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BULLETIN No. 160-66

IMPLEMENTATION OF THE CALIFORNIA WATER PLAN

Appendixes A Through F

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AUGUST 1967

RONALD REAGAN
Governor
State of California

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Director
Department of Water Resources

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RONALD REAGAN
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This volume consists of the following:

FOREWORD

This volume contains six appendixes, prepared under the Coordinated Statewide Planning Program, in support and extension of the information presented in Bulletin No. 160-66, "Implementation of The California Water Plan", published March 1966. They are described briefly in the following paragraphs.

Appendix A, "Water Requirements", presents information on basic data, study criteria, and methods used in estimating future water requirements; discusses the relationships among study phases; indicates limitations of the information now available; and describes current analytical studies directed toward improving those estimates for inclusion in subsequent editions of the Bulletin No. 160 series.

Appendix B, "Water Supply and Operation Studies", discusses the development of basic water supply forecasts and the coordinated operation studies for the State Water Project-Central Valley Project System necessary to estimate the present and future dependable water and hydroelectric power yields of the system.

Appendix C, "Legislation and Court Decisions", presents short descriptions of the more significant federal and state water legislation and court decisions during the period 1956 through 1966.

Appendix D, "Role of Electric Power", presents and discusses forecasts of the California power load, technological developments in power production, the market for and value of hydroelectric power, sources and costs of power for water project pumping, the future role of power, and California's hydroelectric power resources.

Appendix E, "The Colorado River", provides a discussion of the events leading to the United States Supreme Court decision in Arizona v. California, the impact of that decision on the West, basic water supply deficiencies in the Colorado River System, and a recognition of the need for future augmentation of supplies from sources outside of the Colorado River Basin.

Appendix F, "Water Project Statistical Data", presents tabulations of certain physical and cost information on the present major water developments throughout the State.

Each of these appendixes is self-contained with a minimum of cross referencing. The information provided is intended to be of statewide significance.

The next edition of the Bulletin No. 160 series is scheduled for publication in December 1968.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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APPENDIX A

WATER REQUIREMENTS

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FOREWORD

The primary purpose of this appendix is to present some of the basic considerations and information used in making the estimates of future water requirements shown in Department of Water Resources' Bulletin No. 160-66, "Implementation of The California Water Plan", March 1966.

The material in this appendix includes criteria, techniques, and methods used for estimating both municipal-industrial, and agricultural water requirements on a statewide basis and for the 11 hydrologic study areas reported on in Bulletin No. 160-66 (Figure A-1). Brief descriptions are presented of the relationships among study phases such as population projections, crop market outlook forecasts, land use and classification surveys, and other considerations leading to the estimates of net water requirements.

The appendix will indicate the limitations of this information and briefly describe work in progress aimed at improving it for subsequent editions of this Bulletin series.

DESCRIPTION AND MEANING OF WATER REQUIREMENTS IN BULLETIN NO. 160-66

Very simply, agricultural water requirements are those quantities of water necessary for crop production. Because the aim of the Department's effort is to determine the need for water development, the main concern is with that portion of agricultural water requirements dependent on irrigation (applied water) rather than natural precipitation. Unless otherwise indicated, subsequent references to water requirements in this report connote applied water requirements.

The basic approach for determining agricultural water requirements is to apply estimates of unit water use values (acre-feet of water per acre of crop) to crop acreage estimates. Similarly, per capita unit use values are applied to population forecasts in arriving at municipal-industrial water requirements.

Before some of the considerations and procedures used in determining future water requirements are discussed in detail, several aspects of the information should be understood and clarified. These relate to water requirements as contrasted with economic demands; differentiation between applied and net water requirements; and areal interpretation of surplus or deficiency estimates for specific hydrologic study areas.

The use of the term water requirements has, at times, been substituted too loosely and interchangeably with other terms, particularly economic demand. The latter is an expression of market demand or the quantity of water that can be sold at a given price under given market conditions. In a very strict sense, requirements have been associated with physical need. It takes, for example, so much water to grow a particular crop. As such, requirements establish an upper limit or maximum quantity of water necessary to support a given level of development. While this proves useful in pointing up apparent conflicts between regional supplies of water and potential use, it does not provide an indication of the amount of water that more realistically may be sold in light of anticipated water costs and ability to pay.

Generally, the requirement figures referred to in Bulletin No. 160-66 fit neither the classical definition of economic demand nor the strict interpretation of water requirements. The Department's estimates include both physical factors and some broad economic considerations. Among these are: knowledge of the extent and nature of irrigable lands and present land uses; estimates of future population growth; market outlook studies for California crop production; future land use patterns; and unit values of applied water associated with various types of anticipated development.

With the exception of the service areas of the State Water Project, however, these estimates do not reflect the full consideration of the economic constraints involved. More specifically, a cost-price relationship between probable water costs and payment capacity or ability to pay for water is not reflected in the estimated requirement levels, except as noted. There are many areas where water costs are now and will likely remain comparatively low. In such instances the estimates, as given, will probably stand up under further analysis. In most cases, however, this and other judgments leading to a refinement of the figures in Bulletin No. 160-66 must be substantiated and documented. The latter is a necessary step if the Department is to reach a level of comparability in its forecasts of future water demands throughout the State.

Both applied water requirements and net water requirements are referred to in this appendix. The former represent the actual amounts needed at farm headgates and at urban distribution system intakes. These need modification, however, to allow for the possibility of reuse. This is particularly significant because the actual quantities of water necessary for import into an area, or available for export, are determined on the basis of net water requirements. The net water requirement consists of the quantity of water consumptively used plus irrecoverable losses. Consumptive use includes disposal through transpiration by plants and any evaporative losses. Outflow to the ocean and percolation of water to a ground water basin, where depth to water or quality considerations make reuse impracticable, are examples of irrecoverable losses.

Another qualification concerns the interpretation of data for the separate hydrologic study areas. The 11 hydrologic study areas for this report were selected as large geographic units within which the watersheds possess similar characteristics of streamflow, local water development, economic development, and water import requirements or water export potential. The selected study areas generally meet these requirements. Occasionally they do not. General statements made herein about a hydrologic study area may not apply to a specific subunit in that area. For example, the North Coastal Hydrologic Study Area possesses an extremely large surplus in developable water supplies, but the Round Valley-Covelo vicinity, within that study area, has an estimated future water deficiency. Variations in growth patterns and the uneven distribution of local water supplies account for this apparent anomaly. In future reports of the Bulletin No. 160 series it is planned to present information by major subdivisions or by specific water service areas of the hydrologic study area where necessary to diminish the possibilities of such seemingly inconsistent results.

DERIVATION OF AGRICULTURAL WATER REQUIREMENTS

This section of the appendix sets forth the basic inputs that have gone into the estimates of future water requirements appearing in Bulletin No. 160-66. Some of the major considerations and assumptions behind the estimates are discussed including: basic land use and class data; crop market outlook study; urban expansion; unit use figures; and areal allocations of crop acreages. Following this, specific studies and considerations that apply to the individual hydrologic study areas are discussed.

Steps in the Analysis

The most meaningful measure of the future need for water is obtained by determining estimates of economic or effective demand. In other words, the amount of water that consumers will be willing and able to buy at a given cost. Estimates of economic demand are determined as follows:

1. Information is collected on present land use and suitability for future development.
2. Economic development parameters, such as population growth and future crop market conditions, are evaluated.
3. Estimates are made of the nature and magnitude of future agricultural land use development.
4. Water requirements are determined by applying unit water use values to future crop acreage.

5. Based on these requirements, estimates of possible sources of water and probable costs are developed.
6. The ability to pay for water is estimated, based upon the determination of payment capacities for specific agricultural crops.
7. Water costs are compared with estimates of the ability to pay for water, and projected land development and associated water requirements are adjusted accordingly.

As discussed previously, not all of these steps are reflected in the figures shown in Bulletin No. 160-66. In some cases, the analysis does not go beyond step four which represents the determination of water requirements only. One of the objectives of the Coordinated Statewide Planning Program, however, is to obtain comparability throughout the State within the scope of all the listed items.

A more detailed discussion of some of the specific inputs that went into the estimates for Bulletin No. 160-66 and some of the considerations influencing the allocation of those projections among the hydrologic study areas follows.

Land Use Surveys

The Department and its predecessor agencies have long engaged in the collection of land use information as the best means of pinpointing the location and estimating the quantities of water used. Accurate land use survey data,when segregated into categories to which valid estimates of water use can be applied, constitutes the basic foundation upon which practically all water development planning studies are based.

In the Department's standard land use survey legend, over 60 individual crop types, 16 native vegetation classes, 5 major urban groupings, and 4 recreational water-using categories are recognized as having some unique basis for segregation (see Figure A-2). Actually, in many instances, the need for these detailed segregations are for economic and demographic as well as water use evaluations. The agricultural sector is segregated in detail in order to detect where acreage changes are occurring as well as trends in the plantings of specific crops.

Rapid changes in the pattern of land use are occurring throughout most of the State. The San Francisco Bay Area and Southern California counties are experiencing accelerated urban expansion on agricultural lands while the Sacramento- San Joaquin Valley areas are experiencing large increases in irrigated agriculture. Since the season of use, quantities of total applied water needed and the consumptive water loss associated with these land uses are usually different, reliable methods to monitor change are essential.

Conventional recurring land use surveys involving 100 percent field canvass are by far the most effective, although a costly, means of detecting change. New, highly sophisticated, aerial photogrammetric interpretation techniques involving little field canvass show promise as a method to lower cost and time requirements without sacrificing needed accuracy. In the future, the land use data collection program of the Department will make greater use of the latter technique.

History

It was not until the late 1940's that any attempt was made to obtain accurate measurements of land and water use on a statewide basis. During 1947, the Legislature directed the State Water Resources Board to make an investigation of the water resources and present and future ultimate water requirements of each of the river basins of the State. These studies were deemed essential to formulation of a comprehensive overall state water development plan. Under this broad directive, the then Division of Water Resources collected data from the most reliable sources available and compiled maps that depicted irrigated agriculture and urban development. The data that went into the resulting report, State Water Resources Board, Bulletin No. 2, "Water Utilization and Requirements of California", June 1955, came from numerous federal agencies, irrigation districts, county agricultural office files, and the like. For some areas of the State the data gathered for Bulletin No. 2 is still the best information of record.

Following Bulletin No. 2, the next major land use data collection effort of significance was accomplished during the period 1954-56 for preparation of Department of Water Resources' Bulletin No. 58, "Northeastern Counties Investigation", June 1960. The latter covered 15 counties of California that lie generally north of the City of Sacramento and east of the Coast Range. The study was done in considerably more detail than that for Bulletin No. 2.

In 1956, legislation was enacted (Water Code Section 232) which directed the Department to determine the present and future water needs of the respective watersheds of the State, the quantities of water originating therein, and the amount, if any, available for export. In response to this legislation, the Department initiated a series of very detailed land and water use studies that had as their goal the collection and presentation of land use, land classification, water use data, and apparent water rights for many of the river basins of the State. The data from these studies has been presented in numerous land and water use (Bulletin No. 94 series) reports since 1956. In addition, recurring land use surveys have been conducted for many years in Southern California and the results presented in the Bulletin 24, 70, 71, 101, 102, 103, 121, and 122 series of reports. Land use surveys of limited extent have also been conducted for specific investigations in many parts of the State. The current status of land use surveys in California is shown in Figure A-3.

Field Survey Procedures

The land use surveys accomplished by the Department since 1956 have been field canvass surveys accomplished during the height of the agricultural growing season, usually June, July, or August. The major types of land uses mapped have been both irrigated and dry-farmed agricultural land, urban areas, recreational lands, and in some special instances various types of native vegetation. The Department uses 1:20,000 scale aerial photographs as working field maps upon which land use types are delineated and identified by use of special symbols.

Preparation of Maps

Maps are prepared from the aerial photographs to facilitate the analysis of data, for presentation in reports, and for aiding the acreage determination. However, there is so much variation in the scale of aerial photographs that measuring area directly from them is subject to considerable error.

The delineations on the photographs are transferred to copies of 1:24,000 United States Geological Survey quadrangle maps. The transfer is accomplished through the use of an opaque projector, which allows proper adjustment of scale and accurate alignment of the delineations. After delineations are coded, transparent reproducible copies are made so that inexpensive diazo prints can be produced on demand. An example is shown in Figure A-4.

Area Measurement by "Cutting and Weighing"

One of the most rapid and accurate methods for measuring area on a map surface, particularly when many maps with numerous delineations are involved, is by the cutting and weighing process. Diazo copies of the land use maps are made, the weight of the total quadrangle is determined, each individual parcel is cut out and weighed, and then, because the total area of the quadrangle is known, the acreage of each parcel can be determined through simple proportioning. The vellum paper used in the diazo printing process exhibits nearly constant weight per unit area. An analytical balance, calibrated to one-ten thousandth of a gram, is used for weighing.

Electronic Machine Computation and Tabulation Procedures

Prior to 1958, the computation and tabulation of land use information was accomplished using tedious hand methods. Since that time, the utilization of electronic data processing techniques has resulted in increased speed, greater accuracy, and lower unit cost. The location, identification, area and weight of the quadrangle, the weight of the delineated parcels, and the appropriate parcel identification coding are key punched onto computer cards. After the computer has made the computations, a standard machine tabulation print out is produced.

There are many checks built into the program to keep errors to a minimum. One check is that the total weight of the sum of the pieces must be within ± 2 percent of the total weight of the quadrangle. In actual practice, these checks usually show variations of less than 1 percent.

Figure A-5 is a sample of a land use print out sheet.

Land Classification Surveys

While land use surveys pinpoint the type and location of land and water use, land classification surveys identify types of land being developed and the capability of remaining undeveloped lands for further development. Such identification is especially important for projecting agricultural acreage and is becoming increasingly significant in urban and recreation planning.

Over the years, the Department has developed a land classification system that is almost completely independent of economic judgments or other subjective evaluations. The present system employs the evaluation of the physical and chemical aspects of soil and land in making a classification. To the extent that the classification system has been consistently applied, the data collected by the Department will probably be valid for many years into the future.

Since 1956, the departmental land classification criteria have not changed materially, and classification work done since that date is essentially comparable. For an example of the land classification legend currently used by the Department, see Figure A-6. To the present time (1967), practically all of the North Coastal and Central Valley areas have been classified to these standards (Figure A-7). Although much of the land in the northeastern, central coastal, and southeastern portions of the State has not been mapped to these standards, completion of scheduled mapping in the Central Coastal area will fulfill current statewide planning needs.

Field Survey Procedures

As in the land use surveys, departmental land classification surveys are conducted in the field using 1:20,000 scale stereoscopic aerial photographs. The field surveys included a determination of the character of the soils as established by examination of materials from auger holes, road cuts and ditch banks, together with an evaluation of the types of native vegetation or the crops being produced. The presence of rock, high water table, alkalinity and other soil conditions such as dense clay or hardpan subsoil layers, fine clay or coarse soil texture, are all recorded by the field surveyor. In many areas, soil samples are taken and analyzed in the laboratory to ascertain the degree of alkali (sodic) condition or the presence of boron.

Since slope and microrelief conditions generally restrict the types of crops that may be grown and regulate the mode and efficiency of irrigation, the departmental legend is divided into three broad slope group categories: smooth valley lands, gently rolling lands, and gently to steeply sloping lands. A clinometer is used to measure slopes, and then slope groups are segregated by use of stereoscopic aerial photographs. Although 30 percent is considered about the upper limit of slope for irrigation, this restriction is not applicable in certain areas of the State, particularly along the Southern California coast where avocados and citrus fruits are grown.

After adequate familiarization with an area, obtained by measuring slopes, augering test holes and evaluating other soil characteristics, delineations are drawn on an aerial photograph in such a way as to define areas with similar characteristics. Each of these delineations is identified by the use of one or a series of symbols descriptive of the classifier's observations. Where available, the land classifier always utilizes United States Department of Agriculture and University of California soil surveys and Bureau of Reclamation land classification information to supplement his knowledge of an area. An example of a completed land class quadrangle is presented in Figure A-8.

Data Processing

Like the tabulation of land use information, all land classification field data is transferred to a United States Geological Survey quadrangle sheet. The quadrangles are copied, the parcels are cut out and weighed, and then the acreages are calculated and tabulated through electronic data processing techniques. The final product is a print out showing acreages of land in various land class categories systematically arranged by any boundary subdivision desired such as an irrigation district or potential water service area. An example of the detail obtainable through the use of this procedure is shown in Figure A-9.

Urban Expansion on Agricultural Lands

In the course of making estimates of total irrigated acreage in the several hydrologic study areas of the State, it was necessary to estimate the extent of urban expansion to be anticipated on land that is now, or in the future would be, otherwise occupied by irrigated agriculture. This was necessary to determine possible limitations on lands available for irrigation.

Present population density patterns were, in general, used as the basic guides for setting future densities. High densities were assumed in the Los Angeles and San Francisco metropolitan areas, where topographic limitations are already producing typically congested patterns. In the valley and desert areas, however, the ample availability of land for expansion was assumed to allow considerably lower densities.

Since the forecasts were made for two key years in the future, 1990 and 2020, the densities were applied in a pattern of stages. Thus, in the period between 1960 and 1990, areas presently occupied at less than full density were assumed to be brought up to the assumed standards, with rings of new development projected at lesser density to accommodate the residual population increase. In the succeeding period, to 2020, these rings were in turn brought to the standard densities, before again adding further acreage. With the exception of the Central

Valley area, these densities were applied on a county unit basis. In the hydrologic study areas of the Central Valley, densities were determined for each of the geographic subunits adopted for the Joint Delta Depletion Study of the Department of Water Resources and the Bureau of Reclamation, described in Appendix B.

In most cases, numbers of rural residents were subtracted from total population forecasts before establishing urban populations, densities, and areas. In the San Joaquin Basin and Tulare Basin Hydrologic Study Areas, however, densities were adjusted downward to account for the rural population. These adjusted densities were then applied to the entire population of each study unit.

Crop Market Outlook Study

Originally the crop market outlook study was initiated to provide long-term projections of market demands for California crops to be used specifically by the Department's Southern District in its evaluation of water demands associated with the State Water Project. It was also anticipated that the study would serve as a general guide in developing future crop patterns for various areas throughout the State.

The Department has continued to use the crop market outlook study as a tool in the agricultural crop projection phase of its planning studies. In order to avoid the pitfall of projecting unduly large acreages of certain crops and underestimating others, an overall crop outlook serves to relate supply to demand, at least on a statewide basis.

Once an overall crop market outlook has been estimated for the State, crop acreages are allocated to regions based upon local agricultural trends and variations in physical factors of climate and soils. The resulting agricultural estimates serve as guidelines for more definitive studies within an area. It can be expected that such closer looks will result in some changes in the regional allocations of crop acreage and a refined crop market outlook study.

The initial outlook study was completed in 1959. In 1964, a quick review was undertaken and some adjustments made in the original forecasts as suggested by crop production trends in the intervening years between 1959 and 1964. Some of the major considerations and methodology that lie behind the original study are discussed briefly in the following paragraphs.

Determination of Demand Levels

In general, the study is limited to a historical review of production and consumption patterns; an analysis of the impact of population and income on consumption; and assumptions concerning California's share of the national market for each crop. Crops considered in the study included the following:

Fruits, Nuts and Vines	Vegetables	Field Crops
Almonds	Artichokes	Alfalfa Hay
Apples	Asparagus	Cotton
Apricots	Broccoli	Dry Beans
Avocados	Celery	Field Corn
Figs, dried	Green Limas	Hops
Grapes	Lettuce	Potatoes
Lemons	Melons	Rice
Olives	Onions	Sugar Beets
Oranges	Sweet Corn	
Peaches	Tomatoes	
Pears		
Plums		
Prunes, dried		
Walnuts		

Two sets of projections were made. The first being for comparative reasons and to serve as a general guide. It was assumed for this projection that per capita consumption and California's share of the expected market demand would remain unchanged from the levels of 1950-56. Thus, aggregate demand would increase at the same rate as population. All crops except sweet corn, field corn, and alfalfa were related to United States population. These three crops were related to California population because of the localized aspects of the market for these crops.

The second set of projections involved an appraisal of per capita consumption for the various decades to the year 2020. These projected rates of consumption were based on rates of consumption for families with incomes above $8,000, together with some consideration of the long-term historical trend of consumption for all families in the United States. After determining the estimated future per capita consumption rates during the period of analysis, the projected population of the market area was applied to determine the aggregate domestic market demand likely to prevail. To this domestic market demand, import and export considerations were added whenever it was believed that these items were of significance to the total market demand.

After determining total market demand for United States production, estimates were made of the percent of the total market demand that the State of California might be expected to acquire if the forces of economics were allowed to freely determine areas of production. It should be kept in mind that land limitations did not influence these projections. The projections are intended to indicate the approximate economic limits beyond which producers would be faced with substantially reduced prices on a national scale, and the point beyond which California producers would likely find it difficult to produce on a competitive basis. It is recognized that changes in the comparative advantage of the new areas of production within California as compared to those outside of California are an important factor; however, these advantages could occur in either direction--increasing or decreasing California's comparative advantage.

Historical trends were developed to show the percentage of a given crop that has been produced in California. For most of the crops, these trends covered a period of 30 years or more. In developing projections, cognizance was taken of those crops in which California demonstrated a definite economic advantage by assuming a continuing increase in the percentage of the total market which California farmers may be expected to acquire. However, it is expected that this comparative economic advantage for many California crops will tend to disappear over the long period of analysis. Thus the rate of growth in California's share of total market demand is expected to decrease, particularly as the year 2020 is approached.

Because of the divergent changes that are predicted to take place in the various rates of per capita consumption over the period of analysis, a final check was made to see that total consumption per person did not exceed a reasonable amount. It was found that the per capita consumption of all foods was approximately the same as per capita consumption during the past 50 years. Essentially, changes will occur in the dietary mix, rather than poundage of food consumed. Figure A-10 illustrates, on an index basis, the projected trends for all food classes.

Conclusions

Some of the conclusions reached in the study with respect to major crop groupings are as follows:

Fruits, Nuts, and Grapes. Historical data developed in the outlook study indicate a considerable rise in the per capita consumption of nuts and citrus fruits with continued future increases due primarily to increased disposable real income. Deciduous fruits display a variation of per capita consumption patterns, although the overall trend is toward higher consumption. By year 2020, for instance, per capita consumption is expected to average 20 to 30 percent higher than the 1950 to 1956 period. Additional technological improvements in both processing and handling will tend to encourage the consumption of fruits, both citrus and deciduous.

Increased per capita consumption of wine will lead to increased demand for grapes, not only for wine varieties, but also for table and raisin varieties, all of which contribute sizable amounts of their total production to the wine industry. The general tendency of high income groups to consume more fresh fruits will lend additional strength to the future demand for grapes as average disposable income increases in the future.

California's present dominant position as a supplier of most fruit, nut and vine crops is expected to continue. This, together with indications of a strong total demand for these products should assure an expanding market for California producers.

Vegetables. The general upward trend in consumption of vegetables is expected to continue. This trend is the result of three major influences--population growth, increased real disposable income, and higher levels of technology in food processing.

Consumption of all forms of processed vegetables will tend to increase because of greater urbanization and the resultant decrease in home vegetable gardens. In canned vegetables, however, the upward influence will be modified by a greater emphasis on frozen varieties.

The latter will have higher rates of consumption mainly because of higher disposable incomes. Refined technology will encourage the upward trend by increasing availability and lowering unit costs. Increased consumption of processed vegetables will also tend to reduce the consumption of fresh vegetables, except in noncompeting varieties such as lettuce and celery.

Field Crops. In contrast with vegetables, nuts and fruits, field crops, as a group, are expected to show a decline in terms of per capita consumption. However, this decline will not be true for all field crops because of the wide variety of types and historical consumption patterns in this group.

Dry beans, peas, and sugar beets are expected to become less important in the future while feed crops, influenced by the increased demand for livestock and poultry products, will probably continue to climb. Notable among the latter will be hybrid corn and the more concentrated feeds.

Field crops are generally low dollar-yield crops, and as such will be in a relatively poor position to compete for the available land and water. An important exception to this is cotton which, ignoring acreage quotas, can compete quite strongly for land in the central valleys.

Acreage Requirements

Once consumption levels had been determined, conversion was made to acreage requirements. The latter was done by applying productivity per acre to the consumption estimates.

Historical data were used to project productivity levels out to year 2020. As a result of these computations and based upon the original crop market outlook study, it was estimated that approximately 13 million acres would be irrigated in California by year 2020.

As indicated earlier, however, the original projections have been reviewed and modified. Another estimate was made of California's share of the national market for certain crops and changes in yields. The result was a revised projection of 11.1 million acres of irrigated land by year 2020. Work done by the University of California served as a basis for the revision. In the course of its studies, the University has projected crop yields to 1975. The projections reflect anticipated advances in technology and a price-cost relationship like that of 1954-57. For departmental purposes, the University's projections were extrapolated to 2020. The resulting yield levels by crop are shown in Table A-1. Total irrigated crop acreages for the State are shown in Table A-2.

As a subsequent phase of the Crop Market Outlook Study, statewide acreages were allocated to various regions within California. This was done to serve as a general guide to determine more localized growth rates and any corresponding need to develop additional water supplies.

As a first step, the regional forecasts were made by extrapolating the shifts in crop acreages among different producing areas of the State during the past 30 years. These initial allocations were further adjusted on the basis of specific considerations for each area. These included: the rapidity of urban expansion on agricultural land, the comparative advantages of land and water supply; and, in many instances, the results of detailed studies done at one time or another in various major agricultural areas of the State.

Unit Applied and Consumptive Agricultural Water Requirements

In planning for water project development, it is necessary to know water needs expressed in two different ways. One is an expression of quantity of water that must be made available at the actual place of use, the applied water requirement, and the other is the quantity that must be delivered to the service area as a whole. As a general rule, this latter amount, the net water requirements, will be less than the former due to the possibilities of reuse of excess applied water within the boundaries of the service area.

The net water requirement includes transpiration, evaporation, and all other irrecoverable losses associated with irrigation.

Unit Applied Water Requirements

The unit applied water requirement of an acre of crop land is comprised of consumptive use of applied water and the surface runoff and deep percolation that normally occur during irrigation. The percent of the total applied water that is consumptively used is called the irrigation efficiency. The usual approach to determining unit applied water requirement is to apply an estimate of the irrigation efficiency to the unit consumptive use of applied water. In addition, the Department has made many measurements of applied water in conjunction with numerous investigations and water rights adjudications. Other data have been collected from the files of County Agricultural Extension Service offices. These data show that, as might be expected, unit applied water is lower than normal for a given crop where water costs are high and higher where water costs are low and there is an abundant supply.

Unit Consumptive Use of Applied Water

Prior to 1954, the Department depended largely on the Blaney-Criddle method for estimating the total consumptive use of water. This method required evaluation of historic mean monthly temperatures and the monthly percent of annual daylight hours. To obtain the consumptive use of applied water, these values were further modified to account for the consumptive use of natural precipitation. The water requirement determinations developed for Bulletin No. 2, "Water Utilization and Requirements of California", were based largely on this approach.

The succeeding Department program, initiated in July 1954, has the goal of obtaining accurate long-term monthly and seasonal values of water requirements and evapotranspiration for the principal crops grown within the State. The work of the Department and the continuing research being conducted by colleges and universities, particularly the University of

California at Davis, has greatly broadened knowledge of the parameters that affect the consumptive use of water by crops. The values of consumptive use of applied water for individual crops used in determining the water requirements presented in Department of Water Resources' Bulletin No. 160-66, "Implementation of The California Water Plan", are the results of these years of study. In general, the indicated studies since 1954 suggest that Bulletin No. 2 values of consumptive use are significantly low for hot interior valleys and high for moist coastal areas. The resulting adjustments were included in the work done for Bulletin No. 160-66.

In 1967, the Department will publish Bulletin No. 113-2, "Vegetative Water Use Studies in California", which will present new findings and discuss new techniques for measuring the consumptive use of applied water.

Specific Studies and Considerations of Agricultural Water Requirements by Hydrologic Study Areas

The foregoing sections discuss the standard procedures and some of the considerations used by the Department for estimating agricultural water use. The actual details of procedures, depth of study of any particular data input, and overall scale of appraisal used in past studies varied in accordance with the objective and scope of the study. The older Department studies are more general in many respects. In early years, studies of future land use were confined to conditions of "ultimate" development, for the purpose of assessing maximum physical water needs within specific areas. Project planning work in more recent years has made it necessary to estimate "staged" or decadal land and water use development expected over the next several decades. Several bulletins have been written with this objective in mind, including Department of Water Resources' Bulletin No. 142-1, "Water Resources and Future Water Requirements, North Coastal Hydrographic Area, Volume 1: Southern Portion", Preliminary Edition, April, 1965.

Studies under the Coordinated Statewide Planning Program as well as specific project investigations provided most of the agricultural water requirements information presented in Bulletin No. 160-66. For some portions of some hydrologic study areas, however, staged land and water use projections have not been made. Therefore, to complete a picture of conditions in the State as a whole, it was necessary to make rough estimates for these areas. These reconnaissance-level estimates resulted from very limited considerations, usually because basic input data were not available.

The published bulletins and specific studies which provided staged agricultural water requirement estimates and the portion of the study areas for which reconnaissance estimates had to be made are given in the following pages.

North Coastal Hydrologic Study Area

The present and future agricultural water requirements of the southern half of this area have been studied in detail, resulting in relatively reliable estimates of future water demands as defined on page A-5. These studies are reported in Bulletin No. 142-1. The area covered included the Trinity

River, Mad River-Redwood Creek, Eel River, and Mendocino Coast Hydrographic Units. The Russian River Hydrographic Unit, which is a portion of the San Francisco Bay Hydrologic Study Area, completed the study area.

Similar studies had not been made for the remaining area, namely, the Smith River, Klamath River, Lost River-Butte Valley and the Shasta-Scott Valley Hydrographic Units. For these units, therefore, it was necessary to make reconnaissance-level estimates. Although they represent a minimum effort, a greater confidence has been placed on the estimates for these remaining areas than might otherwise be the case. The reasons for this can be attributed to information available at the time, including the results of recently completed land use and land classification surveys, allocations from the crop market outlook study, and the land and water use studies presented in Department of Water Resources' Bulletin No. 58, "Northeastern Counties Investigation", June 1960.

San Francisco Bay Hydrologic Study Area

The Russian River Hydrographic Unit portion of this area was studied in detail and the resulting estimates of present and future agricultural water requirements were reported in Bulletin No. 142-1.

No work of a comparable nature has been done for the remaining portion of this area. Land classification and land use surveys have not been made since the late 1940's, except in the North Bay area. It was necessary, therefore, to make reconnaissance level estimates for Bulletin No. 160-66.

In the South Bay area, and to a significant extent in the North Bay area, urban development will dictate the limits of agricultural activity. Consequently, population and density estimates had great significance in the process of determining future agricultural water use.

Central Coastal Hydrologic Study Area

Future agricultural water use in the San Luis Obispo and Santa Barbara Counties' portion of this area was based upon Department of Water Resources' Bulletin No. 78, "Investigation of Alternative Aqueduct Systems to Serve Southern California", Appendix D, "Economic Demand for Imported Water", March 1960.

For the remaining area, no land use or land classification surveys have been made with the exception of a few small areas. As a consequence, reconnaissance-level estimates had to be made based upon Bulletin No. 2, preliminary allocations of the crop market outlook study to this area, analysis of unit water requirements conducted in other areas, and United States Bureau of Reclamation studies of the San Felipe Division for San Benito and Southern Santa Clara Counties. Allowances were made for the possible effect expansion of the Bay Area metropolitan development would have on the availability of agricultural land.

South Coastal Hydrologic Study Area

Estimates of future agricultural land development and water use were taken from Bulletin No. 78, Appendix D. The present level of land and water use was obtained from recently completed land and water use surveys.

Sacramento Basin Hydrologic Study Area

Concurrent with the preparation of Bulletin No. 160-66, a joint Central Valley Depletion Study involving the Department of Water Resources and the Bureau of Reclamation was being conducted in areas tributary to the Sacramento-San Joaquin Delta to determine the future reduction in streamflows that might occur due to additional water-using development.

The depletion study work, described more fully in Appendix B, provided a basis for the water requirements reported in Bulletin No. 160-66 and continues to provide information for work currently being conducted under the Coordinated Statewide Planning Program.

Results of recent land use and classification surveys were available for all the area except the Pit River drainage basin where it was necessary to use 1955-56 information reported in Bulletin No. 58.

Delta-Central Sierra Hydrologic Study Area

The estimates of irrigated land and the basis for the unit applied water requirements were obtained from the Depletion Study noted above. Much of the information for the latter was developed by the Department's long-term hydrologic studies of the Sacramento-San Joaquin River Delta.

San Joaquin and Tulare Basin Hydrologic Study Areas

Projections of irrigated crop land and applied water requirements were developed during the course of the depletion studies. To a large extent, the basic work on crop projections used in these studies had been accomplished at an earlier date as part of the Coordinated Statewide Planning Program activities. Estimates of consumptive use of applied water and irrigation efficiencies were based on the latest information available from the Department's long-term Vegetative Unit Water Use Studies being conducted in the San Joaquin Valley.

North Lahontan Hydrologic Study Area

No studies had previously been made of staged water requirements for this area. Therefore, it was necessary to make reconnaissance-level estimates based on information presented in Bulletin No. 2, Bulletin No. 58, and the broad guideline provided by the Crop Market Outlook Study.

South Lahontan and Colorado Desert Hydrologic Study Areas

Estimates of future agricultural water requirements for these two areas were based upon Bulletin No. 78, Appendix D.

DERIVATION OF MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

Municipal and industrial water requirements are, essentially, the product of two factors: population and unit water use. Before each of these items are discussed in detail, it should be noted that the discussion pertaining to population estimates has been purposely placed in this section of the Appendix to facilitate the presentation of the derivation of municipal and industrial water requirements. It is recognized, however, that these projections have a much broader significance and applicability. They serve as the basic parameter for establishing levels of future economic growth, the availability of land, the character of future regional growth patterns, as well as demands for agricultural products, power production, and recreational facilities.

Population Projections

Essentially, the Department and its predecessor, the Division of Water Resources, have made three statewide sets of population projections since the beginning of the Statewide Water Resources Investigation in 1947: (1) Projections of "ultimate" populations for Bulletin No. 2, (2) projections of statewide, regional, and county populations, by decade to 2020, for Bulletin No. 78, Appendix D, and (3) the present set of projections.

Projections for Bulletin No. 2

The first set of projections, part of the studies basic to Bulletin No. 2, was related to a physical inventory of lands available for various types of future development. Within this framework, the habitable areas within the basins immediately surrounding the Los Angeles, San Francisco Bay, and San Diego metropolitan areas would be completely occupied by urban development under "ultimate" conditions. Populations for these areas were derived by application of urban population densities. Population increases in the rest of the State were made essentially proportional to the increases in irrigated acreage as determined from land classification surveys. The grand total of population obtained for California as a result of these studies was approximately 42 million. As will be seen later, this total is considerably less than the median 2020 estimate for the State used for the later Southern California Aqueduct routing studies. The reason for this difference can be explained by two factors: an underestimate of urban population densities in the future metropolitan areas; and a lack of consideration for development factors other than agriculture in the rest of the State.

Projections for Bulletin No. 78

The second of the major sets of population projections made by the Department was that referred to above as related to the aqueduct routing studies. This set, made in 1958, consisted of high, median and low estimates for the United States, for the

State of California, and for ten multiple-county regions of California, as well as county and subunit projections within the nine-county Southern California region. The county and subunit populations were consistent with the median projections for Southern California.

Forecasts for the United States, California, and Southern California were based on estimates of components of change--that is, births, deaths, and migration. Age differentials in all of these components are quite significant, requiring the separate computation of values for each of the several age groups in the population. Death rate changes, as well as ratios among such rates in different parts of the country, have been quite stable; thus, it was quite straightforward to make a single set of projections of these rates.

Birth rates are considerably more variable than death rates. For that reason, three different sets of age-specific birth rate projections were made in each area, corresponding to different assumptions as to the relationship between future and past fertility levels, as reflected by the gross reproduction rate. The basic projections of this rate were for the United States, with ratios established to obtain the corresponding rates for California and Southern California.

Migration is the most highly variable of the components of population change, particularly for areas less than national in scope. Projections of declining levels of migration to California and to Southern California were based on the assumption, that to a continually greater extent, natural increase within each of these areas would provide the labor demands of a growing economy. Specific estimates of economic activity were made for 1970 and 1980 only. Labor requirements were established on the basis of these estimates.

Projections for each of the regions of the State other than Southern California, under high, median, and low assumptions, were made by assigning appropriate proportions of the total state populations for 2020 under these assumptions, and obtaining figures for the intervening decades by considering rational differentials among rates of growth to be anticipated in the various regions during different portions of the projection period. The factors evaluated in both phases of this projection were quite complex and gave rise to assignments that involved a considerable amount of judgment.

For purposes of estimating demands for water from the California Aqueduct System, the median populations for California and its regions were chosen. In the case of California, the 2020 population for this series is 55,800,000.

Population projections for the counties which make up the nine-county Southern California region, for the portions of each of those counties in the anticipated aqueduct service area, and for subunits within that service area, were made on a basis similar to that for the regions of the State. In the case of the urban complex centered in Los Angeles, the subunit projections were made by considering the expansion of that complex within the framework of a theory of urban growth developed by Hans Blumenfeld. This theory describes the expansion of such a complex within the framework of a set of concentric zones surrounding the central nucleus of the complex. Subunit populations within the complex were obtained by geographical subdivision of the populations indicated at each decade for the several zones.

Subsequent to the completion of the aqueduct route studies, population projections were made in 1959 and 1960 for the counties making up the regions other than Southern California. These were explicitly made as subdivisions of the several regional projections. For each region, assignments of 2020 populations to counties were based on assessments of comparative economic opportunities in terms of assumed levels of employment of the various counties. County populations for intervening decades were obtained by interpolating percentages of regional totals. The shapes of the interpolation curves were defined by judgments concerning differential rates of change for the various counties.

Recent Population Projections

Early in 1965, a revised statewide population estimate was made that represented a departure from the median projection prepared for Bulletin No. 78. The revision was necessitated by two basic factors: new information and changing rates of natural increase. In the first category was the publication of 1960 census data not available at the time the projections were made for Bulletin No. 78; the issuance of new population projections by the Department of Finance to year 1980; and more intensive local studies by the Department. The changing rates of natural increase were based upon reports of the U. S. Bureau of the Census, Current Population Reports, Population Estimates, Series P-25, No. 286, and Projections of the Population of the United States, by Age and Sex: 1964 to 1985, with Extensions to 2010, published in July 1964. The manner in which the revised statewide population projection was derived is discussed in the following paragraphs.

Differentials in rates of natural increase between California and the United States, as used in the studies for Bulletin No. 78, were applied to more recent projections of national rates of natural increase, derived in this Department from the above-mentioned Census Bureau birth and death rates. The Census Bureau birth rates, chosen in consultation with population specialists of the Department of Finance, were those identified in Series C in the indicated census report.

The Series C rates represent a significant reduction from those basic to the Bulletin No. 78 median projections, particularly in the early portion of the projection period. They reflect an actual and unanticipated decrease in birth rates in the six years following the Bulletin No. 78 studies. After 1995, however, estimated birth rates are higher under Series C than those for the median projection in Bulletin No. 78. The reason for this is that in the latter, birth rates were depicted as decreasing to year 2010, whereas in Series C, birth rates remain essentially unchanged after year 1970. The Census Bureau assumption took account of almost 10 years of death records indicating a practically constant mortality rate after 1955. This assumption was based, as well, on studies of causes of deaths which gave little hope for significant future developments in combating the degenerative diseases. These diseases account for a large and growing proportion of deaths, and are responsible for the maintenance of overall mortality rates at current levels.

Volumes of net migration to California, in the absence of more adequate indicators of determining factors, were assumed, for the current study, to be the same as given in Bulletin No. 78.

The result of the statewide population study, as outlined above, showed a 2020 population for California of about 54,000,000.

Population Projections for Hydrologic Study Areas

In addition to the state total, future estimates of population have been made for counties and hydrologic study areas. Figures for 1960, 1990, and 2020 are shown in Tables A-3, A-4, and A-5. In Table A-3 the populations for 1960 consist of county totals, to the nearest hundred persons, as given by the United States Bureau of the Census for that year. Assignments of partial county populations to appropriate hydrologic study areas were made on the basis of the location of census county divisions; in some cases reference was made to even finer subdivisions of the published data.

Like the agricultural crop projections, much of the information necessary for making projections for subdivisions of the State had been or was developed in connection with specific, local studies. For the most part, these were done by programs or investigations of the Department of Water Resources. In the North Coastal Hydrologic Study Area, for example, the Department's Bulletin No. 142-1 served as a basis for the projections, although supplemented by work done by U. S. Army Corps of Engineers in San Francisco.

Similarly, the joint Central Valley Depletion Study provided population data to segments of the North Coastal and San Francisco Bay Hydrologic Study Areas, as well as major portions of the North Lahontan, Sacramento Basin, Delta-Central Sierra, San Joaquin Basin, and Tulare Basin Hydrologic Study Areas.

Population projections for those counties and portions of counties within the South Coastal Hydrologic Study Area were originally based upon Bulletin No. 78. Revisions were made for Bulletin No. 160-66, however, to reflect actual changes that had occurred between the publication dates of the two bulletins. Statistics from the Department of Finance, including their projections to year 1980, served as a basis for the revisions. A similar procedure was followed in arriving at the estimates for the Colorado Desert and South Lahontan Hydrologic Study Areas.

Various studies contributed to the population forecasts in the Central Coastal Hydrologic Study Area including work done in connection with the South Bay Aqueduct; the Coastal San Mateo Investigation (Bulletin No. 138); the U. S. Army Corps of Engineers' Soquel Creek survey report; and work done specifically for the Coordinated Statewide Planning Program.

Unit Municipal and Industrial Water Use

The method for determining unit municipal and industrial water requirements has been to relate total water delivery as determined from records of water service agencies to population within the service area, arriving at a unit requirement expressed in terms of quantity of water per capita. This present gross per capita water requirement is then increased or decreased to reflect anticipated changes in the makeup of the urban complex. Special studies, such as one conducted in the San Joaquin Valley and which is described below, have given indications of changes in unit use that might be expected, as well as some of the problems inherent in the gross per capita water requirement approach to estimating future water needs.

Urban Water Use in Five San Joaquin Valley Cities

In March 1960, the Department published an office report showing the per capita water use for five San Joaquin Valley cities. The study was intended to develop per capita water use for the total developed urban area and to identify those factors that have an influence on water use. Some of the conclusions reached were:

1. The use of meters tends to decrease per capita use.
2. As the irrigated acreage in the valley increases and the humidity rises, the per capita water use requirement tends to be lowered.
3. Municipal water service systems are frequently undersized and fail to meet peak delivery demands. Per capita water requirements would generally be higher if the systems were redesigned to meet these peak demands.
4. In the study area, unmeasured water used from private sources was estimated to be as much as 30 percent of recorded use.
5. Conservation programs to stop "gutter-flooding" materially lower per capita use.
6. All other factors remaining constant, the monthly pattern of per capita water use has a strong correlation to average monthly temperature.

This study demonstrated that the evaluation of per capita water requirements has many pitfalls. Data are frequently lacking or inadequate. Census data, even in census years, is hard to evaluate as enumeration districts and municipal water service area boundaries do not typically coincide. It is frequently impossible to isolate all the water being used; thus surveys of this nature tend to develop low estimates.

Industrial Water Use Studies

In order to improve the Department's knowledge about industrial water use, an industrial water use study was initiated in 1960. Questionnaires were sent to an estimated 27,000 manufacturing establishments asking for information regarding water intake; kinds of use within the plant; source of water; water treated, recirculated, and discharged; employment and size of plant. About 20 percent of the establishments responded. The results of the study were presented in Department of Water Resources' Bulletin No. 124, "Water Use by Manufacturing Industries in California, 1957-59". In summary, the report found:

1. Brackish water is used in 13 counties and amounts to approximately 46 percent of all intake water reported as used for manufacturing.
2. A relatively few major industry groups use most of the water. Among these, the food and kindred products group has the highest fresh water use; however, if brackish water is included, the petroleum refining and related industries group has the highest total use.
3. During the period from 1957 through 1959, manufacturing industries used about 917,000 acre-feet of fresh water annually.
4. The South Coastal area has the highest manufacturing water use in the State at about 266,000 acre-feet annually. The San Francisco Bay area total was 253,000 acre-feet.

The above industrial survey is one of a series of studies to refine municipal and industrial water use estimates by accounting separately for the major components of urban water use.

NET WATER REQUIREMENTS

As used in Bulletin No. 160-66, net water requirements are the sum of the consumptive use of applied water and the portion of the excess applied water that becomes unavailable for reuse in the area, i.e., irrecoverable losses. Consumptive use is loss through evaporation and transpiration. Irrecoverable losses may occur when applied water percolates into ground water of poor quality, empties into water bodies of poor quality, or the ground water level to which it moves is at too great a depth for economic extraction. They may also occur when surface water return flows empty into stream systems from which it is impractical to redivert within an area. However, in the latter case, these waters often become accretions to downstream areas and are available for reuse.

Part of the irrecoverable loss of many areas is a portion of the developed water that can best be termed "transport water". This is the quantity necessary to fill the distribution canals of a surface water diversion system. In many systems this quantity flows out of the area, unused, after the irrigation season.

In Bulletin No. 160-66, net water requirements apply to both agricultural and urban water needs. They were developed for each hydrologic study area based upon estimates of consumptive use of applied water and judgment evaluation of irrecoverable losses in the study area. More reliable estimates will be available when current studies, which will divide each hydrologic study area into a number of individual service areas, will permit a more thorough appraisal of irrecoverable losses.

LIMITATIONS OF INFORMATION CONTAINED IN BULLETIN NO. 160-66 AND WORK IN PROGRESS

Bulletin No. 160-66 is the first of a new series being published by the Department of Water Resources. The series will maintain the statewide water resources planning and development picture on a current basis. It will point up the needs for project services for various regions within the State and the magnitude and timing of future developments to meet those needs.

To do this, the information reported should be equally reliable and on a comparable basis throughout the State. In this respect, the water requirements reported in Bulletin No. 160-66 leave something to be desired. Both the amount of basic data available and the thoroughness of analysis vary among areas. As a consequence, some of the projected water requirements incorporate considerations that others do not. Work done in connection with the State Water Project service areas, for example, include an explicit analysis of the ability to pay for water and costs of water in the derivation of cropping patterns and associated water quantities. Comparable studies have been conducted for specific investigations in other areas. In many others, however, economic constraints affecting agricultural development have either not been considered or not documented.

Scope of Water Demand Studies Under Present Program

To correct this situation, the Department, under the Land Use and Classification Surveys Program and the Coordinated Statewide Planning Program, is making a systematic attempt to cover the entire

State on a comparable study level. To accomplish this, the five districts of the Department have been subdivided into four study areas. Each of these areas will be analyzed with a similar product in mind. Content and procedures will be standardized. The end product will be projected water demands through year 2020. These will be derived for both urban and agricultural purposes. Basic land use and class data will be updated and work scheduled to coordinate with the analytical phase of the program. The latter will include population and industrial projections; crop pattern forecasts; payment capacity analysis; identification of possible sources of water supply and associated water costs; determination of demand schedules within the range of prices corresponding to the estimates of water costs; and, finally, a determination of net water demands.

Necessity to Review Crop Market Outlook Study

Some of the specific data basic to the water demand studies need to be reevaluated in some detail. The Crop Market Outlook Study is a case in point. Although a recent revision of this study was incorporated in the projections of Bulletin No. 160-66, it is felt that further analysis is warranted. Changes are occurring so rapidly in American agriculture, both in the technical and policy fields, that a continuing effort must be made to keep abreast of these changes. The impact of foreign markets, in particular, must be thoroughly analyzed. Just a few years ago, there was concern over the large food surpluses in this country. Now there is concern over the extent of their disappearances, largely as a result of increases in our food exports. These and other considerations could have a very significant impact on the Department's crop projections and estimates of future water demands.

Reexamination of Population Estimates

With respect to population estimates, several aspects require reexamination in view of both incompletely verified assumptions, and of changed judgments concerning certain components of change. The most crucial problem, from a conceptual point of view, has to do with expected levels of migration. Up to the present time, the determinants of migration have been expressed only in very general terms. It is intended to express these determinants with much greater precision. It is the belief of many demographic experts that the primary influence determining migration is differential economic opportunity, and that this opportunity can be most effectively expressed in terms of employment levels. For that reason, as well as for directly determining industrial water demands, the Statewide Planning Office is engaged in an industrial outlook study which will establish anticipated levels of future industrial production and employment. The employment data will be converted, through allowances for unemployment and nonlabor force components, into employment-related populations. To this will be added the population attracted to California subsequent to retirement. Migration between any two dates will then consist of the excess or deficiency of the total population so determined, as compared with that resulting from the application of assumed birth and death rates to the population at the beginning of the period.

Further developments have occurred to require changes in vital rates (particularly birth rates) in making future projections of California's population. Continuing reductions in the experienced birth rates have prompted the Department of Finance to recommend a change to the Census Bureau's lower Series D as the standard for California projections. In addition, the Census Bureau has made certain revisions in the method of determining the birth rate series which had the effect of further lowering the estimated number of births to be anticipated in the next 20 years. Finally, the question of differentials in vital rates between California and the rest of the United States should be examined in light of experience over the considerable number of years since the studies which were made for Bulletin No. 78.

The preparation of a set of consistent projections for the major regions of California is equally as important as the need to revise the forecasts for the entire State. Fundamental to this task is the development of a consistent set of assumptions and procedures. To achieve this consistency will require an objective assessment of the relative growth prospects of the various regions of the State and of the dynamic factors operating in each. It is anticipated that the industrial outlook study, including an analysis of regional growth characteristics, will serve as a basis for making regional allocations of population.

Water Use Considerations

Basically, unit municipal and industrial water requirements have been developed by collecting and evaluating historic gross water deliveries to municipal water systems and relating these to appropriate populations. This approach, however, permits little more than generalities regarding the characteristics of urban water use and the importance of those factors likely to affect future changes. Little information has been collected or evaluated to correlate urban water use with the domestic, commercial, or industrial components of an urban complex. Departmental studies, however, demonstrate a need for this type of information. They indicate that there are great variations in per capita water rates from city to city and from year to year under apparently similar conditions.

To improve the reliability of water demand estimates, the various causative factors affecting the level of water use are being analyzed. This is a follow-up on a study done for the Department by the MevA Corporation, entitled "Domestic Water Use Planning", October 1965. In addition to suggestions in that report, consideration is being given to such items as the effect of price, metering and personal income on unit water use rates.

The studies reported in Bulletin No. 160-66 indicated the need to emphasize the planning for and designing of major water transportation facilities. This will require the development of reliable estimates of peak water delivery demands. This, in turn, will require better information on monthly rates of unit applied water and unit consumptive use of applied water than is presently available for both agricultural and urban development. In addition, future studies to determine water demand, by relating ability to pay for water with probable water costs, will require more reliable estimates of total seasonal unit applied water requirements for agricultural purposes.

Finally, it was noted in the section on net water requirements that the latter should be based on consideration of much smaller geographic areas than was done for Bulletin No. 160-66 in order to account, adequately, for irrecoverable water losses.

Status of Studies in Hydrologic Study Areas

It was mentioned earlier in this appendix that one of the objectives of the Coordinated Statewide Planning Program is to develop estimates of future water demands for the entire State of California at a more or less uniform technical level. This would be done within the scope of the seven steps outlined under the heading, Derivation of Agricultural Water Requirements, Page A-5.

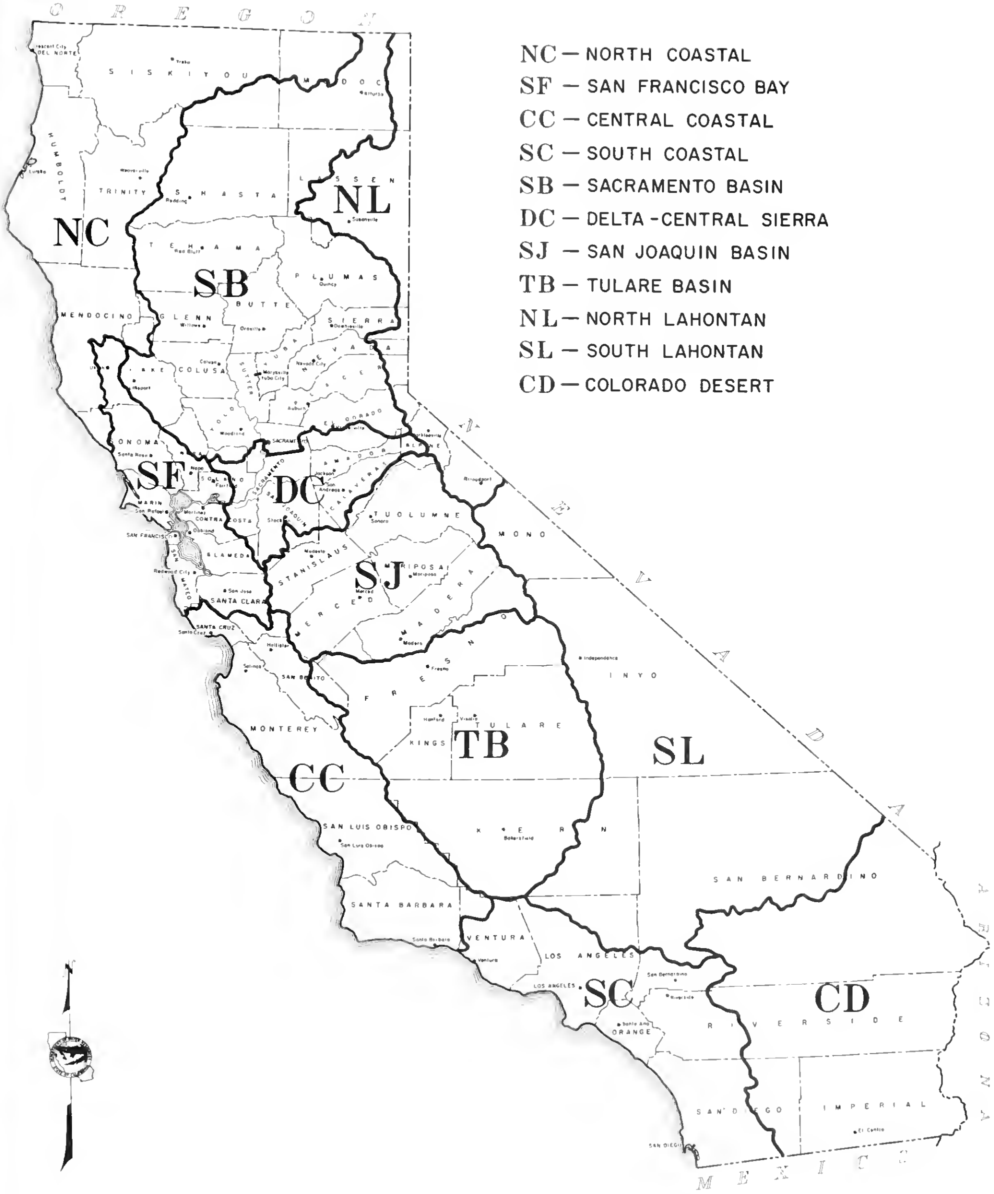
In the context of this objective, work done to date varies in the several hydrologic study areas. In the San Francisco Bay and Central Coastal Study Areas, for example, only preliminary estimates have been possible. Reliable forecasts of water demands will depend on the completion of basic land use and classification surveys. In addition, more work is needed in the San Francisco Bay Hydrologic Study Area relative to future unit use values of applied water for such important crops as grapes, prunes, and pears. Although a considerable portion of the fruit acreage in this study area has not been irrigated in the past, there are strong indications that if water were available, irrigation would become more widespread.

Water demand studies in the Central Valley portion of California are more advanced than in the San Francisco Bay and Central Coastal Study Areas. This is a consequence of special studies and investigations that have been carried on in the Central Valley including the joint Central Valley depletion study previously mentioned. Some land classification work remains to be done in the Delta-Central Sierra Hydrologic Study Area. In the San Joaquin and Tulare Basin Hydrologic Study Areas, estimates of the rate of irrigation development require reexamination in the light of land use changes that have occurred since the date of the last land use surveys in 1957-58. In all study areas of the Central Valley, including the Sacramento Basin Hydrologic Study Area, existing estimates of future water requirements should be evaluated in light of probable costs of water and the ability to pay for water as was done for the service areas of the State Water Project.

Only reconnaissance-level estimates were made of future water demands in the North Lahontan and northern portion of the North Coastal Hydrologic Study Areas. In the southern portion of the latter, estimates of future water demands of the pulp and paper industry will require periodic review to determine the actual rate of growth of this new, large water user.

An in-depth study of probable future growth in Southern California was made for Bulletin No. 78. The report served as a basis for the estimates of future water requirements shown in Bulletin No. 160-66 for the South Coastal, South Lahontan, and Colorado Desert Hydrologic Study Areas. Much of the basic data and information that went into Bulletin No. 78, however, are now nearly ten years old. In an area such as the South Coast, where change has been rapid, periodic review and revisions, if necessary, must be made. This not only includes estimates of population totals but distribution. The latter is particularly significant in determining the extent of urban development on present and potential areas of irrigated agriculture. The importance of such knowledge is not limited to the derivation of water demands in the South Coastal Area but to the extent of possible shifts in agricultural production to other areas of the State, particularly the San Joaquin Valley.

The need for an analysis and evaluation of unit water use has been described above and is applicable to many areas in California, especially Southern California.



HYDROLOGIC STUDY AREAS OF CALIFORNIA

LAND USE LEGEND

The following land use descriptions are divided into five categories. With the exception of "miscellaneous", the first letter of the notation on each land parcel indicates the category in which the description may be found.

First Letter	Section of Legend
"i" or "n"	Agriculture
"U"	Urban
"R"	Recreation
"N"	Native

AGRICULTURE

Each parcel of agricultural land use is labeled with a notation consisting basically of three symbols. The first of these is a lower case "i" or "n" indicating whether the parcel is irrigated or non-irrigated. This is followed by a capital letter and number which denote the use group and specific use as shown in Part A below.

PART A

C SUBTROPICAL FRUITS

1 Grapefruit
2 Lemons
3 Oranges
4 Dates
5 Avocados
6 Olives
7 Miscellaneous sub-tropical fruits

D DECIDUOUS FRUITS AND NUTS

1 Apples
2 Apricots
3 Cherries
5 Peaches and nectarines
6 Pears
7 Plums
8 Prunes
9 Figs
10 Miscellaneous or mixed deciduous
12 Almonds
13 Walnuts

G GRAIN AND HAY CROPS

1 Barley
2 Wheat
3 Oats
6 Miscellaneous and mixed hay and grain

F FIELD CROPS

1 Cotton
2 Safflower
3 Flax
4 Hops
5 Sugar beets
6 Corn (field or sweet)
7 Grain sorghums
9 Castor beans
11 Miscellaneous field

T TRUCK AND BERRY CROPS

1 Artichokes
2 Asparagus
3 Beans (green or dry)
4 Cole crops
6 Carrots
7 Celery
8 Lettuce (all types)
9 Melons, squash, and cucumbers (all kinds)
10 Onions and garlic
11 Peas
12 Potatoes
13 Sweet potatoes
14 Spinach
15 Tomatoes
16 Flowers and nursery
18 Miscellaneous truck
19 Bushberries
20 Strawberries
21 Peppers (all types)

P PASTURE

1 Alfalfa and alfalfa mixtures
2 Clover
3 Mixed pasture
4 Native pasture
5 Induced high water table native pasture
6 Sudan

V VINEYARDS

R RICE

I IDLE

1 Land cropped within the past three years but not tilled at time of survey
2 New lands being prepared for crop production

S SEMIAGRICULTURAL AND INCIDENTAL TO AGRICULTURE

1 Farmsteads
2 Feed lots (livestock and poultry)
3 Dairies
4 Lawn areas

PART B

Special conditions are indicated by the following additional symbols and combinations of symbols.

Symbols and Explanations	Examples
A ABANDONED ORCHARDS AND VINEYARDS Condition such that renewal of cultural practices would restore economic production	iD1-A Apple orchard previously irrigated but now abandoned
F FALLOW (tilled but not cropped at time of survey) "F" following symbol of [illegible] group most common in the area or that of last season's crop, if known	iTF Fallow land with irrigation facilities in a truck crop area
[illegible] SEED CROP Crops grown specifically for seed	iP1-[illegible] Irrigated alfalfa [illegible]
[illegible] PARTIALLY IRRIGATED CROPS	iP3-[illegible] Partially irrigated mixed pasture. Crops irrigated for only part of their normal irrigation season.
[illegible] YOUNG ORCHARDS AND VINEYARDS Production commercially insignificant [illegible] maturity	[illegible] Young [illegible]
[illegible] Intercropping	[illegible] interplanted with [illegible]
[illegible] RECLAMATION [illegible]	iI-[illegible] [illegible]

LAND USE LEGEND (continued)

URBAN

UC - URBAN COMMERCIAL

- UC 1 Miscellaneous establishments (offices and retailers)
- UC 2 Hotels
- UC 3 Motels
- UC 4 Apartments, barracks (three family units and larger)
- UC 5 Institutions (hospitals, prisons, reformatories, asylums, etc., having a reasonably stable 24-hour resident population)
- UC 6 Schools (yards mapped separately if large enough)
- UC 7 Municipal auditoriums, theaters, churches, buildings, and stands associated with race tracks, football stadiums, baseball parks, rodeo arenas, etc.
- UC 8 Miscellaneous high water use (indicates a high water use not covered above)

UI - URBAN INDUSTRIAL

- UI 1 Manufacturing, assembling, and general processing
- UI 2 Extractive industries (oil fields, rock quarries, gravel pits, public dumps, rock and gravel processing plants, etc.)
- UI 3 Storage and distribution (warehouses, substations, railroad marshalling yards, tank farms, etc.)
- UI 6 Saw mills
- UI 7 Oil refineries
- UI 8 Paper mills
- UI 9 Meat packing plants
- UI 10 Steel and aluminum mills
- UI 11 Fruit and vegetable canneries and general food processing
- UI 12 Miscellaneous high water use (indicates a high water use not covered above)

UV - URBAN VACANT

- UV 1 Miscellaneous unpaved areas (vacant lots, graveled surfaces, playing fields, nonirrigated freeway strips, raw lands within metropolitan areas, etc.)
- UV 4 Miscellaneous paved areas (parking lots, runways, freeways, oiled surfaces, flood control channels, tennis court areas, auto sales lots, etc.)

UR - URBAN RESIDENTIAL

One and two family units, including trailer courts

May be followed by Development Factor or Water Use Factor

Example:

UR 41

Water Use Factor — Development Factor

Development Factor:

Factor	Houses per acre	Percent total area developed
0	0.5 to 2	75 - 100
1	3 to 4	75 - 100
2	3 to 4	50 - 75
3	5 to 6	75 - 100
4	5 to 6	50 - 75
5	5 to 6	25 - 50
6	7 or more	75 - 100
7	7 or more	50 - 75
8	7 or more	25 - 50
9	7 or more	0 - 25

Water Use Factor:

Factor	Percent of the total area that is irrigated
0	0 - 10
1	10 - 20
2	20 - 30
3	30 - 40
4	40 - 50
5	50 - 60
6	60 - 70
7	70 - 80
8	80 - 90
9	90 - 100

U - URBAN

[illegible]

RECREATION

RR RESIDENTIAL

Permanent and summer home tracts within a primarily recreational area. (The estimated number of houses per acre is indicated by a number in the symbol.)

RC COMMERCIAL

Commercial areas within a primarily recreational area (includes motels, resorts, hotels, stores, etc.)

RT CAMP AND TRAILER SITES

Camp and trailer sites in a primarily recreational area

NATIVE

- NV NATIVE VEGETATION
- NR RIPARIAN VEGETATION
  - NR 1 Swamps and marshes
  - NR 2 Meadowland
- NW WATER SURFACE
- NC NATIVE CLASSES UNSEGREGATED

MISCELLANEOUS

This [illegible] symbols which may [illegible] preceding four sections.

E ENTRY DENIED

Permission to enter [illegible]

M MILITARY AREAS

Indicates lands [illegible] military and is used [illegible].

Example: IF1-M [illegible]

P PARKS

Indicates all types [illegible] private, and is used following the land use symbol.

Example: I.4-P [illegible]

MIXED LAND USE

Indicated by [illegible] following [illegible] symbols

Examples: [illegible] / IG [illegible] UI1 - 30 / I34 - [illegible] / UV - 50

FIGURE A-3


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
YEAR OF MOST RECENT
LAND USE SURVEY
JANUARY 1967
SCALE OF MILES
40 0 40 80
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
1959
1958
1957
1963
1955
1962
1959
1958
1963
1959
1961
1957
1960
1956
1950
1955
1960
1956
1959
1962
1950
1957
1962
1958
1950
1957
1961
1959
1960
1963
1964
1958
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
LAKE
COLUSA
SUTTER
YUBA
PLACER
YOLO
SONOMA
NAPA
EL DORADO
SACRAMENTO
AMADOR
ALPINE
MARIN
SOLANO
CONTRA COSTA
SAN JOAQUIN
CALAVERAS
TUOLUMNE
MONO
ALAMEDA
STANISLAUS
MARIPOSA
SANTA CLARA
SANTA CRUZ
MERCED
MADERA
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
KERN
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
Crescent City
Yreka
Alturas
Eureka
Weaverville
Redding
Susanville
Red Bluff
Quincy
Willows
Oroville
Downieville
Ukiah
Colusa
Marysville
Yuba
Nevada City
Lakeport
Auburn
Woodland
Santa Rosa
Napa
Fairfield
Sacramento
Martinez
San Rafael
San Francisco
Oakland
Stockton
Sonora
Redwood City
Modesto
Mariposa
San Jose
Merced
Santa Cruz
Madera
Hollister
Salinas
Fresno
Independence
Hanford
Visalia
Bridgeport
San Luis Obispo
Bakersfield
Santa Barbara
Ventura
Los Angeles
San Bernardino
Riverside
Santa Ana
San Diego
El Centro
Salton Sea

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

16-20

SACRAMENTO VALLEY FLOOR
HYDROGRAPHIC UNIT

SCALE
1 0 1 MILE
1000 0 2000 4000 6000 FEET

LAND AND WATER USE
1961
LOS MOLINOS QUADRANGLE

FIGURE A-5

STUDY NO 62-56

THE RESOURCES AGENCY OF CALIFORNIA
QUAD SUMMARY

LAND · USE — IN ACRES — 1961

DEPARTMENT OF WATER RESOURCES
SACRAMENTO VALLEY FLOOR

REPORT DATE 10/16/63

① SPECIAL CONDITIONS: S SEED, Y YOUNG, A ABANDONED, F FALLOW, M MILITARY, I RECLAMATION, B BURNED, X PARTIALLY IRRIG, P PARKS

② PLANTING SEASON: A SPRING, B SUMMER, C FALL, D WINTER

③ SOURCE OF WATER & TYPE OF DIVERSION: 1 STREAM PUMP, 2 DRAIN PUMP, 3 WELL PUMP, 4 OTHER PUMP, 5 STREAM GRAVITY, 6 DRAIN GRAVITY, 7 WELL GRAVITY, 8 OTHER GRAVITY

QUAD NUMBER	COUNTY CODE NO	HYDRO UNIT NO	SERVICE AREA CODE NUMBER	DIVERSION CODE NO	LAND USE SYMBOL: MAJOR CROP	LAND USE SYMBOL: INTER CROP	① SPECIAL CONDITION	② PLANT SEASON	③ SOURCE OF WATER & TYPE OF DIVERSION	IRRIGATED LANDS: INCLUDING FALLOW	IRRIGATED LANDS: EXCLUDING FALLOW	NONIRRIGATED LANDS: INCLUDING FALLOW	NONIRRIGATED LANDS: EXCLUDING FALLOW	SERVICE AREA AND/OR HYDRO UNIT TOTALS	QUAD TOTALS
16-20	52		11		P4				3	4	4				
										4*	4*				
										4**	4**				
					NV							551	551		
												551*	551*		
												551**	551**	555	
16-20	52		14		G1							4	4		
												4*	4*		
												4**	4**		
					NV							49	49		
												49*	49*		
												49**	49**		
				895	P1				5	21	21				
					P3				5	33	33				
										54*	54*				
					T9				5	7	7				
										7*	7*				
					D5				5	16	16				
					D8				5	335	335				
					D8		Y		5	96	96				
					D12				5	89	89				

LAND CLASSIFICATION LEGEND

Each land parcel delineated on the "Classification of Lands" figures is classified in one of four general categories--urban, recreational, irrigable, or miscellaneous--and is labeled accordingly. These categories and the related symbols are explained in the following sections.

URBAN AND RECREATIONAL LANDS

This section defines the urban and recreational classes as indicated by symbols on the figures. Some of these lands, though well suited or presently used for recreational purposes, are also mapped as to irrigability. On these lands the irrigable class symbol appears under the recreational class as a fraction.

RR Existing and potential permanent and summer home tracts within a primarily recreational area. The estimated number of houses, under conditions of full development, is indicated by a number in the symbol, i.e., RR-3 is suitable for three houses per acre.

RT Existing and potential picnic, camp and trailer sites within a primarily recreational area.

RC Existing and potential commercial areas which occur within a primarily recreational area and which include motels, resorts, hotels, stores, etc.

PP Existing race tracks, fair grounds, and private, city, county, state, and federal parks.

UD The total area of cities, towns and small communities presently used for residential commercial, recreational, and industrial purposes.

IRRIGABLE LANDS

Irrigable lands are identified by notations which begin with a letter "V", "H", or "M". These symbols indicate the general slope conditions, and may appear alone or followed by (other) modifying symbols. The slope conditions indicated by these letters are:

V These lands are level or slightly sloping and vary from smooth to hummocky or gently undulating relief. The maximum allowable slope is 6 percent for smooth, reasonably large bodies lying in the same plane.

H These are lands with greater slope and/or relief than those of the "V" class. They vary from smooth to moderately rolling or undulating relief. The maximum allowable slope is 20 percent for smooth, reasonably large bodies lying in the same plane.

M These are lands with greater slope and/or relief than those of the "H" class. They vary from smooth to steeply rolling or undulating relief. The maximum allowable slope is 30 percent for smooth, reasonably large bodies lying in the same plane.

The description below applies to all "V", "H", and "M" lands on which these slope symbols appear by themselves:

Have soils of medium or deep effective root zones; are permeable throughout; are relatively free of salinity, alkalinity, rock, or other conditions which would limit crop adaptability; are suitable for all climatically adapted crops, being limited only by topographic conditions.

FIGURE A-6

LAND CLASSIFICATION LEGEND (continued)

IRRIGABLE LANDS (Continued)

The symbols below, appended to "V", "H", or "M", indicate the described modifying conditions.

S Indicates the presence of an excess of soluble salts or exchangeable sodium in slight amounts, which limits the present adaptability of these lands to crops tolerant to such conditions. The application of small amounts of amendments and some additional water over and above crop requirements to leach out the harmful salts may be required.

SS Indicates the presence of an excess of soluble salts or exchangeable sodium in sufficient quantity to require the application of moderate amounts of amendments and some additional water over and above crop requirements to effect reclamation.

SA Indicates the presence of an excess of soluble salts or exchangeable sodium in sufficient quantity to require the application of large amounts of amendments and some additional water over and above crop requirements to effect reclamation.

P Indicates shallow depth of the effective root zone, which in general limits use of these lands to shallow-rooted crops.

W Indicates the presence of a high water table, which in effect limits the present crop adaptability of these lands to pasture crops. Drainage and a change in irrigation practice would be required to affect the crop adaptability.

L Indicates fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuitable for production of shallow-rooted crops.

H Indicates very fine textures, which in general make these lands best suited for production of shallow-rooted crops.

R Indicates enough rock on the surface or within the plow zone to limit use of the land for cultivated crops.

-B Indicates low-lying basin and seep areas.

-(L) Indicates ground cover varying from a light to moderately dense growth of low brush through a low-density growth of medium-height trees.

-(M) Indicates ground cover varying from a high-density growth of low brush to a moderately dense growth of medium-height to tall trees.

-(H) Indicates ground cover varying from a high-density growth of tall brush (manzanita, etc.) and or medium-height trees to a very dense growth of large trees.

-2,-4,-6, or -8 Number indicates, in feet, the average difference between highs and lows due to microrelief.

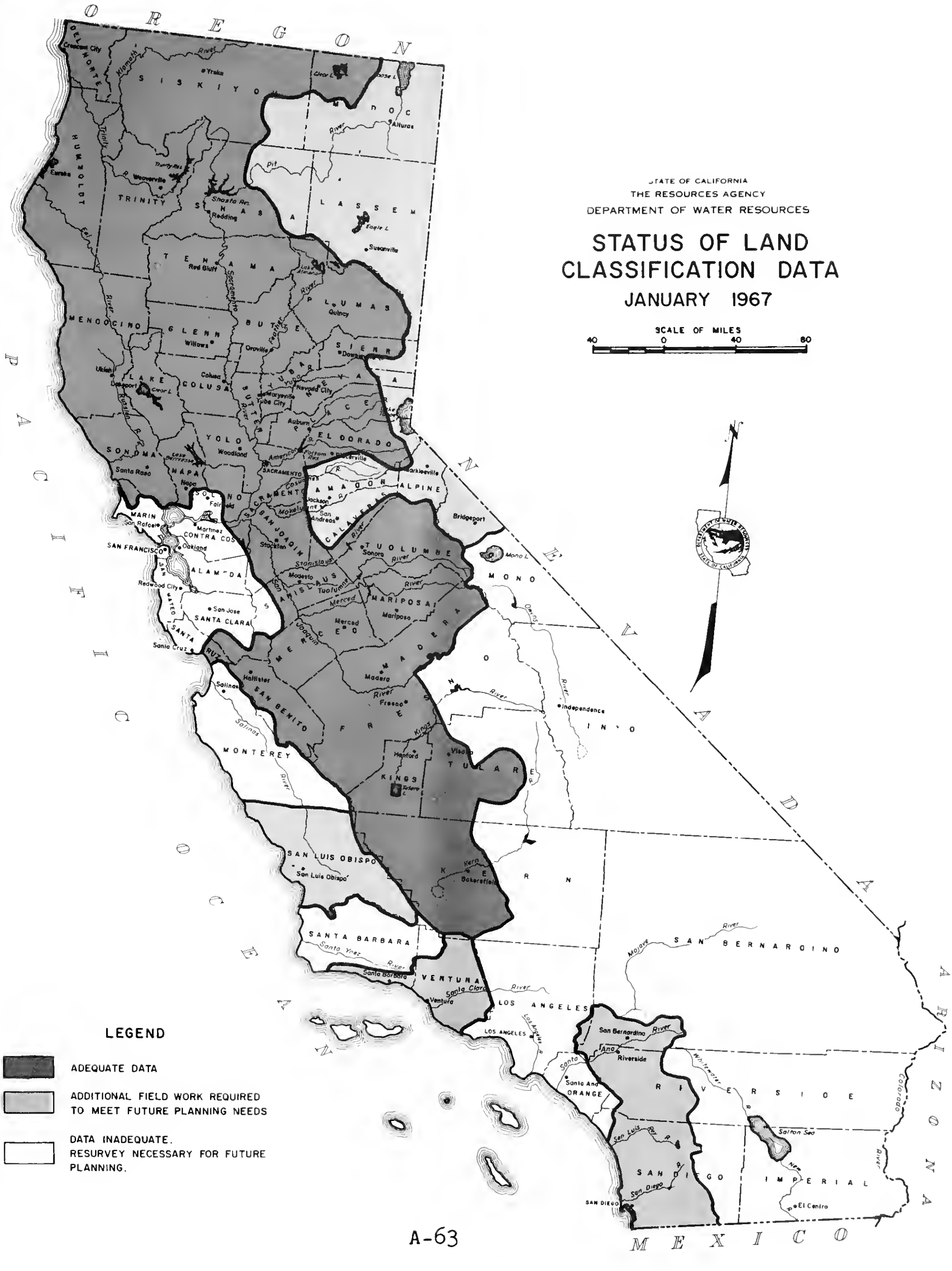
MISCELLANEOUS LANDS

F Presently forested lands, or lands subject to forest management, which meet the requirements for irrigable land but which, because of climatic conditions and physiographic position, are better suited for timber production or some type of forest management program rather than for irrigated agriculture.

SM Swamp and marsh lands which usually support a heavy growth of phreatophytes and are covered by water most of the time.

VA Smooth lying valley lands which are affected by such heavy concentrations of salts that further detailed studies would be required to determine the feasibility of reclaiming these lands for irrigated agriculture.

N Includes all lands which fail to meet the requirements of any of the foregoing classes.



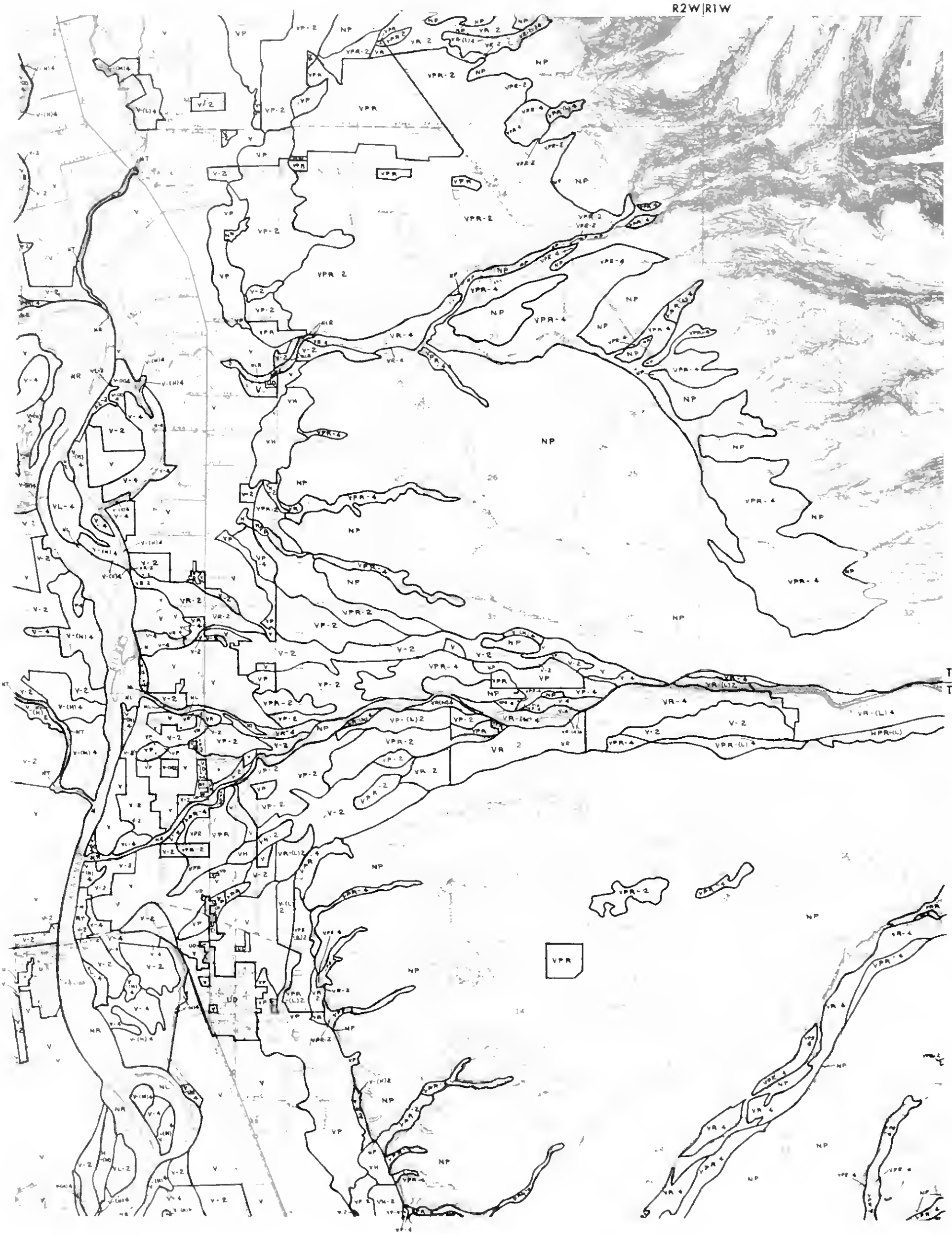
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

STATUS OF LAND CLASSIFICATION DATA
JANUARY 1967

FIGURE A-8

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

16-20



SACRAMENTO VALLEY FLOOR
HYDROGRAPHIC UNIT

SCALE
1 MILE
1000 0 2000 4000 6000 FEET

CLASSIFICATION OF LANDS
1962
LOS MOLINOS QUADRANGLE

STUDY NO 62-55 THE RESOURCES AGENCY OF CALIFORNIA

QUAD SUMMARY

LAND CLASS – 1963

IN ACRES

DEPARTMENT OF WATER RESOURCES

SACRAMENTO VALLEY FLOOR

REPORT DATE 3/17/65

QUAD NUMBER	COUNTY CODE NO	HYDRO UNIT NO	SERVICE AREA CODE NUMBER	LAND CLASS SYMBOL	GROUND COVER	LEVELING (IN FEET)	DRAINAGE	ACRES	SERVICE AREA AND OR HYDRO UNIT TOTALS	QUAD TOTALS
16-20	52		11	VR		2		23		
				VR	L	4		29		
				VPR		2		80		
				VPR		4		35		
				VPR	L	4		14		
								181*		
								181**		
				N				374		
								374*		
								374**	555	
16-20	52		14	V				954		
				V		2		3		
				V	H	4		8		
								965*		
								965**		
				N				14		
								14*		
								14**	979	
16-20	52		16	V				629		
				V		2		249		
				V		4		63		
				V	M	4		90		
				V	H	4		270		

FIGURE A-9

FIGURE A-10

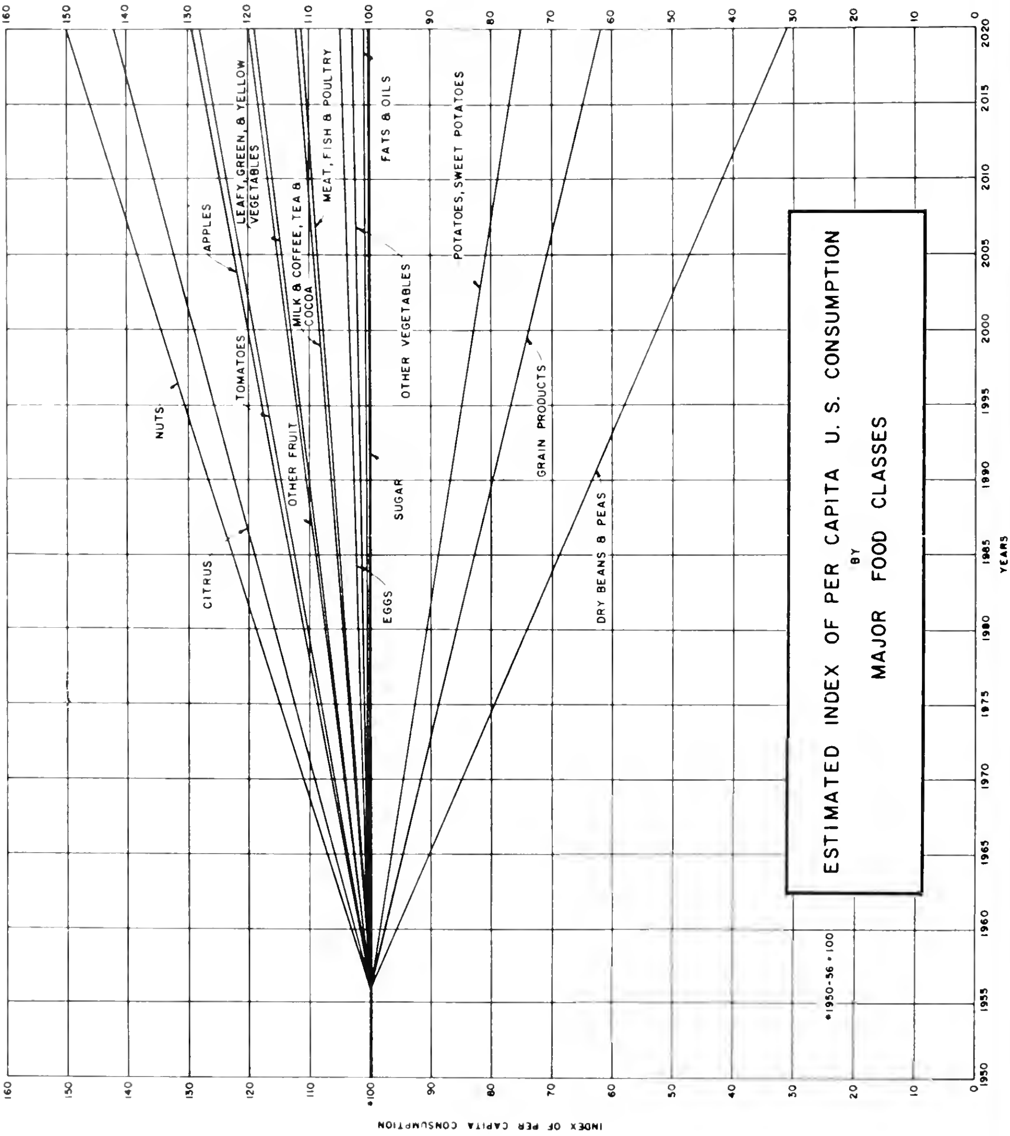

ESTIMATED INDEX OF PER CAPITA U. S. CONSUMPTION
BY
MAJOR FOOD CLASSES
*1950-56 = 100
NUTS
CITRUS
APPLES
TOMATOES
LEAFY, GREEN, & YELLOW VEGETABLES
OTHER FRUIT
MILK & COFFEE, TEA & COCOA
MEAT, FISH & POULTRY
FATS & OILS
SUGAR
EGGS
OTHER VEGETABLES
POTATOES, SWEET POTATOES
GRAIN PRODUCTS
DRY BEANS & PEAS
YEARS
INDEX OF PER CAPITA CONSUMPTION

TABLE A-1

Future Yield Levels by Crops in Year 2020

Crops	Yield in 2020	
	Index (1956-60 = 100)	Units per acre
Apples	130	577 bu.
Apricots	130	6.2 tons
Cherries	130	3.3 tons
Peaches	130	14.6 tons
Pears	130	13.1 tons
Plums	130	4.7 tons
Prunes	130	2.2 tons
Grapes	148	9.6 tons
Almonds	130	.75 ton
Walnuts	172	.95 ton
Oranges	145	311 bxs.(75 lb.)
Lemon	145	17.5 tons
Asparagus	160	3,940 lbs.
Cantaloupes	160	11.0 tons
Lettuce	160	25,500 lbs.
Potatoes	157	43,400 lbs.
Tomatoes	160	27.0 tons
Alfalfa	154	7.7 tons
Cotton	127	3.8 bales
Rice	154	7,050 lbs.
Sugar Beets	154	32.0 tons
Beans	127	1,960 lbs.

TABLE A-2

Total Irrigated Crop Acreages by
Major Crop Categories in California
1960 and 2020

Crop 1/	Land Acreage (in 1,000's of Acres)	
	1960 2/	2020 3/
Hay and Grain	1,067.2	757
Rice	374.4	240
Cotton	811.8	1,265
Sugar Beets	169.7	312
Miscellaneous Field	817.3	1,286
Alfalfa	1,229.6	1,937
Pasture	1,521.1	1,741
Truck	920.1	1,260
Deciduous	686.8	1,063
Subtropical	329.8	360
Vineyard	446.5	890
Fallow (Southern District Only)	162.1	--
TOTAL	8,536.4	11,111

1/ Refer to DWR's Standard Land Use Legend for specific crops within these categories.

2/ Gross irrigated land, including "fallow" land and "NR2" land. As shown, Southern District "fallow" entered as a separate item.

3/ Net water service land. Excludes "fallow", roads and rights-of-way, farmsteads, etc.

TABLE A-3

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

Interim Revision
Issued January 1966

1960 POPULATIONS OF CALIFORNIA COUNTIES AND HYDROLOGIC STUDY AREAS (In thousands)

County	HYDROLOGIC STUDY AREA											Total
	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	
Alameda		908.1				0.1						908.2
Alpine									0.4			0.4
Amador						10.0						10.0
Butte					82.0							82.0
Calaveras						7.4	2.9					10.3
Colusa					12.1							12.1
Contra Costa		358.0				51.0						409.0
Del Norte	17.8											17.8
El Dorado					18.9	2.7			7.8			29.4
Fresno							9.9	356.0				365.9
Glenn					17.2							17.2
Humboldt	104.9											104.9
Imperial											72.1	72.1
Inyo										11.7		11.7
Kern								255.1		36.9		292.0
Kings								50.0				50.0
Lake	0.1				13.7							13.8
Lassen					2.6				11.0			13.6
Los Angeles				5,975.9						62.9		6,038.8
Madera							40.5					40.5
Marin		146.8										146.8
Mariposa							5.1					5.1
Mendocino	29.1	22.0										51.1
Merced							90.4					90.4
Modoc	1.4				5.6				1.3			8.3
Mono									0.8	1.4		2.2
Monterey			198.3									198.3
Napa		65.6			0.3							65.9
Nevada					19.0				1.9			20.9
Orange				703.9								703.9
Placer					53.8				3.2			57.0
Plumas					11.6							11.6
Riverside				225.2							81.0	306.2
Sacramento					477.6	25.2						502.8
San Benito			15.1					0.3				15.4
San Bernardino				415.6						65.8	22.2	503.6
San Diego				1,031.1							1.9	1,033.0
San Francisco		740.3										740.3
San Joaquin						220.8	29.2					250.0
San Luis Obispo			81.0									81.0
San Mateo		444.4										444.4
Santa Barbara			169.0									169.0
Santa Clara		621.9	20.4									642.3
Santa Cruz			84.2									84.2
Shasta					59.5							59.5
Sierra					2.1				0.1			2.2
Siskiyou	23.2				9.7							32.9
Solano		106.8			6.7	21.1						134.6
Sonoma	0.9	146.5										147.4
Stanislaus						0.3	157.0					157.3
Sutter					33.4							33.4
Tehama					25.3							25.3
Trinity	9.7											9.7
Tulare								168.4				168.4
Tuolumne							14.4					14.4
Ventura				199.1								199.1
Yolo					48.6	17.1						65.7
Yuba					33.9							33.9
Total	187.1	3,561.0	568.0	8,550.8	933.6	355.7	348.8	829.8	26.5	178.7	177.2	15,717.2

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

Interim Revision
Issued January 1966

1990 POPULATIONS OF CALIFORNIA COUNTIES AND HYDROLOGIC STUDY AREAS (In thousands)

County	HYDROLOGIC STUDY AREA											Total
	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	
Alameda		1,734.7				0.3						1,735.0
Alpine									1.4			1.4
Amador						23.0						23.0
Butte					191.0							191.0
Calaveras						17.9	7.1					25.0
Colusa					26.0							26.0
Contra Costa		950.0				85.0						1,035.0
Del Norte	32.0											32.0
El Dorado					50.9	9.0			26.0			85.9
Fresno							15.9	874.1				890.0
Glenn					30.0							30.0
Humboldt	200.0											200.0
Imperial											146.0	146.0
Inyo										13.7		13.7
Kern								558.6		117.0		675.6
Kings								170.0				170.0
Lake	0.5				49.5							50.0
Lassen					1.9				26.1			28.0
Los Angeles				9,204.1						647.9		9,852.0
Madera							100.0					100.0
Marin		440.0										440.0
Mariposa							12.8					12.8
Mendocino	113.0	29.0										142.0
Merced							195.0					195.0
Modoc	3.7				12.1				2.2			18.0
Mono									12.7	2.0		14.7
Monterey			600.0									600.0
Napa		209.0			6.7							215.7
Nevada					29.6				4.0			33.6
Orange				2,564.0								2,564.0
Placer					157.5				12.0			169.5
Plumas					23.9							23.9
Riverside				887.0							290.0	1,177.0
Sacramento					1,293.1	76.9						1,370.0
San Benito			39.7					0.3				40.0
San Bernardino				1,482.0						382.0	111.0	1,975.0
San Diego				2,241.4							8.6	2,250.0
San Francisco		930.0										930.0
San Joaquin						599.1	48.3					647.4
San Luis Obispo			254.0									254.0
San Mateo		933.0										933.0
Santa Barbara			593.0									593.0
Santa Clara		1,720.0	180.0									1,900.0
Santa Cruz			230.0									230.0
Shasta					160.0							160.0
Sierra					6.6				0.2			6.8
Siskiyou	43.0				14.0							57.0
Solano		323.0			37.7	97.3						458.0
Sonoma	1.8	418.2										420.0
Stanislaus						0.4	304.6					305.0
Sutter					79.1							79.1
Tehama					61.0							61.0
Trinity	18.0											18.0
Tulare								315.0				315.0
Tuolumne							33.0					33.0
Ventura				1,100.0								1,100.0
Yolo					163.3	45.7						209.0
Yuba					72.6							72.6
Total	412.0	7,686.9	1,896.7	17,478.5	2,466.5	954.6	716.7	1,918.0	84.6	1,162.6	555.6	35,332.7

TABLE A-5

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

Interim Revision
Issued January 1966

2020 POPULATIONS OF CALIFORNIA COUNTIES AND HYDROLOGIC STUDY AREAS (In thousands)

County	HYDROLOGIC STUDY AREA											Total
	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	
Alameda		2,519.7				0.3						2,520.0
Alpine									5.0			5.0
Amador						58.0						58.0
Butte					437.0							437.0
Calaveras						46.5	18.5					65.0
Colusa					46.0							46.0
Contra Costa		1,584.8				165.2						1,750.0
Del Norte	56.0											56.0
El Dorado					103.0	20.0			45.0			168.0
Fresno							36.4	1,563.6				1,600.0
Glenn					52.0							52.0
Humboldt	390.0											390.0
Imperial											220.0	220.0
Inyo										15.2		15.2
Kern								1,179.0		296.0		1,475.0
Kings								350.0				350.0
Lake	1.0				100.0							101.0
Lassen					4.3				45.7			50.0
Los Angeles				9,601.0						1,041.0		10,642.0
Madera							275.0					275.0
Marin		680.0										680.0
Mariposa							32.0					32.0
Mendocino	204.9	45.1										250.0
Merced							375.0					375.0
Modoc	6.6				20.1				3.3			30.0
Mono									35.7	2.3		38.0
Monterey			1,185.0									1,185.0
Napa		446.5			23.5							470.0
Nevada					64.0				10.0			74.0
Orange			3,194.0									3,194.0
Placer					354.0				20.0			374.0
Plumas					58.2							58.2
Riverside				2,133.1							623.9	2,757.0
Sacramento					2,156.5	143.5						2,300.0
San Benito			114.7					0.3				115.0
San Bernardino				2,580.0						749.0	221.0	3,550.0
San Diego				3,298.0							57.0	3,355.0
San Francisco		990.0										990.0
San Joaquin						1,164.5	112.0					1,276.5
San Luis Obispo			749.0									749.0
San Mateo		1,163.0										1,163.0
Santa Barbara			1,123.0									1,123.0
Santa Clara		2,280.0	320.0									2,600.0
Santa Cruz			505.0									505.0
Shasta					300.0							300.0
Sierra					18.0				0.8			18.8
Siskiyou	95.0				20.0							115.0
Solano		695.0			108.8	246.2						1,050.0
Sonoma	3.0	737.0										740.0
Stanislaus						0.5	649.5					650.0
Sutter					185.0							185.0
Tehama					148.0							148.0
Trinity	29.0											29.0
Tulare								525.0				525.0
Tuolumne							80.0					80.0
Ventura				2,165.0								2,165.0
Yolo					505.3	108.7						614.0
Yuba					163.0							163.0
Total	785.5	11,141.1	3,996.7	22,971.1	4,866.7	1,953.4	1,578.4	3,617.9	165.5	2,103.5	1,121.9	54,301.7

APPENDIX B

WATER SUPPLY AND OPERATION STUDIES

TABLE OF CONTENTS

TABLES

INTRODUCTION

Insofar as the existing Central Valley Project-State Water Project water system is concerned, the primary water-producing area of California is the great Central Valley drainage basin. Within the Central Valley, most of the water supply comes from the Sacramento River and its tributaries. The Sacramento-San Joaquin Delta provides a convenient focal point from which the surplus flows originating in the Central Valley drainage basin can be exported to those portions of the State with inadequate local water supplies. As areas within the Central Valley develop and increase their use of water, the amounts of surplus water available for export from the Sacramento-San Joaquin Delta will decrease. At the same time the demands for export of water are expected to progressively increase. As these demands for export of water outstrip the dependable water supply, new sources of water will have to be developed.

The quantity of the dependable supply of water, power, or some other water-related product that any system of man-made works can produce or yield is determined by means of operation studies. If the project is a single dam and reservoir with a single purpose, such as irrigation, the operation study is simple and would usually be done by hand. As a project, or a system of project works, becomes more complex and has more than one purpose, the possible alternative courses of action are many. Correspondingly, operation studies become more and more complicated. Today, electronic computers are used to perform complex operation studies.

The network of reservoirs, powerhouses, conduits, and channels comprising the Central Valley Project-State Water Project (CVP-SWP) system is very complex. Estimating the potential water yield of this system requires complicated operation studies, which, in turn, depend on a long chain of supporting water supply studies.

The CVP-SWP system operation studies were made for two basic purposes: (1) to provide estimates of water yield of the system under given future conditions of development, and (2) to show the timing and amounts of water which will need to be added to the CVP-SWP system in order to fully satisfy the future projected water demands within the areas of origin and the demands of the existing CVP-SWP facilities exporting water from the Delta.

THE CVP-SWP SYSTEM

The facilities of the CVP-SWP system which were included in the operation studies for Bulletin No. 160-66 are listed below:

1. Central Valley Project

    a. Trinity River Division

        Clair Engle Lake
        Trinity Powerplant
        Lewiston Reservoir
        Lewiston Powerplant
        Clear Creek Tunnel
        Judge Francis Carr Powerplant
        Whiskeytown Reservoir
        Spring Creek Powerplant

    b. Shasta Division

        Shasta Reservoir
        Shasta Powerplant
        Keswick Reservoir
        Keswick Powerplant

    c. American River Division

        Folsom Reservoir
        Folsom Powerplant
        Nimbus Reservoir
        Nimbus Powerplant

    d. Delta Division

        Tracy Pumping Plant
        Delta-Mendota Canal
        Contra Costa Canal

2. State Water Project

    a. Oroville Division

        Oroville Reservoir
        Oroville Powerplant
        Thermalito Diversion Dam
        Thermalito Canal
        Thermalito Forebay
        Thermalito Powerplant
        Thermalito Afterbay

b. North Bay Aqueduct

c. South Bay Aqueduct

d. North San Joaquin Division

Delta Pumping Plant
North San Joaquin Portion of California Aqueduct

3. DWR-USBR Joint-Use Facilities

a. Peripheral Canal

b. San Luis Division

San Luis Reservoir
San Luis Pumping-Generating Plant
San Luis Forebay
San Luis Forebay Pumping Plant
San Luis Canal to Mile 18 (Dos Amigos Pumping Plant)
Dos Amigos Pumping Plant

COORDINATED CVP-SWP OPERATION STUDIES

Monthly studies of the coordinated operation of the CVP-SWP system were performed to determine the dependable power production and the firm water yield which could be maintained with increased diversions of water in areas tributary to the Delta under future conditions of development. The yield of the CVP-SWP system was measured at the Dos Amigos Pumping Plant located 18 miles south of San Luis Reservoir. This provided a convenient location to measure the yield of the CVP-SWP system for the purpose of determining the requirement for additional conservation and import projects.

The hydrologic period of study for the water supply and operation studies was the 1928-34 historic condition. This seven-year period represents the most severe drought period of record in the Central Valley and includes the critical drought years of 1931, 1933, and 1934. Although 1924 was drier than any of these three years, it occurred between more normal years of water supply. During the 1928-34 period, the computed mean annual natural runoff into the Delta was about 65 percent of the 1910-11 to 1959-60 average.

The CVP-SWP system was operated under these water supply conditions with the system demands for water and with the estimated depletion of water in areas tributary to the Delta which existed in 1960 and which was projected for the 1990 and 2015 level of development. The system was simulated by a mathematical model which was programmed on an IBM 7094 electronic computer using Fortran II coding language.

Major Assumptions of the CVP-SWP Operation Studies

Two major assumptions were fundamental to the operation studies. The first was the "Delta Pooling Concept" and the second was that of coordinated operation of the federal Central Valley Project and the State Water Project.

The "Delta Pooling Concept" assumes that state and federal water agencies will export from the Delta only those waters arriving in the Delta after local upstream requirements (including those in the Delta) have been satisfied. Additional or supplemental water conservation facilities will be constructed when total demands for water from the State Water Project and the Central Valley Project exceed the yield available to the Projects from the Delta.

The purpose of the coordinated operation of the CVP-SWP system was to combine water and power production of each facility within the two projects to obtain the greatest firm water yield at near optimum peak power output for the two projects. Required releases were made from the most advantageous facility regardless of ownership. In effect, the water supply, water yield, and power yield of the federal Central Valley Project and the State Water Project were pooled. Reservoir operation was consistent with each agency's long-term plans and operational constraints. The coordinated operation of the CVP-SWP system results in the greatest overall benefit of public water development by taking advantage of the diversity between the water supplies for and water and power demands on the two projects.

Operational Criteria

The operation studies considered the combined project functions of irrigation, municipal, and industrial water supply in local valley service areas, in the Delta, and for export; power production, and navigation on the Sacramento River; reservoir releases for fish; flood control; recreation; and Sacramento-San Joaquin Delta salinity repulsion. Each project service was met by the unit or units which could supply that service most efficiently. The criteria relating to these functions are discussed below. More specific details of many individual constraints are described later in the accretion phase of the studies.

As stated previously, the main objective was, insofar as possible, to optimize the firm power yield and to develop the maximum water yield of the system. A maximum annual firm commercial power production was scheduled from the coordinated CVP-SWP system, using a system minimum generating capacity of about 1,200,000 kilowatts measured at the Delta load center. The firm production was assumed to be generated in most cases by mandatory releases from reservoirs and as additional releases from the reservoir capable of supplying power with a minimum loss of water from the system, considering pump-back potentials. Power losses between point of generation and the Delta load center were deducted in the power output.

Flood control reservations in the major reservoirs are defined through operating agreements with the U. S. Army Corps of Engineers. These agreements specify criteria for storage reservations depending upon hydrologic and weather conditions.

Releases to maintain these storage limits were met unconditionally in the operation studies.

A minimum 1,800 cubic-feet-per-second outflow from the Sacramento-San Joaquin Delta was maintained for repulsion of ocean salinity and for maintenance of adequate water quality in the Delta channels for agricultural and other purposes. This requirement was assumed to be met either by available uncontrolled flow into the Delta or by reservoir releases.

Minimum reservoir storage levels were maintained at system reservoirs to insure an adequate water supply for mandatory releases in future months. In the operation studies, when any reservoir reached its minimum storage level, water demands not mandatory on that particular reservoir were met from other sources, if available.

In-basin irrigation, municipal, and industrial demands on the CVP-SWP system were taken as mandatory requirements on a particular unit if that was the only facility in a location strategic to the service. Otherwise, the demands were met by the unit most efficiently able to supply the demand consistent with other demands on the CVP-SWP system.

Operation Study Results

Results of the operation study showed the annual water yield of the CVP-SWP system, measured at Dos Amigos Pumping Plant near San Luis Reservoir, while maintaining a dependable power yield of 1,200,000 kilowatts. Firm annual yields of water for the three levels of development, 1960, 1990, and 2015, with the water supply available during the 1928-34 critically dry period were as follows:

Item	CVP-SWP System Yield Capabilities for Levels of Development in Central Valley (in thousands of acre-feet)		
	1960 Level	1990 Level	2015 Level
CVP-SWP System Water Yield	9,500*	4,400	3,250
CVP-SWP Contractual Demand	0	5,389	5,405
Additional Water Required to Meet Contractual Demand (rounded)	0	1,000	2,150

*If sufficient Delta diversion capacity had existed.

Although the 1990 level operation study showed a need to develop 1,000,000 acre-feet in project yield, it is unlikely that all the requirements for water service north of Dos Amigos Pumping Plant will be as great as the system demands in this particular operation study. It was estimated that the water demands in the American River service area and in the areas to be served by additional CVP exports from the Delta would be approximately 600,000 acre-feet per year less than that assumed in the CVP-SWP operation studies. Therefore, a projected system yield shortage of around 400,000 acre-feet was deemed more realistic for the 1990 level.

These operation study results, as modified in 1990, became the basis for Figure 33, "Staging of Major Conservation Facilities", in Bulletin No. 160-66. The basic system yield shown in Figure 33 was computed as the sum of the above system yield, at Dos Amigos Pumping Plant, and the use of authorized service in the Central Valley. The gradual reduction in yield results from increased water use in areas tributary to the Delta.

SUPPORTING WATER SUPPLY STUDIES

The CVP-SWP system operation study represents the final stage of a series of supporting water supply studies. The water supply input to the CVP-SWP operation study itself was provided by an accretion study. In turn much of the input data for the accretion study was derived from consumptive use and depletion studies. The basic purpose of these supporting studies was to estimate the amounts of water under given future conditions which will flow into system reservoirs and into the Delta. These amounts were determined by analyzing the probable changes or depletions of historic flows which would occur under conditions of future development.

At the time of the preparation of Bulletin No. 160-66, the Department of Water Resources and the United States Bureau of Reclamation were engaged in a joint Central Valley depletion study for the purpose of developing a common estimate of the depletionary effect of future land development within the Central Valley on the water supply arriving at the Delta. The first of these joint depletion studies, a depletion estimate for the 2015 level of development, was finished during the summer of 1966. It was used as the basic water supply for the operation study presented at the State Water Rights Board hearings on the Department of Water Resources' applications for storage and diversion for the State Water Project.

However, the framework of the DWR-USBR joint depletion study had been quite well established by fall of 1965 and certain results were ready. Therefore, as much as possible of the joint depletion method was included in preparation of the water supply input to the operation studies which were conducted for Bulletin No. 160-66.

Previous DWR water supply projections have always made an allowance for future depletion in the amounts of water reaching the Delta, but the DWR-USBR Joint Depletion Study method is probably the most comprehensive approach ever used to estimate this depletion. But, because of the incomplete nature of the depletion studies at the time the yield estimates for Bulletin No. 160-66 were made, the input to the Bulletin No. 160-66 operation studies represented a blending of the new depletion study method into the early DWR water supply framework. Essentially, the method employed was to use the previous DWR accretion study procedure, based on historic diversions and projected diversions, on the main stem of the Sacramento River and to use depletion study principles in estimating inflow to the Delta from the major remaining tributary areas. The projected diversions from the Sacramento River main stem were also estimated by depletion study methods. In general, the depletion effect in mountainous areas was regarded as insignificant.

Where the joint depletion method was employed, the sequence of estimating the water supply involved a consumptive use phase, a depletion study phase, and an accretion study phase. The last item, the accretion study, became the water supply and demand input to the coordinated CVP-SWP operation study program.

Consumptive Use Studies

The depletion study method requires estimating the total consumptive use requirements of projected land use patterns and then obtaining the depletion by subtracting the consumptive use of replaced native vegetation. The irrigated and urban consumptive use requirements and the estimated consumptive use of native vegetation were derived by a monthly consumptive use machine program taking into account the parameters of rainfall, soil moisture, potential consumptive use by various crops and native vegetation, and estimated historic and projected land use patterns. The annual crop unit potential consumptive use values which were used are listed in Table B-1. These values were developed for use only in the Central Valley drainage basin.

It was assumed in the consumptive use studies that all water diverted for nonconsumptive purposes, such as domestic use inside the house, would be returned to the system.

Depletion Studies

The water requirements developed in the consumptive use phase were used in the depletion study phase to estimate the effects of the projected level of development on the historic streamflow base. For study purposes, the Central Valley was divided into a number of individual study areas.

The standard depletion study method adopted for each study area consisted of several basic steps and procedures, outlined as follows:

1. A presentation of historic conditions of water supply development and outflow.
2. An evaluation of future increase in water requirements. Estimated future water needs were compared with water use by historic developed areas and by replaced native vegetation. Parameters of rainfall, soil moisture, and potential consumptive use of various crops and native vegetation were taken into account in determining future water needs and net increase in consumptive use in each study area.
3. A modification of the historic water supply by superposition of existing and proposed future nonsystem water supply developments or facilities. The nonsystem facilities are discussed in subsequent paragraphs.

4. A comparison of the modified historic water supply and future water demands in order to evaluate the depletionary effect on historic flows and the need for future storage in or above each study area to regulate flows to provide for future demands.

Depletion studies extending over the seven-year hydrologic dry period were made of the larger subdivisions of the Central Valley and in a few of the tributary mountain basins, namely, the Yuba-Bear and the Sacramento River Basin above Shasta Reservoir. In much of the Sacramento Valley, results of the depletion study phase furnished projected diversion requirements for the accretion phase. In those areas draining directly into the Delta, the results of the depletion study phase were used as accretions to the Delta supply.

Modifications of the historic water supply were introduced in several of the study areas to reflect the operation of reservoirs which were not operated directly in the operation study. These reservoirs were operated separately and the net effects on the streamflow were reflected in the water supply input of the operation of the CVP-SWP system. Those reservoirs included were:

Pardee and Camanche Reservoirs

Millerton Reservoir

New Exchequer (Lake McClure) Reservoir

New Don Pedro Reservoir

New Melones Reservoir

Marysville Reservoir

Camp Far West Reservoir

Auburn, Monticello, Black Butte, and Almanor Reservoirs were handled in the accretion phase of the water supply studies as explained later.

It was also assumed that ground water would supply a portion of the total irrigation requirement and that ground water storage reductions in excess of historic net changes would be replenished in the years following the 1928-34 hydrologic dry period of study. The percentage of the total irrigation demand supplied from ground water at projected future levels of development was 40 percent in the San Joaquin Basin hydrologic study area, 40 percent to the east of the Delta (eastern valley portion of Delta-Central Sierra hydrologic study area), and an average of about 38 percent in the Sacramento Valley. The percentages used for individual areas of the Sacramento Valley ranged from 20 to 50 percent. These values were judgment assumptions based largely on what was known of present-day ground water pumping. The subject of ground water use needs more examination. Reliable data on ground water movement, recharge, and the interaction between surface and ground water is lacking in many Central Valley areas.

Accretion Study

The accretion study phase furnished an analysis of water demands (diversion requirements) on the CVP-SWP system by reaches or control points. The key control locations were: (1) Trinity River, (2) Clear Creek, (3) Sacramento River, Keswick to the Navigation Control Point (NCP), (4) Yuba River, (5) Bear River, (6) Feather River, (7) American River, (8) Sacramento River, Navigation Control Point to Sacramento, (9) Eastside stream group (Cosumnes, Mokelumne, and Calaveras Rivers), (10) San Joaquin River, (11) Sacramento-San Joaquin Delta, and (12) Delta to San Luis, ending at Dos Amigos Pumping Plant.

The accretion study phase determined the flows available from uncontrolled sources and the flows available from CVP-SWP system mandatory releases for each stream reach and for the Delta under future development. The accretion study reflected the use of ground water and the timing and quantities of return flow to the river system. Auburn, Monticello, Black Butte, and Almanor Reservoirs were operated separately and the effects on the streamflow were reflected in the water supply input of the operation of the CVP-SWP system. The combination of upstream depletions, operation of nonsystem projects, local demands, return flows, uncontrolled inflows, minimum flows for navigation, and minimum flows for fish preservation established the mandatory demands by reaches of each stream below the respective facilities of the CVP-SWP system.

CVP-SWP System Water Demands

Both fixed and variable demands for water service were included in the accretion study to set constraints on the operation of each CVP-SWP system reservoir. Fixed demands are those water diversions which remained on a constant schedule each year throughout the study period while variable demands fluctuated depending on climatic conditions. Within this study all CVP-SWP system demands were assumed to be fixed with the exception of those for the Sacramento Valley and Feather River service area water users.

Fixed or constant water demands for each level of development were included for the following irrigation uses:

		Normal Annual Amount 1,000 acre-feet		
		1960	1990	2015
1.	Folsom South Canal	0	426	852
2.	Delta Uplands and Lowlands Channel Depletion	1,872	2,060	2,060
3.	Exchange contract (part of Delta-Mendota Canal)	1,070	1,070	1,070
4.	Delta-Mendota service area	546	546	546
5.	Federal San Luis deliveries	1,250*	1,247	1,250
6.	State San Joaquin Valley deliveries	1,203*	1,203	1,203
7.	Additional irrigation from the Delta for the CVP	0	735	735
8.	Shasta County (served from Whiskeytown Reservoir)	34	65	65
9.	Stockton and East San Joaquin County	80	80	80

* For yield estimating purposes

In addition to the fixed irrigation demands shown in the preceding tabulation variable irrigation demands for the Sacramento River and Feather River users were also included in the accretion study.

All of the irrigation demands shown above, except for the Delta channel depletion, were subject to deficiencies in critically dry years.

System demands for municipal and industrial uses and for salinity repulsion in the Delta were not assumed to be subject to deficiency. These demands were:

		Annual Amount 1,000 acre-feet		
		1960	1990	2015
1.	Feather River service area	25	44	49
2.	City of Sacramento (Sacramento River)	43	43	43
3.	City of Sacramento (American River)	10	201	201
4.	North Fork and Natomas Ditches	69	69	69
5.	San Juan Suburban	20	80	80
6.	El Dorado County	0	110	110
7.	Salinity Repulsion	1,305	1,305	1,305
8.	City of Vallejo	15	15	15
9.	Additional Municipal and Industrial from the Delta for the CVP	0	540	540
10.	South Bay Aqueduct	56	189	189
11.	North Bay Aqueduct	0	64	64
12.	California Aqueduct below Dos Amigos (including losses)	2,952*	2,939	2,952
13.	Contra Costa Canal	75	195	195

*For yield estimating purposes.

Mandatory Fish, Navigation, and Irrigation Demands

By agreement between the operating agencies and California Department of Fish and Game, minimum releases for fish preservation are or will be specified at the outlet works of the major facilities including Lewiston Reservoir, Whiskeytown Reservoir, Keswick Dam, Thermalito Diversion Dam and Afterbay, and Nimbus Dam. These releases are constant throughout each month but vary from month to month. They were assumed to be met in full at all times. The fish releases which were used in the accretion study phase are presented in Table B-2.

An agreement between the U. S. Army Corps of Engineers and the Bureau of Reclamation established minimum flows for navigation of 4,000 cubic feet per second on the Sacramento River at a location between Colusa Basin Drain near Knights Landing and Chico Landing. The Navigation Control Point (NCP) mandatory demand on Keswick Reservoir was the release necessary to bring the projected minimum flow up to 4,000 cubic feet per second.

Fish, navigation, and irrigation mandatory releases made from Keswick Reservoir are closely related since some releases serve a dual purpose. The initial step in computing the total mandatory release began by calculating the revised flow at the NCP. Revised flows were determined by adding historic net water requirements (historic diversions less historic return flows) to the historic flow at the NCP and then subtracting estimated future net water requirements.

The next step was the computation of accretions at the NCP due to tributary inflow between Keswick Reservoir (and Whiskeytown Dam) and the NCP. The accretions were determined by subtracting the inflow of Shasta and Whiskeytown Reservoirs from the revised flow at the NCP and then adding the Whiskeytown Reservoir fish release. This residual was compared to the minimum flow required for navigation to see if a release for navigation was required at Keswick Reservoir.

The demands for release from Keswick Reservoir for Sacramento Valley irrigation were determined by subtracting the revised flow at the NCP from the sum of Shasta Reservoir inflow and the storable Clear Creek inflow to Whiskeytown Reservoir.

If the sum of the demands at Keswick Reservoir for irrigation and navigation requirements were insufficient to meet the minimum fish flow required at Keswick Reservoir an additional release was made from Keswick Reservoir for fish purposes.

The total mandatory demand at Keswick Reservoir then became the sum of the releases to meet fish, navigation, and irrigation demands.

Sufficient flows were always available to satisfy irrigation demand along the Sacramento River in the reach between the NCP and Sacramento. These flows were made up of fish and navigation releases, uncontrolled flows, and irrigation return flows to the Sacramento and Feather Rivers.

Irrigation demands of the Feather River service area comprised a mandatory release from Oroville Reservoir. These irrigation demands were derived from consumptive use and depletion studies. Total mandatory releases at Oroville also included the fish flow and municipal and industrial requirements. Estimated future discharges of the Kelly Ridge Powerhouse were assumed to be available to help meet the Feather River service area water requirements.

Mandatory irrigation releases at Whiskeytown and Folsom Reservoirs were made to fulfill the demands set forth in the preceding section, CVP-SWP System Water Demands.

Sacramento Valley Accretions

Future accretions to flows in the Sacramento Valley at Sacramento were estimated by assuming that all inflows into Whiskeytown, Shasta, Oroville, and Folsom Reservoirs would be held in storage except for the mandatory releases. Beginning with the historic flow of the Sacramento River at the I Street gage, the following items were added or subtracted to compute the accretions at Sacramento. These were:

1. (-) Historic flows at Whiskeytown, Shasta, Oroville, and Folsom Reservoirs
2. (+) Historic diversions above Sacramento
3. (-) Historic return flows above Sacramento
4. (-) Projected diversions above Sacramento
5. (+) Projected return flows above Sacramento
6. (-) Historic Yuba and Bear River inflows
7. (+) Projected Yuba and Bear River inflows as determined by a depletion analysis
8. (+) Fish releases at Keswick, Thermalito, and Nimbus Reservoirs
9. (+) Navigation releases from Keswick Reservoir
10. (+) Net change due to Black Butte and Monticello Reservoir operation

Delta Operation

The Sacramento-San Joaquin Delta was considered as the focal point of the water supply studies and the coordinated CVP-SWP operation study. The Delta operation within the accretion study determined the amount of water available for export to San Luis Reservoir, whether mandatory Delta demands could be met from unregulated flows, and the releases required if the mandatory Delta demands could not be met from unregulated flows. If a shortage existed, the necessary releases were made from upstream CVP-SWP system reservoirs prior to export from the Delta to meet CVP-SWP system requirements at San Luis Reservoir and for the South Bay Aqueduct. Delta surpluses or shortages were computed by adding up all Delta inflows and comparing the total with Delta requirements.

The unregulated water available in the Delta included only the accretions left after net storage (inflow less mandatory releases) in system reservoirs had been taken out of the water supply at the Delta. The Delta inflow consisted of the following items:

1. Sacramento Valley accretions
2. Eastside Delta tributary streams
3. San Joaquin River inflow
4. Other tributary Delta inflow
5. Precipitation on the Delta uplands and lowlands

Delta mandatory water requirements consisted of the following:

1. Delta uplands and lowlands water requirements
2. Exchange contract (Delta-Mendota Canal)
3. CVP exports in the Delta-Mendota Canal for irrigation purposes
4. Contra Costa Canal
5. Additional CVP export from the Delta for irrigation purposes
6. North Bay Aqueduct
7. Salinity repulsion
8. City of Vallejo
9. Additional CVP export from the Delta for municipal and industrial purposes
10. Stockton and East San Joaquin County

Deficiencies

Deficiencies or shortages in agricultural water supply delivered by the federal CVP and SWP facilities were taken during critically dry years. No deficiency was permitted on municipal and industrial deliveries. The deficiency criteria allowed a 50 percent reduction in agricultural water deliveries during the period April through October in the years 1931 and 1933. The only exceptions to this pattern were the Exchange Contract, where the deficiency was taken as 20 percent, and within the Delta, where no deficiency was assumed.

CONTINUING WATER SUPPLY STUDIES

The task of estimating future water supplies is constantly being revised to reflect new data, new projections, and new water developments. Probably the most meaningful accomplishment since the conduct of the operation studies for Bulletin No. 160-66 was the continued progress on the joint Central Valley depletion study by engineers of the United States Bureau of Reclamation and the Department of Water Resources.

Both the Department and the Bureau of Reclamation are engaged in the planning of large-scale conservation and conveyance works in the Central Valley and in the California North Coastal Area. It is of mutual interest to develop a common framework to evaluate the depletionary effect on the water supply resulting from future land development in the Central Valley. It is also of mutual interest to develop a common basic water supply for both agencies to use in long-range planning of works which will affect Delta inflow. The comprehensive joint DWR-USBR Central Valley depletion study was designed to help fulfill this mutual need. The objective is to reach agreement on a projected water supply as presently estimated, recognizing the need for continuing refinement and revision as new data become available.

Sufficient progress had been made on the joint DWR-USBR depletion studies so that an introductory study at the 2015 level of development could be presented to the State Water Rights Board during the summer of 1966 in connection with the hearings on the Department's water rights applications for the State Water Project.

The operation study presented in the water rights hearings indicated a need for an additional import of 1,550,000 acre-feet annually to meet present CVP-SWP system contractual commitments. In addition, another 930,000 acre-feet average annual supply would be required to fully meet water requirements in several basin areas draining directly into the Delta. If these latter water shortages were to be supplied directly from the Delta pool (the only likely source) on a fairly uniform yearly schedule, additional sources providing 2,480,000 or approximately 2,500,000 acre-feet per year of water yield would be needed in 2015. Much of this amount would undoubtedly be derived from imports from the North Coastal region.

By contrast, comparable estimates used in Bulletin No. 160-66 indicated a CVP-SWP system yield shortage of around 2,150,000 acre-feet per year in 2015 after all Central Valley demands north of Tulare Lake Basin had been met.

Other studies are now in progress to determine the system yield under several other levels of development using the joint DWR-USBR depletion method of estimating future flows.

TABLE B-1

TOTAL ANNUAL UNIT CONSUMPTIVE USE POTENTIAL BY PRECIPITATION ZONE
JOINT CENTRAL VALLEY DEPLETION STUDY

Land Use	Potential Consumptive Use (in inches) by Precipitation Zone (in inches)						Higher Mountain Basin*
	6"	10"	16"	24"	34"	50"	
Pasture	46.8	46.8	46.8	46.8	46.8	46.8	42.0
Alfalfa	43.5	44.2	44.9	45.2	45.3	45.3	40.0
Sugar Beets	37.2	38.1	38.7	39.1	39.4	39.5	-
General Field	23.1	25.0	26.3	28.8	29.8	30.9	24.0
Rice	56.1	56.1	56.1	56.1	56.1	-	-
Miscellaneous Truck	21.5	22.8	23.9	24.5	24.8	24.9	20.4
Tomatoes	32.4	33.7	34.8	35.4	35.7	35.8	-
Deciduous Orchard	35.0	36.3	37.4	38.0	38.3	38.4	32.0
Vineyard	29.8	31.1	31.2	31.8	32.1	32.2	-
Subtropical Orchard	32.8	34.1	35.2	35.8	36.1	-	-
Cotton	37.4	37.4	-	-	-	-	-
Native Vegetation	Same as pasture but limited to naturally available water.						
Historic Urban	25 percent pasture and 37 percent native vegetation.						
Projected Urban	34 percent pasture and 19 percent native vegetation.						

*Used in study areas above Shasta and Oroville Reservoirs.

TABLE B-2

MONTHLY FISH FLOW REQUIREMENTS
(in thousands of acre-feet)

Month	Trinity River below Lewiston Dam	Clear Creek below Whiskeytown Dam	Sacramento River below Keswick Dam	Feather River below Thermalito Afterbay	American River below Nimbus Dam
Jan.	9	3	160	50	15
Feb.	9	3	144	44	14
Mar.	9	2	141	50	15
Apr.	9	2	137	48	15
May	9	2	141	50	15
June	9	1	137	48	15
July	9	2	141	50	15
Aug.	9	1	141	50	15
Sept.	9	1	232	48	22
Oct.	12	1	240	50	31
Nov.	15	6	232	48	30
Dec.	12	6	160	50	31
TOTAL	120	30	2,006	586	233

APPENDIX C

LEGISLATION AND COURT DECISIONS

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MAJOR STATE LEGISLATION IMPLEMENTING THE CALIFORNIA WATER PLAN
1956-1966

Prior to 1956 the Division of Water Resources was engaged primarily in water rights administration and in water resources investigation and planning activities. While these important functions, except water rights administration, continued to be performed by the Department during the next decade, the significant change in the State's role was the commencement of construction of a major water project by the State. This project, popularly known as the State Water Project, is the largest single water project ever undertaken anywhere in the world. Even so, the project is only a part of the California Water Plan. The California Water Plan is a guide for the development of all the water resources of the State. All state legislation of the past decade believed to be of significance in implementing the entire California Water Plan is included in this portion of the Appendix.

1956

Department of Water Resources Created. Calif. Stats. 1956 (Ex. Sess.), Ch. 52, abolished the Office of State Engineer, the Division of Water Resources, and the Water Project Authority, and created a Department of Water Resources and a State Water Rights Board. Except for functions transferred to the State Water Rights Board, the Department succeeded to all powers and matters pertaining to water or dams then vested in the Department and Director of Public Works, and all the powers then vested in the Division of Water Resources, the State Engineer, and the Water Project Authority. The Department also succeeded to the powers of the State Water Resources Board and to the powers of the Department of Finance under Part 2 of Division 6 of the Water Code relating to state filings for the appropriation of water. The State Water Resources Board was continued in existence within the Department, but its name was changed to the State Water Board and it was made an advisory body. (Later it was renamed the California Water Commission to avoid confusion with the State Water Rights Board. Calif. Stats. 1957, Ch. 1941.) It was authorized to advise the Director with respect to any matters under his jurisdiction, and all rules and regulations of the Department other than those relating exclusively to the internal administration and management of the Department were required to be submitted to the Board for approval. The Reclamation Board was continued in existence within the Department, but the Board continued to exercise its powers independently. The State Water Rights Board was given jurisdiction over water rights, including permits and licenses for the appropriation of water, court reference proceedings, statutory adjudication proceedings, and recordation of ground water extractions and diversions. Thus by this act the foundation was laid for the Department of Water Resources to construct and operate the State Water Project.

Investment Fund Created. Calif. Stats. 1956 (Ex. Sess.), Ch. 29, established a basis for partial financing of the State Water Project by creation of the Investment Fund (later renamed the California Water Fund) in which was deposited the State's share of the Long Beach tideland oil and gas revenues. The Act provided that no portion of the fund should be expended unless and until specifically appropriated by the Legislature.

Income from State Land Leases Routed to Investment Fund. Calif. Stats. 1956 (Ex. Sess.), Ch. 53, amended Section 6816 of the Public Resources Code to provide that all income in any fiscal year from state land leases in excess of that required for certain specified purposes and in excess of a sum to be transferred to the General Fund, should be transferred to the Investment Fund. Thus the Investment Fund had two sources of revenue - the Long Beach tideland revenues and revenues from state land leases.

Feather River Project Redefined. Calif. Stats. 1956 (Ex. Sess.), Ch. 54. The Feather River Project, which included most of the features now designated the State Water Project, was authorized for state construction in 1951 (Water Code Section 11260) as set forth in the publication of the State Water Resources Board entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of the California Water Plan", dated May, 1951. The 1956 amendment further defined the Project to include modifications set forth in the publication of the Division of Water Resources entitled "Program for Financing and Constructing the Feather River Project as the Initial Unit of the California Water Plan", dated February, 1955.

Appropriations for State Water Project. In the Budget Act of 1956, Calif. Stats. 1956, Ch. 1, appropriations were made not only for continuing investigations and planning for the State Water Project, but also for acquisition of land. For example, Item 419.5 appropriated

$9,350,000 "for surveys, explorations, investigations, preparation of construction plans and specifications; surveys of, negotiations for, and acquisitions of, rights-of-way, easements, and property.... for the Feather River Project ..." Item 419.6 appropriated $273,000 for acquisition of dam and reservoir sites in the Upper Feather River Service Area of the Feather River Project. Among the appropriations for investigations, Item 223 appropriated $1,041,551 for investigations in the North Coastal area and Sacramento Valley Basin, for major water resource developments in California including preparation of plans and estimates; for investigations of projects to meet local water needs in the "areas of origin"; for geological exploration on major structures proposed for the California Water Plan; and for continuing comprehensive statewide collection, compilation, and publication of basic water resources data. Item 223.1 appropriated $385,000 for completion of engineering and geological investigations, studies, and reports with recommendations for a construction program for multipurpose water development and flood control projects in the Upper Feather River Service Area. Item 211 appropriated $6,000 for a land use survey on West Walker River; Item 222 appropriated $15,000 for investigations under the State Water Resources Act of 1945; Item 224 appropriated $60,350 for investigations to be matched in equal amounts by local agencies; Item 225 appropriated $200,000 for investigation and study of the Junction Point Barrier and Chipps Island Barrier pursuant to the Abshire-Kelly Salinity Control Barrier Act of 1955; Item 226 appropriated $207,014 for water right studies and negotiations concerning diversion and use of waters of the Sacramento River and Sacramento-San Joaquin Delta; and Item 228 appropriated $33,767 for similar studies and negotiations with respect to the waters of the American and Feather Rivers. This list of appropriations is not exhaustive, but is typical of the appropriations being made at this period of time preliminary to actual state construction. As noted above, acquisition of lands for the State Water Project began at this time. In addition, Item 418 appropriated $1,700,000 to the Reclamation Board and Items 419, 437-441 appropriated $5,024,500 to the Department for payment of costs of lands, easements and rights-of-way for federal flood control projects.

Appropriation for Flood Control Projects. Calif. Stats. 1956 (Ex. Sess.), Ch. 27, appropriated $1,000,000 for use in paying costs of land, easements and rights-of-way for federal flood control projects between sessions of the Legislature when construction funds for projects authorized by the State are first made available by Congress when the Legislature is not in session. The Act was clarified by Calif. Stats. 1957, Ch. 32, and subsequent Budget Acts extended the availability of the funds.

Investigations in Areas of Origin. Calif. Stats. 1956 (Ex. Sess.), Ch. 61, added Section 232 to the Water Code, authorizing and directing the Department to conduct investigations and hearings and to prepare findings therefrom and to report thereon to the Legislature with respect to the boundaries of the respective watersheds of the State and the quantitities of water originating therein; the quantities of water reasonably required for ultimate beneficial use in the respective watersheds; the quantities of water, if any, available for export from the respective watersheds; and the areas which can be served by the water available for export. The Act also required the Department to hold public hearings before adopting any findings reported to the Legislature.

San Lorenzo River Flood Control Project. Calif. Stats. 1956 (Ex. Sess.), Ch. 19, authorized the San Lorenzo River Flood Control Project in Santa Cruz County for state financial assistance pursuant to the State Water Resources Law of 1945, under which the State has undertaken to pay the cost of land, easements, and rights-of-way, including relocation of roads and utilities, required for construction of federal flood control projects.

1957

Feather River Project: Relocation Appropriation. Calif. Stats. 1957, Ch. 15, which became effective in February 1957, appropriated $25,190,000 from the Investment Fund to the Department for relocation of the Western Pacific Railroad tracks and State Highway Route 21 around Oroville reservoir. Thus construction of the State Water Project began in 1956 with commencement of land acquisition and was continued in 1957 with the start of relocation of the Western Pacific Railroad and State Highway Route 21 as a necessary prelude to construction of Oroville Dam.

Budget Act of 1957. Calif. Stats. 1957, Ch. 600. Item 417 appropriated from the Investment Fund to the Department $673,000 for studies, investigations, and geologic exploration to determine the best and most economical aqueduct routes for the delivery of water to the Lower San Joaquin Valley and Southern California. Other important appropriations in the Budget Act included Item 263 which appropriated $2,682,418 for water resources investigations, surveys, and studies, preparing plans and estimates, and making reports thereon. Item 265 appropriated $33,250 for local cooperative investigations. Item 265.5 appropriated $35,000 for preparation of a comprehensive plan for development of the water resources of the Upper Tule River Basin. Item 266 appropriated $65,500 for special water resources investigations reports. Item 415 appropriated $90,000 for restoration of Cache Creek Settling Basin Weir. Item 419 appropriated $5,410,000 to the Reclamation Board and Item 434 appropriated $5,868,000 to the Department for payment of costs of lands, easements, and rights-of-way for federal flood control projects pursuant to the State Water Resources Law of 1945.

North Bay Aqueduct Authorized. Calif. Stats. 1957, Ch. 2252, added the North Bay Aqueduct to the State's Central Valley Project (Water Code Sections 11270, 11271), and appropriated $1,340,000 from the Investment Fund to the Department for expenditure for completion of engineering studies and preparation of construction plans and specifications for the North Bay Aqueduct.

Upper Feather River Service Area of Feather River Project Further Defined. Calif. Stats. 1957, Ch. 2359, amended Water Code Section 11260 to exclude from the Upper Feather River Service Area of the Feather River Project features on the South Fork of the Feather River.

American River Development. Calif. Stats. 1957, Ch. 1121, provides that the American River Development, as described in Public Law 356 of the 81st Congress, First Session, and as constructed by the Federal Government, is part of the State Water Plan and of the State Central Valley Project.

Small Corps Projects Authorized. Calif. Stats. 1957, Ch. 254, added Sections 12750 and 12751 to the Water Code to authorize small flood control projects undertaken by the Corps of Engineers for state financial assistance pursuant to the State Water Resources Law of 1945.

Santa Maria River Flood Control Project Authorized. Calif. Stats. 1957, Ch. 13, authorized the Santa Maria River Flood Control Project in Santa Barbara County for State financial assistance pursuant to the State Water Resources Law of 1945.

Abshire-Kelly Salinity Control Barrier Act of 1957. Calif. Stats. 1957, Ch. 2092. This Act authorized the Department to limit its studies of salinity control barriers in the Delta to the Biemond Plan as described in Bulletin No. 60 of the Department entitled "Salinity Control Barrier Investigation", dated March, 1957, subject to such modifications as the Department might adopt, such studies being for the purposes of developing plans for delivery of fresh water to the counties of Solano, Sonoma, Napa, and Marin, providing flood protection in the Sacramento-San Joaquin Delta, accomplishing salinity control, improving the quality of water exported from the Delta, making the most beneficial use of the water resources of the State, and studying integration of the proposed project in the California Water Plan.

State Financial Assistance for Local Projects. Calif. Stats. 1957, Ch. 2052, was the forerunner of the Davis-Grunsky Act. It added Section 12880 to the Water Code establishing the policy of the State to provide grants and loans to cities, counties, and districts for aid in construction of projects for water development in which there is a statewide interest, and also to provide for state participation in such projects. State grants and loans could be made upon application to the Department, a report thereon by the Department, and specific authorization by the Legislature for each project.

Participation with United States in Planning Projects. Calif. Stats. 1957, Ch. 2417, added Sections 12895 and 12896 to the Water Code to authorize the Department to participate with the United States in the planning of water projects, and in particular in the planning of the New Melones and the New Hogan projects.

Whale Rock Project Authorized. Calif. Stats. 1957, Ch. 1080, appropriated over $3 million to the Department of Finance for construction of the Whale Rock project in San Luis Obispo County. Since under the State Contract Act the Department of Water Resources in 1956 became the constructing agency of the State in matters pertaining to waters and dams, the Department of Finance contracted with the Department of Water Resources for construction of the project.

Klamath River Basin Compact Approved. Calif. Stats. 1957, Ch. 113. This compact is now set forth in Water Code Section 5901, added by Calif. Stats. 1959, Ch. 586. It has been approved also by the State of Oregon and by the Congress, and it is in effect.

Appropriation of Water: Terms and Conditions. Calif. Stats. 1957, Ch. 2082, amended Section 1257 of the Water Code to enumerate beneficial uses which the State Water Rights Board may consider in acting upon applications to appropriate water, including domestic, irrigation, municipal, industrial, preservation of fish and wildlife, recreational, mining and power purposes, and to authorize the Board to subject such appropriations to such terms and conditions as in its judgment will best develop, conserve, and utilize in the public interest the water sought to be appropriated.

Beach Erosion Control: State Participation. Calif. Stats. 1957, Ch. 2376, added Sections 335 through 339 to the Water Code to authorize the Department to pay one-half of the costs of local participation required by federal legislation for beach erosion control projects in this State.

Recreational Use of Water Supply Reservoirs. Calif. Stats. 1957, Ch. 2412, added Sections 4050 through 4055 to the Health and Safety Code to require that all water supply reservoirs of the State, cities, counties, and districts, other than terminal reservoirs for the supply of domestic water, shall be open for recreational use by the people of the State, subject to regulations of the Department of Public Health.

Fishing in Publicly Owned Domestic Water Supply Reservoirs. Calif. Stats. 1957, Ch. 2413, added Sections 4462 through 4468 to the Health and Safety Code to authorize a city, city and county, district, or other public agency owning or operating a reservoir used for domestic or drinking water purposes, toopen to public fishing all or any part of the reservoir and its surrounding lands, subject to terms and conditions.

1958

Appropriations by Budget Act of 1958. Calif. Stats. 1958, (Second Ex. Sess), Ch. 1. Major appropriations for the State Water Project included Item 425, which appropriated $3,723,672 to the Department from the Investment Fund for surveys, explorations, investigations, preparation of construction plans and specifications; surveys and negotiations for rights-of-way, easements and property, for the Feather River Project, and Item 257, which appropriated $3,787,056 from the Investment Fund to the Department for water resources investigations, surveys and studies, including seepage control studies along the Sacramento River. Item 257.1 appropriated $200,000 from the Investment Fund to the Department for conducting water resources investigations requested by concurrent resolution of the Legislature. Item 425.4 appropriated $10,000,000 from the Investment Fund to the Department for expenditure, without regard to fiscal years, in cooperation with the United States in the construction of multipurpose projects which include flood control; this money subsequently was pledged to ensure the payment to the Federal Government of the costs of Black Butte and New Hogan Dams allocated to irrigation. Item 426.5 appropriated $95,000 for the State's share and Item 426.6 appropriated $95,000 for advancing the federal share of the cost of a beach erosion control project at Seal Beach. Item 426.7 appropriated $24,000 for the State's share, and Item 426.8 appropriated $32,000 for advancing the federal share of the cost of a beach erosion control project at Imperial Beach. Item 427.5 reappropriated $300,000 for acquisition of real property for recreational purposes in the vicinity of reservoirs constructed by the State. Item 428 appropriated $4,150,000 to the Reclamation Board for acquisition of lands, easements and rights-of-way for flood control projects in the Sacramento and San Joaquin Valleys, and Item 445 appropriated $6,272,000 to the Department for costs of lands, easements and rights of way for federal flood control projects pursuant to the State Water Resources Law of 1945 and the California Watershed Protection and Flood Prevention Law. Item 446.2 appropriated $780,000 from the Investment Fund to the Department for repair of the Sacramento River Flood Control Project required as a result of the 1958 flood. Item 446.7 appropriated $15,000,000 from the Investment Fund to the Department for repair of storm damage to public real property. Item 446.8 appropriated $1,000,000 to the Department from the Investment Fund for expenditure, without regard to fiscal years, for flood fighting during emergencies authorized by the Director pursuant to Section 128 of the Water Code.

Recreational Development at State Water Projects. Calif. Stats. 1958 (First Ex. Sess.), Ch. 101, added Section 345 to the Water Code to require the Department to plan recreation development associated with state-constructed water projects, in consultation with affected local, state, and federal agencies.

Truckee River Flood Control Project Authorized. Calif. Stats. 1958 (First Ex. Sess.), Ch. 84, authorized State financial participation in the Truckee River Flood Control Project pursuant to the State Water Resources Law of 1945. This is the only project for which the Department has been authorized to give the assurances of local cooperation required by federal legislation.

1959

California Water Fund Created. Calif. Stats. 1959, Ch. 140. This Act, adding Sections 12900 through 12915 to the Water Code, abolished the Investment Fund and created in its place the California Water Fund. It provided for deposit in the fund of all moneys in the Investment Fund, all revenues to be received by the State from Long Beach tideland oil and gas revenues, and revenues from state land leases which formerly were required under Public Resources Code Section 6816 to be transferred to the Investment Fund.

California Water Resources Development Bond Act (Burns-Porter Act). Calif. Stats. 1959, Ch. 1762. This Act, adding Sections 12930 through 12942 to the Water Code, and approved by the people at the general election in November 1960, is the major financing act for the construction of the State Water Project. It authorized the sale of general obligation bonds of the State in the amount of $1,750,000,000. The bond proceeds are appropriated to the Department, without regard to fiscal years, to construct the "State Water Facilities" and certain "additional facilities". The State water facilities are defined to include Oroville Dam and appurtenant features, the Upper Feather River Basin developments, an aqueduct system to carry water from the Delta to Southern California and various points in between, the North Bay Aqueduct, the South Bay Aqueduct, the San Luis Dam and Reservoir, levee protection and water transfer facilities in the Delta, drainage facilities for the San Joaquin Valley, and facilities for generation and transmission of electrical energy. $130,000,000 is made available exclusively for local water development facilities under the Davis-Grunsky Act. The Act also appropriates for the project all money in the California Water Fund and all accruals thereto, without regard to fiscal years, and provides that any money in the California Water Fund shall be used for construction of the State Water Facilities in lieu of bond proceeds. To that extent, an equal amount of authorized bonds are offset, and the bond proceeds appropriated, for construction of such "additional facilities" in the watersheds of the Sacramento, Eel, Trinity, Mad, Van Duzen, and Klamath Rivers, as the Department shall determine to be necessary and desirable to meet local needs and to augment the supplies of water in the Sacramento-San Joaquin Delta. The Act also authorizes the Department to construct and operate the facilities in accordance with the provisions of the state Central Valley Project Act, and authorizes the Department to enter into contracts with public or private corporations, entities, or individuals, for the sale, delivery, or use of water or power or other services made available by the project. The revenues from the facilities are pledged first to operation, maintenance and replacement, second to payment of principal and interest on the bonds, third to reimbursement of the California Water Fund, and fourth, as to any surplus revenues, for acquisition and construction.

Feather River Project Further Modified. Calif. Stats. 1959, Ch. 2043, further amended Section 11260 of the Water Code to modify the Feather River Project in accordance with the recommendations contained in Bulletin No. 78 of the Department of Water Resources, entitled "Preliminary Summary Report on Investigation of Alternative Aqueduct Systems to Serve Southern California", dated February, 1959.

California Water Plan Adopted. Calif. Stats. 1959, Ch. 2053, provided for legislative adoption of the California Water Plan as a general guide for the orderly and coordinated development and utilization of the water resources of the State. It authorizes the Department of Water Resources to adopt such amendments, supplements and additions from time to time as it finds necessary and desirable, which become effective when reported to the Legislature at any session. The Act also requires the State Water Rights Board, in acting upon applications for the appropriation of water, to give consideration to the California Water Plan in determining the public interest under Sections 1253 and 1255 of the Water Code. It also requires regional water pollution (quality) control boards to give consideration to the plan in establishing requirements for waste discharges.

Davis-Grunsky Act. Calif. Stats. 1959, Ch. 1752, amended Section 12880 of the Water Code added by the Grunsky bill in 1957, added additional sections, and provided that the chapter in which these sections occur shall be known as the Davis-Grunsky Act. The earlier 1957 Act set forth the policy of providing state loans, grants, and participation in local water development projects. The 1959 Act expanded on this policy and authorized the Department of Water Resources to make loans and grants up to specified maximum amounts without legislative approval, but with approval of the California Water Commission. Larger loans and grants may be made upon approval by the Legislature. It also provided $15 million in a Local Projects Assistance Fund for financing the program. It further provided that upon approval of the California Water Resources Development Bond Act by the people at the November 1960 election, the Local Projects Assistance Fund would be abolished and thereafter projects under the Davis-Grunsky Act would be financed from the $130 million made available by the Bond Act. Calif. Stats. 1959, Ch. 2163, authorized the Department to loan up to $1,260,000 from the Local Projects Assistance Fund to the South Sutter Water District for construction of an irrigation project.

State Assistance to Impact Areas: The Byrne Act. Calif. Stats. 1959, Ch. 2019, added Division 19 to the Water Code (the provisions of which were subsequently transferred by Calif. Stats. 1963, Ch. 464, to Division 6, Part 7, Sections 12950 through 12961), to provide for state assistance to local governments where construction of water resources projects financed, in whole or in part, by the State creates a burden on the local government. The State will pay increased operating expenses of public hospitals, fire, health, sanitation and police protection, and other activities approved by the Departments of Finance and Water Resources, caused by the influx of workers on the project, and 75 percent of increased costs of emergency and indigent relief. Funds for capital outlay for police and fire protection, essential health services, and water and sewerage systems may be obtained by state loans; direct state expenditures may be made for temporary systems. Assistance may be provided only within impact areas designated by the Governor as provided in the Act.

Planning for Recreation and Fish and Wildlife at State Water Projects. Calif. Stats. 1959, Ch. 2047, added Section 233 to the Water Code to require that any plans or proposals submitted by the Department to the Legislature for construction and operation of a water project by the State must include comments of the Department of Fish and Game and provision for any water or facilities necessary for public recreation and the preservation and enhancement of fish and wildlife resources that the Department of Water Resources determines to be justifiable and feasible as a nonreimbursable cost of the project.

Acquisition of Land for Recreation. Calif. Stats. 1959, Ch. 2143, added Section 346 to the Water Code to authorize the Department to acquire land by condemnation or other means for recreational development in connection with state-constructed water projects, and to authorize for such purpose the use of any funds theretofore or thereafter appropriated to the Department for acquisition of rights-of-way, easements, and property.

Use of Water for Recreation and Fish and Wildlife. Calif. Stats. 1959, Ch. 2048, added Section 1243 to the Water Code to provide that use of water for recreation and the preservation and enhancement of fish and wildlife resources is a beneficial use, and to require that the State Water Rights Board take into account, whenever it is in the public interest, the amounts of water required for recreation and the preservation and enhancement of fish and wildlife resources in determining the amount of water available for appropriation for other beneficial uses. It also amended Section 1257 of the Water Code to make it mandatory rather than discretionary that the State Water Rights Board, in acting upon applications to appropriate water, consider the relative benefit to be derived from all beneficial uses of the water concerned.

Budget Act of 1959. Calif. Stats. 1959, Ch. 1300. In addition to appropriations for various other water resources investigations and studies, Item 262 appropriated $3,336,530 to the Department from the Investment Fund (California Water Fund) for conducting water resources investigations, preparing plans and estimates, and making reports thereon. Item 262.5 appropriated $80,000 from the Investment Fund to the Department for a comprehensive study of the Colusa Basin. Item 263 appropriated $70,441 from the Investment Fund for nuclear engineering studies. Item 382 appropriated $4,136,159 to the Department from the Investment Fund for investigations, preparation of construction plans and specifications, and surveys and negotiations for rights-of-way, easements, and property for the Feather River Project. Item 383 appropriated $27,972,000 from the Investment Fund to the Department for surveys of, negotiations for, and acquisition of lands and rights-of-way for the San Joaquin Valley-Southern California Aqueduct system and the San Luis Reservoir site. Similarly, Item 383.5 appropriated $1,000,000 for acquisition of lands for the North Bay Aqueduct, Item 384 appropriated $8,013,000 for construction and land and property acquisition for the South Bay Aqueduct, Item 384.1 appropriated $100,000 for acquisition of lands for the Pacheco Pass Tunnel, Item 386 appropriated $11,883,000 for a bridge over the west branch of the Feather River in connection with the railroad and highway relocation around Oroville Dam, Item 387 appropriated $2,394,000 for construction and land acquisition for the Upper Feather River Dams and Reservoirs, Item 388.1 appropriated $13,562,000 for construction and land acquisition for the Oroville Dam and for relocation of the Western Pacific Railroad, and Item 389 appropriated $20,000 for protection and maintenance of structures, improvements and equipment acquired or constructed for the Feather River Project. All the above appropriations were from the Investment Fund (California Water Fund). The purpose of these appropriations was to continue the construction and land acquisition activities already undertaken so as to not delay the construction time schedule pending approval of the Bond Act at the November 1960 election. In addition, Item 385 appropriated

$3,740,000 from the Investment Fund to the Department for expenditure in cooperation with the Federal Government in the construction of multipurpose projects which included flood control. This appropriation was needed as additional security to the Federal Government for construction of Black Butte and New Hogan Dams. Item 388 appropriated $1,600,000 to the Department from the Investment Fund for expenditure in cooperation with the Federal Government in the investigation, planning and construction of a sea water conversion plant. For payment and costs of lands, easements, and rights-of-way for federal flood control projects, Item 390 appropriated $6,000,000 to the Reclamation Board and Item 405 appropriated $7,688,000 to the Department. For small Corps projects, Item 405.1 appropriated $210,000 and Item 405.5 appropriated $325,000. For watershed projects, Item 406 appropriated $1,267,300. Item 407 appropriated $42,000 to the Department for beach erosion control projects.

Additional Investigations and Appropriations, Calif. Stats. 1959, Ch. 2090, amended Section 226 of the Water Code to authorize the Department to investigate the rate of use of water for various purposes, considering various soil conditions, and appropriated $250,000 from the California Water Fund to the Department for making such investigations. Chapter 1909 appropriated from the California Water Fund $130,000 to the Department for studies of pollution in the Sacramento River and $83,000 to the University of California for studies of pollution in the San Francisco Bay Area. Chapter 1698 appropriated $70,000 from the Investment Fund (California Water Fund) to the Department for expenditure either independently or in cooperation with others for an investigation of electrical power sources in the Pacific Northwest for possible use in California, especially for California state water project pumping. Chapter 1765 appropriated $200,000 to the Department to investigate the water supplies for the Sacramento-San Joaquin Delta and $230,000 for additional studies under the Abshire-Kelly Salinity Control Barrier Act of 1957, including study of types and methods of construction of levee systems.

Black Butte and New Hogan Dams and Reservoirs. Calif. Stats 1959, Chapters 1774 and 1750, authorized Black Butte Dam and Reservoir and New Hogan Dam and Reservoir, respectively, as units of the state Central Valley Project. The purpose of this authorization was to enable the Department to contract with the United States under the cooperative provisions of the State Central Valley Project Act to ensure repayment of the costs of the dams and reservoirs allocated to irrigation.

Cache Creek Project. Calif. Stats. 1959, Ch. 2056, amended the authorization in Water Code Section 12663 of the Cache Creek Project to adopt the Wilson Valley Reservoir site in place of the Guinda Reservoir site.

State Filings. Calif. Stats. 1959, Ch. 2101, transferred custody of state filings for the appropriation of water from the Department to the California Water Commission. Chapter 2099 added a provision to require public hearings by the Commission before any such applications are assigned or released from priority. Chapters 1769, 1770, and 1771 extended the exemption of state filings for the appropriation of water from the requirements of diligence for another four years.

Areas of Origin. Calif. Stats. 1959, Ch. 2063, added

Section 108 to the Water Code to require that any coordinated plan by the Department must take into consideration the needs of the areas in which the water originates, and to declare that whenever the Legislature authorizes any project which will develop water for use outside the watershed in which such water originates, it shall at the same time consider authorization and construction of works necessary to develop water to satisfy the requirements of the watershed.

Water Seepage. Calif. Stats. 1959, Ch. 2128, added Sections 12627.3 and 12627.4 to the Water Code, declaring it to be the policy of the State that the costs of solution of seepage and erosion problems arising by reason of construction and operation of water projects should be borne by the project, and requiring the Department to include consideration of seepage and erosion problems in its investigations and recommendations, and to plan for the solution thereof as a part of project development.

Archaeological Investigations. Calif. Stats. 1959, Ch. 806, added Section 234 to the Water Code to authorize the Department, either independently or in cooperation with others, to investigate, excavate, and preserve any historic or prehistoric ruin or monument, or any object of antiquity, situated in areas to be used for state water development purposes.

Clearing of Reservoir Sites. Calif. Stats. 1959, Ch. 984, added Section 1393 to the Water Code to require the State Water Rights Board to require clearing of reservoir sites as a condition in permits for appropriation and storage of water.

Sacramento-San Joaquin Delta Protection. Calif. Stats. 1959, Ch. 1766, added Part 4.5 (commencing at Section 12200) to

Division 6 of the Water Code, defining the Sacramento-San Joaquin Delta and declaring that the maintenance of an adequate water supply in the Delta sufficient for uses in the Delta and to provide a common source of fresh water for export are necessary, but that the delivery of such waters shall be subject to the county of origin and watershed protection provisions in Sections 10505 and 11460 to 11463, inclusive, of the Water Code. It provides that among the functions to be provided by the State Water Resources Development System, in coordination with the activities of the United States in providing salinity control through operation of the Federal Central Valley Project, shall be the provision of salinity control and an adequate water supply for the users of water in the Delta. It provides that if a substitute water supply is provided for salinity control, no added financial burden shall be placed on the Delta water users solely by virtue of such substitution. It declares the policy that no waters should be diverted from the Delta to which the users within the Delta are entitled, and that in determining the availability of water for export, no water shall be exported which is necessary to meet the requirements of the Delta, including salinity control.

Dickey Water Pollution Act Strengthened. Calif. Stats. 1959, Ch. 1299, made numerous changes to the Dickey Water Pollution Act in Division 7 of the Water Code for the purpose of strengthening the Act. It required that the disposal of waste into the waters of the State be so regulated as to achieve highest water quality consistent with maximum benefit to the people of the State. It provided that a discharge pursuant to prescribed requirements shall not create a vested right to continue such discharge, and made it clear that regional boards may revise requirements. It required the State and regional boards, in formulating policies, to take cognizance of the California Water Plan. It enabled the regional boards to prescribe requirements as to discharges which began prior to the effective date of the Dickey Water Pollution Act. It required the reporting of material changes in the character, location or volume of discharge and authorized the boards to prescribe requirements relative thereto. It authorized the regional boards to allow and maintain a margin of safety in receiving waters, and to specify certain conditions and locations where no direct discharge of sewage or industrial waste would be permitted. Enforcement procedures were strengthened by repealing the cumbersome procedure for enforcement of requirements and providing a more direct and simplified procedure whereby the boards could issue cease and desist orders against violators of prescribed requirements and then go directly into court for a restraining order. Under the prior procedure the boards had first to hold a hearing, order correction, and then bring an injunction proceeding. In addition, a summary abatement procedure to abate a pollution or nuisance which is transitory in nature or is of short duration but periodic in occurrence was provided. Boards were authorized to institute injunction proceedings requiring the discharger to file required reports and to restrain such dischargers from making discharges in the region until the required reports are filed. Failure to file required reports was made a misdemeanor.

Flood Control Projects. Two new projects were authorized for state financial assistance pursuant to the State Water Resources

Law of 1945. Chapters 202 and 217, Statutes of 1959, authorized the project for flood protection on the Eel River, in the Sandy Prairie region. Chapter 1912 authorized the project from Chico Landing to Red Bluff on the Sacramento River.

Storm and Flood Damage Repair. Calif. Stats. 1959, Ch. 1511, enacted the Emergency Flood Relief Law (Art. 6, commencing at Sec. 54150, of Ch. 5 of Pt. 1 of Div. 2 of Title 5 of the Government Code), to provide basic legislation for state financial assistance for repair of real property owned by cities, counties, and districts, which is damaged by storm or flood.

Fishing in Water Supplies. Calif. Stats. 1959, Ch. 493, added Article 2.5 (commencing at Section 4470) to Chapter 4, Part 2, Division 5 of the Health and Safety Code to authorize a county board of supervisors to request a governmental agency (any city, city and county, and district, but not a chartered city or a county) owning a body of water used for human consumption (except reservoirs which supply water directly without further purification) to open the body of water to public fishing and the surrounding land area to other recreational uses. The board of supervisors at the same time shall deposit costs of completing a coordinated plan for such use, up to $2,500. The governmental agency shall thereupon complete the plan and apply to the Department of Public Health for an amended water supply permit. After receipt of the amended permit, if the agency refuses to allow recreational use, the issue must be voted on by the constituents of the agency. The agency may fix and collect fees and establish rules and regulations for the public use.

Investigations in Watersheds of Origin. Calif. Stats. 1959, Ch. 2025, amended Section 232 of the Water Code (the "drop by drop" survey investigation provisions), to authorize the Department to investigate present uses of water within each watershed of the State, together with the apparent claim of water right attaching thereto.

1960

Budget Act of 1960, Calif. Stats. 1960, Ch. 11. Since the California Water Resources Development Bond Act could not become effective until approved by the voters at the November 1960 election, additional appropriations for the State Water Project were made in the Budget Act of 1960. For example, Item 257 appropriated $5,814,541 from the California Water Fund for investigations, preparation of construction plans and specifications, and acquisition of lands and rights-of-way. Item 353 appropriated $21,537,721 from the California Water Fund for construction and land acquisition at the Oroville site; Item 354 appropriated $8,362,922 from the California Water Fund for construction of the South Bay Aqueduct; and Item 355 appropriated $4,095,059 from the California Water Fund for construction of the California Aqueduct, then known as the San Joaquin Valley-Southern California Aqueduct System. Item 256 appropriated $3,736,480 from the California Water Fund for investigations and reports relative to the California water planning program, and Item 255 appropriated $283,571 from the California Water Fund to the Department to conduct a comprehensive water pollution study in the Sacramento River. Item 371 appropriated $9,204,000 to the Department for lands, easements, and rights-of-way for federal flood control projects under the State Water Resources Law of 1945, Item 373 appropriated $3,610,000 to the Reclamation Board for such projects, and Item 372 appropriated $1,151,000 to the Department for lands, easements, and rights-of-way for small watershed projects pursuant to the California Watershed Protection and Flood Prevention Law. Item 374 appropriated $1,136,500 to the Department for beach erosion control projects.

1961

Recreation and Fish and Wildlife at State Water Projects: Davis-Dolwig Act. Calif. Stats. 1961, Ch. 867, added the Davis-Dolwig Act to the state Central Valley Project Act as Chapter 10 (commencing with Section 11900) of Part 3 of Division 6 of the Water Code. It declares the policy that recreation and enhancement of fish and wildlife resources are among the purposes of state water projects; that the acquisition of real property for such purposes should be planned and initiated concurrently with and as a part of the land acquisition program for other purposes; and that facilities for such purposes be ready and available for public use when each project is completed. It provides that the costs of preservation of fish and wildlife are reimbursable by the water and power users, but that the costs incurred for recreation and for enhancement of fish and wildlife shall be nonreimbursable. It further declares the policy of paying the nonreimbursable costs from General Fund appropriations in the annual Budget Acts. It requires the Department to plan recreation at state water projects, in cooperation with state and federal agencies, through the advance planning stage. It authorizes the Department of Parks and Recreation to construct, operate and maintain public recreation facilities at state water projects and the Department of Fish and Game to manage fish and wildlife resources at state water projects.

Ground Water: Porter-Dolwig Ground Water Basin Protection Law. Calif. Stats. 1961, Ch. 1620, enacted the Porter-Dolwig Ground Water Basin Protection Law as Chapter 7.5 (commencing with Section 12920) to Part 6 of Division 6 of the Water Code. It declares the intention of the Legislature that the Department shall initiate investigations, studies, plans and design criteria for construction of ground water basin protection projects deemed by the Department to be practical, economically feasible and urgently needed; and that upon the submission by any local agency to the Department of plans and design criteria for any such project, a review, evaluation, and any necessary revision of such plans and design criteria shall be made by the Department to ensure that construction will provide protection to the ground water basin. It appropriated $250,000 to the Department for the 1961-1962 fiscal year.

Sacramento River and Delta: Recreational and Wildlife Habitat Study. Calif. Stats. 1961, Ch. 324, directed the Director of Natural Resources, in cooperation with the Director of Water Resources, the Director of Fish and Game, and the State Reclamation Board to make a survey and report on the reaches and banks of the Sacramento River and Delta suitable to be preserved and developed as recreational and wildlife habitat areas. It provided for appointment of four members of the Legislature as a joint interim investigating committee to participate in the study, and appropriated $25,000.

Recharge of Ground Water from Reclaimed Water. Calif. Stats. 1961, Ch. 1131, amended Section 4458 of the Health and

Safety Code, to provide a procedure for permitting water reclaimed from sewage to be injected via a well into a subterranean water-bearing stratum that is used, or suitable for or intended to be used, as a source of water supply for domestic purposes. The procedure requires a hearing and finding by the State Board of Public Health that the proposed recharge will not impair the quality of the water in the receiving aquifer as a source of water supply for domestic purposes. It also requires a finding by the appropriate regional water pollution (quality) control board that water quality considerations do not preclude controlled recharge.

Davis-Grunsky Act Amendments. Calif. Stats. 1961, Chapters 1286 and 1723 amended the Davis-Grunsky Act. Chapter 1286 provided that preference be given to projects involving development of new basic water supplies and that no funds should be loaned for distribution system projects except in cases which involve extreme hardship which jeopardizes the public health, safety or welfare. However, a loan may cover distribution facilities that are a necessary and integral part of an over-all water development project. Chapter 1723 authorized loans for preparation of feasibility reports; provided that construction costs of a dam and reservoir allocable to recreation for grant purposes may include costs of lands needed for public recreation located above the high water line; granted independent power to public agencies to contract with the Department under the Davis-Grunsky Act; and made other changes. Chapter 1292 authorized a grant up to $3,090,100 for the Paskenta Dam and Reservoir on Thomes Creek in Tehama County.

Flood Control Projects. Calif. Stats. 1961, Ch. 211, authorized the Walnut Creek Flood Control Project for state financial assistance pursuant to the State Water Resources Law of 1945.

Organization. Calif. Stats. 1961, Ch. 2037, created the Resources Agency, consisting of the Departments of Water Resources, Conservation, Fish and Game, Parks and Recreation, and also the State Water Rights Board, the State Water Pollution Control Board, each regional water pollution control board, and the Fish and Game Commission.

San Joaquin River Water Quality. Calif. Stats. 1961, Ch. 1454, added Part 4.6 (commencing with Section 12230) to Division 6 of the Water Code to declare that a serious problem of water quality exists in the San Joaquin River between its junction with the Merced River and with the Middle River, which is of statewide interest, and that a solution to the problem is a responsibility of the State.

Appropriations: Budget Act of 1961, Calif. Stats. 1961, Ch. 888. With the continuing appropriation in the California Water Resources Development Bond Act going into effect in November, 1960, fewer appropriations for the State Water Project were made in the Budget Act of 1961. Item 339.1 appropriated $100,000 to the Division of Beaches and Parks for recreational facilities at Frenchman Reservoir. For payment of costs of lands, easements and rights-of-way for federal flood control projects, Item 399 appropriated $2,075,949 to the Department for projects under the State Water Resources Law of 1945, Item 400 appropriated $753,500 to the Department for projects under the California Watershed Protection and Flood Prevention Law, Item 400.1

appropriated $50,000 to the Department for the Ulatis Creek Watershed Project, and Item 401 appropriated $6,155,000 to the Reclamation Board. Item 402 appropriated $570,968 to the Department for beach erosion control projects.

Goose Lake. Calif. Stats. 1961, Ch. 1389, created the Goose Lake Compact Commission to formulate an interstate compact relative to the waters of Goose Lake.

1962

Appropriations: Budget Act of 1962, Calif. Stats. 1962, (Second Ex. Sess.) Ch. 1. In addition to appropriations for various investigation activities of the Department, Item 348 appropriated $487,866 to the Department for access roads and recreational facilities at Frenchman Reservoir and for onshore recreational facilities at Antelope Valley Reservoir. For lands, easements and rights-of-way for federal flood control projects, Item 408 appropriated $10,806,348 to the Department and Item 410 appropriated $5,894,000 to the Reclamation Board for projects under the State Water Resources Law of 1945; Item 409 appropriated $2,759,314 to the Department for projects under the California Watershed Protection and Flood Prevention Law. Item 410.1 appropriated $270,000 to the Reclamation Board for the Sacramento River Bank Protection Project. Item 411 appropriated $1,265,790 to the Department for beach erosion control projects.

Tahchevah Creek Flood Control Project. Calif. Stats. 1962 (First Ex. Sess.) Ch. 41, authorized this project for state financial assistance pursuant to the State Water Resources Law of 1945.

Davis Grunsky Act Grant. Calif. Stats. 1962 (First Ex. Sess.), Ch. 47, authorized the Department to make a grant to the Monterey County Flood Control and Water Conservation District not to exceed $3,820,000 for recreational functions incidental to the construction of San Antonio Dam and Reservoir.

The Cameron-Unruh Park and Recreation Bond Act. Calif. Stats. 1962 (First Ex. Sess.), Ch. 24, provided authorization for issuance of $150,000,000 in general obligation bonds for park and recreational facilities. The Act provided that no funds could be expended on construction of reservoirs in the State Water Facilities, but that they could be expended for the acquisition and establishment of beaches, parks, recreational facilities, and historical monuments at or in the vicinity of any such reservoir.

1963

Delta Recreation Plan. Calif. Stats. 1963, Ch. 2094, directed the Resources Agency Administrator, in collaboration with the State Office of Planning, to undertake a study for the purpose of developing a comprehensive master recreation plan for the Sacramento-San Joaquin Delta and along the Sacramento River. It appropriated $40,000 for carrying out the study.

Dickey Water Pollution Control Act Strengthened. Calif. Stats. 1963, Ch. 1463, renamed the State Water Pollution Control Board the State Water Quality Control Board, and authorized that Board to formulate and adopt a statewide policy for water quality control binding on other agencies of the State.

Davis-Grunsky Act Amendments. Calif. Stats. 1963, Ch. 2023, amended the Davis-Grunsky Act to authorize the making of loans and grants for projects that are primarily for recreation or fish and wildlife enhancement purposes; to authorize the making of grants for initial water supply and sanitary facilities needed for public recreational use of dams and reservoirs; and to authorize the Department to participate with local agencies in constructing and operating local projects up to an amount not exceeding $1,000,000 without specific legislative authorization. It also liberalized the Act in a number of other particulars. Additional liberalizing amendments to the Act were made at the same session by Chapters 53, 82, 769, 908, and 1075.

Davis-Grunsky Act Grants Authorized. Grants in excess of the statutory limit were authorized to be made to the following agencies: Browns Valley Irrigation District for the Virginia Ranch Dam Project in Yuba County (Chapter 132); San Luis Obispo County Flood Control and Water Conservation District for Lopez Dam and

Reservoir (Chapter 521); Oroville-Wyandotte Irrigation District for its South Fork Feather River Project (Chapter 1925); Tuolumne County Water District No. 2 for its Tuolumne River Project (Chapter 1932); Helix Irrigation District for Chet Harritt Dam in San Diego County (Chapter 1962); Placer County Water Agency for its Middle Fork American River Project (Chapter 1969); Nevada Irrigation District for its Yuba-Bear River Development (Chapter 1970); South Sutter Water District for its Camp Far West Project (Chapter 1973); Siskiyou County Flood Control and Water Conservation District for Box Canyon Dam (Chapter 1987); Yuba County Water Agency for its Yuba River Development (Chapter 1993).

Flood Control Projects. The following flood control projects were authorized for state financial assistance pursuant to the State Water Resources Law of 1945: Alameda Creek in Alameda County (Chapter 468); Mormon Slough Channel Improvement on the Calaveras River (Chapter 915); New Melones Reservoir Channel Improvement on the Stanislaus River (Chapter 918); Hidden Reservoir Channel Improvement on the Fresno River (Chapter 1202); Buchanan Reservoir Channel Improvement on the Chowchilla River (Chapter 1203); and the Russian River, Dry Creek Project (Chapter 2056).

Loan Authorization to Merced Irrigation District. Calif. Stats. 1963, Ch. 1435, appropriated $8,000,000 from the California Water Fund to the Department for a loan to the Merced Irrigation District to be used if necessary for expenditure in anticipation of receipt of federal contributions for flood control for the District's Merced River Development.

Agua Fria Project. Calif. Stats 1963, Ch. 1854, authorized the Department to complete feasibility studies of the proposed Agua Fria Project on Mariposa Creek in Mariposa County, and appropriated $78,000 for this purpose.

Interstate Compact. Calif. Stats. 1963, Ch. 1059, ratified the Oregon-California Goose Lake Interstate Compact and added it to the Water Code, commencing with Section 5950. (The Compact has been ratified by Oregon but has not been approved by the United States.)

State Filings. Calif. Stats. 1963, Ch. 159, again extended the exemption of state filings for the appropriation of water from the requirements of diligence for another four years, until October 1, 1967.

Budget Act of 1963, Calif. Stats. 1963, Ch. 1050. In addition to appropriations for general investigations and other activities of the Department, the following appropriations are of significance: Item 262 appropriated $78,300 to the Department from the California Water Fund for conducting recreation surveys. Item 262.1 appropriated $124,499 to the Department from the California Water Fund to assess the impact of the United States Supreme Court's decision in Arizona v. California on the State's water program. Item 362 appropriated $689,000 for recreation access roads, onshore development, and tree planting at various of the following state water facilities: Frenchman Reservoir, Antelope Valley Reservoir, Del Valle Reservoir, and San Luis Reservoir. For payment of costs of lands, easements and rights-of-way for flood control projects pursuant to the State Water Resources Law of 1945, Item 429 appropriated $12,366,800 to the Department and Item 431 appropriated

$3,517,922 to the Reclamation Board; Item 430 appropriated $2,173,291 to the Department for projects under the California Watershed Protection and Flood Prevention Law. Item 432 appropriated $993,000 to the Reclamation Board for the Sacramento River Bank Protection Project. Item 433 appropriated $4,328,200 to the Department for Beach Erosion Control Projects. Section 3.5 of the Budget Act appropriated $20,000,000 out of the California Water Fund for schools, and Section 3.6 appropriated all amounts accruing to the California Water Fund during the 1963-64 fiscal year in excess of $10,000,000 for schools.

Supplementary Appropriations. Supplementary appropriations to the Budget Act of 1963, made by Chapter 8, Statutes of 1963, First Extraordinary Session, included Item 31 appropriating $55,000 to the Department for geologic studies of ground water basins in Orange County, Item 31.5 appropriating $75,000 to the Department for a final feasibility study for Box Canyon Project on the Sacramento River, Item 32 appropriating $70,453 for the San Mateo County Coastal Investigation, and Item 33 appropriating $7,000 for a reconnaissance study and report on Ewing Dam and Reservoir in Trinity County.

1964

Yuba River Development Loan Authorized. Calif. Stats. 1964 (First Ex. Sess.), Ch. 41, authorized the Department to loan, from funds appropriated but now encumbered for Black Butte and New Hogan Dams, not to exceed $10,000,000 to the Yuba County Water Agency in anticipation of federal flood control contributions for the Yuba River Development. (These funds are still encumbered under the Black Butte and New Hogan contracts, and no loan has been made to the Yuba County Water Agency.)

Long Beach Tideland Revenues for the State Water Project. Calif. Stats. 1964 (First Ex. Sess.), Ch. 138, limited the amount of Long Beach tideland oil and gas revenues accruing annually to the California Water Fund to $11,000,000.

Appropriations. Significant appropriations in the Budget Act of 1964, Calif. Stats. 1964 (Second Ex. Sess.), Ch. 2, included the following: Item 255 appropriated to the Resources Agency $40,000 for the Delta Master Recreation Plan studies. Item 276 appropriated over $10,000,000 for general investigations, basic data collection, project planning, and similar activities of the Department. Item 276.1 appropriated $45,000 for a feasibility study and report on Ewing Dam and Reservoir in Trinity County. Item 277 appropriated $100,311 to the Department for recreation surveys. Item 327 appropriated $351,000 to the Department for onshore recreation facilities at Grizzly Valley, Del Valle, and San Luis Reservoirs; and Item 327.1 appropriated $775,000 for recreation facilities and access roads at Frenchman Reservoir. For payment of costs of lands, easements and rights of way for flood control projects pursuant to the State Water Resources Law of 1945, Item 394 appropriated $7,930,600 to the Department and Item 396 appropriated $7,990,406 to the Reclamation Board. Item 395 appropriated $5,339,300 to the Department for lands, easements and rights of way for watershed projects under the California Watershed Protection and Flood Prevention Law. Item 397 appropriated $3,003,480 to the Department for beach erosion control projects. Section 3.6 of the Budget Act limited the amount accruing to the California Water Fund for the 1964-65 fiscal year to $11,000,000 and appropriated the excess for school purposes.

1965

Saline Water Conversion. Calif. Stats. 1965, Chs. 991 and 993, enacted the Cobey-Porter Saline Water Conversion Law (Water Code Sections 12945 through 12949) to authorize the Department of Water Resources, either independently or in cooperation with any county, state, federal, public or private agency or corporation to conduct a program of investigation, study, and evaluation in the field of saline water conversion, and, upon specific legislative authorization, to finance, construct, and operate saline water conversion facilities. Chapters 992 and 994 added Section 12949.5 to the Water Code to authorize the Department of Water Resources, in cooperation with the United States Department of the Interior, to participate in financing costs of construction and operation of a saline water conversion test center and to sell any water made available by such test center; these acts also authorized the Department to use refunds or credits from the United States because of the State's investment in the former plant at San Diego.

Regional Water Resources Planning. Calif. Stats. 1965, Ch. 1647, added Article 4 (commencing with Section 190) to Chapter 2 of Division 1 of the Water Code to provide that whenever the State is specifically invited by federal law to participate in any interstate commission to plan for the regional development of water and related resources, the Governor shall appoint each California member of such commission, subject to Senate confirmation. Each California member shall serve at the pleasure of the Governor. These provisions specifically apply to the Western States Water Council established by the Western Governors' Conference at its meeting in Portland, Oregon, in June 1965. The act also provides for the creation of a California Advisory Committee to advise the State's representatives on the regional commissions.

Federal Reports. Calif. Stats. 1965, Ch. 55, adds Sections 450 through 453 to the Water Code to designated the Governor as the state official to receive the reports of the Chief of Engineers and the Secretary of the Interior with respect to proposed flood control or reclamation projects. The Governor is required within ten days to transmit copies of the reports to both houses of the Legislature, if in session, or to the Rules Committees. Any legislative committee to which such a report has been assigned may submit written comments to the Governor. The Governor, if such comments are submitted in time, is required to transmit such comments to the appropriate federal agency, together with the other comments of the State.

Water Pollution Control Law of 1965. This Act, enacted by Calif. Stats. 1965, Ch. 1351, authorizes the State Water Quality Control Board to make a comprehensive waste disposal study of the San Francisco Bay and Sacramento-San Joaquin Delta areas and to develop a comprehensive plan for the control of water pollution in the area. It establishes a steering committee to assist the Board and also a technical coordinating committee. Various state departments, under service agreements, are required to provide staff assistance.

Water Quality Control. Calif. Stats. 1965, Ch. 1656, amended the Dickey Water Pollution Act to make state departments and agencies subject to its regulatory provisions, to authorize the State Water Quality Control Board to determine discharge requirements in the event of disagreement between regional boards regarding requirements applicable to waste discharges affecting more than one region, and to clarify the power of the State Board to review the action or inaction of a regional board and its power to take appropriate action. Chapter 1657 changed the name of the regional boards from regional water pollution control boards to regional water quality control boards, and authorized them to formulate water quality control policy of a regional nature, in conformity with any water quality policy adopted by the State Board.

Lake Tahoe Study. Calif. Stats. 1965, Ch. 1231, created a Lake Tahoe Joint Study Committee to study and develop recommendations concerning an area-wide agency to provide for the orderly development of the Lake Tahoe Basin.

San Francisco Bay Conservation. Calif. Stats. 1965, Ch. 1162, created a San Francisco Bay Conservation and Development Commission to prepare a plan for conservation of the water of the San Francisco Bay and the development of its shoreline, and requires a permit from the Commission for bay filling or extraction projects prior to the 1969 Session of the Legislature.

Floodplain Management. Calif. Stats. 1965, Ch. 506, enacted the Cobey-Alquist Floodplain Management Act, commencing at Section 8400 of the Water Code, to provide for review, at the request of local government, by the Reclamation Board within the area of its jurisdiction and by the Department of Water Resources within the rest of the State, of floodplain management plans of cities and counties. Provides that where the appropriate public agency fails to establish necessary floodplain regulations within the area of a federal flood control project after completion of the federal project report and after notification by the Reclamation Board or the Department, the State will not appropriate money to pay the cost of lands, easements and rights-of-way associated with that project.

Flood Control Projects. The following projects were authorized for state financial assistance pursuant to the State Water Resources Law of 1945: The project for flood control debris basins and channel clearing in the Santa Barbara Area (Ch. 300); the Redwood Creek Project in Humboldt County (Ch. 405); and the Corte Madera Creek Flood Control Project in Marin County (Ch. 1388).

Davis-Grunsky Act Grants. Grants in excess of the statutory limit were authorized for the following projects: The Merced River Development of the Merced Irrigation District (Ch. 143); the New Don Pedro Dam and Reservoir Project of the Turlock and Modesto Irrigation Districts (Ch. 282); the Lopez Dam and Reservoir Project of San Luis Obispo County Flood Control and Water Conservation District, in excess of an amount previously authorized (Ch. 338); an additional amount for the Box Canyon Project (Ch. 478); an additional amount for the Camp Far West Project of the South Sutter Water District (Ch. 775); the Agua Fria Project of the Mariposa County Water Agency (Ch. 778); the Santa Rosa Creek Reservoir Project of the Sonoma County Flood Control and Water Conservation District (Ch. 1399); the proposed water development projects of Calaveras County Water District (Ch. 1412); an increased amount for the Yuba-Bear River Development of the Nevada Irrigation District (Ch. 1428); and the Alisal-Gabilan Watershed Project of the City of Salinas and the County of Monterey (Ch. 1432).

Water Well Reports. Calif. Stats. 1965, Ch. 1088, revised Chapter 7 (commencing with Section 7076) of Division 4 of the Water Code to require every person who intends to drill or alter a water well to file a notice of intent with the Department of Water Resources before commencing such construction or repair, and to require the filing of well logs upon completion of a well with the Department of Water Resources rather than with the regional water quality control boards.

Geothermal Wells. Calif. Stats. 1965, Ch. 1483, provides for regulatory control by the Department of Conservation over wells for discovery and production of geothermal energy.

State Filings for the Appropriation of Water. Calif. Stats. 1965, Ch. 989, provided for the transfer from the California Water Commission to the State Water Rights Board of jurisdiction over state filings for the appropriation of water and the duties with respect to the assignment or release from priority of such filings.

Records of Water Diversion. Calif. Stats. 1965, Ch. 1430, added Part 5.1 (commencing with Section 50100) to Division 2 of the Water Code to require recordation of surface water diversions, and diversions from subterranean streams, with the State Water Rights Board, with certain exceptions.

Supervision of Safety of Dams. Calif. Stats. 1965, Ch. 1225, amended the Supervision of Dams Act, Part 1 of Division 3 of the Water Code, to extend the State's jurisdiction to off-stream dams and over reservoirs as well as dam structures. It requires owners of dams to promptly report unusual occurrences that may affect the dams and reservoirs, to maintain suitable staffs for close surveillance, and to make appropriate investigations. It authorizes the Department of Water Resources to cancel or amend certificates of approval when the dams and reservoirs become unsafe and to consider hazardous conditions in the vicinity of dams and reservoirs in determining their safety.

River Forecasting and Flood Warning. Calif. Stats. 1965, Ch. 1291, added Section 236 to the Water Code to specifically authorize the Department of Water Resources, either independently or in cooperation with others, to collect hydrologic data necessary for river forecasting, to make forecasts of streamflow, to provide for flood warning, and to provide for communication necessary for the collection and dissemination of such information.

Budget Act of 1965. Calif. Stats. 1965, Ch. 757. Item 235 appropriated $36,000 to the Resources Agency for the Delta Master Recreation Plan study. Item 257.5 appropriated $310,000 to the Department for sea water intrusion studies. For the payment of lands, easements and rights-of-way for flood control projects, Item 307 appropriated $6,122,333 to the Department and Item 308 appropriated $5,079,992 to the Reclamation Board. Item 338 and 339 made appropriations to the Department of Parks and Recreation for recreation development, including developments at various state water projects. Section 3.6 of the Budget Act limited accruals to the California Water Fund during the 1965-66 fiscal year to $11,000,000 from both state land leases and Long Beach tideland oil and gas revenues.

1966

Federal-State Contracts for Water Supplies. Calif. Stats. 1966 (First Ex. Sess.), Ch. 42, added Part 4.3 (commencing with Section 12050) to Division 6 of the Water Code, to authorize the Department of Water Resources to contract with the United States Bureau of Reclamation for water supplies from the Washoe Reclamation

Project on the Truckee and Carson Rivers or their tributaries, if requested by the governing body of one or more of the counties or countywide water agencies or districts in the area where the water supply will be used. It also authorizes public agencies to contract with the Department for such water supply upon approval of their electorate, and the creation of zones of benefit within the areas of use for paying the cost of the water supply.

Nonreimbursable Costs of the State Water Project. Calif. Stats. 1966 (First Ex. Sess.), Ch. 27, amended the Davis-Dolwig Act and provided $5,000,000 annually of Long Beach tideland oil and gas revenues for the nonreimbursable costs of state water projects allocated to recreation and to enhancement of fish and wildlife, and for specific recreation land costs. It requires the Department of Water Resources to report annually to the Legislature on cost allocations and specific recreation land costs. It requires the Department to obtain and include comments of the Departments of Parks and Recreation, and Fish and Game, on the cost allocations. It provides for the deposit of the $5,000,000 annually in the Central Valley Water Project Construction Fund, and appropriates such money to the Department for expenditure without regard to fiscal years for the purposes of the Fund in amounts equal to the amounts of allocations and specific land cost expenditures which have been approved by the Legislature. The appropriation is subject to the priority of the appropriation of $11,000,000 annually to the California Water Fund.

Accruals to California Water Fund. Calif. Stats. 1966 (First Ex. Sess.), Ch. 155, in addition to providing for the deposit of Long Beach tideland oil and gas revenues above certain amounts appropriated for other purposes (including the purposes of the California Water Fund and the Central Valley Water Project Construction Fund) in the Capital Outlay Fund for Public Higher Education, eliminates revenues from state land leases as a source of revenue for the California Water Fund. As a consequence, the California Water Fund is now limited to the $11,000,000 accruing annually from the Long Beach tideland oil and gas revenues. Chapter 155 provided an appropriation of $2,000,000 annually for the next five years from Long Beach tideland oil and gas revenues to the State Water Pollution Control Fund for expenditure, when appropriated by the Legislature, for capital outlay expenditures for works to prevent and correct water pollution.

Recreation at Federal Water Projects. Calif. Stats. 1966 (First Ex. Sess.), Ch. 143, added Chapter 1.5 (commencing with Section 5094) to Division 5 of the Public Resources Code, which chapter is cited as the Porter-Cobey Federal Water Project Recreation Act. It authorizes the Administrator of the Resources Agency, with the approval of the Director of Finance, and upon specific authorization by the Legislature as to each project, to indicate in writing the State's intent to agree to administer any federal multiple-purpose water project land and water area for recreation or fish and wildlife enhancement as provided in the Federal Water Project Recreation Act (Public Law 89-72, 79 Stat. 213). After a letter of intent has been authorized by the Legislature and given by the Administrator, further action by the State is dependent upon specific authorization by the Legislature. To the extent authorized, the Department of Parks and Recreation and the Department of Fish and Game may cooperate and participate with the Federal Government pursuant to Public Law 89-72 in the development of recreation and fish and wildlife enhancement at federal water projects. In addition, Chapter 143 specifically authorizes the Administrator to indicate in writing the State's intent to agree to administer the project land and water areas at the Marysville Dam and Reservoir Project on the Yuba River for recreation or fish and wildlife enhancement, or both. Calif. Stats. 1966 (First Ex. Sess.), Ch. 66, authorizes the Department of Parks and Recreation to participate with the Federal Government in development of recreational facilities at Auburn, Folsom, Nimbus, and County Line dams, and also, with the approval of the Department of Fish and Game, the development of fish and wildlife enhancement facilities at said dams.

Lake Tahoe Sewage. Calif. Stats. 1966 (First Ex. Sess.), Ch. 47, appropriated $1,800,000 to the State Allocation Board for a loan to the South Tahoe Public Utility District for construction of facilities for transportation of sewage effluent out of South Lake Tahoe Basin from Luther Pass to Diamond Valley in Alpine County. Chapter 137 of the same session appropriated $2,000,000 to the State Water Quality Control Board for loans to the North Lake Tahoe Public Utility District and the Tahoe City Public Utility District for construction of sewage and storm drainage facilities to prevent and control water pollution in the North Lake Tahoe area. Chapter 48, also enacted at the same session, requires connections to sewer systems in the Lake Tahoe Basin area, when facilities are available for handling and treating the sewage and for transporting the effluent out of the Basin.

Budget Act of 1966. Calif. Stats. 1966 (Second Ex. Sess.), Ch. 2. In addition to appropriations for various statewide investigations, of particular interest is Item 273.5 which appropriated $40,000 for the Upper Sacramento River Basin investigation, $20,000 for the North Coastal Action study, $50,000 for West Side Crop Adaptability study, and $145,000 for ground water investigations in Southern California. Item 273 appropriated $6,281,579 for water development planning and $2,337,895 for water development implementation. Item 277.5 appropriated $1,078,000 to the State Water Quality Control Board for the study of water quality control in the San Francisco Bay and Delta areas. For payment of costs of lands, easements and rights-of-way for federal flood control projects, Item 352 appropriated $15,000,000 to the Department of Water Resources and Item 353 appropriated $5,598,786 to the Reclamation Board. Item 354 appropriated $786,525 to the Department of Water Resources for beach erosion control projects. Items 398 and 399 appropriated funds to the Department of Parks and Recreation for recreation facilities to be associated with the State Water Project. Item 400 appropriated $350,000 to the Department of Water Resources for distribution facilities for the San Diego sea water conversion plant. Section 3.6 again limited the California Water Fund to $11,000,000 for the fiscal year.

FEDERAL LAWS RELATED TO WATER RESOURCE DEVELOPMENT

1956 - 1966

The principal purposes of the federal laws related to water resources development enacted during the years, 1956 - 1966, inclusive, have been to encourage and to support financially (1) comprehensive river basin and regional planning for the purpose of matching the need for water with available supplies; (2) water pollution control; (3) water associated recreation development; (4) construction of urgently needed federal multiple-purpose projects and (5) assistance to state and local public entities. Such legislation and programs have a significant impact upon water resources development in California.

There also has been progress in the area of international cooperation. The Columbia River Treaty between Canada and the United States, signed in January, 1961, and a Protocol Agreement, signed in January, 1964, and attached to the Treaty, both of which are now in force, relate to a cooperative development of the water resources of the Columbia River Basin.

The Treaty provides, among other things, for construction of three dams in Canada to regulate the flow of the Columbia River for flood control and power production in the United States as well as for benefits in Canada. The downstream benefits resulting from increased power generation in the United States are to be shared equally by the two countries, and the United States is to compensate Canada for the flood protection it receives.

The State of California has concluded negotiations for the assignment to it of a portion of the downstream power benefits to which Canada is entitled under the Treaty and which have been sold, pursuant to the terms of the Protocol Agreement, through the British Columbia Hydro and Power Authority, and the Columbia Storage Power Exchange (a nonprofit corporation organized for the specific purpose of purchasing and selling such downstream power benefits) to various entities in the Pacific Northwest. (The Treaty is printed in Senate Executive Document C, 87th Cong., 1st Sess., 44 Department of State Bulletin 234, (February 13, 1961). The Protocol Agreement is printed in 50 Department of State Bulletin 200-206 (February 10, 1964).)

Principal federal laws related to water resources development enacted during the years 1956 - 1966 are:

Water Resources Planning

1958 P.L. 85-500 72 Stat. 297	Water Supply Act of 1958. Provides for inclusion of storage in federally constructed reservoirs for present or future needs of municipal or industrial water if state or local interests give reasonable assurances they will repay such costs within 50 years.
1964 P. L. 88-379 78 Stat. 329	Water Resources Research Act. Initiated a modest water research grant program for water resources development. Established water research centers or institutes at land grant colleges in each state. Authorized formation of regional research centers by states cooperating in such research. Authorized a matching fund grant program to assist states in conducting research approved by the Department of the Interior.

1965 P.L. 89-80 79 Stat. 250	Water Resources Planning Act. Objective is to provide framework for optimum development of nation's water resources through coordination of state and federal planning activities. Created Water Resources Council responsible for continuing studies on water availability and requirements. Authorized formation of River Basin Commissions responsible as principal coordinating agency for all planning within its area. Authorized grants to states for comprehensive planning.
1965 P.L. 89-136 79 Stat. 552	Public Works and Economic Development Act. Authorized $500 million annually for five years for grants to states, and political subdivisions thereof, for up to 80 percent of cost of public works in economically distressed areas. Public works are defined to include water projects and sewage systems. Also authorized $170 million annually for 40-year loans for public works to develop lands for industrial use.
1966 P.L. 89-404 80 Stat. 129	Water Resources Research Act Amendments. Established a more adequate program of water research geared to national water programs. Authorized a grant program on matching basis with state agencies to provide for research.
1966 P.L. 89-672 80 Stat. 951	Interim Research Contracts Act. Authorized the Secretary of the Interior to enter into contracts with educational institutions, public or private

agencies, or persons for the conduct of scientific or technological research on problems related to authorized programs of the Department of the Interior.

Water Pollution Control

1956 P.L. 84-660 70 Stat. 498	Federal Water Pollution Control Act. Declared national policy to be that states have the primary responsibility to prevent and control water pollution. Encouraged and assisted research relating to such prevention and control and authorized grants to states, municipalities and interstate agencies for such work.
1961 P.L. 87-87 75 Stat. 204	Federal Water Pollution Control Act Amendment. Authorized the Secretary of Health, Education, and Welfare to establish field laboratories and research facilities. Increased the size of grants for water pollution studies and construction programs and expanded federal water pollution abatement authority.
1965 P.L. 89-234 79 Stat. 903	Water Quality Act. Established a national policy for prevention, control and abatement of water pollution, including the promulgation of water quality standards for interstate waters if affected states fail to establish acceptable standards by June 30, 1967. Doubled the ceilings on grants for construction of waste treatment plants from $600,000 to $1,200,000 for individual projects and from $2.4 million to $4.8 million for joint projects.

1966
P.L. 89-753
80 Stat. 1246

Clean Rivers Restoration Act. Amended the Federal Water Pollution Control Act of 1956, as amended, by increasing grant moneys to states and local public agencies engaging in comprehensive water quality control and abatement plans for river basins and construction of sewage treatment works. Also increased the pollution abatement authority of the Secretary of the Interior.

Recreation

1964
P.L. 88-578
78 Stat. 897

Land and Water Conservation Fund Act. Created a fund from entrance and user fees, motorboat fuel taxes, and sales of surplus property, from which grants to states were authorized for acquisition of outdoor recreation areas.

1965
P.L. 89-72
79 Stat. 213

Federal Water Project Recreation Act. Created a uniform policy for treatment and federal participation in development of recreation and fish and wildlife potential at federal water projects. Requires nonfederal agency to administer land and water areas allocated to recreation and to bear all costs of operation and maintenance and no less than one-half of the separable capital costs for such purposes. Requires repayment of such capital costs within 50 years of first use. If nonfederal agencies fail to participate in such development, the

Federal Government will provide only minimal recreation facilities to protect public health and safety at the project.

1965
P.L. 89-336
79 Stat. 1295

Whiskeytown-Shasta-Trinity National Recreation Area Act. Authorized the sixth national recreation area in the United States. This recreation area in Northern California is to be coordinated with the operation of Whiskeytown, Shasta, Clair Engle, and Lewiston Reservoirs.

1966
P.L. 89-666
80 Stat. 919

Point Reyes National Seashore Act Amendment. Increased the amount authorized to be appropriated for land acquisition in connection with the Point Reyes National Seashore from $14 million to about $19 million and clarified the original Act as to the location of right of way for access to the area.

Construction

1958
P.L. 85-500
72 Stat. 315

Flood Control Act of 1958. Authorized a federal flood control contribution toward the cost of construction of Oroville Dam equal to an economically justified flood control allocation. Approval of the allocation by the Secretary of the Army and the President was required. Also required an agreement with the State of California providing for operation of the dam so as to produce the flood control benefits upon which the construction was based.

1960
P.L. 86-488
74 Stat. 156

<u>An Act Authorizing the Construction of the San Luis Unit of the Central Valley Project</u>. Authorized the Secretary of the Interior to construct San Luis Dam and Reservoir, the San Luis Canal and the Pleasant Valley Canal. Authorized the Secretary to contract with the State of California for joint-use and operation of these facilities.

1962
P.L. 87-874
76 Stat. 1171

<u>Rivers and Harbors Act of 1962</u>. Authorized a flood protection project to be constructed by the Corps of Engineers on Alameda Creek at an estimated cost of $14,680,000 substantially in accordance with Senate Document 128, 87th Congress. This document recommended a federal flood control contribution by the Chief of Engineers not to exceed $4,080,000 toward the construction cost of Del Valle Reservoir of the State Water Project.

1965
P.L. 89-161
79 Stat. 615

<u>Auburn-Folsom South Unit</u>. Authorized the Secretary of the Interior to construct and operate the Auburn-Folsom South Unit of the Central Valley Project, consisting of the 2.5 million acre-foot Auburn Dam and Reservoir. Authorized $425 million to be appropriated for this purpose.

1966
P.L. 89-561
80 Stat. 707

<u>Feasibility Investigations Act</u>. Authorized the Secretary of the Interior to conduct designated water project feasibility investigations, thirty-three of which apply to California.

1966
P.L. 89-640
80 Stat. 884

Tijuana River Flood Control Project Act. Authorized the Secretary of State to conclude with Mexico an agreement for the joint construction and operation of an international flood control project on the Tijuana River.

1966
P.L. 89-789
80 Stat. 1405

Flood Control Act of 1966. Authorized construction of flood control projects including Marysville Dam and Reservoir, the Knights Valley Project and the Corte Madera Creek Project.

Irrigation Works Assistance - Watershed Protection

1956
P.L. 84-972
70 Stat. 1044

Small Reclamation Projects Act. Authorized 50-year loans and grants not to exceed $5 million to local public agencies for construction of reclamation projects primarily for agricultural use not exceeding $10 million in total cost. Such construction could be any undertaking similar to that which could be constructed by Bureau of Reclamation. Authorized $100 million for such purposes.

1966
P.L. 89-553
80 Stat. 376

Small Reclamation Projects Act Amendments. Authorized loans and grants not to exceed $6.5 million on small reclamation projects not exceeding $10 million in total cost. Authorized grants for one-half of the separable and of the joint-use costs allocable to providing recreation facilities. Authorized an additional $100 million for such purposes.

Watershed Protection

1956
P.L. 84-1018
70 Stat. 1088

Watershed Protection and Flood Prevention Act Amendments. Federal assistance under the Watershed Protection and Flood Prevention Act (16 U.S.C. 1001) for flood prevention, erosion and sediment detention works constructed by local public agencies was extended to include such assistance for municipal or industrial water supplies.

Hydroelectric Power

1964
P.L. 88-552
78 Stat. 756

Northwest Intertie Act. Guaranteed consumers in the Pacific Northwest first call on electric energy generated at federal hydroelectric plants in that region and guaranteed electric consumers in other regions reciprocal priority. Authorized the interconnection of the Bonneville power system with the systems of other regions of the country by means of high voltage transmission lines with no risk that new customers would be preferred.

1966
P.L. 89-448
80 Stat. 200

An Act to Authorize Construction of a Third Power Plant at Grand Coulee Dam. Authorized the Secretary of the Interior to construct and operate a third power plant at Grand Coulee Dam with a rated capacity of 3,600,000 k.w. as an addition to the Columbia River Basin Project. Authorized to be appropriated, $390 million for this purpose.

Salt Water Conversion

1958
P.L. 85-883
72 Stat. 1706

Salt Water Demonstration Program. Authorized the Secretary of the Interior to provide for the construction and operation of at least five salt water conversion demonstration plants to produce fresh water for beneficial uses, one of which was to be located on the West Coast. Authorized funds to be appropriated for such construction.

1961
P.L. 87-295
75 Stat. 628

Saline Water Conversion Act Amendments. Authorized an expansion and extension of the existing saline water conversion program conducted by the Secretary of the Interior by encouraging and conducting research, the acquisition of technical personnel and facilities, and other measures which would provide for the development of practical low-cost means for the conversion of salt water for beneficial uses. Authorized to be appropriated, $76 million for this purpose.

1965
P.L. 89-118
79 Stat. 509

Saline Water Conversion Act Amendments. Authorized a further expansion, extension and acceleration of the existing saline water conversion program. Authorized the construction and use of modules and components in addition to the laboratory and demonstration plant facilities previously authorized and extended the program an additional five years. For this purpose, authorized to be appropriated

$80 million and additional moneys subject to further authorization by Congress.

1966
P.L. 89-648
80 Stat. 895

AEC - Desalting Plant. Authorized the Atomic Energy Commission to enter into cooperative arrangements with the Department of the Interior, the Metropolitan Water District of Southern California, and others for participation in the development, design, construction and operation of a large-scale, combination nuclear power generation and desalting project.

Miscellaneous

P.L. 89-531
80 Stat. 340

An Act Approving Interstate Compact Regarding Boundary Between Arizona and California. Granted consent of the Congress to the interstate compact defining the boundary between the States of Arizona and California as ratified by Arizona April 2, 1963, and by California, June 6, 1963.

LITIGATION

During the decade 1956 to 1965, litigation in the state and federal courts resulted in a number of important water law decisions. Cases of particular significance to the progress of the California Water Plan are summarized hereafter.

Financial Implementation of the State Water Project

(a) Metropolitan Water District v. Marquardt, 59 Cal.2d 159, 28 Cal.Rptr. 724, 379 P.2d 28 (1963)

This action for writ of mandate was brought in the State Supreme Court, as the court of original jurisdiction, to test the validity of the prototype water service contract between the State and The Metropolitan Water District of Southern California.

In a lengthy decision determining many important issues, the court held that:

(1) The California Water Resources Development Bond Act (Burns-Porter Act) is, in respect to all challenges levied against it, constitutional; and

(2) All of the provisions of the contract with The Metropolitan Water District are valid.

Among other matters, the decision affirmed the broad discretion vested in the Department of Water Resources to construct and operate the State Water Project; upheld the authority of the Department to bind itself to make all water service contracts substantially uniform with the Metropolitan contract; rejected the contention that the law required water to be priced so as to be within the ability to pay of agriculturalists; sustained the price surcharge provided in the contract for water served to lands in excess of 160 acres in a single ownership; declared the federal excess land (160-acre) provisions inapplicable to the State project; held that Metropolitan's debt limitation was not exceeded by the obligation imposed under the contract; and held that the ad valorum tax limit provided in the Metropolitan Water District Act was superseded by the provision of the Central Valley Project Act allowing a contracting district to levy the taxes necessary to pay water service contract obligations.

(b) Warne v. Harkness, 60 Cal.2d 579, 35 Cal. Rptr. 601, 387 P.2d 377 (1963)

In a similar suit involving a petition for writ of mandate in the California Supreme Court, it was held that the Department of Water Resources had authority to issue revenue bonds under the Central Valley Project Act (Water Code Section 11100 et seq.) to finance the costs of constructing power facilities in the Oroville Division of the State Water Project.

The court held that the Burns-Porter Act (Water Code Section 12930, et seq.) pledge of State Water Project revenues to the payment of bonds issued pursuant to that Act did not apply to revenues from facilities financed by revenue bonds issued under the Central Valley Project Act.

(c) California Water Resources Development Finance Committee v. Betts, 60 Cal.2d 595, 35 Cal.Rptr. 611, 387 P.2d 387 (1963)

In this companion case to Warne v. Harkness, supra, also a mandamus proceeding, the Supreme Court upheld the validity of certain waiver provisions in bonds proposed to be issued under the authority of the Burns-Porter Act, and upheld the authority of the Burns-Porter Act Finance Committee to include the waivers in such bonds. These waiver provisions would have: (1) allowed certain surplus system revenues to be used to back general obligation bonds other than Burns-Porter bonds and (2) allowed revenue derived from power facilities constructed with revenue bond proceeds to be used to back such revenue bonds.

Both the Betts case and Warne v. Harkness were concerned with the relationship between the Burns-Porter Act and the Central Valley Project Act (Water Code Sec. 11000, et seq.); as a result of the favorable decision in Warne v. Harkness, the proposed waiver provisions became unnecessary.

Eminent Domain Powers of Department of Water Resources

State of California v. The Superior Court of Butte County (Popularly known as the Natomas Case), 208 Cal. App.2d 659, 25 Cal.Rptr. 363 (1962)

In this action the State of California sought and obtained a writ of mandate requiring the Superior Court of Butte County to make an order giving the State immediate possession (during the pendency of condemnation proceedings) of certain lands containing dredger tailings owned by the real party in interest, Natomas Company. The Superior Court had refused to issue the order because it was of the opinion that the lands in question were not "to be used for reservoir purposes" within the meaning of Article I, Section 14, of the State Constitution.

The Appellate Court decided:

(1) The language of Article I, Section 14, permitting immediate possession of lands to be used for reservoir purposes, does not limit such immediate possession solely to lands to be used for reservoir sites; if land is needed for reservoir construction, it is land for reservoir purposes whether it is the site of a dam or land containing construction materials necessary for the creation of a reservoir; and

(2) The dredger tailings in question are land (rather than personalty) as a matter of law because the only

inference that can be drawn from the facts is that Natomas Company had always treated the tailings as land rather than personalty.

Colorado River Water Rights

Arizona v. California, 373 U.S. 546, 10 L.Ed.2d 542, 83 S.Ct. 1468 (1963)
Decree: 376 U.S. 340, 84 S.Ct. 755 (1964)

After many years of litigation between the states of Arizona and California, the United States Supreme Court has determined that California is entitled to only 4.4 million acre-feet of water per year from the Colorado River, instead of the present annual allocation of 5,362,000 acre-feet, and the new allotment shall continue only so long as 7.5 million acre-feet per year are available to the Lower Basin States below Lee Ferry on the Colorado River.

This decree had a serious impact on the State Water Project, resulting in a decision to increase the project yield and the size of the California Aqueduct.

This case is discussed in more detail at pages 30 to 32 of Bulletin No. 160-66.

Federal Central Valley Project: Application of 160-Acre Limitation (The Ivanhoe Cases)

The questions at issue in the Ivanhoe case, and three companion cases, concern the application of the 160-acre limitation and other provisions of the reclamation laws in California. These were considered and acted upon by both the California Supreme Court and the United States Supreme Court.

The California Supreme Court, in Ivanhoe Irrigation District v. All Parties and Persons, 47 Cal.2d 597, 306 P.2d 824 (1957), refused to confirm a proposed contract with the United States by which the United States undertook to deliver water from the Central Valley Project to the irrigation district and to expend funds for the construction of a distribution system within the district. In its majority opinion the court determined that:

(1) The title to unappropriated domestic water of the State is held by the State in trust for the water users of the State as beneficiaries, and the United States stands in the same trustee relationship as does the State;

(2) As a purveyor of water, the United States Bureau of Reclamation is required by Reclamation law to comply with state laws relating to the control, use or distribution of waters for irrigation; and

(3) The 160-acre limitation contained in the Ivanhoe contract conflicts with California law; its application to an irrigator would be unconstitutional.

This judgment was reversed by the United States Supreme Court in Ivanhoe Irrigation District and the State of California v. McCracken, et al., 357 U.S. 275, 78 S. Ct. 1174, 2 L.Ed.2d 1313 (1958). In this case the court held with respect to contracts entered into between the two state irrigation districts and a water agency on the one hand and the United States on the other, that:

(1) The question of title to water was not pertinent to the validity of the contracts since if the water rights held by the United States are not sufficient, it may acquire the needed water rights by eminent domain;

(2) The provision of reclamation law requiring the Bureau of Reclamation to conform to state laws relating to irrigation water rights does not override the provision of reclamation law prohibiting the sale of water from reclamation projects for lands in excess of 160 acres in a single ownership;

(3) Congress intended the 160-acre limitation of the reclamation law to be applied to the Central Valley Project;

(4) The imposition of the 160-acre limitation is not a denial of due process or of equal protection of the law under the Fifth and Fourteenth Amendments to the Federal Constitution;

(5) The Federal Government may impose reasonable conditions on the use of federal funds, property or privileges; Central Valley Project water is furnished to irrigators at below cost and what the government subsidizes it may regulate;

(6) The 160-acre provision is a reasonable limit on the amount of federal subsidy provided to each individual;

(7) It is also reasonable that the contract does not recite a definite sum due the federal government from the districts for the water supply facilities since at the time of contracting the total cost of the facilities and the portion of such cost to be attributed to irrigation was uncertain;

(8) It is proper that the contract does not guarantee that the districts will obtain title to the water distribution facilities when the districts' obligations under the contract have been discharged -- there is a substantial federal subsidy to the districts and, even after 40 years, the districts still will not have repaid their allocated share of the cost of the water supply facilities:

> "it does not seem untoward for the recipients of a huge federal bounty to have to depend in small measure on the continued beneficence of their donor."

In Ivanhoe Irrigation District v. All Parties and Persons, 53 Cal.2d 692, 3 Cal. Rptr. 317, 350 P.2d 69 (1960) and companion cases, the California Supreme Court again considered the contracts with the United States and, in light of the United States Supreme Court decision, affirmed the power of the districts to enter into the contracts and the propriety of the proceedings leading to the contracts' execution.

As already noted, the California Supreme Court has since held that the federal excess land (160-acre) limitations do not apply to lands served by the State from the San Luis facilities jointly used by the State and the Federal Government. (Metropolitan Water District v. Marquardt, 59 Cal.2d 159 at pages 188-193.)

Federal Central Valley Project: Exchange of Waters

Wolfsen v. United States, 162 F.Supp. 403 (1958) (Ct.Cl. 1958)

In this action the plaintiffs claimed that they were deprived of their riparian water rights in waters of a branch channel of the San Joaquin River by the defendent United States which, in connection with the construction and operation of the federal Central Valley Project, substituted Sacramento River waters for those waters formerly withdrawn from the San Joaquin. The holding of the court was that the plaintiffs suffered no actual damage as a result of the exchange of waters, and there was no taking of plaintiffs' rights for which just compensation had not been made.

Federal Central Valley Project: Taking of Downstream Water Rights

Dugan v. Rank, 372 U. S. 609, 83 S.Ct. 999, 10 L.Ed.2d 15 (1963)

This is the latest in a long series of decisions in the case which began in 1947 in the state courts of California under the name Rank v. Krug and thereafter was removed to the federal courts.[1]

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1. Other opinions in this case are California v. Rank, 293 F.2d 340 (C.A. 9th Cir. 1961); Rank v. (Krug) United States, 142 F. Supp. 1 (D.C. S.D. Cal. 1956); Rank v. Krug, 90 F. Supp. 773 (D.C. S.D. Cal. 1950); United States v. United States District Court, 213 F.2d 818 (C.A. 9th Cir. 1954); Rank v. United States, 16 F.R.D. 310 (D.C. S.D. Cal. 1954); Fresno v. Edmonston, 131 F.Supp. 421 (D.C. S.D. Cal. 1955). See also summary of Fresno v. California, infra.

The plaintiffs were claimants of water rights from the San Joaquin River in the reach from Friant Dam to Mendota or from underground waters in the Fresno area. The construction of Friant Dam and the diversion of the waters of the San Joaquin River to the Madera Canal and the Friant-Kern Canal severely diminished the water flow in the San Joaquin River between Friant and Mendota. The plaintiffs sought to enjoin federal officials from storing and diverting water at Friant Dam or, in the alternative, to require the restoration of this section of the river to its pre-project natural flow conditions. It was claimed that underground water supplies extending many miles from the river would be affected.

This opinion by the United States Supreme Court holds that the proceeding against the Federal Reclamation officials is in fact a suit against the United States without its consent; that the Reclamation officials did not act beyond the scope of their duties when they took part of the water from the river, since they have plenary power to seize the water rights of riparian and overlying owners; that the actions of such officials were, therefore, not a trespass, but were rather a partial taking of such water rights for which the proper recourse was a suit against the United States for monetary compensation. Compensation is to be ascertained not by the amount of water taken from the river, but by the value of the land before and after the partial taking.

Federal Central Valley Project: Application of Area of Origin Laws; Rights of Municipal Water Users

Fresno v. California, 372 U.S. 627, 83 S.Ct. 996, 10 L.Ed.2d 28 (1963)

This is a companion case to Dugan v. Rank. The City of Fresno intervened as plaintiff in the Dugan case seeking, in addition to the injunctive relief requested by the other plaintiffs, a declaration as to (1) its water rights as an overlying owner to underground water fed by the San Joaquin River; (2) its statutory priority to water for municipal or domestic purposes under California Water Code Sec. 1460; (3) its priority rights under the California county of origin statute and the watershed protection provisions of the Central Valley Project Act (California Water Code Sec. 10505 and Sec. 11460, et seq.); and (4) its right to receive project water from the United States at the same rate charged for irrigation water. The Supreme Court held that (1) insofar as injunctive relief was sought, the suit could not be maintained because it was one against the United States without its consent, the proper recourse for water rights seized by the United States was through a suit for damages; (2) the United States was not required to comply with California statutes relating to preferential water rights, but could acquire such rights by the power of eminent domain; (3) Fresno was not entitled to any preference for water devoted to municipal or domestic uses because federal reclamation law, to the contrary, gives first preference to water for irrigation purposes; (4) United States Bureau of Reclamation officials had properly acted within the discretion given them by law in charging more for water for municipal purposes than for water for irrigation.

APPENDIX D

ROLE OF ELECTRIC POWER

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No.

INTRODUCTION

The basic concept of electric power as an essential partner in water resource development was endorsed in The California Water Plan* and that endorsement is reaffirmed at this time. The contributions of electric power are optimized when each hydroelectric opportunity is made to yield the maximum in terms of power capacity and energy output and revenues, but in proper balance with the other demands on and for the water resources concerned. Furthermore, in developments such as California's State Water Project (SWP), where large amounts of power are required for pumping, a major consideration is the determination of how to obtain and utilize the needed power at the lowest possible cost. This is accomplished by investigating all feasible alternative power sources and methods of system operation and selecting the most economical plan.

The manner in which these concepts materialize, in the form of hydroelectric plants and definite schemes for furnishing and utilizing pumping power, is of necessity a matter subject to continuing study and evaluation. This is so because of the rapid advancement of electric power technology which is taking place in our time and also the changing nature of the needs and desires of society.

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* Bulletin No. 3, May 1957, referred to herein as CWP

Some of the figures on power data in Bulletin No. 160-66 are slightly different than those presented herein. Historical data and projected loads and resources used in this appendix have been revised to reflect all information available as of December 1966.

In general, the material on cost and value of power included in this Appendix D is on the same basis as that presented in Bulletin No. 160-66. In view of recent developments in this rapidly evolving electric power supply and transmission field, however, a qualifying statement is added at the end to indicate several changed factors whose impact will be more completely detailed in Bulletin No. 160-68, the next issue of this biennial series.

POWER IN THE CALIFORNIA WATER PLAN

The role of power in the development of the water resources of California as visualized in the CWP will be outlined here to serve as a backdrop against which we can measure the accomplishments of the past decade and compare our updated view of the future.

The pumping power requirement for implementation of the ultimate plan was estimated to be about 12.3 million kilowatts with an energy requirement of about 49 billion kilowatt-hours per annum. Included in the CWP were hydroelectric plants with a total installed capacity of about 7.8 million kilowatts and an average annual energy generation of about 34 billion kilowatt-hours. These figures, though substantial in relation to the power loads and resources of California in 1957, were seen to be quite manageable when compared to the then projected California load of 85 million kilowatts in the year 2000.

The power demand on a typical utility system varies considerably throughout the day and from week to week. The peak demand may be as much as three times the minimum demand, or base load, which occurs during the early morning hours. Hydroelectric plants have several important advantages over steam plants for supplying system peaks, following the load variations, and serving as standby or spinning reserve capacity. These advantages include factors such as greater reliability, flexibility, and speed of response. For these reasons it was anticipated that there would be a greater demand for the development of hydroelectric power in a system having a relatively small amount of hydro capacity in comparison to its thermal plant capacity.

The measure of the relative amounts of steam plant capacity and hydro capacity in a power system or area is referred to as the steam-hydro ratio. The steam-hydro ratio for Northern California at the start of 1957 based on dependable capacity was 1.4 steam to 1.0 hydro. This ratio was expected to remain constant until about 1965 and then resume its upward trend. The ratio for Southern California, a hydro—deficient region, was 2.0 to 1.0 and was expected to continue its rapid increase.

Projections of the trends in the load characteristics and steam-hydro ratio indicated that there would be a sustained need for much additional economical hydroelectric capacity for peaking service in California, and that the load would readily absorb all of the power from the hydroelectric projects which were then expected to be developed in the foreseeable future.

The at-plant site-value of hydro power used for evaluating the hydroelectric possibilities under the CWP, was estimated on a two-part rate basis to be:

Capacity component	$22.00 per kilowatt-year
Energy component	2.8 mills per kilowatt-hour

This value was based on the cost of alternative steam-electric generation. It appeared, in 1957, that the steam plant capital costs, and hence the capacity component of power value, would remain fairly constant for some time and that the energy component, as affected by a rising cost for fossil fuels, would trend upward despite some continuing improvements in thermal plant efficiencies.

In 1957, prospects for nuclear powerplant development seemed quite bright but there was some uncertainty as to just when this power source would become competitive with fossil-fuel plants. It was assumed, however, that when that time came, the nuclear plants would supply the base load and would be complemented by hydro-peaking plants in the same manner as for fossil-fuel plants.

It was expected that nuclear plants with their very low energy cost would eventually furnish large amounts of cheap power for offpeak pumping operations, as there is little or no capacity component of steam plant production cost involved in supplying offpeak power. Furthermore, it was reasoned that with the development of extra-high-voltage transmission lines, low cost power and energy could be made available throughout the State.

The availability of low cost offpeak energy was expected to be conducive not only to offpeak aqueduct pumping but also to the development of hydroelectric plants utilizing the pumped storage principle. Pumped storage hydro plants use offpeak energy to pump water from a low reservoir to a higher reservoir and then generate higher value onpeak power during the weekday periods of high demand.

It was felt, in 1957, that the increasing steam-hydro ratio and future expansion of the nuclear-electric industry would lead to modification of some of the hydroelectric power projects contemplated under the CWP. The principal change would be a trend to the development of hydro projects for higher degrees of peaking (generation for fewer hours per year during the periods of high demand for power), including extensive application of the pumped storage principle.

THE CALIFORNIA POWER LOAD

The historical and estimated future power requirements for Northern, Southern, and total California are presented in Tables D-1, D-2, and D-3 and Figure D-1.

The method employed in estimating the future power load involved population and annual per capita energy use projections for Northern and Southern California. These two elements were combined to give the estimates of required annual total energy generation. The next steps involved estimating the annual load factor and using it with the annual total energy generation to determine the annual maximum demand.

The division of the State into Northern and Southern California as shown in Figure D-1 is approximately on the basis of the service areas of the electric power systems serving the two areas.

Population estimates were based on the Department of Water Resources' median projection. The sources of historical power data were reports of the California Public Utilities Commission.

Since the year 1920, the population of Northern California has increased at an average annual compounding rate of about 3.3 percent. It is anticipated that this growth rate will be maintained through the year 1980. Except for the decade 1940 to 1950, when the rates of growth were nearly comparable, the population has been increasing at a faster rate in Southern

California than in Northern California. This trend is estimated to continue through the 1960's. Thereafter, the rate of growth in Southern California is estimated to decrease to less than 1.0 percent by the decade ending 2020, as compared to 1.5 percent for Northern California.

The per capita use of electric energy during the 1920's increased at a more rapid rate in Northern California than in Southern California due in part to the large increase in irrigation pumping. The rates of increase during the 1930's were comparable and moderate. During the period 1945 to 1960 the rates of increase in per capita use for the two areas were approximately equal, at an average annual compounding rate of 4.5 percent.

Looking to the future, it is anticipated that the declining cost of power generation in coal-fired plants and in nuclear plants will improve the competitive position of electric power in relation to other forms of energy such as gas. The impact of coal-fired generation, at remote locations, will be greater in Southern California than in Northern California, whereas, nuclear generation should have greater effect in Northern California, which is more remote from sources of fossil fuels.

The growth of electric cooling and heating loads in homes, commercial establishments, and public buildings should continue to increase, the latter at a more rapid rate than in the past. An improved electric storage battery for the family's second car and for delivery trucks is being developed. Battery charging will not only increase the requirements for power but also electric cars and trucks will go a long way toward eliminating the largest single source of air pollution in the State's metropolitan areas. The electrification of public interurban transportation also is expected to increase the power requirements in California. The Bay Area Rapid Transit District is constructing a 75-mile rapid-transit network to connect the City of San Francisco and Alameda and Contra Costa Counties. Expansion of this system and construction of systems in other California metropolitan areas are anticipated.

It is estimated that the residential and commercial classes of load will increase more rapidly than other classes, including the industrial load. The industrial load should continue to increase, as the State develops toward industrial maturity commensurate with its expanding market and labor potentials. With the low cost of fuel for coal-fired plants and the even lower cost of nuclear fuel, it is expected that offpeak loads, such as battery charging, will markedly increase at such time as sufficient coal-fired and/or nuclear capacity has been installed to permit supply of offpeak energy from these sources.

As between Northern and Southern California, it is estimated that per capita use will remain higher in the northern area in spite of anticipated decreases in the proportion of irrigation pumping requirement in the total Northern California load. It is estimated that more industrial plants of the types which require large amounts of power will locate in Northern California. Offpeak battery charging should develop earlier in Southern California due to greater need for air pollution control; however, Northern California with its somewhat higher proportion of nuclear plants should eventually also experience a considerable expansion of offpeak load. Another factor tending to explain and maintain the lower per capita use in Southern California is the higher proportion of multiple dwellings, having lower residential use per customer and per capita.

Historically, per capita energy generation after the year 1920 has been higher in Northern California than in Southern California. During the period 1955 to 1965, however, the annual rates of increase in per capita use were about 4.0 percent and 4.7 percent for the northern and southern areas respectively. For conservatism, gradually declining future rates of increase in per capita generation were assumed for both Northern and Southern California. The forecast rate of increase after 1990 was maintained at a somewhat higher level in Northern California.

The Federal Power Commission's National Power Survey report of October 1964 indicates that the annual per capita generation in the United States was about 5,400 kilowatt-hours in 1963 and is expected to be 10,600 kilowatt-hours in 1980. California's per capita generation was 4,585 kilowatt-hours in 1963 and is expected to overtake the national average early in the 1980's.

Historically the load factor has been higher in Northern California than in Southern California. The estimated future load factors for Northern, Southern and total California reflect an anticipated increase in the pooling of California power systems. The load factors also roughly take into account the impact of air conditioning loads and offpeak energy requirements.

The foregoing estimates of population and annual per capita use growth were combined to give the estimates for required annual total energy generation presented in the tables and figures. The estimated annual load factors were used with the estimates of annual total energy generation to determine the estimated annual maximum power demands.

Referring to Table D-3 and Figure D-1, the estimated total California maximum demand for the year 1970 is about 25 million kilowatts compared to 11.6 million for 1960. The estimates for 1980 and 2000 are, respectively, about 46 million and 132 million kilowatts.

CALIFORNIA'S HYDROELECTRIC RESOURCES

The developed hydroelectric resources in California as of the end of 1965 are given in Table D-4. This table lists the developments for each hydrologic study area and shows that the installed hydro capacity is about 5.4 million kilowatts. The average annual energy produced by this capacity is about 25.5 billion kilowatt-hours, resulting in a plant factor* of about 54 percent.

Table D-5 is a compilation, by study areas, of the hydroelectric plant additions in California during the period 1956 through 1965. During this decade the total capacity added was slightly under 2.2 million kilowatts. The average annual energy generation of these additions is about 8.3 billion kilowatt-hours for a plant factor of 43 percent.

Table D-6 is a list of hydroelectric plants completed since December 31, 1965, under construction, or scheduled to be under construction by 1970. About 2,000 megawatts of capacity will be added to California's hydroelectric capability in the period 1966 through 1970, and an additional 1,400 megawatts will be added in the next five-year period, 1971 through 1975.

The present estimate (January 1967) of undeveloped hydroelectric resources is about 11.1 million kilowatts with an average annual energy generation of approximately 36.3 billion

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* Plant factor is based on installed capacity, whereas capacity factor is based on dependable capacity which for some hydro plants is less than installed capacity.

kilowatt-hours. This corresponds to an annual plant factor of 37.5 percent for all of the undeveloped potential. The estimate made for Bulletin No. 3, of approximately 7.8 million kilowatts with about 34 billion kilowatt-hours resulted in a plant factor of 49.8 percent.

Thus, while more than 2 million kilowatts of hydroelectric capacity were developed during the decade, 1956 through 1965, the present estimate of total undeveloped hydroelectric resources is higher than the 1956 estimate. This is explained in part by the fact that the overall plant factor of the present estimate is lower than that of the 1956 estimate.

This is the manner in which estimates change, and changes are natural and expected consequences of continuing technological developments and changes in public needs and attitudes, and therefore in planning criteria.

Development of the State's resources will be continued to the maximum feasible extent. The increased interest in pumped storage hydroelectric applications may have a marked effect on future estimates of the potential hydroelectric development.

The proportions of developed hydroelectric resources to steam-electric capacity in Northern, Southern, and total California, on the basis of installed capacity, are indicated in Tables D-7, D-8 and D-9 and Figure D-2. In 1953 the steam-hydro ratio was about unity (1.0) in both Northern and Southern California, after having been about 0.5 in both areas prior to

World War II. The ratio since 1953 has held fairly constant in Northern California at about 1.25*. In Southern California, however, the steam-hydro ratio has increased continually, to 4.5 in 1965.

* The Northern California steam-hydro ratio of 1.4 in 1957, referred to earlier, was based on dependable capacity, whereas the ratio of 1.25 in Table D-8 was based on installed capacity.

TECHNOLOGICAL DEVELOPMENTS IN POWER

The electric power utility field is experiencing technological advances which have an important bearing on water resources planning and development. The most significant changes of the decade 1956-65 occurred in the following areas:

Nuclear Powerplants

Fossil-Fuel Powerplants

Fossil-Fuel Cost Trends

Extra-High-Voltage Transmission

Power Pooling through Interconnection

Hydroelectric Plants, including Pumped Storage

Thermal Peaking Plants

Dual-Purpose Power and Desalting Plants

Brief descriptions of these technological developments with estimates of further advances follow:

Nuclear Powerplants

Great progress has been made in the development of competitive nuclear powerplants during the last decade. In 1957 experts were predicting that the total cost of nuclear power would be about eight mills per kilowatt-hour by 1967. That this prediction was not overly optimistic is evidenced by the fact that commercially available nuclear plants of current design have an estimated total power cost, based on private financing, of less than five mills per kilowatt hour. In fact the estimated total unit cost of the 1,060,000 kilowatt unit which Pacific Gas and Electric Company proposes to install at Diablo Canyon is 4.38 mills per kilowatt-hour at 80 percent capacity factor (for the first three cores, having an estimated life of 7.79 years). The Tennessee Valley Authority (TVA), with federal financing, is installing nuclear units of about the same size at an estimated total unit power cost of 2.39 mills per kilowatt-hour (based on two units, 12-year fuel warranty, and 85 percent capacity factor). In both cases the units are planned for commercial operation in the early 1970's. It should not be inferred, however, that the two total unit power cost figures reflect accurately the difference between private and public financing. In addition to the differences in fuel and capacity factor bases, there is the fact that the two-unit TVA plant had an estimated production plant capital cost of $112 per kilowatt compared to $145 per kilowatt for the one unit at Diablo Canyon.

The total unit power cost of nuclear-electric generation by light water reactors of current design is expected to decline to even lower value by 1980, with further decreases in the energy component and moderate decreases in the capacity component of cost of units of the same or larger sizes.

To fully appreciate the rapid pace of nuclear power development, it will be recalled that prior to 1957 no electric power for commercial use was being derived from nuclear reactors in the United States. At the present time nuclear generating capacity, in operation or under contract, totals in excess of

27 million kilowatts in this country. Several large plants in the one-half to one million kilowatt range are under contract for near future construction. The Federal Power Commission National Power Survey report of October 1964 (FPC Advisory Committee Report No. 18) indicates that by the early 1970's substantially all new thermal generation added in Northern California will be nuclear, and that by 1983 nuclear plants will account for 50 percent of all energy generation in California.

Nuclear steam-electric units are expected to be used for peaking service in the intermediate capacity factor range, but with a lifetime capacity factor somewhat higher than for fossil fuel-fired units. Commercially feasible base load nuclear units of current design, having lower operating pressures and temperatures than modern base load fossil fuel-fired units, will be better adapted for peaking service than the fossil-fuel units.

Fossil-Fuel Powerplants

The cost per kilowatt of new fossil-fuel powerplants has decreased significantly since the middle 1950's. This is due, primarily, to the development of much larger boilers and steam turbine-generator units. The resulting "economies of scale" together with the effects of related advances, such as higher operating temperatures and pressures, reheat, etc., have reduced the investment costs per kilowatt by about one-third since 1957.

In order to realize the savings of cost inherent in energy production at high temperatures and pressures, these large plants should be operated at high capacity factor. Furthermore, any type of plant operation other than continuous, near constant loading would increase significantly the forced outage rate and maintenance requirements for these units due to the increased cycling of their complex control systems and to the imposition of more damaging thermal stresses on plant equipment which would result from too rapid or frequent changes in the level of loading.

Notwithstanding these limitations, large fossil-fuel units, after initial base load operation and perhaps some modification for peaking service, will operate at less than maximum capacity factor as even more efficient units are added to the system.

Fossil-Fuel Cost Trends

Several developments in recent years have moderated the upward trend of fossil-fuel costs. Two such developments, stemming in part from the threat of nuclear-electric competition, were the improvements in coal mining and coal transportation techniques, which reduced the cost of coal both at the mine and at the point of use. Further progress in high-voltage transmission of electric power also has increased the competition in the field of energy transportation, and has brought remote hydroelectric and coal-fired plants into competition with load center steam-electric plants burning natural gas and oil.

The delivered costs of electric power generated by the several fossil fuels will vary from one geographical area to another depending in part on the distances between each area and the sources of supply of the different fuels. Even though

California is relatively distant from the coal fields of Southern Utah, Northern Arizona, and the Four Corners, and from the hydroelectric resources of the Pacific Northwest and Canada, this State's power users will benefit from the cost-moderating influence of these economic energy sources. Nuclear-electric plants, which have no smog or fuel transportation problems, will provide a ceiling on the costs of all fossil fuels for use in power generation.

Construction of coal-fired plants at locations remote from California is underway, and additional construction is being planned. Southern California Edison Company and other participants in Western Energy Supply and Transmission Associates (WEST) are constructing two 755 megawatt coal-fired generating units at Four Corners, New Mexico. These units are expected to be completed in 1969 and 1970. Edison will own 48 percent of the generating capacity of these two units. Edison also will own 74 percent of the output of the 1500 megawatt Mohave Powerplant which members of WEST are planning to construct in Nevada, near Davis Dam on the Colorado River. This plant will consist of two 750 megawatt coal-fired units, scheduled to be completed in 1970 and 1971. Plans call for fuel for this plant to be transported from Northeastern Arizona by slurry pipeline. Edison, Arizona Public Service Company and San Diego Gas and Electric Company, through subsidiaries, are studying plans for a 5000 megawatt coal-fired plant on the Kaiparowits Plateau, near Glen Canyon Dam on the Colorado River, in Southern Utah. This plant ultimately may be increased to 10,000 megawatts.

It is anticipated that most of the new fossil-fuel units constructed for supply of power to the California load will be coal-fired. Gas and oil will still be required for generation in existing plants and to supply the expanding requirements of the premium uses of these fuels. For some of these higher uses, such as house heating, gas and oil will be under strong competition from electric power. For these and other reasons the cost of gas, oil and coal are expected to remain at about the present levels for the next 15-20 years. Thereafter, any tendency to increase will be moderated by further declines in the cost of nuclear-electric generation.

Extra-High-Voltage Transmission

As a result of extensive research and development following World War II, the mileage of 345,000 volt transmission lines, in service in the United States, has increased from zero in 1950 to over 4,000 circuit miles at the present time. Rapid progress is being made on 500,000 volt transmission with more than 3,000 circuit miles expected to be in service by the end of 1967. A further advance to 765,000 volts now is underway in Canada and the United States. The American Electric Power Company has ordered 765,000 volt equipment from domestic and foreign manufacturers for initial delivery in 1968. It is also expected that the required technical development will proceed to permit even higher voltages as needed in the future. The main reason for trying to achieve higher transmission voltages is simply that it is much less costly to transport large amounts of electric power over great distances at the higher voltage levels.

The circuit mileage figures given above were for alternating current (ac) lines; however, noteworthy progress also has been made in the field with direct current (dc) transmission. Within the last decade, the successful development in Sweden of a mercury arc "valve" capable of operating at voltages in excess of 100,000 volts and currents in the order of a thousand amperes has reduced considerably the former prohibitive cost of converting ac to dc (and vice-versa) at the extra high voltages. This has renewed interest in dc lines as a supplement to ac systems because dc power transmission has several important advantages over ac for long distance, point-to-point transmission of large blocks of power. Some 1700 circuit miles of 750 Kv dc transmission lines will be constructed by 1970 as part of the Pacific Northwest-Pacific Southwest Intertie.

This Intertie is a concrete example of the pertinence of extra high voltage transmission to California. It will include ultimately about 2000 circuit miles of 500,000 volt and 500 circuit miles of 345,000 volt ac lines in addition to the 1700 circuit miles of 750,000 volt dc lines.

Power Pooling Through Interconnection

The Pacific Northwest-Pacific Southwest Intertie is a good example of the mutual benefits of pooling through interconnected operation of power systems. Major savings will be realized by both areas due to load and also hydroelectric resources diversities. Less generating capacity will be required to serve the integrated load, and the effective generating capacity of the integrated resources will be greater.

Initial benefits will accrue from transmission of Northwest surplus hydroelectric generation to replace thermal generation in the Southwest and from transmission of Southwest offpeak energy to firm up Northwest hydroelectric capacity. Until such time as it is needed in the Northwest, a portion of the Columbia River firm power resulting from the Treaty with Canada, (Canadian Entitlement Power) will be transmitted to Southwest purchasers.

Northwest and Canadian Entitlement power will ultimately be required for use in the local areas. It is expected, however, that the Intertie will be used to transmit to the Southwest hydroelectric generation which Canada plans to develop in advance of the local need. In any case, the Intertie will continue to provide other advantages of pooling, including load and resource diversities, reduced total generating reserves, and addition of larger generating units for the same reliability.

Hydroelectric Plants, Including Pumped Storage

Hydroelectric generating units have been very efficient for many years, with hydraulic turbines normally operating at efficiencies of 90 percent or better. Thus, the opportunity for improving the economics of hydroelectric developments through higher efficiencies is limited. Savings in investment and operating costs per kilowatt have been realized by utilizing larger turbines, at appropriate sites, and through increased application of automatic control; however, these savings have not had as great an impact on power costs as the development in steam plants.

A very substantial increase in activity has been noted in the development of pumped storage hydroelectric plants. Pumped storage hydro functions as a gigantic electric storage battery which stores low-value offpeak energy by using it to pump water from a lower to a higher reservoir from which it can be returned through turbines to generate power during peak periods when the plant output has capacity as well as energy value. A prerequisite for such developments is the availability of low cost offpeak energy for pumping, which in California will almost always come from thermal plants.

Reduced equipment cost brought about by the further development in recent years of the reversible pump-turbine unit, which permits the pumping and generating operations to be combined in a single machine, has been a significant factor in the improved economics of pumped storage installations.

In 1956 the total capacity of pumped storage hydroelectric units in operation in the United States was less than 88,000 kilowatts. At present the total is in excess of 1,150,000 kilowatts, a thirteenfold increase.

Pumped storage is playing an important role in the State Water Project. The dependable capacity of the Oroville-Thermalito power facilities was significantly increased, and their feasibility enhanced, by incorporation of pumped storage. The cooperative development of 1,250,000 kw of peaking power on the West Branch, California Aqueduct, will employ reversible pump-turbines, as will the San Luis Pumping Generating Plant.

Three continuing developments will contribute to the future increase of pumped storage in California. One is the rapidly expanding power load. Another is the increasing ratio of steam-electric to hydroelectric generating capacity, which expands the market for low capacity factor pumped storage generation. The third development is the sharp decline in the energy component of cost of steam-electric generation, due to the introduction of low fuel cost coal-fired plants with extra high voltage power transmission, and nuclear plants. The future availability of low-cost offpeak power from coal-fired and nuclear-fueled plants, particularly nuclear plants with the continuing decline in the cost of nuclear fuel, will readily compensate for the double hydraulic loss associated with pumped storage pumping and generating.

Thermal Peaking Plants

Special designs have been developed for fossil fuel steam-electric units intended for use as peaking or reserve capacity. These moderately large units will operate at relatively low pressures and temperatures. The capital cost for these special units is somewhat less than the cost of standard base load units; however, the modifications required to achieve this saving result in a substantial decrease in generating efficiency.

These special steam-electric peaking units become quite competitive with other types of peaking units in the market for very low capacity factor generation. The reason for this is that the penalty incurred due to the lower plant efficiency is relatively small when the plant produces electrical energy for only a small percentage of the time.

Recently, simple open-cycle gas turbines have received increased consideration as economical sources of peaking capacity. This type of plant is low in first cost and relatively quick starting; however, the generating efficiency is even lower than that of the special steam peaking plant.

Diesel engines have been used for peaking service in special situations, but wide application of diesel plants on major power systems is not too likely since available sizes are too small.

Dual-Purpose Power and Desalting

In recent years there have been many studies of combining a water desalting plant and thermal-electric power facilities at the same location, to utilize a common energy source. Currently the most feasible scheme is the combination of a distillation plant with a steam-electric plant where at least part of the steam produced, after being extracted from a turbine or exhausted from a back pressure turbine, is sent to the desalter, for heating the saline water.

Analyses have shown that in higher fossil fuel cost areas the cost of both power and converted water would be minimized by using a nuclear reactor as the energy source. One such development is the dual-purpose facility which is to be constructed under the sponsorship of the Metropolitan Water District of Southern California, the Federal Atomic Energy Commission, and the Office of Saline Water of the U. S. Department of the Interior.

The combination nuclear-electric and thermal distillation facility will include two condensing units and a non-condensing, or back-pressure, turbine-generator unit, supplied with high-pressure steam from the two nuclear reactors. The back-pressure unit will discharge steam at a back pressure of about 35 pounds per square inch absolute to a thermal desalter of the multi-stage flash distillation type. The combined installation will produce ultimately 150 million gallons of desalted water per day and a net electric power output of about 1500 megawatts.

The Southern California Edison Company and the San Diego Gas and Electric Company will own one of the nuclear-electric plants; the second nuclear-electric plant will be owned by the City of Los Angeles. The Metropolitan Water District will own the back-pressure turbine-generator and the desalter. The cost to the utilities will be that which they would have been required to expend for the same amount of power from single-purpose nuclear-electric units. Hence, the dual-purpose development provides a subsidy to the desalting function.

Studies for these dual-purpose developments should include thorough consideration of the area electric power needs and water requirements and sources in order to arrive at the optimum ratio of water to power production.

Another recent development was the signing of an agreement by the United States, Mexico, and the International Atomic Energy Agency under which the two countries will explore the possibilities for a joint undertaking of a large-scale dual-purpose nuclear power and desalting plant to serve the arid region embracing the border areas of California and Arizona and the adjoining Mexican States of Sonora and Baja California.

Most studies to date have assumed that both the desalter and the electric powerplant would be base loaded, operating at 80-90 percent capacity factor, but it is also possible, with certain equipment arrangements, to vary the amounts of water and power produced in order to supply peaking power to the power system load. However, the economic penalty incurred by operation of the desalter and the electric power facilities at less than maximum capacity could be severe by virtue of the fixed charges on idle equipment and would have to be justified by the value of the power for peaking.

Looking to the future, other desalination processes which require electrical or mechanical energy, such as electrodialysis, reverse osmosis, freezing, or vapor compression, could also be utilized to absorb the output of a base loaded thermal-electric plant during the power system load's offpeak hours. Some of these processes are easily started and stopped and this would further enhance the prospects for peaking operation of the electric power facilities. There would still be an economic penalty due to less than maximum utilization of the desalter.

MARKET FOR AND VALUE OF HYDROELECTRIC POWER

Practically all of the State's undeveloped hydroelectric potential is in Northern California. The principal market for this potential is Northern California; however, the recent progress in extra high voltage transmission is tending to expand the market to include the power systems south of the Tehachapi Mountains. The extra high voltage interties also are placing Pacific Northwest hydroelectric development in competition with that in California.

With the rapidly expanding power load there will be a market for the relatively limited hydroelectric energy as it becomes available, mainly through multiple-purpose development of water resources. The question now, as in 1957, is to the degree of peaking, or capacity factor, which can be absorbed by the power market. Power systems having higher proportions of steam-electric capacity can more readily absorb low capacity factor hydro generation. It follows that Southern California with its rapidly increasing steam-hydro ratio is a larger potential market for low capacity factor hydro than Northern California. However, the longer transmission distance involved in the delivery of Northern California hydro peaking power to Southern California will be a cost factor to be considered even though only a portion of the cost of the multiple-purpose transmission system would be allocated to this purpose.

In The California Water Plan studies it was assumed that the market would absorb hydro generation at a capacity factor of about 40 percent. This was the dry period capacity factor, which determined the dependable capacity of the hydro plants. The capacity factor based on average annual generation was about 50 percent. Further reference to capacity factor unless stated otherwise will indicate dry period capacity factor.

Anticipating a gradual increase in the steam-hydro ratio in Northern California starting about 1975 and a more rapid increase after about 1985, it appears reasonable to assume that the future market for the output of hydro plants installed in Northern California will absorb generation at capacity factors, as follows:

	1965-1974	1975-1984	After 1984
Capacity Factor (%)	30	25	20

This means that a hydro plant planned for initial operation in 1970 could have sufficient installed capacity for operation at 20 percent capacity factor after 1984. The plant would be operated initially at 30 percent capacity factor and proportionately lower dependable capacity. Alternatively, the plant could be designed for initial operation at 30 percent capacity factor but with provision for later installation of additional capacity to permit operation at lower capacity factor, and higher dependable capacity, at a later date.

Basic to the foregoing suggestion of hydro peaking in the intermediate capacity factor range (20-30 percent) is the assumption that California's near future need of peaking at lower capacity factors will be largely supplied by other sources including surplus peaking capacity from the Pacific Northwest, additional capacity installed at the most favorable existing hydro plants, pumped storage units, gas turbine units, and special design thermal-electric units. Wherever possible these peaking units would be located near the load centers.

The determination of the true value of hydro peaking power requires a total system study in which the system economics and operating reliability and flexibility are evaluated with the hydro unit integrated into the system and compared on the same basis to the integrated system with the alternative peaking equipment substituted for the hydro unit. Such a comprehensive comparison study is justified where a decision to construct is involved. For preliminary planning purposes, however, a simpler approach usually can be justified.

In the planning study method, the principal measure of value of hydro peaking power in the intermediate capacity factor range is the cost of producing equivalent power in the alternative base load steam-electric unit which probably would be installed in the absence of the proposed hydro plant. (In California the steam alternative traditionally has been a privately financed gas- and oil-fired unit). However, hydroelectric capacity has several important advantages over the alternative steam unit which, though difficult to evaluate economically, should be accounted for in the overall measure of value.

Several of these advantages result from the fact that hydroelectric units are relatively simple, rugged machines which operate at low speeds whereas the modern steam-electric units are complex machines which operate at high speeds and steam temperatures.

It follows that the hydro plant will experience far fewer equipment failures and require much less down time for maintenance. In other words the hydroelectric units have greater reliability and availability for serving the load than do steam-electric units. Hence, one kilowatt of hydroelectric capacity is the operating equivalent of more than one kilowatt of steam-electric capacity.

Another important advantage, which is more difficult to assess in terms of dollars, is the hydro unit's superiority in speed of response to rapid changes in load requirements. A hydro unit can, with relative facility, go from standstill to full load in a few minutes and from minimum load, or even a motoring condition, to full load in a matter of seconds. Steam units cannot approach this performance. This operating flexibility explains hydro's outstanding advantage for supplying peaking power and serving as spinning and standby reserves.

For these and other reasons, but primarily because of its superior availability, hydro usually is given a credit in the form of an upward adjustment of the at-load center estimate of value of capacity as measured by the alternative cost of steam-electric generation. Most agencies have used a capacity credit ranging up to 10 percent; however, the Northeast power failure of November 9, 1965 and similar recent experiences in other regions have prompted many agencies to reevaluate the true worth of hydro in total system operation, including maintenance of system stability and restoration of service after system shutdown. Continuing studies appear to justify increasing the capacity credit but the present estimates of value were derived using a 10 percent credit.

In the CWP studies the at-plant site value of hydro power was estimated to be:

Capacity component	$22 per kilowatt-year
Energy component	2.8 mills per kilowatt-hour

This value was based on a typical transmission distance between hydro site and load center of about 100 to 150 miles, or an average of 125 miles. This is only slightly less than the transmission distance between Oroville and the Northern California load center, in the Tesla-Tracy-Delta area.

The estimated <u>at-load center</u> values of hydro power for future developments are, as follows:

	Date of Initial Operation		
	1965-74	1974-84	After 1984
	Value at Load Center		
Capacity Component ($ per kw-yr)	17.90	18.35	19.20
Energy Component (Mills per kw-hr)	2.75	1.9	0.7

It will be noted that in Bulletin No. 160-66 the estimated values of the energy component for the first and second periods were, respectively, 3.0 and 2.1 mills per kilowatt-hour.

These estimated values are based on fossil fuel units only for the initial, 1965-74 period; fossil fuel and nuclear units, in the proportion of two fossil fuel units and one nuclear unit, in the 1975-84 period ; and nuclear units only after 1984.

In deriving the at-plant site value of hydro power, the at-load center capacity component of value is decreased by an allocated portion of the annual cost of transmission facilities and transmission losses. For general application, a figure of $1.00 per kilowatt-year per 100 miles, based on 345 kv or 500 kv transmission is used herein. This figure is believed to be appropriate for hydro sites north of the City of Sacramento except in the area of the authorized Upper Eel River Development and in the lower Trinity and Klamath River areas. The appropriate figures for the annual cost of transmission facilities and losses applying to these sparsely-populated North Coastal areas would depend on the specific plan of development, including staging of generation and pumping.

With 345 kv or 500 kv transmission, the transmission losses are so low that for planning purposes the energy component of value of hydro power may be assumed to be the same at the hydro site as at load center.

Taking into account the effect of transmission cost and loss on the capacity component of value, and also the capacity factor estimates mentioned earlier, the estimated at-plant site values of hydro power for future developments in Northern California at a distance of about 125 miles from load center, are as follows:

	Date of Initial Operation		
	1965-74	1975-84	After 1984
	Capacity Factor (%)		
Capacity Factor (%)			
Dry Period	30	25	20
Average Annual	37	31	25
	Value at Plant Site		
At-Plant Site Value			
Capacity Component ($ per kw-yr)	16.65	17.10	17.95
Energy Component (Mills per kw-hr)	2.75	1.9	0.7
Total Unit Value* (Mills per kw-hr)	7.9	8.2	8.9

These present estimates of total unit value of hydro power indicate moderate increases between successive periods in spite of sizable decreases in the energy component. This is explained by the higher capacity component of cost, and value, of the nuclear units compared to fossil fuel units, in combination with successively lower capacity factors.

The above estimates of the at-plant site two-part value for the three periods compare with the constant value of $22 per kilowatt-year plus 2.8 mills per kilowatt-hour used for The California Water Plan. The decline in the estimated value of the capacity component between the time of the CWP studies and the present is due to reductions in the capital cost of fossil fuel generating units. The decrease in the value of the energy component between successive periods results from the projected use of low-cost nuclear fuel.

* Based on average annual capacity factor.

The decreases in the component of value of hydroelectric power, discussed above, are offset by the increase in total unit value, or revenue, due to the lower capacity factor for such power. The total unit value of power at hydroelectric plant sites in the CWP studies was 7.8 mills per kilowatt-hour as compared to the current estimates of 7.9, 8.2, and 8.9 mills per kilowatt-hour for the respective periods.

SOURCES AND COST OF POWER FOR PUMPING

In the CWP studies the principal measure of the cost of power for continuous pumping was the alternative base load gas- and oil-fired fossil fuel unit then used in estimating the value of hydro peaking power. Today, as a result of technological developments, other sources of low cost power are becoming available for aqueduct pumping.

Low cost power from a mine-mouth coal-fired plant, presently under construction in Northwestern New Mexico, will be available to serve loads in California by 1969. Other coal-fired plants, on the Colorado River in Nevada and Southern Utah, are being planned for near future delivery of power to California. Power from these plants will be for use primarily in Southern California.

Progress in the development of nuclear powerplants with their declining costs indicates such plants are competitive with mine-mouth coal-fired plants. Firm plans for construction of nuclear plants are underway in both Northern and Southern California.

The Pacific Northwest-Pacific Southwest Intertie has opened up other sources of relatively low-cost power for pumping in California during an interim period. Canadian Entitlement power combined with Pacific Northwest hydro dump power will provide relatively economic continuous pumping power for the near term. Both the Pacific Northwest dump power and the Canadian Entitlement power ultimately will be withdrawn for use in the Pacific Northwest and Canada.

The determination of the true cost of power for a large pumping load requires a total system study. Such a study comprises comparative analyses of the costs of operating the area power system with and without the pumping load included as a part of the area power requirement. In addition to being extremely complex, a total system study requires very specific data regarding the pumping load to be served. For example there would be considerable differences in the costs of furnishing pumping power for various degrees of service reliability, and also, for different locations. For preliminary planning purposes a simpler method than a total system study, such as that used in the CWP studies, normally will suffice.

The current estimates of the future cost of power for continuous* pumping based on the same combinations of privately-financed gas- and oil-fired units and nuclear units as were used in estimating the value of hydro peaking power to be developed in Northern California are, as follows:

	1965-74	1975-84	After 1984
	Cost at Load Center		
Capacity component ($ per kw-yr)	18.75	18.30	19.20
Energy Component (mills per kw-hr)	2.75	1.9	0.7
Total Unit Cost*	5.1	4.2	3.1

* The total unit cost of power for continuous pumping was based on the use of power for 8000 hours per year.

In deriving the at-plant site cost of power for continuous pumping, based on the at-load center estimates, consideration must be given to the annual cost of transmission facilities and losses, to the pumping plant. If the transmission system serves several purposes, an allocated portion of the annual cost of transmission facilities and losses is added to the at-load center capacity component of cost of power. In certain instances the allocated portion could be small, or even negative, because a power flow study might indicate a net reduction in transmission losses due to the transmission of power for pumping.

With 345 kv or 500 kv transmission, the transmission losses are so low that for planning purposes the energy component of cost of power for continuous pumping may be assumed to be the same at the pumping plant site as at load center.

In the CWP studies the at-load center total unit cost of power for continuous pumping was about 6.3 mills per kilowatt-hour compared to the present estimate of 5.1 mills for the period 1965-74. This difference is largely explained by the higher capital cost of fossil fuel-fired units in the 1956 estimate. In the present estimates of total unit cost of power for continuous pumping, the successive decreases for the later periods result primarily from the low cost of nuclear fuel.

In the CWP studies the energy component of cost of power for offpeak pumping was based on the same fossil fuel unit as was used in estimating the value of hydro peaking power. There was no capacity component of cost due to steam-electric plant cost of generation; however, the cost of offpeak power at the pumping plant did include a capacity component comprising an allocated portion of the annual cost of transmission facilities and losses.

Today, with the large interconnected power system in California, the true cost of offpeak power can only be determined by a system study. Such a study would involve ascertaining the cost of operating the area power system with and without the offpeak load.

At the present time the power system in California can furnish offpeak power at nominal rates. The reason is that the highly efficient but inflexible steam-electric units must be kept operating during the low load, offpeak hours. This is accomplished by decreasing the output of these units, with resultant low operating efficiency. As offpeak load is added to the area power system the output of the steam-electric units is increased and they operate more efficiently. Thus a system study would show an increase in production cost due to adding the offpeak load which was less, per kilowatt-hour, than the incremental energy cost for these units.

It would appear, therefore, that the cost of offpeak power should be no greater than the incremental energy cost of the system steam-electric units whose operation was modified in supplying the offpeak load.

With the rapid addition of nuclear units with their relatively low fuel cost the cost of offpeak power ultimately will decline.

As more and larger steam-electric units are added to the area power system, and the steam-hydro ratio increases, larger amounts of offpeak power will be available at nominal rates. However, the portion of this inexpensive offpeak power available for pumping will depend on several factors, including the competition of other uses such as pumped storage pumping and electric battery charging.

THE FUTURE ROLE OF POWER

Power requirements in California are projected to increase by more than ten times to a power demand of nearly 250 million kilowatts by the year 2020.

The cost of generating thermal-electric power, which is the principal basis for determining the value of hydro peaking power and the cost of power for pumping, has declined markedly since the CWP Studies. However, the projected lower capacity factors at which hydroelectric power is predicted to be generated will increase the total unit value, and revenue, of the hydro peaking power to more than that estimated for the CWP. The use of lower capacity factors can greatly enhance the economics of hydroelectric proposals if, as is usually the case, the incremental cost of adding capacity at the hydro site is relatively moderate.

The estimated costs for pumping power, which exhibit a continuing decline as nuclear power approaches fulfillment of its promising potential, could greatly increase the feasibility of higher pumping lifts which would result in shortening or elimination of tunnels. Furthermore, the low costs predicted for offpeak power could increase the feasibility of offpeak pumping schemes, utilizing more pumping capacity and larger conduits. Low cost offpeak power for pumping also would be conducive to the development of pumped storage hydroelectric facilities for generation of low capacity factor peaking power.

DEVELOPMENTS SINCE PUBLICATION OF BULLETIN NO. 160-66

Since Bulletin No. 160-66 was issued, there have been several developments which are not fully reflected in this Appendix D. With the 1968 issue of the biennial Bulletin in prospect, it was decided to present the Appendix material on substantially the same basis as Bulletin No. 160-66, and include this qualifying statement indicating the probable impact of the changes.

Three recent developments could have the effect of increasing the estimates of the value of dependable hydro peaking power in the intermediate capacity factor range (20-30 percent), as measured principally by the alternative cost of producing equivalent power in a modern base load thermal unit which probably would be installed in the absence of the hydro unit.

The first development relates to the assumptions that the alternative thermal unit for the period 1965-74 would be a modern base load fossil fuel unit and that for the middle period, 1975-84, the alternative thermal unit would be a combination of fossil fuel and nuclear units in the proportion of two fossil fuel to one nuclear. As reported in this Appendix under the discussion of Nuclear Powerplants in the section on Technological Developments in Power, the National Power Survey report of October 1964 indicates that by the early 1970's substantially all new thermal generation added in Northern California will be nuclear. On this basis the thermal alternative for the middle period should have been exclusively nuclear, and the alternative for the initial period, 1965-74, should have included some proportion of nuclear. During the preparation of Bulletin No. 160-66, however, public acceptance of nuclear plants was uncertain and it was decided to assume a more conservative rate of nuclear expansion than predicted in the National Power Survey report.

Currently the nuclear siting difficulty appears to have eased somewhat, with the apparent public acceptance of the Diablo Canyon site on the coast near San Luis Obispo for the installation of a 1060 megawatt nuclear unit. It now seems evident that in California public acceptance will pose greater difficulty in connection with smog-producing fossil fuel plants than with nuclear units.

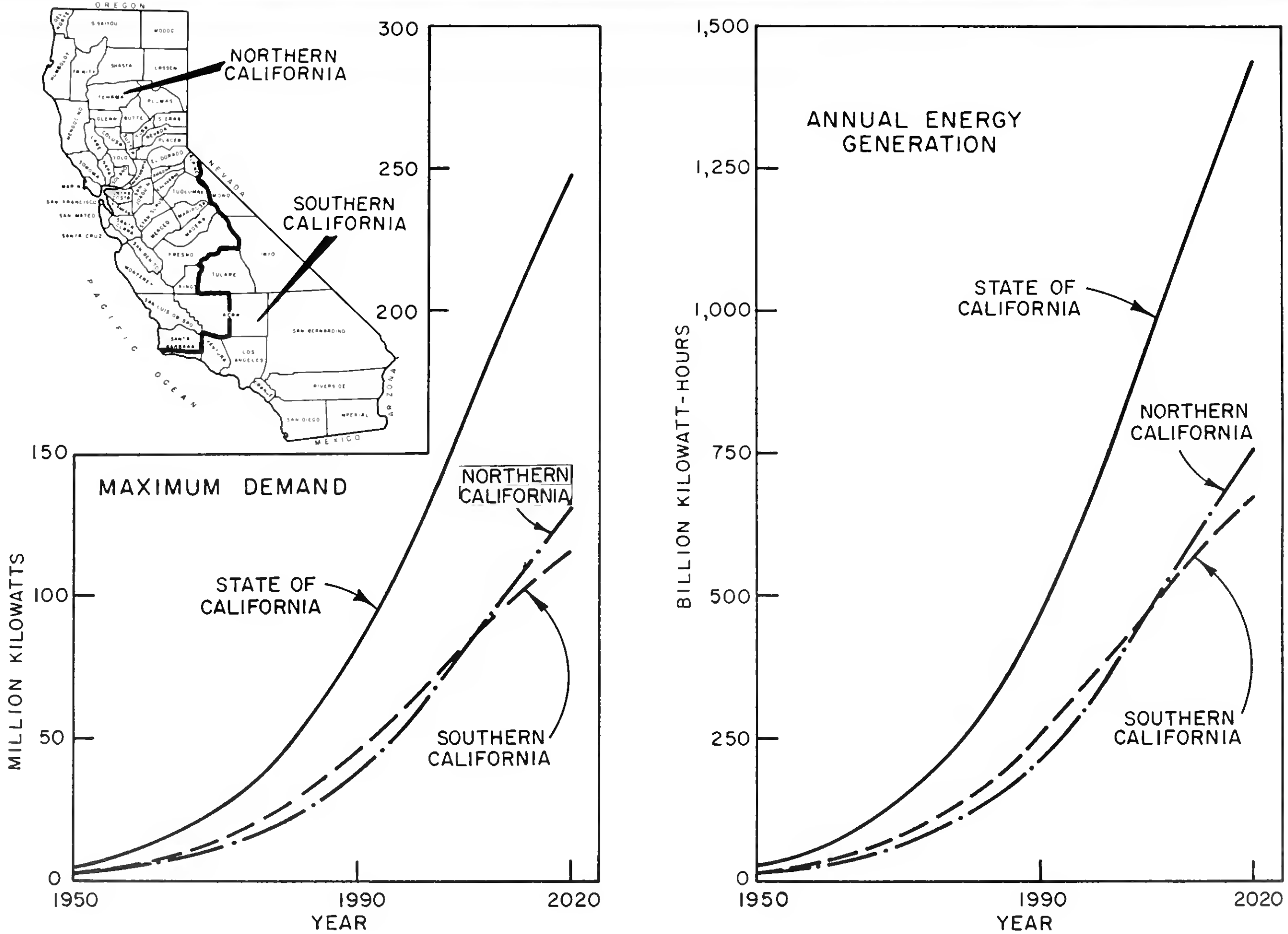
With nuclear units the capacity component of cost is higher and the energy component is lower than for fossil fuel units. This means that giving greater weight to nuclear units in establishing the thermal alternative to hydro will result in higher estimates of the value of hydro peaking power.

Another development is the current reversal of the downward trend in construction cost of fossil fuel and nuclear units. In recent years the cost per kilowatt has been decreasing, in spite of continuing inflation, as unit sizes have sharply increased. Making allowance for normal inflation, the cost estimates for the Diablo Canyon nuclear and fossil fuel alternatives indicate a marked reversal of the recent trend, despite the fact that the size of the Diablo Canyon alternatives is comparable to that of the largest units being constructed.

The present estimates of cost and value in Bulletin No. 160-66 and in this Appendix were based on cost estimates of fossil fuel units which, for several reasons, were believed to be below the long-range trend curve. These cost estimates were increased, using judgment, in arriving at the present estimates of value of hydro and cost of power for pumping; however, they were much below the Diablo Canyon cost estimates.

The third development tending to increase the estimates of value, and revenue, of future hydro plants is the recent experience with widespread power system failure, including the Northeast power failure of November 9, 1965. Many agencies are reevaluating the true worth of hydro in total system operation. It is anticipated that continuing studies, including probability studies of reliability, will reenforce the judgment of an increasing number of authorities that one kilowatt of hydro capacity frequently is the operating equivalent of more than 1.1 kilowatt of thermal capacity, the ratio used in preparing the current estimates of value of peaking power.

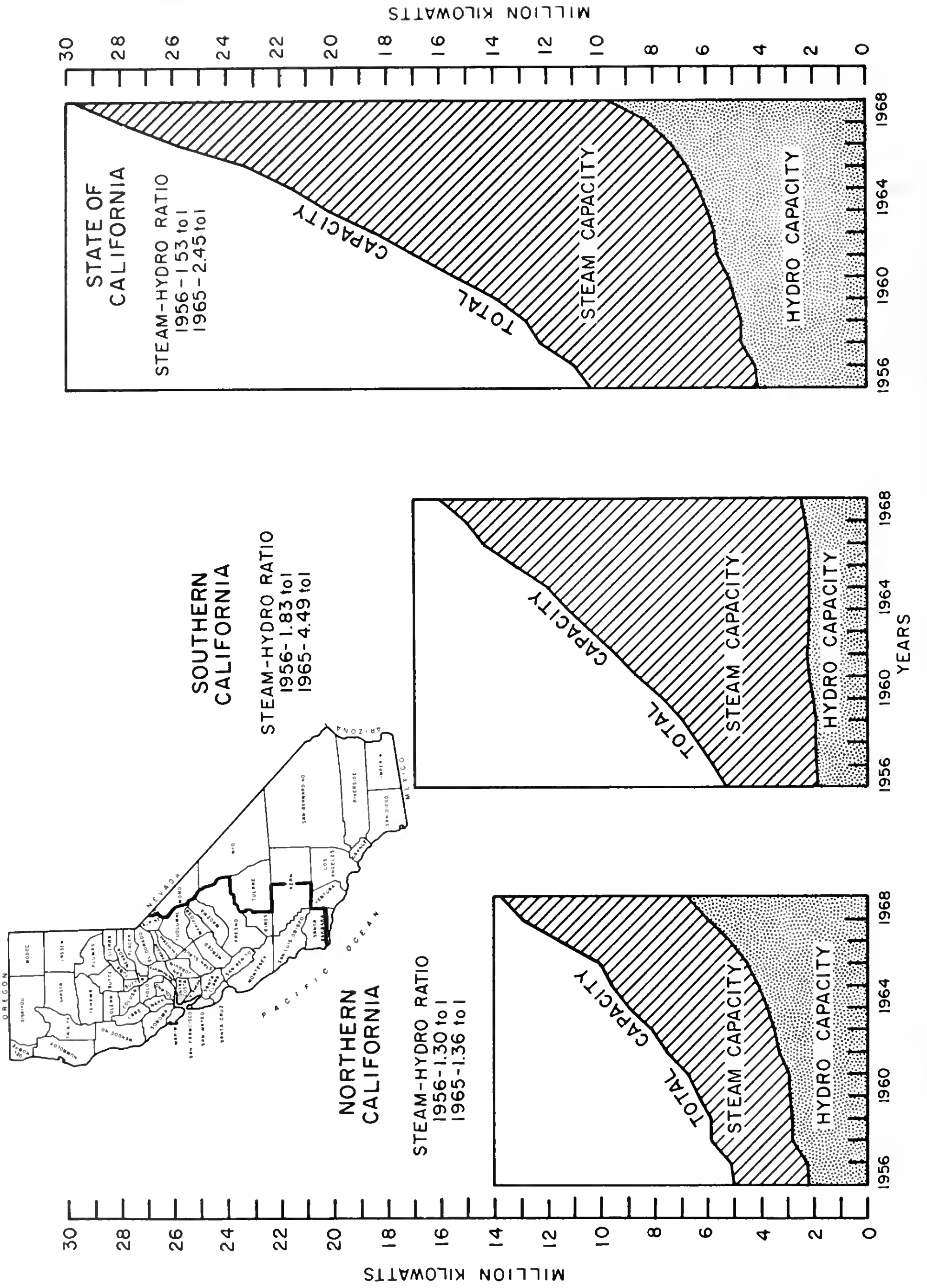
The combined impact of these recent developments on the value, and revenue, of intermediate capacity factor hydro peaking power may well be substantial.



PROJECTED GROWTH OF ELECTRIC POWER

FIGURE D-1

FIGURE D-2



INSTALLED GENERATING CAPACITY, STATE OF CALIFORNIA

TABLE D-1

HISTORICAL AND ESTIMATED POPULATION, PER CAPITA AND TOTAL GENERATION, AND MAXIMUM DEMAND

NORTHERN CALIFORNIA

Year	Population	Annual Generation			Load Factor	Maximum Demand
		Per Capita		Total		
			Annual Growth			
	Millions	Kwh	%	Billion Kwh	%	Million Kw
1920	2.073	1,100	---	2.280	61.0	0.427
1925	2.435	1,531	6.8	3.727	60.0	0.710
1930	2.738	1,882	4.7	5.153	60.9	0.966
1935	2.852	1,796	-1.0	5.122	59.8	0.977
1940	3.227	2,083	3.0	6.721	59.9	1.280
1945	4.190	2,344	2.3	9.781	65.6	1.702
1950	4.802	2,898	4.4	13.917	63.6	2.497
1955	5.500	3,782	5.5	20.800	63.5	3.740
1960	6.541	4,561	3.8	29.832	62.1	5.488
1965	7.600	5,576	4.1	42.378	63.8	7.579
			ESTIMATED			
1970	8.900	6,786	4.00	60.4	64.5	10.7
1980	11.800	9,840	3.75	116.1	65.0	20.4
1990	15.400	13,844	3.50	213.8	65.5	37.3
2000	19.300	19,118	3.25	369.0	66.0	63.8
2010	23.100	24,471	2.50	565.3	66.5	97.0
2020	26.800	28,403	1.50	761.2	67.0	130.0

TABLE D-2

HISTORICAL AND ESTIMATED POPULATION, PER CAPITA AND TOTAL GENERATION, AND MAXIMUM DEMAND

SOUTHERN CALIFORNIA

Year	Population	Annual Generation			Load Factor	Maximum Demand
		Per Capita		Total		
			Annual Growth			
	Millions	Kwh	%	Billion Kwh	%	Million Kw
1920	1.354	1,126	---	1.525	60.9	0.286
1925	2.327	1,293	2.8	3.009	59.9	0.573
1930	2.939	1,541	3.6	4.530	60.9	0.849
1935	3.179	1,488	-0.7	4.729	59.8	0.903
1940	3.680	1,721	2.9	6.333	59.7	1.210
1945	4.365	2,225	5.3	10.311	62.8	1.871
1950	5.866	2,480	2.4	14.549	59.4	2.793
1955	7.503	3,067	4.4	23.011	60.1	4.372
1960	9.176	3,878	4.8	35.589	62.4	6.513
1965	11.000	4,682	4.6	53.483	62.6	9.758
			ESTIMATED			
1970	12.900	6,058	4.50	78.2	63.5	14.1
1980	16.600	8,966	4.00	148.8	65.0	26.1
1990	19.900	13,001	3.75	258.7	65.5	45.1
2000	22.700	17,473	3.00	396.6	66.0	68.6
2010	25.200	21,807	2.25	549.5	66.5	94.3
2020	27.500	24,696	1.25	679.1	67.0	115.7

TABLE D-3

HISTORICAL AND ESTIMATED POPULATION, PER CAPITA AND TOTAL GENERATION, AND MAXIMUM DEMAND

CALIFORNIA

Year	Population Millions	Annual Generation: Per Capita: Kwh	Annual Generation: Per Capita: Annual Growth %	Annual Generation: Total Billion Kwh	Load Factor %	Maximum Demand * Million Kw
1920	3.427	1,110	---	3.805	60.9	0.713
1925	4.762	1,415	5.0	6.736	59.9	1.283
1930	5.677	1,706	3.8	9.683	60.9	1.815
1935	6.031	1,633	-0.9	9.851	59.8	1.880
1940	6.907	1,890	3.0	13.054	59.8	2.490
1945	8.825	2,277	3.8	20.092	66.4	3.454
1950	10.668	2,668	3.2	28.466	62.5	5.198
1955	13.003	3,369	4.8	43.811	64.3	7.783
1960	15.717	4,162	4.3	65.421	64.5	11.585
1965	18.600	5,154	4.4	95.863	63.1	17.337
			ESTIMATED			
1970	21.800	6,355	4.28	138.5	63.8	24.8
1980	28.400	9,329	3.91	264.9	65.0	46.5
1990	35.300	13,386	3.68	472.5	65.5	82.4
2000	42.000	18,229	3.14	765.6	66.0	132.4
2010	48.300	23,081	2.39	1114.8	66.5	191.3
2020	54.300	26,526	1.40	1440.4	67.0	245.7

* non coincident except for years 1945 thru 1965.

TABLE D-4

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA
AS OF DECEMBER 31, 1965

Powerplant	Owner	FPC1/	Installed Capacity Kw	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft	Year of Initial Operation	River
North Coastal Area								
Junction City	PG&E	+	2,720	10.0	42.0	602	1905	Caynon Cr. Div.
Salyer	Swanson	+	1,600	NA	---	NA	----	Trinity
Iron Gate	PP&L	+	18,000	150.0	95.2	158	1962	Klamath
Fall Creek	PP&L	-	2,200	12.8	66.5	730	1903	Fall Creek
Copco No. 2	PP&L	+	27,000	130.0	55.0	152	1925	Klamath
Trinity	USBR	-	100,000	409.0	46.7	472	1964	Trinity
Copco No. 1	PP&L	+	20,000	106.0	60.5	125	1918	Klamath
Lewiston	USBR	-	350	2.6	84.8	60	1964	Trinity
Total			171,870	820.4	54.5			
San Francisco Bay Area								
Potter Valley	PG&E	+	9,040	61.0	77.1	476	1910	E. Fork Russian Riv. (Eel Div.)
Total			9,040	61.0	77.1			
Central Coastal Area								
None								
South Coastal Area								
Santa Ana No. 1	SCE	+	3,200	18.0	64.3	726	1899	Santa Ana
Santa Ana No. 2	SCE	+	800	8.0	114.2	310	1905	Santa Ana
Santa Ana No. 3	SCE	+	1,200	7.0	66.6	354	1947	Santa Ana
Azusa	Pasadena	+	3,000	10.0	38.1	401	1949	San Gabriel
Ontario No. 1	SCE	-	600	4.8	91.4	700	1902	San Antonio Creek

1/ (+) Indicates FPC License, (-) Indicates Not Licensed

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

South Coastal Area (continued)

Powerplant	Owner	FPC	Installed Capacity Kw	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Ontario No. 2	SCE	-	320	1.1	39.3	NA	1963	San Antonio Creek
Sierra	SCE	-	480	4.0	95.2	628	1922	San Antonio Creek
Fontana	SCE	-	1,920	8.8	52.3	658	1917	Lytle Creek
Lytle Creek	SCE	+	400	4.0	114.2	483	1904	Lytle Creek
Mill Creek No. 1	SCE	-	800	4.7	61.0	510	1893	Mill Creek
Mill Creek No. 2	SCE	+	200	1.5	85.7	620	1904	Mill Creek
Mill Creek No. 3	SCE	+	1,800	14.0	88.8	1,911	1904	Mill Creek
Rincon Power	Escondido	+	240	0.3	14.3	824	1915	Escondido Cr. Div.
Bear Valley	Escondido	+	520	4.8	105.4	400	1915	Escondido Cr.
San Gorgonio No.1	SCE	+	1,500	3.0	22.8	1,775	1923	San Gorgonio Cr.
San Gorgonio No.2	SCE	+	750	1.5	22.8	898	1923	San Gorgonio Cr.
Franklin Canyon	LADW&P	-	2,000	8.8	50.2	285	1921	L. A. Aqueduct
San Fernando	LADW&P	-	5,600	50.0	102.0	250	1922	L. A. Aqueduct
San Francisquito No. 1	LADW&P	-	58,125	210.0	41.3	935	1917	L. A. Aqueduct
San Francisquito No. 2	LADW&P	-	42,000	115.0	31.3	540	1920	L. A. Aqueduct
Total			133,415	479.3	41.0			

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Sacramento Basin Area

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Alta	PG&E	-	2,000	6.4	41.5	660	1902	Bear
Big Bend	PG&E	-	52,800	490.0	106.0	465	1908	N. F. Feather
Bucks Creek	PG&E	+	66,000	241.3	41.8	2,558	1928	N. F. Feather
Bullards Bar	PG&E	+	6,500	39.6	69.6	166	1924	N. F. Yuba
Butt Valley	PG&E	+	36,000	84.2	26.7	358	1958	Butt Creek
Caribou No. 1	PG&E	+	75,000	355.9	22.0	1,150	1921	N. F. Feather
Caribou No. 2	PG&E	+	109,800	Plants Combined		1,150	1958	N. F. Feather
Centerville	PG&E	-	6,400	43.8	78.2	577	1904	Butte Creek
Coal Canyon	PG&E	-	800	7.5	107.1	350	1907	M. Miocene Can.
Coleman	PG&E	-	13,800	56.8	47.0	482	1911	Battle Creek
Colgate	PG&E	-	24,000	150.0	71.3	820	1949	N. F. Yuba
Cow Creek	PG&E	-	1,440	12.0	95.2	715	1907	S. F. Cow Creek
Cresta	PG&E	+	67,000	330.5	56.3	290	1949	N. F. Feather
Deer Creek	PG&E	+	5,500	30.6	63.5	837	1908	Deer Creek
De Sabla	PG&E	-	18,450	120.0	74.2	1,530	1963	W. Br. N. F. Feather
Drum No. 1	PG&E	+	49,200	280.3	34.3	1,375	1913	Bear (S.F. Yuba Div.)
Drum No. 2	PG&E	+	44,100	Plants Combined		1,375	1965	Bear (S.F. Yuba Div.)
Dutch Flat	PG&E	+	22,000	125.0	64.9	643	1943	Bear
Eldorado	PG&E	+	20,000	97.9	55.9	1,910	1924	S. F. American

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Sacramento Basin Area (continued)

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Halsey	PG&E	-	12,000	66.0	62.8	331	1916	Dry Creek
Hamilton Branch	PG&E	-	5,390	15.8	33.5	410	1921	Hamilton Br
Hat Creek No. 1	PG&E	-	10,000	19.3	22.0	217	1921	Hat Creek
Hat Creek No. 2	PG&E	-	10,000	39.3	44.9	198	1921	Hat Creek
Inskip	PG&E	-	6,000	37.9	72.1	378	1910	S. F. Battle Creek
Kilarc	PG&E	-	3,000	22.0	83.7	1,150	1903	N. F. Cow Creek
Lime Saddle	PG&E	-	1,600	11.0	78.5	462	1906	W. Br. N. F. Feather
Narrows	PG&E	+	9,350	72.0	87.9	240	1942	Yuba
Pit No. 1	PG&E	-	56,000	264.1	53.9	454	1922	Pit (Fall Div.)
Pit No. 3	PG&E	+	74,750	385.4	58.9	315	1925	Pit
Pit No. 4	PG&E	+	90,000	422.2	53.6	382	1955	Pit
Pit No. 5	PG&E	+	128,000	836.0	74.6	630	1944	Pit
Poe	PG&E	+	124,200	512.0	47.1	477	1958	N. F. Feather
Rock Creek	PG&E	+	113,500	482.5	48.6	535	1950	N. F. Feather
South	PG&E	-	4,000	36.0	102.8	516	1910	S. F. Battle Creek
Spaulding No. 1	PG&E	+	6,400	38.0	67.8	197	1928	S. F. Yuba
Spaulding No. 2	PG&E	+	3,713	20.0	61.5	344	1917	S. F. Yuba
Spaulding No. 3	PG&E	+	6,300	25.1	45.5	318	1929	S. F. Yuba
Volta	PG&E	-	6,400	39.6	70.7	1,254	1906	Millseat Cr.
Wise	PG&E	-	12,000	89.9	85.6	519	1917	Auburn Ravine

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Sacramento Basin Area (continued)

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Pit No. 6	PG&E	+	79,000	370.0	53.5	155	1965	Pit
Pit No. 7	PG&E	+	104,000	522.0	57.3	205	1965	Pit
McCloud-Pit	PG&E	+	155,000	688.0	50.7	1,227	1965	Pit
Kelly Ridge	OWID	+	9,900	48.0	55.4	668	1963	Feather
Forbestown	OWID	+	28,800	110.0	43.6	835	1963	S. F. Feather
Woodleaf	OWID	+	52,200	176.0	38.5	1,495	1963	S. F. Feather
Lewiston	USBR	-	350	2.6	84.8	60	1964	Trinity
Spring Creek	USBR	-	150,000	543.6	41.4	646	1964	Spring Creek (Trinity Div.)
Shasta	USBR	-	375,000	2,021.6	61.5	480	1944	Sacramento
Keswick	USBR	-	75,000	477.5	72.5	101	1950	Sacramento
Judge Francis Carr	USBR	-	134,000	491.5	41.8	712	1963	Clear Cr. (Trinity Div.)
Trinity	USBR	-	100,000	409.0	46.7	472	1964	Trinity
Jaybird	SMUD	+	133,000	505.0	43.4	1,549	1961	Silver Creek
Union Valley	SMUD	+	33,000	96.0	33.2	435	1963	Silver Creek
Camino	SMUD	+	71,250	263.0	42.1	1,067	1963	S.F. American (Silver Cr. Div.)
Chili Bar	PG&E	+	7,000	42.0	68.5	60	1964	S. F. American
Robbs Peak	SMUD	+	25,000	55.0	25.1	410	1965	Trib. Silver Cr. (S.F. Rubicon Div.)
Nimbus	USBR	-	13,500	91.0	76.9	41	1955	American
Folsom	USBR	-	162,000	702.7	49.5	340	1955	American
Total			3,011,293	13,520.4	51.3			

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Delta-Central Sierra Area								
Electra	PG&E	+	89,100	347.2	44.5	1,268	1948	Mokelumne
Salt Springs	PG&E	+	39,050	175.6	51.3	2,109 and 255 2/	1931	N. F. Mokelumne
Tiger Creek	PG&E	+	51,000	353.2	79.1	1,219	1931	N. F. Mokelumne
West Point	PG&E	+	13,600	87.6	73.5	312	1948	N. F. Molelumne
Pardee	EBMUD	-	15,000	81.0	61.7	327	1929	Mokelumne
Total			207,750	1,044.6	57.4			
San Joaquin Basin Area								
Crane Valley	PG&E	+	800	3.2	45.7	90	1919	N. F. Willow Creek
Melones	PG&E	+	24,300	102.3	48.1	230	1927	Stanislaus
Merced Falls	PG&E	-	3,440	14.0	46.5	26	1930	Merced
Murphys	PG&E	+	3,600	16.0	50.8	685	1953	N. F. Stanislaus Div
Phoenix	PG&E	-	1,600	10.0	71.4	1,087	1940	S. F. Stanislaus Div
San Joaquin No. 1-A	PG&E	+	340	1.7	57.1	43	1919	N. F. Willow Creek
San Joaquin No. 2	PG&E	+	2,400	14.0	66.6	307	1917	N. F. Willow Creek
San Joaquin No. 3	PG&E	+	4,000	17.5	50.0	405	1923	N. F. Willow Creek
Spring Gap	PG&E	+	6,000	48.5	92.3	1,865	1921	M. F. Stanislaus (S.F. Div.)

2/ The two units have different water sources.

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

San Joaquin Basin Area (continued)

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Stanislaus	PG&E	+	81,900	376.0	52.4	1,525	1963	M. F. Stanislaus
A. G. Wishon	PG&E	+	12,800	94.2	84.1	1,412	1910	N. F. Willow Creek
Angels	PG&E	-	1,400	6.2	50.6	448	1920	Angels Creek
Kerckhoff	PG&E	+	34,080	264.1	88.5	350	1920	San Joaquin
Yosemite	Gov't	-	2,000	13.2	75.3	356	1916	Merced
Donnells	Tri-Dam	+	54,000	279.0	59.0	1,484	1957	M. F. Stanislaus
Beardsley	Tri-Dam	+	9,900	51.5	59.4	264	1957	M. F. Stanislaus
Tulloch	Tri-Dam	+	17,100	80.0	53.4	145	1958	Stanislaus
Exchequer	MID	+	31,250	128.5	46.9	300	1926	Merced
Cherry	City of S.F.	-	135,000	600.0	50.7	2,481	1960	Cherry River
Moccasin	City of S.F.	-	70,000	520.0	84.8	1,316	1925	Tuolumne Div
La Grange	TMID	-	3,900	18.0	52.7	117	1924	Tuolumne
Don Pedro	TMID	-	26,990	200.0	84.6	262	1923	Tuolumne
Big Creek No. 1	SCE	+	67,000	521.0	88.8	2,131	1913	Big Creek
Big Creek No. 2	SCE	+	57,750	451.0	89.2	1,858	1913	Big Creek
Big Creek No. 3	SCE	+	106,500	779.0	83.6	827	1923	San Joaquin
Big Creek No. 4	SCE	+	84,000	428.0	58.2	416	1951	San Joaquin
Big Creek No. 8	SCE	+	58,500	337.0	65.8	713	1921	San Joaquin
Big Creek No. 2-A	SCE	+	80,000	387.0	55.3	2,418	1928	Big Creek

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

San Joaquin Basin Area (continued)

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
Portal	SCE	+	10,000	51.0	58.2	230	1956	Big Creek
Mammoth Pool	SCE	+	129,360	546.0	59.6	1,100	1960	San Joaquin
Total			1,119,910	6,357.4	64.8			
Tulare Basin								
Balch No. 1	PG&E	+	31,000	490.5	43.7	2,379	1927	N. F. Kings
Balch No. 2	PG&E	+	97,200	Plants Combined		2,389	1958	N. F. Kings
Haas	PG&E	+	135,000	355.7	30.1	2,444	1958	N. F. Kings
Kern Canyon	PG&E	+	8,480	47.2	63.6	260	1921	Kern
Kings River	PG&E	+	44,100	157.0	40.7	798	1962	Kings
Tule River	PG&E	+	4,800	26.5	63.0	1,532	1914	M. F. Tule
Kaweah No. 1	SCE	-	2,250	16.0	81.2	1,326	1929	Kaweah
Kaweah No. 2	SCE	-	1,800	13.0	82.5	367	1929	Kaweah
Kaweah No. 3	SCE	-	2,800	25.0	102.0	775	1913	Kaweah
Lower Tule	SCE	+	2,000	19.0	108.5	1,140	1909	Tule
Kern River No. 1	SCE	+	16,000	173.0	123.5	877	1907	Kern
Kern River No. 3	SCE	-	32,000	200.0	71.4	821	1921	Kern
Borel	SCE	+	9,200	64.0	79.4	270	1913	Kern
Total			386,630	1,586.9	46.9			

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
				North Lahonton Area				
Farad	Sierra Pacific	+	2,800	19.0	82.2	83	1899	Truckee
Total			2,800	19.0	82.2			
				South Lahonton Area				
Rush Creek	SCE	+	8,400	43.0	58.5	1,807	1916	Rush Creek
Poole	SCE	+	10,000	26.0	29.7	1,675	1924	Lee Vining Creek
Lundy	SCE	+	2,400	8.6	40.9	785	1910	Mill Creek
Bishop Cr. No. 2	SCE	+	7,320	39.0	60.8	953	1908	Bishop Creek
Bishop Cr. No. 3	SCE	+	6,600	34.0	58.8	809	1913	Bishop Creek
Bishop Cr. No. 4	SCE	+	6,800	42.0	70.5	1,112	1905	Bishop Creek
Bishop Cr. No. 5	SCE	+	3,500	18.0	58.7	420	1907	Bishop Creek
Bishop Cr. No. 6	SCE	-	1,800	11.0	69.8	260	1913	Bishop Creek
Upper Gorge	LADW&P	-	37,500	133.0	40.5	802	1953	Owens
Middle Gorge	LADW&P	-	37,500	133.0	40.5	767	1952	Owens
Control Gorge	LADW&P	-	37,500	133.0	40.5	781	1952	Owens
Big Pine No. 3	LADW&P	-	3,200	15.0	53.5	1,243	1925	Big Pine Creek
Division Creek	LADW&P	-	600	4.0	76.1	1,250	1909	Division Creek
Cottonwood	LADW&P	-	1,500	8.0	60.9	1,267	1908	Cottonwood Creek

DEVELOPED HYDROELECTRIC RESOURCES IN CALIFORNIA

Powerplant	Owner	FPC	Installed Capacity KW	Avg. Annual Generation Million Kwh	Plant Factor %	Static Head Ft.	Year of Initial Operation	River
South Lahonton Area (continued)								
Haiwee	LADW&P	-	5,600	34.0	69.3	193	1927	L. A. Aqueduct
Pleasant Valley	LADW&P	-	3,200	15.0	53.5	76	1958	Owens
Total			173,420	696.6	45.6			
Colorado Desert Area								
Siphon Drop	USBR	-	1,600	13.0	92.8	15	1926	Yuma Canal
Parker	USBR	-	120,000	659.0	62.8	78	1942	Colorado
Pilot Knob	Imperial I.D.	-	33,000	50.0	17.3	55	1957	All American Canal
Turnip	Imperial I.D.	-	420	NA	---	NA	1964	West Side Main Canal
Drop No. 2	Imperial I.D.	-	10,000	60.0	68.5	26	1953	All American Canal
Double Weir	Imperial I.D.	-	560	NA	---	NA	NA	Central Main Canal
Drop No. 3	Imperial I.D.	-	4,800	49.0	116.6	25	1941	All American Canal
Drop No. 4	Imperial I.D.	-	19,600	120.0	69.9	51	1941	All American Canal
Total			189,980	951.6	57.5			
State Total			5,406,108	25,537.7	53.9			

TABLE D-5

HYDROELECTRIC PLANT ADDITIONS
1956 - 1965 INCLUSIVE

CALIFORNIA

Hydrologic Area	Powerplant	Owner	Installed Capacity in Kw	Avg. Annual Generation Million Kwh	Year of Initial Operation	River
North Coastal						
	Iron Gate	PP&L	18,000	150.0	1962	Klamath
	Area Total		18,000	150.0		
South Coastal						
	Ontario No. 2	SCE	320	1.1	1963	San Antonio Creek
	Area Total		320	1.1		
Sacramento Basin						
	Drum No. 2	PG&E	44,100	35.1	1965	Bear (S.F. Yuba Div.)
	Butt Valley	PG&E	36,000	84.2	1958	Butt Creek
	Caribou No. 2	PG&E	109,800	211.5 Est.	1958	N. F. Feather
	De Sabla	PG&E	18,450	120.0	1963	N. F. Feather
	Poe	PG&E	124,200	512.0	1958	N. F. Feather
	Pit No. 6	PG&E	79,000	370.0	1965	Pit
	Pit No. 7	PG&E	104,000	522.0	1965	Pit
	McCloud-Pit	PG&E	155,000	688.0	1965	Pit
	Chili Bar	PG&E	7,000	42.0	1964	S. F. American
	Kelly Ridge	OWID	9,900	48.0	1963	Feather
	Forbestown	OWID	28,800	110.0	1963	S. F. Feather
	Woodleaf	OWID	52,200	176.0	1963	S. F. Feather
	Lewiston	USBR	350	2.6	1964	Trinity
	Spring Creek	USBR	150,000	543.6	1964	Spring Cr. (Trinity Div.)
	Judge Francis Carr	USBR	134,000	491.5	1963	Clear Cr. (Trinity Div.)
	Trinity	USBR	100,000	409.0	1964	Trinity
	Jaybird	SMUD	133,000	505.0	1961	Silver Creek
	Union Valley	SMUD	33,000	96.0	1963	Silver Creek
	Camino	SMUD	71,250	263.0	1963	S.F. American (Silver Creek Div.)
	Robbs Peak	SMUD	25,000	55.0	1965	Trib. Silver Cr. (S.F. Rubicon Div.)
	Area Total		1,415,050	5,284.5		

HYDROELECTRIC PLANT ADDITIONS (con't)

Hydrologic Area	Powerplant	Owner	Installed Capacity in Kw	Avg.Annual Generation Million Kwh	Year of Initial Operation	River
San Joaquin Basin						
	Stanislaus	PG&E	81,900	376.0	1963	M. F. Stanislaus
	Donnells	Oakdale & S. Joaquin Irrigation District	54,000	279.0	1957	N. F. Stanislaus
	Beardsley	"	9,900	51.5	1957	N. F. Stanislaus
	Tulloch	"	17,100	80.0	1958	Stanislaus
	Cherry	City of San Francisco	135,000	600.0	1960	Cherry River
	Portal	SCE	10,000	51.0	1956	Big Creek
	Mammoth Pool	SCE	129,360	546.0	1960	San Joaquin
	Area Total		437,260	1,983.5		
Tulare Basin						
	Balch No. 2	PG&E	97,200	311.9	1958	N. F. Kings
	Haas	PG&E	135,000	355.7	1958	N. F. Kings
	Kings River	PG&E	44,100	157.0	1962	Kings
	Area Total		276,300	824.6		
South Lahonton						
	Pleasant Valley	LADW&P	3,200	15.0	1958	Owens
	Area Total		3,200	15.0		
Colorado Desert						
	Turnip	Imperial I.D.	420	N.A.	1964	West Side Main Canal
	Pilot Knob	" "	33,000	50.0	1957	All American Canal
	Area Total		33,420	50.0		
	STATE TOTAL		2,183,550	8,308.7		

TABLE D-6

HYDROELECTRIC PLANTS IN CALIFORNIA
COMPLETED SINCE DECEMBER 31, 1965,
UNDER CONSTRUCTION OR SCHEDULED TO BE UNDER CONSTRUCTION BY 1970

Powerplant	Owner	Installed Capacity kw	Static Head ft.	Est. Yr. of Init. Operation	River
Castaic*	Los Angeles (DWP)	1,250,000	1063	1971 1/	West Branch California Aqueduct
Thermalito*	State DWR	115,000	99	1968	Feather
Oroville*	State DWR	644,000	675	1968	Feather
Pyramid	State DWR	150,000	755	1971	West Branch California Aqueduct
Cottonwood	State DWR	15,000	140	1972	California Aqueduct
Devil Canyon	State DWR	117,000	1435	1972 2/	California Aqueduct
White Rock	SMUD	200,000	870	1968	South Fork American
Camino (increase)	SMUD	71,250	1067	1968	So.Fork American(Silver Cr.Div.)
Jones Fork	SMUD	15,000	580	1972	Jones Fork Silver Creek (So. Fork Silver Creek Div.)
Loon Lake	SMUD	80,000	1145	1971	Gerle Creek
Ralston	Placer County Water Agency	79,200	1344	1967	Rubicon (Middle Fork American Div.)
Middle Fork	Placer County Water Agency	109,800	2096	1967	Middle Fork American (Rubicon Div)
French Meadows	Placer County Water Agency	15,300	655	1967	Rubicon (Middle Fork American Div.)
Oxbow	Placer County Water Agency	6,000	89	1967	Middle Fork American

HYDROELECTRIC PLANTS IN CALIFORNIA

Powerplant	Owner	Installed Capacity kw	Static Head ft.	Est. Yr of Init. Operation	River
Dutch Flat #2	Nevada Irrigation District	22,800	480	1966	Bear
Chicago Park	Nevada Irrigation District	36,300	480	1966	Bear
New Colgate	Yuba County Water Agency	282,600	1388	1971	Yuba (North Fork Div)
New Narrows	Yuba County Water Agency	46,250	240	1971	Yuba
New Don Pedro	Turlock and Modesto Irrigation Districts	107,000	261	1971	Tuolumne
Belden	PG&E	117,000	770	1969	North Fork Feather
Moccasin (New)	City of San Francisco	90,000	1316	1970	Tuolumne
Robert C. Kirkwood	City of San Francisco	67,500	1452	1966	Tuolumne
San Luis*	USBR and State DWR	424,000	327	1967	California Aqueduct
McSwain	Merced Irrigation District	9,000	55	1967	Merced
New Exchequer	Merced Irrigation District	80,100	462	1966	Merced
San Luis Forebay*	USBR	25,200	56	1966	Delta-Mendota Canal

*Pumped Storage Powerplants
1/ Initial unit is a 50 mw pump starting turbine generator. Six 200 mw reversible units will be installed during the period, 1973 to 1980.
2/ Second unit to be installed in 1977.

TABLE D-7

INSTALLED CAPACITY AND MAXIMUM DEMAND
(Thousand Kilowatts)

NORTHERN CALIFORNIA

Year	Fuel Capacity	Hydro Capacity	Fuel-Hydro Ratio	Total Capacity	Maximum* Demand	Margin * %
1948	737	1,513	0.67	2,250	2,125	5.9
1949	821	1,628	0.50	2,449	2,295	6.7
1950	1,116	1,810	0.62	2,926	2,497	16.8
1951	1,527	1,810	0.84	3,337	2,907	14.8
1952	1,752	1,905	0.92	3,657	3,143	16.4
1953	1,962	1,905	1.03	3,867	3,410	13.4
1954	2,500	1,907	1.31	4,407	3,598	22.5
1955	2,624	2,182	1.20	4,806	3,740	28.5
1956	2,839	2,182	1.30	5,021	3,952	27.0
1957	2,843	2,246	1.27	5,089	4,291	18.6
1958	3,051	2,765	1.11	5,816	4,334	34.2
1959	3,051	2,765	1.10	5,816	4,925	18.1
1960	3,371	2,906	1.16	6,277	5,488	14.4
1961	3,697	2,953	1.25	6,650	5,887	13.0
1962	4,210	3,303	1.27	7,513	6,031	24.6
1963	4,565	3,489	1.31	8,054	6,080	32.5
1964	5,165	3,746	1.38	8,911	6,923	28.7
1965	5,493	4,052	1.36	9,545	7,579	25.9
1966	5,518	4,496	1.23	10,014	8,329	20.2
1967	6,218	5,114	1.22	11,332	8,947	26.7
1968	6,943	5,952	1.17	12,895	9,569	34.8
1969	6,943	6,734	1.03	13,677	10,246	33.5

*Historical through 1965

Note: Installed capacities and historical and estimated maximum demands are from California Public Utilities Commission's Electric Power Surveys.

TABLE D-8

INSTALLED CAPACITY AND MAXIMUM DEMAND
(Thousand Kilowatts)

SOUTHERN CALIFORNIA

Year	Fuel Capacity	Hydro Capacity	Fuel-Hydro Ratio	Total Capacity	Maximum* Demand	Margin* %
1948	1,254	1,789	0.70	3,043	2,421	25.7
1949	1,578	1,630	0.97	3,208	2,637	21.7
1950	1,628	1,640	0.99	3,268	2,793	17.0
1951	1,558	1,671	0.93	3,229	3,088	4.6
1952	1,698	1,803	0.94	3,501	3,350	4.5
1953	1,988	1,852	1.07	3,840	3,561	10.8
1954	2,382	1,852	1.29	4,234	3,922	8.0
1955	2,832	1,857	1.53	4,689	4,372	7.2
1956	3,407	1,867	1.83	5,274	4,810	9.6
1957	3,885	1,900	2.04	5,785	5,088	13.7
1958	4,452	1,903	2.34	6,355	5,591	13.7
1959	4,995	1,903	2.63	6,898	5,941	16.1
1960	5,620	2,033	2.76	7,653	6,513	17.5
1961	6,444	2,161	2.98	8,605	7,118	20.9
1962	7,150	2,260	3.16	9,410	7,685	22.4
1963	8,173	2,158	3.79	10,331	8,311	24.3
1964	9,037	2,158	4.19	11,195	8,944	25.2
1965	9,772	2,177	4.49	11,949	9,758	22.5
1966	11,023	2,177	5.06	13,200	10,530	25.4
1967	12,253	2,177	5.63	14,430	11,375	26.9
1968	12,703	2,273	5.59	14,976	12,199	22.8
1969	13,063	2,983	4.38	16,046	13,303	20.6

*Historical through 1965

Note: Installed capacities and historical and estimated maximum demands are from California Public Utilities Commission's Electric Power Surveys.

TABLE D-9

INSTALLED CAPACITY AND MAXIMUM DEMAND
(Thousand Kilowatts)

CALIFORNIA

Year	Fuel Capacity	Hydro Capacity	Fuel-Hydro Ratio	Total Capacity	Maximum* Demand	Margin* %
1948	1,991	3,302	0.60	5,293	4,532	16.8
1949	2,399	3,258	0.74	5,657	4,873	16.1
1950	2,744	3,450	0.80	6,194	5,198	19.2
1951	3,085	3,481	0.89	6,566	5,816	12.9
1952	3,450	3,708	0.93	7,158	6,321	13.2
1953	3,950	3,757	1.05	7,707	6,685	15.3
1954	4,882	3,759	1.30	8,641	7,089	21.9
1955	5,456	4,039	1.35	9,495	7,783	22.0
1956	6,246	4,049	1.53	10,295	8,670	18.7
1957	6,728	4,146	1.62	10,874	9,150	18.8
1958	7,503	4,668	1.61	12,171	9,838	23.7
1959	8,046	4,668	1.72	12,714	10,692	18.9
1960	8,991	4,939	1.82	13,930	11,585	20.2
1961	10,141	5,114	1.98	15,255	12,561	21.4
1962	11,360	5,563	2.04	16,923	13,427	26.0
1963	12,738	5,647	2.26	18,385	14,120	30.2
1964	14,202	5,904	2.26	20,106	15,743	27.7
1965	15,265	6,229	2.45	21,494	17,337	24.0
1966	16,541	6,673	2.48	23,214	18,791	23.5
1967	18,471	7,291	2.53	25,762	20,315	26.8
1968	19,646	8,225	2.39	27,871	21,768	28.0
1969	20,006	9,717	2.06	29,723	23,480	26.6

*Historical through 1965

Note: Installed capacities and historical and estimated maximum demands are from California Public Utilities Commission's Electric Power Surveys.

APPENDIX E

THE COLORADO RIVER

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FIGURES

INTRODUCTION

Two events occurred almost simultaneously which have provided catalysts for western states water planning. They were the U. S. Supreme Court decree in Arizona v. California, dated March 9, 1964; and a general agreement in the early 1960's that there will not be enough water from the Colorado River to supply the long-range needs of the Colorado River Basin States. The Court decree and the agreement on overall water supply deficiency from the Colorado River constitute two of the most important developments related to water resources planning which have occurred since publication of The California Water Plan.

A brief account of the legal and hydrologic history of the Colorado River as it pertains to California will help to explain these events and why they have become catalysts for western states water planning. Even though encumbered by perhaps the most intense, prolonged controversy over water rights of any major river system in the country, the main stream of the Colorado River has been either the locale or the starting point for many unprecedented large-scale water projects. At one time, about 30 years ago, the highest dam, the largest reservoir, the biggest hydroelectric powerplant, and the largest and longest aqueducts and canals in the world were Colorado River projects. Those facilities and others constructed since have been instrumental in the development of the largest concentration of population and wealth of any like desert area in the world.

Much of the strife in the Basin stemmed from insistence that western water law embodied in the phrase "first in time, first in right" would not provide adequate protection for slower-growing upstream areas. The upstream areas sought -- and eventually received -- water right protection from the fast-growing downstream areas. However, there was an unfortunate underlying premise that future water supply could be forecast with sufficient accuracy to enable the reservation of supposedly a safe part of the supply for the slower-growing areas. But as time passed, water availability studies were consistently revised downward and apprehension began to grow. About the time the Supreme Court rendered its opinion and entered a decree, the states of the Basin finally realized that inbasin water supplies to fully satisfy supposedly "safe" apportionments as embodied in the Colorado River Compact of 1922 and the Boulder Canyon Project Act of 1928 could not be permanently guaranteed. The need for interbasin water planning then achieved the public acceptance that it has long deserved.

For these reasons, the impetus for western states water planning is derived largely from these two events, and the obvious fact that the Colorado River Basin is extremely important to the west. At the outset, however, it is emphasized that the success of any long-range plan for augmenting the water supplies of the Colorado River Basin will depend largely upon formulation of a plan which allows for "staging". Staging means timing the development of water projects to fit the needs of the market -- in other words, scheduling the construction of dams, reservoirs, aqueducts, and other works so that the supply of water resulting from such projects can readily be absorbed by the demand which exists at the time.

Lead time in regional planning is also an important factor. Experience in California indicates that 25 years is the minimum lead time for major water projects. This means that water from long-distance sources should not be expected to reach the Southwest before the 1990's.

EARLY HISTORY

Irrigation in Arizona and California in the Lower Basin of the Colorado River developed much more rapidly than in the four states of Colorado, New Mexico, Utah, and Wyoming. The Palo Verde Valley in California appropriated water as early as the 1870's, and the Imperial Valley has appropriations dating back to the 1890's. The first diversions in Arizona in the lower river began in 1904 in the Yuma area. A few years later, the whole natural flow of the river was appropriated, and the river was dry for long periods in the summer at the Mexican boundary. During this period, upstream development increased gradually and leveled off in the early 1920's. Nevertheless, the spring floods, depositing great quantities of silt and raising the riverbed several feet in some years, were a continuing menace to lands in the Imperial Valley below sea level and to lands in the Yuma Valley in Arizona.

A major multiple-purpose reservoir project was a necessity -- not only for flood control and power, but also to make possible any further development in the Colorado River Basin. But the four states in the Upper Basin knew that the Lower Basin had a big population advantage, better lands, flatter contours, and a longer growing season. They feared that if the flood waters were stored, that Arizona, California, and Nevada would appropriate all of them, unless the Upper Basin could insulate itself against the law of prior appropriation. The great storage dam was to be located on the river which constitutes the Nevada-Arizona border, enabling Nevada to use water from the main stream of the Colorado River for the first time. The Upper Basin States got some of this insulation in the 1922 Colorado River Compact.

The Colorado River Compact

The Colorado River Compact was signed by representatives of all seven basin states at Santa Fe, New Mexico, November 24, 1922, subject to ratification by their Legislatures and the consent of Congress.

Article II of the Compact defines the Colorado River system as including the main stream and its tributaries. The Upper Basin is defined as the drainage area above Lee Ferry (a point on the river in northwestern Arizona) near the Utah border, and the Lower Basin as the drainage area below that point. Colorado, Utah, New Mexico, and Wyoming were named as the states of the Upper Division and Arizona, California, and Nevada as the states of the Lower Division.

Negotiators gave up in their attempts to allocate all the water and to allocate to individual states. They decided on allocating beneficial consumptive uses instead of flow of the stream, and made a general division between the Upper and Lower Basins. Allocation to states was left to the future. To provide a safety factor, the Compact allocations for beneficial consumptive use were thought to amount to only about 75 percent of the total usable streamflow in the Basin.

In 1923, all the Basin States but Arizona ratified the Compact. Arizona's Legislature rejected the Compact because of Arizona's desire to exclude the Gila River from Compact accounting. In 1925, at the suggestion of the State of Colorado, seven-state ratification was waived and the other six states ratified the Compact again as a six-state document and presented it to Congress.

The Boulder Canyon Project Act

The Boulder Canyon Project Act, after three unsuccessful bills, was enacted in December 1928. However, Section 4(a) provided that it should not take effect unless, at the end of six months, the President should proclaim that the Colorado River Compact had been ratified by seven states, or failing that, had been ratified by six states, including California, and in the latter event that California's Legislature had enacted a statute in terms prescribed by the Congress limiting California's use of Colorado River water.

The President, on June 25, 1929, proclaimed the failure of seven-state ratification, and the success of six-state ratification. The six-state Compact and the Project Act thereupon became effective, authorizing the construction of Hoover Dam and the All-American Canal, on the further condition that the benficiaries contract in advance to pay their costs. California's Legislature had enacted its Limitation Act in the spring of 1929, which was to limit the State's use of Colorado River water to not more than 4,400,000 acre-feet a year of the quantity apportioned by Article III(a) of the Colorado River Compact, plus one-half of any excess or surplus waters unapportioned by the Compact.

During the period from 1930 to 1934, contracts for storage and delivery of water from Lake Mead were executed under the terms of the Project Act by the Secretary of the Interior with the Southern California agencies concerned. Before the execution of the contracts, it was necessary for these California agencies to agree among themselves as to the division or allocation of Colorado River water to which California would be entitled under the limitation placed upon the State by the Project Act and accepted by act of the State Legislature. On November 5, 1930, the Department of the Interior requested that this be accomplished with the assistance and approval of the State Division of Water Rights, and further suggested that the agreed allocation be included as a uniform clause in all of the water contracts.

The Seven-Party Water Agreement

On August 18, 1931, after several months of negotiations, the California agencies concerned signed an agreement (subsequently known as the "Seven-Party Water Agreement") apportioning among themselves the waters of the Colorado River available for use in California under the Compact and the Project Act. The amounts and priorities were as follows:

Priority No.	Agency and Description	Annual quantity in acre-feet
1.	Palo Verde Irrigation District .... 104,500 acres in and adjoining existing district	3,850,000
2.	Yuma Project (California Division). Not exceeding 25,000 acres. . . .	
3.(a)	Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	
(b)	Palo Verde Irrigation District .... 16,000 acres of adjoining mesa .	
4.	Metropolitan Water District, City of Los Angeles and/or others on coastal plain	550,000
5.(a)	Metropolitan Water District, City of Los Angeles and/or others on coastal plain	550,000
(b)	City and/or County of San Diego . .	112,000
6.(a)	Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	300,000
(b)	Palo Verde Irrigation District .... 16,000 acres of adjoining mesa .	
	TOTAL	5,362,000

A seventh priority concerning all remaining water available for use in California was apportioned for agricultural use in the Colorado River Basin in California.

Between 1930 and 1936, the State of Arizona attempted unsuccessfully three times to bring suit in the U. S. Supreme Court over Colorado River matters. Work on the projects authorized by the Boulder Canyon Project Act continued. Hoover Dam began to generate power in 1936. Construction was initiated on the

All-American Canal in 1934, and the first significant use of the Canal was made in 1940. The Metropolitan Water District of Southern California financially obligated itself and constructed the Colorado River Aqueduct to furnish Colorado River water to the South Coastal Plain around Los Angeles. Deliveries began in 1941.

By 1944, several new events happened. Arizona belatedly passed an act to ratify the Colorado River Compact and also obtained a Hoover Dam water delivery contract signed by the Secretary of the Interior for 2,800,000 acre-feet of water each year. Nevada, in 1942 and 1944, secured contracts with the Secretary for 300,000 acre-feet per year.

The Mexican Water Treaty

The State Department in 1944 announced the terms of the proposed Colorado River water treaty with Mexico. The terms were endorsed by Arizona and the Upper Basin States but opposed by California and Nevada. The proposed treaty would grant 1,500,000 acre-feet of Colorado River water each year to Mexico in return for Mexican concessions on the Rio Grande. This was about twice the amount that Mexico had been able to use before the Hoover Dam was built to control and salvage flood waters under a statute which declared that such water should be used exclusively within the United States. The Senate ratified the treaty in 1944, and it became effective in November 1945.

The Central Arizona Project

Proposals to authorize construction of the Central Arizona Project were actively before the Congress from 1946 to 1952, and as far as Arizona was concerned the project was of utmost importance. This project would divert 1.2 million acre-feet of main stream Colorado River water into the Phoenix and Tucson areas each year.

Because the Colorado River Compact and the Boulder Canyon Project Act do not provide for a division of waters among States in the Lower Basin, there were differences of opinion concerning the availability of water for the Central Arizona Project. To resolve this controversy, a committee in the U. S. House of Representatives recommended in 1951 that Arizona apply to the U. S. Supreme Court.

LITIGATION BEFORE THE SUPREME COURT

In 1952, Arizona, temporarily putting the Central Arizona Project on the shelf, brought suit against the State of California and the water-using agencies in Southern California in the U. S. Supreme Court. This suit was not decided until the decree was entered in March of 1964--more than 12 years after it was initiated.

Although the decree settled several controversial issues, it reserved the key issue of allocating shortage for subsequent decision by the Secretary of the Interior subject to actions by the Congress.

One important issue settled by the litigation was whether the water in the Lower Basin tributaries should be considered in the interstate allocations (the legal position held by California), or whether the apportionment should be made from the main stream alone (the position of Arizona).

Interpreting the legislative intent of the Boulder Canyon Project Act and deferring interpretation of the Colorado River Compact, the Court ruled in favor of the latter division. Under the decree, Arizona and New Mexico were assigned sole use of the Gila River, the principal tributary in the Lower Basin.

The decree awarded 4.4 million acre-feet a year to California, 2.8 million acre-feet a year to Arizona, and 0.3 million acre-feet to Nevada, provided that 7.5 million acre-feet is available in the Lower Basin. The Court also ruled that supplies in excess of 7.5 million acre-feet be shared alike by California and Arizona (with the possibility of a small part of Arizona's share going to Nevada), but left the allocation of an annual supply of less than 7.5 million to the Secretary of the Interior, or to a future Congressional action.

Even with 7.5 million acre-feet of water available each year in the Lower Basin (an unlikely event because studies indicate that the permanent supply will be less than 6 million acre-feet), California's share (4.4 million acre-feet) is 0.7 million less than that being used now and 1.0 million less than has been planned for use by projects already constructed. Deduction of 4.4 from 6.0 million acre-feet would leave Arizona and Nevada only 0.6 million more than present use. This is not nearly enough to satisfy either decreed rights or needed additional water supplies.

The prospect of reduced diversions from the Colorado River for California, unless augmentation is accomplished as upstream areas deplete the downstream flow in ever-increasing amounts, is but a forerunner to water problems that all the basin states will face. Ground water supplies are being overdrawn in many areas, in Arizona alone by about 2 million acre-feet each year.

The litigation convinced most of the water leaders in the Colorado River Basin that no state can effectively insulate itself legally in a water-short river basin. The decision in Arizona v. California spelled out the division of 7.5 million acre-feet among Arizona, California, and Nevada although there now appears to be only a remote chance that there will be 7.5 million acre-feet to permanently divide. The fundamental issue of how to divide shortages was put in the hands of the Secretary of the Interior and the Congress, no doubt recognizing that the only satisfactory solution to the Colorado River dilemma would be to augment its supply.

RECOGNITION OF NEED FOR REGIONAL WATER PLANNING

The Colorado River Board of California and the Department of Water Resources have been concerned for many years about the ability of the Colorado River water supply to meet future demands. Figure E-1 shows how the estimates of dependable water supply on the Colorado River have been revised with the passage of years and the timing of those estimates with important decisions on the Colorado.

In the Department of Interior's report on the Pacific Southwest Water Plan, an annual water supply shortage in the Southwest of some 3.5 to 4 million acre-feet was forecast to occur by the year 2000 unless additional water supplies are imported. Recurrence of drought conditions, water quality considerations, and other problems may mean a greater impending shortage.

The Pacific Southwest Water Plan

Anticipating that the Colorado River decision was imminent -- and would soon result in renewed efforts in the Lower Basin to authorize and build new projects -- Wayne N. Aspinall, Chairman, Interior and Insular Affairs Committee, U. S., House of Representatives, in November 1962 requested that the Secretary of the Interior review the situation and develop a regional plan of water resources development for the Pacific Southwest. On August 26, 1963, only about two and one-half months after the Supreme Court of the United States rendered its opinion in *Arizona v. California*, the first report of the Secretary of the

Interior on the Pacific Southwest Water Plan was mailed to the Governors of the seven Colorado River Basin States for review pursuant to provisions of the 1944 Flood Control Act.

The report proposed a Phase I development for immediate needs and a Phase II development which required additional investigation to take care of growing future needs. Total cost was estimated at approximately $4 billion, about half in each phase.

The largest features of Phase I would include the Bridge and Marble Canyon power developments on the Colorado River between Lake Mead and Lake Powell, the Central Arizona Project to divert 1,200,000 acre-feet a year from the river into the Phoenix-Tucson area and enlargement of the California Aqueduct to bring an additional 1,200,000 acre-feet a year into Southern California from north coast California streams as replacement for the Colorado River water to be taken for the Central Arizona Project.

Phase II included expansion of the Central Arizona Project to a diversion capacity of 2,400,000 acre-feet a year, an aqueduct to export a second increment of 1,200,000 acre-feet a year from Northern California and deliver it to Lake Havasu on the Colorado River, and storage and regulating reservoirs on the Trinity River, California.

The report proposed establishment of a regional development fund to finance the works with water and power revenues, primarily the power revenues from the Bridge and Marble plants and from the Hoover-Parker-Davis system after payout of existing cost obligations.

After receiving comments from the states and other federal agencies, in accordance with the 1944 Flood Control Act, the Secretary of the Interior, on February 14, 1964, transmitted to the President, through the Bureau of the Budget, a modified report on the Pacific Southwest Water Plan. The revised plan incorporated most of the comments of the State of California. However, no bill was introduced in the Congress to authorize the Pacific Southwest Water Plan.

The two reports caused considerable controversy in the State and to a lesser extent in the West, but they served an important purpose which was to emphasize the need for regional water resources planning. Consequently, unprecedented efforts have been made among the states in the Southwest, and within the State of California, to resolve differences for the common good.

Attention recently has been concentrated on finding ways to protect existing project uses and Compact rights until the Colorado River water supply is augmented. Attention has also been turned to coordinating efforts so that legislation and studies by the Bureau of Reclamation and other concerned federal agencies leading to augmentation may proceed. An agreement was reached between Arizona and California early in 1965 which resulted in 40 identical bills being introduced in the Senate and the House to authorize the Lower Colorado River Basin Project. These bills would provide:

1. The Secretary of the Interior would be authorized to investigate sources of water and to plan projects for the importation of at least 2.5 million acre-feet annually into the main stream of Colorado River below Lee Ferry, and to report within three years.
2. Existing main stream users in Arizona, California, and Nevada would be protected against shortages in the basic supply for consumptive use of 7.5 million acre-feet a year as against the Central Arizona Project, although California's protection would be limited to 4.4 million acre-feet per annum of consumptive use. The protection would cease when works were completed to permanently deliver at least 2.5 million acre-feet a year into the main stream from outside sources which the President proclaimed could supply this quantity without adverse effect on the satisfaction of the foreseeable water requirements of the areas of origin. The quantity of imported water needed to bring the consumptive use from the main stream in the Lower Basin up to 7.5 million acre-feet a year would be made available at Colorado River prices.
3. The Secretary would be authorized to construct the Central Arizona, Bridge Canyon, and Marble Canyon Projects.

4. The Secretary would be directed to provide for adequate and equitable protection of the interests of the states and areas from which water would be exported to the Colorado River, including assistance from the development fund to be established by the Act, so that ultimate water requirements of the areas of origin could be satisfied at prices to users not adversely affected by the exportation.
5. Into the fund would be deposited all authorized appropriations and all project revenues including the power revenues from the Bridge and Marble Canyon projects and from the Hoover, Davis, and Parker projects after these latter have paid out. The fund would be applied to repayment of the cost of the entire project including the cost of importation works when subsequently authorized.

Hearings on the proposed new Colorado River Basin legislation were held before a House subcommittee in late summer 1965 and in May 1966. The latter hearing related to a negotiated seven-state version of the bill.

The compromise between the Upper and Lower Basins retained most of the key provisions contained in the bills introduced early in 1965 with the following changes:

1. Relief of both basins from the Mexican Treaty burden when works to import 2.5 million acre-feet annually are in operation.

2. A plan for coordinating the operation of Lake Powell and Lake Mead so that both reservoirs share the benefits of wet years and neither of them bears alone the burden of drawdowns during droughts.
3. Provisions for reimbursing the Upper Basin's fund for payments that must be made out of that fund to keep the Hoover power contractors whole under their contracts if water is withheld from power generation at Hoover to build up Lake Powell.
4. Authorization for the Secretary of the Interior to construct five new projects located principally in Colorado.
5. A substantially revised Title II, directing the Secretary to investigate shortages in the entire Colorado River Basin, and to formulate and report to Congress a regional plan for their alleviation through importations of water or otherwise.

The subcommittee made further amendments before reporting the bill, which was subsequently reported by the full committee late in the season. The Committee version of Title II added an authorization for a seven-man National Water Commission under whose general direction the Secretary would make his study and report. He would first make a reconnaissance report and, if this was favorable as to availability of a water surplus in the areas of origin and as to the benefit-cost ratio of the importation works and the probability of repayment of their cost, he would be authorized to proceed with a feasibility report on these importation works without further direction from Congress. Authorization of actual construction would await action from Congress on his feasibility report. The Committee also deleted Title VII which would have created "The Colorado-Pacific Regional Water Commission".

The bill did not reach the floor of the House, but favorable committee action was significant progress on such a complicated bill. Much of this progress can be traced to resolution of long-standing hydrologic differences. In the summer of 1965, hydrologists from Arizona, California, and Nevada agreed that it was time to emphasize before congressional committees that future water supplies cannot be forecast with precision. These engineers presented joint testimony on Colorado River water availability before the House Subcommittee on Irrigation and Reclamation. This testimony provided means of weighing future probabilities without trying to pinpoint the so-called "safe yield". For example, it was shown that there are nine chances in ten that the 69-year average virgin flow of the Colorado River at the key gage near Lee Ferry could be anywhere between 13.3 and 16.5 million acre-feet, which is a fairly broad range for such a long-time average. An interpretation of the study also indicates that the historic average for the dry period 1930-1964 has about one chance in four of being repeated.

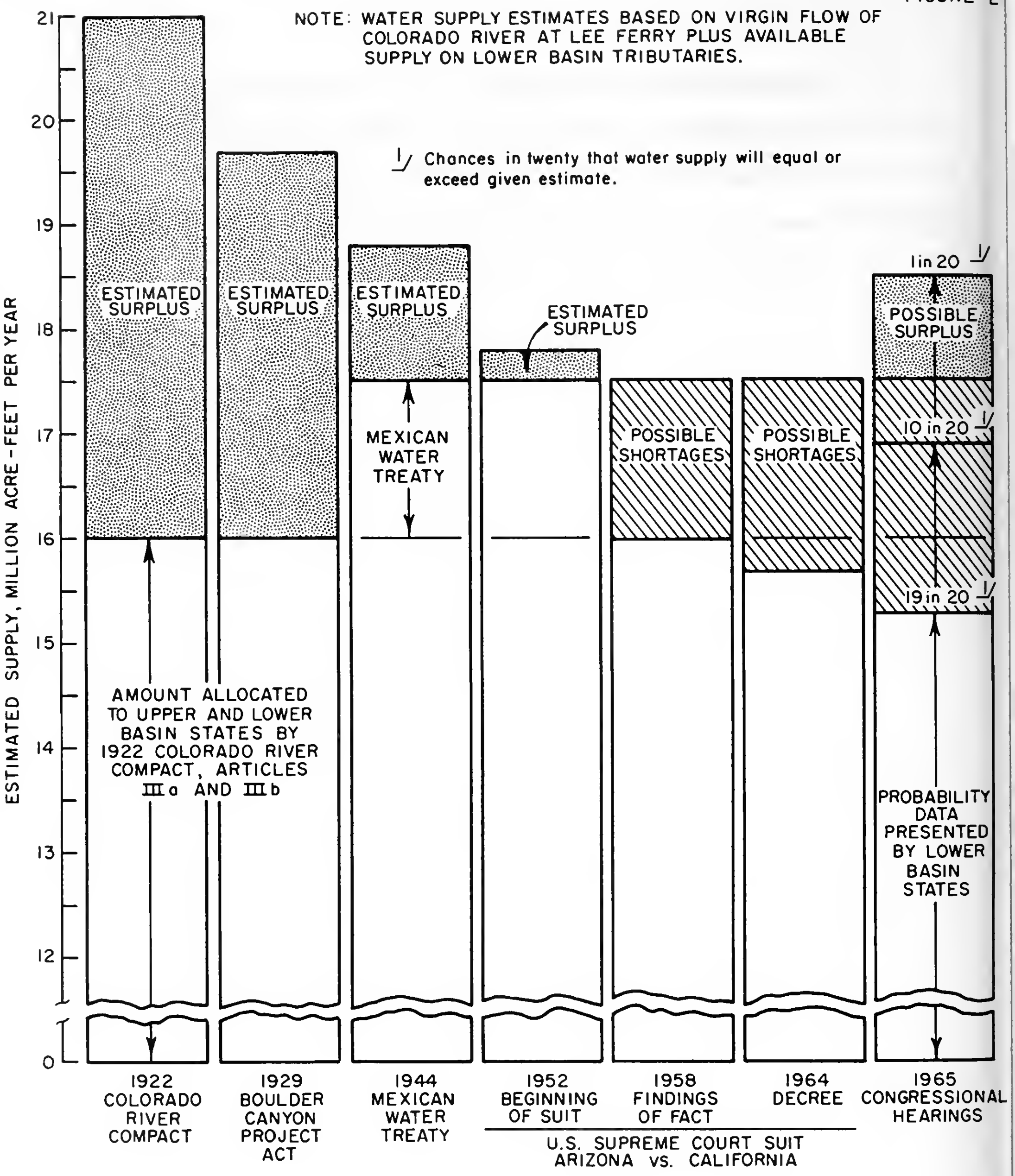
The joint statement acknowledged that estimates can be made only of future possibilities within reasonable limits, based upon what has happened in the past. Risks are inherent in all such projections.

The supply of the river will be insufficient to meet future demands, estimated to reach about 18 million acre-feet per annum by year 2000, or to meet apportionments of use of water made by the Colorado River Compact to the Upper and Lower Basins, and the Mexican Treaty burden. It is simply a question as to how long it will take the demands to surpass the water available. Both basins are ultimately dependent upon substantial importations which should be made available by the last decade of the present century.

The joint statement concluded, however, that there is a 50-50 chance that the supply in the main stream will equal or exceed the amount needed to provide: (1) 4.4 million acre-feet a year for California; (2) water for decreed rights and existing mainstream projects in Arizona and Nevada and the southern Nevada water supply project; (3) water for increasing demands of the Upper Basin; and (4) a full supply of 1.2 million acre-feet per annum for the proposed Central Arizona Project until about the turn of the century, gradually reducing thereafter.

This type of information helps put hydrology in proper perspective. Hydrologists from the states of the Upper Division have also acknowledged that the probability studies have considerable merit, and that repetition of historic runoff sequence would be highly improbable. Figure E-1 shows the results of the Lower Basin probability study as compared to recent estimates of safe yield.

Although much work remains to be done on regional planning, the progress during the recent years of the 1956-65 decade toward an overall solution to western water problems is encouraging. All present evidence indicates that progress during the next decade will be equally encouraging.



WATER SUPPLY ESTIMATES AND HISTORIC EVENTS
1922-65
COLORADO RIVER BASIN

APPENDIX F

WATER PROJECT STATISTICAL DATA

TABLE OF CONTENTS

INTRODUCTION

This appendix presents physical and cost data on the more significant features of major water resource developments in California. The information is shown in tabular form by hydrologic study areas in accordance with the sequence of presentation used in Bulletin No. 160-66. These eleven study areas are outlined on Figure 4, page 41 of the bulletin, and on Figure A-1 of Appendix A, "Water Requirements" bound in this volume.

Information on single-purpose beach erosion, navigation, and flood control developments and on distribution and water treatment facilities is not included in this appendix. The reservoir projects described are limited to those having a gross storage capacity of 10,000 acre-feet or more, although certain reservoirs of lesser capacity are listed when they are integrally operated with a project system. An alphabetical listing and table page number index for the major reservoirs immediately follows the tables.

When a water project or project system is located in more than one hydrologic study area, the data shown in the tables for a particular area covers only the features located therein. The major project systems and the page numbers of tables containing information about them are as follows:

Project	Table Page Number
Central Valley Project	F-5, 6, 12, 17, 18, 21
Colorado River Aqueduct	F-9, 25
Hetch-Hetchy Aqueduct	F-6, 18
Los Angeles Aqueduct	F-9
Mokelumne Aqueduct	F-6, 17
Solano Project	F-6, 12, 17
State Water Project	F-6, 9, 12, 17, 18, 21, 24

Explanations of the table column headings which are not self-explanatory, and the general footnote designations, are as follows:

Project Purposes - Seven symbols are used to designate primary project purposes as follows:

C - Conservation	F - Flood Control
I - Irrigation	R - Recreation
M - Municipal and Industrial Water Supply	P - Hydroelectric Power
D - Debris Control	

Capital Costs - Information on capital costs is either the estimated cost at the time the feasibility or preconstruction report was prepared, or the actual cost of construction as reported by the constructing agency. The costs of reservoirs, where listed separately, are generally the costs of the dam and appurtenant works only and do not include the associated costs of relocation, rights-of-way, clearing and grubbing, or interest during construction. The costs shown for powerplants are those of the powerhouse structure and generating equipment. Except as specifically indicated, they do not include costs of switchyard or transmission facilities.

Some projects, particularly those to generate power, have been enlarged since initial construction. For those projects, the costs shown are commensurate with the completion dates indicated. A listing of hydroelectric power developments and powerplant additions during the 1956-65 decade is presented in Tables D-4 and D-5, respectively, of Appendix D. Table D-6 lists hydroelectric plants completed during 1966 and those presently under construction or scheduled for construction by 1970.

Reservoir Capacities - Gross capacity refers to reservoir storage volume below the level of the maximum controllable pool elevation. Active capacity is the storage volume between the elevation of the maximum controllable pool and the elevation of the minimum controllable outlets. Flood space reservation is the maximum flood detention storage assigned to the flood control function of the project, and excludes surcharge storage which may also be available for flood control purposes.

Footnotes - A footnote is used on the tables where clarification is needed to qualify or explain the indicated information.

The footnote "S", under the date of completion, signifies the project is under construction and is scheduled for completion during the calendar year shown. An asterisk, "*", indicates incomplete or unavailable information. Two additional footnotes, "a" and "b", carry the same meaning throughout the tables:

Footnote "a" indicates that the cost of a dam only is given. This is used when a reservoir and another feature (s) are listed together, but where the cost data of the other feature (s) have not been obtained.

Footnote "b" refers to the cost of a powerplant. The cost includes those of land and right-of-way, structures and improvements, reservoirs, dams and waterways, equipment road, and railroad and bridge costs. This footnote indicates that the cost of the powerhouse structure and equipment is inseparable from the total cost.

In addition to footnotes "a" and "b", certain hydrologic study area tables have special footnotes commencing alphabetically with "c". The corresponding explanations are given on the last sheets of the respective tables.

Where blanks occur, the items are judged to be inapplicable to the indicated project or feature.

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

NORTH COASTAL HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U.S. Bureau of Reclamation														
Trinity River Division	C,I,M,P,R	Clair Engle Lake (Trinity Dam)				1960	91,680	2,500	2,160					
				Trinity		1964	7,735						100	409
		Lewiston				1963	3,865	14.6	2.6					
			Clear Creek Tunnel			1964	49,266				3,200	10.8		
				Lewiston		1964	427						0.35	2.6
Klamath Project U.S. Bureau of Reclamation	C,I	Clear Lake				1910	115	527	513.3					
Eel River Pacific Gas & Electric Company	P	Lake Pillsbury (Scott Dam)				1921	2,435	93.7	93.7					
			Potter Valley Tunnel			1907	1,524				345	1		
Mad River Humboldt Bay Municipal Utility District	C,I,M	Ruth				1962	2,880	51.8	47					
Klamath River Pacific Power and Light Company	P	Copco No. 1				1922	2,001	77	5					
				Copco No. 1		1918	605						20	106
				Copco No. 2		1925	1,233						27	130
		Iron Gate				1962	3,886	58	*					
				Iron Gate		1962	1,905						18	150
				Fall Creek		1903	95						2.2	12.8
Canyon Creek (Trinity River Basin) Pacific Gas & Electric Company	P			Junction City		1905	230						2.7	10
Shasta River Montague Water Conservation District	C,I	Lake Dwinnell (Shasta River Dam)				1928	641	72	72					

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA: RESERVOIRS	MAJOR FEATURES: CONVEYANCE FACILITIES	MAJOR FEATURES: POWER PLANTS	MAJOR FEATURES: PUMPING PLANTS	COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF: GROSS	RESERVOIR CAPACITIES: ACTIVE	RESERVOIR CAPACITIES: FLOOD SPACE RESERVATION	CONVEYANCE FACILITIES: INTAKE CAPACITY IN CFS	CONVEYANCE FACILITIES: LENGTH IN MILES	POWER AND PUMPING PLANTS: INSTALLED CAPACITY IN MW	POWER AND PUMPING PLANTS: AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U.S.Bureau of Reclamation														
Delta Division			Contra Costa Canal			1948	c				350	30		
Hetch Hetchy Project City and County of San Francisco			Hetch Hetchy Aqueduct			1934	230,000				460[d]	49.8		
	C,M	Calaveras				1925	3,888	96.6	96.6					
	C	James H. Turner				1964	5,450	50.5	*					
	C,M	San Andreas				1870	782	18.5	18.5					
	C,M	Crystal Springs				e	2,430	69.5[e]	69					
Solano Project U.S.Bureau of Reclamation	C,I,M		Putah South Canal			1957	f				956	19.5		
State Water Project South Bay Aqueduct	I,M,F,R						59,384							
		Del Valle	South Bay Aqueduct			1965		78.5	68.5	38	363	43.7		
					Del Valle	S-1968							0.75	2
North Bay Aqueduct (Phase 1) California Department of Water Resources			Napa Pipeline			S- *	*				46	6	0.7	5
Pajaro River South Santa Clara Valley Water Conservation District		Uvas[g]				1958	908	10	10					
Guadalupe River Santa Clara Valley Water Conservation District	I	Lexington[g]				1953	2,495	21.4	21.4					
	I,M,R	Calero[g]				1935	277	9.6	9.3					
Coyote River Santa Clara Valley Water Conservation District	I,M	Anderson[g]				1950	2,336	91.3	91.3					
	I	Coyote[g]				1936	787	24.6	24.6					
Mokelumne Aqueduct East Bay Municipal Utility District			Mokelumne Aqueduct			1930	128,233				590	20		
	C,I,M	San Pablo				1920	2,288	40.8	39.1					
		Lake Chabot				1875	*	10.3	7.4					
		Upper San Leandro				1926	1,177	41.4	34.6					
		Briones				1965	14,200	60.6	60.6					
		Lower San Leandro				1892	1,273	12.6	9.6					
Sacramento River City of Vallejo			Cache Slough Pipeline			1953	2,709				32	17		
	C,M	Lake Curry				1926	300	10.7	10					

Footnotes on Sheet 2

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Lagunitas Creek														
Marin Municipal Water District	C,M	Kent (Peters Dam)				1954	2,193	16.5	15.9					
	C,M	Nicasio				1961	1,000	22						
			North Marin Transmission			1961	*				65	9		
Napa River														
City of Napa	M	Lake Hennessey (Conn Creek Dam)				1948	572	33	31					
Russian River														
U.S.Corps of Engineers	C,F,R	Lake Mendocino (Coyote Dam)				1958	17,000	122.5	70	48				
Sonoma County Flood Control & Water Conservation District			Santa Rosa Aqueduct			1959	8,000				62	15		
			Petaluma Aqueduct			1961	h				9	16		
			Sonoma Aqueduct			1963	h				14	16		
			Novato Aqueduct			1961	1,000				15.5	10		
Pacific Gas & Electric Company	P			Potter Valley		1910	488						9.04	61

c - Included in $8,895,000 shown for Contra Costa Canal in Delta-Central Sierra Study Area
d - Upon completion of enlargement in 1968
e - Upper and lower Crystal Spring Dams combined--completion date of upper dam - 1877; lower dam - 1888
f - Included in $32,291,000 for Solano Project in Sacramento Basin Study Area
g - Flood retention reservoirs used for ground water recharge
h - Included in total cost for Santa Rosa Aqueduct

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

CENTRAL COASTAL HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Cachuma Project U.S. Bureau of Reclamation	C,I,M	Cachuma	Tecolote Tunnel			1956	43,360	204.9	202		100	6.4		
Old Creek California Department of Finance	C,M	Whale Rock	Pipeline			1961	4,274[a]	40	39.5		18.94	17.6		
Salinas River Monterey County Flood Control Water Conservation District	C,I,M,F,R C,I,M,F,R	Nacimiento San Antonio				1957 1966	4,600 7,440	350 350	190 280	150 50				
U.S. Corps of Engineers	C,M	Salinas	Pipeline			1942	3,933[a]	26	26		12.4	13.3		
San Benito River San Benito County Flood Control Water Conservation District	C,I,R	Hernandez				1961	1,265	18	18					
Santa Maria River U.S. Bureau of Reclamation	C,I,M,F,R,D	Twitchell				1958	9,233	250	121	89				
Santa Ynez River City of Santa Barbara	C,M	Gibraltar	Mission Tunnel			1920	1,725[a]	15	14.7		80	3.7		

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SOUTH COASTAL HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
<u>Colorado River Aqueduct</u>														
Metropolitan Water District of Southern California	I,M	Lake Mathews	Colorado River Aqueduct			1941	16,571[a]	182	182		1,605	32		
		Morris				1935	6,311	35	33.9					
			First San Diego Aqueduct			1954	19,803[c]				200	36.3		
			Second San Diego Aqueduct			1960	15,565				1,000	33.7		
San Diego County Water Authority			First San Diego Aqueduct			1947	14,901				165	34.8		
			Second San Diego Aqueduct			1960	33,466				250	59		
<u>Los Angeles Aqueduct</u>														
City of Los Angeles	C,I,M	Bouquet Canyon	Los Angeles Aqueduct			1934	26,509	36.5	35		710	49		
				San Francisco No. 1		1917	2,252						58.12	210
				San Francisco No. 2		1920	1,950						42	115
				San Fernando		1922	*						5.6	50
	M	Lower San Fernando				1918	1,326	20.5	18.9					
	C	Encino				1924	3,793	10.3	3.2					
				Franklin Canyon		1921	363						2	8.8
	C	Stone Canyon				1924	3,876	10.4	8					
<u>State Water Project</u>	I,M,R													
California Department of Water Resources														
Santa Ana division		Perris	California Aqueduct			S-1972	117,283	97	91.3		1,220	31.1		
				Devil Canyon		*	19,243						99	*
West Branch, California Aqueduct		Castaic	California Aqueduct			S-1971	185,529	350	332		3,160	21.4		
					Castaic		24,163						214	1,284
					Pyramid		27,303						158	943
		Pyramid					32,268	146.7	130.1					
<u>Ventura River Project</u>														
U.S.Bureau of Reclamation	C,I,M,R	Casitas				1959	10,956	251.6	250					
<u>Cottonwood Creek</u>														
City of San Diego	C,M	Barrett				1922	1,650	44.9	43.9					
		Morena				1895	1,302	50.2	49.9					
<u>Otay River</u>														
City of San Diego	C,M	Savage				1919	745	56.3	53.6					
<u>Sweetwater River</u>														
California Water & Telephone Company	C,I,M	Lake Loveland				1945	2,000	27.7	27.6					
	C,I,M	Sweetwater				1888	640	27.7	27					

Footnotes on Sheet 3

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SOUTH COASTAL HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA: RESERVOIRS	MAJOR FEATURES: CONVEYANCE FACILITIES	MAJOR FEATURES: POWER PLANTS	MAJOR FEATURES: PUMPING PLANTS	COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF: GROSS	RESERVOIR CAPACITIES: ACTIVE	RESERVOIR CAPACITIES: FLOOD SPACE RESERVATION	CONVEYANCE FACILITIES: INTAKE CAPACITY IN CFS	CONVEYANCE FACILITIES: LENGTH IN MILES	POWER AND PUMPING PLANTS: INSTALLED CAPACITY IN MW	POWER AND PUMPING PLANTS: AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
<u>Quail Canyon Creek</u> Helix Irrigation District	C,I,M,R	Chet Harritt				1962	2,071	10.5	5.8					
<u>San Diego River</u> City of San Diego	C,I,M	El Capitan				1934	3,125	116.5	116.5					
<u>San Vicente Creek</u> City of San Diego	C,M	San Vicente				1943	2,697	90.2	76.3					
<u>San Dieguito River</u> City of San Diego	C,M	Lake Rodges				1918	631	33.6	33.6					
<u>Santa Ysabel Creek</u> City of San Diego	C,M	Sutherland				1954	3,004	29	28.3					
<u>Escondido Creek</u> Escondido Municipal Water Company	P			Rincon Bear Valley		1915 1915	1,162[d] d						0.34 0.52	0.3 4.8
<u>San Luis Rey River</u> Vista Irrigation District	C,I	Henshaw				1923	1,000	204	204					
<u>Temecula Creek</u> Vail Company	C,I,M	Vail				1949	981	51	51					
<u>San Jacinto River</u> Lake Hemet Municipal Water District	C,I,M	Lake Hemet				1895	213	14	14					
Temescal Water Company	C,I	Railroad Canyon				1928	269	15.2	15					
<u>Santiago Creek</u> Irvine County Carpenter Irrigation District & Serrano Irrigation District	C,I	Santiago				1933	741	25	25					
Orange County Flood Control District	F	Villa Park				1963	2,360	15.6	15.6	15				
<u>Los Angeles River</u> U. S. Corps of Engineers	F	Sepulveda				1941	6,651	17.3	17.3	17.3				
<u>Big Tujunga Creek</u> U. S. Corps of Engineers	F	Hansen				1940	11,330	35.8	32	32				
<u>Calleguas Creek</u> Calleguas Municipal Water District	I,M	Wood Ranch				1965	2,000	10	10					
<u>Piru Creek</u> United Water Conservation District	C,I,M	Santa Felicia				1955	5,048	100	*					

Footnotes on Sheet 3

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SOUTH COASTAL HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
<u>Boulder Creek</u> Helix Irrigation District	C,I,M	Cuyamaca				1887	35	11.6	11.6					
<u>San Gorgonio Creek</u> Southern California Edison Company	P			San Gorgonio No. 1 San Gorgonio No. 2		1923 1923	297 153						1.5 .75	3 1.5
<u>Mill Creek</u> Southern California Edison Company	P			Mill Creek No. 1 Mill Creek Nos. 2 & 3		1893 1904	166[b] 725[b]						8 2	4.7 15.5
<u>Santa Ana River</u> Southern California Edison Company	P			Santa Ana River No. 1 Santa Ana River No. 2 Santa Ana River No. 3		1899 1905 1947	215 331[b] 361[b]						3.2 .8 1.2	18 8 7
U. S. Corps of Engineers	F	Prado				1941	9,473	223	217	217				
<u>Bear Creek</u> Bear Valley Mutual Water Company	C,I,R	Big Bear Lake (Bear Valley Dam)				1911	149	72 4	72.4					
<u>Lytle Creek</u> Southern California Edison Company	P			Fontana Lytle Creek		1917 1904	342[b] 217[b]						1.92 .4	8.8 4
<u>San Antonio Creek</u> Southern California Edison Company	P			Ontario No. 1 Ontario No. 2 Sierra		1902 1963 1922	413 90 171						.6 .32 48	4.8 1.1 4
<u>Walnut Creek</u> Los Angeles Flood Control District	F,R	Puddingstone				1928	1,021	17.2	17	17				
<u>San Gabriel River</u> Los Angeles County Flood Control District	F	Cogswell San Gabriel No. 1				1935 1938	3,850 16,828	10.4 44.6	10.4 44.6	10.4 44.6				
U. S. Corps of Engineers	F	Santa Fe Whittier Narrows				1949 1955	12,637 32,254	33 36	33 36	33 36				
City of Pasadena	P			Azusa		1949	*						3	10

c - Includes cost of 2nd barrel completed in 1954
d - Cost of Rincon and Bear Valley powerhouses

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U.S.Bureau of Reclamation														
American River Division	C,I,M,F,P,R	Folsom		Folsom		1956	97,161	1,010.3	912	400			162	702.7
		Nimbus		Nimbus		1955	6,512[a]	8.8	3				13.5	91
		Sly Park	Camp Creek Tunnel			1955	6,727[c]	41	40.5		500	0.5		
			Camino Tunnel			1955	c				125	7.2		
Sacramento River Division	I	Red Bluff Diversion Dam				1964	8,818	1.9	1.9					
			Corning Canal			1960	6,979				500	21	0.4	10
			Tehama-Colusa Canal			S-1969	64,322				2,300	122		
Shasta Division	C,I,M,F,P,R	Shasta				1949	120,603	4,500	4,377	1,300				
				Shasta		1944	22,056						375	2,021.6
		Keswick				1950	8,791	23.8	20					
				Keswick		1950	11,401						75	477.5
Trinity River Division	C,I,M,P,R	Whiskeytown				1963	17,040	241	214					
				Judge Francis Carr		1963	10,865						134	401.5
			Spring Creek Tunnel	Spring Creek		1964	26,655				3,600	2.4	150	543.6
Cow Creek Unit	I		Pipeline			S- *	6,750				93	7.8		
Clear Creek South Unit	I		*			S- *	5,593				70	21		
Middle Fork American River Project	C,I,M,P						117,381							802.6
Placer County Water Agency		French Meadows	French Meadows Tunnel	French Meadows		1965	22,000	132.5	123.8		400	2.6	15.3	
		Hell Hole				1966	21,000	207	201.5					
			Middle Fork Tunnel	Middle Fork		1966	35,000				836	10.4	109.8	*
		Ralston Afterbay		Ralston		1966	21,600	2.7	1.6		836	6.7	79.2	*
			Oxbow Tunnel	Oxbow		*	4,800				1,000	0.1	6	
Orland Project	C,I													
Orland Unit Water Users' Association		East Park				1910	213	50.9	50.6					
		Stony Gorge				1928	1,137	50	50					
			North Canal			1913	170[d]				125	0.3		
			South Canal			1916	d				260	9.6		
		Rainbow Diversion Dam	East Park Feed Canal			1915	31	0.2			250	7		
Solano Project U.S.Bureau of Reclamation	C,I	Lake Berryessa (Monticello Dam)	Putah-South Canal			1957	32,291	1,602.3	1,570		950	10		
State Water Project Upper Feather division	C,I,R	Frenchman Lake				1961	3,174	55.4	53.4					
		Antelope Lake				1963	4,486	22.5	22					
		Lake Davis (Grizzly Valley Dam)				1966	4,129	83.0	83					

Footnotes on Sheet 5

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA: RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS	COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF: GROSS	ACTIVE	FLOOD SPACE RESERVATION	CONVEYANCE FACILITIES: INTAKE CAPACITY IN CFS	LENGTH IN MILES	POWER AND PUMPING PLANTS: INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
State Water Project (cont'd) Oroville division California Department of Water Resources	C,I,M,F,P,R	Oroville		Oroville		S-1969	104,144[e] 211,354 82,141	3,484	2,549	750			644	2,467
		Thermalito Diversion Dam					13,545	13.5						
			Thermalito Power Canal	Thermalito			34,758				17,000	2.5	115	379
		Thermalito Forebay					32,492[f]	11.4	*					
		Thermalito Afterbay					f	57	45					
Upper American River Project Sacramento Municipal Utilities District	C,I,M,P	Loon Lake				1963	7,718	76.5	71					
				Loon Lake		S-1971	15,000[g]						75	94
		Gerle Creek				1962	2,411	1.2	*		800	2		
		Ice House				1959	6,686	46	45.8					
				Jones Fork		S-1972	8,000						15	40
			Robbs Peak Tunnel	Robbs Peak		1965	6,800				1,000	3.2	25	55
		Union Valley				1963	18,600	271	264					
			Union Valley Tunnel	Union Valley		1963	8,072				1,400	0.1	33	114
			Jaybird Tunnel	Jaybird		1962	22,811				1,400	4	133	575
			Camino Tunnel	Camino No. 1		1963	21,495				1,400	4.9	71.2	263
				Camino No. 2		S-1968	5,300						71.2	178
		Slab Creek				1966	5,000	16.6	16					
			White Rock Tunnel	White Rock		S-1967	8,760				3,500	4.4	150	619
American River Pacific Gas & Electric Company	P	Medley Lake				1923	35	5.4	5.2					
		Silver Lake				1876	33	11.8	8.6					
		Twin Lake				1922	1,029	21.6	21.6					
			El Dorado Ditch	El Dorado		1924	1,187				165	25	20	97.9
				American River		1903	277						5.5	29.6
				Chili Bar		1964	1,983						7	42
Georgetown Divide Public Utilities District	C,I,M	Stumpy Meadows				1961	2,011	20	19					
California Debris Commission	D	North Fork				1939	735	14.6	14.6					
Cache Creek Clear Lake Water Company	C,I	Clear Lake				1914	118	1,100[h]	319					
Yuba and Bear Rivers Pacific Gas & Electric Company Colgate Division	P	Bullards Bar				1924	1,147	31.5	13.1					
				Bullards Bar		1924	424						6.5	39.6
			Colgate Tunnel	Colgate		1949	2,208[i]				450	4.7	24	147.6
				Narrows		1942	942						9.35	72

Footnotes on Sheet 5

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA: RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS	COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF: GROSS	ACTIVE	FLOOD SPACE RESERVATION	CONVEYANCE FACILITIES: INTAKE CAPACITY IN CFS	LENGTH IN MILES	POWER AND PUMPING PLANTS: INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Yuba and Bear Rivers (cont'd) Drum Division	P	Fordyce				1926	2,029	46.7	46.5					
				Lake Spaulding No. 1		1928	573						6.4	38
				Lake Spaulding No. 2		1928	203						3.71	20
				Lake Spaulding No. 3		1929	328						6.3	25.1
				Lake Spaulding		1913	2,445	74.5	68.4					
				Drum		1928	1,614						48	245.2
				Drum No. 2		1965	9,240						44.1	81.5
				Alta		1902	1,290						2	6.4
				Dutch Flat No. 1		1943	1,241						22	125
				Deer Creek		1908	160						5.5	30.6
Wise Division	P			Halsey		1916	411						12	65.8
			Bear River Canal	Wise		1917	325				490	*	12	89.9
California Debris Commission	P,D	Harry L. Englebright (Narrows Dam)				1941	3,912	70	45					
Browns Valley Irrigation District	C,I	Merle Collins				1963	5,500	57	55					
South Sutter Water District	C,I,R	Camp Far West				1964	8,200	103.5	102					
Nevada Irrigation District	C,I,M,R,P	Jackson Meadows				1965	8,500	68	65					
		French Lake				1859	151	12.5	11.6					
		Bowman	Milton-Bowman Tunnel			1927	680[a]	68	68		500	4.6		
			Bowman-Spaulding Conduit			1965	4,200				325	9.2		
			Dutch Flat Conduit	Dutch Flat No. 2		S- *	9,100				570	5.7	22.8	24.2
			Chicago Park Conduit	Chicago Park		S- *	12,800				1,160	4.1	36.3	123.6
		Rollins				1965	11,500	66	60					
		Scotts Flat				1948	1,800	49	47					
Feather River Oroville-Wyandotte Irrigation District	C,I,M,P	Little Grass Valley				1962	69,231[j]	93	92.5					
		Sly Creek				1961	j	65	64.5					
				Woodleaf		1963	j						52.2	176
				Forbestown		1963	j						28.8	110
				Kelly Ridge		1963	j						9.9	48
Pacific Gas & Electric Company	I,P	Mountain Meadows				1924	30	24.8	24.1					
				Hamilton Branch		1921	367						5.39	15.8
				Lake Almanor		1927	2,632	1,308	638					
				Butt Valley		1958	4,370						36	126.9
		Butt Valley				1924	388	49.8	32.6					
				Caribou		1921	12,125						184.8	541.8
				Belden		S-1969	14,333[k]						113	383

Footnotes on Sheet 5

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Feather River (cont'd)		Bucks Lake				1928	2,359	103	102					
				Bucks Creek		1928	1,963						66	241.3
				Rock Creek		1950	5,751						113.4	522.6
				Cresta		1949	4,978						67.5	334.5
				De Sabla		1963	2,185						18.45	120
				Lime Saddle		1906	1,125						1.6	11
Sutter Buttes Joint Water Districts Board	I		Sutter Butte Canal			1905	*				2,000	30		
Pacific Gas & Electric Company	I		Western Canal			1927	1,900				1,200	23		
Butte Creek Pacific Gas & Electric Company	P			Centerville		1904	324						6.4	43.8
Miocene Canyon Pacific Gas & Electric Company	P			Coal Canyon		1907	875						0.8	7.5
McCloud River Pacific Gas & Electric Company	P	McCloud				1965	5,500	35.3	24.5					
Pit River Hot Springs Valley Irrigation District	C,I	Big Sage				1921	111	77	*					
South Fork Irrigation District	C,I	West Valley				1936	158	20.7	20					
Mr. John Galvin (owner)	C,I	Tule Lake				1904	35	39.5	*					
Pacific Gas & Electric Company	P			Pit No. 1		1922	3,166						56	264
				Hat Creek No. 1		1921	843						10	19.3
				Hat Creek No. 2		1921	679						10	39.3
		Pit No. 3				1925	8,676	40.6	39.6					
				Pit No. 3		1925	2,858						74.25	385.4
				Pit No. 4		1955	6,740						90	422.2
				Pit No. 5		1944	6,947						128	836
		Iron Canyon				1965	1,900	24.3	23.3					
				McCloud-Pit		1965	12,547k						155	688
				Pit No. 6		1965	6,040						79	370
		Pit No. 6				1965	7,000	15.7	8.2					
				Pit No. 7		1965	6,060						104	522
		Pit No. 7				1965	9,000	34	15					
Sacramento River Pacific Gas & Electric Company	P			Kilarc		1903	255						3	22
				Cow Creek		1907	389						1.44	12
				Volta		1906	416						6.4	39.6
				South		1910	203						4	36
				Inskip		1910	406						6	39.6
				Coleman		1911	652						13.8	56.8

Footnotes on Sheet 5

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Sacramento River (cont'd) Glenn-Colusa Irrigation District	I		Glenn-Colusa Canal			1924	3,153				2,750	64		
Stony Creek U.S.Corps of Engineers	C,F,R	Black Butte				1962	14,700	160	150	150				

c - Total cost of Sly Park Reservoir, Camp Creek Tunnel, and Camino Tunnel
d - Cost includes North and South Canal
e - Additional cost other than cost of major features
f - Cost of Thermalito Forebay includes Thermalito Afterbay
g - Includes cost of 18,000 feet of tailrace tunnel
h - Approximate capacity at elevation 1,325 feet
i - Cost excludes Colgate Tunnel
j - Total cost of Little Grass Valley and Sly Creek Reservoirs, and Woodleaf, Forbestown, and Kelly Ridge Powerhouses included in cost for Little Grass Valley Reservoir
k - Includes cost of switchyard

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

DELTA - CENTRAL SIERRA HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U.S.Bureau of Reclamation														
Delta Division	I,M		Contra Costa Canal			1948	8,895				350	18		
			Delta Cross Channel			1951	2,448				3,500	0.8		
					Tracy	1952	16,170						100	660
			Delta Mendota Canal			1951	51,759				4,600	20		
Solano Project U.S.Bureau of Reclamation	C,I,M		Putah South Canal			1957	*				956	5.5		
State Water Project North San Joaquin Division	I,M		California Aqueduct			S-1968	134,783[c]				10,000	22.5		
					Delta	S-1967	25,123						243.35	1,258
South Bay Aqueduct California Department of Water Resources	I,M		South Bay Aqueduct			1965	31,905[d]				363	43.7		
					South Bay	1965	3,129[d]						18.65	138
Littlejohns Creek Rock Creek Water District U.S.Corps of Engineers	I,M	Salt Springs Valley				1882	100	10.9	10.9					
	F	Farmington				1951	3,675	52	52	52				
Calaveras River U.S.Corps of Engineers	C,I,F,R	New Hogan				1964	15,200	325	310	165				
Jackson Creek Jackson Valley Irrigation District	C,I	Jackson Creek				1965	2,700	22	19					
Mokelumne River Pacific Gas & Electric Company	P	Lower Bear River				1952	4,227	48.5	48.5					
		Salt Springs				1931	6,291[a]	139.5	139.5					
				Salt Springs		1931	2,100						39.05	175.6
				Tiger Creek		1948	1,400						51	353.2
				West Point		1948	3,616						13.6	87.6
				Electra									89.1	347.2
East Bay Municipal Utility District	M,P	Pardee		Pardee		1929	6,240[a]	210	193				15	81
	M,F	Camanche	Mokelumne Aqueduct			1963	36,700	431.5	431.5	200	590	70		
Sacramento River City of Vallejo	M		Cache Slough Pipeline			1953	*				32	8		

c - Cost includes 44 miles in San Joaquin Study Area
d - Included in $59,384,000 shown in San Francisco Bay Study Area

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA: RESERVOIRS	MAJOR FEATURES: CONVEYANCE FACILITIES	MAJOR FEATURES: POWER PLANTS	MAJOR FEATURES: PUMPING PLANTS	COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF: GROSS	RESERVOIR CAPACITIES: ACTIVE	RESERVOIR CAPACITIES: FLOOD SPACE RESERVATION	CONVEYANCE FACILITIES: INTAKE CAPACITY IN CFS	CONVEYANCE FACILITIES: LENGTH IN MILES	POWER AND PUMPING PLANTS: INSTALLED CAPACITY IN MW	POWER AND PUMPING PLANTS: AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U.S.Bureau of Reclamation														
Delta Division	I		Delta-Mendota Canal			1951	c				4,600	96.6		
San Luis Unit	I				San Luis Forebay	S-1967	8,807						27	82
Friant Division	C,I,F,R	Millerton Lake (Friant Dam)				1947	20,885	520	503.2	170				
			Madera Canal			1952	2,900				1,000	35.9		
State Water Project North San Joaquin Division California Department of Water Resources	I,M		California Aqueduct			S-1968	d				10,000	44		
State Water Project and Central Valley Project San Luis division (joint use) California Department of Water Resources and U.S.Bureau of Reclamation	C,I,M,R		California Aqueduct			S-1968	111,803[e]				13,100	29.3		
		Los Banos Detention Dam				1966	5,625	34.5	20.5	14				
		Little Panoche Creek Detention Dam				S-1967	3,350	13.3	5.3	5.3				
					Dos Amigos	1966	24,670						168	608
		San Luis				S-1967	84,600	2,095	2,017					
		San Luis Forebay				S-1967	8,807	58	20					
					San Luis Pumping-Generating	S-1967	61,470						f	f
Tri-Dam Project Oakdale & South San Joaquin Irrigation Districts	C,I,P	Donnells	Tunnel	Donnells		1958	21,939	64.5	62		650	7.2	54	279
		Beardsley		Beardsley		1958	10,810	97.5	77.5				9.9	51.5
		Tulloch		Tulloch		1958	8,311	68.4	56.4				17.1	80
Hetch-Hetchy Project City & County of San Francisco	C,M,F,P						g							
			Canyon Tunnel	Canyon		1966					*	11	67.5	572
			Lower Cherry Aqueduct	Early Intake		1918					200	3.2	3.6	28
		Hetch-Hetchy	Hetch-Hetchy Aqueduct			1923		360	360	160	460	87.8		
		Lake Eleanor	Eleanor Tunnel			1956		27.1	26.1		*	*		
		Lake Lloyd (Cherry Valley Dam)		Cherry		1956		268	268	80	550	5.7	135	600
			Hetch-Hetchy Tunnel	Moccasin		1966					1,240	19	70	520
San Joaquin River Southern California Edison Company	P	Lake Edison (Vermilion Valley Dam)	Tunnel & Pipeline			1954	7,582[a]	125	125		530	4.8		

Footnotes on Sheet 3

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
<u>San Joaquin River</u> (cont'd)		Florence Lake	Ward Tunnel	Portal		1926	2,980[a]	89	64		2,080	12.8	10	51
		Huntington Lake	Tunnel	Huntington Lake No. 1		1917	3,583[a]	89	89		672	0.8	67	521
		Mammoth Pool	Mammoth Tunnel	Mammoth Pool		1960	27,228	123	120		2,150	7.5	129.36	546
		Shaver Lake	Tunnel	Shaver Lake No. 2a		1927	3,927[a]	135.	135		617	2.6	80	387
		Redinger Lake (Big Creek No. 7 Dam)	Tunnel	Redinger Lake No. 4		1951	7,525[a]	35	26		3,300	1.9	84	428
Pacific Gas & Electric Company	P	Crane Valley	Flume Tunnel & Ditch			1910	1,450[a]	45.4	45.4		*	10	20.34	130.6
				Kerckhoff		1920	1,803						34.08	264.1
<u>Big Creek</u> (San Joaquin River Basin) Southern California Edison Company	P			Big Creek No. 2		1913	3,740						57.75	451
				Big Creek No. 3		1923	6,355						106.5	779
				Big Creek No. 8		1921	3,450						58.5	337
<u>Merced River</u> Merced Irrigation District	C,I,F,P,R	New Exchequer		New Exchequer		1966	34,527	1,026	911	400			80.1	335
		McSwain		McSwain		1966	1	9.4	2.9				9	31
Pacific Gas & Electric Company	P			Merced Falls		1930	233						3.44	14
National Park Service	P			Yosemite		1916	*						2	7.7
<u>Tuolumne River</u> Modesto Irrigation District	I	Dallas Warner	Modesto Canal			1911	225[a]	28	28		2,000	162.7		
Turlock & Modesto Irrigation District	C,I,F,P	Don Pedro		Don Pedro		1923	3,097	289	259	200			26.99	200
				La Grange		1924	500						3.9	18
Turlock Irrigation District	C,I	Owens	Turlock Canal			1914	140[a]	49	48		2,150	250		
<u>Stanislaus River</u> South San Joaquin Irrigation District	I	Woodward				1918	523	36	36					
Oakdale & South San Joaquin Irrigation District	C,I,P	Melones	Tunnel	Melones		1926	2,351	112.5	103.5		1,500	0.9	24.3	102.3
Pacific Gas & Electric Company	I,M,P	Spicers Meadows				1929	55	4	*					
				Murphys		1953	705						3.6	16.6
				Angels		1940	813						1.4	6.2
		Relief	Tunnel	Stanislaus		1910	850	15.1	15.1		465	10.9	81.9	376
		Strawberry	Philadelphia Ditch	Spring Gap		h	985	18.6	17		56.5	4.7	6	48.5
		Lyons	Tuolumne Ditch	Phoenix		1932	394	5.5	5.5		52	10	1.6	10
<u>Utica Creek</u> (Stanislaus River Basin) Pacific Gas & Electric Company	I,M,P	Silver Valley (Alpine Dam)				1906	107	4.6	46		*			
		Union	Utica Ditch			1902	20[a]	2	2		*	88	21	
		Utica				1908	34	2.4	2.4		*			

Footnotes on Sheet 3

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

FOOTNOTES

c - Cost included in $51,759,000 shown in Delta-Central Study Area
d - Cost included in $134,783,000 shown in Delta-Central Study Area
e - Cost includes 75 miles of aqueduct in Tulare Basin Study Area
f - San Luis Powerplants will have installed capacity of 424 MW and will generate 118,000,000 KWH. The pumping plant will have installed capacity of 387.612 MW and will require 159,000,000 KWH.
g - Cost included in $230,000,000 shown in San Francisco Bay Study Area
h - 1916 - dam; 1921 - powerhouse
i - Cost included in New Exchequer value
j - Total for 5 plants

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

TULARE BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Central Valley Project U. S. Bureau of Reclamation														
Friant Division	C,I,M,F,R		Friant Kern Canal			1945	60,000				4,000	152.1		
State Water Project South San Joaquin division	I,M		California Aqueduct			S-1971	158,729				8,100	120		
					Buena Vista	S-1971	30,085						96.98	707
					Wheeler Ridge	S-1971	27,864						101.46	779
					Wind Gap	S-1971	35,713						223.8	1,685
Tehachapi division California Department of Water Resources	I,M		California Aqueduct			S-1971	99,590[c]				4,100	5.4		
					Tehachapi	S-1971	135,292						775.84	5,990
State Water Project and Central Valley Project San Luis division (joint use) California Department of Water Resources and U.S.Bureau of Reclamation	C,I,M,R		California Aqueduct			S-1968	d				13,100	75		
Kern River Pacific Gas & Electric Company	P			Kern Canyon		1921	584[b]						8.48	47.2
Southern California Edison Company	P			Borel		1913	559						9.2	64
				Kern River No. 1		1907	969						16	173
				Kern River No. 3		1927	2,275						32	200
U.S.Corps of Engineers	C,I,F	Isabella				1953	21,956	570	535	400				
Tule River Pacific Gas & Electric Company	P			Tule River		1914	234						4.8	26.5
Southern California Edison Company	P			Lower Tule		1909	834[b]						2	19
U.S.Corps of Engineers	C,I,F,R	Success				1961	14,212	80	75	75				
Kaweah River Southern California Edison Company	P			Kaweah No. 1		1929	793[b]						2.25	16
				Kaweah No. 2		1929	653[b]						1.8	13
				Kaweah No. 3		1913	703[b]						2.8	25
U.S.Corps of Engineers	I,F,R	Terminus				1962	19,350	150	142	115				
Kings River Pacific Gas & Electric Company	P	Wishon				1958	14,160	128	128					
			Tunnel	Haas		1958	10,337				760	5.6	135	355.7
				Balch No. 1		1927	1,860						31	406.1[e]
				Balch No. 2		1958	6,775						97.2	e
				Kings River		1962	3,498						44.1	157

Footnotes on Sheet 2

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

TULARE BASIN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Kings River (cont'd) U.S.Corps of Engineers	C,I,F	Pine Flat				1954	41,515[f]	1,000	1,000	475				
Helms Creek(Kings River Basin) Pacific Gas & Electric Company	P	Courtright				1958	8,111	123	123					

c - Cost includes 6.3 miles aqueduct in South Lahontan Study Area
d - Cost included in San Joaquin Study Area
e - Average annual energy generated by Balch No. 1 and Balch No. 2 Powerhouses totals 406,100,000 KWH
f - Cost includes recreation facilities and downstream channel improvements

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

NORTH LAHONTAN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
Newlands Project Truckee-Carson Irrigation District	C,I,P,R	Lake Tahoe				1913[c]	159	122,000	732					
Truckee Storage Project Washoe County Water Conservation District	C,I	Boca				1939	960	41.2	40.9					
Washoe Project U.S.Bureau of Reclamation Stampede Division	C,I,F	Prosser Creek				1962	3,792	30	28.8	20				
Walker River Walker River Irrigation District	C	Topaz Lake				1937	421[d]	125	59.4					
	C,I	Bridgeport				1924	425[d]	42.5	42.5					
Truckee River Truckee-Carson Irrigation District and Sierra Pacific Power Company	C,I,P	Donner Lake				1927	5	11	9.5					
Sierra Pacific Power Company	C,P	Independence Lake				1939	32	18.5	17.5					
	P			Farad		1899	*						2.8	19
Susan River Lassen Irrigation Company	C,I	McCoy Flat				1891	18	17.3	12.5					
	C,I	Hog Flat				1891	10	8	3					
	C,I	Lake Leavitt				1891	30	14	14					

c - Replacement of dam constructed in 1870
d - Amount of bonds issued

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

SOUTH LAHONTAN HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
State Water Project														
Mojave division	I,M,R		California Aqueduct			S-1972	105,763				1,560	106		
					Cottonwood	S-1972	12,091						14	113
		Cedar Springs Lake				S-1972		78	70					
					Pearblossom	S-1972	29,142						76.09	585
Tehachapi division	I,M,R		California Aqueduct			S-1971	c				4,100	6.3		
Little Bear Creek (Mojave River Basin) Lake Arrowhead Development Company	C,I,M	Lake Arrowhead				1922	500	47	47					
Cottonwood Creek (Owens River Basin) City of Los Angeles	P			Cottonwood		1908	314						1.5	8
Big Pine Creek (Owens River Basin) City of Los Angeles	I,P			Big Pine		1925	817						3.2	15
				Division Creek		1909	123						0.6	4
Bishop Creek (Owens River Basin) Southern California Edison Company	I,P	Sabrina (Hillside Dam)				1910	325.6	13.4	7.4					
				Bishop Creek No. 2		1908	944^{b}						7.32	39
				Bishop Creek No. 3		1913	1,285^{b}						6.6	34
				Bishop Creek No. 4		1905	1,135^{b}						6.8	42
				Bishop Creek No. 5		1907	633^{b}						3.5	18
				Bishop Creek No. 6		1913	268^{b}						1.8	11
Owens River City of Los Angeles	M,P		Los Angeles Aqueduct			1927	91,400				710	184		
		Grant Lake	Mono Crater Tunnel			1940	1,101^{a}	47.5	44.9		365	11		
				Upper Gorge		1953	4,580						37.5	133
				Middle Gorge		1952	4,145						37.5	133
				Control Gorge		1952	3,926						37.5	133
				Pleasant Valley		1958	1,700						3.2	15
		Tinemaha				1928	672	16.4	16.4					
		Lake Crowley (Long Valley Dam)				1940	2,263	183.5	183.5					
		Haiwee		Haiwee		1913	355^{a}	58.5	54.3				5.6	34
Rush Creek (Mono Lake Basin) Southern California Edison Company	P	Gem Lake				1917	796	17.6	17.6					
				Rush Creek		1916	1,011						8.4	43
Lee Vining Creek (Mono Lake Basin) Southern California Edison Company	I,P			Poole		1924	844^{b}						10	26
		Saddlebag				1921	257	11.1	11.1					
Mill Creek (Mono Lake Basin) Southern California Edison Company	P			Lundy		*	377^{b}						2.4	8.6

c - Cost included in $99,590,000 shown in Tulare Basin Study Area

WATER RESOURCE DEVELOPMENT PROJECTS
EXISTING OR UNDER CONSTRUCTION

COLORADO DESERT HYDROLOGIC STUDY AREA

PROJECT OR WATERSHED AND OPERATING AGENCY	PROJECT PURPOSES	MAJOR FEATURES OF PROJECT WITHIN AREA				COMPLETION DATE	CAPITAL COST IN $1,000	RESERVOIR CAPACITIES IN 1,000 AF			CONVEYANCE FACILITIES		POWER AND PUMPING PLANTS	
		RESERVOIRS	CONVEYANCE FACILITIES	POWER PLANTS	PUMPING PLANTS			GROSS	ACTIVE	FLOOD SPACE RESERVATION	INTAKE CAPACITY IN CFS	LENGTH IN MILES	INSTALLED CAPACITY IN MW	AVERAGE ANNUAL ENERGY GENERATED OR REQUIRED IN 1,000,000 KWH
All American Canal Imperial Irrigation District	I			Double Weir		*	*						0.56	*
				Drop No. 2		1941	*						10	60
				Drop No. 3		1941	*						4.8	49
				Drop No. 4		1941	*						19.6	120
				Pilot Knob		1957	5,300						33	50
All American Canal System Imperial Irrigation District & Coachella Valley County Water District	I		All American Canal			1940	66,000				15,155	80		
			Coachella Canal			1947	c				2,500	123		
Colorado River Aqueduct Metropolitan Water District of Southern California	I,M		Colorado River Aqueduct			1962[d]	194,770[e]				1,605[f]	210		
		Copper Basin				1938	635	22	7.6					
					Eagle Mountain	1964[d]	10,684						150.8	562.6
					Gene	1964[d]	11,937						108.5	393
					Hay Field	1964[d]	12,202						150.8	568.3
					Intake	1964[d]	9,765						108.5	372.3
					Iron Mountain	1964[d]	8,735						51.9	189.5
Parker-Davis Project U.S.Bureau of Reclamation	I,P	Havasu Lake (Parker Dam)				1938	8,805	717	180					
				Parker		1942	5,416						120	659.6
Yuma Project U.S.Bureau of Reclamation	I		Yuma Main Canal	Siphon Drop		1909	*				2,000	3.5	1.6	13
		Senator Wash		Senator Wash	g	1966	8,500	13.4	11.7				7.2	*

c - Included with capital cost shown for All American Canal
d - Completion of enlargement
e - Does not include cost of Copper Basin Reservoir
f - Total capacity since 1960 when the remainder of the pumping plants were installed
g - Pump-generating plant

INDEX TO RESERVOIRS
LISTED IN APPENDIX F

THIS BOOK IS DUE ON THE LAST DATE
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