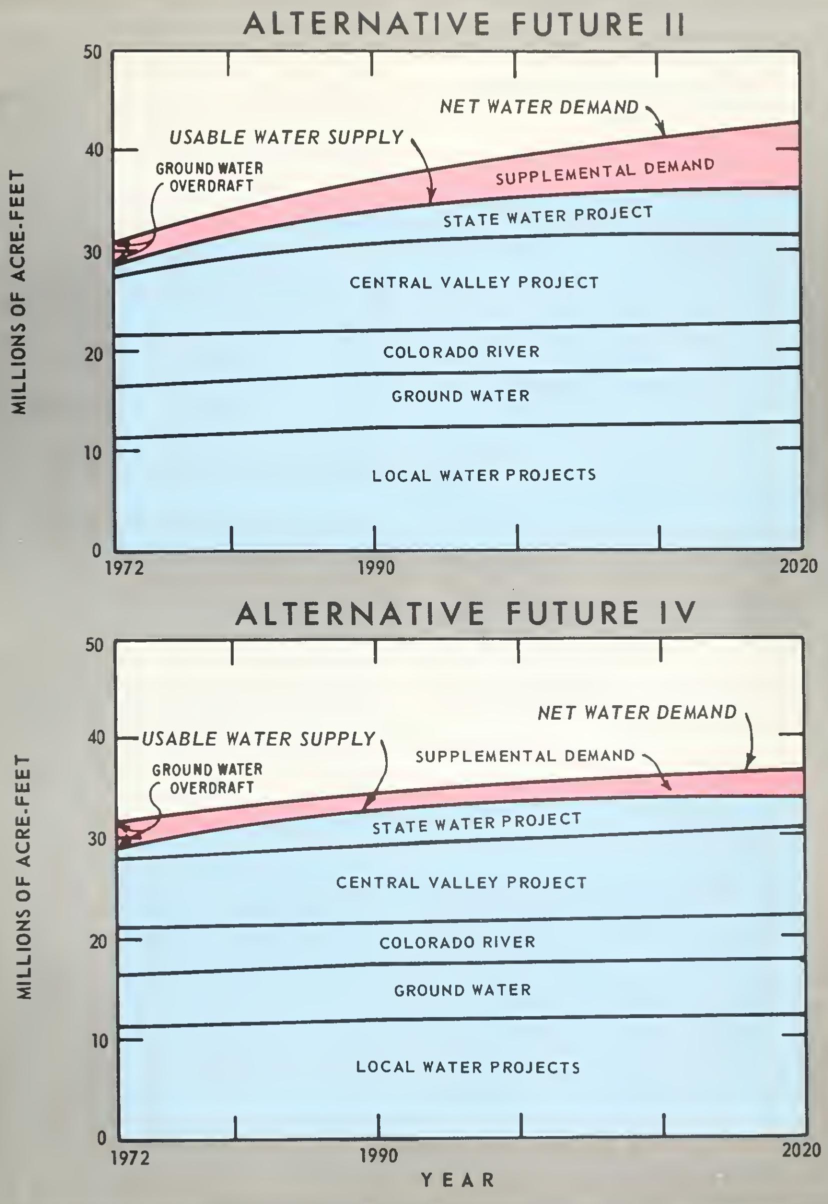


Figure 29. (Continued)

Effect of State Water Resources Control Board Decisions on Water Supply

During the past four years, the State Water Resources Control Board has made several decisions in regard to water rights which will significantly affect the water supply outlook.

Decision 1379

Chief among these is Decision 1379 relating to water quality in the Sacramento-San Joaquin Delta, issued in July 1971. The water quality standards established for fish and wildlife require substantially higher fresh water outflows, including greater releases of stored water, than the amounts used in planning the State Water Project and the federal Central Valley Project. In making Decision 1379, the Board stated that its hearings would be reopened not later than July 1978 to receive further evidence relating to salinity control and fish and wildlife protection.

Decision 1379 prescribes water quality standards at various locations in the Delta. Some are for protection of municipal and industrial supplies, some for agriculture, and some for fish and wildlife. The fishery standards would normally be controlling. The amounts of water required to meet the standards are large. Decision 1379 standards, without dry year relaxation, will result in a reduction in the combined water yields (critical dry period) of the Central Valley Project and State Water Project of about 1.8 million acre-feet per year. About 1.1 million acre-feet of this would be the responsibility of the Central Valley Project and 0.7 million acre-feet that of the State Water Project, assuming that the responsibility for increased outflow would be shared by the 60-40 ratio used in negotiating the yet unsigned Coordinated Operation Agreement for the Central Valley Project and State Water Project. Execution of this agreement has been delayed pending completion of an Environmental Impact Statement on the agreement.

There have been indications that the Board would consider relaxation of some of the fishery criteria in dry years. For example, the guidelines given to the basin contractors working on the Water Quality Control Planning Program included consideration of a dry year relaxation in fisheries flow in the Delta in formulating alternative water quality control plans. Estimates of water supply presented in the previous section of this report are based on a relaxation of the criteria which results in an estimated reduction in combined water yield (dry period) of 0.6 million acre-feet.

Decision 1400

In Decision 1400 (April 1972) the State Water Resources Control Board decreed minimum lower American River flows for fishery and recreation purposes. Releases from Folsom Reservoir would provide 1,250 cubic feet per second (cfs) for fisheries purposes during the cool season of the year and 1,500 cfs for recreation from mid-May to mid-October in all but dry years. These levels of flow were judged the minimum to provide a good in-stream fishery and recreation environment in the lower reaches of the American River where it flows through the Metropolitan Sacramento area.

The previous fishery release requirement was based on an agreement with the Department of Fish and Game negotiated when Folsom Dam was built. Fishery releases amounted to about 234,000 acre-feet per year, 250 cubic feet per second from January to mid-September and 500 cubic feet per second the rest of the year. The increased requirement under Decision 1400, about 750,000 acre-feet per year, imposed a substantial reduction in the amount of firm water supply available for diversion at the head of Folsom South Canal.

In this case, a physical engineering solution would be the Hood-Clay pump connection. Water released to flow down the American River into the Sacramento River would be diverted at a point just south of Sacramento and conveyed back to the Folsom-South Canal through a pumping plant and canal. The connection probably would not be needed until after year 1990, when American River and Folsom South Canal service area demands will have built up and exceed the amount available for direct diversion from the American River.

Decision 1422

In Decision 1422, concerning the New Melones Project on the Stanislaus River, the State Water Resources Control Board restricted conservation storage in the federal reservoir to such water as necessary to provide (a) for prior rights at existing Melones Reservoir, (b) for preservation and enhancement of downstream fish and wildlife up to 98,000 acre-feet per year, and (c) additional water to maintain dissolved oxygen in the Stanislaus River and control of water quality in the lower San Joaquin River at Vernalis. The storage restriction will be reconsidered by the Board when there is a demonstrated need for more water for downstream purposes or additional diversions and evidence that benefits therefrom would outweigh the damage above New Melones Dam that would result from such storage. The storage limitation will preserve a popular "white water" area and protect some limestone caves and, possibly, some archaeological and historical sites. (Previously constructed headwater reservoirs contribute substantially to the length of the "white water" rafting season.)

The practical effect of the decision is to limit water supply storage to about 30 percent of the New Melones total capacity of 2,400,000 acre-feet. The firm water supply would then be around 210,000 AF less than without the storage limit, with substantial loss of electric power from the planned 300-megawatt power plant and much reduced reservoir "flat water" recreation.

Supplemental Water Demands

Supplemental water demands are the difference between net water demand and useable water supply in each hydrologic study area. Useable water supply is defined as that portion of the dependable water supply that is useable in the area of need. Many of the study areas are quite large and while the total water supply appears adequate to meet projected water demands, local shortages may occur because the location of regulated water supplies and conveyance systems do not permit adequate water service to all places requiring water.

Quantities of dependable water supplies not useable to satisfy hydrologic study area demands, as explained in the foregoing paragraphs, were classified as "reserve supplies". While there is a possibility of using certain reserves from one hydrologic study area to offset the supplemental demands of another hydrologic study area, both institutional and physical modifications would be required.

Present and projected supplemental water demands are given in Table 27. Under the 1972 level of development, the supplemental demand was 2,450,000 acre-feet per year. Assuming completion and delivery of water from facilities under construction and facilities required to conserve water to meet requirements under existing contracts, supplemental water demand in 1990 could range from 1.6 to 3.8 million acre-feet per year. Under similar assumptions regarding additional supplies by 2020, the supplemental water demand in California is estimated to range from 2.6 to 9.6 million acre-feet per year for the alternative futures described earlier.

About 2.2 million acre-feet of the supplemental demand shown at the 1972 level represents ground water overdraft (i.e., the net withdrawals from underground water storage in excess of the safe yields). This has resulted in lowering ground water tables in certain areas. The largest amount of overdraft is in Tulare Basin where an estimated 1.3 million acre-feet of ground water overdraft is shown for 1972. The Tulare Basin overdraft is less than the 1967 estimated overdraft of 1.8 million acre-feet which was reported in Bulletin No. 160-70. The reduction is due to deliveries of Central Valley Project and State Water Project water along the west side of the San Joaquin Valley. Figures 21 and 22 show this impact on ground water levels in the area.

Table 28 is intended as an aid in comparing current projections of the need for new water supplies with former bulletins in the 160 series. Adjustments were made to the figures shown in previous bulletins to harmonize the major items of supply to those used in this report. For example, Bulletin No. 160-66 showed many proposed Central Valley Project works, such as the San Felipe and the Eastside Divisions, as part of the supply and only a relatively small "Remaining Net Water Requirement" (see Table 7 of Bulletin No. 160-66). Bulletin No. 160-74 does not count these works as assured firm supplies. The harmonizing adjustments were made only for specific project sources which are different from one report to another. No adjustment was made when the changes consisted of refinements in the estimates of water supply capability.

Table 28. Comparisons of Supplemental Demand Between Bulletin No. 160-74 and Previous Bulletins (1,000 acre-feet)

Hydrologic study area	1990						2020					
			160-74						160-74			
	160-66	160-70	I	II	III	IV	160-66	160-70	I	II	III	IV
North Coastal	0	80	20	20	20	20	0	100	30	30	20	20
San Francisco Bay	30	0	80	70	70	30	340	710	600	480	370	120
Central Coastal	80	220	290	250	230	200	600	480	610	530	460	300
South Coastal	0	0	0	0	0	0	1,540	940	780	300	60	0
Sacramento Basin	210	240	500	360	290	210	300	350	1,210	730	530	320
Delta-Central Sierra	100	90	220	120	110	80	140	180	930	710	550	280
San Joaquin Basin	0	100	670	510	280	130	400	400	1,420	850	460	170
Tulare Basin	1,400	1,060	1,920	1,500	1,030	920	2,670	1,920	3,640	2,750	1,800	1,340
North Lahontan	0	30	20	20	20	20	0	120	20	10	10	0
South Lahontan	0	60	0	0	0	0	0	60	100	70	30	10
Colorado Desert	0	80	90	30	20	10	180	150	270	140	130	60
State Totals	1,820	1,960	3,810	2,880	2,070	1,620	6,170	5,410	9,610	6,600	4,420	2,620

Note: Supplemental demands above do not include amounts to be developed by additional conservation facilities which will be needed to maintain State Water Project water service contracts as it is expected that these commitments will be met.

Analysis of Central Valley Project and State Water Project Capability and Demands

The Central Valley Project and the California State Water Project both involve major transfers of water from areas of water surplus to areas of water deficiency. Since these two integrated projects account for much of the present water service and are expected to provide a greater share of the future water service, the capabilities of the two systems are significant in the analysis of California's water supplies.

Project Water Supplies

As indicated in the previous section on available water supplies, the capability of the Central Valley Project to provide for the projected net demands computed for this report appears to be about 9.2 million acre-feet per year. This assumes completion of Auburn and New Melones Reservoirs and the Peripheral Canal in the Delta.

The current sustained yield capability of the existing State Water Project conservation facilities, together with the Peripheral Canal, would be about 3.4 million acre-feet. About 1 million acre-feet of additional authorized conservation capability will be added to meet contractual demands plus conveyance losses of 4.46 million acre-feet.

The Peripheral Canal

In 1959, California authorized, in the Burns-Porter Act, construction of physical works to transfer Sacramento River water through the Delta and concurrently to solve water quality and fishery problems within the Delta. In 1964, the Peripheral Canal was recommended as the best plan for the Delta. It would accomplish five objectives:

(1) Protect and enhance the Delta fishery by restoring downstream flows in Delta channels.

(2) Provide water quality control for the interior Delta uses by releasing water from many outlets.

(3) Correct a deteriorating environmental condition by isolating project pumps from the Delta channels.

(4) Improve Delta recreation by providing new facilities along the Canal and by improving Delta access.

(5) Ensure the quality of the water supply needed by agriculture, industry, and millions of Californians west and south of the Delta served by the State and federal projects.

It is worth noting that two of the standards of Decision 1379 cannot be met without the Peripheral Canal or some other cross-Delta transfer facility. These are the requirement for positive downstream flow in all principal Delta channels for fishery purposes, and the requirement for a predominance of San Joaquin River water in the southern and eastern Delta in fall months.

Although the Peripheral Canal was planned as a joint federal-state undertaking, federal authorization to participate in its construction has not yet been obtained. With projected export, the canal is needed by 1980 to protect the water quality of the State Water Project, Central Valley Project, and the southwestern Delta in dry and critical years. In the event that there is not formal federal participation by congressional authorization or other means in time to meet a 1980 operational date, the Department would have to proceed alone with construction of a water conveyance facility if it is to meet the needs of the SWP. A program of staged construction by the State that would meet the needs of both state and federal projects is a feasible course of action.

Briefly, the first stage of such a plan would be a full-sized, full-length gravity flow canal with full-size channel release facilities which would satisfy the interim needs of the State Water Project and Central Valley Project systems and of the Delta until about 1985. With the addition of a pumping plant and other deferred features in 1985, the capacity and operating capability of the first-stage facility would be expanded to meet the increasing needs of the projects. Using this approach, federal financial participation would be feasible at any time.

The State of California strongly supports federal authorization of the Peripheral Canal and financial participation in the construction of the canal. However, regardless of whether or not such financial participation is effective during the construction period of the canal, the Department of Water Resources will proceed with construction of Stages 1 and 2. Should congressional authorization be delayed, the Department expects that the U.S. Bureau of Reclamation would pay an interim "wheeling charge" or other form of temporary compensation, for the conveyance of federal Central Valley Project water through the canal.

Water Demands on the Central Valley Project

The estimated 1972-level water demands and projected further water demands in the Central Valley Project service areas which are capable of being served by the project works, either existing or under construction and within commitments to the service areas, are summarized in Table 29. Inherent in the table is the assumption that Folsom South Canal will be completed into San Joaquin County and that New Melones Reservoir will serve areas of need in the San Joaquin Hydrologic Study Area.

Table 29. Net Water Demands on the Central Valley Project [a]
(1,000 acre-feet)

Hydrologic study area	1972	1990				2020			
		Alternative future				Alternative future			
		I	II	III	IV	I	II	III	IV
San Francisco Bay	60	100	90	90	80	270	210	180	110
Sacramento Basin	2,090	3,050	2,900	2,720	2,660	3,490	3,270	2,930	2,810
Delta-Central Sierra	90	840	730	570	520	900	910	910	800
San Joaquin Basin	1,620	1,940	1,940	1,940	1,930	1,940	1,940	1,940	1,940
Tulare Basin	2,180	2,840	2,850	2,820	2,810	3,040	3,040	3,040	3,020
Total	6,040	8,770	8,510	8,140	8,000	9,640	9,370	9,000	8,680

[a] Up to authorized commitments upon facilities existing or under construction.

Table 30 summarizes the additional water supply demands in the Central Valley Project service areas that would occur under each alternative future. In effect these additional demands represent that portion of the supplemental water demand that lies within or adjacent to the Central Valley Project service areas but exceeds the current service area commitments. Figure 30 graphically depicts the water supply and demand picture of the Central Valley Project.

Table 30. Possible Additional Demands on the Central Valley Project [a]
(1,000 acre-feet)

Hydrologic study area	1990				2020			
	Alternative future				Alternative future			
	I	II	III	IV	I	II	III	IV
San Francisco Bay	50	50	40	20	190	180	160	70
Central Coastal	80	80	80	80	110	110	110	110
Sacramento Basin	400	310	230	190	770	580	430	280
Delta-Central Sierra	150	110	100	80	760	540	380	220
San Joaquin Basin	670	500	280	120	1,360	800	450	170
Tulare Basin	1,550	1,290	980	910	2,690	2,110	1,410	1,130
Total	2,900	2,340	1,710	1,400	5,880	4,320	2,940	1,980

[a] In addition to authorized commitments upon facilities existing or under construction.

New facilities which could provide additional water supplies to the Central Valley Project service areas to meet the additional requirements shown in Table 30 are:

Feature	Hydrologic Study Areas Which Could Be Served
1. San Felipe Division*	SF and CC
2. Marysville Reservoir*	SF, CC, SB, DC, SJ and TB
3. West Sacramento Canal†	SB, DC and SF
4. Mid-Valley Canal†	SJ and TB
5. East Side Division†	SJ and TB
6. Allen Camp†	SB
7. Cosumnes River Division†	DC

* Authorized
† Not authorized

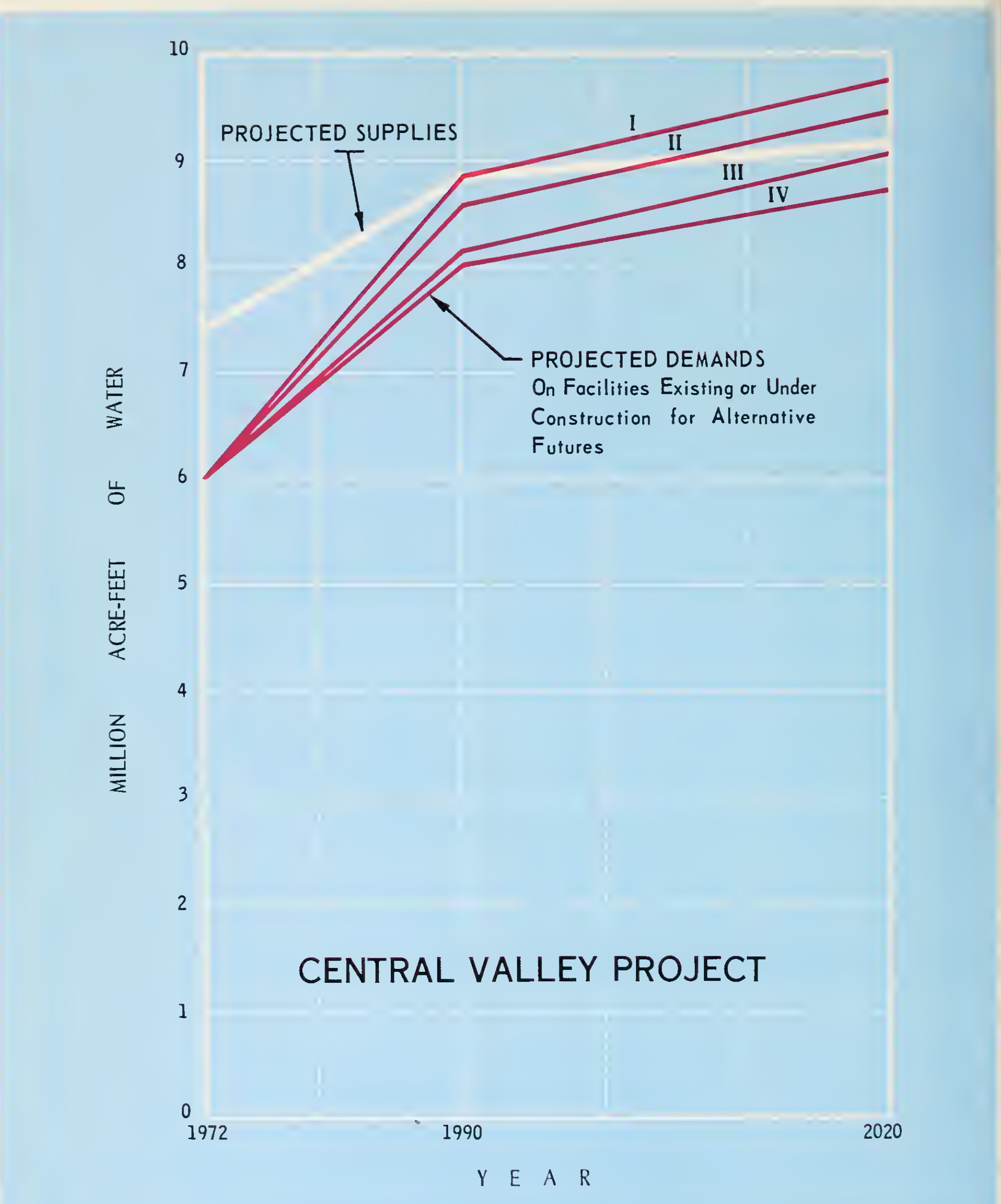


Figure 30. Projected Net Water Demands and Dependable Water Supply—Central Valley Project

Water Demands on the State Water Project

Despite the slow-down in population growth and urban water use, demands for State Water Project service are building up at a fairly rapid pace now that the basic aqueduct system is complete. Additional impetus to this build-up results from the fact that Colorado River supplies to the South Coastal area will be reduced when the Central Arizona Project begins to use some of Arizona's entitlement to Colorado River water. Another factor tending to increase State Water Project demands in Southern California is the better quality of the Northern California water compared with the Colorado River water which has a relatively high content of dissolved salts.

State Water Project demands in this report are based on assumed completion of the North Bay Aqueduct and Coastal Branch, as well as the necessary final pump units at the Delta and Edmonston Pumping Plants. Projected demands, including recreation water and conveyance losses, are as shown in Table 31.

There is potential demand for additional State Water Project service either to areas now served by the project or to areas immediately adjacent to present service areas. Satisfaction of these demands would require additions to the present or authorized State Water Project. In developing the estimates of possible future demand shown in Table 32, a limit of 880,000 acre-feet in additional service to Southern California was set. This is the estimated additional capacity in the tunnels through the Tehachapi Mountains. However, enlargement of the Edmonston Pumping Plant and many sections of the California Aqueduct north of the Tehachapi would be required to convey that much additional water. Supplemental conservation facilities would also be required to increase the water supplies of the project.

Comparison of Supply and Demand

Figure 31 shows a comparison of the State Water Project system supply and net demands for each of the four alternative projections. The demand lines for the first two alternative futures terminate when they reach the amount under contract. The supply line is the estimated capability of existing State Water Project conservation facilities.

Table 31. Net Water Demands on the State Water Project Under Present Contracts
(1,000 acre-feet)

Hydrologic study area	1972	1990 Alternative future I	1990 II	1990 III	1990 IV	2020 Alternative future I	2020 II	2020 III	2020 IV	Maximum[1] annual entitlement
San Francisco Bay	130	200	200	200	200	260	260	260	240	260
Central Coastal	0	90	90	90	90	90	90	90	90	90
South Coastal	100	1,690	1,620	1,560	1,310	2,340	2,340	2,340	1,370	2,340
Sacramento Basin	0	40	40	40	40	40	40	40	40	40
San Joaquin Basin	10	10	10	10	10	10	10	10	10	10
Tulare Basin	790	1,410	1,410	1,410	1,410	1,410	1,410	1,410	1,410	1,410
South Lahontan	0	160	150	150	130	220	220	200	110	220
Colorado Desert	0	80	80	80	80	90	90	90	90	90
Total	1,030	3,680	3,600	3,540	3,270	4,460	4,460	4,440	3,360	4,460

[1] Includes recreation water and conveyance losses.

Table 32. Possible Demands on the State Water Project in Addition to Present Contracts
(1,000 acre-feet)

Hydrologic study area	1990 Alternative future I	1990 II	1990 III	1990 IV	2020 Alternative future I	2020 II	2020 III	2020 IV
San Francisco Bay	10	10	10	0	120	80	60	20
Central Coastal	40	20	10	10	100	90	70	40
South Coastal	0	0	0	0	610	300	60	0
San Joaquin Basin	0	0	0	0	40	30	0	0
Tulare Basin	370	210	60	10	800	500	240	80
South Lahontan	0	0	0	0	80	50	20	0
Colorado Desert	70	10	0	0	190	70	70	20
Total	490	250	80	20	1,940	1,120	520	160

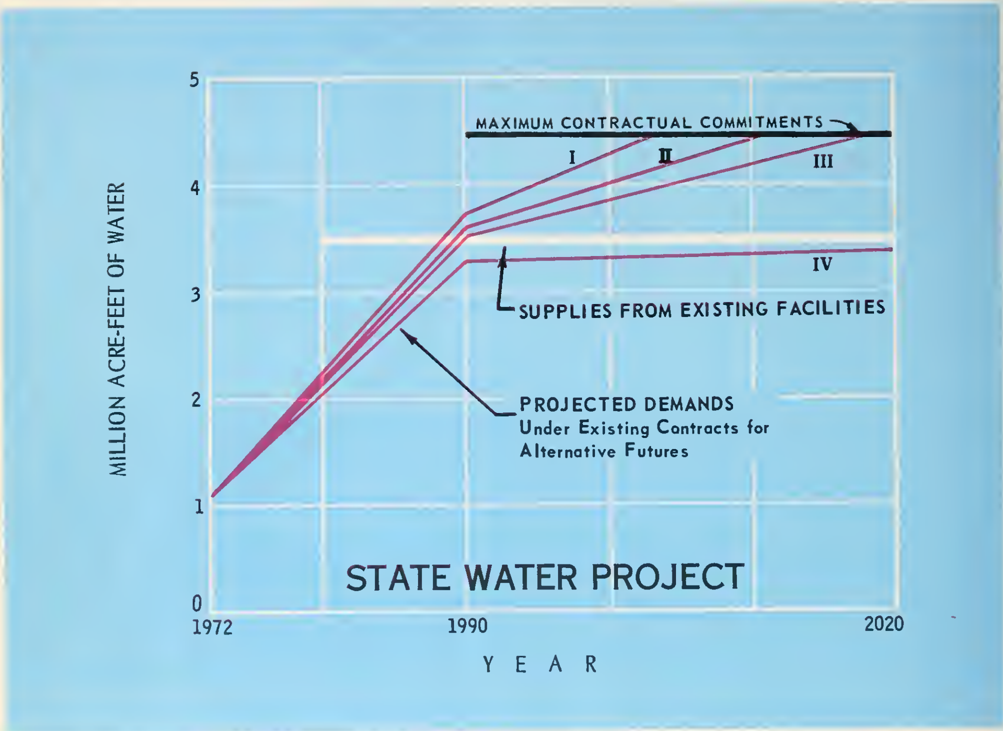


Figure 31. Projected Net Water Demands and Dependable Water Supply—State Water Project

Summary of Regional Water Supply and Demand

Throughout the text of this bulletin, "The California Water Plan—Outlook in 1974", most of the presentation has been given from the statewide viewpoint. Data on projected future growth, water demands, and water supply has been summarized in tabular form to show statewide total quantities and their distribution.

The statewide picture is important for an overall assessment and serves to set the stage for identifying possible future problem areas and planning future actions. However, it does not always reflect the local situation and problems. Most of the input data developed during the course of study leading to this publication was first assembled by "planning subareas" or subdivisions of the hydrologic study areas. These planning subareas are delinated and named on the following figures. While the scope of this bulletin does not permit publication of all the data for each planning subarea, the information is available in backup computations.

For convenience in assessing the water supply and demand outlook for each hydrologic study area, data are summarized for each area on Figures 32 through 53. The concurrent projection of both a reserve water supply and a supplemental demand for water is an indication that surplus water supply is available to some planning subareas of a hydrologic study area while at the same time there is a deficiency of supply in others. The usable water supplies shown on the figures are based on the expectation that facilities under construction and others needed to meet contractual commitments will be completed and provide water.

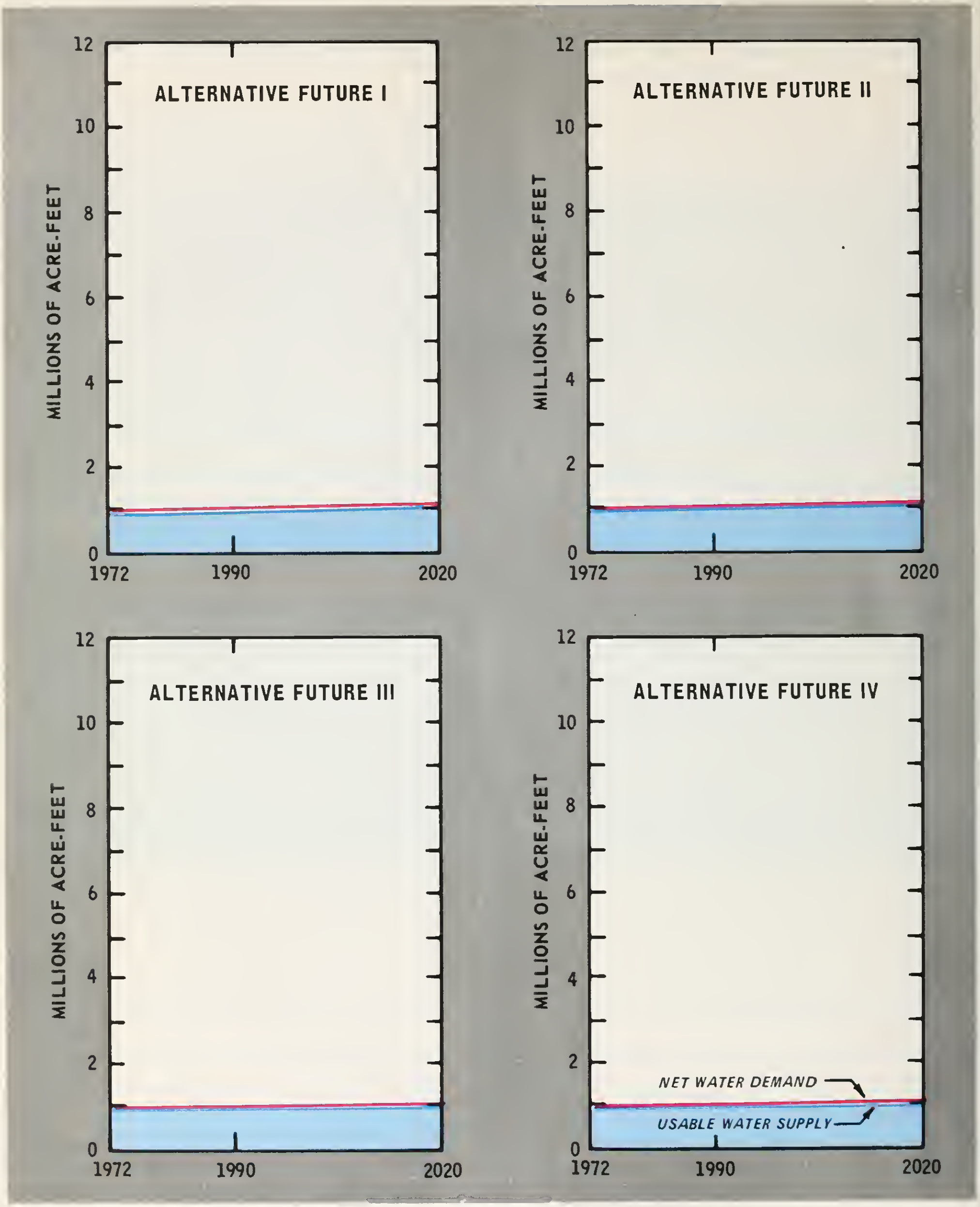
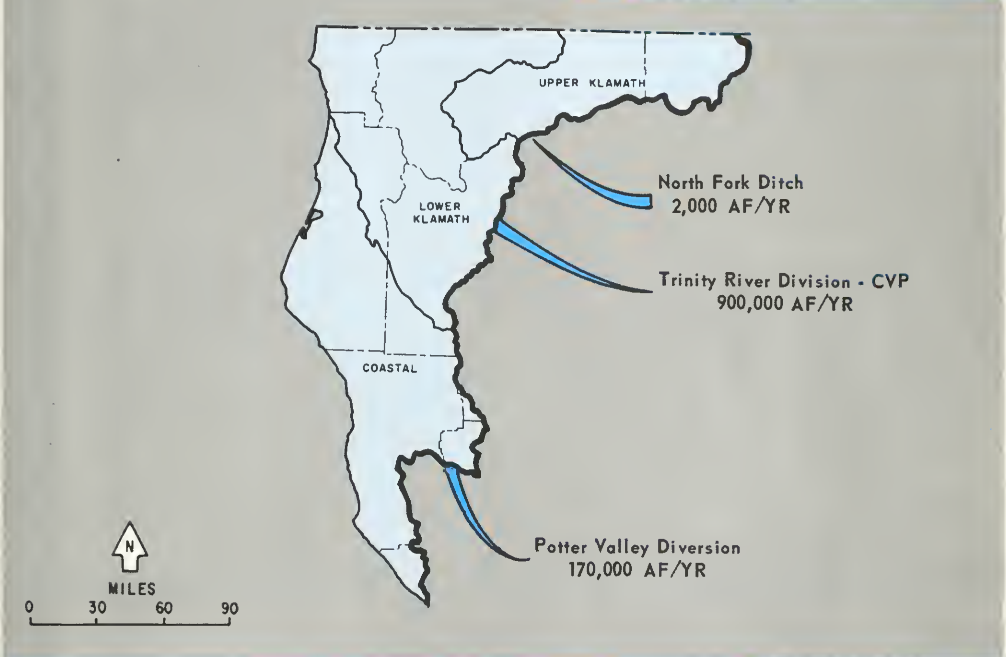


Figure 32. Net Water Demands and Water Supply—North Coastal Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	390
IMPORTS BY LOCAL WATER AGENCIES	2
GROUND WATER SAFE YIELD	140
OTHER FEDERAL WATER DEVELOPMENT	430
RESERVE SUPPLY	–20
USABLE WATER SUPPLY	940
GROUND WATER OVERDRAFT	0
TOTAL	940



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	180	250	390	240	350	230	310	210	230
URBAN AREA (ACRES)	50	60	80	60	80	60	70	50	60
M & I WATER DEMAND (AF/YR)	93	104	126	102	120	101	114	97	100
IRRIGATED LAND (ACRES)	240	240	260	240	260	240	250	240	250
REMAINING IRRIGABLE LAND (ACRES)	580	570	540	570	540	570	560	580	560
IRRIGATION WATER DEMAND (AF/YR)	710	720	740	720	740	710	730	710	730
POWER PLANT COOLING (AF/YR)	0	0	0	0	0	0	0	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	323	359	362	359	362	359	362	359	362
TOTAL APPLIED WATER DEMAND (AF/YR)	1,120	1,180	1,230	1,180	1,220	1,170	1,210	1,170	1,190
TOTAL NET WATER DEMAND (AF/YR)	940	990	1,040	990	1,030	980	1,010	980	1,000
DEPENDABLE WATER SUPPLY (AF/YR)	960	980	1,010	980	1,010	980	1,010	980	1,010
SUPPLEMENTAL WATER DEMAND (AF/YR)	2	20	30	20	30	20	20	20	20

Figure 33. North Coastal Hydrologic Study Area

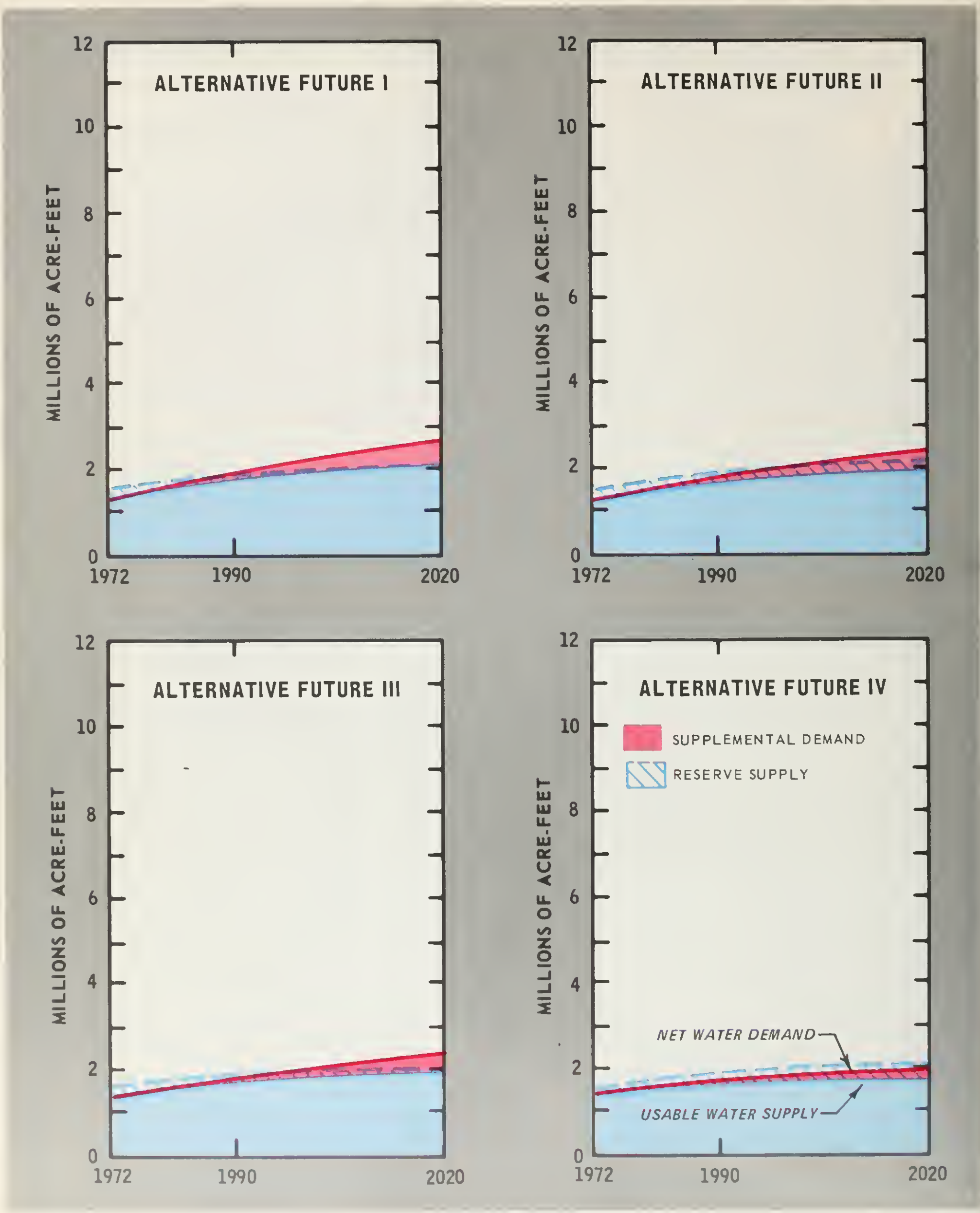
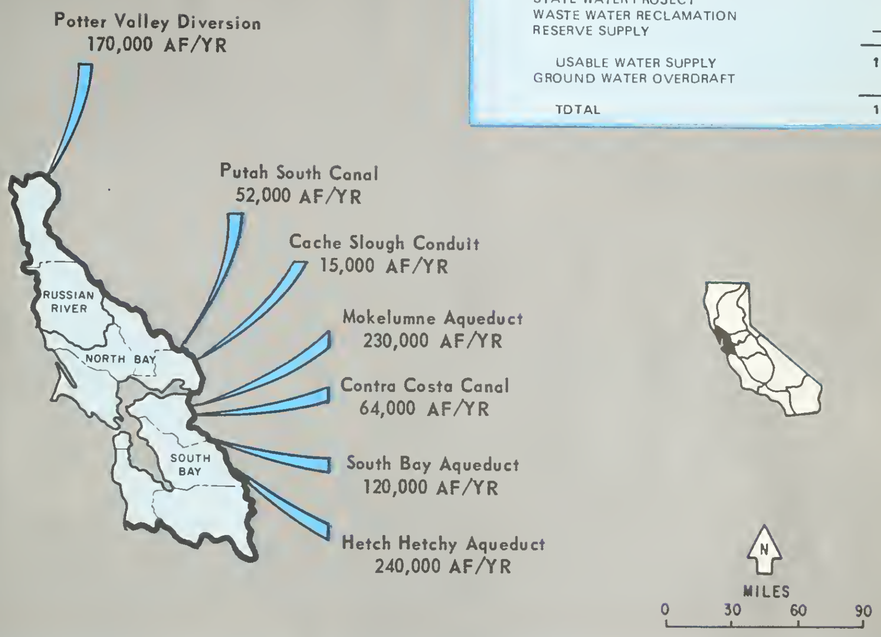


Figure 34. Net Water Demands and Water Supply—San Francisco Bay Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	170
IMPORTS BY LOCAL WATER AGENCIES	700
GROUND WATER SAFE YIELD	330
CENTRAL VALLEY PROJECT	80
OTHER FEDERAL WATER DEVELOPMENT	100
STATE WATER PROJECT	130
WASTE WATER RECLAMATION	8
RESERVE SUPPLY	− 260
USABLE WATER SUPPLY	1,260
GROUND WATER OVERDRAFT	0
TOTAL	1,260



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	4,630	5,940	8,670	5,800	7,920	5,680	7,350	5,270	5,700
URBAN AREA (ACRES)	485	600	810	580	750	570	690	530	540
M & I WATER DEMAND (AF/YR)	990	1,480	2,240	1,460	2,070	1,430	1,940	1,340	1,570
IRRIGATED LAND (ACRES)	110	130	150	120	140	120	140	120	120
REMAINING IRRIGABLE LAND (ACRES)	590	490	330	510	380	520	420	550	540
IRRIGATION WATER DEMAND (AF/YR)	250	290	330	280	320	290	310	280	280
POWER PLANT COOLING (AF/YR)	5	10	0	10	0	10	0	10	0
FISH, WILDLIFE & RECREATION (AF/YR)	24	37	46	37	46	37	46	37	46
TOTAL APPLIED WATER DEMAND (AF/YR)	1,250	1,810	2,620	1,770	2,440	1,750	2,300	1,660	1,890
TOTAL NET WATER DEMAND (AF/YR)	1,270	1,820	2,630	1,780	2,450	1,760	2,310	1,660	1,900
DEPENDABLE WATER SUPPLY (AF/YR)	1,520	1,860	2,030	1,860	2,030	1,860	2,030	1,860	2,030
SUPPLEMENTAL WATER DEMAND (AF/YR)	9	80	600	70	480	70	370	30	120

Figure 35. San Francisco Bay Hydrologic Study Area

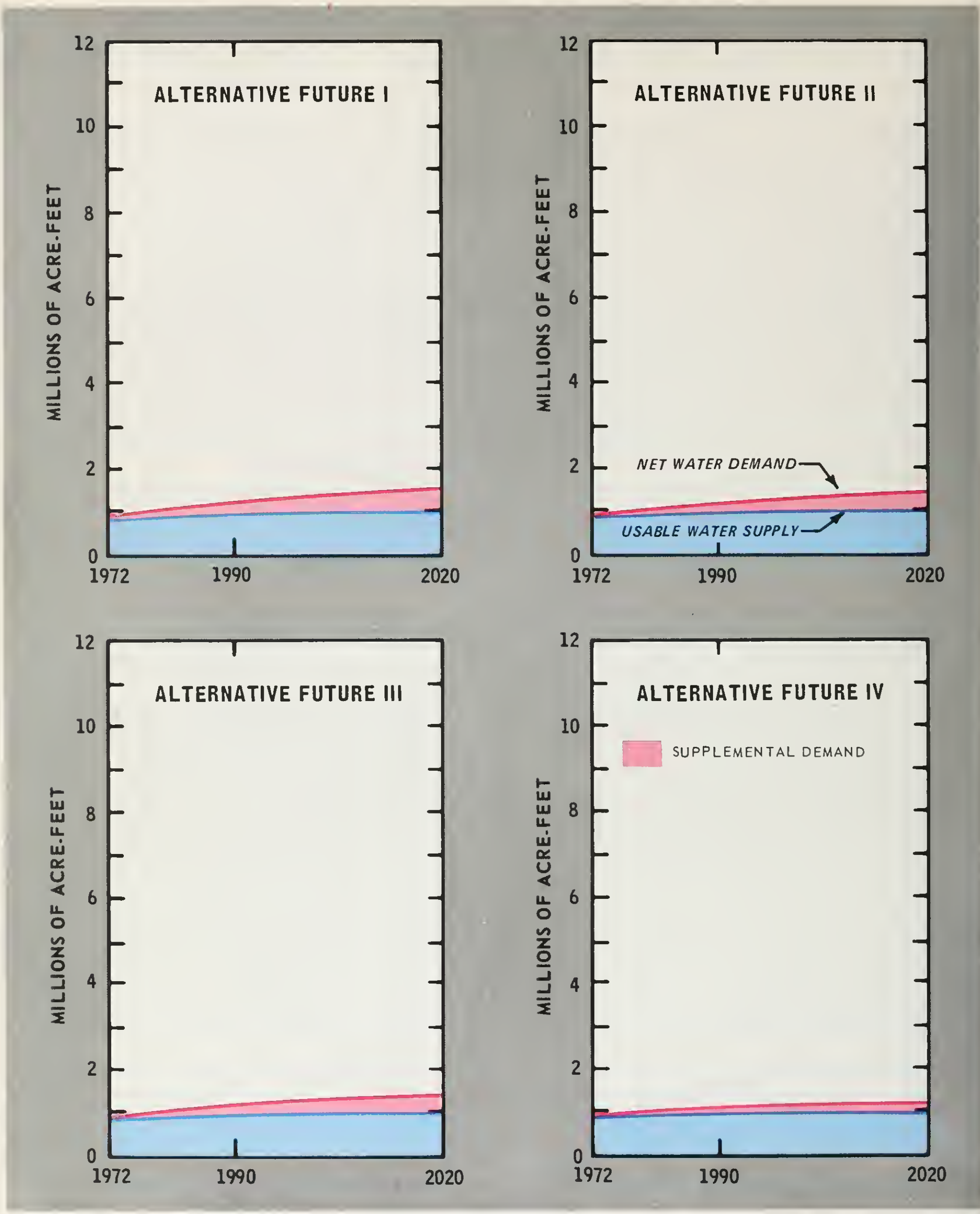
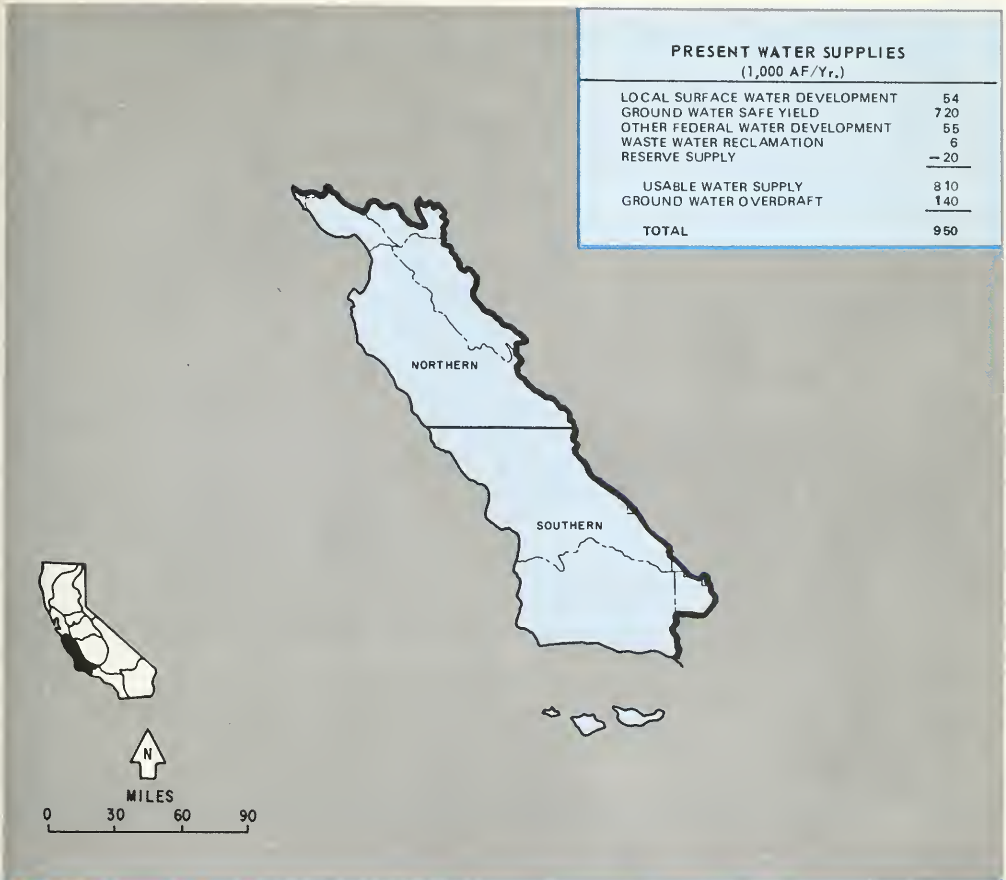


Figure 36. Net Water Demands and Water Supply—Central Coastal Hydrologic Study Area



PRESENT WATER SUPPLIES
(1,000 AF/Yr.)

LOCAL SURFACE WATER DEVELOPMENT	54
GROUND WATER SAFE YIELD	720
OTHER FEDERAL WATER DEVELOPMENT	55
WASTE WATER RECLAMATION	6
RESERVE SUPPLY	−20
USABLE WATER SUPPLY	810
GROUND WATER OVERDRAFT	140
TOTAL	950

ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I		II		III		IV	
		1990	2020	1990	2020	1990	2020	1990	2020
POPULATION	840	1,370	2,430	1,340	2,200	1,290	2,030	1,130	1,370
URBAN AREA (ACRES)	140	200	300	200	290	200	270	170	190
M & I WATER DEMAND (AF/YR)	181	308	569	300	516	289	473	252	318
IRRIGATED LAND (ACRES)	420	500	530	480	520	480	520	480	510
REMAINING IRRIGABLE LAND (ACRES)	1,070	960	880	980	890	980	900	990	950
IRRIGATION WATER DEMAND (AF/YR)	1,030	1,240	1,310	1,200	1,270	1,190	1,240	1,200	1,220
POWER PLANT COOLING (AF/YR)	0	0	0	0	0	0	0	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	2	3	6	3	6	3	6	3	6
TOTAL APPLIED WATER DEMAND (AF/YR)	1,210	1,550	1,890	1,500	1,790	1,480	1,720	1,460	1,540
TOTAL NET WATER DEMAND(AF/YR)	950	1,240	1,560	1,200	1,480	1,180	1,410	1,150	1,250
DEPENDABLE WATER SUPPLY(AF/YR)	830	950	950	950	950	950	950	950	950
SUPPLEMENTAL WATER DEMAND (AF/YR)	140	290	610	250	530	230	460	200	300

Figure 37. Central Coastal Hydrologic Study Area

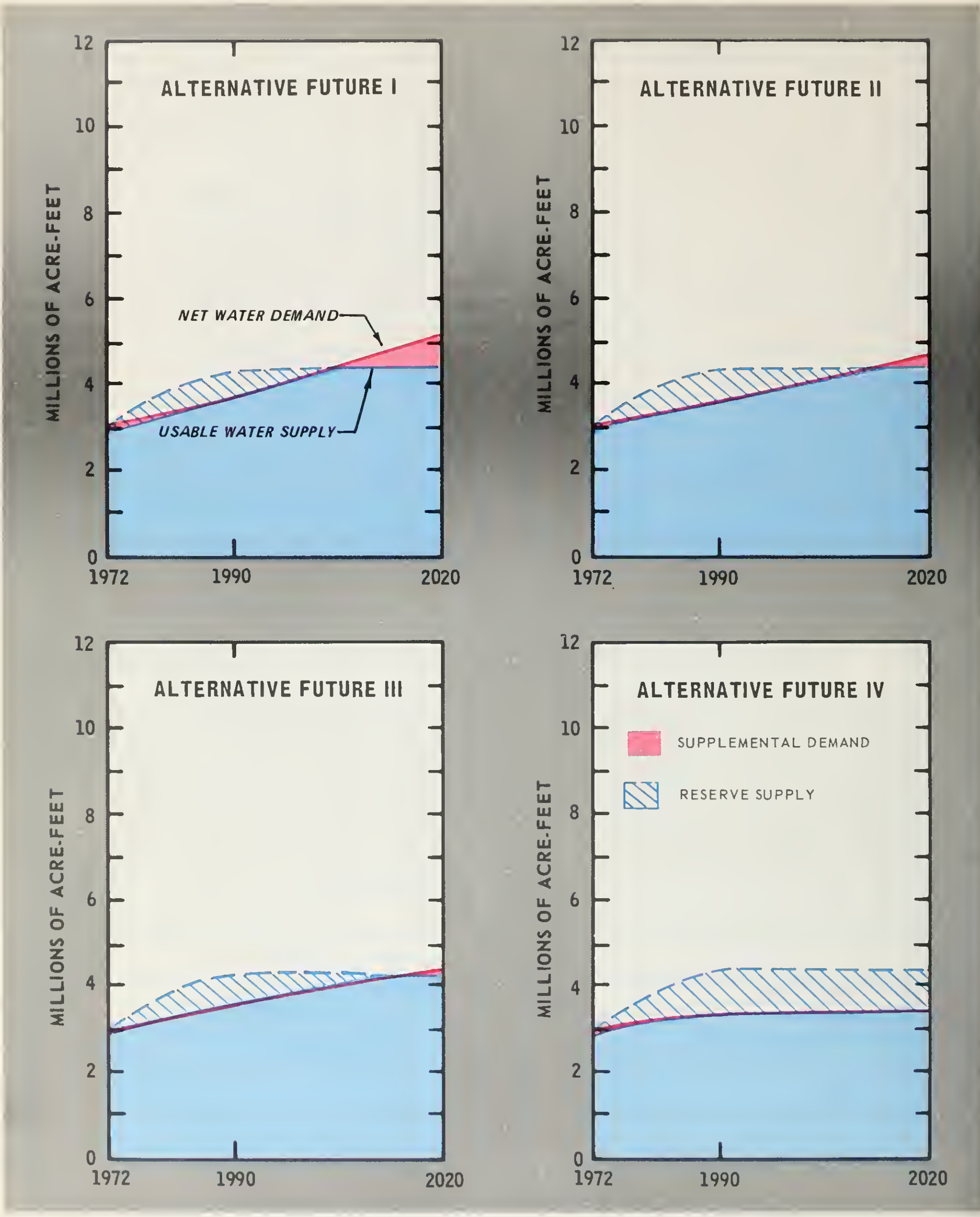
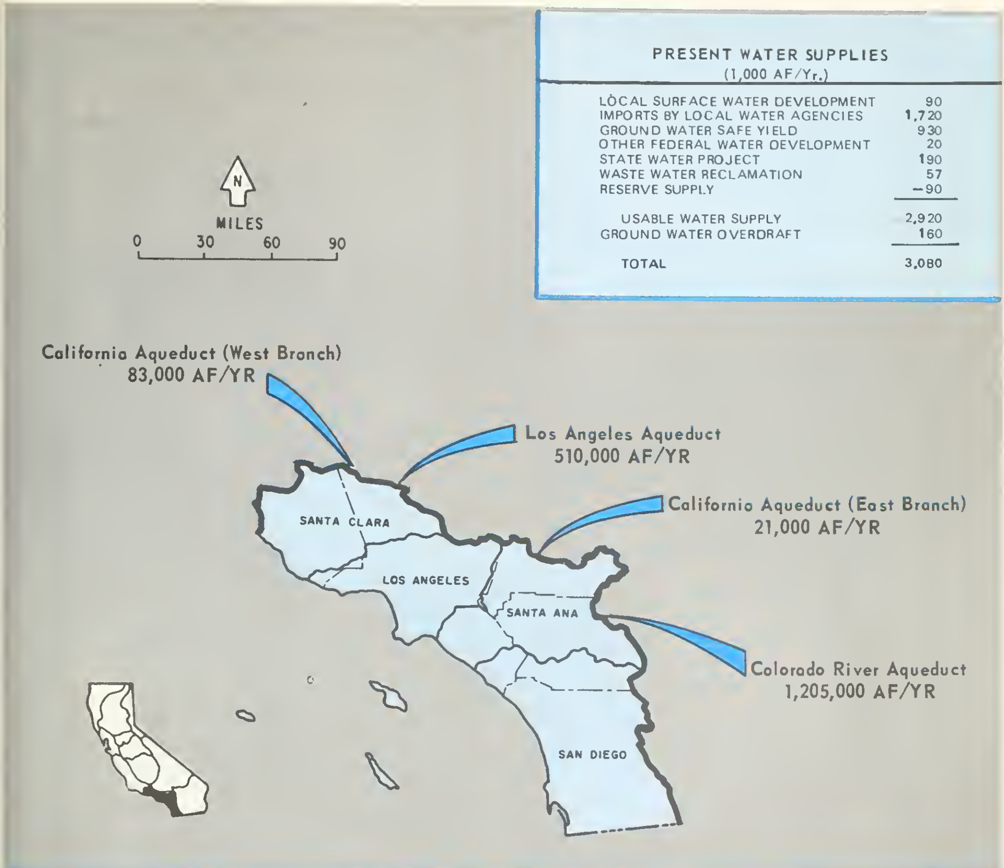


Figure 38. Net Water Demands and Water Supply—South Coastal Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	90
IMPORTS BY LOCAL WATER AGENCIES	1,720
GROUND WATER SAFE YIELD	930
OTHER FEDERAL WATER DEVELOPMENT	20
STATE WATER PROJECT	190
WASTE WATER RECLAMATION	57
RESERVE SUPPLY	−90
USABLE WATER SUPPLY	2,920
GROUND WATER OVERDRAFT	160
TOTAL	3,080



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	11,240	14,620	22,510	14,260	20,300	13,930	19,140	12,510	13,790
URBAN AREA (ACRES)	1,340	1,570	1,870	1,550	1,820	1,530	1,780	1,480	1,520
M & I WATER DEMAND (AF/YR)	2,370	3,130	4,830	3,050	4,360	2,980	4,120	2,670	2,980
IRRIGATED LAND (ACRES)	390	290	220	290	220	290	220	300	220
REMAINING IRRIGABLE LAND (ACRES)	1,000	870	640	890	680	910	730	950	940
IRRIGATION WATER DEMAND (AF/YR)	920	730	530	720	510	720	520	750	520
POWER PLANT COOLING (AF/YR)	18	30	80	30	40	30	0	30	0
FISH, WILDLIFE & RECREATION (AF/YR)	6	19	23	19	23	19	23	19	23
TOTAL APPLIED WATER DEMAND (AF/YR)	3,320	3,900	5,470	3,820	4,940	3,750	4,660	3,470	3,520
TOTAL NET WATER DEMAND (AF/YR)	3,030	3,770	5,200	3,700	4,720	3,640	4,480	3,390	3,460
DEPENDABLE WATER SUPPLY (AF/YR)	3,010	4,420	4,420	4,420	4,420	4,420	4,420	4,420	4,420
SUPPLEMENTAL WATER DEMAND (AF/YR)	160	0	780	0	300	0	60	0	0

Figure 39. South Coastal Hydrologic Study Area

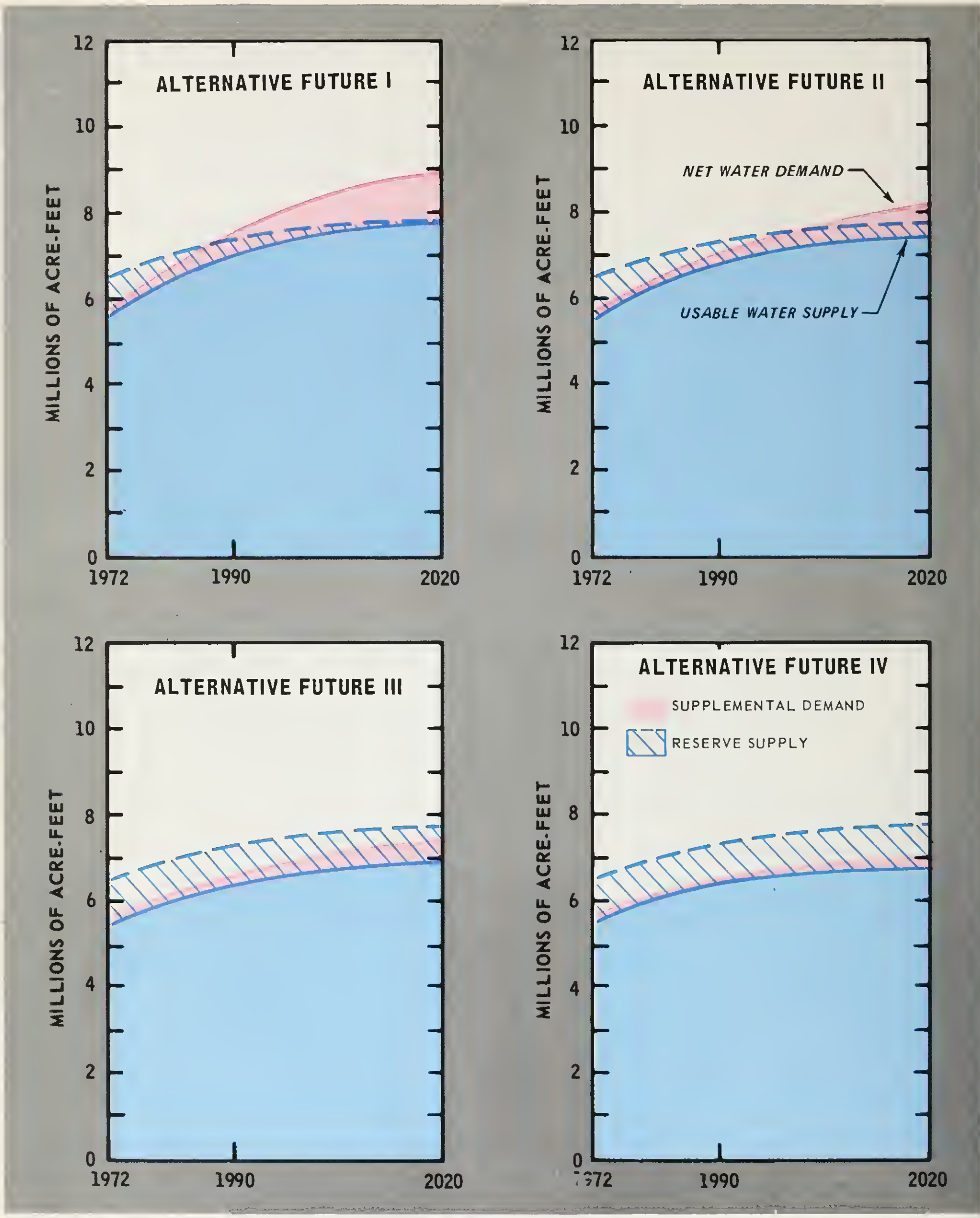
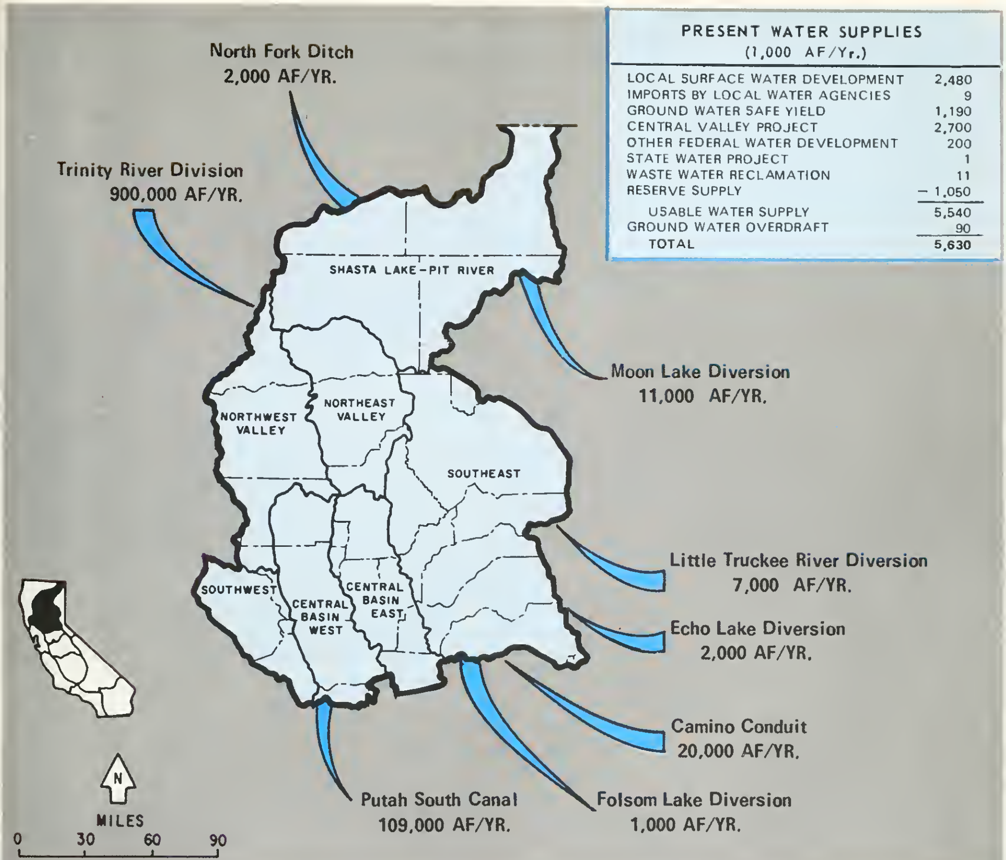


Figure 40. Net Water Demands and Water Supply—Sacramento Basin Hydrologic Study Area



PRESENT WATER SUPPLIES
(1,000 AF/Yr.)

LOCAL SURFACE WATER DEVELOPMENT	2,480
IMPORTS BY LOCAL WATER AGENCIES	9
GROUND WATER SAFE YIELD	1,190
CENTRAL VALLEY PROJECT	2,700
OTHER FEDERAL WATER DEVELOPMENT	200
STATE WATER PROJECT	1
WASTE WATER RECLAMATION	11
RESERVE SUPPLY	– 1,050
USABLE WATER SUPPLY	5,540
GROUND WATER OVERDRAFT	90
TOTAL	5,630

ITEM (Quantities in 1,000s)		ALTERNATIVE FUTURE							
		I		II		III		IV	
	1972	1990	2020	1990	2020	1990	2020	1990	2020
POPULATION	1,210	1,700	2,600	1,670	2,400	1,630	2,230	1,470	1,620
URBAN AREA (ACRES)	215	260	350	250	330	250	300	230	230
M & I WATER DEMAND (AF/YR)	470	700	1,040	687	968	674	908	621	702
IRRIGATED LAND (ACRES)	1,520	1,950	2,250	1,850	2,060	1,740	1,890	1,680	1,760
REMAINING IRRIGABLE LAND (ACRES)	2,730	2,250	1,870	2,360	2,080	2,470	2,280	2,550	2,470
IRRIGATION WATER DEMAND (AF/YR)	6,020	7,940	9,080	7,540	8,350	7,050	7,540	6,960	7,410
POWER PLANT COOLING (AF/YR)	0	50	140	0	60	0	50	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	125	170	174	170	174	170	174	170	174
TOTAL APPLIED WATER DEMAND (AF/YR)	6,610	8,860	10,400	8,400	9,550	7,900	8,670	7,750	8,290
TOTAL NET WATER DEMAND (AF/YR)	5,780	7,610	9,030	7,200	8,240	6,800	7,530	6,630	7,080
DEPENDABLE WATER SUPPLY (AF/YR)	6,590	7,390	7,820	7,390	7,820	7,390	7,820	7,390	7,820
SUPPLEMENTAL WATER DEMAND (AF/YR)	240	500	1,210	360	730	290	530	210	320

Figure 41. Sacramento Basin Hydrologic Study Area

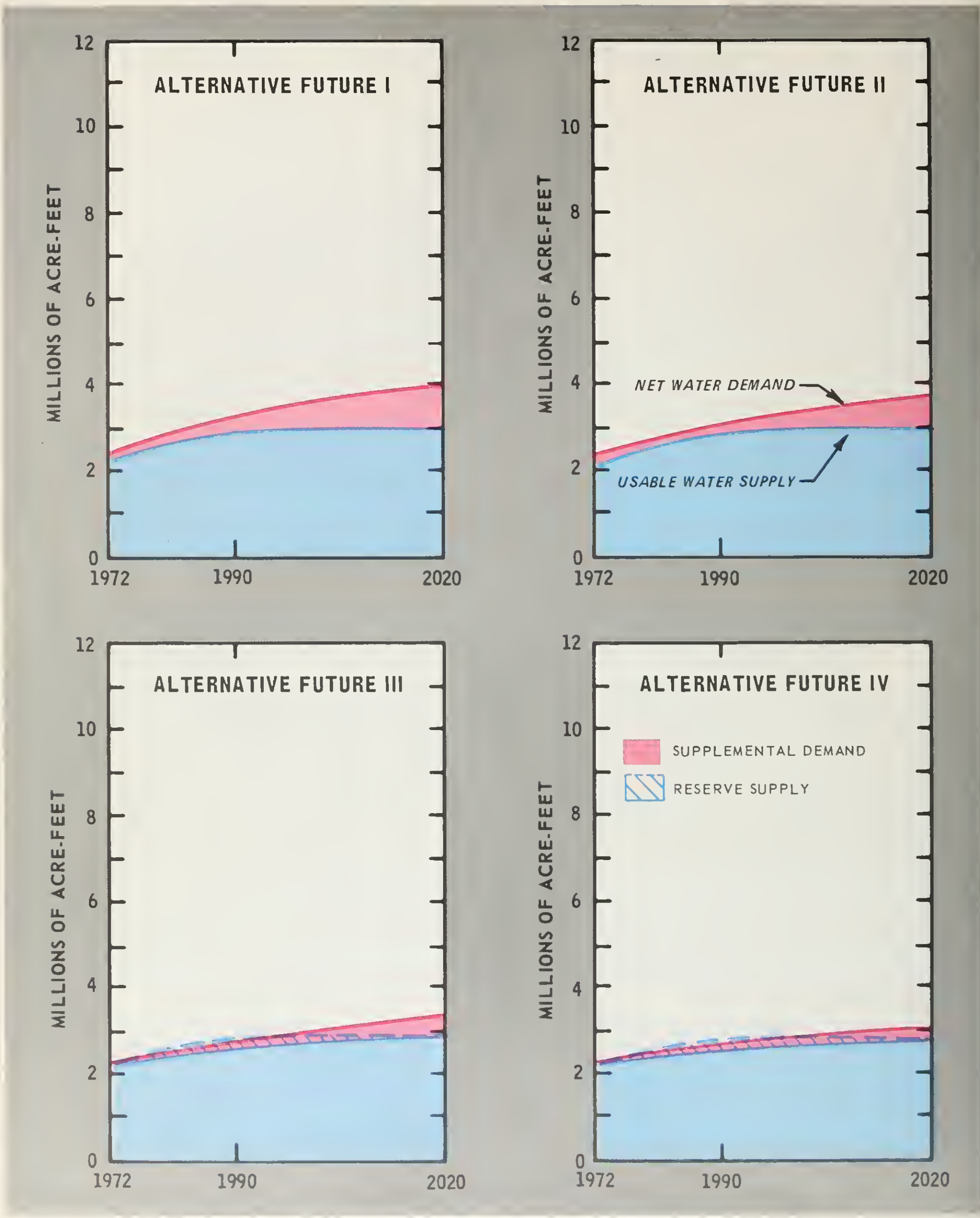
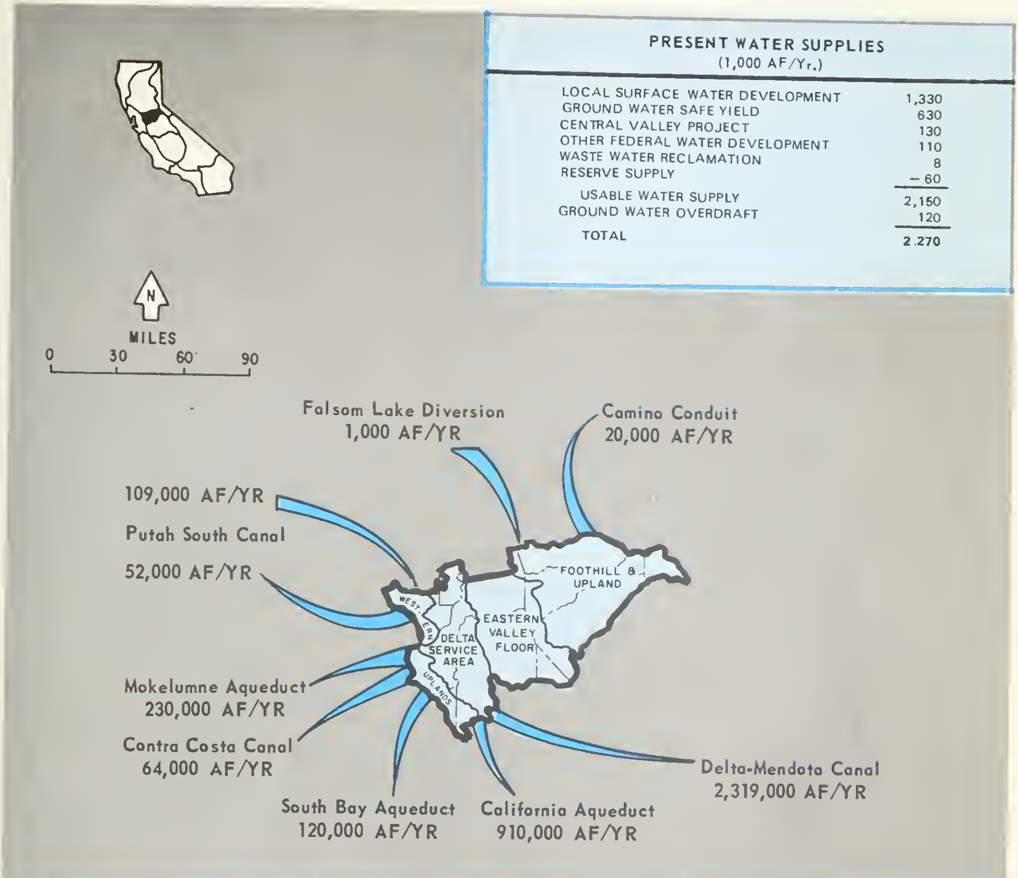


Figure 42. Net Water Demands and Water Supply—Delta-Central Sierra Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	1,330
GROUND WATER SAFE YIELD	630
CENTRAL VALLEY PROJECT	130
OTHER FEDERAL WATER DEVELOPMENT	110
WASTE WATER RECLAMATION	8
RESERVE SUPPLY	– 60
USABLE WATER SUPPLY	2,150
GROUND WATER OVERDRAFT	120
TOTAL	2.270



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	470	760	1,730	730	1,550	710	1,420	640	930
URBAN AREA (ACRES)	75	110	230	110	210	110	190	100	120
M & I WATER DEMAND (AF/YR)	173	251	537	247	490	239	451	219	323
IRRIGATED LAND (ACRES)	800	990	1,130	930	1,060	880	980	850	920
REMAINING IRRIGABLE LAND (ACRES)	900	670	410	730	500	780	600	820	730
IRRIGATION WATER DEMAND (AF/YR)	2,470	3,220	3,700	3,010	3,540	2,810	3,250	2,710	3,020
POWER PLANT COOLING (AF/YR)	20	100	150	75	100	50	110	40	70
FISH, WILDLIFE & RECREATION (AF/YR)	6	7	9	7	9	7	9	7	9
TOTAL APPLIED WATER DEMAND (AF/YR)	2,670	3,570	4,400	3,340	4,140	3,110	3,820	2,970	3,420
TOTAL NET WATER DEMAND (AF/YR)	2,270	3,110	3,860	2,900	3,630	2,700	3,360	2,580	3,010
DEPENDABLE WATER SUPPLY (AF/YR)	2,210	2,910	2,930	2,910	2,930	2,910	2,930	2,910	2,930
SUPPLEMENTAL WATER DEMAND (AF/YR)	120	220	930	120	710	110	550	80	280

Figure 43. Delta-Central Sierra Hydralogic Study Area

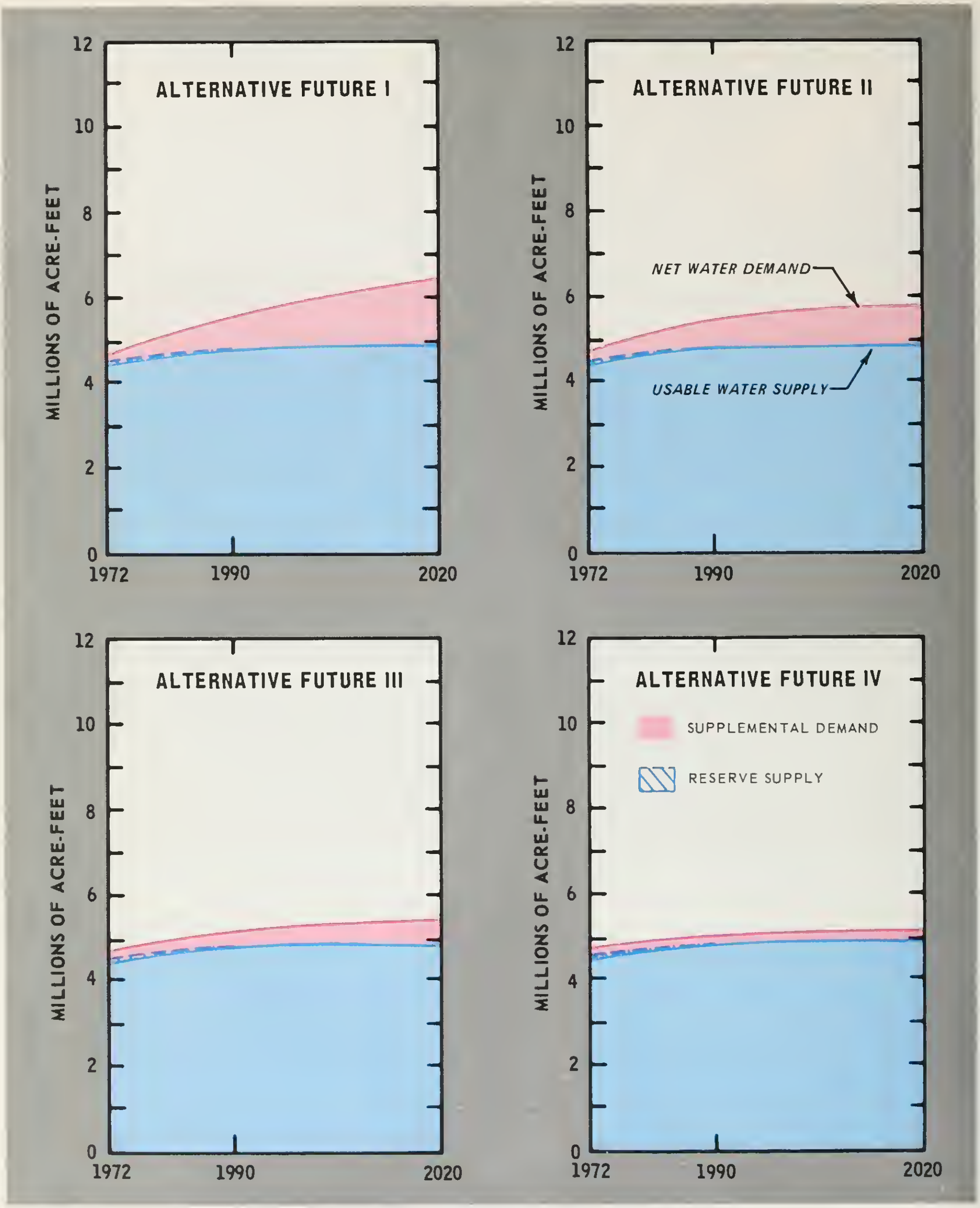
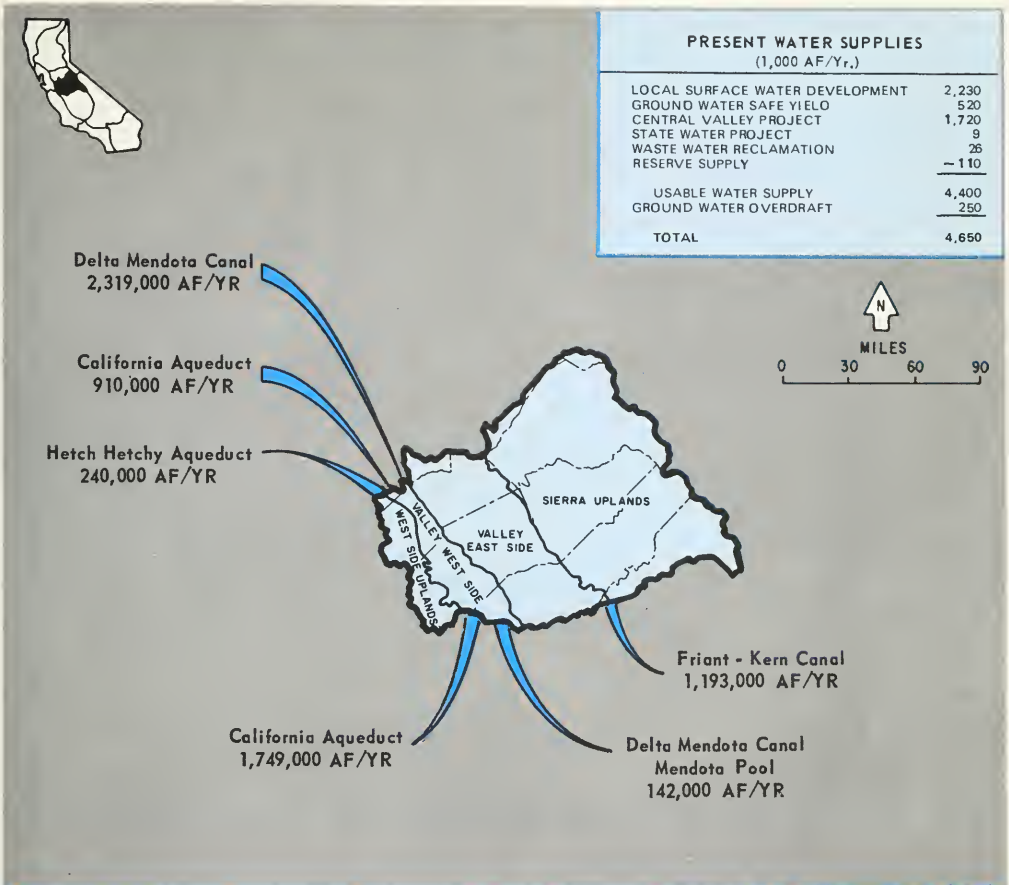


Figure 44. Net Water Demands and Water Supply—San Joaquin Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	2,230
GROUND WATER SAFE YIELD	520
CENTRAL VALLEY PROJECT	1,720
STATE WATER PROJECT	9
WASTE WATER RECLAMATION	26
RESERVE SUPPLY	−110
USABLE WATER SUPPLY	4,400
GROUND WATER OVERDRAFT	250
TOTAL	4,650



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	440	650	1,140	640	1,010	620	940	560	660
URBAN AREA (ACRES)	55	80	130	80	120	80	110	70	90
M & I WATER DEMAND (AF/YR)	192	295	548	287	485	279	451	249	307
IRRIGATED LAND (ACRES)	1,350	1,690	1,920	1,610	1,690	1,530	1,580	1,480	1,490
REMAINING IRRIGABLE LAND (ACRES)	1,160	790	510	870	750	950	870	1,010	980
IRRIGATION WATER DEMAND (AF/YR)	5,450	6,620	7,320	6,390	6,600	6,040	6,180	5,750	5,750
POWER PLANT COOLING (AF/YR)	0	0	140	0	70	0	0	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	91	94	95	94	95	94	95	94	95
TOTAL APPLIED WATER DEMAND (AF/YR)	5,730	7,010	8,100	6,770	7,250	6,410	6,730	6,090	6,150
TOTAL NET WATER DEMAND (AF/YR)	4,650	5,510	6,280	5,350	5,710	5,120	5,320	4,960	5,030
DEPENDABLE WATER SUPPLY (AF/YR)	4,510	4,840	4,860	4,840	4,860	4,840	4,860	4,840	4,860
SUPPLEMENTAL WATER DEMAND (AF/YR)	250	670	1,420	510	850	280	460	130	170

Figure 45. San Joaquin Hydrologic Study Area

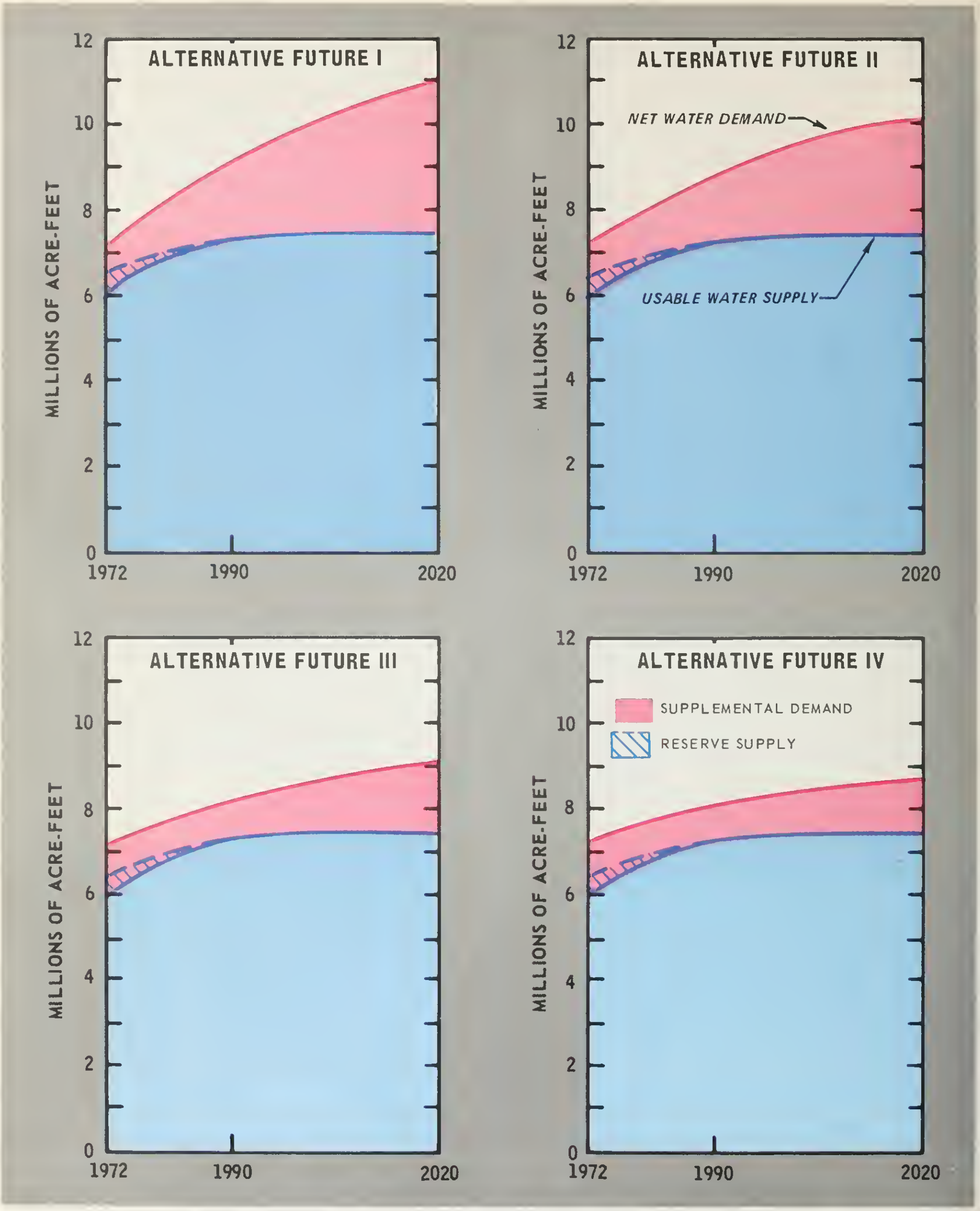
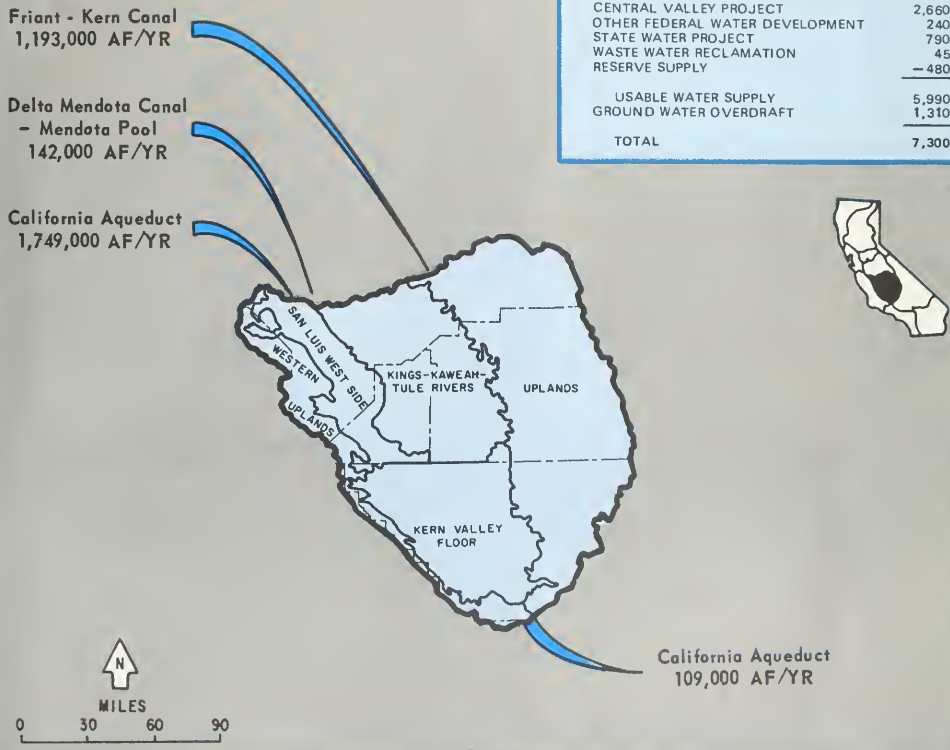


Figure 46. Net Water Demands and Water Supply—Tulare Basin Hydrologic Study Area

PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	2,220
GROUND WATER SAFE YIELD	510
CENTRAL VALLEY PROJECT	2,660
OTHER FEDERAL WATER DEVELOPMENT	240
STATE WATER PROJECT	790
WASTE WATER RECLAMATION	45
RESERVE SUPPLY	−480
USABLE WATER SUPPLY	5,990
GROUND WATER OVERDRAFT	1,310
TOTAL	7,300



ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	980	1,280	2,030	1,250	1,820	1,240	1,730	1,160	1,360
URBAN AREA (ACRES)	135	160	230	160	210	160	200	150	170
M & I WATER DEMAND (AF/YR)	363	493	798	479	718	471	679	441	530
IRRIGATED LAND (ACRES)	3,100	3,560	4,040	3,370	3,730	3,250	3,430	3,190	3,260
REMAINING IRRIGABLE LAND (ACRES)	1,940	1,450	900	1,640	1,230	1,760	1,540	1,830	1,740
IRRIGATION WATER DEMAND (AF/YR)	10,890	13,070	14,870	12,510	13,720	11,750	12,360	11,580	11,750
POWER PLANT COOLING (AF/YR)	0	70	240	35	130	20	60	20	60
FISH, WILDLIFE & RECREATION (AF/YR)	43	68	70	68	70	68	70	68	70
TOTAL APPLIED WATER DEMAND (AF/YR)	11,300	13,700	16,000	13,100	14,600	12,300	13,200	12,100	12,400
TOTAL NET WATER DEMAND (AF/YR)	7,300	9,200	11,000	8,800	10,110	8,290	9,160	8,180	8,700
DEPENDABLE WATER SUPPLY (AF/YR)	6,470	7,330	7,360	7,330	7,360	7,330	7,360	7,330	7,360
SUPPLEMENTAL WATER DEMAND (AF/YR)	1,310	1,920	3,640	1,500	2,750	1,030	1,800	920	1,340

Figure 47. Tulare Basin Hydrologic Study Area

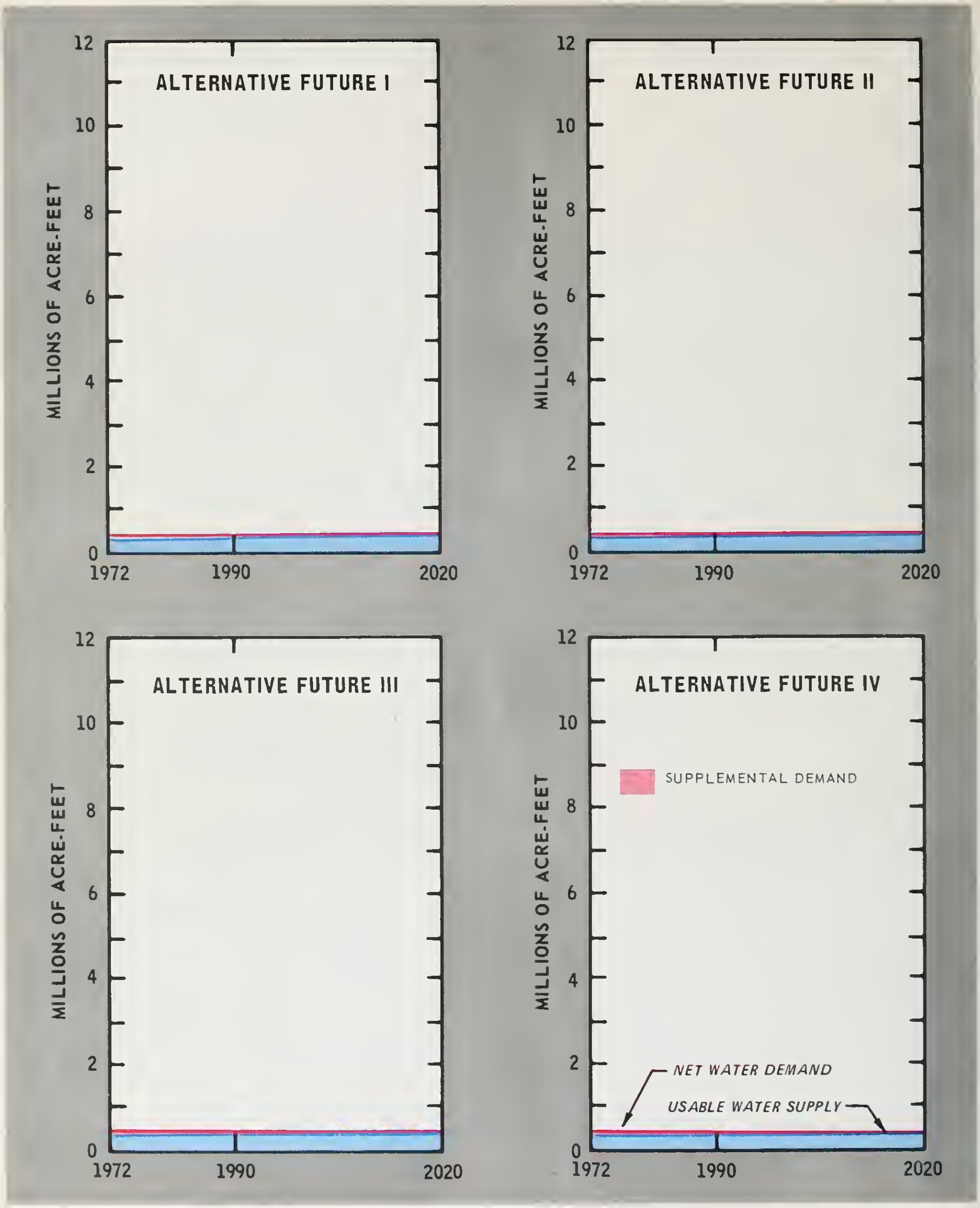
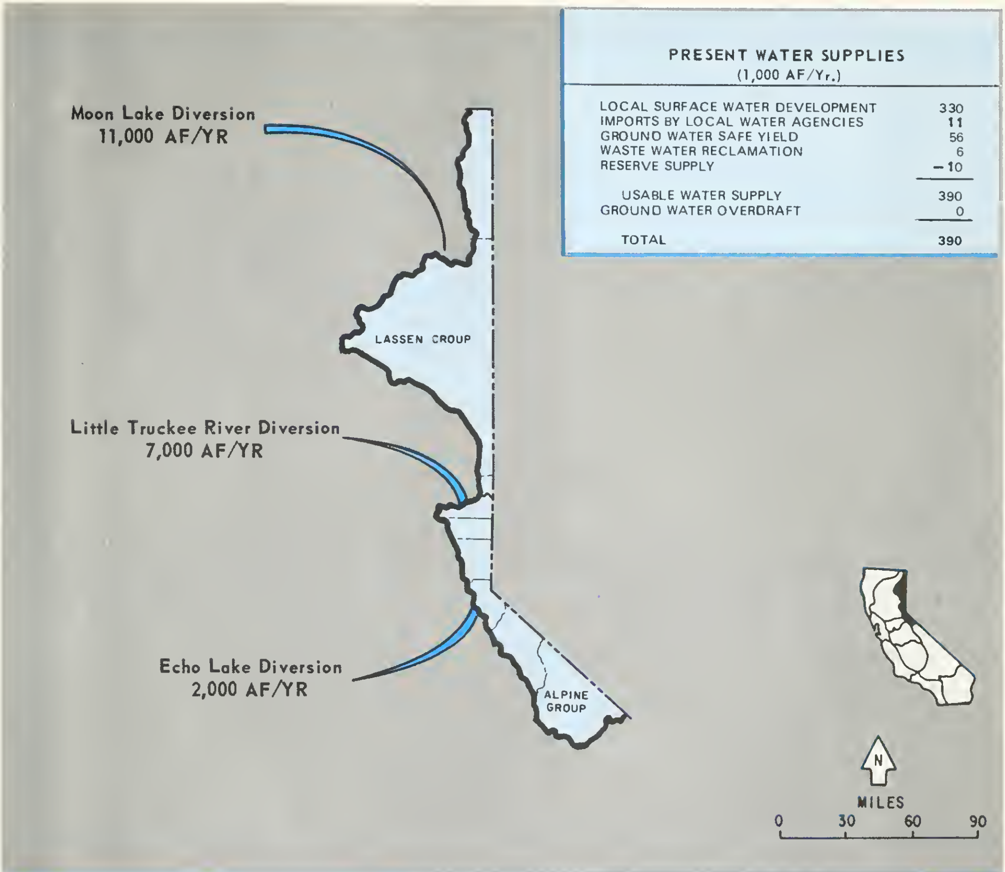


Figure 48. Net Water Demands and Water Supply—North Lahontan Hydrologic Study Area



PRESENT WATER SUPPLIES
(1,000 AF/Yr.)

LOCAL SURFACE WATER DEVELOPMENT	330
IMPORTS BY LOCAL WATER AGENCIES	11
GROUND WATER SAFE YIELD	56
WASTE WATER RECLAMATION	6
RESERVE SUPPLY	−10
USABLE WATER SUPPLY	390
GROUND WATER OVERDRAFT	0
TOTAL	390

ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I		II		III		IV	
		1990	2020	1990	2020	1990	2020	1990	2020
POPULATION	40	70	110	70	100	70	90	60	60
URBAN AREA (ACRES)	20	40	50	40	50	40	40	30	30
M & I WATER DEMAND (AF/YR)	23	40	68	40	59	39	54	32	35
IRRIGATED LAND (ACRES)	140	140	140	140	140	140	140	130	130
REMAINING IRRIGABLE LAND (ACRES)	470	460	460	460	460	460	460	470	470
IRRIGATION WATER DEMAND (AF/YR)	420	430	430	430	430	430	430	400	400
POWER PLANT COOLING (AF/YR)	0	0	0	0	0	0	0	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	11	11	13	11	13	11	13	11	13
TOTAL APPLIED WATER DEMAND (AF/YR)	454	479	507	479	498	478	493	441	444
TOTAL NET WATER DEMAND(AF/YR)	430	450	480	450	470	450	470	420	420
DEPENDABLE WATER SUPPLY(AF/YR)	400	440	460	440	460	440	460	440	460
SUPPLEMENTAL WATER DEMAND (AF/YR)	40	20	20	20	10	20	10	20	0

Figure 49. North Lahonton Hydrologic Study Area

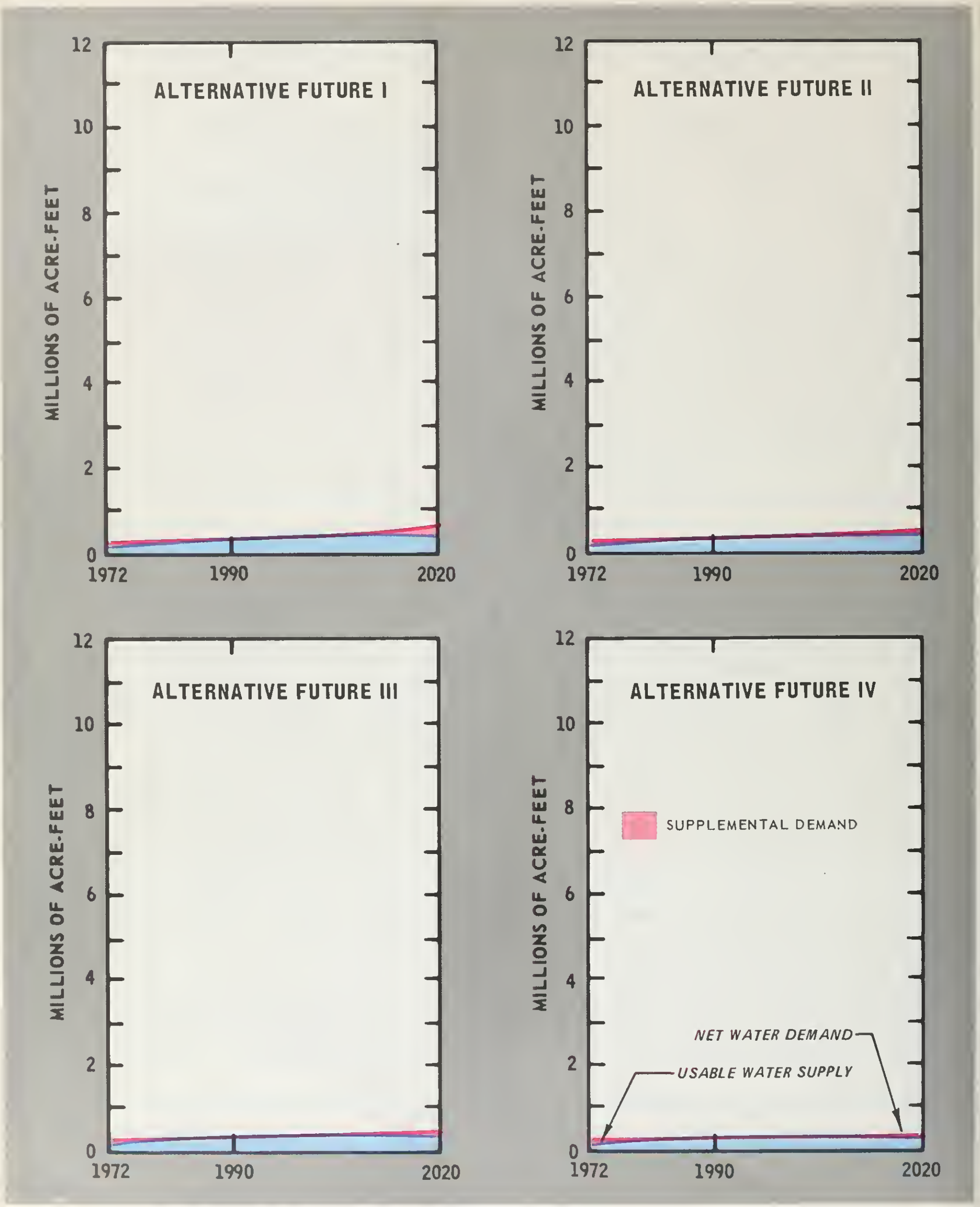
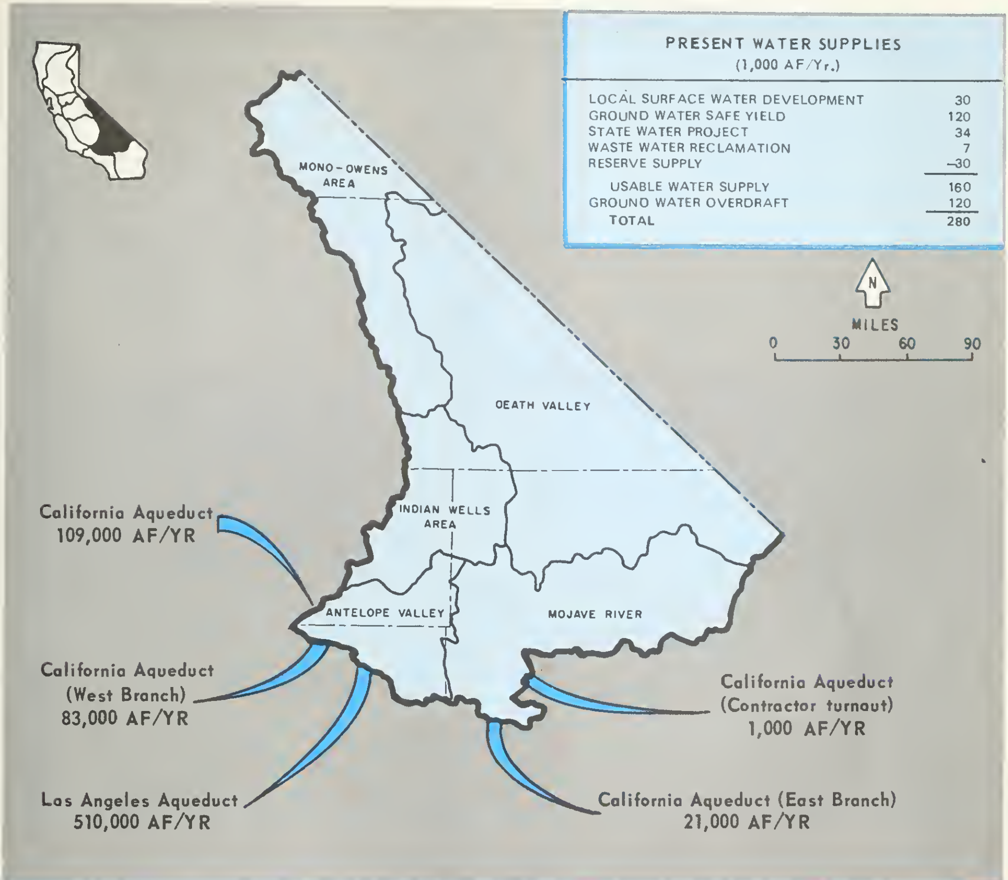


Figure 50. Net Water Demands and Water Supply—South Lahontan Hydrologic Study Area



PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
LOCAL SURFACE WATER DEVELOPMENT	30
GROUND WATER SAFE YIELD	120
STATE WATER PROJECT	34
WASTE WATER RECLAMATION	7
RESERVE SUPPLY	–30
USABLE WATER SUPPLY	160
GROUND WATER OVERDRAFT	120
TOTAL	280

ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE							
		I		II		III		IV	
		1990	2020	1990	2020	1990	2020	1990	2020
POPULATION	240	410	1,040	370	870	370	820	290	380
URBAN AREA (ACRES)	65	90	170	80	150	80	150	70	80
M & I WATER DEMAND (AF/YR)	89	154	387	139	326	136	306	108	143
IRRIGATED LAND (ACRES)	80	80	70	80	70	80	70	80	70
REMAINING IRRIGABLE LAND (ACRES)	2,400	2,380	2,330	2,390	2,340	2,390	2,340	2,400	2,400
IRRIGATION WATER DEMAND (AF/YR)	310	300	250	300	250	300	250	300	250
POWER PLANT COOLING (AF/YR)	0	10	100	10	50	10	0	0	0
FISH, WILDLIFE & RECREATION (AF/YR)	4	16	22	16	22	16	22	16	22
TOTAL APPLIED WATER DEMAND (AF/YR)	399	478	762	463	651	460	581	422	418
TOTAL NET WATER DEMAND (AF/YR)	280	330	510	330	430	320	370	300	290
DEPENDABLE WATER SUPPLY (AF/YR)	190	400	410	400	410	400	410	400	410
SUPPLEMENTAL WATER DEMAND (AF/YR)	120	3	100	3	70	3	30	3	10

Figure 51. South Lahontan Hydrologic Study Area

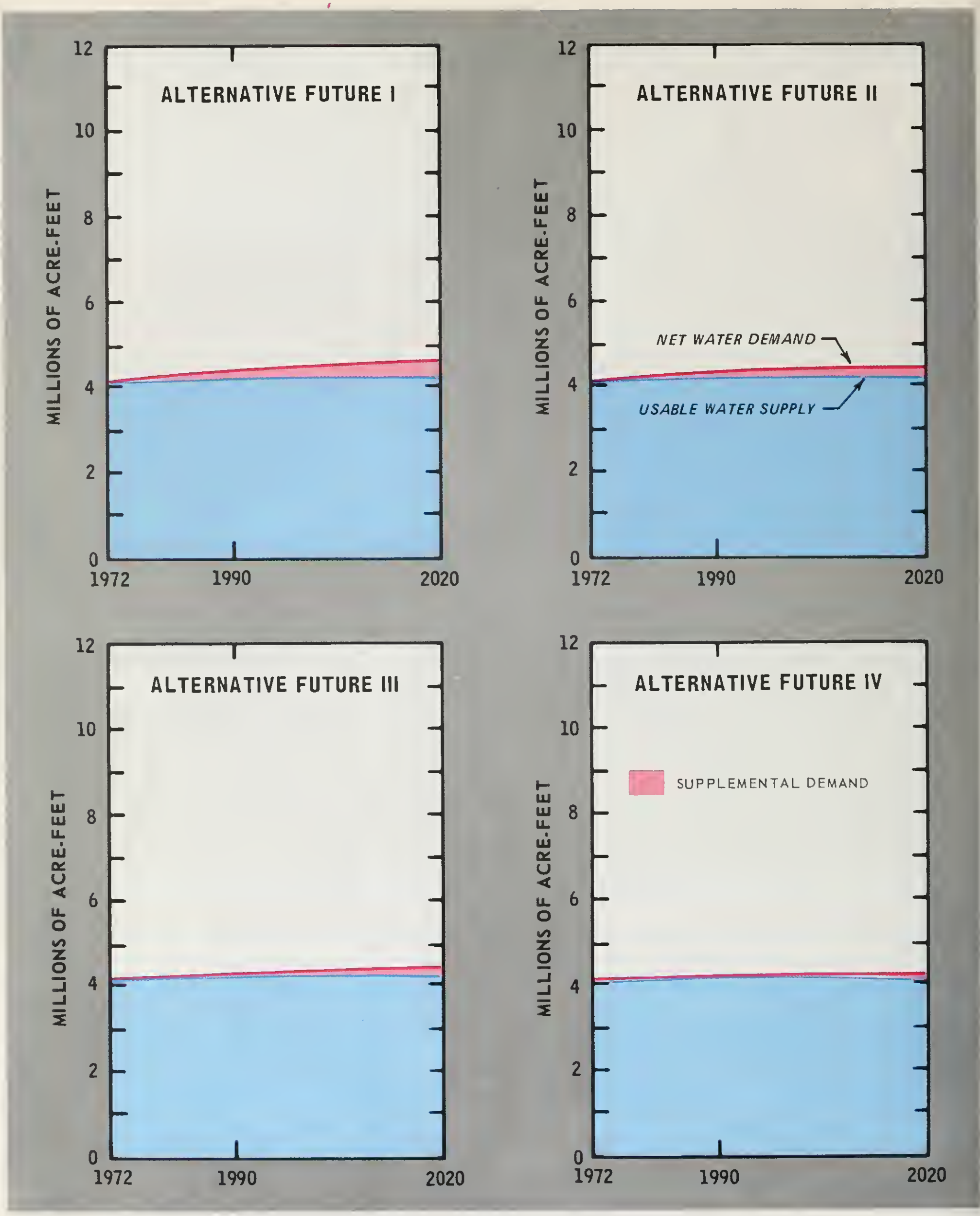
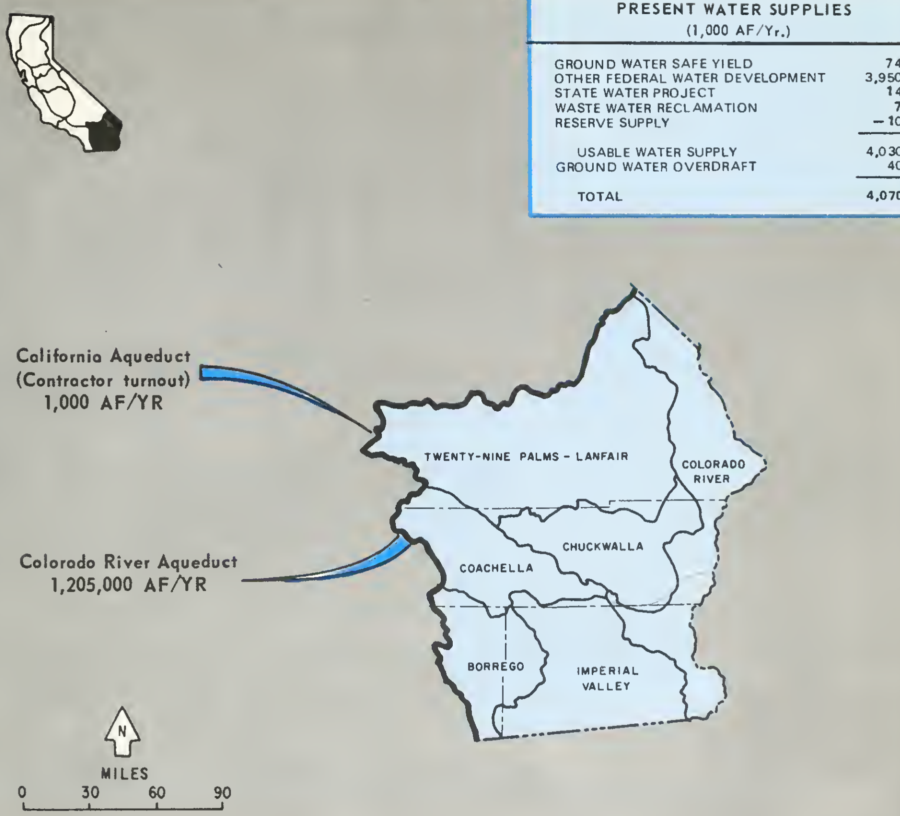


Figure 52. Net Water Demands and Water Supply—Colorado Desert Hydrologic Study Area



PRESENT WATER SUPPLIES (1,000 AF/Yr.)	
GROUND WATER SAFE YIELD	74
OTHER FEDERAL WATER DEVELOPMENT	3,950
STATE WATER PROJECT	14
WASTE WATER RECLAMATION	7
RESERVE SUPPLY	–10
USABLE WATER SUPPLY	4,030
GROUND WATER OVERDRAFT	40
TOTAL	4,070

ITEM (Quantities in 1,000s)	1972	ALTERNATIVE FUTURE I 1990	I 2020	II 1990	II 2020	III 1990	III 2020	IV 1990	IV 2020
POPULATION	230	350	650	330	580	330	540	300	400
URBAN AREA (ACRES)	65	80	130	80	120	80	110	70	90
M & I WATER DEMAND (AF/YR)	99	148	275	142	246	139	230	126	173
IRRIGATED LAND (ACRES)	630	630	650	630	630	630	630	630	630
REMAINING IRRIGABLE LAND (ACRES)	800	790	640	790	660	790	770	800	780
IRRIGATION WATER DEMAND (AF/YR)	3,220	3,320	3,320	3,320	3,320	3,320	3,320	3,320	3,320
POWER PLANT COOLING (AF/YR)	0	130	250	70	130	40	130	40	80
FISH, WILDLIFE & RECREATION (AF/YR)	20	22	26	22	26	22	26	22	26
TOTAL APPLIED WATER DEMAND (AF/YR)	3,340	3,620	3,880	3,560	3,730	3,530	3,710	3,510	3,600
TOTAL NET WATER DEMAND (AF/YR)	4,070	4,240	4,430	4,180	4,300	4,150	4,290	4,140	4,210
DEPENDABLE WATER SUPPLY (AF/YR)	4,040	4,150	4,160	4,150	4,160	4,150	4,160	4,150	4,160
SUPPLEMENTAL WATER DEMAND (AF/YR)	40	90	270	30	140	20	130	10	60

Figure 53. Colorado Desert Hydrologic Study Area

APPENDIX

WORKSHOPS FOR BULLETIN NO. 160-74

WORKSHOPS FOR BULLETIN NO. 160-74

As part of the Department of Water Resources' coordinated statewide planning program, a series of public workshops was held in January and February of 1974. The purpose was to give various interested groups an opportunity to express themselves on California's future and the related water issues and water management concepts that might be highlighted in this bulletin.

The workshops were responsive to requests of several organizations for an opportunity to participate in planning the report. They were held on Saturdays in Sacramento, Los Angeles, Oakland, Fresno, and Redding. Seventy-six persons attended the five sessions representing more than 50 different organizations. Close to 100 suggestions were received for consideration in the bulletin.

The workshops were conducted in an informal manner and everyone attending was given an opportunity to speak. Written comments were also received. All comments and suggestions were reviewed by those writing this report, and to the extent possible, the subject matter is discussed in the bulletin.

Following is a summary of the suggestions received at the workshop sessions and from written communications. The suggestions have been arranged in eleven categories. Numbers following each suggestion are the page(s) in the report on which there is some discussion that relates to the suggestion.

Alternative Futures and Water Development Needs

1. Adopt the concept of "alternative futures" in making projections. (Page 45)
2. The "most likely" population projections should not be the only criteria, use alternative population projections including the E-0 (no growth) schedule. (Page 46)
3. Carefully review and analyze carrying capacity (at county level) and desires for population growth.
4. An alternative to population dispersal should be vertical growth. (Page 68)
5. Agricultural production projections should be based on current shortages and worldwide factors of supply and demand. (Page 51)
6. Summarize the California agricultural profile study, the national agricultural market study and the crop market outlook. (Pages 49–55)
7. Take a close look at the agricultural water supply and demand situation and determine what effect alternative actions of other agencies might have. (Pages 146–49)
8. Direct more attention to irrigation water and its use and our need to place more land under irrigation. (Pages 69–72)
9. Consider the additional water supply that may be needed to meet demands presented by SWRCB Decisions 1379, 1400, 1422, and 1290. (Page 150)
10. Take a careful look at projected water needs for the State Water Project. (Pages 155–156)
11. Emphasize what would happen if no water supply imports were available and how it would affect agricultural productivity and the Central Valley economy. (Page 42)
12. Water shortages should be emphasized and construction of new water facilities in local areas should not be ignored, particularly in some of the developing counties in the North. (Page 151 and Table 27)
13. Discuss the growth inducing aspects of water development. Do water projects encourage growth or are they the result of growth? (Page 46)
14. Refer back to previous projections and determine the impact that those projections had on current conditions.
15. Attention should be given to offstream storage in the southern San Joaquin Valley. (Pages 95–96)
16. The Department should take the lead in floodplain management planning. (Pages 122–124)

Alternative Means of Water Supply and Water Management

17. Include a discussion of the problems, or lack of problems, associated with alternative sources of water such as waste water reclamation, increased efficiency, and desalination so that decisions as to the development of new water supplies can be made intelligently. (Pages 40–42, 104–110, 117)
18. Look into all possibilities for reclaiming and reusing both agricultural waste water and M&I waste water. The Department should take a strong position on waste water reclamation, recognizing also the amounts of energy required, and public health's concern with heavy metals and stable organics Pages 42, 104–110)
19. Discuss the effect of various water conservation measures such as canal lining, metering, trickle irrigation, and use of native plants for landscaping. (Pages 71, 118)
20. Discuss the possibilities of joint operation of the CVP and SWP and how the efforts of federal agencies and the State are being coordinated. (Page 119)

21. Examine methods of increasing overall efficiency of agricultural water use including working with farmers for ways to conserve agricultural water. (Pages 40, 71, 117–118)
22. Prepare an inventory of technological changes that are expected to occur.
23. Consider the feasibility of desalting units taking into account their requirement for energy. (Pages 110–113)
24. State agencies should step in and provide assistance for demineralization to help solve local problems. (Page 112)
25. Advance techniques of water management for additional water supply development should be encouraged, improved, and developed. (Pages 117–124)
26. The report should take a positive view of total comprehensive water management and include an assessment of the impact of total water management. (Page 117)
27. Consider the amount of water to be saved by better watershed management, forest practices, improved ground cover, and snow-zone management.
28. Recognize the possibility that the Central Arizona Project will be abandoned and that the water used by California will remain available.
29. The State should set priorities on allocation of use of water and there should be payment for that allocation. (Page 42)
30. Investigate and evaluate claims that there is a long-term surplus of developed water in California. (Pages 146–147)
31. Analyze contracts for water by CVP to determine if they need to be fulfilled, and explain differences between contracts and projections. (Pages 152–154)
32. The bulletin should take into account delayed or blocked water projects of recent years. (Pages 18, 94)
33. Consider alternative management plans for dams which block mainstem streams such as Trinity, Friant, and New Don Pedro. (Page 38)
34. Consider reducing surface water applications in areas having drainage problems.
35. Discuss the potential water management plans being developed for north coastal water resources. (Page 120)
36. No proposal should be made to divert water from the Los Angeles Aqueduct to future urban areas in the South Lahontan area. (Page 38)
37. In studying feasible alternatives, look into geothermal water potential. (Page 113)
38. Alternative sources of water should be considered that reflect need to conserve energy.

Ground Water

39. More attention should be given to the use of Sacramento Valley ground water resources. (Page 102)
40. There should be some attention to coordination of ground water and surface water between the Central Valley Project and the State Water Project. (Page 119)
41. Information is needed on the impact of using ground water, both benefits and detriments, and on how ground water use integrates with surface supply. (Pages 119–120)
42. The State should consider management of ground water pumping. (Pages 36, 97)
43. Discuss the "borrow-replacement" approach to conjunctive ground water use. (Pages 96–97)
44. The bulletin should provide some specific data on rising ground water areas, and give a full accounting of the water balance. (Pages 97–99)
45. The bulletin should highlight the overdraft situation in the San Joaquin Valley. (Pages 2, 98)

Power Plants and Thermal Energy

46. Projected needs for electrical energy should be reviewed. (Page 59)
47. Plan for a low growth increase in energy needs. (Page 59)
48. The use of energy to move water around the State should be questioned. (Page 58)
49. Quantify new demands for water for all forms of energy, including new oil refineries and oil shale conversion.
50. Consider the power plant siting problem and evaluate the impact of competition for water if power plants are located inland. (Pages 32, 60–61)
51. Recognize that additional water conservation projects will be needed to meet cooling water demands for inland power plants. (Pages 31, 60, 74)
52. Consider the feasibility of new hydroelectric projects. (Page 86)
53. Pay special attention to potential power and water available from geothermal sources. (Pages 87, 113)
54. More effort should be spent on research into possible use of heat rejected by thermal power plants. (Page 74)

SWRCB Activities and Water Quality

55. Consider water quality as well as water quantity. (Pages 35, 65, 82, 109, 124–138)
56. Encourage the federal agencies to recognize requirements as imposed by SWRCB Decision 1379. (Pages 14, 150)
57. Discuss who will pay the additional cost brought about by SWRCB Decisions 1379 and 1400. (Page 34)
58. Explore in depth the possible effect on water supplies and agricultural production brought about

by the proposed guidelines being prepared by SWRCB.

59. Include more information on water quality, showing coordination of activities between DWR studies and SWRCB studies. (Pages 20, 126)
60. Drainage should be given a higher priority than it has in the past since the State is the only agency that can take the leadership in providing an overall solution to the drainage problems in the San Joaquin Valley. (Pages 38, 108)

Recreation

61. Consider recreation as an integral part of water development including consideration of single-purpose reservoirs for recreation. (Pages 61, 75)
62. Stress the recreational use and benefits of San Joaquin east side reservoirs and the downstream reaches of those rivers. (Pages 80–81)

Pricing Policies and Cost Sharing

63. Determine the demand for water if agencies priced water to reflect the actual cost. (Page 40)
64. Discuss the effect of eliminating declining block rate water pricing structures and predict water demand on this basis. (Page 40)
65. Take a more realistic approach and identify all water project beneficiaries. (Page 34)
66. Consider pricing policies for charging for all water project accomplishments. (Page 34)

Land Use Planning and Environmental Impact

67. Land use planning should precede water use planning but take careful cognizance of the potential availability or nonavailability of water. (Pages 24–29)
68. The bulletin should consider the interface between water resource planning and land use planning since the two types of planning need to be coordinated at this interface. (Pages 24–29)
69. Indicate the trade-offs required under various patterns of land use.
70. Give an example of what would happen in a basin if the State controlled some of the resources and land use.
71. Consider planning urban areas on marginal lands and preserving the agricultural land from urban encroachment. (Page 27)
72. Show the effects of water project construction on local employment and economy.
73. Long-term plans should include not only water needs but the impacts upon the people from where the water is taken and where it is used. (Page 42)
74. The importance of water to a community should be emphasized. (Pages 40, 65, 80)
75. Incorporate the "Environmental Goals and Policies" in the report. (Page 27)
76. Set specific goals and criteria for fish, wildlife, and recreation, and plan toward them. (Pages 75–79)
77. Obtain the public views in the south coastal area toward growth, bringing in more water, and pollution. (Page 183)
78. Environmental considerations should be part of long-range plans and be given more emphasis..Water must be made available for recreation, environmental use and to improve the quality of life. (Pages 14–19, 80–81)
79. Water resource planning should provide for environmental protection and economic-social considerations, be flexible to allow for development of alternative water sources, and be done in the context of overall state land use planning. (Page 45)
80. Reappraise the wild river law to determine if it is realistic in the energy shortage era.
81. Take into account the wild river acts and do not plan water development on these rivers or on the Yuba, Stanislaus, and Russian Rivers. (Pages 16, 96, 121, 141)
82. The Department should prepare an environmental impact statement as part of this bulletin.

National Water Commission Report

83. Summarize the ways in which the California Water Plan conform with the National Water Commission recommendations. (Pages 11–13)
84. Recognize the conclusions of the NWC report and speak to their recommendations and what would happen if we follow them. (Pages 11–13)
85. The NWC report was damaging to water development and we should look at our water problems from the western viewpoint. (Pages 11–13)

Presentation of Data and Study Results

86. Continue factual presentation of data but hold down on philosophy and rhetoric.
87. Emphasize factual matters as well as planning philosophy. (Page 146)
88. Write the document for understanding by the layman. The report should have broad distribution and be advertised to let its availability be known. (See Summary Report)
89. Assumptions used in the report should be discussed in a prominent position. (Pages 45–66, 88–90)
90. More data should be presented by counties and by watershed.
91. References should be included as to where additional information can be found. (See Footnotes)
92. Do not discard items from previous bulletins because of a change in planning emphasis.
93. The State should provide uniform periodic land use maps, particularly in developing agricultural areas. (Page 56 and Plate 2)

94. Explain the large discrepancy in the amount of irrigated acreage in California reported by DWR and that of the Census Bureau.
95. The "breathing room" has increased since Bulletin 160-70 and the analysis in 1960–74 should support this. (Page 155)
96. The "breathing spell" philosophy used in Bulletin 160-70 led to an incorrect conclusion that was particularly damaging in the San Joaquin-Tulare Basin. (Page 155)

Miscellaneous

97. Consideration should be given to financial help for the mountain counties in solving their problem.
98. Discuss the effects of mixing Northern and Southern California water and the effect of northern water on southern ground water basins. (Pages 3, 97)
99. Define what is meant by "water demand". (Pages 67, 88)

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