IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA
IN AND FOR THE COUNTY OF LOS ANGELES

THE CITY OF LOS ANGELES, a Municipal Corporation, *Plaintiff,* vs. CITY OF SAN FERNANDO, a Municipal Corporation, et al., *Defendants.*	No. 650079

REPORT OF REFEREE

Volume I

TEXT AND PLATES

By
STATE WATER RIGHTS BOARD
REFEREE

July, 1962

APPROVAL AND ADOPTION BY STATE WATER RIGHTS BOARD

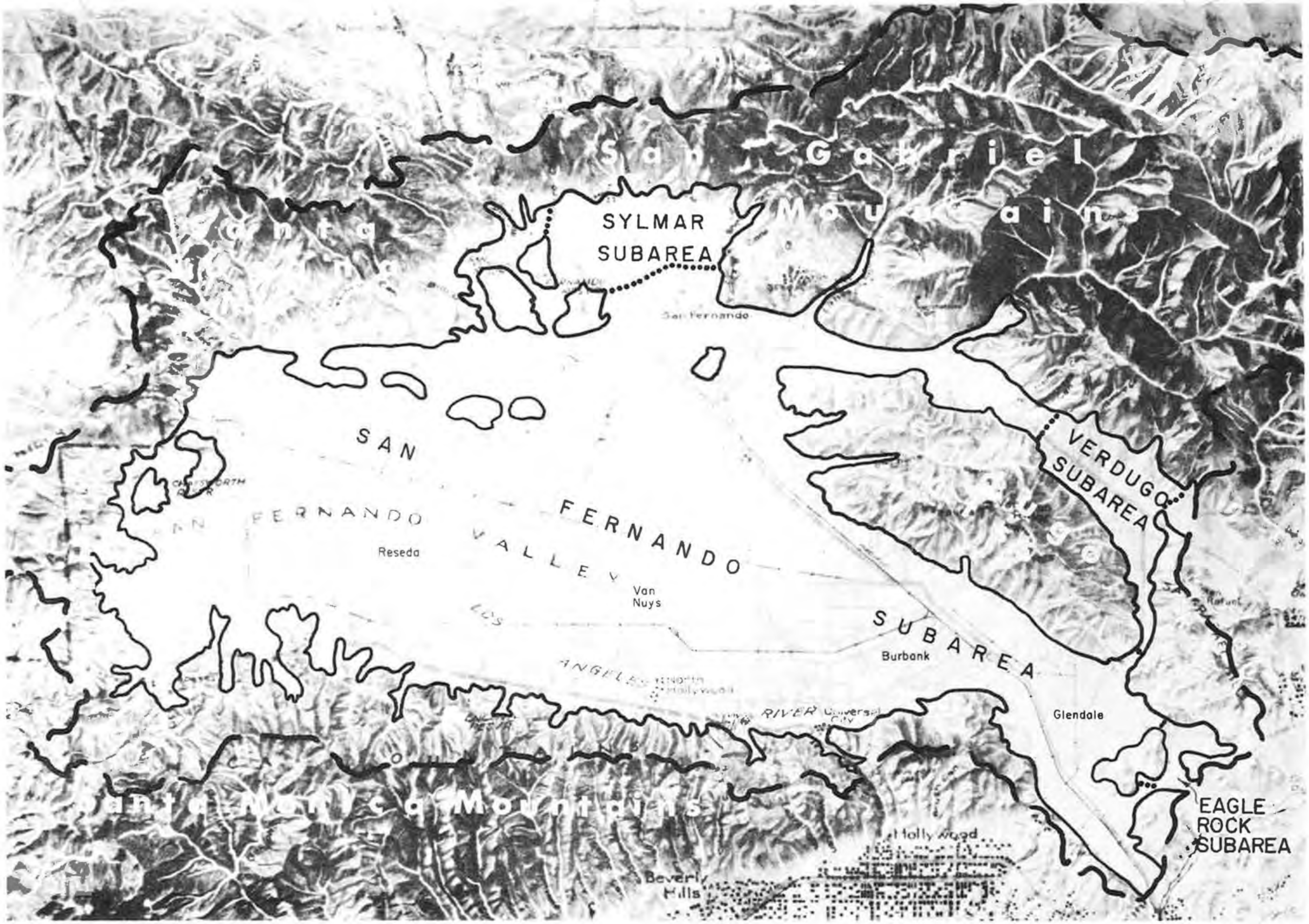
The State Water Rights Board, Referee in the action entitled "The City of Los Angeles, a Municipal Corporation, Plaintiff, vs. City of San Fernando, a Municipal Corporation, et al., Defendants," before the Superior Court of the State of California in and for the County of Los Angeles, No. 650079, approves and adopts this "Report of Referee" dated July 1962, pursuant to the requirements of the "Order of Reference to State Water Rights Board to Investigate and Report Upon the Physical Facts (Section 2001, Water Code)," dated June 11, 1958, and the "Interim Order," dated November 19, 1958, entered by the Court in said action. In accordance with paragraph III of said Order of Reference dated June 11, 1958, the Board will file with the Court and retain in its office the basic data upon which it bases its findings.

Approved and adopted by the State Water Rights Board at a meeting duly called and held at Sacramento, California, on the 27th day of July, 1962.

Kent Silverthorne, Chairman

Ralph J. McGill, Member

W. A. Alexander, Member


San Gabriel Mountains
SYLMAR SUBAREA
San Fernando
SAN FERNANDO SUBAREA
SAN FERNANDO VALLEY
Reseda
Van Nuys
Burbank
North Hollywood
LOS ANGELES RIVER
Universal City
VERDUGO SUBAREA
Glendale
EAGLE ROCK SUBAREA
Santa Monica Mountains
Hollywood
Beverly Hills

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and basic data which have not been reproduced for general distribution but will be filed in the proceedings.

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BASIC DATA

ORGANIZATION

STATE WATER RIGHTS BOARD

Kent Silverthorne	Chairman
Ralph J. McGill	Member
W. A. Alexander*	Member

Leland K. Hill . . . Executive Officer

This Investigation Was Conducted And Report Prepared Under The General Direction Of

Leslie C. Jopson . . . . Chief Engineer

And The Technical Direction Of

John M. Page . . . . Supervising Engineer, Water Resources

By

Donald J. Finlayson . . . . Senior Engineer, Water Resources**
In Charge of Los Angeles Office

Assisted By

Wilbert T. Chung . . . . Associate Engineer, Water Resources

Hydrologic Studies

Elwood C. Johnson . . . . Water Resources Engineering Associate
David J. Leve . . . . Assistant Civil Engineer
Ronald H. Barrett . . . . Assistant Civil Engineer
Joseph F. Montagna . . . . Assistant Civil Engineer

Geologic And Water Quality Studies

Glenn A. Brown . . . . Senior Engineering Geologist***
Joseph M. Gonzalez . . . . Geologic Aid

Special Studies By

Gilbert J. Matson . . . . Senior Engineer, Water Resources
Alvin L. Franks . . . . Associate Engineering Geologist
Ben Rinehart . . . . Assistant Civil Engineer
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Luther H. Gulick . . . . Senior Attorney

Plates And Drawings By

Virginia Richardson . . . . Delineator
Leonard E. Grady . . . . Delineator

* Replaced W. P. Rowe whose term expired on January 15, 1961, and who was continued in office to April 9, 1961.

** Resigned July 1, 1962.

*** Under service agreement with the Department of Water Resources.

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ACKNOWLEDGMENTS

Preliminary study of the availability of hydrologic data in the area involved in the reference indicated that much of the information needed by the Referee was available from various public agencies and other sources. As a result, the State Water Rights Board contacted various entities and individuals not parties to the lawsuit to secure from them this information prior to and during original investigations of its own.

The Board is greatly indebted to the sources contacted for the material supplied, and wishes to acknowledge its appreciation of the cooperation and helpful attitude of the entities and individuals and their staffs in providing copies of the available information to the Board. Particular appreciation is expressed to the following agencies:

Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture
Ground Water and Surface Water Branches, Geological Survey, U. S. Department of Interior
California Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture
State Department of Water Resources
Division of Oil and Gas, State Department of Natural Resources
Water Resources Center, University of California at Los Angeles
Department of Irrigation, University of California at Davis
Metropolitan Water District of Southern California
Los Angeles County Flood Control District

The whole-hearted assistance of these agencies and their staffs appreciably lightened the task of the Referee and lessened the time and expense which would otherwise have been required to develop the information needed. Many other entities and parties not herein named were helpful in many ways and their services to the Board are appreciated.

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DEFINITIONS

Alluvial Fan or Cone[2/] - A body of alluvial material deposited by a stream debouching from the region undergoing erosion above the apex of the cone.

Aquiclude[2/] - A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Aquifer[2/] - A geologic formation or structure that transmits water in sufficient quantity to supply pumping wells or springs.

Artesian[1/] - An adjective applied to ground water, or things connected with ground water, such as a well, underground basin, etc., where water is under pressure and will rise to a higher elevation if afforded an opportunity to do so.

Capillary Fringe - The partly saturated zone immediately above the water table in which water is held above the water table by capillary forces.

Consumptive Use - The amount of water used by the vegetative growth of a given area in transpiration or building of plant tissue and evaporated from adjacent soil. It also includes the evaporation of precipitation intercepted by vegetative growth or impervious area, the water evaporated in industrial processes, household uses, or that which is permanently incorporated in the product.

Culture (Land Use) - The land use or land cover existing under natural conditions or as modified by man.

Deep Percolation[1/] - The moisture which penetrates below the depths from which it may be used by plants; it represents that part of the water absorbed which exceeds the field capacity of the soil within the depth of root development. In this report deep percolation is water which moves downward from the surface of the ground and reaches the water table.

Evaporation[1/] - The process by which water passes from a liquid state, at temperatures below the boiling point, to vapor.

Export - Water that is conveyed out of the drainage area in artificial conduits for use in other areas or as sewage.

Fall Soil Moisture Deficiency - The depth of water in inches required at the beginning of the rainy season to bring the soil up to field capacity.

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Field Capacity - The maximum amount of capillary water that can be held in a freely drained root zone, measured as the ratio of weight of water retained by the soil to the weight of the dry soil.

Ground Water[2] - The water in the zone of saturation.

Ground-Water Cascade - Descent of ground water on a steep hydraulic gradient to a lower and flatter water table slope. A cascade occurs when ground water flows over a sharp drop in the configuration of the nonwater-bearing rock forming the base of a free ground water body.

Ground Water, Confined[2] - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water except at the intake.

Ground Water, Free, (Unconfined)[4] - Unconfined water is found in the zone of saturation whenever the upper surface of the zone forms a water table under atmospheric pressure, free to rise and fall with changes in volume of stored water.

Import - Water supplied from a source outside the area.

Irrigation Efficiency - The percentage of irrigation water applied that is consumed.

Isohyet[1] - A line on the earth's surface as represented on a map connecting all points of equal precipitation.

Percolation[1] - The movement or flow of water through the interstices or the pores of a soil or other porous medium.

Permeability[1] - The property of a material which permits appreciable movement of water through it when saturated and actuated by hydrostatic pressure of the magnitude normally encountered in natural subsurface water.

Permeability, Coefficient of[1] - The rate of flow of a fluid through a cross section of a porous mass under a unit hydraulic gradient, at a temperature of 60°F. The standard coefficient of permeability used in the hydrologic work of the United States Geological Survey is defined as the rate of flow of water at 60°F, in gallons a day, through a cross section of one square foot, under a hydraulic gradient of 100 percent.

Permeability, Field Coefficient of[5] - The rate of flow of water, in gallons a day, under prevailing conditions, through each foot of thickness of a given aquifer in a width of one mile, for each foot per mile of hydraulic gradient.

Phreatophyte[1/] [3/] - A plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe.

Porosity - The sum of specific yield and specific retention which is equivalent to the total void space in the material, expressed as a percentage of the total volume of the material.

Precipitation[1/] - The total measurable supply of water received directly from clouds, as rain, snow, hail, and sleet; usually expressed as depth in a day, month, or year, and designated as daily, monthly or annual precipitation.

Residual Rain - The residual amount of precipitation on a given impervious area after evaporation has occurred, expressed either in units of depth or in acre-feet.

Rising Water - Ground water effluent which appears as surface flow in stream channels.

Safe Yield - The maximum quantity of water which can be withdrawn annually from a ground water supply under a given set of conditions without causing an undesirable result.

Sewage Export - Sewage that is removed from the drainage area by pipelines or other artificial conduits.

Sewer Infiltration - Movement of ground water into conduits.

Specific Capacity - The discharge in gallons per minute per foot of draw-down in a pumped well.

Specific Retention - As applied to water-bearing material it is the ratio of the volume of water which will be retained by the material against the force of gravity, expressed as a percentage of the total volume of the material.

Specific Yield - As applied to water-bearing materials it is the volume of water drained by the force of gravity from a saturated material over a reasonably long period of time, expressed as a percentage of the total volume of the saturated material.

Spread Water - Native or imported water discharged into spreading basins for the purpose of percolating to the zone of saturation.

Storm Runoff - The residual of precipitation that is drained from the surface of the land and appears in surface streams. (Storm runoff does not include rising water, industrial waste, or sewage which may comprise a portion of the flow in surface streams).

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Thiessen Polygon - The area, surrounding a precipitation station, which is circumscribed by the perpendicular bisectors of straight lines drawn to adjacent stations.

Transmissibility - The characteristic property of the entire saturated portion of an aquifer to transmit water.

Transmissibility, Coefficient of[5/] - The field coefficient of permeability multiplied by the thickness, in feet, of the saturated part of the aquifer.

Underflow - Relatively horizontal movement of water through saturated granular material under hydraulic gradients commonly developed underground.

Water Table - The upper surface of the body of free water which completely fills all openings in a granular material sufficiently pervious to permit percolation.

Wilting Point - The amount of water present in the soil when the leaves of plants first undergo permanent reduction in their water content as the result of deficiency in the supply of soil moisture.

Year - Unless otherwise noted, the water year from October 1 to September 30. The year 1928-29 is October 1, 1928 through September 30, 1929. The period 1929-57 is October 1, 1928 through September 30, 1957.

Zone of Aeration - The zone above the water table in which interstices are partly filled with air.

Zone of Saturation - The zone below the water table in which interstices are completely filled with ground water.

1/ Glossary - Water and Sewage Control Engineering, APHA, ASCE, AWWA, FSWA.
2/ Tolman, C. F. - "Ground Water", 1937.
3/ Glossary of Geology and Related Sciences, AGI, 2nd Edition, November, 1960.
4/ Ground Water Basin Management, ASCE Manual of Engineering Practice No. 40.
5/ Meinzer, O.E. - "Hydrology", 1942.

SUMMARY OF FINDINGS

The Order of Reference in the case of City of Los Angeles vs. City of San Fernando, et al., No. 650079, Superior Court, Los Angeles County, directs the State Water Rights Board to investigate, find, and report upon physical facts as enumerated in the Order. The results of the referee's investigation are contained in this report and are summarized as follows, with reference at the beginning of each section to the specific requirements of the Order.

Description of Area

> "I.1. THE GEOGRAPHIC AND HYDROLOGIC (SURFACE AND GROUND WATER) BOUNDARIES OF THE WATERSHED OF THE LOS ANGELES RIVER AND ITS TRIBUTARIES ABOVE THE JUNCTION OF THE SURFACE CHANNELS OF THE LOS ANGELES RIVER AND THE ARROYO SECO AT A POINT NOW DESIGNATED AS LOS ANGELES COUNTY FLOOD CONTROL DISTRICT GAUGING STATION NO. F57. (NOTE: IF SAID BOUNDARY DIFFERS FROM THAT DEPICTED ON AND DESCRIBED IN APPENDICES 'A' AND 'B' ATTACHED TO PLAINTIFF'S AMENDED COMPLAINT, THEN THE AREAS INCLUDED WITHIN BOTH BOUNDARIES SHALL BE STUDIED AND SHALL BE INCLUDED IN THE TERM 'SAID AREA' AS HEREINAFTER USED.)"

The term "Upper Los Angeles River Area", as used in this report, refers to the surface area comprising all of the watershed of the Los Angeles River and its tributaries above the junction of the surface channels of the Los Angeles River and the Arroyo Seco at a point now designated as Los Angeles County Flood Control District gaging station No. F-57. The geographic boundary of this area has been interpreted to mean and is in fact identical with the boundary of the Upper Los Angeles River area and conforms generally with that described in Appendixes A and B attached to Plaintiff's Amended Complaint. This boundary is described on pages 17 and 18 and is the watershed boundary delineated on Plate 2. The hydrologic boundary has been

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interpreted as that boundary which delimits the areal extent of major ground water sources within the Upper Los Angeles River area and is the boundary of valley fill depicted on Plate 5 and described on pages 43 and 44 of Chapter III. A bedrock ridge located to the west of Pickens Canyon traverses the valley fill in a southwesterly direction (see Plate 6 and page 42) and is an impediment to ground water flow. The Report of Referee, Raymond Basin Reference, used the easterly bank of Pickens Canyon as an approximation of this impediment, the valley fill area to the east being a portion of the Monk Hill Basin. For convenience this boundary has also been adopted by the Referee for the San Fernando Valley Reference (see Plate 5).

The Upper Los Angeles River area is situated northwesterly of the original Pueblo of Los Angeles and contains a total of about 329,000 acres, of which about 123,000 are valley fill area and about 206,000 are hill and mountain area. The major tributary streams, Pacoima Wash and Tujunga Wash, originate in the San Gabriel Mountains, which form the northeasterly portion of the watershed. These streams traverse the valley fill area in a southerly direction and join the Los Angeles River, which follows an easterly course along the base of the Santa Monica Mountains before it turns south through the Los Angeles River Narrows leaving the Upper Los Angeles River area at Gage F-57. Several minor streams in the Simi Hills and Santa Susana Mountains in the westerly portion of the watershed are tributary to the Los Angeles River in the westerly portion of the valley fill area. Other minor streams, including Verdugo Wash, drain the easterly portion of the watershed comprising the Verdugo Mountains, the Elysian, San Rafael and Repetto Hills and the La Crescenta area.

Ground Water Occurrence and Movement

"I.2. THE COMPLETE GEOLOGY, INSOFAR AS IT AFFECTS THE OCCURRENCE AND MOVEMENT OF GROUND WATER, AND THE SURFACE AND GROUND WATER HYDROLOGY OF SAID AREA, INCLUDING BASINS AND SUB-BASINS THEREIN, INCLUDING BUT NOT LIMITED TO:

A. THE TOPOGRAPHY AND SOILS.

B. THE SURFACE LOCATION OF THE BED AND BANKS OF THE CHANNELS OF THE LOS ANGELES RIVER AND ITS TRIBUTARIES.

C. THE AREAS, LIMITS AND DIRECTION OF FLOW OF ALL GROUND WATER IN SAID AREA, INCLUDING, BUT NOT LIMITED TO, ANY AND ALL WATERS PERCOLATING THEREIN."

The major water-bearing formation is the valley fill material areally bounded by the generally nonwater-bearing hill and mountain formations which also comprise the underlying bedrock (See Plate 4 and pages 27 through 40). Topographically the valley fill area has a generally uniform grade in a southerly and easterly direction with the slope gradually decreasing from the base of the hills and mountains to the surface drainage outlet at Gage F-57. The valley fill soil mantle is of greatest permeability along and easterly of Pacoima and Tujunga Washes and generally throughout the eastern portion of the valley fill area except in the vicinity of the City of Glendale where it is of lesser permeability. Valley soils west of Pacoima Wash are in turn generally less permeable than those in the vicinity of Glendale. Topography and soil types are depicted on Plates 2 and 3 respectively. Source and characteristics of the valley soils are described on pages 24 and 25.

Ground water occurs mainly within the valley fill with only minor amounts occurring in hill and mountain areas. Ground water movement into the water-bearing valley fill from bedrock fractures and from

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the small amounts of permeable materials existing in the hill and mountain formations is possible but is believed to be minor and is not susceptible to evaluation. Available geologic data do not indicate that there are any sources of native ground water other than that which is derived from precipitation. No indications of juvenile water or water transported from outside the watershed along faults or fracture systems have been found.

Ground water movement in the valley fill generally follows the surface topography and drainage except where geologic or man-made impediments occur or where the natural flow has been modified by extensive pumping. The area of the major water-bearing material is described by the boundary of valley fill delineated on Plates 2 and 5. Vertical limits of this water-bearing fill material are defined by the surface topography elevation shown on Plate 2 and the bedrock elevations depicted by contours on Plate 6 and are described on pages 40 through 43. Direction of ground water flow within the water-bearing fill material is along the gradient taken normal to the ground water contours.

The ground water conditions which have existed during the 1928-29 through 1957-58 period are illustrated by Plates 27, 28, 29 and 30 which show ground water contours for the years 1931, 1938, 1944 and 1958 respectively.

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The valley fill material is a heterogeneous mixture of clays, silts, sands and gravels laid down by the alluviation process. Characteristic composition of the fill is depicted on Plates 5A through 5H. Clays and finer materials predominate west of Pacoima Wash, whereas coarser materials predominate in the easterly portion of the valley. Specific yields or water-yielding capacities of these materials vary from 3 percent for clay to 26 percent for coarse sand or fine gravel. Specific yield of the water-bearing materials is set forth on page 63.

The surface location of the bed and banks of the Los Angeles River and its tributaries is shown on Plate 2. Location of these channels on the valley floor in 1893 is shown on Plate 11 and the improved channels existing in 1958 are shown on Plate 12.

Hydrologic Subareas

"I.2,D. THE AREA, LOCATION, NATURE, CHARACTERISTICS AND LIMITS OF ANY AND ALL BASINS AND SUB-BASINS AND THE INTERCONNECTION OR INTERDEPENDENCE THEREOF, WITHIN SAID AREA."

There are four hydrologic subareas consisting of San Fernando, Sylmar, Verdugo and Eagle Rock which, along with the portion of the Monk Hill Basin within the area (609 acres), comprise the ground water reservoir of the Upper Los Angeles River area. The areal extent of these subareas and the portion of Monk Hill Basin, which occupy the total valley fill area, are shown on Plate 5. The subareas are bounded by impediments to flow of ground water which are caused by faulting, folding, alluvial constrictions or man-made works. The San Fernando, Sylmar, Verdugo and Eagle Rock Subareas comprise 90.8, 4.5, 3.8 and 0.6 percent of the total valley fill respectively.

The San Fernando Subarea is adjacent to and receives surface drainage from each of the other three subareas. The amount of subsurface flow from the smaller subareas to San Fernando Subarea depends upon ground water gradient, transmissibility and the extent of the connection between the subareas. The Eagle Rock, Sylmar and Verdugo Subareas are not directly interrelated or interdependent upon each other. Estimated amount of subsurface flow from the Sylmar Subarea to the San Fernando Subarea is shown in Table 32, page 161, and averages 550 acre-feet annually. Subsurface flow from the Verdugo and Eagle Rock Subareas to the San Fernando Subarea is insignificant and has been considered as nil.

The San Fernando Hydrologic Subarea contains 112,047 acres and occupies all of the valley fill area except that occupied by the other three subareas and the Monk Hill Basin. The valley fill materials in the eastern portion of the subarea are generally sand and gravel and have the ability to store a higher percentage of water than the fine-grained materials in the western portion (see pages 46 through 50).

The Sylmar Hydrologic Subarea contains 5,565 acres and is located northerly of the San Fernando Subarea. Both free and confined ground water areas exist in this subarea. Subsurface flow from the Sylmar Subarea to the San Fernando Subarea takes place at two notches that have been eroded into the truncated south limb of the Little Tujunga syncline which forms the southern boundary of the Sylmar Subarea (see pages 51 through 55).

The Verdugo Hydrologic Subarea is located northeasterly of the San Fernando Subarea and contains 4,400 acres. Available information indicates that movement of ground water from the Verdugo Subarea to the San Fernando Subarea is almost completely controlled by a man-made submerged dam and well diversions by the City of Glendale in the cross-sectional area of the Verdugo Wash Canyon between the Verdugo Mountains and the San Rafael Hills. Subsurface outflow from the portion of the Monk Hill Basin (609 acres) within the Upper Los Angeles River area easterly to the main portion of the Monk Hill Basin is by means of a buried erosion channel of an ancestral Pickens Canyon Wash and has ranged from 250 acre-feet to 400 acre-feet per year and has averaged 300 acre-feet per year during the base period (see pages 42, 56 through 58, and Table 31 on page 160). Subsurface flow from Monk Hill Basin southwesterly to the Verdugo Subarea is prevented, in all but high ground water conditions, by a bedrock ridge on the westerly side of the above ancestral Pickens Canyon Wash.

The Eagle Rock Hydrologic Subarea contains 807 acres and is situated to the southeast of the San Fernando Subarea. Eagle Rock Subarea is an artesian basin lying above the Raymond fault zone. Available information indicates that subsurface flow to the San Fernando Subarea is entirely or almost entirely stopped by this fault zone (see pages 58 through 61).

Amounts and Quality of Water Supply

"I.2.E. THE QUALITY OF ALL WATERS WITHIN SAID AREA AND THE EFFECT THEREON OF THE IMPORTATION OF OWENS VALLEY WATER.

I.2.F. THE SOURCE AND QUANTITY OF ALL WATERS, AND THE PLACES OF APPLICATION AND USE OF FOREIGN WATERS, ENTERING SAID AREA EACH WATER YEAR FOR THE PERIOD COVERED BY AVAILABLE RECORDS AND INFORMATION.

I.7. ALL SOURCES OF WATER SUPPLY OF PLAINTIFF AND DEFENDANTS, AND THE QUANTITY THEREOF FOR THE PERIOD OF AVAILABLE RECORDS AND INFORMATION TO AND INCLUDING THE DATE OF THE REPORT:

(a) DIVERTED AND USED; AND

(b) AVAILABLE FOR DIVERSION AND USE."

The present water supply to the Upper Los Angeles River area is comprised of precipitation on the watershed, import from the Mono Basin Owens River System and import from the Colorado River. The average annual precipitation for the 85-year period, 1871-72 through 1956-57 on the valley floor is about 16.3 inches or 167,740 acre-feet, and on the hill and mountain area is about 22 inches or 377,110 acre-feet, making a total average annual water crop of about 544,850 acre-feet. Of the rain on the mountain and hill areas only an average of 44,000 acre-feet per year reached the valley fill area as runoff during the 29-year base period from 1928-29 through 1956-57. During the 29-year base period, the annual precipitation was above normal for about one-third of the years and subnormal for about two-thirds. This approximates the proportion of years of subnormal and above normal annual precipitation occurring in the 85-year period. Annual precipitation for the 29-year period averaged 541,720 acre-feet or 99.5 per cent of the 85-year normal. During this 29-year period the annual water crop from precipitation ranged from a minimum of about 50 per cent of normal in 1947-48 and 1950-51, to a maximum of 224 per cent of normal in 1940-41. Annual amounts of precipitation are listed in Table 1, page 69, for the period 1928-29 through 1957-58.

Runoff from the hill and mountain area plus precipitation on the valley fill less storm runoff at Gage F-57 is the native water supply available to the valley fill area. An average of about 88 per cent of the annual precipitation on the hill and mountain area is consumed there. Runoff to the valley floor accounts for the remaining 12 per cent. Annual runoff reaching the valley floor from precipitation on the hill and mountain area ranged from 3,450 acre-feet in 1950-51 to 191,400 acre-feet in 1940-41 and averaged 44,000 acre-feet during the base period (Table 3, page 76 and pages 74 and 75).

Annual storm runoff leaving the area at Gage F-57 has varied from 1,330 acre-feet in 1929-30 to 138,990 acre-feet in 1940-41 and averaged 30,790 acre-feet during the base period 1928-29 through 1956-57 (Table 28, page 155).

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Owens River water was first served in the Upper Los Angeles River area via the Los Angeles Aqueduct, owned and operated by the City of Los Angeles, in May 1915. A portion of the water from this source is passed through the area to serve other portions of the City of Los Angeles. The net annual amount of Owens River water remaining in the area during the 30-year period from 1928-29 through 1957-58 has varied from 74,000 acre-feet in 1940-41 to about 162,000 acre-feet in 1957-58 including the portion which has been spread for direct recharge of ground water which has averaged 7,800 acre-feet per year during the base period (Table 8, page 97 and Table 24, page 145).

Colorado River water has been imported into the area since 1939-40 with the 70 acre-feet imported that year increasing to 13,250 during 1956-57. Annual amounts imported from this source during the 19-year period averaged about 4,300 acre-feet (Table 8, page 97).

The amounts of water available at their source of import for diversion and import and use by the parties from sources outside the Upper Los Angeles River area have been considered primarily from the viewpoint of physical availability at points of diversion of existing works. A determination of legal availability would involve findings concerning other rights to these sources which are not within the purview of this reference. Information available indicates that there is no additional firm supply for plaintiff and for defendants from the Central and West Coast Basins because these ground water sources are now overdrawn. Runoff which has occurred in channels tributary to diversion works of the Los Angeles Aqueduct from the Owens and Mono Basins and amounts in excess of the quantities diverted are shown in Table 5 on page 83. The net diversions from the Colorado River by The Metropolitan Water District of Southern California are shown in Table 6 on page 86. Preferential rights and priorities of members of The Metropolitan Water District are shown on pages 88 and 91 respectively.

Annual amounts of water imported through the Los Angeles and Colorado River Aqueducts for delivery within the Upper Los Angeles River area are listed in Table 8, page 97, for the years prior to 1958-59.

The water service areas are shown on Plates 19 and 20 respectively for large and small entities. The annual amounts of imported water delivered to each of the larger entities are listed by water service areas in Table M-2 for Mono Basin-Owens River water and in Table M-3 for Colorado River water.

Water delivered in the Upper Los Angeles River area may be imported water, local ground water or local surface diversions, or a mixture depending on the area and water system operation. In the 1928-29 through 1957-58 period, gross ground water extractions in the Upper Los Angeles River area for all purposes including export have increased from 67,330 acre-feet in 1932-33 to 163,270 acre-feet in 1956-57 and have averaged 111,920 acre-feet during the base period (See Table 15, page 124). During the same period, surface water diversions averaged 660 acre-feet and varied from 160 acre-feet in 1956-57 to 1,470 acre-feet in 1943-44 (See Table 16, page 125).

Quality of water imported from the Owens-Mono Basins is good, being of sodium calcium bicarbonate character and averaging about 215 parts per million (ppm) total dissolved solids (TDS). Colorado River import is of sodium sulfate character and has averaged about 774 parts per million (ppm) total dissolved solids (TDS). Surface runoff in the Upper Los Angeles River area varies from a calcium sulfate type in the southwesterly portion to a predominantly calcium bicarbonate type from the north and easterly portion. Concentration of total dissolved solids in surface runoff at the valley outlet vary generally in an inverse proportion to the magnitude of runoff rates and vary from about 100 ppm at peak flows to over 1,000 ppm during times of minimum flow. Ground waters reflect the same general source area influence on their character as indicated by surface flows, being predominantly calcium sulfate in the westerly portion and calcium bicarbonate in the remainder of the area. Ground waters of the basin are generally within U. S. Public Health Drinking Water Standards of 1946 (See pages 98 through 105).

Quality characteristics of Upper Los Angeles River area ground waters and waters imported thereto are shown on Plate 15. Concentrations of total dissolved solids, and sulfate, chloride and nitrate ions found in solution in ground waters in the area are shown in Table 9, on pages 101 and 102 and Plates 17A, B, C and D.

Except for a short period of time in 1932 when boron concentrations were above normal, the quality of waters imported from Owens River and Mono Basin have been equal or superior to the native waters of the Upper Los Angeles River area and have not otherwise adversely affected the quality of the native waters (page 105).

"I.2,G. THE NATURE AND QUANTITY OF ALL WATER LOSS AND DIMINUTION WITHIN AND FROM SAID AREA, EACH WATER YEAR FOR THE PERIOD COVERED BY AVAILABLE RECORDS AND INFORMATION.

I.4. AS TO EACH PARTY TO THE WITHIN ACTION FOR THE PERIOD OF AVAILABLE RECORDS AND INFORMATION:

(a) THE LOCATION AND CAPACITY OF HIS OR ITS DIVERSION WORKS;

(b) THE CHARACTER OF HIS OR ITS USE OR USES OF WATER; AND

(c) THE AMOUNT OF HIS OR ITS TAKING AND USE OF WATER."

Water is used in the area for agricultural and municipal purposes, the latter including commercial, industrial and recreational uses. Diminution of water so used is by evaporation, or transpiration to the air or by leaving the area as sewage or waste outflow in surface channels. Major surface outflow occurs from storm runoff. Minor additional outflows occur comprised of rising ground water and Owens River water released to the river system in excess of percolation and rediversion. Minor subsurface outflow occurs through the alluvium at Gage F-57 and from the Verdugo Subarea immediately east of Pickens Canyon Wash.

Land Use

During the 30-year period 1928-29 through 1957-58, the type of land use has changed from primarily agricultural to urban. In that period irrigated agriculture was reduced from 58,400 acres, or 47 per cent of the 123,400 acres of valley fill in 1928-29, to about 16,200 acres or 13 per cent in 1957-58. Urban land use, comprising residential, commercial and industrial

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acreage, has more than tripled during the period, increasing from about 22,000 acres in 1928-29 to about 75,400 acres during 1957-58 (See Plates 22 through 25, Table 17, page 128 and Figure 1, page 129).

Extraction and Export of Ground Water

In addition to import supplies, ground water is pumped from the valley fill and applied thereon for the named uses. Total annual extractions so used ranged from 34,890 acre-feet in 1928-29 to 73,390 acre-feet in 1952-53 and averaged 54,320 acre-feet during the base period (Table 20, page 138).

The capacity and location of the diversion works of the parties are listed in Tables 11 and 12 on pages 112 through 115 and 117 through 119 respectively. The location of all wells of record is shown on Plate 18. Where more than one party has an interest in a diversion works, the data on the diversion works are listed under the party believed to have the major interest. A cross reference to joint interests of parties is shown in Table 10 on pages 107 through 109.

The character of water use (accounted as municipal, domestic, irrigation, industrial, commercial or recreation) is indicated for each of the parties in Table 11 on pages 112 through 115.

Annual amounts of the taking of water by each of the parties are listed in Tables 12 and 13 on pages 117 through 120 for the period of available record.

Ground water has been pumped and exported from the area mainly by the City of Los Angeles with minor amounts exported from the Verdugo Subarea by La Canada Irrigation District. Total annual export of ground water has varied from 32,010 acre-feet in 1932-33 to 90,750 acre-feet in 1956-57 and has averaged 57,600 acre-feet during the base period (Table 19, page 135).

Sewage

Sewage has been exported from the area via the North Outfall sewer since 1928 and the San Fernando Valley Sewer Relief tunnel since 1956. Total annual sewage exported, including a minor amount of ground water infiltration, has varied from 6,320 acre-feet in 1928-29 to 63,960 acre-feet in 1957-58 and averaged 24,670 acre-feet during the base period. A portion of the water delivered in the area is disposed to the ground water table through local disposal units including cesspools. This amount has increased in recent years from 3,950 acre-feet in 1934-35 to 20,550 acre-feet during 1956-57 and has averaged 9,330 acre-feet annually during the base period (Table 26, page 151).

Surface Outflow and Native Runoff Spread

Annual total surface outflow passing Gage F-57, which is comprised of storm runoff, Owens River water, rising ground water and industrial waste, including a small amount of spilled sewage, ranged from 1,660 acre-feet in 1929-30 to 164,960 acre-feet in 1940-41 and averaged 39,940 acre-feet during the base period (Table 28, page 155).

A portion of the mountain and hill runoff reaching the valley fill has been spread for direct recharge of the ground water. Annual spreading of runoff water ranged from zero in several years to 30,380 acre-feet in 1957-58 and averaged 3,060 acre-feet during the base period (Table 30, page 158).

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Subsurface Outflow

Subsurface flow leaves the Upper Los Angeles River area at two locations, one southerly through the Los Angeles Narrows and the other easterly in the vicinity of Pickens Canyon. Subsurface outflows at these locations have averaged about equal amounts for a total of 650 acre-feet per year during the base period (Table 31, page 160).

Consumptive Use

Disposal of water from the valley fill area through the combined consumptive use of precipitation, delivered water and ground water has been computed in Chapter V by the Inflow-Outflow Method. Consumptive use determined in this manner averaged 227,200 acre-feet per year for the base period from 1928-29 through 1956-57 (Table 34, page 169).

Effect of Water Supply and Use
on Ground Water Recharge and Storage

"I.2. THE COMPLETE GEOLOGY, INSOFAR AS IT AFFECTS THE OCCURRENCE AND MOVEMENT OF GROUND WATER, AND THE SURFACE AND GROUND WATER HYDROLOGY OF SAID AREA, INCLUDING BASINS AND SUB-BASINS THEREIN. INCLUDING BUT NOT LIMITED TO:"

The net effect of water supply and disposal is reflected by the ground water levels in the ground water reservoir. Water levels in the westerly portion of the valley fill in San Fernando Subarea have had relatively minor fluctuation indicating a net gain of about 10 feet during the 29-year base period. In contrast, levels in the easterly portion of that subarea dropped slightly and recovered between 1928-29 and 1934-35 and then generally increased to a maximum in 1944, at which time the basin contained the maximum amount of water in storage during the 1928-29 through 1957-58 period. After 1944 levels dropped at a rapid rate to record lows in 1957-58, when water in storage was the minimum of record to that time. Water levels in the Sylmar and Eagle Rock Subareas have had relatively minor fluctuations during the period, with those in the former indicating a small net drop and in the latter reflecting little net change. Water levels in the Verdugo Subarea followed the same general pattern as those in the easterly portion of San Fernando Subarea but with fluctuations of less magnitude.

Concentration of pumping activity in the Los Angeles Narrows area has resulted in a reversal of the ground water gradient in that area subsequent to 1958 (see Plates 27, 28, 29, 30, 31, 31A, 31B, 32, 33, 34A, 34B and 34C).

The maximum annual change in ground water storage during the base period occurred in 1940-41 with an increase of water in storage of 128,020 acre-feet. The average annual change in storage during the base period was a decrease of 11,950 acre-feet (see Table 33, page 166).

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A summary of the items comprising the water supply and disposal on the valley fill is presented in the following tabulation in terms of the range in each item during the 30-year period 1928-29 through 1957-58 and the average of each during the 29-year base period 1928-29 through 1956-57.

During the 29-year base period 1928-29 through 1956-57, total annual historic ground water recharge has ranged from 58,700 acre-feet in 1928-29 to 247,200 acre-feet in 1940-41 and averaged 112,200 acre-feet (see Table 43, page 203).

WATER SUPPLY AND DISPOSAL ON THE VALLEY FILL

In 1,000 Acre-Feet Per Year

Item	Average during base period 1928-29 thru 1956-57	Range in Values During Period 1928-29 through 1957-58: Maximum Amount	Maximum Year ending	Minimum Amount	Minimum Year ending	Reference Table No.	Reference Page No.
WATER SUPPLY TO VALLEY FILL AREA							
Precipitation on Valley Fill	173.1	409.8	'41	80.1	'48	34	169
Import to Valley Fill	124.6	170.7	'57	68.8	'41	34	169
Hill and Mountain Runoff	44.0	191.4	'41	3.5	'51	34	169
Surface Diversions from Hill Areas	0.5	1.3	'44	0.1	'29	34	169
Water from Ground Water Storage	12.0					34	169
Total Water Supply (rounded off)	354						
WATER DISPOSAL FROM VALLEY FILL AREA							
Ground Water Transfers							
Out of Upper Los Angeles River Area	57.6	90.8	'57	32.0	'33	34	169
To Hill and Mountain Areas	5.9	8.0	'46	2.3	'29	34	169
Subtotal (rounded off)	63						
Surface Outflow							
Net Storm Flow	30.8	139.0	'41	1.3	'30	28	155
Rising Water	6.8	28.6	'42	0		28	155
Wastes	0.8	2.4	'56	0		28	155
Owens River Water	1.6	8.7	'43	0		28	155
Subtotal (rounded off)	40						
Net Sewage Export and Sewer Infiltration							
Net Sewage Export	20.3	55.1	'58	5.1	'29	26	151
Sewer Infiltration	2.7	6.3	'41	0.2	'30	26	151
Subtotal (rounded off)	23						
Subsurface Outflow	0.6	0.8	'39	0.4	'58	34	169
Consumptive Use	227.2	323.9	'43	141.4	'57	34	169
Total Water Disposal (rounded off)	354						

Safe Yield and the Effect of Import

"I.2.H. THE SAFE YIELD, AND THE EFFECT THEREON OF THE IMPORTATION OF FOREIGN WATERS, SHALL BE DETERMINED FOR THE WATER YEAR IMMEDIATELY PRECEDING THE FILING OF THE REPORT FOR WHICH DATA IS AVAILABLE, AND FOR THE WATER YEARS ENDING 1950 AND 1955."

The safe yield of the Upper Los Angeles River area ground water reservoir has been determined as the maximum average annual pumpage draft which can be continually withdrawn for useful purposes under a given set of conditions without causing an undesired result.

Safe yield has been based on cultural conditions existing during the water years 1949-50, 1954-55 and 1957-58. The latter is the last year preceding the filing of the report for which data are available.

Safe yield has been determined through the evaluation of the average net ground water recharge which would occur if the culture of the safe yield year and the average historic import and export for that year had existed over a period of normal native supply. All items of supply and disposal responsive to both precipitation and economic conditions were based on the 9 year period from 1949-50 through 1957-58, whereas items responsive primarily to precipitation on the valley fill area were based on the 29 year base period 1928-29 through 1956-57. Base ground water levels used were those existing as of the end of 1957-58 (See pages 208 through 243).

Availability of regulatory ground water storage space does not impose any limitation on safe yield under the conditions adopted (see page 207).

The safe yield, in acre-feet per year, of the Upper Los Angeles River area ground water reservoir, determined under the conditions adopted, is 100,800, 100,400 and 97,600 for the years 1949-50, 1954-55 and 1957-58 respectively. That portion of the safe yield derived from native sources, in acre-feet per year, is 62,100, 57,700 and 54,700 for the years 1949-50, 1954-55 and 1957-58 respectively. That portion of the safe yield derived from import sources, in acre-feet per year, is 38,700, 42,700 and 42,900 for the years 1949-50, 1954-55 and 1957-58 respectively (see Table 55, page 246b).

Importation of foreign waters increased the safe yield of the ground water reservoir by 38,700, 42,700 and 42,900 acre-feet for the respective safe yield years of 1949-50, 1954-55 and 1957-58. As a result there was a decrease in deficiency of supply to meet the water requirements of the culture existing during the safe yield years to less than the deficiency which would have occurred had local sources been the sole supply (see Table 56, page 249 and page 250).

To eliminate the total water requirement not satisfied by total water available under safe yield conditions of 33,900, 52,800 and 63,800 acre-feet per year for the respective safe yield years of 1949-50, 1954-55 and 1957-58, it would be necessary to modify the import, export and/or demand (see Table 56, page 249). The foregoing deficiencies of water requirements are equivalent to a consumptive demand of 25,200, 38,500 and 46,800 acre-feet per year for the respective safe yield years of 1949-50, 1954-55 and 1957-58 (see Table 56, page 249).

<u>Use of Water by the City of Los Angeles and Others</u>

"I.5. THE USE OF WATER BY THE CITY OF LOS ANGELES AND ITS INHABITANTS:

(a) SINCE 1948 WITHIN THE TERRITORY OF THE ORIGINAL PUEBLO; AND

(b) FOR THE PERIOD OF AVAILABLE RECORDS WITHIN THE EXPANDED BOUNDARIES OF SAID CITY AS THE SAME EXISTED FROM TIME TO TIME UP TO THE DATE OF THE REPORT HEREIN.

"I.6. THE AMOUNT OF WATER DISTRIBUTED BY PLAINTIFF FOR THE PERIOD OF AVAILABLE RECORDS AND INFORMATION TO AND INCLUDING THE DATE OF THE REPORT, FOR USE OUTSIDE ITS BOUNDARIES AS SUCH BOUNDARIES HAVE EXISTED FROM TIME TO TIME.

"I.7. ALL SOURCES OF WATER SUPPLY OF PLAINTIFF AND DEFENDANTS, AND THE QUANTITY THEREOF FOR THE PERIOD OF AVAILABLE RECORDS AND INFORMATION TO AND INCLUDING THE DATE OF REPORT:

(a) DIVERTED AND USED; AND

(b) AVAILABLE FOR DIVERSION AND USE."

Sources of water supply of the City of Los Angeles are the Owens and Mono Basins via the Los Angeles Aqueduct, Colorado River via The Metropolitan Water District Aqueduct, surface diversions from the Los Angeles River in the Upper Los Angeles River area and ground water extractions from that area and from Central and West Coast Basins located outside the Upper Los Angeles River area. Location of the Los Angeles and The Metropolitan Water District Aqueduct systems and of well fields outside the Upper Los Angeles River area are depicted on Plates 13, 14 and 35. Flow chart of the import-export system in the Upper Los Angeles River area is depicted on Plate 21. The Los Angeles Aqueduct has operated at full capacity since prior to 1949-50. Design capacities along The Metropolitan Water District's Santa Monica feeder which conveys Colorado River water to the area are shown on the profile depicted on Plate 13.

Total annual water use by the City of Los Angeles within its expanded boundaries, including all import and local supplies from West Coast Basin, Central Basin and San Fernando Valley has varied since 1928-29 from 227,992 acre-feet in 1934-35 to 477,634 acre-feet in 1956-57 and averaged 336,128 acre-feet during the 29-year period. Annual amounts of water used by the City of Los Angeles and its inhabitants within its expanded boundaries are shown on pages 255 through 257 by sources.

Deliveries by the city for use outside its boundaries varied during the period 1950-51 through 1954-55 from 4,316 acre-feet in 1950-51 to 5,386 acre-feet in 1953-54. Annual amounts of water served by the City of Los Angeles outside its boundaries are shown on page 258.

Use of water by the city within the territory of the original Pueblo ranged from 73,533 acre-feet in 1949-50 down to 60,692 acre-feet in 1957-58 and averaged 65,750 acre-feet during the nine-year period. Annual amounts of water delivered by the City of Los Angeles within the original Pueblo are shown on page 252 for the period 1949-50 through 1957-58.

Sources of water supply of defendants are Colorado River water through The Metropolitan Water District Aqueduct and from the Upper Los Angeles River area through surface diversions and ground water extractions from wells. The amounts imported or diverted from these sources are set forth in Tables 12 and 13 on pages 117 through 120 and in Tables J-3, J-4 and J-5 on pages J-12 through J-17 of Appendix J.

Watershed of Los Angeles River Tributary to South Boundary of Pueblo Exclusive of the Upper Los Angeles River Area

"I.3. THE GEOGRAPHIC AND HYDROLOGIC (SURFACE AND GROUND WATER) BOUNDARIES OF ALL WATERSHEDS SUPPLYING THE LOS ANGELES RIVER BELOW LOS ANGELES COUNTY FLOOD CONTROL DISTRICT GAUGING STATION NO. F57 AND ABOVE THE SOUTHERN BOUNDARY OF THE ORIGINAL PUEBLO."

All of the area draining to the portion of the Los Angeles River above the southern boundary of the Pueblo is shown on Plate 35. The only large channel draining to the Los Angeles River between Gage F-57 and the southern pueblo boundary is the Arroyo Seco which drains a portion of the Raymond Basin area (Monk Hill Basin). The watershed boundary of the Los Angeles River system below Los Angeles County Flood Control District gaging station F-57 and above the southerly boundary of the original Pueblo is depicted on Plate 35.

CHAPTER I. INTRODUCTION

This report has been prepared for and pursuant to orders of the Superior Court of California in and for the County of Los Angeles in action No. 650,079 entitled "The City of Los Angeles, a Municipal Corporation, Plaintiff, vs. City of San Fernando, a Municipal Corporation, et al., Defendants." The complaint in the action requests a decree determining that the plaintiff has a pueblo right paramount to the right of all defendants; that the City has a prior right to all foreign water imported by it, spread within the drainage area of the Los Angeles River, and transmitted to the City's wells and other diversion works by the "surface and subsurface channel" of the Los Angeles River; and that an injunction be issued terminating pumping by the defendants within the watershed boundary of the Los Angeles River above the confluence of Arroyo Seco.

Authorization

The basic Court order, pursuant to which this report has been prepared, consists of the "Order of Reference to State Water Rights Board to Investigate and Report Upon the Physical Facts (Section 2001, Water Code)," entered on June 11, 1958, as modified by: (1) Interim Order entered on November 19, 1958, which directed that no further investigations, studies, proceedings, or reports be made with respect to Paragraph II of the Reference Order of June 11, 1958 unless further ordered; and (2) Orders made in open Court on February 15, 1960, September 20, 1960 and November 15, 1960, Reporter's Transcript, pages 5470, 6377, and 6756, respectively, and ex parte orders extending the time for serving the draft report on the parties, the last such extension being to November 20, 1961, but ordering that copies of the proposed draft report be made available to the parties at least 60 days prior to that date.

The Order of Reference of June 11, 1958, had been preceded by an Interim Order of Reference entered by the Court on March 19, 1958, pursuant to which the Board had studied the availability of records and data and had given the Court its estimates of time and expense of reporting thereon. In Paragraph I of the Order of Reference, the State Water Rights Board is requested to investigate, find, provide data and report upon physical facts in accordance with the authorization of Section 2001 of the Water Code, as follows:

> "1. The geographic and hydrologic (surface and ground water) boundaries of the watershed of the Los Angeles River and its tributaries above the junction of the surface channels of the Los Angeles River and the Arroyo Seco at a point now designated as Los Angeles County Flood Control District Gauging Station No. F57. (Note: If said boundary differs from that depicted on and described in Appendices 'A' and 'B' attached to plaintiff's Amended Complaint, then the areas included within both boundaries shall be studied and shall be included in the term 'said area' as hereinafter used.)
>
> 2. The complete geology, insofar as it affects the occurrence and movement of ground water, and the surface and ground water hydrology of said area, including basins and sub-basins therein, including but not limited to:
>
> A. The topography and soils.
>
> B. The surface location of the bed and banks of the channels of the Los Angeles River and its tributaries.
>
> C. The areas, limits and direction of flow of all ground water in said area, including, but not limited to, any and all waters percolating therein.
>
> D. The area, location, nature, characteristics and limits of any and all basins and sub-basins and the interconnection or interdependence thereof, within said area.
>
> E. The quality of all waters within said area, and the effect thereon of the importation of Owens Valley Water.

F. The source and quantity of all waters, and the places of application and use of foreign waters, entering said area each water year for the period covered by available records and information.

G. The nature and quantity of all water loss and diminution within and from said area, each water year for the period covered by available records and information.

H. The safe yield, and the effect thereon of the importation of foreign waters, shall be determined for the water year immediately preceding the filing of the report for which data is available, and for the water years ending 1950 and 1955.

3. The geographic and hydrologic (surface and ground water) boundaries of all watersheds supplying the Los Angeles River below Los Angeles County Flood Control District Gauging Station No. F57 and above the southern boundary of the original pueblo.

4. As to each party to the within action for the period of available records and information:

(a) The location and capacity of his or its diversion works;

(b) The character of his or its use or uses of water; and

(c) The amount of his or its taking and use of water.

5. The use of water by The City of Los Angeles and its inhabitants:

(a) Since 1948 within the territory of the original pueblo; and

(b) For the period of available records within the expanded boundaries of said city as the same existed from time to time up to the date of the Report herein.

6. The amount of water distributed by plaintiff, for the period of available records and information to and including the date of the report, for use outside its boundaries as such boundaries have existed from time to time.

7. All sources of water supply of plaintiff and defendants, and the quantity thereof for the period of available records and information to and including the date of the report:

(a) Diverted and used; and

(b) Available for diversion and use."

Copies of the Interim Order of Reference, the Order of Reference, and the Interim Order suspending further investigations, studies, or reports pursuant to Paragraph II of the Order of Reference, are included in Appendix S.

History of Proceeding

The case of City of Los Angeles, Plaintiff, vs. City of San Fernando, City of Glendale, City of Burbank, et al., Defendants, is an action for declaratory relief, to quiet title to waters and water rights, and for an injunction to restrain defendants from doing any act which may interfere with the free and uninterrupted flow of the surface and subsurface waters of the Los Angeles River and its tributaries and of the foreign waters brought by the City of Los Angeles from sources outside the watershed of the Los Angeles River and spread within the watershed or served to customers of the City of Los Angeles from its wells and other diversion works where such waters can be taken and used by the City of Los Angeles for its inhabitants.

The complaint names some 214 defendants and includes numerous Does alleged to have facilities which are operated and maintained for the taking of water, both surface and underground, from the Upper Los Angeles River drainage area as defined in Appendix A of the amended complaint.

Answers filed in the proceeding by various defendants allege that the water taken and diverted has been necessary for the purposes for which it has been taken and that each of them has a right to the water so taken.

The initial or Interim Order of Reference to State Water Rights Board made by the Court on March 19, 1958 directed the Board to study the availability of any and all public and private records, documents, reports and data relating to a proposed order of reference in the case and to approximate the time required for, and to estimate the cost of obtaining, correlating and reporting upon, such records, documents, reports, and data, and to report the results of its investigation and study to the Court on June 9, 1958.

The Board, in making its report, presented an estimate that two years would be required to complete the studies and prepare a report of referee pursuant to the proposed order of reference.

On June 11, 1958, the Court by its Order of Reference to the State Water Rights Board, appointed the Board as referee to investigate and report within two years on the physical facts enumerated in the Order of Reference in accordance with Section 2001 of the Water Code. The Board was further instructed under Paragraph II of the Order of Reference to investigate the nature, extent and availability of any and all records and data reasonably necessary for the study of the Board with respect to water years from and including that ending 1900 to the year preceding the Board's report, and to report the results of such investigation to the Court on November 17, 1958.

On November 17, 1958, the State Water Rights Board reported to the Court, pursuant to Paragraph II of the Order of Reference, that in its opinion insufficient data are available to justify a valid base period of study or of safe yield determination prior to the water year 1928-29, and that as to other items in Paragraph II, a report would be made at a later date after the Board had proceeded further with its studies.

By Interim Order of November 19, 1958, the Court accepted the Board's report of November 17, 1958 and released the Board from any further investigation pursuant to Paragraph II of the Order of Reference until and unless further ordered by the Court. The Court as a part of its order instructed the Board to appear at pre-trial conference sessions in the proceeding and to render progress reports, oral and written, on the matters on which it is required to report.

Representatives of the State Water Rights Board, in accordance with the Order of November 19, 1958, appeared before the Court on March 16, 1959, June 1, 1959, and February 15, 1960, and presented written and oral reports as to the Board's progress in investigating and compiling the data and information required under the Order of Reference.

Upon being advised on the latter date that deficiencies in available data had required additional time and added investigation by the parties and by the Board of certain items of information essential to answering portions of the Order of Reference, such added investigation having been made with knowledge and approval of engineering representatives of the parties, the Court by oral order in open Court extended the time allowed the Board for service of its Draft of Report of Referee on the parties to December 12, 1960. The date for service of the draft was further extended from time to time by verbal orders of the Court and by ex parte order upon being advised that additional time was required to fully comply with the Order of Reference. The last order designated November 20, 1961 as the date for service and directed the Referee to make available to the parties or their engineering representatives copies of the proposed draft report at least 60 days prior to November 20, 1961. The Court further directed that distribution of the proposed draft 60 days prior to the date of service of the draft was not to constitute a mailing of notice and copies of the draft under Section 2014 of the Water Code.

The Draft of Report of Referee was approved and adopted by the State Water Rights Board on November 13, 1961, and was served on the parties on November 20, 1961. The parties had thirty days to make formal objection to the draft. At the request of the parties, the Court extended the time to make objection an additional ninety days to March 20, 1962.

On February 23, 1962, the Referee transmitted to the parties a document entitled "Errata to Draft of Report of Referee". The errata which contained a list of errors, minor omissions and clarifications, was submitted to assist the parties in their review of the draft and to eliminate the necessity for objecting to many minor items.

Objections to Draft of Report of Referee

Objections (dated March 19, 1962 through March 21, 1962) to the Draft of Report of Referee (November 1961) were received from the following parties:

City of Los Angeles, Plaintiff.

City of San Fernando, Defendant No. 1.

City of Glendale, Defendant No. 2 and City of Burbank, Defendant No. 3.

La Canada Irrigation District, Defendant No. 7, Crescenta Valley County Water District, Defendant No. 8, and from Defendants Nos. 131, 171, 201 and 202.

Southern California Edison Company, Defendant No. 75.

Sparkletts Drinking Water Company, Defendant No. 78.

Deep Rock Artesian Water Company, Defendant No. 34, and from Defendants Nos. 12, 36, 37, 38, 39, 40, 43, 54, 64, 97, 100, 101, 102, 104, 106, 113, 117, 123, 140, 141, 142, 164, 168, 172, 181, 182, 186, 187 and 204.

Consideration of Objections to Draft of Report of Referee

All objections have been considered by the Referee. As a result of objections by the parties and review by the Referee, the Report of Referee contains the revisions to the Draft of Report of Referee set forth in the following paragraphs.

A. The changes specified in "Errata to Draft of Report of Referee" have been made to the draft and carried through the various tables, diagrams and plates, with the exception of items listed in the errata as Nos. 11, 34, 37, 43, 45, 46, 47, 56, 57 and 58, which were superseded by other changes or made ineffective because of other corrections.

B. Modifications by clarification of language, due to objections, have been made to the following pages in Volumes I and II:

Pages xxxi, xxxiv, 10, 23, 53, 54, 82, 106, 115, 135, 138, 138a, 173, 189, 199, 233, 247, 248, 249, A-46, A-48, E-6, I-3, I-8, J-20, K-19 through K-24 and M-16.

C. Further clarification has been made by the Referee to improve language, more clearly state meaning or to correct errors on the following pages and plates in Volume I:

Pages xxiv, xxvi through xxxiii, xxxv through xxxix, xlii through li, 10, 14, 26, 29, 39, 40, 42, 43, 45, 52, 56, 57, 58, 59, 61, 68, 69, 70, 76, 79, 80, 88, 90, 93, 97, 101, 123 through 126, 130, 131, 135, 136, 137, 139, 145, 151a, 155, 160, 166, 168, 169, 176 through 179, 181 through 187, 189 through 197, 200 through 203, 205, 207, 208, 209, 211, 212, 217, 220, 221, 223, 226, 227, 229, 233, 235 through 239, 242 through 247, 249, 250, 255, 256, and on Plates 1, 2, 5A through 5H, 11 through 16, 22, 23, 28, 30, 31, 31A, 31B, 32, 33 and 35.

Further clarification has been made in the appendixes on the following pages:

Pages A-29, A-45, C-12, D-7, E-3, E-6, E-8, E-10, E-12, E-15, F-2, F-4, F-7, F-8, F-13, F-17, F-18, F-24 through F-27, F-29 through F-32, G-8, G-9, G-12, I-8, I-19, I-23, I-24, I-30, I-40, I-41, I-56, J-6, J-7, J-12 through J-17, J-21, J-34, K-15, K-17, K-20, L-6, L-19, L-25, L-31, L-32, L-33, L-40, L-43, L-44, L-45, L-47, L-49, L-50, L-53, L-56 through L-68, L-70, L-71, L-75, M-7, M-8, M-10, M-12, M-14, M-18, N-4, N-9, N-34, N-36, O-7, O-12, Q-5, Q-6, R-4, R-5, R-8, R-9, R-10, R-13, R-14, R-16, R-17, R-18, and by adding pages L-49a and L-71a.

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D. Certain objections required more than clarification or language improvement and material has been added or deleted in connection with such objections. This has been done in regard to water supply and disposal by subareas by adding Appendix T; in regard to the description of the Little Tujunga syncline by adding Plate 5J; in regard to the description of boundaries by adding material to pages 17 and 18; in regard to imported water by adding material on surplus Northern California water on page 95; and in regard to the presentation of information on geologic defenses on pages A-61 through A-65 by changing the form of presentation.

E. Revisions of the Table of Contents to reflect the foregoing changes as well as those necessary to change from "draft report" to "report" have been made.

Investigation by Referee

The Board started its investigation as Referee immediately after entry of the Order of Reference on June 11, 1958 and contacted all parties named in the action regarding the availability of records and data pertinent to the proceeding.

Continuing contact was thereafter maintained with the parties and with Los Angeles County Flood Control District, State Department of Water Resources, State Bureau of Mines, United States Department of Agriculture and other sources, both private and public, through which added material was provided from time to time as deficiencies became apparent in the records and data first made available.

Detailed investigation was made of the area referred to in the Order of Reference as the watershed of the Los Angeles River and its tributaries above the junction of the surface channels of the Los Angeles River and the Arroyo Seco at a point now designated as Los Angeles County Flood Control District Gaging Station No. F-57. This area is referred to in this report as the Upper Los Angeles River area. Investigation was made outside the Upper Los Angeles River area as necessary to provide information required by the Order of Reference concerning the Pueblo of Los Angeles and of other sources of water supply available to the parties.

Investigation of physical facts indicated that records and data prior to 1928 were lacking or incomplete regarding a number of phases of the investigation, and that utilization of a period of analysis or base period for water supply and disposal and safe yield prior to the 1928-29 water year would be difficult and costly to make. This was reported to the Court on November 17, 1958. It was apparent also that any study extending into the period of poor and inadequate records could not be supported when compared to the results of a study over a period of more complete records as were available beginning with the 1928-29 water year. Consideration of these factors and release by the Court from reporting on other than the requirements set forth in Paragraph I of the Order of Reference, resulted in the adoption of a base period of study beginning with the 1928-29 water year and continuing through the 1956-57 water year. However, all readily available data of which the Referee has knowledge for years prior to 1928-29 and after 1956-57 have been compiled and included in the report and accompanying basic data for reference and such use as may be justified.

The Referee utilized material from all readily available published and unpublished reports and other sources to determine the geologic and the hydrologic factors applicable to the area of investigation. Factors thus developed are believed to be appropriate for the particular area under study although they may not be applicable elsewhere unless similar conditions prevail.

The Referee, in using the records, data and information provided as described, reviewed the material and where possible verified its acceptability for the Referee's purposes and made field checks where data permitted.

The need became apparent from time to time during the investigation for added work to establish facts under controversy between engineering representatives of certain of the parties and where uncertainties existed as to the application of available data. Such work included the drilling of 20 test holes by the parties and the Referee to determine the physical characteristics of the southerly boundary of the Sylmar Subarea; a detailed soil survey of the San Fernando cienaga area to determine the historic extent of the moist area associated with the cienaga; pump tests and water analyses, as well as an extended study of existing data relating to water origin in the Eagle Rock Subarea; the observation of new well drillings and continued study of existing wells throughout the period to provide more complete information concerning the specific geologic contentions of the parties; and analyses by different procedures to assure proper recognition of all factors relating to various specific studies.

Nomenclature

The term hydrologic subarea has been used herein to designate certain regions within the area of investigation for which the Referee was instructed to ascertain the location, area, nature, characteristics, limits and hydrologic and geologic interdependence thereof. For this reason the area within the boundary of valley fill (Plate 5) of the Upper Los Angeles River area was divided for study purposes, according to geologic and topographic conditions, into four subareas referred to in the report as the San Fernando, Sylmar, Verdugo and Eagle Rock "Hydrologic Subareas" or simply as "Subareas". These are shown on Plate 5 and further described in Chapter III.

The wells referred to in this report are designated by Los Angeles County Flood Control District numbers which had previously been assigned to wells known to have existed in the area and which were and are presently being utilized by local agencies to index well data. The well number consists of four digits, the first two designating one of a series of 6-minute U.S.G.S. quadrangles beginning at the southwest corner of Los Angeles County, and the last two being rectangular coordinates within the quadrangle with the coordinates beginning in the northwest corner of the quadrangle. The well number is followed by a letter to identify the actual well when more than a single well is located in that subdivision. The first well in a subdivision is usually identified by the number only and designated on the map by a short line drawn from the dot signifying the well location. Locations of all wells referred to in this report, with the guide to the well numbering system, are shown on Plate 18.

Stream flow stations and precipitation stations, referred to in the report and shown on Plate 9, have been designated by the same numbers assigned to them by the Los Angeles County Flood Control District.

The hydrologic "water year", which has generally been used throughout this report, is from October 1 through the following September 30 and is indicated as "1957-58". Whenever the calendar year is referred to for any purpose it is designated in the conventional manner, e.g., "1954". Whenever a period different from those noted above is intended, that period is identified at the place used in the report.

Engineering Advisory Committee

In accordance with recommendations by the Court in the Order of Reference, the engineers of the parties and representatives of the Board have maintained close contact and have met as a group to discuss procedures utilized by the Board's representatives and to review results of computations and of the material to be included in the Board's report to the Court. This group, referred to in the proceeding as the "Engineering

Advisory Committee", held a total of 22 meetings beginning September 23, 1958, spaced at approximately monthly intervals. In addition, conferences were held from time to time with engineering representatives of two or more of the parties on special problems. The information developed as a result of the meetings and conferences aided the staff of the Board materially.

The names of the engineering representatives attending the various meetings were as follows:

City of Los Angeles
- Samuel B. Morris (deceased)
- Milton Anderson
- Harold Conkling (resigned)
- Raymond A. Hill
- John F. Mann, Jr.
- E. C. Marliave
- Richard H. Gilman
- Gerald W. Jones
- Eldridge B. Lowry
- G. Marvin Litz
- Stanley A. Wilfong

City of San Fernando
- R. E. James
- Stuart E. Bergman
- A. L. Sonderegger (resigned)
- Ray Walker

City of Glendale
- Harold E. Butler (retired)
- Max Bookman
- A. W. Jagow
- Charles H. Lee

City of Burbank
- Clarence Shadel
- Max Bookman
- Alan Capon
- Charles H. Lee

Crescenta Valley County Water District
- A. L. Sonderegger (resigned)
- V. B. Tipton

California Materials Company
- Vernon E. Lohr

Consolidated Rock Products Company
    Byron P. Weintz

Forest Lawn Company
    H. O. Adair
    John S. Clough
    Luis E. Kemnitzer
    R. G. Spencer

Knickerbocker Plastic Company, Inc.
    Rudolph W. Chaplar

Livingston Rock and Gravel Company
    E. Misenheimer

Lockheed Aircraft Corporation
    H. D. Pinkney (deceased)
    G. W. Stosskopf

Southern California Edison Company
    Leonard Longacre
    E. L. Kerry

Southern Pacific Railroad Company
    J. G. Sinclair
    R. E. Frame
    M. J. Stephens

Sparkletts Drinking Water Corporation
    R. Bruce Lockwood
    G. Austin Schroter
    Max Alex
    O. R. Angelillo (through 18th meeting)

Technicolor Corporation
    T. A. Tarr

Sidney Smith
    K. Q. Volk

In addition to the representatives of parties as named, various representatives of interested public agencies attended meetings to supply information and to make suggestions regarding data and material provided through their respective agencies as follows:

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United States Department of Agriculture
Harry F. Blaney

State Department of Water Resources

Jack J. Coe	Robert Y. D. Chun
H. C. Kelly (retired)	Robert Thomas

Organization of Report of Referee

The Report of Referee contains Summary of Findings and nine chapters as follows:

I. Introduction

II. Description of the Upper Los Angeles River Area

III. Geology

IV. Water Supply, Upper Los Angeles River Area

V. Water Utilization and Disposal of Water

VI. Historic Ground Water Recharge

VII. Determination of Safe Yield

VIII. The Use of Water by the City of Los Angeles and Its Inhabitants

These chapters present discussion and summary illustrations of information developed by the Referee in answer to the requirements of the Order of Reference. They are supported by tables and a group of 36 plates containing 52 sheets immediately following the text. Twenty appendixes wherein detailed methods and procedures followed by the Referee are set forth, accompanied by extensive tabulations from which text summaries were prepared, are included in Volume II. Included in the appendixes are copies of relevant Orders of the Court.

The basic data upon which the Board bases its report and findings will be available and filed with the Court in accordance with Paragraph III of the Order of Reference dated June 11, 1958, and will be tabulated as listed in the table of contents of this report.

CHAPTER II. DESCRIPTION OF THE UPPER LOS ANGELES RIVER AREA

A general description of the geographic and hydrologic boundaries, physiography, soils, climate and culture of the Upper Los Angeles River area is presented in this chapter. In addition, the geographic and hydrologic boundaries of all watersheds supplying the Los Angeles River below Los Angeles County Flood Control District Gaging Station No. F-57 and above the southern boundary of the original pueblo are described.

The location of the Upper Los Angeles River area within the State and its relationship to Los Angeles County is delineated on Plate 1. The area, with the exception of small portions of the Simi Hills and the Santa Susana Mountains in Ventura County, is located within Los Angeles County.

Boundaries

The watershed boundary shown on Plate 2 is the boundary of the Upper Los Angeles River area and is based on data shown on the United States Geological Survey topographic maps covering the area. Maps of $7\frac{1}{2}$-minute series, dated from 1951 through 1953, were used wherever available with maps of the 6-minute series, dated from 1933 through 1948, being used for the northeastern portion of the area. A field check was made of locations where more than one interpretation of the topographic maps was possible. The watershed boundary of the area as determined by the referee conforms generally to that depicted on and described in Appendixes "A" and "B" attached to the Plaintiff's Amended Complaint. The description of the watershed boundary of the Upper Los Angeles River area is as follows:

Beginning at the most southerly point of said boundary at a point on the Los Angeles River at Los Angeles County Flood Control District gaging station F-57; thence westerly toward Elysian Hills to a point on Figueroa Street approximately 500 feet westerly of where said street crosses the Los Angeles River; thence northwesterly along the drainage divide of the Elysian Hills to the Santa Monica Mountains at a point on Los Feliz Boulevard approximately 4,000 feet southwesterly of where said boulevard crosses the Los Angeles River; thence northwesterly along the drainage divide of the Santa Monica Mountains to Cahuenga Peak, thence westerly along said divide through San Vicente Mountain, southerly of a number of small stream systems, which drain into the Upper Los Angeles River area, including Caballero and Calabasas Creeks, to an unnamed peak (elevation 1,689), in Sec. 33, T. 1 N., R. 17 W., S.B.B.&M.; thence in a northerly direction along said divide along the westerly watershed boundary of the Arroyo Calabasas stream system to the Simi Hills crossing Ventura Boulevard at a point approximately 8,000 feet westerly of the westerly boundary of the City of Los Angeles, as of October 1, 1958; thence in a northerly direction and following the crest of the Simi Hills through Laskey Mesa, Burro Flats and Chatsworth Peak, along the westerly watershed boundary of the Chatsworth stream system, to the Santa Susana Mountains at Santa Susana Pass and Highway 118; thence in a northerly direction and following said drainage divide to an unnamed peak (elevation 3,670) in Sec. 13, T. 3 N., R. 17 W., S.B.B.&M., thence easterly along said divide, northerly of several small stream systems which drain into the Upper Los Angeles River area, including Browns Canyon and Aliso Canyon; thence passes through Oat Mountain Lookout to the San Gabriel Mountains at U. S. Highway 99, approximately 5,000 feet northwesterly of the western boundary of the City of Los Angeles, as of October 1, 1958; thence easterly along the drainage divide of the San Gabriel Mountains, following the northerly watershed boundary of the Pacoima and Big Tujunga stream systems, passing through Magic Mountain and Mt. Gleason to Pacifico Mountain; thence southeasterly along said divide to an unnamed peak (elevation 6,192) in Sec. 13, T. 3 N., R. 11 W., S.B.B.&M.; thence southerly along said divide to an unnamed peak (elevation 5,410) in Sec. 10, T. 2 N., R. 11 W., S.B.B.&M.; thence westerly along said divide, passing through Barley Flats, Strawberry Peak, southerly of the Big Tujunga stream system to an unnamed peak (elevation 4,306) in Sec. 14, T. 2 N., R. 13 W., S.B.B.&M.; said peak being common to the drainages of Big Tujunga, Verdugo Wash and Arroyo Seco; thence southerly along a drainage divide, easterly of the Hall-Beckley Canyon stream system to the base of the San Gabriel Mountains; thence southerly along the drainage divide, which is approximately 6,000 feet easterly and parallel to Pickens Canyon Channel,

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to the San Rafael Hills; thence southerly along the crest of the San Rafael Hills, passing through Eagle Rock, to the Repetto Hills at the intersection of Colorado Boulevard and Avenue 64; thence in a southwesterly direction along the drainage divide of the Repetto Hills, passing through Mt. Washington to the base of the Repetto Hills at a point approximately 2,000 feet northeasterly of the intersection of Figueroa Street and San Fernando Road; thence southwesterly to the point of beginning.

The hydrologic (ground water) boundary is the areal boundary of the major water-bearing formations within the Upper Los Angeles River area and is delineated as the boundary of valley fill on Plate 5. This boundary is more completely described on pages 43 and 44 of Chapter III. Boundaries of hydrologic subareas within the hydrologic boundary of the area and the criteria used in their determination are described on pages 44, et seq., of Chapter III.

The surface drainage area tributary to the portion of the Los Angeles River below gaging station F-57 and above the southern boundary of the original Pueblo of Los Angeles, along with hydrologic (ground water) boundaries within the area, are shown on Plate 35.

Physiography

The Los Angeles River drainage system comprises a portion of the coastal watershed of Southern California. The general location of the area is shown on Plate 1. The Upper Los Angeles River area is that portion of the drainage system above the junction of Arroyo Seco at the lower end of the Los Angeles River Narrows. Plate 2 shows the important physiographic features associated with the area. Elevations range from a high of 7,124 feet above mean sea level at Pacifico Mountain to a low of 293 feet at Gage F-57.

The San Fernando Valley in general includes the alluvial-filled portion of the Upper Los Angeles River area. The valley is composed primarily of the complex surfaces of coalescing alluvial fans formed by subaerial deposition from the various streams tributary to the Los Angeles River above the Los Angeles Narrows. It is roughly elliptical in shape with a major axis of approximately 23 miles and a minor axis of approximately 12 miles, comprising 123,428 acres of valley floor lands and 205,709 acres of hill and mountain lands for a total of 329,137 acres.

Hill and Mountain Areas

The valley is bounded on the northeast by the San Gabriel Mountains, on the northwest by the Santa Susana Mountains, on the west by the Simi Hills, on the south by the Santa Monica Mountains and on the east by the San Rafael Hills and the Repetto Hills. The Verdugo Mountains, located in the northeast portion of the area, separate the Sunland-La Crescenta area from the main valley.

The San Gabriel Mountains are the highest as well as the largest mountain group in the area. They rise precipitously from the valley floor and contain many steep-sided canyons and to a large degree are composed of nonwater-bearing Basement Complex rocks which have been fractured and faulted. These rocks form a portion of the basement, which with other nonwater-bearing rocks, underlie at various depths the water-bearing formations in the area.

The Santa Susana Mountains lie westerly of the San Gabriel Mountains and are separated from them by an area of low relief in the vicinity of State Highway 99. The Santa Susana Mountains attain a maximum elevation of 3,747 feet within the area. They are composed mainly of sedimentary nonwater-bearing rocks which have been faulted and folded. Petroleum production is obtained within the Santa Susana Mountains primarily from the Aliso Canyon field.

The Simi Hills are separated from the Santa Susana Mountains at the pass crossed by Highway 118. The Simi Hills are a relatively low-lying group with a maximum elevation of 2,314 feet. These hills are composed of essentially sedimentary nonwater-bearing rocks.

The Santa Monica Mountains are separated from the Simi Hills by the area of low relief which is traversed by Highway 101. These mountains separate the San Fernando Valley from the Coastal Plain. The maximum elevation of 1,961 feet lies on the drainage boundary south of Encino Reservoir. The Santa Monica Mountains are composed of nonwater-bearing rocks of sedimentary, igneous and metamorphic types which have been extensively faulted and folded. Rocks of the sedimentary type predominate in the portion of these mountains within the Upper Los Angeles River area. In general these formations dip underneath the adjoining water-bearing series. The eastern end of the Santa Monica Mountains is considered to be the divide at Los Feliz Boulevard in the vicinity of the Los Angeles River Narrows.

The Elysian Hills (maximum elevation 753 feet) form the southerly boundary of the Los Angeles River Narrows. These hills consist of intensely folded nonwater-bearing materials.

The Verdugo Mountains represent a large block of nonwater-bearing Basement Complex rocks which have been isolated from the main portion of the San Gabriel Mountains by faulting. This block has a maximum elevation of 3,126 feet. The San Rafael Hills (maximum elevation 1,888 feet) southeast of Verdugo Mountains and across Verdugo Wash are composed of crystalline materials similar to those of the Verdugo Mountains. A small group of hills southerly of Colorado Boulevard, comprised largely of nonwater-bearing sedimentary rocks, is also considered a part of the San Rafael Hills.

The Repetto Hills are located south of the San Rafael Hills and easterly of the Los Angeles River Narrows. These hills are composed of sedimentary nonwater-bearing materials which have a maximum elevation of about 880 feet.

Features Related to the Valley Floor

In addition to the surrounding hill and mountain formation there are nine prominent physiographic features which are in contact with or related to the valley floor. These are: The Burbank Piedmont Slope, Pacoima Hills, Mission Hills, Northridge Hills, Chatsworth Hills, Woodland Hills, Chalk Hills, Van Nuys Plain and the Sunland-La Crescenta Piedmont Slope.

The Burbank Piedmont Slope is a series of coalescing alluvial fans which have the Verdugo Mountains as their source area. The higher degree of weathering on the surface of this feature indicates that it is somewhat older than the deposits of the Van Nuys Plain.

The Pacoima Hills are composed of nonwater-bearing materials and form one of the six hill groups in the valley. These hills probably represent the northwesterly extension of the Verdugo Mountains which has been eroded from the main mountain block by flows in Big Tujunga and Little Tujunga Washes. Exploratory work for Hansen Dam, which connects the Pacoima Hills to the Verdugo Mountains, indicates existence of sandstones at relatively shallow depths along the axis of the dam.

The Mission Hills are low hills which essentially surround Upper and Lower San Fernando Reservoirs. They are composed of water-bearing and nonwater-bearing materials which structurally are on the south flank of the Little Tujunga syncline which has extensively affected the topography of these portions of the valley.

The Northridge Hills constitute a short chain of low-lying hills which owe their existence to movements along the Northridge Hills fault. Tectonic disturbances have formed a complex structural pattern of anticlines and synclines in the nonwater-bearing series which have been of interest to oil companies in recent years. The upper surfaces of the hills are composed of Older alluvium which is underlain by Saugus formation.

The Chatsworth Hills comprise a group of low hills in the vicinity of Chatsworth Reservoir. They are composed essentially of nonwater-bearing Modelo shales and Cretaceous sandstones. These formations are capped in several places with a thin veneer of Older alluvium.

The Woodland and Chalk Hills are located in the southwestern portion of the valley. They are nonwater-bearing and are composed essentially of the diatomaceous shale member of the Modelo formation.

The Van Nuys Plain constitutes the major portion of the recently alluviated valley floor. The surficial deposits vary from relatively impermeable clays in the western part of the valley to permeable sands and gravels in the eastern portion of the valley. The Los Angeles River Narrows area which passes through the topographic constriction between the Elysian Hills on the west and the San Rafael and Repetto Hills to the east is considered to be a feature genetically related to the Van Nuys Plain. Other associated features on the valley floor are the incised channels of several streams, the major ones being Tujunga and Pacoima Washes and the Los Angeles River.

The Sunland-La Crescenta Piedmont Slope is a series of coalescing alluvial fans which have had their source areas in the San Gabriel Mountains. The fans are composed of coarse detritus with some boulders reaching a size of four feet in diameter.

Surface Drainage System

The Los Angeles River stream system is the surface drainage medium of the Upper Los Angeles River area. The main stream extends along the southerly side of the valley floor in a southeasterly direction through the Los Angeles Narrows and out of the area. The major drainage network is composed of the main stream and its principal tributaries draining Big Tujunga, Little Tujunga, Pacoima, Aliso, Browns,

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Bull and Arroyo Calabasas Canyons. Historic changes in the drainage system are discussed in Chapter IV.

Soils

Soils are related to the water supply insofar as they, in combination with other factors, influence the rate of recharge to the ground water. This is particularly true of the soils on the valley fill. However, it is not feasible nor is it required for the purposes of the investigation to make a quantitative evaluation of the infiltration capacities of the various soils known to exist in the area. Therefore, only the relative infiltration characteristics of the valley soils have been evaluated.

In general, the soils in the valley fill areas can be grouped with respect to relative infiltration capacities in a manner utilized by Musgrave (Water, the Yearbook of Agriculture, 1955, U.S.D.A.), which takes into account the depth of soil, relative drainage, ability to retain moisture and the degree of permeability based on grain size. The U. S. Department of Agriculture Soil Surveys of 1917 and 1919 give a detailed description of all soils found in the Upper Los Angeles River area. These soils have been classified into High, Medium and Low infiltration groups on the basis of Musgrave's criteria. Individual soils contained in each group are shown in Appendix B and areal extent of each of the three soil groups is shown on Plate 3.

In general the soils present in the Upper Los Angeles River area consist of three types. First is the residual type soils including the Holland, Altamont, Sites and Diablo soil series occupying the hill and mountain areas which are derived in place by the weathering of granitic or sedimentary rocks. Secondly is the Ramona series, which in contrast, are old valley fill soils derived from ancient weathered, fluvial deposits. The third type consists of the recent alluvial soils including the Hanford, Tujunga, Yolo and Dublin soil series.

Climate

The Upper Los Angeles River area has the climate of an interior coastal valley and is hotter in the summer and wetter in the winter than the coastal area which has a Mediterranean type climate. The range of temperature and occurrence of fog and frost vary within the valley with the west and north sections being subject to the highest temperatures.

The variations of temperature and frost conditions within the area is sufficient to have influenced the location of citrus orchards. The northern edge of the valley along the base of the mountains where most of the groves are located, is higher, warmer and more frost free than areas of lower elevation in the westerly portion.

The central portion of the valley is at times swept by hot, dry and strong winds of short duration.

Culture

The San Fernando Valley, prior to the importation of water from Owens River by the City of Los Angeles, was mainly an area of large holdings devoted to dry farming. The importation of water in 1915 brought about a shift to irrigated agriculture and subdivision of the large holdings into smaller farm and home acreages. The cities of Burbank, Glendale and San Fernando were incorporated prior to 1915. During 1915 the City of Los Angeles annexed large areas in the San Fernando Valley which resulted in the greater portion of the valley fill and lower hill area being included in incorporated areas.

Urbanization of the area has been a continuous process except for the depression period from 1932 to 1938. Growth was further accelerated after the end of World War II by the general trend toward suburban living and more recently by the development of new industries in the central and west portions of the valley.

Continuing growth is evidenced by the filing during 1959 of tentative subdivision maps for 8,100 lots on 5,500 acres of land within the portion of the City of Los Angeles located west and north of Burbank. The same area had 29,000 building permits, totaling $300 million in valuation, issued during 1959.

CHAPTER III. GEOLOGY

This chapter is an evaluation of geologic features and conditions insofar as they affect the occurrence and movement of ground water and the surface and ground water hydrology of the Upper Los Angeles River area and any subdivisions which may exist and the interconnection or interdependence thereof. It is designed to satisfy in part, paragraphs I. 1, I. 2A, I. 2C, I. 2D, and I, 2G, of the Order of Reference. Items such as water-bearing and nonwater-bearing rocks, faults and folds which affect the water-bearing materials, and the configuration of the valley fill and its characteristics are discussed. The various hydrologic subareas and their interrelation are described.

Areal Geology

A map of the areal geology compiled from published sources and supplemented by unpublished Masters and Doctors theses from the graduate schools of the colleges and universities in Southern California and through investigation by the Referee, is presented on Plate 4. This map, entitled "Areal Geology", presents the general geologic framework necessary for the study of ground water and its movement within the Upper Los Angeles River area. Plate 4 also shows the relative ages and briefly describes the various lithologic units found within the area. The plate also shows the relationship of mountain areas which are for the most part composed of nonwater-bearing materials, and the valley fill which comprises most of the water-bearing material.

The approximate depths of the nonwater-bearing materials below the valley floor are indicated on Plate 6, entitled "Contours on Base of Valley Fill". The geologic cross sections on Plates 5A through 5H have been plotted to aid the understanding of the relationship between the water-bearing and nonwater-bearing formations. The location of the various cross sections is shown on Plate 5.

Previous Investigations

The many bulletins and papers published on the geology of various portions of the Upper Los Angeles River area have been related primarily to the rocks which surround the valley fill area of the basin. State Division of Water Resources Bulletin 45 (1934) reports on the only investigation which has studied the water-bearing properties of alluvial materials. This bulletin has been studied in detail and information therein pertaining to geology, specific yield and ground water storage capacity, modified in the light of additional and more recent data, has been incorporated into this report.

Present Investigation

The present geological investigation has been limited to the determination of the hydrologic units or subareas existing in the Upper Los Angeles River area and to studying the nature and distribution of alluvial materials which would be considered a source of ground water. Numerous wells and test holes were inspected and logged during the course of the investigation. Many cuts, trenches and gravel pits were studied to become familiar with the composition of the sediments in the various portions of the basin and to aid in the interpretation of well logs. Geologic mapping was mainly confined to the alluviated areas with special attention being given to the contacts between the water-bearing and nonwater-bearing units.

Detailed descriptions of the items covered in this chapter, as well as a discussion of field investigations made during the investigation, are contained in Appendix A.

Geologic Formations

The ages of geologic rock units and formations of the Upper Los Angeles River area represent a long span of geologic time. Rock units of the Basement Complex have been assigned an age of Pre-Cambrian, whereas other units within the Basement Complex represent various periods through the upper Jurassic or Lower Cretaceous. The sedimentary formations present in the area of investigation are represented by the Cretaceous Chico, lower Eocene Martinez, middle Eocene Domengine, middle Miocene Topanga, upper Miocene Modelo, lower Pliocene Repetto, upper Pliocene Pico and lower Pleistocene Saugus formations. Upper Pleistocene, Older alluvium and Recent alluvium are unconsolidated deposits which are of special interest in this study. The location of the different formations with geologic legend is shown on Plate 4.

Nonwater-Bearing Series

The nonwater-bearing series are rocks which do not absorb, transmit or yield water readily; however, they may contain a limited amount of water in fractures. The nonwater-bearing series comprise the following lithologic units: Basement Complex granitic and metamorphic rock types; Chico sandstone and some conglomerates; Martinez shales and sandstones; Domengine sandstone and conglomerate; Topanga conglomerate sandstone with interbedded volcanics, Modelo shale, sandstone and conglomerage; Repetto siltstone, sandstone and conglomerate; and Pico shale and siltstone.

The Basement Complex yields small flows (20-30 gpm) of good quality water from tunnels, while water wells drilled into the Chico, Topanga and Modelo formations have very poor yields of generally poor quality water. The Martinez and Domengine formations are of limited areal extent and therefore of minor importance as possible sources of water.

Water-Bearing Series

The water-bearing series consist of rock units which absorb, transmit and yield water to wells readily. The Saugus formation (including Sunshine Ranch formation), Older alluvium (including Pacoima formation) and Recent alluvium comprise this group.

Alluviation. Sedimentary deposits may originate from one of three environments: marine, transitional or continental. The water-bearing deposits of the Upper Los Angeles River area are classified as primarily continental. They may be further subdivided as alluvial stream deposits.

In late Pleistocene and Recent time, when most of the water-bearing deposits were being laid down, the valley area was above sea level and was lowering with respect to the continued rising of the San Gabriel Mountain block. As the block rose, increased stream gradients resulted and heavier loads of debris were transported down the mountain block face. Upon reaching the gentler piedmont slope at the mountain front, gradients and velocities were sharply decreased with a resultant lessening of load carrying capacity and deposition of the transported load commenced along the mountain front.

Materials were deposited by the individual streams as large and small alluvial fans. The coarser debris was normally deposited near the conal apices while the finer materials were carried farther out toward the distal portions of the cones. During wet and dry years or cycles when stream carrying power varied considerably, coarse deposits might be deposited over fines or vice versa, resulting in fine materials near the apices in dry periods and coarse material in the distal portions in wet periods.

Changes in stream position on the developing conal surfaces caused centers or axes of deposition to shift from time to time. Overlapping and interfingering of the conal deposits both laterally and axially occurred. Frequent incision of the developing conal surfaces by the streams resulted in reworking and redeposition of some of the original conal material during the alluviation process. Crude stratification exists locally, though in general the deposits are lenticular in shape with the long axis roughly parallel to the main stream course.

During and after deposition, alternate wetting and drying of buried material due to a fluctuating water table and other normal weathering

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processes allowed accelerated weathering with a resultant development of more clay in the coarser deposits than might be normally expected. Weathering continues to occur at the surface and at depth, slowly increasing the clay content of these materials. The increase in clay content has the effect of reducing the specific yield and general permeability. The latter two items have been further reduced as a result of consolidation by load.

The most recent streams (present day) have incised their channels in the older conal deposits, which have coalesced near the mountain front. The most permeable deposits are now found in these channels. These channel deposits are the best means of percolating stream flow to the underground and transmitting underflow through the area.

Saugus Formation. The Saugus formation crops out in the hills and southern slopes of the mountains along the northern part of the valley floor and underlies the other members of the water-bearing series. The maximum thickness of this unit as measured in Lopez Canyon is 6,400 feet. From here the formation thins rapidly in an easterly direction to 2,000 feet thick two miles east of little Tujunga Canyon and in a westerly direction to 3,000 feet of thickness at San Fernando Reservoir. There are no outcrops of the Saugus formation in the Simi Hills, Santa Monica Mountains or Verdugo Mountains, indicating that this formation probably underlies only the northern portion of the valley floor. Only those portions of the Saugus formation which are overlain by Older and Recent alluvium and are below the water table are considered herein to be part of the ground water reservoir. The Saugus formation has been included in the water-bearing materials comprising the ground water reservoir within the Sylmar Hydrologic Subarea and in the northern portion of the San Fernando Hydrologic Subarea. Those portions of the exposed Saugus formation located in the hill and mountain area to the east and west of the Sylmar Hydrologic Subarea have in general been considered as part of the nonwater-bearing series because the change in storage and extractions from those areas were negligible and the areas of recharge are of limited extent.

The Saugus formation is composed of uncemented continental and marine deposits of conglomerates, sands, silts and clays. Some of these materials make good aquifers under saturated conditions whereas others are aquicludes. The materials of the Saugus formation have been derived from the Basement Complex in the eastern part of its exposures and from Tertiary sedimentary formations in the area adjacent to the Santa Susana Mountains. There is a marked difference within the formational materials derived from the different source areas in terms of porosity and permeability, with those deposits having their source areas in the San Gabriel Mountains being the most permeable.

Older Alluvium. The Older alluvium is composed of generally coarse-grained unconsolidated or uncemented deposits of modern streams laid down in earlier cycles of erosion. The source areas of the streams during earlier and present stages of erosion have undergone little change. With the exception of remnants (terrace deposits) which have been isolated by erosion around the margin of the valley floor, deposition has been nearly continuous to the present time.

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The materials that comprise Older alluvium consist of red-brown to gray, dirty, unsorted, angular to subangular debris which is of local origin. During the numerous intervals of time between periods of deposition weathering played an important role in forming horizons which represent ancient soils.

The water-bearing properties of these materials are variable, depending upon the source areas; however, the permeabilities are generally greater than that of the Saugus formation due primarily to the fact that the Older alluvium is less compacted and less consolidated and also generally contains less residual clay.

Recent Alluvium. Recent deposits east of Pacoima Wash and north of the Los Angeles River consist of predominantly coarse accumulations of boulders, gravels and sands in the form of coalescing alluvial fans derived primarily from Basement Complex sources. The median particle diameter of the fan deposits decreases as the distance increases from the canyon mouths. Westerly of Pacoima Wash and south of the Los Angeles River the sediments are derived primarily from sedimentary rocks and are finer grained and deposited in much the same manner as the underlying Older alluvium. Well logs from the western portion of the valley floor indicate an average of about 75 percent clay, 5 percent sand and 20 percent gravel, whereas the materials underlying the eastern portion of the area average 20 percent clay, 35 percent sand and 45 percent gravel.

Structural Features

The geologic structure of the Upper Los Angeles River area is very complex. Extensive faulting and folding of the rocks that surround the ground water reservoir indicate that the rocks beneath the valley fill materials are also faulted and folded. The major faults and folds which affect the movement of ground water within the valley fill are discussed below.

Faulting

Faulting in the area of investigation is dominated by the San Gabriel fault system. Faults of the Sierra Madre system are important features in the Santa Susana and San Gabriel Mountains; however, only those faults which may affect the movement of ground water are described in this report. The Verdugo, Eagle Rock and Raymond fault zones have an effect on the movement of ground water in certain locations. The Northridge Hills fault or folds are believed to have an effect on ground water movement, but data to evaluate this effect are lacking. The locations of the faults are shown on Plate 4. Detailed discussions of the faults and fault zones are contained in Appendix A.

Verdugo Fault Zone. The water levels southerly of the City of Glendale's submerged dam suggest a gradient steeper than would normally be expected. The Verdugo well 3963A, and well 3954 which is about 7,000 feet southerly of the Verdugo well, show a difference in water levels of approximately 300 feet. Measurements at well 3963 (destroyed in 1944) indicate a water level above a hydraulic grade line connecting the two aforementioned wells. Depth to bedrock is 54 feet in the Verdugo well (3963A), more than 535 feet at well 3954, and unknown at well 3963, although this well is reported to be 100 feet deep. Water levels given in Water Supply Paper 219 (1908) for Verdugo Canyon indicate a similar condition existed at that time. On the basis of the foregoing information, a ground water cascade controlled by offsets in bedrock along the Verdugo fault zone has been postulated as the reason for the anomalous water level condition (Plates 4 and 5G).

Movements on this fault system during the Quaternary period have had some effect on the aquifers by the formation of clayey gouge seams in the sands and gravels which extend between the Verdugo Mountains and Pacoima Hills. The effect of the faulting has been to create a zone of lower permeability which causes a distinct break in the ground water surface when the Hansen spreading grounds are in operation. When the spreading grounds are not in operation the difference in ground water elevations on either side of the fault are of a much smaller magnitude.

Eagle Rock Fault. Presence of the aforementioned step-like ground water cascade at the mouth of Verdugo Canyon may have been caused by a northwesterly extension of the Eagle Rock fault to the Verdugo fault. Although no surface alluvium appears to have been displaced by the Eagle Rock fault in this vicinity, the general structural pattern suggests that the Eagle Rock fault may be related to the Verdugo fault system (Plates 4, 5G and 5H). There has been some conjecture by previous workers that this fault may extend westerly under the valley fill passing near the junction of the Los Angeles River and Verdugo Wash. Such an inferred extension would explain the abrupt rise in the nonwater-bearing rocks which underlie the water-bearing series where the Los Angeles River turns southerly into the Los Angeles River Narrows. This feature is shown on Section M-M' on Plate 5E. A scissors-type movement on the Eagle Rock fault would be necessary to explain the relationship of the blocks on either side of the fault. More detailed geologic information is needed before the relationship can be established between the Eagle Rock fault and the fault in the nonwater-bearing series that underlies the alluvium near the south side of the Los Angeles River immediately upstream from its confluence with the Verdugo Wash.

Raymond Fault. The surface of the Older alluvium which overlies the trace of the Raymond fault (Plate 4) has not been disturbed by movement on this fault within the area of investigation; however, movement along this fault zone prior to the deposition of the uppermost strata of the Older alluvium has faulted the water-bearing sediments against the nonwater-bearing rocks of the Puente formation (Plate 5H) and thus forming a barrier to the movement of ground water from the Eagle Rock Subarea. The movement necessary to bring about this condition is contrary to the general direction of movement on the fault to the east of the area of investigation.

Older movements on this fault have also affected the configuration of the base of the valley fill in the central part of the Los Angeles River Narrows. A small knob of nonwater-bearing rocks (Plate 6) is present north of the fault and a depressed area lies immediately south of the fault. The knob has created a constriction in the water-bearing materials and

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probably is the cause of the rising water that has been reported in the past near Los Feliz Boulevard.

Smaller Unnamed Faults. In the Sunland area, which is adjacent to Big Tujunga Wash, there is an offset in the nonwater-bearing formations below the valley fill amounting to about 30 feet (Plate 5F). The location of this offset is in well grid coordinates 4983 (Plate 6). This feature may be due to faulting which is evident in the hills to the northeast and southwest of this feature. This feature has also caused a ground water cascade of similar magnitude in the water-bearing materials.

In the western portion of the San Fernando Subarea, there are several faults which may or may not have an effect on the movement of ground water in the vicinity of Devonshire Street and Topanga Canyon Boulevard (Plate 4). The most prominent of these faults extends northeasterly beneath the valley fill. This fault has displaced the nonwater-bearing materials forming a ground water cascade on the order of 80 feet in height. The area is underlain at shallow depths by Cretaceous sandstones northwest of the fault and by the Modelo shale at greater depths south of the fault. There is a small northwesterly-bearing fault inferred in the water-bearing series paralleling the Northridge Hills fault to the northeast and extending into the nonwater-bearing Cretaceous sandstones to the northwest. The existence of such a feature is substantiated by the difference in ground water levels in this area.

Faults have affected the movement of ground water within the Upper Los Angeles River area by formation of ground water cascades as a result of offsetting nonwater-bearing series; by forming relatively impervious gouge along fault planes during movement; by folding strata so that their position is unfavorable for the percolation of water through them; and by the tilting associated with fault movement which has caused a reduced cross-sectional area for underflow.

Folding

The dominant fold structures affecting the storage and flow of ground water in the San Fernando Valley are located in the northern portion of the valley and delineated on Plate 4. Other folds have little or no effect on the ground water and no extensive study was made of them.

The Little Tujunga syncline (Plate 5J), located between the Verdugo Mountains and the San Gabriel fault, is one of the principal structural features along the north edge of the valley. The effects of this feature on the movement of ground water are of interest in the Sylmar Hydrologic Subarea and are discussed under the description of that subarea. The axis of this fold closely parallels the trace of the Sierra Madre fault zone, following it with a west northwest trend in the area from Tujunga to the Veterans Hospital at Pacoima Canyon, where it may have been overridden by the crystalline rocks along the Hospital fault. Continuing westward, the axis changes to a southwest trend paralleling the northeastern end of the Santa Susana fault. The dip of formations along the south limb ranges from 25 to 80 degrees; the north limb is very steep to overturned and has minor folds

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superimposed on it. Saugus beds are overturned in several places along the Lopez fault, particularly in upper Lopez Canyon (see Plate 5J). Overturning of the Saugus formation also occurs along the Sunland fault where the north limb of the syncline has been almost completely cut out by the fault.

The anticlines and synclines associated with the Northridge Hills fault undoubtedly affect the movement of ground water; however, the extent of the effect is unknown due to an absence of wells. A small anticline is located in the southeast portion of the Mission Hills. This fold may be related to movement on the inferred Mission Hills thrust fault and as a result may not extend under the alluvium easterly of the hills.

Configuration of the Base of the Valley Fill

The configuration of the base of the valley fill is shown by the generalized contours on Plate 6 and by means of geologic cross sections which are indexed on Plate 5. The base of the valley fill was determined by plotting the elevation of the nonwater-bearing materials indicated by various well logs throughout the area of investigation.

The contours on the base of the valley fill (Plate 6) in the western portion of the San Fernando Subarea (Plate 5 and pages 46 to 50) in the vicinity of Arroyo Calabasas and southerly of Bell Creek indicate the existence of an old drainage system. This ancient drainage appears to have flowed northerly, east of Aliso Canyon Wash into the deep portion of the basin which is traversed by the Southern Pacific Railroad (S.P.R.R.).

The depth of water-bearing material is unknown in the central and eastern portion of the subarea, but probably extends to depths of 1,000 to 1,500 feet. An anomalous dome-like feature is present in the vicinity of Lankershim Boulevard and Vanowen Street. The cause of this feature and its relationship to the geology of the area are unknown.

In the vicinity of the confluence of Verdugo Wash and the Los Angeles River, the depth to nonwater-bearing material rapidly decreases as the Los Angeles River enters the Los Angeles River Narrows. The reason for this rapid change in the bedrock profile is not known; however, it has been postulated that this feature is caused by a westerly extension of the Eagle Rock fault or an unnamed fault, the scarp of which was modified by erosion prior to burial. This feature is located in well grid coordinates 3914 and 3924 on Plate 6.

The Elysian Hills anticline, which is located on the southerly side of the Los Angeles River Narrows, is of interest in that continued movement on this feature after the mid-Pleistocene orogeny may have caused the "reversed gradient" on the base of the water-bearing series in the Los Angeles Narrows area. This "reversed gradient" feature shown in profile on Section M-M', Plate 5E, indicates that the base of the water-bearing materials is lower in elevation near Colorado Boulevard than at Figueroa Street or Gage F-57. This is also shown by contours on the base of valley fill on Plate 6. Another possible explanation of this feature is that the Arroyo Seco flowed northerly into the San Fernando Subarea for a period of time in the mid-Pleistocene, as postulated by Homer Hamlin in United States Geological Survey Water Supply and Irrigation Paper 112 (1905).

The Sylmar Hydrologic Subarea (Plate 5 and pages 51 to 55) is almost entirely underlain by the folded Saugus formation which extends to great depths. Immediately below the Saugus formation is the nonwater-bearing Repetto formation which is exposed in both banks of Pacoima Wash at the Pacoima submerged dam, located in the vicinity of well 5989A. These outcroppings and their westerly extension constitute the eastern portion of the southern boundary of the subarea. In the Mission Hills and possibly in the adjacent portion of the Sylmar Hydrologic Subarea, the Saugus formation is underlain directly by the Pico formation. The Repetto formation dips approximately 70 degrees to the north and drops rapidly in elevation under the water-bearing materials.

Contours of the base of the valley fill (Plate 6) in the Verdugo Hydrologic Subarea (Plate 5 and pages 55 to 58) show several interesting features. The most important of these is the existence in the Basement Complex of the buried erosion channel of an ancestral Pickens Wash draining easterly into the Monk Hill Basin (Plate 35). Under low water table conditions this buried channel carries all tributary percolating water to the Monk Hill Basin. Under high water table conditions the southwesterly bedrock ridge, which is the westerly bank of the buried erosion channel, has been overtopped and it is therefore believed that percolation in a westerly direction has occurred.

A second important feature is the depression in the buried bed-rock surface in the vicinity of well 5058J. The bedrock elevation in this depression is some 80 feet lower than the lowest bedrock surface in the mouth of Verdugo Canyon. This depression may be due to displacement on the La Crescenta Valley fault. Maximum depth of water-bearing materials is about 54 feet at Verdugo well (3963) adjacent to the Verdugo submerged dam, while upstream approximately 1-1/2 miles the depth of fill material has increased to a maximum of 190 feet.

The configuration of the base of the valley fill in the Eagle Rock Hydrologic Subarea (Plate 5 and pages 58 to 61) is not shown in detail on Plate 6 due to the small area involved and to the 100-foot contour interval which was utilized on the plate. A more graphic representation of the valley fill in the subarea is shown on Geologic Cross Section S-S' on Plate 5H. This section shows the deepest portion of the fill in this subarea to be located in the vicinity of the Raymond fault. The configuration of the base of the valley fill along Colorado Boulevard in the subarea is not known; however, the depth to bedrock at a well located just northwest of the intersection of Colorado Boulevard and Eagle Rock Boulevard was stated as 140 feet (well No. 333, U.S.G.S. Water Supply Paper 219 field notes). The depth to the nonwater-bearing Topanga formation near the Raymond fault is about 200 feet.

Description of Hydrologic Subareas

The valley fill area of the Upper Los Angeles River area comprises with a few minor exceptions, the areal extent of all Recent alluvium and Older alluvium known to have been saturated or to overlie water-bearing materials. Isolated areas of Saugus and Recent alluvium in upper Little and Big Tujunga Canyons, as shown on Plate 4, have been excluded from the valley fill area because of lack of information on water-bearing properties, minor extractions and isolation from the main ground water body. The valley fill boundary was mapped on $7\frac{1}{2}$-minute U.S.G.S. quadrangles from field observations and other available information concerning extent and thickness of water-bearing materials. This boundary was generalized across the mouths of minor canyons to exclude thin tongues of alluvium which would not contain any appreciable amounts of ground water in storage. The valley fill boundary so determined is delineated on Plate 5.

Both the Basement Complex pre-Quaternary sediments and volcanics, which are known to underlie the valley fill area, are deep-seated and relatively impervious and any contribution by ground water movement from them must therefore be small. This investigation has not revealed evidence of any appreciable subsurface inflow from these rocks although records of extractions from wells in these rocks indicate the existence of small amounts of water therein. Water elevations in wells and water inflows encountered in tunnels attest to the fact that where water surfaces exist in these materials they are at elevations substantially higher than the water levels in the valley fill areas. The yield from these rock formations is apparently limited because of the very small specific capacity of wells in these materials, ranging from 0.036 to 0.38 gallons per minute per foot of drawdown as compared to a range in specific capacity for wells located within the valley fill of from three to more than 264 gallons per minute per foot of drawdown.

The aforementioned valley fill area of the Upper Los Angeles River area, exclusive of the portion of the Monk Hill Basin located therein, has been divided into four hydrologic subareas: San Fernando, Sylmar, Verdugo and Eagle Rock, containing 112,047, 5,565, 4,400 and 807 acres respectively. The total valley fill area, including the 609 acres in the Monk Hill Basin portion, is 123,428 acres. Each of these subareas has been defined on the basis of the existence of an apparent impairment of ground water flow from one to the other, caused by man-made works and physiographic or geologic features. The boundaries of the various subareas are shown on Plate 5.

The source of ground water supply in the Upper Los Angeles River area is percolation of rainfall, surface runoff from adjacent valley areas, and hill and mountain areas, spread waters, imported waters, and possibly some underground percolation of water from the mountain masses to the alluvium. Supply from this latter possible source is believed to be minor for the reasons heretofore stated and is not feasible to evaluate. Disposal of the supply, other than by export, evaporation from reservoirs, consumptive use and surface runoff, is by underflow out of the area at the Los Angeles Narrows and in the Pickens Canyon area. These amounts are relatively small and amount to an average of 340 and 300 acre-feet per year at the Los Angeles Narrows and from the Pickens Canyon areas, respectively. Determinations of these amounts are discussed in detail in Appendix P and annual values tabulated in Chapter V.

San Fernando Hydrologic Subarea

The boundaries of the San Fernando Hydrologic Subarea, as shown on Plate 5, are the alluvial contacts with the nonwater-bearing series along the San Rafael Hills and Verdugo Mountains on the east and northeast, the Santa Susana Mountains and Simi Hills on the northwest and west, and the Santa Monica Mountains on the south. The Los Angeles River Narrows area, also part of the San Fernando Hydrologic Subarea, is bounded on the east by the alluvial contact with the San Rafael and Repetto Hills and on the west by this contact with the Elysian Hills. The southern boundary of this subarea has been established at Los Angeles County Flood Control District gaging station F-57, which is about 300 feet upstream from the Figueroa Place (Dayton Street) bridge. The San Fernando Subarea is separated from the Sylmar Subarea to the north by the eroded south limb of the Little Tujunga syncline which causes a break in the water surface of about 40 to 50 feet. This latter boundary is discussed in detail under the Sylmar Hydrologic Subarea.

The portion of the San Fernando Hydrologic Subarea westerly of Pacoima Wash is generally composed of valley fill materials that have a high clay content, whereas the portion that lies easterly of Pacoima Wash is generally composed of coarse deposits of sand and gravel. The valley fill westerly of Pacoima Wash is essentially fine-grained material derived from the surrounding sedimentary rocks. This material transmits water at a relatively slow rate, whereas easterly of Pacoima Wash the material is composed of coarse detritus eroded mainly from the granitic Basement Complex of the San Gabriel Mountains and transmits water at a relatively rapid rate. The eroded debris of the eastern portion is generally very coarse; in places boulders up to three feet in diameter are relatively common. The deposits are essentially sand and gravel with some fines in the interstices. These materials constitute about one-third of the surface area of the ground water reservoir and contain approximately two-thirds of the ground water storage capacity of the San Fernando Hydrologic Subarea. Transition from the fine-grained materials in the western portion to the coarse-grained materials in the eastern portion is depicted on Section M-M' on Plate 5E.

An area of high ground water level is present in the western portion of the hydrologic subarea. The area is bounded on the east by Reseda Boulevard, on the south by the Los Angeles River and to the west by De Soto Avenue. The northern boundary is somewhat L-shaped following Saticoy Street to the vicinity of Tampa Avenue then northerly to Parthenia Street. This area was studied by the United States Department of Agriculture Soil Conservation Service, Research, during the period 1947 through 1950 and is further discussed in Appendix L.

The aforementioned investigation pointed out the following: water level fluctuations in the piezometers installed by the Soil Conservation Service are cyclic with precipitation; these water levels also respond to irrigation water applied in excess of the consumptive use; and deep artesian and/or pressure wells within the area apparently leak into the shallow zone to the extent that small ground water mounds are developed around certain wells. The source of the confined water derived through these wells appears to be from aquifers in the older materials which presumably underlie the alluvium at relatively shallow depths and are recharged by precipitation.

Because of the existence of more permeable gravel stringers in the fine-grained deposits found in the western portion of the subarea, small localized pressure effects can be observed. These gravel stringers represent the former stream channels which have braided over the fine-grained deposits and in turn have been buried by additional fine-grained material.

The eastern portion of the San Fernando Subarea is composed of very permeable deposits. It is in this area that the majority of the large pumping plants are located. In addition to the pumping plants of the City of Los Angeles, shown on Plate 21, the Cities of Burbank and Glendale also extract large quantities of water from this portion of the subarea. The pumping patterns existing in 1930-31 and 1957-58 are shown on Plates 31A and 31B, respectively. This heavy concentration of pumping is reflected by the large depression in ground water levels occurring in the area during the period 1944 to 1958, as indicated on Plate 33.

The water-bearing deposits of the Los Angeles River Narrows are very permeable. The City of Los Angeles has two pumping plants in the area. Due to heavy pumping, large depressions or pumping holes have been created in the ground water surface. The largest of these pumping depressions is located at the bend in the Los Angeles River where the river begins its southerly course through the Narrows. This well field, called the Crystal

Springs well field, along with the City of Glendale's Grandview wells immediately north of the City of Los Angeles' Crystal Springs well field, have created the ground water depression indicated by the ground water contours shown on Plate 30. The heavy pumping of the Pollock well field of the City of Los Angeles has caused a second such depression to develop during 1959 and 1960 and has caused a reversal of the ground water gradient in the Los Angeles Narrows.

Rising water which has occurred historically in reaches of the Los Angeles River along the south side of the valley is due in part to the reduction in the cross-sectional area of the water-bearing material as the stream approaches the F-57 gage. The maximum depth of water-bearing materials at Huron Street (Gage F-57) is about 110 feet, whereas the maximum depth at the Pollock well field is 260 feet. A comparison of the two areas is shown by sections K-K' and L-L' on Plate 5D.

Ground water moves in the direction of the hydraulic gradient or slope of the ground water surface from areas of recharge to points of discharge. General direction of ground water flow is from the recharge areas in the alluvial cones along the edges of the valley fill toward the discharge area in the Los Angeles River Narrows.

Pumping large quantities of water for municipal uses has greatly modified the predevelopment condition in the eastern portion of the San Fernando Subarea with respect to the depths to water, hydraulic gradients and local direction of ground water movement.

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Ground water elevation contours for the fall of 1931, 1938, 1944 and 1958 are shown on Plates 27, 28, 29 and 30, respectively. These contours were based upon the water level measurement data which were collected from the various parties and the Los Angeles County Flood Control District. The depths to water at the wells have been converted to elevation above sea level (U.S.G.S. datum) by subtracting them from the surface elevation or reference point elevation obtained by direct surveying methods or by interpolation between contours on U.S.G.S. $7\frac{1}{2}$-minute quadrangles. The ground water contours are solid where a satisfactory degree of control and accuracy exists and dashed where there is a paucity of information. The notations "area of no control" and "area of poor control" are in valley fill areas where there are insufficient measurements or lack of well information from which to draw satisfactory contours.

The subsurface outflow from the San Fernando Subarea averaged about 340 acre-feet per year during the 29-year base period. A detailed discussion of this item is contained in Chapter V and Appendix P.

Water level fluctuations in the subarea are depicted by the hydrographs of wells considered generally representative and are shown on Plates 34A and 34B.

Sylmar Hydrologic Subarea

The Sylmar Hydrologic Subarea comprises the area enclosed by the boundary of valley fill contacting the San Gabriel Mountains on the north, the Mission Hills on the southwest, the Upper Lopez Canyon Saugus formation on the east along the east bank of Pacoima Wash, and the eroded south limb of the Little Tujunga syncline on the south. The boundary of this subarea is delineated on Plate 5. The topographic divide in the valley fill lying between the Mission Hills and San Gabriel Mountains has been utilized as the subarea boundary because of lack of data with which to determine the ground water divide. Although the eastern boundary has been taken as the east bank of Pacoima Wash, it is possible that movement of ground water in a westerly direction can occur in the Saugus formation from the Upper Lopez Canyon and Upper Kagel Canyon area which lies immediately to the east of Pacoima Wash. Available data are insufficient to evaluate this possible movement; however, if such movement does occur it is believed to be minor in amount because of the small tributary drainages and rain consumption of native cover. The southern boundary of the subarea is taken along the contact between the Saugus formation and underlying Repetto formation in the vicinity of Pacoima Wash, thence westerly to the intersection of Foothill Boulevard and Fernmont Street, thence in a southwesterly direction following the break in the ground water surface, as defined by the test drilling performed during the course of the investigation. This boundary intersects the Mission Hills immediately southeast of the Mission well field.

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The geology of the Sylmar Subarea is greatly complicated by faulting and folding. The nonwater-bearing materials to the north of the subarea have been faulted and in part thrust southerly over portions of the water-bearing Saugus formation. The compressive forces that are related to the thrust faulting are also related to the formation of the Little Tujunga syncline,(See Plate 5J for Block Diagram) which is the most important feature of the subarea. At least 6,000 feet of Saugus formation and an even greater thickness of older nonwater-bearing sediments have been folded into an asymmetric syncline with the north limb overturned. This syncline has been truncated by erosion and covered by a relatively thin blanket of Older and Recent alluvium. The southeastern boundary of the subarea, as hereinbefore noted, is formed by the steep northerly dipping beds of the nonwater-bearing Repetto and Pico formations that are part of the same synclinal structure. The Repetto formation is exposed in both banks of the Pacoima Wash at the topographic constriction, which is the site of the Pacoima submerged dam located about 2.5 miles south of Pacoima Dam. These strata continue westerly under the cover of the Older alluvium and are exposed in roadcuts near the intersections of Gladstone Avenue and Maclay Avenue and Foothill Boulevard and Fernmont Street (see Figure A-1 for street locations).

The valley fill material in the gap between outcrops of nonwater-bearing materials extending from Foothill Boulevard to Mission Hills contains a very marked discordance in water levels. In order to more accurately locate the break in the water surface and the eroded south limb of the Little Tujunga syncline, 20 bucket auger holes were drilled. Nine of the twenty holes were drilled under the direction of and at the expense of the City of San Fernando, five by the City of Los Angeles, and the remaining six by the Referee. Representatives of the Referee were present at the drilling of all holes and prepared detailed logs of each boring. The locations of the test holes are shown on Figure A-1 of Appendix A, and relative locations of the formations are shown on Section H-H' (Plate 5C) and Sylmar Notch (Plate 5H). The logs of the test holes are included in the well log section of the basic data. The boundary of the subarea was delineated in the gap area on the basis of water levels.

The analysis of available water level data, data obtained from the test holes and the geology of the area indicate the following:

1. Water levels northwesterly of the break in the water surface are about 50 feet higher than those to the southeast of the break. (See Plate 30).

2. Water levels northwesterly of the break are related to the eroded ends of confined aquifers in the Saugus formation.

3. Water levels southeasterly of the break are free ground water levels and are associated with coarse alluvial deposits which had the Pacoima drainage as a source area.

4. The discordance in water levels is related to the eroded south flank of the Little Tujunga syncline which has been covered with a thin veneer of alluvium.

5. Subsurface flow from the Sylmar Subarea into the San Fernando Subarea occurs only at two places; namely, the Sylmar and Pacoima Notches (see Plates 5 and 5H). There is hydraulic continuity between the confined aquifers and the veneer of alluvium that overlies the eroded south flank of
63 the Little Tujunga syncline.

6. Continuity exists between the Sylmar and San Fernando Subareas through the saturated alluvium in the two notches.

7. The configuration of the break in water surface through the Sylmar and Pacoima Notches is not sharp as would be caused by a fault but is a steep gradient which is similar to that found in a ground water cascade.

The average underflow from Sylmar Subarea to the San Fernando Subarea through the Pacoima and Sylmar Notches is estimated at 160 and 400 acre-feet per annum, respectively, during the base period. The Pacoima submerged dam which is located at the Pacoima Notch was constructed in 1888. Prior to its construction and under conditions equivalent to those occurring during the base period, it is estimated that 350 acre-feet per annum would have moved southerly from Sylmar into San Fernando Subarea through the Pacoima Notch. It is therefore concluded that when the Pacoima submerged dam was not in place there was less opportunity for the underflow of Pacoima Wash to move westerly within the Sylmar Subarea.

The information obtained from the test holes was necessary to evaluate the occurrence and movement of ground water within the subarea. The noticeable pressure rise of the water surface which took place in several of the test holes during and immediately after drilling, coupled with the fact that there are historic records of artesian flows for the Mission well field of the City of Los Angeles and the City of San Fernando well field at Fourth and Hubbard Streets, indicates that confined water exists within the Sylmar Subarea. The existence of an area of free ground water between the aforementioned well fields was also determined during the test drilling. All wells in the subarea, however, derive their water supplies from the confined aquifers of the Saugus formation. In 12 of the test holes, the Saugus formation was penetrated before saturated materials were reached.

There was a decline in water levels in the free ground water area coincident with heavy pumping of the Mission well field. Therefore, on the basis of the short period of record available (since December 1958), it appears that the free ground water area is in hydraulic continuity with the confined aquifer system.

The exact location and extent of the forebay or recharge area for the confined aquifers are not definitely known; however, the porous alluvial materials in the Pacoima Wash are in a favorable position to recharge along the strike of the westerly plunging aquifers of the Saugus formation. These aquifers are in contact with the stream gravels in the incised and backfilled portion of Pacoima Wash. These permeable deposits, which are 50 to 60 feet in depth, hold water behind the submerged dam, increasing the possibility of percolation into the aquifers of the Saugus formation. Ground water elevation contours (Plates 27 through 30) indicate that there is a slope of the water surface from Pacoima Wash toward the lower portion of the subarea where the majority of extractions are made.

Water level fluctuations within Sylmar Subarea during the base period are represented by hydrographs of wells 5939, 5969 and 5989A, which are shown on Plate 34C.

Verdugo Hydrologic Subarea

The Verdugo Hydrologic Subarea, as shown on Plate 5, is located in the northeastern portion of the San Fernando Valley. It is a narrow alluvial-filled trough bounded by the alluvial contact with the nonwater-bearing hill and mountain groups. This contact is against the San Gabriel Mountains on the north, the Verdugo Mountains to the south and west, and the San Rafael Hills to the southeast. The western boundary has been taken as the topographic divide between the drainage area that is tributary to Big Tujunga Wash to the west and Verdugo Wash to the east. Location of the eastern hydrologic boundary is variable dependent on whether ground water levels are higher or lower than the bedrock ridge westerly of Pickens Canyon as described on page 42. Geologic cross sections O-O', P-P' and Q-Q' on Plates 5F and 5G, and contours showing the elevation of the base of the valley fill on Plate 6, indicate that bedrock to the east of Pickens Canyon is lower than this ridge and that a buried ancestral Pickens Canyon channel slopes to the east.

Available ground water elevations indicate that the bedrock ridge diverts ground water to the east under low water table conditions as existed in the fall of 1958, (see Plate 30) and is the ground water divide under these conditions. During high water table periods, such as occurred in 1944, (see Plate 29) ground water levels are above the ridge and water would also flow across the ridge into the Verdugo Subarea. The ground water divide under this condition would be situated to the east of Pickens Canyon toward the location of the watershed boundary of the Upper Los Angeles River area. Because of this variation in actual location of the ground water divide, depending on water table elevations, the location of the Raymond Basin Reference boundary (i.e. a line extending southerly along the east bank of Pickens Canyon to Foothill Boulevard, thence easterly along Foothill Boulevard to the edge of the valley fill, see Plate 5) was adopted as the eastern hydrologic boundary of the Upper Los Angeles River area and the Verdugo Hydrologic Subarea.

The ground water elevation contours in Verdugo Subarea shown on Plates 27 to 30 indicate a movement of ground water in a southerly direction from the mouths of canyons in the San Gabriel Mountains toward Verdugo Canyon. The surface and subsurface drainage from the Verdugo Subarea would thus naturally flow southerly through the relatively long and narrow Verdugo Canyon into the San Fernando Hydrologic Subarea. The boundary between these subareas has been taken at the submerged dam of the City of Glendale. The submerged dam which was originally constructed in 1895 was reconstructed in 1935 when the Verdugo Wash Channel was improved. The dam, as rebuilt, is shown in profile on Plate 5H. The effect of the dam is discussed in Appendix P.

The water-bearing materials of the Verdugo Subarea are surrounded by a complex of granitic and metamorphic rocks which have been highly fractured. This Basement Complex yields only small amounts of water to springs and tunnels from fracture systems which in turn are supplied by infiltration of precipitation. Nine tunnels drilled into the Basement Complex in the Verdugo area were observed to have flows ranging from 4 to 30 gallons per minute with an average flow during September 1959 of 20 gpm.

The valley fill is composed essentially of coarse ditritus which has been deposited in a series of coalescing fans. The principal source area has been the San Gabriel Mountains. Well logs indicate a fairly high content of sand, gravel and boulders; however, numerous clay designations in well logs indicate that there is considerable clay in the matrix of some of these materials. Well log information indicates that the material in the area north of Foothill Boulevard has a lower specific yield than elsewhere in the subarea with the result that wells in this area have a much smaller specific capacity than those located in the southerly portion of the subarea.

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Most of the ground water extractions in the Verdugo Subarea are by wells of Crescenta Valley County Water District located along the southwest side, by wells of the City of Glendale at the Glorietta well field (see Plate 31A), in Verdugo Canyon, and by the Verdugo submerged dam and Verdugo well (3963). Studies described in Appendix P indicate that the subsurface outflow from Verdugo Subarea to San Fernando Subarea has become very small in magnitude as a result of the diversion and pumping at the submerged dam by the City of Glendale.

Water level fluctuations within the Verdugo Subarea during the base period are represented by the hydrograph of well 5058 shown on Plate 34C.

Eagle Rock Hydrologic Subarea

The Eagle Rock Hydrologic Subarea, shown on Plate 5, is located in the eastern portion of the Upper Los Angeles River area, adjacent to the east side of the Los Angeles River Narrows. The subarea is bounded by the valley fill contact with the nonwater-bearing materials of the San Rafael Hills on the north and west and the Repetto Hills to the east and south, with the exception of the small alluviated area on the southeastern boundary of the subarea which has been taken as the topographic divide. All surface drainage easterly of the topographic divide in this alluviated area is tributary to the Arroyo Seco via the Avenue 50 storm drain. Little subsurface flow enters the Eagle Rock Subarea at this location due to the limited cross-sectional area, low permeability materials and a very flat hydraulic gradient through the valley fill materials from east to west.

The surface drainage within the subarea flows generally toward the alluviated area between the San Rafael and Repetto Hills, then southwesterly to the Los Angeles River. Glassell Creek, a tributary to the Los Angeles River, drained the area prior to urbanization and the installation of drains. Spot measurement made by J. B. Lippincott from 1898 through 1900 show a maximum discharge of 1.35 second-feet for Glassell Creek at the Los Angeles River.

The southern boundary of the subarea has been taken to be along the buried trace of the Raymond fault zone. Southerly of the fault zone the nonwater-bearing Puente formation is at or near the ground surface. The total drainage area of the subarea above the Raymond fault zone (see Plate 4) is about 2,910 acres. Of this total 807 acres constitute valley fill area.

There is no direct hydraulic connection indicated between the ground water in the main aquifer of the subarea and the ground water in the Los Angeles River Narrows. The subarea is an artesian basin (see Section S-S', Plate 5H) in which all present day pumping is located at the lower end of the pressure area in the vicinity of well 3987F. This well develops about 22 feet of artesian head over week ends when there is no pumping. It should be noted that in the computation and description of hydrologic items of supply and disposal, the Eagle Rock Subarea has been combined with the San Fernando Subarea.

The water-bearing materials are essentially composed of older alluvial deposits of sand, gravel and considerable clay. Recent alluvium occurs only as a thin veneer along stream channels. There is no surface indication that movement on the Raymond fault zone has affected the Older alluvium in the subarea although this has occurred to the east in the Raymond Basin. Some movement, with the direction of the throw being reversed, must have occurred after the deposition of the gravelly aquifer materials to cause the change to the essentially fine-grained materials of the upper aquiclude. The lower aquiclude and aquifer terminate abruptly against the nonwater-bearing Puente formation south of the Raymond fault zone. The upper aquiclude may not have been affected by faulting and may extend southerly of the fault zone. The pressure area extends northerly from the fault zone toward Colorado Boulevard. Hydraulic continuity exists between wells that are located immediately north of the fault and a well which is 3,000 feet north of it in the pressure area. All wells located within the pressure area, estimated at 250 acres in extent, have had a historic record of artesian flows. There are no wells with water level measurements within the forebay or recharge portion of the subarea.

The Eagle Rock artesian system is supplied from percolation of runoff and deep percolation of applied water into the forebay area. This area extends along Colorado Boulevard and easterly of Eagle Rock Boulevard along Yosemite Drive. These waters recharge the pressure aquifer which has lost about four feet of pressure head since 1941 (measured at well 3986B).

The ground waters in the Eagle Rock Subarea move southerly from the forebay areas into the pressure area. The direction of movement within the pressure aquifer is southerly to the vicinity of the pumping wells located above the Raymond fault. There is presently no known subsurface escape of ground water from the pressure aquifer.

Water level fluctuations in the Eagle Rock Subarea are represented by the hydrograph of well 3986B, which is shown on Plate 34C.

Specific Yield of Water-Bearing Materials

To select specific yield values applicable to the various materials described in driller's logs in the Upper Los Angeles River area, the Referee evaluated previous investigations and presently available data. A direct measurement of specific yield by laboratory methods was not considered feasible due to time limitation.

The specific yield of water-bearing materials is defined as the volume of water drained by the force of gravity from a saturated material over a reasonably long period of time, expressed as a percentage of the total volume of the saturated material.

The specific retention of a material is the ratio, expressed as a percentage, of the volume of water which will be retained by the material against the force of gravity to its own volume. The sum of specific yield and specific retention thus equals the total porosity of the saturated materials.

The particle size is an important textural element in fragmental materials because it is related to the dynamic conditions of transportation and deposition. The most common method of measuring particle size is by sieving. This method consists of taking a sample, a sand for example, and shaking it through a series of sieves. The particles are sorted into size groups controlled by the openings in the sieves. The Wentworth grade scale (1922) provides a means of standardizing terminology. Wentworth's grade scale is used by the majority of sedimentologists. This is a geometric scale which is well adapted to the description of sediments because it gives equal significance to the ratios of sizes, regardless of whether these ratios occur in gravel, sand, silt or clay. The difference of a centimeter in the size of a boulder is negligible, whereas a difference as small as one micron in the size of a clay particle may be enough to double or halve it.

The original work on specific yield reported upon in Bulletin 45* utilized the Wentworth system for describing the various particles. This system has also been utilized in the present investigation. The following tabulation shows the grade limits of the various material classifications by Wentworth size class and the comparable nomenclature used in this investigation:

* See Appendix A

WENTWORTH'S PARTICLE SIZE CLASSIFICATION

Grade Limits (Diameters in mm.)	Name	Grade Limits (Diameters in mm.)	Name
Above 256	Boulder	1/2-1/4	Medium sand
256-128	Large cobble	1/4-1/8	Fine sand
128-64	Small cobble	1/8-1/16	Very find sand
64-32	Very large pebble	1/16-1/32	Coarse silt
32-16	Large pebble	1/32-1/64	Medium silt
16-8	Medium pebble	1/64-1/128	Fine silt
8-4	Small pebble	1/128-1/256	Very fine silt
4-2	Granule	1/256-1/512	Coarse clay
2-1	Very coarse sand	1/512-1/1024	Medium clay
1-1/2	Coarse sand	1/1024-1/2048	Fine clay

After consideration of available information in previous investigations, values similar to those used in Bulletin 45 were adopted as being the most representative of the area of investigation. The reasons for minor modifications of the Bulletin 45 values and the method developed are discussed in Appendix D.

The specific yield values utilized in this investigation are as follows:

Material	Specific yield, in percent
Clay	3
Silty clay	5
Clayey sand	5
Fine sand	16
Medium sand	21
Coarse sand	26
Fine gravel	26
Medium gravel	21
Coarse gravel	14

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CHAPTER IV. WATER SUPPLY, UPPER LOS ANGELES RIVER AREA

This chapter contains evaluations of the gross water supply of the Upper Los Angeles River area from all sources, which satisfies in part the requirements of paragraphs I, 2. E., I, 2. F. and I, 7. of the Order of Reference. Included are the amounts of precipitation and import, the historic quality of native and imported waters in the Upper Los Angeles River area, and the selection of base study periods used in determining the safe yield.

The gross water supply to the Upper Los Angeles River area comprises precipitation falling within the watershed and imports through the Colorado River and Los Angeles Aqueducts. The water supply available for ground water recharge is derived from precipitation on the valley floor, runoff from precipitation on tributary hills and mountains, and imports.

Precipitation

Precipitation in the Upper Los Angeles River area is generally in the form of rainfall with snow occurring at times on the higher ridges of the San Gabriel Mountains. Precipitation varies noticeably with elevation and topographic influence as well as from season to season. The mean seasonal precipitation varies from about 14 inches at the western end of the valley to about 35 inches in the San Gabriel Mountains. Precipitation in maximum seasons may be over twice the mean seasonal rainfall while in minimum seasons it may be only one-half the mean. On the average, approximately 80 percent of the annual rainfall occurs during the four winter months of December through March.

Precipitation Characteristics

The greater portion of winter precipitation is derived from rain storms which move inland from the Pacific Ocean. The storms, cyclonic in nature, generally originate in the North Pacific and approach the Pacific Coast moving generally in southeasterly and easterly directions. The storm centers most frequently reach the coast north of San Francisco and in such instances may cause only moderate precipitation in Southern California. However, storm centers which strike the coast farther south often bring intense precipitation to Southern California. Tropical storms which originate in the South Pacific also can bring rain to the Los Angeles area. These storms are irregular in occurrence and the resulting precipitation varies considerably, often bringing warm and heavy rain. During the summer season thunderstorms have occurred in the mountains and although the precipitation may be of high intensity the areal extent of such storms is usually small. Occasionally during the late summer season tropical air from Mexico moves northward and produces heavy but short duration showers over the mountain portion of the Upper Los Angeles River area.

The United States Weather Bureau has reported the distribution of rain* as follows:

> "In the case of the Los Angeles area, the orographic barriers determine to a great extent the general distribution of the highest amounts of rainfall. In the ten major storms there was some variation in the location of the highest centers of rainfall, but there was little variation in the location of the 10,000 square mile area over which the maximum precipitation occurred. This fact demonstrates that the orographic features are the major controlling factors for precipitating the moisture and determining its distribution over area. However, there is one important exception: Intense local rainfall associated with the convergent processes of the cyclonic system itself can and does occur over any area irrespective of topography. In the Los Angeles area this rainfall usually has a relatively short duration (less than 12 hours); for longer periods the largest amounts of precipitation occur over the windward slopes or ridges, where precipitation continues as long as moist air flows in any direction that will force it up slope.
>
> "Obviously, the topography of the region is effective in producing precipitation only when the wind is blowing up slope, any downslope motion being rain-inhibiting rather than rain-producing. Also to be considered is the fact that air coming into the Southern California region from a direction other than between south-southeast (157.50°), and west-northwest (292.5°), clockwise, is either flowing down slope or is considerably drier than air coming from those directions. Examination of all storms showed that when the wind was from any direction outside this SSE-WNW range no appreciable rain occurred and therefore all winds outside this range could be disregarded, except in cases where a front or marked trough extending in a west-to-east direction moved southward over California. During these conditions appreciable rain could occur in the air preceding the front or trough passage even though the isobars indicated movement of air from a direction slightly north to west-northwest."

* Hydrometeorological Report Number 21B, United States Department of Commerce, December 29, 1945.

The isohyetal map (see Plate 9) clearly indicates the orographic effects on the distribution of rainfall in the Upper Los Angeles River area from storms which predominantly come from southerly and westerly directions. The mean annual precipitation increases with increasing elevation on the windward slopes of the San Gabriel and Santa Susana Mountains and then diminishes on the leeward slopes.

As noted by the United States Weather Bureau, intense local rainfall can occur over any area irrespective of topography. It is possible that this rainfall may or may not be recorded at a precipitation station, and in either case, because of the local nature of the rainfall, could induce an undeterminable error in the quantity of precipitation determined from such records.

Quantity of Precipitation

The mean depths of precipitation over the Upper Los Angeles River area, as shown on Plate 9, are based on the 85-Year Mean Seasonal Isohyetal Map for Los Angeles County for the period from 1872-73 through 1956-57, prepared by the Los Angeles County Flood Control District. The isohyetal map is based on 130 master precipitation stations established by the District. The Los Angeles and Pasadena precipitation stations have records throughout the 85-year period and all other master station records were extended to that period by methods described in Appendix E.

The 85-year mean precipitation was computed by applying the Isohyetal Method to the 85-year isohyets within polygons of a Thiessen network. The Thiessen network was constructed by utilizing 22 controlling precipitation stations (see Plate 9 and Table E-1) located within the Upper Los Angeles River area. A more detailed discussion of this procedure is presented in Appendix E. The Isohyetal Method was used to compute the 85-year normal amounts of precipitation rather than applying the normal annual depth of precipitation at the controlling station over the entire polygon area because of the variable effect on occurrence and amount of precipitation resulting from topography and other influences. Some of these influences, particularly those caused by topography, are generally reflected by the isohyets.

The annual amount of precipitation during any year was computed as the product of the index of wetness for that year at the controlling station (see Table E-5), the normal annual depth of precipitation on the polygon containing the station (as determined from the isohyets), and the area of the polygon. The controlling station was considered to be representative of the index of wetness at any point within the polygon because the resulting area of influence is not large compared to the extent of most of the winter storms from which the major portion of the precipitation is derived.

The annual amounts of precipitation on the valley floor hydrologic subareas and the hill and mountain areas were computed separately and are shown in Table 1 for the 30-year period 1928-29 through 1957-58. Annual precipitation in percent of 85-year normal is shown in Table 2. It should be noted that the average values shown in Table 2 indicate that the mean annual precipitation on the valley floor for the 29-year period 1928-29 through 1956-57 is slightly greater than the 85-year normal; however, the combination of valley fill and hill and mountain precipitation for this period is practically the same as the 85-year normal for the total area.

TABLE 1

ANNUAL PRECIPITATION

In Acre-Feet[a] and Inches

Year	Hydrologic subareas						Upper Los Angeles River area					
	San Fernando[b]		Sylmar		Verdugo[c]		Valley fill		Hill and mountain		Total	
	Acre-feet	Inches	Acre-feet	Inches	Acre-feet	Inches	Acre-feet	Inches	Acre-feet	Inches	Acre-Feet	Inches
1928-29	108,970	11.59	6,190	13.35	7,280	17.44	122,440	11.90	260,010	15.17	382,450	13.94
29-30	112,130	11.92	7,090	15.29	6,500	15.58	125,720	12.22	276,060	16.10	401,780	14.65
1930-31	140,410	14.93	8,070	17.40	7,280	17.44	155,760	15.14	311,010	18.14	466,770	17.02
31-32	186,030	19.78	10,350	22.32	11,070	26.51	207,450	20.17	440,210	25.66	647,660	23.61
32-33	119,750	12.73	6,360	13.71	7,380	17.67	133,490	12.98	283,120	16.52	416,610	15.19
33-34	132,680	14.11	7,170	15.46	10,190	24.42	150,040	14.59	300,100	17.51	450,140	16.41
34-35	184,260	19.59	10,430	22.49	12,420	29.76	207,110	20.14	461,580	26.93	668,690	24.38
1935-36	115,460	12.28	7,580	16.34	7,960	19.07	131,000	12.74	284,090	16.57	415,090	15.13
36-37	215,710	22.94	12,470	26.88	13,980	33.48	242,160	23.54	549,310	32.04	791,470	28.86
37-38	228,990	24.35	12,870	27.76	16,690	39.99	258,550	25.14	595,540	34.74	854,090	31.14
38-39	197,910	21.04	10,350	22.32	10,870	26.04	219,130	21.30	418,050	24.39	637,180	23.23
39-40	155,230	16.50	8,230	17.75	8,540	20.46	172,000	16.72	322,680	18.82	494,680	18.04
1940-41	371,580	39.51	18,250	39.36	19,990	47.90	409,820	39.84	811,180	47.32	1,221,000	44.52
41-42	124,200	13.21	6,360	13.71	7,180	17.21	137,740	13.39	279,120	16.28	416,860	15.20
42-43	229,220	24.37	12,710	27.41	17,080	40.92	259,010	25.18	587,100	34.25	846,110	30.85
43-44	230,250	24.48	11,980	25.83	12,030	28.83	254,260	24.72	553,860	32.31	808,120	29.46
44-45	131,020	13.93	7,660	16.52	9,800	23.48	148,480	14.44	352,800	20.58	501,280	18.28
1945-46	125,990	13.40	7,250	15.64	8,060	19.30	141,300	13.74	342,760	19.99	484,060	17.65
46-47	137,690	14.64	8,390	18.10	9,900	23.72	155,980	15.16	377,670	22.03	533,650	19.46
47-48	71,730	7.63	3,990	8.61	4,370	10.46	80,090	7.79	190,890	11.14	270,980	9.88
48-49	75,680	8.05	4,970	10.72	5,920	14.18	86,570	8.42	212,450	12.39	299,020	10.90
49-50	97,480	10.36	6,360	13.71	7,380	17.67	111,220	10.81	247,900	14.46	359,120	13.09
1950-51	79,700	8.47	5,300	11.42	4,860	11.63	89,860	8.74	180,000	10.50	269,860	9.84
51-52	281,800	29.96	15,890	34.26	17,280	41.39	314,970	30.62	647,000	37.74	961,970	35.07
52-53	107,200	11.40	6,190	13.35	5,530	13.25	118,920	11.56	228,930	13.35	347,850	12.68
53-54	122,260	13.00	7,010	15.11	9,120	21.86	138,390	13.45	302,930	17.67	441,320	16.09
54-55	129,180	13.74	6,600	14.23	7,080	16.97	142,860	13.89	278,180	16.23	421,040	15.35
1955-56	153,270	16.30	8,960	19.33	9,020	21.62	171,250	16.65	324,980	18.96	496,230	18.09
56-57	120,000	12.76	6,760	14.58	7,280	17.44	134,040	13.03	270,760	15.79	404,800	14.76
57-58	249,700	26.55	14,260	30.75	14,660	35.11	278,620	27.09	608,250	35.48	886,870	32.33
29-Year Average[d] 1929-1957	154,680	16.45	8,680	18.72	9,730	23.30	173,090	16.82	368,630	21.50	541,720	19.75
85-Year Average[e] 1873-1957	149,880	15.94	8,150	17.57	9,710	23.25	167,740	16.31	377,110	22.00	544,850	19.86

a. Annual water crop rounded off to nearest 10 acre-feet.
b. Includes Eagle Rock Subarea.
c. Includes portion of Monk Hill Basin within Upper Los Angeles River Area.
d. 29-year base period 1928-29 through 1956-57.
e. 85-year period of normal precipitation 1872-73 through 1956-57.

TABLE 2

ANNUAL PRECIPITATION
IN PERCENT OF 85-YEAR NORMAL[a]

Year	Valley fill area: Hydrologic Subarea: San Fernando[a]	Valley fill area: Hydrologic Subarea: Sylmar	Valley fill area: Hydrologic Subarea: Verdugo[b]	Valley fill area: Total	Hill and mountain areas	Upper Los Angeles River area
1928-29	73	76	75	73	69	70
29-30	75	87	67	75	73	74
1930-31	94	99	75	93	82	86
31-32	124	127	114	124	117	119
32-33	80	78	76	80	75	76
33-34	89	88	105	89	80	83
34-35	123	128	128	123	122	123
1935-36	77	93	82	78	75	76
36-37	144	153	144	144	146	145
37-38	153	158	172	154	158	157
38-39	132	127	112	131	111	117
39-40	104	101	88	103	86	91
1940-41	248	224	206	244	215	224
41-42	83	78	74	82	74	77
42-43	153	156	176	154	156	155
43-44	154	147	124	152	147	148
44-45	87	94	101	89	94	92
1945-46	84	89	83	84	91	89
46-47	92	103	102	93	100	98
47-48	48	49	45	48	51	50
48-49	51	61	61	52	56	55
49-50	65	78	76	66	66	66
1950-51	53	65	50	54	48	50
51-52	188	195	178	188	172	177
52-53	72	76	57	71	61	64
53-54	82	86	94	83	80	81
54-55	86	81	73	85	74	77
1955-56	102	110	93	102	86	91
56-57	80	83	75	80	72	74
57-58	167	175	151	166	161	163
29-Year Average[c] 1929-57	103.3	106.6	100.2	103.2	97.9	99.5
85-Year Average[d] 1873-57	100.0	100.0	100.0	100.0	100.0	100.0

a. Includes Eagle Rock Subarea.
b. Includes portion of Monk Hill Basin within Upper Los Angeles River area.
c. 29-year base period 1928-29 through 1956-57.
d. Normal based on 85-year period 1872-73 through 1956-57.

Selection of Base Study Period

The desirable base study period is one during which precipitation characteristics in the Upper Los Angeles River area approximate the 85-year period of record, 1872-73 through 1956-57. A further requirement of such a period is that additional hydrologic information is available sufficient to permit an evaluation of the amount, occurrence and disposal of the normal water supply under recent culture conditions. The desirable base period includes both wet and dry periods similar in magnitude and occurrence to the normal supply, and during which there are sufficient measurements and observations to relate the hydrology to recent culture.

Subsequent to 1927-28, records of stream outflow, culture distribution and water utilization on the valley floor, and ground water levels at wells are fairly comprehensive and adequate. In contrast, earlier records concerning these items are available only on a limited basis. There is a paucity of earlier measurements required to determine basin-wide ground water levels and continuous stream outflow. Because of the aforementioned requirements and limitations, the selection of a base period was restricted to years subsequent to 1927-28.

To determine the regimen of occurrence of rain in the Upper Los Angeles River area, selected precipitation stations on the valley floor having long periods of record were studied for an indication of periods with an occurrence of rain equivalent to the normal period. The 85-year mean seasonal precipitation was used to compute the indices of wetness for these selected stations, and annual averages of these indices of wetness were utilized to construct the cumulative percentage deviation mass diagram for the Upper Los Angeles River area, shown on Plate 10.

Comparison of the precipitation trends in the Upper Los Angeles River area with those reflected by the longer record of precipitation at Los Angeles, Pasadena, Acton and Sawtelle Soldiers Home, also shown on Plate 10, indicates that even though the magnitude of the annual deviation varies, the cyclic trends of these four stations are generally in agreement with the trends indicated by precipitation records within the area.

The 29-year period, 1928-29 through 1956-57, was selected as the base study period for the following reasons:

1. It was a period of normal precipitation during which sufficient records were available for purposes of determining safe yield.
2. It was a representative period of normal precipitation including both wet and dry periods of magnitude and occurrence similar to long-time mean supply conditions of 1872-73 through 1956-57. A wet period occurred from 1936-37 through 1944-45, and a predominantly dry period from 1945-46 through 1956-57. The 29-year period 1928-29 through 1956-57 contains nine years when precipitation was predominantly above average, that is, 115 percent of normal or greater. These nine years comprise 31 percent of the 29-year period as compared to 29 years of similar wetness occurring during the 85-year or normal period which comprise about 34 percent of that period. The average annual amount of precipitation during the 29-year period approximates the long-time mean

having the following average annual deviation from the 85-year mean expressed as a percentage thereof:

Valley lands	+3.5 percent
Hill and mountain areas	-2.2 percent
Combined	-0.4 percent

3. The years immediately preceding the first and last years of this period were of below normal wetness, which thereby minimized the difference of unaccounted-for water in transit to the water table at the start and end of the period.

4. It includes a period of record of supply and disposal under conditions of culture which approximate those existing in 1949-50, 1954-55 and 1957-58, the years during which safe yield is to be determined.

Special Study Periods

The period 1933-34 through 1948-49 is of significance in that it can be used to check change in storage computations. During this 16-year period a substantial rise and fall of ground water levels occurred with average levels at the beginning and end of the period being approximately the same elevation.

The 29-year base study period contains periods of differing practices as to the use of water which are related to change in land use, economic conditions, living standards and téchnological improvements. Thus, to properly evaluate the use of water under current conditions, a study period during recent years having a rain supply equivalent to the long-time mean was desirable. The 9-year period 1949-50 through 1957-58 was selected as a special study period for the valley floor area since the average annual precipitation on the valley floor was 99.7 percent of the 85-year mean and this period included economic conditions and water use practices prevalent during the safe yield years. Hill and mountain precipitation and resulting runoff were less than normal during this same period; because of this the 9-year period was restricted to evaluation of the effects of rain on culture in the valley.

Hill and Mountain Runoff

The surface runoff from 205,709 acres of hill and mountain lands contributes to the water supply on the valley fill. The average annual surface runoff during the base period from these areas was 43,100 acre-feet per year. In a dry year such as 1947-48, the runoff from hill and mountain lands was less than 4,000 acre-feet, while in a wet year such as 1940-41, it was approximately 190,000 acre-feet. This wide variation in the annual amount of runoff is the result of changes in both precipitation and the retentive characteristics of the watersheds.

Surface runoff from about 42 percent of the hill and mountain areas is measured by two stream gaging stations (Plate 9). They are located on Pacoima Creek above Pacoima Dam and Big Tujunga Creek at Gold Canyon. The remaining hill and mountain areas consist of smaller watersheds at lower elevations. The amount of surface runoff contributed by these watersheds under native conditions has been estimated by correlating the surface runoff and index of wetness with runoff measurements of comparable watersheds located in and near the Upper Los Angeles River area (see Appendix F). It was determined from this study that under native conditions the long-time mean runoff for these watersheds was equal to nine percent of the long-time mean precipitation. The annual quantities of surface runoff thus estimated for these smaller watersheds were further adjusted by applying an annual factor based on the difference between the measured and the estimated runoffs of the control watersheds.

Residential development along the foothills produces a larger amount of runoff than would have occurred under native conditions. The amount of increased runoff was calculated as the difference between runoff on impervious areas of residential lots, as shown in Appendix L, and the runoff under native conditions as detailed in Appendix F.

The methods of estimating hill and mountain runoff under native and developed conditions, as well as the amount of runoff tributary to water supply reservoirs, are contained in Appendix F.

Annual amounts of surface runoff from hill and mountain lands to the hydrologic subareas and the entire valley floor are shown in Table 3 for the base period. The total amounts shown include contributions to water supply reservoirs from this source.

TABLE 3

RUNOFF TO VALLEY FILL
FROM HILL AND MOUNTAIN AREAS

In Acre-Feet

Year	To San Fernando Subarea[a]	To Sylmar Subarea	To Verdugo Subarea[b]	Total to valley fill[b]
1928-29	5,960	930	140	7,030
29-30	4,740	960	0	5,700
1930-31	3,580	860	0	4,440
31-32	46,140	10,350	2,400	58,890
32-33	11,280	1,990	340	13,610
33-34	16,560	2,970	800	20,330
34-35	18,430	5,530	350	24,310
1935-36	15,000	3,530	620	19,150
36-37	71,090	17,320	3,280	91,690
37-38	140,130	31,600	5,820	177,550
38-39	24,260	3,890	850	29,000
39-40	16,610	3,470	280	20,360
1940-41	154,930	28,960	7,510	191,400
41-42	18,900	2,520	710	22,130
42-43	135,400	24,790	6,350	166,540
43-44	102,250	18,620	3,720	124,590
44-45	30,790	5,740	1,170	37,700
1945-46	21,640	3,090	340	25,070
46-47	25,490	6,410	670	32,570
47-48	5,970	390	70	6,430
48-49	2,920	740	0	3,660
49-50	4,800	1,120	90	6,010
1950-51	3,190	170	90	3,450
51-52	92,590	18,220	6,020	116,830
52-53	11,870	3,750	340	15,960
53-54	13,760	3,140	410	17,310
54-55	8,660	940	360	9,960
1955-56	12,510	1,540	420	14,470
56-57	8,560	970	450	9,980
57-58	73,620	17,540	2,110	93,270
29-Year Average 1929-57	35,450	7,050	1,500	44,000

a. Includes Eagle Rock Subarea.

b. Includes portion of Monk Hill Basin within area.

Note: Values are the sum of amounts shown in Tables F-7 and F-8, Appendix F, and include hill and mountain runoff flowing into water supply reservoirs.

Imported Water

The inadequacy of local water resources in the South Coastal area of California to meet the needs of rapidly increasing population and expanding industry made the early import of additional water supplies a necessity. The City of Los Angeles, to meet this demand in its service area, constructed the Los Angeles Aqueduct and related facilities to bring water from the Owens River into the City. The system was subsequently extended into Mono Basin to make water from that area available for diversion into the aqueduct. The first water delivered from the aqueduct to the area of investigation was in May 1915, although some water was used in the Los Angeles downtown area starting in 1913. The Department of Water and Power of the City of Los Angeles owns and operates the Los Angeles Aqueduct.

The need for additional water throughout the South Coastal area culminated in the 1927 State Legislature authorizing the formation of The Metropolitan Water District to construct and operate an aqueduct to import Colorado River water.

Construction of the Colorado River Aqueduct pursuant to the authorizing legislation, resulted in delivery in 1940 of the first water from the Colorado River to the South Coastal area of which the City of Los Angeles is a part. The aqueduct system was put on an operational basis in 1941. Other than by these two systems there are no significant importations of foreign water into the area of investigation.

There follows a description of the works and the apparent water supply under the two aqueduct systems.

Los Angeles Aqueduct System of the City of Los Angeles

The Los Angeles Aqueduct system as shown on Plate 14 was constructed to utilize the water supply of the Owens River and Mono Basin to serve the municipal demands of the City of Los Angeles. Construction was initiated in 1907 and the first Owens River water delivered to the City in 1913 and to the Upper Los Angeles River area in May 1915. Subsequent extension of the system into the Mono Basin made water from that area available in 1940.

Description and Capacity of Project. Owens River, tributary to a closed interior basin east of the Sierra Nevada, originally drained into the now dry Owens Lake. Mono Basin drains naturally into Mono Lake and is located immediately north of the Owens River, the two being separated by a low divide.

Diversion from the Owens River is made by the City of Los Angeles upstream from Owens Lake through a diversion canal of 700 cubic feet per second capacity. The canal intercepts the flow of several streams along its course and empties into the 58,525 acre-foot capacity Haiwee Reservoir which is a storage and regulating basin at the head of the aqueduct.

The aqueduct from Haiwee Reservoir is a closed conduit approximately 140 miles in length having a maximum capacity of 500 cubic feet per second. It delivers water into Fairmont Reservoir, the first of several storage and regulating reservoirs near and within the Upper Los Angeles River area. The overall storage in the group of reservoirs along the aqueduct below Haiwee and above San Fernando Reservoir is 44,763 acre-feet. The maximum capacity of the conduit between these reservoirs and the San Fernando Reservoir inlet is 485 cubic feet per second, which is the controlling capacity of the system with respect to rate of delivery to the Upper Los Angeles River area and the City of Los Angeles.

Based on a limiting capacity of 485 cubic feet per second and a seven percent annual shutdown period, it appears that the aqueduct has operated at or near capacity during the latter portion of the base period.

Upstream on the Owens River, a short distance from the head of the aqueduct diversion, is located Tinemaha Reservoir of 16,405 acre-feet capacity which is used as a regulating reservoir to equalize variations in stream flow. Pleasant Valley Reservoir of 3,885 acre-feet capacity located immediately below the lowermost Owens Gorge power plant, is used to stabilize the power plant discharge. Crowley Lake, located above the gorge with a capacity of 183,465 acre-feet, is used to store and regulate upstream runoff.

Water from Mono Basin is delivered into Owens River Valley through the Mono Craters Tunnel, which has a capacity of 365 cubic feet per second. The Mono Basin system has a further limitation in that not more than a total of 93,540 acre-feet per year and 200 cubic feet per second may be diverted from Leevining, Walker, Parker and Rush Creeks into Grant Lake, which stores and regulates the flow before it is released into the Mono Craters Tunnel conduit. Grant Lake Reservoir has a capacity of 47,525 acre-feet.

Further detailed description of the aqueduct system and its operation is set forth in Appendix G.

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Quantities of Water Diverted and Used. The quantity of water diverted by the City of Los Angeles from the Mono Basin-Owens River system is considered to be the inflow to Haiwee Reservoir, which is the sum of the diversion from the Owens River measured in the vicinity of Cartago below the Cottonwood Power Plant gates plus the flows of Ash and Braley Creeks which are intercepted by the diversion canal downstream of the power plant.

Import to the Upper Los Angeles River area as measured in the vicinity of San Fernando Reservoir, the terminus of the Los Angeles Aqueduct, is considered as the quantity delivered for use by the City of Los Angeles through the aqueduct. From 1933 to date, all measurements of import were made in the vicinity of the terminus of the aqueduct. Prior to 1933 all measurements were made at Dry Canyon Reservoir.

Quantities diverted and delivered for use by the City of Los Angeles through the Los Angeles Aqueduct system are shown in Table 4. The differences between quantities diverted and quantities delivered for use can be attributed to seepage and evaporation losses, inaccuracies of measuring devices, operational losses and unmeasured distribution along the aqueduct. Further details are presented in Appendix G.

TABLE 4

QUANTITIES DIVERTED AND DELIVERED FOR USE BY THE CITY OF LOS ANGELES THROUGH THE LOS ANGELES AQUEDUCT SYSTEM

In Acre-Feet

Year	Quantities diverted[a]	Quantities delivered[b]
1913-14	34,290	--- [c]
14-15	44,650	--- [c]
1915-16	66,290	43,710
16-17	95,930	68,180
17-18	194,730	129,330
18-19	194,820	176,030
19-20	211,980	202,260
1920-21	191,860	187,720
21-22	245,310	204,620
22-23	194,800	186,110
23-24	167,790	149,660
24-25	172,790	127,820
1925-26	191,360	169,700
26-27	244,260	173,490
27-28	220,780	194,710
28-29	204,760	190,100
29-30	245,550	198,130
1930-31	245,650	215,750
31-32	258,200	238,200
32-33	243,800	228,430
33-34	236,920	185,580
34-35	251,230	194,920
1935-36	247,680	236,940
36-37	239,250	206,670
37-38	283,090	209.080
38-39	261,510	237,250
39-40	240,870	217,160
1940-41	279,540	200,980
41-42	293,610	246,350
42-43	297,270	264,400
43-44	307,580	274,500
44-45	286,210	267,240
1945-46	307,060	283,970
46-47	338,040	291,020
47-48	326,670	306,460
48-49	308,940	298,460
49-50	316,050	305,400
1950-51	356,610	317,370
51-52	330,690	316,570
52-53	339,950	320,920
53-54	322,180	318,590
54-55	339,430	316,320
1955-56	342,730	321,260
56-57	324,330	318,390
57-58	358,470	325,390

a. Inflow to Haiwee.
b. Prior to 1933 this item was measured at Dry Canyon Reservoir. Subsequently it comprised the total flows through the Penstock meter, Maclay Highline meter and San Fernando Bypass, all located near the cascade immediately above Upper San Fernando Reservoir inlet.
c. No record.

Quantities Available for Diversion and Use. The water supply of the Mono Basin-Owens Valley area available for use is composed of storm runoff and well water. For a limited period the City of Los Angeles extracted water from deep wells in Owens Valley. These wells were pumped continuously from May 1928 to December 1931 and intermittently pumped to 1935. During the years of the period 1918 through 1958 in which there was no pumping, the annual artesian well flow reaching the aqueduct averaged approximately 11,500 acre-feet.

Runoff tributary to the diversion works of the Los Angeles Aqueduct and the amount that it exceeds actual diversions into the aqueduct are shown in Table 5. A detailed determination of these values is contained in Appendix G.

Quantities of water available for diversion and use by the City of Los Angeles from sources tributary to Mono Basin and to the Owens River are limited by the capacity of the Los Angeles Aqueduct system. Transportation of additional water to the City of Los Angeles would require the construction of additional works. Water in excess of the capacity of the aqueduct has existed in the Mono Basin-Owens Valley area; however, towns, communities and some irrigated lands in Owens Valley and Mono Basin have historically used water and rights may pertain thereto. The water use by these entities is not considered within the scope of this reference and therefore has not been determined.

TABLE 5

STREAM RUNOFF TRIBUTARY TO
LOS ANGELES AQUEDUCT DIVERSION WORKS
IN EXCESS OF AQUEDUCT DIVERSIONS

In Acre-Feet

Year	Runoff to aqueduct diversion works[a]	Runoff in excess of aqueduct diversions[b]
1913-14	377,900	343,610
14-15	271,990	227,340
1915-16	378,010	311,720
16-17	332,010	236,080
17-18	263,870	69,140
18-19	201,240[c]	6,420
19-20	211,980[c]	0
1920-21	191,860[c]	0
21-22	245,310[c]	0
22-23	194,800[c]	0
23-24	167,790[c]	0
24-25	172,790[c]	0
1925-26	191,360[c]	0
26-27	261,890[c]	17,630
27-28	231,530	10,750
28-29	207,870	3,110
29-30	248,880	3,330
1930-31	247,570	1,920
31-32	261,630	3,430
32-33	253,800	10,000
33-34	231,110	5,810
34-35	257,420	6,190
1935-36	262,440	14,760
36-37	295,000	55,750
37-38	500,050	216,960
38-39	350,700	89,190
39-40	247,950	7,080
1940-41	488,160	208,620
41-42	456,260	162,650
42-43	447,440	150,170
43-44	333,980	26,400
44-45	456,880	170,670
1945-46	430,780	123,720
46-47	337,580	- 460
47-48	356,520	29,850
48-49	329,870	20,930
49-50	322,060	6,010
1950-51	386,920	30,310
51-52	495,120	164,430
52-53	359,530	19,580
53-54	299,300	- 22,880
54-55	350,570	11,140
1955-56	453,050	110,320
56-57	364,770	40,440
57-58	476,580	118,110

a. Quantities shown for 1913-14 to 1939-40 are for Owens area. For 1940-41 to 1957-58 quantities are for combined Owens and Mono areas.

b. Runoff to aqueduct diversion works less diversions (Table 4). Negative amount indicates water taken from storage in Haiwee Reservoir.

c. There is no record of flow into Owens Lake from November 1918 through December 1926; therefore, these values are too small by that amount, which ranged during the period of measurement from 1,920 acre-feet in 1930-31 to 343,610 acre-feet in 1913-14.

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Colorado River Aqueduct of The Metropolitan Water District of Southern California

The Metropolitan Water District was organized in December 1928 under the authority of The Metropolitan Water District Act (California Statutes of 1927, Chapter 429, page 694). The Metropolitan Water District serves Colorado River system water to all of the municipalities and water districts within the area described in Appendixes A and B attached to the Amended Complaint in Los Angeles vs. San Fernando, et al., with the exceptions of the City of San Fernando and the Los Angeles County Waterworks District No. 21. The City of San Fernando, although within the exterior boundaries of the City of Los Angeles, is not a part of The Metropolitan Water District service area.

Description and Capacity of Project. The Colorado River Aqueduct Project (see Plate 13), financed and constructed by The Metropolitan Water District, diverts from the main stream of the Colorado River above Parker Dam 155 miles below Hoover Dam and 175 miles above the Mexican border.

The major works of the main aqueduct, large scale construction of which began in 1933 and which was completed to the point of delivery of water in 1941, consist of transmission lines, pumping plants, tunnels, canals, covered conduits, inverted syphons, reservoirs, and related works with a designed capacity of 1,605 cfs and a maximum delivery capacity of 1,800 cfs.* The main aqueduct is 242 miles long, including 92 miles of 16-foot diameter lined tunnels and five pumping plants capable of raising the water a net 1,617 feet over mountains intervening between the Colorado River and the coastal plain of Southern California.

* Page 62 of Twenty-First Annual Report of The Metropolitan Water District dated 1959.

Service of water through the Colorado River Aqueduct system, which commenced in 1941 with three pumping units, has continued since that date. Construction authorized in 1952 to bring the system up to full capacity was completed in 1960.

Under this authorization Pumping Unit No. 4 was placed in operation in August 1956. Pumping Unit No. 5 began operating in May 1957 and Pumping Unit No. 6 in January 1959, permitting a maximum delivery of 1,200 cubic feet per second or more until full aqueduct capacity was attained in 1960. Net diversion from the Colorado River by The Metropolitan Water District from 1940-41 through 1958-59 is shown in Table 6. Quantities of Colorado River water delivered to parties are shown in Table M-3 of Appendix M.

Deducting estimated losses in transit, the aqueduct will have the planned capacity to deliver to terminal reservoirs in the Southern California Coastal Basin 1,180,000 acre-feet per annum of the 1,212,000 acre-feet per annum claimed for diversion from the Colorado River.

The major works of the distribution system consist of 232 miles of pipeline, tunnels, reservoirs, and related works serving parts of The Metropolitan Water District in Los Angeles, Orange, Riverside, and San Bernardino Counties, and 71.1 miles of the San Diego Aqueduct (a branch of the Colorado River Aqueduct) serving the parts of Metropolitan Water District in San Diego. Construction of 150 miles of that part of the system serving Los Angeles and vicinity was completed in 1941 and since that time annexations and increased demands have required a continued expansion of the original facilities. The main feeders serving the remaining area of the City of Los Angeles are shown on Plate 35.

TABLE 6

NET DIVERSION FROM COLORADO RIVER
BY THE METROPOLITAN WATER DISTRICT*

In Acre-Feet

Hydrographic year	Net diversion from Colorado River
1940-41	52,460
41-42	13,420
42-43	52,380
43-44	37,340
44-45	65,622
1945-46	65,098
46-47	89,430
47-48	180,558
48-49	172,265
49-50	183,130
1950-51	204,000
51-52	185,779
52-53	216,650
53-54	275,063
54-55	405,157
1955-56	438,247
56-57	597,283
57-58	531,338
58-59	650,617

* Source of data:
1940-41 through 1954-55, U.S.G.S. Water Supply Paper.
1955-56 through 1957-58, The Metropolitan Water District Annual Reports.
1958-59, records of The Metropolitan Water District.

Relative Rights of Constituent Areas of the Metropolitan Water District. The Metropolitan Water District delivers Colorado River water to their constituents (cities, districts, and other public entities) at various service connections.

Section 5-1/2 of The Metropolitan Water District Act provides as follows:

> "Section 5-1/2. Each city, the area of which shall be a part of any district incorporated hereunder, shall have a preferential right to purchase from the district for distribution by such city, or any public utility therein empowered by said city for the purpose, for domestic and municipal uses within such city a portion of the water served by the district which shall, from time to time, bear the same ratio to all of the water supply of the district as the total accumulation of amounts paid by such city to the district on tax assessments and otherwise, excepting purchase of water, toward the capital cost and operating expense of the district's works shall bear to the total payments received by the district on account of tax assessments and otherwise, excepting purchase of water, toward such capital cost and operating expense."

This preferential right does not, at present, limit the quantity of water available to any member but will become effective when the demand of The Metropolitan Water District equals the supply available to the District.

A summary, in terms of percentages, of the preferential rights as of November 30, 1959, of all municipalities and water districts entitled to a preferential right under Section 5-1/2 of The Metropolitan Water District Act is presented in Table 7.

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TABLE 7

PREFERENTIAL RIGHTS OF MEMBERS OF THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA AS OF NOVEMBER 30, 1959 BASED ON TOTAL CUMULATIVE TAX COLLECTIONS*

Municipality or District	Tax collections percent of total	
Beverly Hills	2.23558	
Burbank	2.36381	
Central Basin Municipal Water District	6.59994	
Compton	.60130	
Foothill Municipal Water District	.61549	
Glendale	2.47681	
Long Beach	6.35874	
Los Angeles	49.47865	
Pasadena	3.01992	
Pomona Valley Municipal Water District	1.10728	
San Marino	.56925	
Santa Monica	2.01254	
Torrance	1.06130	
West Basin Municipal Water District (including Reannexed Exclusions)	5.36835	
Total: Los Angeles County		83.86896
Anaheim	.40686	
Coastal Municipal Water District	1.13006	
Fullerton	.66436	
Orange County Municipal Water District	3.18570	
Santa Ana	1.02634	
Total: Orange County		6.41332
San Diego County Water Authority		
Total: San Diego County		7.36589
Chino Basin Municipal Water District		
Total: San Bernardino County		1.18395
Eastern Municipal Water District	.26092	
Western Municipal Water District	.90696	
Total: Riverside County		1.16788
TOTAL:		100.

* Data from The Metropolitan Water District Controllers's Report of December 7, 1959, to The Metropolitan Water District Board of Directors; and Statement No. 7 thereof, Tax Data to November 30, 1959.

According to a statement of policy approved by the Board of Directors of the District on December 16, 1952, "The Metropolitan Water District of Southern California is prepared, with its existing governmental powers and its present and projected distribution facilities, to provide its service area with adequate supplies of water to meet expanding and increasing needs in the years ahead ...". In regard to distribution facilities it has been the policy of the District to provide trunk feeder lines of sufficient capacity to supply the demands for Colorado River water in its constituent municipalities. If a request for more capacity in a trunk line to supply increased demand were made by a constituent municipality, and it were shown that the increased requirements of the constituent municipality could not be supplied by Metropolitan's facilities then available, it would be necessary in accordance with Metropolitan's policy to provide additional feeder capacity for service to the constituent municipality. This applies to the cities of Glendale and Burbank as well as to other constituent municipalities.

Although it has been the general policy of the District to provide trunk feeder lines so that each constituent municipality would have at least one point of connection within the boundaries of the constituent municipality, the terms and conditions of annexation fixed by the District in some of the more recent annexations have required the constituent municipality to construct its own transportation facilities to a point remote from its boundaries to obtain service.

The District has not established an invariable standard to which capacities of transportation facilities are maintained in relation to annual demand of constituent agencies for Colorado River water. In the design of the initial development of the distribution facilities it was assumed that capacity should be provided to supply 130 percent of mean annual demand, but no such fixed percentage has been authorized for design purposes by the District's Board of Directors. Conditions vary among the constituent agencies in respect to justifiable need for capacity in excess of that required to satisfy annual mean demand. In many cases facilities have been constructed to serve requirements known to be short of ultimate needs, with realization that subsequent amplification of facilities would be necessary.

There have been very few instances where it has been necessary for Metropolitan to curtail deliveries due to peak demands exceeding the capability of the transporation facilities. In connection with this situation Metropolitan has urged the member municipalities to acquire adequate storage and maintain existing ground water pumping facilities for emergency service and to provide for peaking during the periods of extraordinary demand.

Water Rights of The Metropolitan Water District. The Metropolitan Water District asserts its right to the consumptive use* of 1,212,000 acre-feet per annum of Colorado River system water. This right is based on

* Refers to the amount of water at the point of diversion.

(1) appropriations of the Cities of Los Angeles and San Diego, made respectively in 1924 and 1926 and (2) contracts with the United States, made in 1930 and amended in 1931, pursuant to the Boulder Canyon Project Act for the storage and delivery of water impounded by Hoover Dam. The appropriative and contract rights are affected in various degrees by the compacts, treaties, statutes, and contracts referred to collectively as "the law of the River".

In 1931, The Metropolitan Water District and six other major users of the Colorado River system in California executed an agreement, with the approval of the California Division of Water Resources, which specifies the following priorities of California water users:

Priority number		Agency description	Annual quantity in acre-feet
1.		Palo Verde Irrigation District - 104,500 acres in and adjoining existing district	
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	3,850,000
	(b)	Palo Verde Irrigation District - 16,000 acres of adjoining mesa	
4.		The Metropolitan Water District, City of Los Angeles, and/or others on coastal plain	550,000
5.	(a)	The 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

Priority number		Agency description	Annual quantity in acre-feet
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
7.		Agricultural use in the Colorado River basin in California, as the basin is designated on Map 23000, U. S. Bureau of Reclamation	All remaining water available for use in California

This agreement is incorporated in General Regulations of the Secretary of the Interior promulgated in 1931 pursuant to Section 5 of the Boulder Canyon Project Act and in water delivery contracts between the United States and the several California agencies using Colorado River system water.

Pendency of Arizona vs. California. The quantity of Colorado River system water which will be available for diversion by The Metropolitan Water District is involved in, and may be affected by the decision in *Arizona vs. California*, No. 9 Original, October Term 1959, initiated by the State of Arizona in 1952 and now pending before the United States Supreme Court. The case was under submission to Special Master Simon H. Rifkind of New York City, who was appointed by the Court to hear the parties and report to the Court with proposed findings of fact and conclusions of law, and a recommended decree. The Special Master released his proposed report to the parties on May 10, 1960 and during August 1960 heard objections to the report by the parties preliminary to submitting his report to the Court. The proposed report was substantially adverse to the contentions of the California defendants in most major respects. The Special Master's final report, dated December 5, 1960, materially unchanged from his draft report, has been submitted to the Court. The parties have filed exceptions to the report, and supporting briefs, pursuant to order of the Court. A final decision of the Supreme Court in this suit is anticipated sometime in 1962.

Other Factors Affecting Water Availability to The Metropolitan Water District. At the present time, the water supply of the Colorado River system is sufficient to satisfy fully the right of all California water users and main stream users in other states of the lower Colorado River area for all their existing projects. When, whether, and to what extent a shortage develops for California water users depends on three major factors:

(1) long range dependable water supply which is determined by runoff and its conservation;

(2) the rapidity of development of water uses throughout the Colorado River Basin, particularly in the relatively undeveloped upper Colorado River Basin; and

(3) the resolution of legal issues, some of which are involved in Arizona vs. California, and some of which concern the rights of the upper Colorado River Basin

versus the lower Colorado River Basin and which are unlikely to be determined in that suit.

The decree recommended by the Special Master in his December 5, 1960 report, establishes the following proration formula for the division of the waters of the "mainstream" (defined as Lake Mead and the main stream of the Colorado River below Lake Mead within the United States):

> Of the first 7.5 million acre-feet of consumptive use available in any year from the "mainstream" waters, 28/75 (37-1/3 percent) to Arizona, 44/75 (58-2/3 percent) to California, 3/75 (4 percent) to Nevada; of the excess over 7.5 million acre-feet, 50 percent to California and 50 percent to Arizona, minus a possible 4 percent to Nevada.

The Special Master concludes that "...the evidence will not support a sufficiently accurate prediction of future supply to determine the effect of the recommended decree on existing uses in California." (Special Master's Report, page 103). Because of this asserted unreliability of water supply estimates, the Master makes no findings as to the quantity of water available for use in the lower basin. The Master states that "...the record in this case gives no indication that the 'chaotic disaster' which California fears will, or is likely to, materialize." (Report, page 102).

This statement, however, is based in part upon the availability in the lower basin of water which the Colorado River Compact apportions in perpetuity to the upper basin. The quantity so apportioned is 7,500,000 acre-feet per annum (subject to certain obligations with respect to the outflow at Lee Ferry). As the present upper basin uses (now approaching 2,500,000 acre-feet per annum) increase, the temporary supply available from the "mainstream" for use in Arizona, California and Nevada will diminish. Accordingly, the District's Colorado River supply under the seven party priority agreement could be adversely affected by about 1970 and in gradually increasing degree thereafter. Thus, it appears probable, if the Supreme Court approves the Special Master's Report, that the District would receive a full supply of Colorado River water for about 10 years and gradually decreasing quantities for about the succeeding 25 years, with the possibility of loss of its entire Colorado River supply at some time approaching the turn of the century.

It should be noted, however, that water made and to be made available to the Metropolitan Water District is firm through a contract entered into between the District and the State of California, Department of Water Resources, entered into prior to November 8, 1960, for 1,500,000 acre-feet per annum from the surplus waters of Northern California to be made available to the District by water facilities to be financed by the State (1) through the issuance of $1.75 billion in bonds authorized by the people at the General Election, November 8, 1960; (2) by the Water Fund; and (3) by the general authority of the State of California.

The California defendants opposed the recommendation of the Special Master in exceptions to his report before the Court. If the Master's recommendation is reversed by the Court in any material respect, a substantial portion of the District's water supply would be assured from the dependable or permanent supply of the Colorado River.

Distribution System. The distribution mains supplying members of The Metropolitan Water District are shown on Plates 13, 21 and 35. The La Canada Irrigation District and Crescenta Valley County Water District receive Colorado River water through the mains of the Foothill Municipal Water District. The City of Los Angeles takes water from the Upper Feeder. The Cities of Burbank and Glendale receive water through the Santa Monica

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Feeder. Design capacity of the Santa Monica Feeder under full flow hydraulic gradient is shown on the profile on Plate 13 and listed below.

DESIGN CAPACITY OF SANTA MONICA FEEDER
UNDER FULL FLOW HYDRAULIC GRADIENT

Section*	Design capacity, in second feet
San Rafael Tunnel No. 2 to Glendale Take-out	125
Glendale Take-out to Burbank Take-out	77
Burbank Take-out to Hollywood Tunnel	49

* Plates 13 and 21.

Amounts of Imported Water

Sole significant importations of water to the Upper Los Angeles River area are supplies brought in via the Colorado River and the Los Angeles Aqueducts by members of The Metropolitan Water District and the City of Los Angeles, respectively. The amount of Owens River water imported for use within the Upper Los Angeles River area has been determined as the quantity of Owens water delivered at the Los Angeles Aqueduct terminus, as set forth in Table 4, less the portion of this water exported out of the area, measured at the inlets to Franklin and Stone Canyon Reservoirs and at the North Hollywood Pumping Plant shown on Plate 21, plus the amount which is returned through the City's system for use within the Narrows water service area of the City of Los Angeles. Annual amounts of Owens River import thus determined and purchases of Colorado River water delivered to entities in the Upper Los Angeles River area are shown in Table 8 along with the total import.

TABLE 8

IMPORTED WATER, UPPER LOS ANGELES RIVER AREA[a]

In Acre-Feet

Year	Owens River water[b] (1)	Colorado River water[c] (2)	Total imported water (3)
1928-29	102,550	0	102,550
29-30	109,070	0	109,070
1930-31	127,720	0	127,720
31-32	126,010	0	126,010
32-33	117,630	0	117,630
33-34	100,020	0	100,020
34-35	100,400	0	100,400
1935-36	128,540	0	128,540
36-37	92,800	0	92,800
37-38	84,550	0	84,550
38-39	102,070	0	102,070
39-40	86,860	70	86,930
1940-41	73,980	250	74,230
41-42	111,750	420	112,170
42-43	120,480	1,200	121,680
43-44	115,110	710	115,820
44-45	110,790	760	111,550
1945-46	125,900	2,210	128,110
46-47	133,210	4,470	137,680
47-48	145,580	2,540	148,120
48-49	136,600	1,730	138,330
49-50	148,460	960	149,420
1950-51	156,050	2,490	158,540
51-52	144,440	3,890	148,330
52-53	160,530	5,020	165,550
53-54	154,700	8,750	163,450
54-55	156,830	9,570	166,400
1955-56	158,580	10,560	169,140
56-57	160,910	13,250	174,160
57-58	162,020	13,050	175,070
Maximum	162,020	13,250	175,070
Minimum	73,980		

a. See Appendix M for details of this determination. Does not include rain on and runoff to water supply reservoirs in the Upper Los Angeles River area.

b. Imported by City of Los Angeles.

87 c. Imported by City of Los Angeles and defendants numbers 2, 3, 7, and 8.

Water Quality

To determine the quality of waters within the area of investigation and effect thereon of the importation of Owens Valley and Colorado River waters, approximately 1,500 ground water analyses, 125 surface water analyses and 500 analyses of imported water were compiled and studied.

The standards of water quality and the quality of native and imported waters are discussed herein with detailed information on water quality contained in Appendix H.

Standards of Water Quality

The drinking water standards adopted by the State of California are generally based on the United States Public Health Service Drinking Water Standards of 1946. However, the adopted standards were revised by the State in 1959 to, in effect, reduce the maximum allowable fluoride content from the previous limit of 1.5 parts per million (ppm) to less than 1.0 ppm for the San Fernando Valley area. The California Department of Public Health has also adopted a policy of issuing temporary permits allowing higher limits for total solids, sulfate, chloride and magnesium than it requires when issuing regular permits.

Chemical Characteristics of Water

The chemical character of water provides a means of identifying the water source and the movement of a particular water as it occurs as runoff or as ground water. The characteristics are expresssed in percent cations (positive ions) and percent anions (negative ions) of the dominant elements or compounds. For example, a sodium bicarbonate water is one in which the sodium is equal to or greater than 50 percent of the cations and the bicarbonate is equal to or greater than 50 percent of the anions; a sodium-calcium bicarbonate water is one in which sodium is more abundant than calcium but is less than 50 percent of the total cations; and a sodium chloride-sulfate water is one in which chloride exceeds sulfate but is less than 50 percent of the total anions. A discussion of the chemical characteristics of imported water, surface water and ground water within the Upper Los Angeles River area follows.

Imported Water

The Los Angeles Aqueduct waters from Owens River and Mono Basin are of excellent quality, being of sodium-calcium bicarbonate character. The total dissolved solids have averaged about 215 ppm for the past 20 years at the Upper San Fernando Reservoir inlet. The highest total dissolved solids content of record, 322 ppm, occurred on April 1, 1946, whereas the low of 149 ppm occurred on September 17, 1941. For a short period of time in 1932 the boron content exceeded one part per million. The high boron water was diluted by the addition of Mono Basin water to the system and by increased storages. The boron content during the following years varied between 0.20 and 0.88 parts per million and averaged approximately 0.53 ppm. No effect of these boron waters on ground waters of the Upper Los Angeles River area has been found.

Untreated Colorado River waters are predominantly calcium sodium sulfate in character changing to sodium sulfate after treatment to reduce the total hardness. Analysis of random samples of softened Colorado River water taken at the Burbank turnout between 1941 and 1958 indicates the total dissolved solids have varied from a high of 875 ppm in August 1955, to a low of 680 ppm in September 1958 and averaged approximately 770 ppm during the period.

Representative mineral analyses of imported waters are shown in Table 9. Copies of all available mineral analyses of waters in the area are contained in the basic data. A comparison of the two imported waters as to total dissolved solids, sulfate and chloride content is shown graphically on Plate 16. These graphs illustrate the relatively consistent quality of the Owens Valley water and the variability of The Metropolitan Water District water.

Owens Valley water is for the most part served directly to customers without being commingled with other supplies. The treated Colorado River water is generally mixed with native water, as is the case with the Cities of Glendale and Burbank. However, in the Eagle Rock area of the City of Los Angeles and the upper portion of the service area of the Crescenta Valley County Water District, Colorado River water is utilized without blending.

Surface Water

Surface runoff contains salts dissolved from the rocks existing in the tributary drainage area. The watersheds of the majority of the streams in the western portion of the Upper Los Angeles River area are underlain by sedimentary rocks which contain numerous seams of gypsum and produce runoff that is calcium sulfate in character. Runoff from streams in the granitic Basement Complex in the eastern portion of the area is characteristically

TABLE 9

REPRESENTATIVE MINERAL ANALYSES OF WATER

Well number or source	Producing aquifer	Date sampled	ECx10⁶ at 25°C	pH	Mineral constituents in Parts per million (ppm) / Equivalents per million (epm): Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3	F	B	Total dissolved solids ppm	Total hardness as $CaCO_3$ ppm	Sources of analysis
IMPORTED WATERS																		
Owens at Upper San Fernando Reservoir inlet,		3- 4-35	387	8.0	22	7	61			140[a]	30	27					83	LADW&P
Owens at Upper San Fernando Reservoir inlet		3-17-59	312	8.01	24	5.8	33	4.8		134[a]	21	18		0.6	0.45		84	LADW&P
MWD water at City of Burbank		6-30-41		7.7	17	9	222		6	26	374	101				760	80	BPS
MWD water at City of Burbank		9-11-58		8.0	47	16	167			162	274	91	T	0.4		680	183	BPS
SURFACE WATERS																		
Los Angeles River at Gage F-57 (Flow = 5.9 cfs)		10- 6-49		8.39	91	33	143			245	186	192			0.49	849	260	SDPH
Los Angeles River at Gage F-57 (Flow = 1,060 cfs)		1-10-55	185	7.4	26 / 1.3	3 / 0.28	13 / 0.57	4 / 0.102		76 / 1.25	43 / 0.89	7 / 0.2	4.4 / 0.071	0.6	0.07	277		DWR
Los Angeles River at Gage F-57 (Flow = 303 cfs)		4-26-56	256	7.3	29 / 1.45	4 / 0.30	16 / 0.69	3.1 / 0.079	0 / 0	92 / 1.50	42 / 0.87	11 / 0.30	1.6 / 0.010	0.5 / 0.026	0.05	152		DWR
Los Angeles River at Gage F-57 (Flow = 1.6 cfs)		6- 4-58		8.4	114	77.5	239			200	349	190				745	514	LAHD
Los Angeles River at Sepulveda Blvd. (Flow = 4.2 cfs)		10- 6-49		7.83	207	62.5	138			29	666	77			0.56	1,557	293	SDPH
Los Angeles River at Sepulveda Blvd. (Flow = 6.7 cfs)		6- 4-58		8.45	148	54	128			229	494	79				1,215	590	LADW&P
Calabasas Creek at Shoup Avenue (Flow = 30 cfs)		4- 1-58	368	7.6	36 / 1.80	11 / 0.90	19 / 0.83	6.0 / 0.154	0 / 0	95 / 1.56	80 / 1.67	16 / 0.45	2.5 / 0.04	0.5 / 0.026	0.14	263	135	DWR
Bull Creek at Devonshire Street (Flow = 15 cfs)		1-20-54			110 / 5.5	40 / 3.34	56 / 2.45	11.7 / 0.300		119 / 1.95	396 / 8.25	28 / 0.8	8.7 / 0.141	0.8	0.06	789		DWR
Big Tujunga Creek at Los Angeles City Boundary (Flow = 2 cfs)		11-16-54	515	7.7	60 / 2.99	18 / 1.48	34 / 1.48	4.8 / 0.123	0 / 0	281 / 4.61	59 / 1.23	10 / 0.28	0 / 0		0.12	310		DWR
Verdugo Wash at Estelle Street (Flow = 7.8 cfs)		3- 1-51	94	6.6	11 / 0.549	4.9 / 0.402	3.8 / 0.165	1.7 / 0.043	0 / 0	34 / 0.557	24 / 0.500	5.2 / 0.147	0.6 / 0.010		0.10	74	48	DWR
GROUND WATER, SAN FERNANDO SUBAREA																		
Los Angeles River Narrows Area																		
2760	Fill	1-24-34	2,500		138	55	335			261[a]	306	469					570	LADW&P
2760	Fill	8- 7-50	1,640	7.45	115	35	186	4		280[a]	234	275	2.0	0.40	0.39		431	LADW&P
3947A	Fill	6-13-32	463		42	19	28			210	24	21	11		0.09			DWR Bull. 40A
3947A	Fill	2- 8-52	540	7.4	60	24	32[b]			220	28	39	44		0.08			DWR
3947A	Fill	7-11-56	699	7.3	69 / 3.44	30 / 2.47	31 / 1.35	1.7 / 0.044		237 / 3.88	46 / 0.96	48 / 1.35	62 / 1.00	0.4 / 0.021	0.02	479	293	DWR

TABLE 9

REPRESENTATIVE MINERAL ANALYSES OF WATER
(continued)

Well number or source	Producing aquifer	Date sampled	$ECx10^6$ at 25°C	pH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3	F	B	Total dissolved solids ppm	Total hardness as $CaCO_3$ ppm	Sources of analysis
					Mineral constituents in					Parts per million (ppm) / Equivalents per million (epm)								
									GROUND WATER, SAN FERNANDO SUBAREA (continued)									
									Western Portion of Subarea									
3701B	Fill	6-15-32	2,240		291	85	151			339[a]	1,015	64	23		0.47			DWR Bull. 40A
3701B	Fill	7- 8-57	1,935	7.42	253	68	109	2.2		302[a]	820	72	20	0.40	0.62		911	LADW&P
4735B	Fill	6-22-32	987		129	33	39			278	228	28	31		0.27			DWR Bull. 40A
4735B	Fill	12- 4-56	945	7.7	112/5.60	31/2.54	44/1.91	2.3/0.06		293/4.8	206/4.29	15/0.42	22/0.35	0.3	0.02	650	407	DWR
									Eastern Portion of Subarea									
3800	Fill	7-24-34	1,210		47	13.0				186[a]	28	9					170	LADW&P
3800	Fill	6-26-58	421	7.75	54	12	18	3.3		171[a]	31	16	10	0.2			183	LADW&P
3813A	Fill	6-15-32	1,210		125	38	91			232	400	48	6		0.27			DWR Bull. 45
3820B	Fill	8-29-56	428	7.56	47	12.0	24	3.1		190[a]	44	9	4.0	0.60	0.07		167	LADW&P
3882E	Fill	9-24-31	444		51	16	21			220	25	14	9		0.12			DWR Bull. 40A
3882L	Fill	7- 2-56	541	8.0	57/2.85	15/1.25	20/0.85	3.2/0.081		216/3.55	24/0.50	18/0.50	21/0.346	0.40/0.021	0.01	289	205	DWR
									GROUND WATER, SYLMAR SUBAREA									
4840B	Saugus	7- 3-56	675	7.7	80/4.0	18/1.48	41/1.79	4.6/0.117		244/4.0	101/2.11	46/1.3	0.9/0.014	0/0	0.25	447		DWR
4850B	Saugus	9-25-31	536		56	23	32			241	59	16	8		0.35			DWR Bull. 45
4850B	Saugus	1-15-59	540	7.65	64	17	28	3.1		229[a]	60	32	10	0.3	0.25		231	LADW&P
5988A	Saugus	7- 3-56	615	7.8	86/4.3	19/1.60	27/1.18	4.9/0.126		287/4.7	67/1.40	16/0.45	36.9/0.595	0/0	0.05	427		DWR
5998A	Saugus	2-27-59			42	11	37	2.5		229[a]	17	15	5	0.4	0.04		149	LADW&P
									GROUND WATER, VERDUGO SUBAREA									
3971	Fill	6-30			41	0	22			131	18	17				161	102	GPS
3971	Fill	5-57		6.9	59	16	3			162	35	26	16	0.2		275	213	GPS
5058E	Fill	2-11-49	280	7.42	33	12	23			159	14	11	15					DWR
5058E	Fill	10-17-58	515	7.8	50/2.5	20/1.65	26/1.11	2.6/0.07		149	33/0.69	31/0.88	81/1.3	0.3/0.01	0.03	318	208	CVCWD
									GROUND WATER, EAGLE ROCK SUBAREA									
3987A	Older alluvium	1- 7-33		7.5	44	15	45			226	31	33				420		Sparkletts
3987A	Older alluvium	1-29-60	841	7.5	74/3.68	34/2.79	48/2.11	2/0.04		276/4.54	85/1.77	53/1.49	31/0.49	0.74/0.04	0.20	585	324	SWRB

a. Bicarbonate value corrected from alkalinity as $CaCO_3$.
b. Value is sum of Na + K.

calcium bicarbonate. The normal character of surface waters passing stream gage F-57 during storm runoff periods is also calcium bicarbonate.

Because of a shorter period of contact between water and rock and increased dilution at large discharge rates, storm flows at Gage F-57 normally have a lower concentration of salts than does water of reduced flows. Low flows of the Los Angeles River ranging from 3 to 15 cfs at Gage F-57 had a total dissolved solids content of about 1,000 ppm in 1948, whereas an analysis of a sample taken at a flow of 3,000 cfs in 1938 indicates 115 ppm total dissolved solids. There is evidence that a large part of the increased salinity of the lower flows has been caused by the increased discharge of industrial wastes into the river during recent years. Representative mineral analyses of surface waters are shown in Table 9.

Ground Water

Ground waters from the major water-bearing formations of the Upper Los Angeles River area are of two general characters, each reflecting the composition of the surface runoff waters draining from the immediately adjacent watersheds within the area. Ground water in the western portion of the area is calcium sulfate in character whereas water pumped from the eastern portion of the area, including Sylmar and Verdugo Hydrologic Subareas, is of calcium bicarbonate character. Representative analyses of ground water in various sections of the area are shown in Table 9.

Ground waters of the area are generally within the recommended limits as set forth in the U. S. Public Health Service Drinking Water Standards, 1946. Principal exceptions to this are wells in the west end of the San Fernando Valley which penetrate the Modelo formation and which have excessive concentrations of sulfate, and waters from wells in the lower part of Verdugo Subarea which have abnormally high concentrations of nitrate.

Ground waters of the Upper Los Angeles River area are classed as moderately hard to very hard. Geochemical charts on Plate 15 show the plots of constituents in these waters in terms of percentage reacting values. All of the native waters in the area fall into the calcium-magnesium-sulfate-bicarbonate group. A comparison of the plots (Plate 15) indicates that the ground waters have remained in the same character group over the period of record. Analyses of water from well 4947A, however, indicate a pronounced increase in the total chlorides and nitrates. This increase may have been caused by the large amounts of chemical fertilizers known to have been applied in neighboring areas.

Representative records of the total dissolved solids and sulfate, chloride and nitrate ion concentrations found in water from various wells in each of the hydrologic subareas are plotted on Plates 17A through 17D. These records indicate a general chronologic increase of total dissolved solids in all subareas with a marked increase in the San Fernando Subarea at wells 3701B and 3571J and at most of the wells in the Verdugo Subarea which, in several instances, also reflect a pronounced increase in nitrate concentration. Total dissolved solids at wells 2760 and 3673 in the San Fernando Subarea, however, decreased about 600 ppm at the former during the period 1936 to 1942 and about 200 ppm at the latter in the period 1955 to 1957.

Effect of Importation of Owens River-Mono Basin Water

Water quality studies made by the Referee indicate that, except for a short period of time in 1932 when boron concentrations were above normal, the quality of waters imported from Owens River and Mono Basin have been equal or superior to the native waters of the Upper Los Angeles River area and have not otherwise adversely affected the quality of the native waters.

CHAPTER V. WATER UTILIZATION AND DISPOSAL

Presented herein are data and information on water development and use in the Upper Los Angeles River area including a determination of consumptive use by the Inflow-Outflow Method.

The data and information pertains to the requirements of Paragraphs I. 2, F., I. 2, G. and I. 4, of the Order of Reference in regard to location and capacity of diversion works of all parties* and non-parties, the amount of each party's taking and use, the place and character of the use or uses of import and other waters, and the nature and quantity of all water use and diminution within and from the area. Material is included to show the effect of changing land use and of channel improvements on the percolation of surface water supplies to the underground.

Joint Interest of Parties in Sources of Supply

In many instances several parties have an interest in the same source (well or diversion). In reporting data on a particular source, an attempt has been made to list all information under the party having the major interest. A cross reference pertaining to the joint interest in any source is listed in Table 10.

* Plaintiff and all defendants named in the Amended Complaint and in subsequent proceedings prior to July 1, 1961.

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TABLE 10

CROSS REFERENCE TO JOINT INTEREST OF PARTIES

Defendant number	Party	Described under defendant number
	City of Los Angeles, Plaintiff*	
1	City of San Fernando	1
2	City of Glendale	2
3	City of Burbank	3
4	Burbank City Unified School District	4
5	Glendale Junior College District of Los Angeles County	2
6	Los Angeles County Flood Control District	6
7	La Canada Irrigation District	7
8	Crescenta Valley County Water District	8
9	State of California	Doe Corp. 4
10	Aetna Life Insurance Company	128
11	American Savings and Loan Association	195
12	American Security and Fidelity Corporation	39
13	The Andrew Jergens Company	13
14	Bank of America National Trust and Savings Association	2 and 53
15	Beatrice Foods Company	15
16	California Bank	80
17	California Bank	80
18	California Materials Company	18
19	California Trust Company	36
20	California Trust Company	36
21	Carnation Company	21
22	Citizens National Trust and Savings Bank of Los Angeles	2, 15, 35, and 200
23	Citizens National Trust and Savings Bank of Los Angeles	200
24	Citizens National Trust and Savings Bank of Los Angeles	35
25	Citizens National Trust and Savings Bank of Los Angeles	2
26	Citizens National Trust and Savings Bank of Los Angeles	35
27	Citizens National Trust and Savings Bank of Los Angeles	2
28	Citizens National Trust and Savings Bank of Los Angeles	15
29	Color Corporation of America	46 and 82
30	Consolidated Rock Products Company	30
31	Corporation of America	2
32	Corporation of America	2 and 150
33	Corporation of America	53
34	Deep Rock Artesian Water Company	34
35	Desco Corporation	36
36	Drewry Photocolor Corporation	36
37	Frank X. Enderle, Inc., Ltd.	64
38	Forest Lawn Cemetery Association	39
39	Forest Lawn Company	39
40	Forest Lawn Memorial Park Association	39
41	Freshpuro Water Company	41
42	Glendale Towel and Linen Supply Company	42
43	Glenhaven Memorial Park, Inc.	43
44	Hidden Hills Corporation	45
45	Hidden Hills Mutual Water Company	45
46	Houston Color Film Laboratories, Inc. of California	46
47	Intervalley Savings and Loan Association	195
48	Knickerbocker Plastic Company, Inc.	48
49	Lakeside Golf Club of Hollywood	49
50	Lakewood Water and Power Company	126 and 67
51	Land Title Insurance Company	42
52	Land Title Insurance Company	42
53	Livingston Rock and Gravel Company	53
54	Lockheed Aircraft Corporation	54
55	Los Angeles Land and Water Company	30
56	Los Angeles Pet Cemetery	56
57	Los Angeles Trust and Safe Deposit Company	141 and 181
58	Los Angeles Trust and Safe Deposit Company	141 and 181
59	Metropolitan Life Insurance Company	2
60	Metropolitan Savings and Loan Association of Los Angeles	173
61	Monteria Lake Association	61
62	Mulholland Orchard Company	62
63	Oakmont Country Club	2
64	Oakwood Cemetery Association	64
65	Pacific Fruit Express Company	76
66	Pacific Lighting and Gas Supply Company	66
67	George E. Platt Company	67
68	Polar Water Company	68
69	Richfield Oil Corporation	105
70	Riverwood Ranch Mutual Water Company	70
71	Roger Jessup Farms	71
72	Sealand Investment Corporation	173
73	Sealand Investment Corporation	173
74	Sears, Roebuck and Company	74
75	Southern California Edison Company	75
76	Southern Pacific Railroad Company	76

* The Plaintiff - City of Los Angeles has been so identified without any number designation.

TABLE 10

CROSS REFERENCE TO JOINT INTEREST OF PARTIES
(continued)

Defendant number	Party	Described under defendant number
77	Southern Service Company, Ltd.	77
78	Sparkletts Drinking Water Corporation	78
79	Spinks Realty Company	79
80	Sportsmen's Lodge Banquet Corporation	80
81	Sun Valley National Bank of Los Angeles	188
82	Technicolor Corporation	82
83	Title Insurance and Trust Company	45
84	Title Insurance and Trust Company	128
85	Title Insurance and Trust Company	188
86	Title Insurance and Trust Company	45
87	Title Insurance and Trust Company	101
88	Title Insurance and Trust Company	164
89	Title Insurance and Trust Company	48
90	Title Insurance and Trust Company	42
91	Title Insurance and Trust Company	188
92	Title Insurance and Trust Company	2 and 150
93	Title Insurance and Trust Company	2 and 150
94	Title Insurance and Trust Company	195
95	Title Insurance and Trust Company	45
96	Title Insurance and Trust Company	46
97	Toluca Lake Property Owners Association	97
98	Union Bank and Trust Company of Los Angeles	41
99	Universal Pictures Company	99
100	Valhalla Mausoleum Park	101
101	Valhalla Memorial Park	101
102	Valhalla Properties	101
103	Valley Lawn Memorial Park	126
104	Van De Kamp's Holland Dutch Bakers, Inc.	104
105	Walt Disney Productions	105
106	Warner Bros. Pictures, Inc.	106
107	Western Mortgage Company	2
108	Leo W. Adair	2
109	Catherine Adams	141 and 181
110	Catherine Adams, Guy Knupp, Security First National Bank of Los Angeles	141 and 181
111	Mary L. Akmadzich	53
112	Peter J. Akmadzich	53 and 111
113	Margaret E. Arine	168
114	Helen Babikian	173
115	B. A. Bannan	46
116	Clotilde R. Bannan	46
117	William O. Bartholomaus	117
118	Barbara Becker	41
119	Bert Becker	41
120	Henry W. Berkemeyer	120
121	Hildur M. Berkemeyer	120
122	Elfrieda M. Bishop	122
123	W. E. Bishop	122
124	Andrea Borgia	68
125	Frances Borgia	68
126	Mark Boyar	126
127	Stella M. Brown	127
128	George A. Burns	128
129	Louise J. Burns	128
130	Rodney E. Busk	34
131	Aurora Carlson	8
132	William M. Chace	132
133	William M. Chace	132
134	Emma S. Clauson	134
135	Donald G. Cowlin	42
136	Dorothy N. Cowlin	42
137	Josephine McC Cowlin	42
138	Cecil B. De Mille	138
139	Michael Diller	67 and 126
140	Ellen S. Du Bois	117
141	Maxine Duckworth	141
142	Maxine Duckworth	141
143	Richard Erratchuo	143
144	Ada H. Fitz - Patrick	101
145	C. C. Fitz - Patrick	101
146	Elton George	2
147	Florence H. George	2
148	Howard Barton Griffith	148
149	Irene W. Guyer	188
150	George Hanna	2
151	Hal B. Hayes	70
152	Forrest W. Hicks	42
153	Neva Bartlett Holmgrin	153
154	Marguerite Rice Jessup	71
155	Marguerite Rice Jessup	71
156	Roger Jessup	71
157	Nathan Kates	141
158	June Kelley	2
159	Victor H. Kelley	2

TABLE 10

CROSS REFERENCE TO JOINT INTEREST OF PARTIES
(continued)

Defendant number	Party	Described under defendant number
160	Samuel P. Krown	8
161	Paul E. Lancaster	188
162	William Lancaster	188
163	Lucille Mack	62
164	E. E. Mahannah	164
165	Hazel E. Mahannah	164
166	Blanche M. Mangan	Doe 1
167	Nicholas Mangan	Doe 1
168	Celeste Louise McCabe	168
169	Marian Y. McDougal	2
170	Murray McDougal	2
171	Irene Minkler	8
172	Dean Peter Moordigian	173
173	Kisag Moordigian	173
174	Eloise V. Mosher	68
175	W. E. Mosher	68
176	Perry Mulholland	62
177	Perry Mulholland	62
178	Rose Mulholland	62
179	Rose Mulholland	62
180	Thomas Mulholland	62
181	John E. Mullin	181
182	Marvel Elizabeth Mullin	141
183	Charles Mureau	183
184	Marie Murray	188
185	Julia N. Nathan	41
186	Paul E. Pendleton	34
187	Evelyn M. Pendleton	34
188	Florence S. Plemmons	188
189	John R. Plemmons	188
190	Charles Pryor	68
191	Pleasant Thomas Renfrow	36
192	Mary Mildred Renfrow	36
193	Helen Rushworth	194
194	Lester Rushworth	194
195	Lester R. Schwaiger	195
196	Cecil A. Schwaiger	195
197	Benjamin B. Smith	46
198	Sidney Smith	8
199	Walter W. Stavert	35
200	G. Henry Stetson	200
201	Steve Urquidez	8
202	William Urquidez	8
203	Grace C. Valliant	2
204	H. M. Warner	204
205	Elizabeth A. Wheeland	205
206	H. W. Wheeland	205
207	Constance Ray White	48
208	Leo L. White	48
209	Ray C. Wilcox	46
210	R. C. Woodward	15
211	Alice M. Wright	211
212	J. Marion Wright	211
213	Donald M. Young	2
214	Marcia S. Young	2
Doe Corp. 1	Security First National Bank of Los Angeles	195
Doe Corp. 2	Southern California Service Corporation	195
Doe Corp. 3	Verdugo Savings and Loan Association	195
Doe Corp. 4	Mollin Investment Corporation	Doe Corp. 4
Doe Corp. 5	Equitable Life Assurance Society of U. S.	2
Doe Corp. 6	Title Insurance and Trust Company	2
Doe Corp. 7	Northwestern Mutual Life Insurance Corporation	2
Doe Corp. 8	Title Insurance and Trust Company	2
Doe Corp. 9	Fidelity Federal Savings and Loan Association	2
Doe 1	Emily Louise Herrman	Doe 1
Doe 2	Henry R. Wheeland	205
Doe 3	Kenneth H. Morgan	195
Doe 4	William M. Bell	195
Doe 5	Sallie C. Bell	195
Doe 6	Anne Morgan	195
Doe 7	Irene Evelyn Wright	195
Doe 8	Ralph Carver Wright	195
Doe 9	Thelma M. Meeker	2
Doe 10	Carl H. Meeker	2
Doe 11	Laura J. LaGuay	2
Doe 12	Gladys J. Amador	2
Doe 13	Joseph E. Amador	2
Doe 14	Lester Townes Hope	Doe 14
Doe 15	Dolores Defina Hope	Doe 14
Doe 16	Leonard W. Block	41
Doe 17	Margery J. Block	41

Location of Wells and Surface Diversions

The locations of wells and surface diversions utilized by each of the parties during the period October 1, 1928 through September 30, 1958 are listed in Table 11. The locations of the wells are indicated by Los Angeles County Flood Control District well number while the surface diversion locations are indicated by the name of the stream upon which the diversion is located and the well grid coordinates wherein the diversion point is situated. The locations of all such wells known to have existed within the area of investigation are shown on Plate 18.

Extractions and Diversions

At the beginning of the investigation each party was contacted by letter and requested to indicate the information which each could furnish regarding his use of water. Those indicating that they had information were interviewed, as were many well operators and long-time residents of the area who had knowledge of the use of water extracted or diverted.

The greater part of the historical data concerning the use of water from wells for the period from 1930 to 1955 was obtained from the files of the City of Los Angeles Department of Water and Power. These data were compiled by Department of Water and Power employees in conjunction with the Department's well measurement program. Engineers of the Board have attempted to verify all data used in determining the extractions or diversions by the parties through comparison of results with correlated information concerning types and areas of crops grown, well logs, pump records and duty of water.

Information as to the beginning of extraction or diversion, the present status of the source and type of use of water (i.e., as of September 30, 1958) are listed for each party in Table 11. The term "present", where used in other tabulations presented within this chapter, also refers to September 30, 1958.

Capacity of Diversion Works

The maximum rate at which a party can extract or divert water with presently existing works has been considered herein as the capacity of his diversion works. In this regard, it should be noted that the combined capacity of a series of wells forming a well field may be less than the aggregate of these wells operated individually because of possible differences in discharge head and increased pumping lifts which may occur under combined operation. Because of the complexity of certain systems and the operational difficulties involved in establishing comparable test conditions for the various well fields belonging to the various parties, the capacity of the combined works belonging to a party has been evaluated as the aggregate of the individual extraction rates of the wells in that system. These values were determined by individual well tests where possible and from name plate or manufacturer's rating where the former method was not feasible. Capacities so determined for the present works of each party are set forth in Table 11.

TABLE 11

INFORMATION ON WATER DEVELOPMENT AND USE BY PARTIES AND THEIR PREDECESSORS

Party	Defendant number	Capacity of diversion works in c.f.s.[a]	First year of extraction or diversion	Status of diversion works[a]	Character of use	Methods of determining extractions and diversions
Los Angeles, City of Department of Water and Power	Plaintiff		1850[c]	Active	Municipal	1911-1958 - Sparling, Simplex, and Neptune meters; pitot measurements. 1929-1931 - production by Southern California Water Company and its predecessors based on number of services; prior to 1929, unknown.
Departments of Recreation and Parks and of Public Works						1929-1951 - owner's estimate of production rate and hours of operation. 1952-1958 - metered.
TOTAL		354				
San Fernando, City of	1	10	1911[c]	Active	Municipal	1929-1931 - estimate based on population. 1932-1958 - Sparling meter. 1951-1958 - kilowatt hours and pump test for one well.
Glendale, City of	2	39	1906[c]	Active	Municipal	1922-1958 - Venturi, Sparling, Triton meters; weir. Prior to 1950 - production by Highway Highlands Water Company unknown.
Burbank, City of	3	32	1911[c]	Active	Municipal	1926-1958 - Sparling meters.
Burbank City Unified School District	4	0	1906	Destroyed	Irrigation	1906-1938 - acres irrigated and duty.
Los Angeles County Flood Control District	6	0	Unknown	Inactive	Municipal, observation	Undeterminable.
La Canada Irrigation District	7	0.8	1924	Active	Municipal	1926-1958 - Sparling and Neptune meters. 1929-1931, 1947-1954 - estimate of surface diversions based on metered sales assuming a transmission loss.
Crescenta Valley County Water District	8	8.1	1916	Active	Municipal	Prior to 1932 - undeterminable. 1932-1958 - Sparling meter.
The Andrew Jergens Company	13	0	1943	Destroyed	Industrial	1943-1956 - owner's estimate of production rate and hours of operation.
Beatrice Foods Company	15	Unknown	1939	Active	Industrial	Prior to 1955 - undeterminable. 1955-1958 - acres irrigated and duty.
California Materials Company	18	1.5	1941	Active	Industrial	1941-1956 - owner's estimate based on production rates and hours of operation. 1956-1958 - Sparling meter.
Carnation Company	21	Unknown	1940	Active	Industrial	1940-1958 - owner's estimate of plant requirement based on period of sole use of municipal water.
Consolidated Rock Products Company	30	7.9	1924	Active	Industrial	1929-1958 - owner's estimate based on material sold and processing requirements.
Deep Rock Artesian Water Company	34	Unknown	1927	Active	Industrial	1927-1928 - owner's estimate of sales and percentage of municipal water used.
Desco Corporation	35	0	1940	Destroyed	Recreation	1940-1953 - capacity of pool and owner's estimate of number of times pool filled.
Drewry Photocolor Corporation	36	0.3	1946	Active	Industrial	1946-1958 - owner's estimate of production rate and hours of operation.
Forest Lawn Company	39	5.5	1914	Active	Irrigation	1915-1924 - owner's estimate of acres irrigated and duty. 1925-1956 - owner's estimate of production rate and hours of operation. 1957-1958 - kilowatt hours and pump test.
Freshpure Water Company	41	Unknown	About 1930	Active	Industrial	1930-1958 - owner's estimate based on volume of business.
Glendale Towel and Linen Supply Company	42	Unknown	1941	Active	Industrial	1941-1958 - owner's estimate based on volume of business.
Glenhaven Memorial Park, Inc.	43	0.2	Prior to 1935	Active	Irrigation	1942-1958 - acres irrigated and duty.
Hidden Hills Mutual Water Company	45	0.4	1950	Active	Municipal	1951-1954 - based on number of services. 1955-1958 - metered.
Houston Color Film Laboratories, Inc.	46	0	1940	Inactive	Industrial	1940-1955 - owner's estimate of production rate and hours of operation.
Knickerbocker Plastic Company, Inc.	48	0.6	1953	Active	Industrial	1953-1958 - pump test and owner's estimate of hours of operation.

TABLE 11

INFORMATION ON WATER DEVELOPMENT AND USE BY PARTIES AND THEIR PREDECESSORS
(continued)

Party	Defendant number	Capacity of diversion works in c.f.s.[a]	First year of extraction or diversion	Status of diversion works[a]	Character of use	Methods of determining extractions and diversions
Lakeside Golf Club of Hollywood	49	0.4	1928	Active	Irrigation	1928-1956 - acres irrigated and duty. 1936-1950 - partially by pump capacity and hours of operation. 1956-1958 - pump test and kilowatt hours.
Livingston Rock and Gravel Company	53	2.4	1932	Active	Industrial	1932-1958 - owner's estimate of production rate and hours of operation.
Lockheed Aircraft Corporation	54	0.9	1940	Active	Industrial	1940-1958 - owner's estimate of production rate and hours of operation.
Los Angeles Pet Cemetery	56	Unknown	1929	Active	Irrigation	1929-1958 - acres irrigated and duty.
Monteria Lake Association	61	0.1	1953	Active	Recreation	1953-1958 - owner's estimate of production rate and hours of operation.
Mulholland Orchard Company	62	1.3	1925	Active	Irrigation	1925-1956 - owner's estimate of production rate and hours of operation. 1956-1958 - kilowatt hours and metered production.
Oakwood Cemetery Association	64	0.3	1932	Active	Irrigation	1932-1957 - acres irrigated and duty. 1958 - pump test and owner's estimate of hours of operation.
Pacific Lighting and Gas Supply Company	66	0	1928	Inactive	Domestic	1928-1950 - number of people served and duty.
George E. Platt Company	67	Unknown	1915	Active	Irrigation, domestic and industrial	1920-1954 - acres irrigated, number of livestock watered and duty. 1955-1958 - number of people served, number of livestock watered and duty.
Polar Water Company	68	Unknown	1888	Active	Industrial	1923-1958 - owner's estimate of production rate and hours of operation.
Riverwood Ranch Mutual Water Company	70	0.3	1914	Active	Irrigation and domestic	1924-1947 - acres irrigated and duty. 1948-1949 - based on period of metered records. 1950-1958 - metered.
Roger Jessup Farms	71	0.3	1931	Active	Industrial	1931-1958 - owner's estimate of production rate and hours of operation.
Sears, Roebuck and Company	74	1.6	1938	Active	Commercial	1938-1943 - average production based on period of record. 1944-1949 - Simplex meter. 1950-1958 - measured pumping rate and average hours of operation based on period of record.
Southern California Edison Company	75	0	1890	Destroyed	Recreation	1931-1953 - estimate of pumping rate and hours of operation.
Southern Pacific Railroad Company	76	3.5	1910	Active	Industrial	1929-1946 - operator's estimate of plant capacity and hours of operation. 1947-1958 - Collins meter.
Southern Service Company, Ltd.	77	Unknown	1940	Active	Industrial	1940-1951 - owner's estimate of production rate and hours of operation. 1952-1958 - metered. 1955-1957 - estimated from partial record.
Sparkletts Drinking Water Corporation	78	0.9	1925	Active	Industrial	1925-1951 - record of sales. 1952-1958 - record of sales and measurement of backwash and zeolite solvent water.
Spinks Realty Company	79	Unknown	1914	Active	Irrigation	Prior to 1932 - undeterminable. 1932-1958 - acres irrigated and duty.
Sportsmen's Lodge Banquet Corporation	80	0.08	1914	Active	Recreation	1928-1958 - owner's estimate of production rate and hours of operation.
Technicolor Corporation	82	1.4	Prior to 1939	Active	Industrial	Prior to 1939 - undeterminable. 1939-1955 - owner's estimate of production rate and hours of operation. 1956-1958 - volumetric measurement of production rate and owner's estimate of hours of operation.
Toluca Lake Property Owners Association	97	0.2	1931	Active	Recreation	1931-1948 - estimate based on lake evaporation. 1949-1952 - undeterminable. 1953-1958 - owner's estimate of production rate and hours of operation.
Universal Pictures Company	99	0	1916	Active	Industrial	1916-1951 - based on period of record and owner's estimate of growth of company. 1952-1958 - metered.

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TABLE 11

INFORMATION ON WATER DEVELOPMENT AND USE BY PARTIES AND THEIR PREDECESSORS
(continued)

Party	Defendant number	Capacity of diversion works in c.f.s.[a]	First year of extraction or diversion	Status of diversion works[a]	Character of use	Methods of determining extractions and diversions
Valhalla Memorial Park	101	3.5	1915	Active	Irrigation	1928-1957 - acres irrigated and duty. 1958 - pump test and record of hours operated.
Van de Kamp's Holland Dutch Bakers, Inc.	104	0.2	1941	Active	Industrial	1941-1958 - owner's estimate of plant requirement based on period of sole use of municipal water.
Walt Disney Productions	105	9.5	1939	Active	Industrial	1939-1946 - based on record of hours pumped and production rate. 1947-1958 - Sparling meters.
Warner Brothers Pictures, Inc.	106	0	1901	Inactive	Industrial	1927-1946 - capacity of pool and owner's estimated number of times filled. 1947-1953 - owner's estimate of production rate and hours of operation.
William O. Bartholomaus	117	Unknown	1885	Active	Irrigation	1933-1950 - acres irrigated and duty, less water purchased. 1950-1958 - kilowatt hours and pump test.
Henry W. Berkemeyer	120	Unknown	1929	Active	Irrigation and domestic	1929-1958 - area irrigated, people served and duty.
Elfrieda M. Bishop	122	0.07	1933	Active	Irrigation	1933-1943 - undeterminable. 1944-1958 - area irrigated and duty.
Mark Boyar	126	Unknown	1948	Active	Domestic	1948-1958 - owner's estimate of production rate and hours of operation.
Stella M. Brown	127	Unknown	1900	Active	Irrigation	1929-1935 - undeterminable. 1936-1958 - acres irrigated and duty.
George A. Burns	128	Unknown	1948	Inactive	Domestic	1948-1955 - owner's estimate of production rate and hours of operation.
William M. Chace	132	0.2	1908	Active	Industrial	1928-1958 - owner's estimate of production rate and hours of operation.
Emma L. Clauson	134	0	1900	Inactive	Domestic	1900-1947 - based on domestic use.
Cecil B. DeMille	138	Unknown	Prior to 1920	Active	Irrigation and domestic	1920-1958 - acres irrigated and duty.
Maxine Duckworth	141	1.4[b]	1926	Active	Irrigation and domestic	Prior to 1936 - undeterminable. 1937-1958 - acres irrigated and duty.
Richard Erratchuo	143	0	1934	Inactive	Domestic	1934-1952 - number of people served and duty.
Howard Barton Griffith	148	Unknown	1953	Active	Irrigation	1953-1958 - based on amount of water previously purchased.
Neva Bartlett	153	Unknown	1949	Active	Domestic	1949-1958 - number of people served and duty.
E. E. Mahannah	164	Unknown	1953	Active	Domestic	1953-1958 - number of people served and duty.
Celeste Louise McCabe	168	Unknown	1932	Active	Commercial	1932-1958 - based on volume of business.
Kisag Moordigian	173	Unknown	1933	Inactive	Irrigation	1933-1958 - acres irrigated and duty.
John E. Mullin	181	Unknown	1949	Active	Irrigation and domestic	1949-1958 - kilowatt hours and pump test.
Charles Mureau	183	Unknown	Prior to 1900	Active	Domestic	Prior to 1945 - undeterminable. 1945-1958 - number of people served and duty.
Florence S. Plemmons	188	0	1920	Destroyed	Domestic, industrial and irrigation	Undeterminable.
Lester Rushworth	194	Unknown	1940	Active	Irrigation and domestic	1940-1958 - area irrigated and duty.
Lester R. Schwaiger	195	0	1928	Destroyed	Domestic	Undeterminable.
Sidney Smith	198	0.02	Unknown	Active	Domestic	Prior to 1943 - undeterminable. 1943-1958 - Sparling meter and weir.
G. Henry Stetson	200	2.3	1915	Active	Domestic and irrigation	1926-1958 - acres irrigated and duty.

TABLE 11

INFORMATION ON WATER DEVELOPMENT AND USE BY PARTIES AND THEIR PREDECESSORS
(continued)

Party	Defendant number	Capacity of diversion works in c.f.s.[a]	First year of extraction or diversion	Status of diversion works[a]	Character of use	Methods of determining extractions and diversions
H. M. Warner	204	Unknown	1910	Inactive	Irrigation	1924-1954 - acres irrigated and duty. 1955-1958 - kilowatt hours assuming a plant efficiency.
Elizabeth A. Wheeland	205	0.02	1924	Active	Irrigation and domestic	1924-1958 - acres irrigated and duty.
Alice M. Wright	211	Unknown	1940	Active	Irrigation	1940-1958 - acres irrigated and duty.
Mollin Investment Corporation	Doe Corp. 4	Unknown	1926	Inactive	Irrigation	1928-1958 - acres irrigated and duty.
Emily Louise Herrmann	Doe 1	Unknown	Unknown	Active	Domestic	Prior to 1940 - undeterminable. 1940-1958 - based on domestic use.
Lester Townes Hope	Doe 14	Unknown	1951	Active	Irrigation	1951-1958 - area irrigated and duty.

a. As of September 30, 1958.
b. Capacity of irrigation wells.
c. Date of incorporation. Except in the case of the City of Los Angeles and its predecessor, the Pueblo of Los Angeles, water was supplied to the named cities by private interests prior to the establishment of city services.

Quantity of Extractions and Diversions

The annual amounts of water extracted and diverted by each of the parties have been determined from meter records or estimated on the basis of the duty of water, pumpage rates and hours of operation, or power consumption and plant efficiency. Whenever possible, estimated amounts were determined by more than one method. The primary method utilized to determine the extractions and diversions of each of the various parties is listed in Table 11. The aggregate annual amounts of water extracted and diverted by all parties are shown for the period 1928-29 through 1957-58 and the years prior to 1928-29, in Tables 12 and 13, respectively. The amounts shown in Table 12 and 13 include water extracted and diverted on the valley floor and in hill and mountain areas. The latter are comparatively minor in magnitude. The annual amounts of ground water extracted and surface water diverted from individual sources within the Upper Los Angeles River area are included in the Basic Data.

TABLE 12

GROUND WATER EXTRACTIONS AND SURFACE WATER DIVERSIONS BY PARTIES AND THEIR PREDECESSORS
1928-29 THROUGH 1957-58

In Acre-Feet

Party	Defendant number	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	Wells and surface diversions active, October 1, 1928 through September 30, 1958
Los Angeles, City of Department of Water and Power	Plaintiff	64,280[m]	66,390[m]	68,640[m]	42,593 116	39,620 95	62,870 61	51,598 78	58,591 63	53,495 111	48,788 88	47,009 219	48,294 133	51,090 264	44,963 439	55,901 441	59,636 556	74,557 485	81,781 333	87,154 208	82,395 142	81,353 110	86,733 126	78,907 84	75,126 124	95,324 95	93,707 72	87,704 49	92,688 31	98,878 27	89,380 69	See well list below. Haines and Blanchard Canyons[g].
Departments of Recreation and Parks and of Public Works[a]		1,750	1,750	2,450	2,370	2,440	2,360	2,030	2,520	2,990	3,540	4,030	3,800	3,470	3,000	3,020	2,740	2,920	4,390	2,820	3,220	3,390	3,430	3,440	2,930	2,920	2,780	2,780	2,440	2,720	2,130	See well list at end of table.
TOTAL		66,030	68,140	71,090	45,080	42,160	65,290	53,710	61,190	56,600	52,420	51,260	52,230	54,820	48,400	59,360	62,930	77,960	86,500	90,180	85,760	84,850	90,290	82,430	78,180	98,340	96,560	90,530	95,160	101,620	91,580	
San Fernando, City of	1	1,100	1,140	1,180	1,190	1,277	1,318	1,205	1,435	1,448	1,411	1,548	1,530	1,522	1,745	1,878	1,799	1,880	1,979	2,084	2,383	2,528	2,470	2,460	2,331	1,988	1,937	2,384	3,010	2,563	2,853	4850B, 4850M, 5959, 5969, 5969A, 5969B.
Glendale, City of	2	7,311 1,332	8,582 1,124	9,756 532	9,156 335	9,036 342	9,665 378	8,467 399	9,691 580	9,758 497	10,194 720	10,738 1,299	10,942 1,225	10,508 1,487	11,750 1,357	12,763 1,454	12,820 1,687	13,546 1,616	16,011 1,231	17,243 1,034	19,299 660	20,166 611	17,794 532	18,500 465	17,056 707	19,459 1,076	19,922 1,120	22,188 1,046	20,918 971	23,396 945	19,392 1,056	See well list at end of table. Verdugo Canyon[f].
TOTAL		8,643	9,706	10,288	9,491	9,378	10,043	8,866	10,271	10,255	10,914	12,037	12,167	11,995	13,107	14,217	14,507	15,162	17,242	18,277	19,959	20,777	18,326	18,965	17,763	20,535	21,042	23,234	21,889	24,341	20,448	
Burbank, City of	3	2,564	2,902	2,805	2,455	2,506	2,819	2,736	3,034	3,140	3,843	5,378	6,250	7,420	10,220	11,570	12,710	13,740	13,590	13,220	15,730	16,050	16,340	17,760	18,020	19,900	20,780	21,520	20,760	20,670	19,050	See well list at end of table.
Burbank City Unified School District[c]	4	10	10	10	10	10	10	10	10	10	10	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	3872A.
La Canada Irrigation District	7	22 140	102 130	112 110	108 137	134 112	145 78	56 142	96 160	37 283	22 369	87 350	134 290	66 410	156 384	155 464	112 524	203 364	270 289	354 300	500 210	431 230	366 190	296 170	287 260	322 290	344 290	346 103	206 73	366 69	251 101	5069D, 5077A. Pickens and Snover Canyons[g].
TOTAL		160	230	220	245	246	223	198	256	320	391	437	424	476	540	619	636	567	559	650	710	660	560	470	550	610	630	449	279	435	352	
Crescenta Valley County Water District	8	* ----	* ----	* ----	714 0	732 0	893 0	659 0	653 22	598 34	648 39	692 48	700 83	629 86	789 89	698 155	805 211	838 130	1,237 72	1,480 118	2,009 185	1,817 83	1,896 104	1,910 78	2,208 99	2,588 89	2,789 67	2,409 85	2,186 81	2,223 55	2,538 89	See well list at end of table. Cooks, Dunsmore, Goss, and Pickens Canyons[t].
TOTAL					714	732	893	659	675	632	687	740	783	715	878	853	1,016	968	1,309	1,598	2,194	1,900	2,000	1,988	2,307	2,677	2,856	2,494	2,267	2,278	2,627	
The Andrew Jergens Company[c]	13	----	----	----	----	----	----	----	----	----	----	----	----	----	----	20[P]	50[P]	50[P]	30[P]	20[P]	30[P]	30[P]	30[P]	30[P]	30[P]	30[P]	30[P]	30[P]	8[P]			3892K.
Beatrice Foods Company	15	----	----	----	----	----	----	----	----	----	----	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	3958F.
California Materials Company	18	----	----	----	----	----	----	----	----	----	----	----	----	80	280	300	310	300	290	330	390	380	380	360	340	370	340	240	300	350	330	4926.
Carnation Company	21	----	----	----	----	----	----	----	----	----	----	----	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3882L.
Consolidated Rock Products Company	30	220	120	130	110	0	80	170	340	350	330	300	410	540	410	340	440	440	820	700	740	560	560	640	580	970	1,250	1,000	1,390	1,340	1,113	4909A, 4909B, 4916, 4916A.
Deep Rock Artesian Water Company	34	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	3987C, 3987D.
Desco Corporation[d]	35	----	----	----	----	----	----	----	----	----	----	----	----	120	120	120	120	120	120	120	120	120	120	90	90	7	----	----	----	----	----	3883J.
Drewry Photocolor Corporation	36	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2	8	11	13	17	21	24	25	27	30	30	29	21	3935.
Forest Lawn Company	39	640	790	850	840	840	760	630	770	700	790	810	790	730	710	800	720	790	880	1,050	1,070	1,180	1,150	1,060	1,080	1,000	930	880	1,010	1,270	920	3947A. 3947B. 3947C, 3947D, 3884T.
Freshpuro Water Company	41	----	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3987E.
Glendale Towel and Linen Supply Company	42	----	----	----	----	----	----	----	----	----	----	----	----	3	10	10	10	10	10	20	20	20	20	20	20	20	20	20	20	30	30	3936.
Glenhaven Mrmorial Park, Inc.	43	----	----	----	----	----	----	----	*	*	*	*	*	*	*	10	30	50	60	70	90	110	110	110	110	120	120	120	120	120	120	6028. 6028A, 6028C, 6028D, 6028E, 6029.
Hidden Hills Mutual Water Company	45	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	2	15	25	41	87	98	115	131	See well list at end of table.
Houston Color Film Laboratories, Inc., of California[e]	46	----	----	----	----	----	----	----	----	----	----	----	20	20	20	20	20	20	20	20	30	70	70	70	70	70	20	----	----	----	----	3882M.
Knickerbocker Plastic Company, Inc.	48	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	150[P]	230[P]	230[P]	230[P]	230[P]	230[P]	3810H.
Lakeside Golf Club of Hollywood	49	330	330	330	330	330	330	330	330	330	390	390	390	390	390	390	390	390	390	390	330	320	340	180	290	280	280	280	200	130	150	3845A, 3845B, 3845C, 3855D.
Livingston Rock and Gravel Company	53	----	----	----	160	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	460	450	450	440	430	440	370	4916B, 4953C.
Lockheed Aircraft Corporation	54	----	----	----	----	----	----	----	----	----	----	----	90[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	310[P]	160[P]	160[P]	160[P]	160[P]	150[P]	3850F, 3870, 3871D, 3871F.
Los Angeles Pet Cemetery	56	1	1	1	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	3544B, 3554A.
Monteria Lake Association	61	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	20	40	40	40	40	40	4722.
Mulholland Orchard Company	62	1,680	1,540	1,400	1,260	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	720	690	660	630	600	570	540	500	460	370	4716, 4735B, 4735C, 4736.
Oakwood Cemetery Association	64	----	----	----	----	70	70	70	70	70	70	70	70	70	70	50	50	50	50	50	50	50	50	50	50	50	50	50	50	60	70	4674, 4684B, 4684C.
Pacific Lighting and Gas Supply Company[f]	66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	----	----	----	----	----	----	----	----	3554.
George E. Platt Company	67	240	240	240	240	240	240	240	290	270	220	230	230	140	270	190	270	680	680	680	680	680	680	680	680	680	680	1	1	1	1	See well list at end of table.
Polar Water Company	68	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3832D, 3832J.
Riverwood Ranch Mutual Water Company	70	10 ----	10 ----	10 ----	10 ----	10 ----	0 10	0 10	0 10	0 10	0 10	10 ----	20 ----	20 ----	20 ----	20 ----	20 ----	20 ----	20 ----	20 ----	10 ----	10 ----	10 ----	9 ----	13 ----	13 ----	12 ----	12 ----	13 ----	14 ----		4982. Big Tujunga Wash[u].
Roger Jessup Farms	71	----	----	10	110	110	110	110	110	110	110	110	110	110	110	110	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	3924G, 3924H.
Sears, Roebuck and Company	74	----	----	----	----	----	----	----	----	----	90[P]	90[P]	90[P]	100[P]	89[P]	94[P]	76[P]	104[P]	22[P]	90[P]	89[P]	109[P]	90[P]	90[P]	90[P]	90[P]	90[P]	90[P]	90[P]	110[P]	110[P]	3945.

* Diversion in existence, but production unknown. See last page of table for footnotes.

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TABLE 12

GROUND WATER EXTRACTIONS AND SURFACE WATER DIVERSIONS BY PARTIES AND THEIR PREDECESSORS
1928-29 THROUGH 1957-58
(continued)

In Acre-Feet

Party	Defendant number	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	Wells and surface diversions active, October 1, 1928 through September 30, 1958
Southern California Edison Company[g]	75	----	----	----	300	300	150	150	150	0	0	120	110	110	110	110	110	110	110	30	30	30	30	30	30	----	----	----	----	----	----	4932 and 4932B.
Southern Pacific Railroad Company	76	2,335	2,335	2,140	1,570	1,680	2,150	2,340	2,170	2,180	1,870	1,750	2,010	1,890	1,600	1,890	1,940	1,910	2,320	2,274	2,284	2,281	2,281	2,259	2,261	2,256	2,256	2,237	2,233	2,225	1,949	2760A, 2760B, 2760D, 2760E, 2760F.
Southern Service Company, Ltd.	77	----	----	----	----	----	----	----	----	----	----	----	----	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	40	30	25	3934A.
Sparklett Drinking Water Corporation	78	20	20	20	20	10	20	20	20	20	20	20	20	20	20	20	30	30	30	40	40	40	40	40	100	110	110	110	120	130	140	3987A, 3987B, 3987F, 3987(1), 3987(2), 3987(3).
Spinks Realty Company	79	*	*	*	10	20	30	30	20	20	60	10	10	10	20	20	20	20	20	10	20	40	20	20	20	20	20	20	20	20	20	4694.
Sportsmen's Lodge Banquet Corporation	80	220	220	220	220	220	220	220	220	220	220	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	3785, 3785A.
Technicolor Corporation	82	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	230	380	380	380	380	380	380	380	380	380	320	300	300	3864C, 3864D, 3864G.
Toluca Lake Property Owners Association	97	----	----	5	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	*	*	*	*	0	120	110	110	100	100	3845F, 3855A.
Universal Pictures Company	99	140	140	140	140	140	140	140	140	140	150	150	150	150	150	150	150	150	150	150	150	150	150	150	174	117	227	202	173	97	14	3845C, 3845D.
Valhalla Memorial Park	101	230	230	230	230	230	230	230	230	230	240	240	240	240	240	240	240	240	240	240	240	240	240	240	250	250	250	250	250	280	280	3830F, 3830H, 3830J, 3830K, 3830L, 3830M.
Van de Kamp's Holland Dutch Bakers, Inc.	104	----	----	----	----	----	----	----	----	----	----	----	----	30	100	100	100	100	100	120	120	120	120	120	120	120	120	120	120	120	120	3958C.
Walt Disney Productions	105	----	----	----	----	----	----	----	----	----	----	290	570	520	440	600	550	680	640	690	700	840	810	910	1,240	1,520	1,850	1,950	1,770	1,480	1,860	3874E, 3874F.
Warners Brothers Pictures, Inc.	106	1	0	0	0	0	1	0	0	0	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	0	0	0	0	0	3864A, 3864B, 3865.
William O. Bartholomaus	117	*	*	*	*	*	150	90	0	0	40	70	150	160	170	150	140	60	110	40	20	0	0	20	2	3	3	0	0	0	20	4921.
Henry W. Berkemeyer	120	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	2	2	2	2	2	2	2	2	1	1	1	4685.
Elfrieda M. Bishop	122	----	----	----	----	----	*	*	*	*	*	*	*	*	*	*	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	5077B.
Mark Boyar	126	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	1	1	1	1	1	1	1	3541.
Stella M. Brown	127	*	*	*	*	*	*	*	*	10	10	10	10	10	10	10	10	10	10	10	10	10	10	2	2	2	2	2	2	2	2	4860C.
George A. Burns[h]	128	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	3	3	3	3	3	3	3	3	----	----	----	3624.
William M. Chace	132	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	40	30	30	20	20	20	20	20	20	6	3833.
Emma L. Clauson[i]	134	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	*	*	*	*	----	----	----	----	----	----	----	3851.
Cecil B. DeMille	138	60	60	60	60	60	60	60	60	60	70	70	70	70	70	70	70	70	70	70	70	70	70	60	60	60	60	60	40	40	40	4930A, 4931, 4931A, 4940, 4940A, 6086.
Maxine Duckworth	141	*	*	*	*	*	*	*	*	*	480	480	480	480	480	480	480	480	480	480	480	530	520	520	530	520	520	520	500	500	520	5997A, 5998, 5998A.
Richard Erratchuo[j]	143	----	----	----	----	----	----	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	----	----	----	----	----	----	4830A.
Howard Barton Griffith	148	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	26	26	26	26	26	26	4702.
Neva Bartlett	153	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	1	1	1	1	1	1	4973J.
E. E. Mahannah	164	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	1	1	5076.
Celeste Louise McCabe	168	----	----	----	----	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3852, 3852D.
Kisag Moordigian	173	----	----	----	----	----	30	20	10	30	40	50	50	50	50	50	50	50	50	30	30	40	40	40	40	0	0	0	40	30	0	5939.
John E. Mullin	181	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	20	20	7	10	10	10	40	40	10	5998B.
Charles Mureau	183	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3544.
Florence S. Flemmons[k]	188	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	----	----	----	4973B, 4983D.
Lester Bushworth	194	----	----	----	----	----	----	----	----	----	----	----	----	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3540B, 3540C.
Lester R. Schwaiger	195	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	----	----	----	5066.
Sidney Smith	198	*	*	*	*	*	*	*	*	*	*	*	*	*	*	22	23	20	19	18	17	16	14	14	15	15	15	13	10	13	11	Pickens Canyon[v].
G. Henry Stetson	200	100	100	100	100	100	100	90	110	100	130	80	70	60	90	90	90	90	90	110	110	110	110	130	130	130	130	130	130	130	130	5937, 5937A.
H. M. Warner	204	390	390	390	390	380	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	60	50	60	60	7	3600, 3601.
Elizabeth A. Wheeland	205	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4830.
Alice M. Wright	211	----	----	----	----	----	----	----	----	----	----	----	----	6	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	3937F.
Mollin Investment Corporation	Doe Corp.	540	540	540	540	630	470	460	580	530	550	520	440	380	580	560	540	460	550	550	520	570					400	400	330	330	270	5988A, 5989D, 5997.
	4	500	500	500	500	270	440	240	120	160	140	180	250	310	110	140	160	230	140	140	180	120					0	0	0	0	0	Pacoima Wash[n].
TOTAL		1,040	1,040	1,040	1,040	900	910	700	700	690	690	700	690	690	690	700	700	700	690	690	700	690	700	700	400	400	400	400	330	330	270	
Emily Louise Herrmann	Doe 1	*	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4850L.
Lester Townes Hope	Doe 14	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	1	1	1	1	1	3855E.
TOTAL		86,490	90,020	93,240	66,690	63,270	88,060	74,700	83,940	79,260	77,230	79,030	81,820	85,690	83,580	97,620	102,860	120,070	131,710	136,740	137,580	137,720	140,880	134,870	130,320	155,800	156,020	151,740	154,620	162,990	147,140	
Surface diversions		640	630	610	750	480	590	470	400	600	650	800	760	1,070	1,020	1,220	1,470	1,230	850	780	730	560	430	350	500	490	440	250	200	160	270	
Extractions returned directly to ground water		----	----	----	----	----	----	----	----	----	90	90	180	410	400	420	440	460	360	420	430	450	430	430	430	580	510	510	490	500	490	
Extractions[w]		85,850	89,390	92,630	65,940	62,790	87,470	74,230	83,540	78,660	76,490	78,140	80,880	84,210	82,160	95,980	100,950	118,380	130,500	135,540	136,420	136,710	140,020	134,040	129,390	154,730	155,070	150,980	153,930	162,330	146,380	

* Diversion in existence, but production unknown. See last page of table for footnotes.

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TABLE 12

GROUND WATER EXTRACTIONS AND SURFACE WATER DIVERSIONS BY PARTIES AND THEIR PREDECESSORS
1928-29 THROUGH 1957-58
(continued)

WELL LIST

City of Los Angeles
Department of Water and Power

2771G	3800B	3821D	3842E	3884N	3884JJ	3894J	3894Z	3924B	3925S	3949	4993C
3700A	3800C	3821E	3843M	3884U	3884KK	3894K	3894AA	3924C	3925T	3949A	4993D
3770	3810	3821F	3844R	3884V	3884LL	3894L	3894BB	3924E	3925U	3949B	4994
3770A	3810A	3821G	3853F	3884W	3884MM	3894M	3914D	3924F	3926A	3959E	4994A
3770B	3810B	3821H	3853O	3884X	3884NN	3894N	3914E	3924J	3926B	4840A	4994B
3771	3810C	3830B	3854	3884Y	3884PP	3894P	3914F	3924K	3926D	4840B	4994C
3780A	3811F	3830C	3854F	3884Z	3884QQ	3894Q	3914G	3924L	3926E	4840C	4994D
3790	3811G	3830D	3863B	3884AA	3884RR	3894R	3914H	3924M	3926G	4840G	5014
3790A	3820	3831E	3863D	3884BB	3893K	3894S	3914J	3924P	3926P	4840H	
3790B	3820B	3831F	3863H	3884CC	3893L	3894T	3914K	3924Q	3926R	4983F	
3790C	3820C	3831G	3863J	3884DD	3894	3894U	3914L	3925	3926S	4983G	
3790D	3820D	3831H	3863K	3884EE	3894A	3894V	3914M	3925A	3926T	4992A	
3790F	3820E	3832K	3863L	3884FF	3894B	3894W	3914S	3925B	3926U	4992B	
3800	3821B	3832L	3874A	3884GG	3894H	3894X	3924	3925C	3926V	4993A	
3800A	3821C	3832M	3884G	3884HH	3894I	3894Y	3924A	3925D	3926W	4993B	

City of Los Angeles
Department of Recreation and Parks
and Department of Public Works

2760	3813A	3894C
3650B	3823A	3894D
3661C	3833D	3894CC
3752	3844C	3904B
3762B	3893G	3914
3764A	3893E	3915

City of Glendale

3903A	3913B	3914B	3971
3903M	3913C	3914C	3971A
3903N	3913D	3924N	3971C
3913	3913E	3961	5036
3913A	3913F	3963A	5036C
		3970	5036D

City of Burbank

3841C	3851B	3882D
3841F	3851C	3882E
3841G	3851D	3882F
3850E	3851F	3882P
	3851G	3882S

Crescenta Valley
County Water District

5036A	5058	5058E
5036B	5058A	5058F
5047	5058B	5058H
5047B	5058C	5069F
5047D	5058D	5069J

Hidden Hills
Mutual Water Company

3532	3533F	3534
3532A	3533G	3534A
3533A	3533H	3534B
3533B	3533J	3534C
3533D	3533K	3543B
		3543C

George E. Platt
Company

3540D	3570B
3561A	3570C
3561B	3571E
3561E	3571H
3561G	3571J

FOOTNOTES

a. Department of Public Works extractions made only during 1945-1946.
b. Well capped in 1938.
c. Well not used after 1955.
d. Well abandoned in 1954.
e. Well not used after 1955.
f. Well not used after 1950.
g. Well No. 4932 capped in 1945; Well No. 4932B capped in 1955.
h. Well capped in 1955.
i. Well capped in 1951.
j. Well abandoned in 1953.
k. Well No. 4973B capped in 1957; Well No. 4983 capped prior to 1955.
m. Includes gravity production.
n. Diversion located in well location grid coordinate 5997.
p. Extractions are returned directly to ground water without loss.
q. Haines Canyon diversion located in well location grid coordinate 5043. Blanchard Canyon diversion located in well location grid coordinate 5035.
r. Diversion located in well location grid coordinate 3963.
s. Pickens Canyon diversion located in well location grid coordinate 5076. Snover Canyon diversion located in well location grid coordinate 5077.
t. Cooks Canyon diversion located in well location grid coordinate 5045; Dunsmore Canyon diversion located in well location grid coordinate 5055; Goss Canyon diversion located in well location grid coordinate 5066; and Pickens Canyon diversion located in well location grid coordinate 5076.
u. Diversion located in the vicinity of well location grid coordinate 4982, exact location unknown.
v. Diversion located in well location grid coordinate 5076.
w. Does not include extractions which are returned directly to ground water without loss.

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TABLE 13

ESTIMATED AND MEASURED GROUND WATER EXTRACTIONS AND SURFACE WATER DIVERSIONS OF PARTIES AND THEIR PREDECESSORS MADE PRIOR TO 1928-29 FROM SOURCES IN THE UPPER LOS ANGELES RIVER AREA

In Acre-Feet

Year	Plaintiff[a]	Defendant Number[b]											
		2	3	4	7	34	39	62	67	70	78	80	138
1913-14				10[c]									
14-15				10			70						
1915-16	52,780			10			100						
16-17	50,400			10			120						
17-18	44,780			10			130						
18-19	43,370			10			140						
19-20	40,590			10			150						60
1920-21	48,110			10			160		240				60
21-22	50,130			10			200		240				60
22-23	51,640	4,156		10			240		240				60
23-24	56,240	5,492		10			270		240				60
24-25	67,180	5,619		10			320	1,440	240	10			60
1925-26	66,150	6,474	2,112	10			400	2,100	240	10	2		60
26-27	56,980	7,296	2,376	10	6		480	1,960	240	10	4		60
27-28	60,620	8,242	2,718	10	86	4	510	1,820	240	10	20	220	60

a. Records are incomplete and do not include extractions made by the Department of Recreation and Parks, Sunland-Tujunga well field and surface diversions.

b. For name of defendant see Table 10.

c. Annual amounts 1906-07 through 1912-13 equal 10 acre-feet.

Extractions by nonparties, other than those directly known by the Referee to have extracted or diverted water, were determined from the records of the City of Los Angeles Department of Water and Power. These records, which covered the period 1932 through 1949, were compiled by Mr. Frank Carr in the course of his duties while employed by that city. The data contained information as to the owner, well location, crop and acreage irrigated, and Mr. Carr's estimate of the annual amount extracted. The Referee's staff, whenever possible, confirmed Mr. Carr's data from other data collected in the course of the investigation. Prior to 1932, the amounts of extractions by nonparties were determined from the acreages irrigated by these entities. Data for the years subsequent to 1949 were collected by the Board staff to complete the amounts of water extracted by nonparties during the 29-year base period. The data collected by the Board staff formed the basis for a report filed with the Court on current extractions of nonparties made pursuant to a request of parties in Open Court on July 29, 1960. The report included all other nonparties known by the Board staff to presently be taking significant amounts of water except single domestic users in the hill and mountain areas. The names and amounts of extractions and diversions by nonparties shown in Table 14 are based on the information presented in the aforementioned report and on other records as heretofore noted.

TABLE 14

ESTIMATED AND MEASURED GROUND WATER EXTRACTIONS
AND SURFACE WATER DIVERSIONS OF NONPARTIES

In Acre-Feet

Year	Nonparty number[a]													Others[b]	Total[c]
	1	2	3	4	5	6A	6B	7	8	9A	9C	9D	9E		
1928-29				20							340			3,510	3,870
29-30				20							340			3,500	3,860
1930-31				20							340			3,420	3,780
31-32				20							190			3,270	3,480
32-33				20							540			3,980	4,540
33-34				20							460			4,010	4,490
34-35				0							320			4,310	4,630
1935-36				0							350			4,370	4,720
36-37				0					60		480			4,470	5,010
37-38				20			40		60		410			5,210	5,740
38-39				20			30		60	0	380			5,620	6,110
39-40				20			40		70	20	180		90[f]	5,170	5,500
1940-41				20			40		70	20	80		150[f]	3,550	3,780
41-42				20			40		60	20	100		150[f]	4,060	4,300
42-43				20			50		90	20	60		150[f]	3,110	3,350
43-44				20			50		90	20	110		150[f]	3,290	3,580
44-45				20			60		70	20	110		150[f]	3,570	3,850
1945-46				20			70		60	20	100		150[f]	2,500	2,770
46-47				20		20	80		40	20	100		150[f]	1,320	1,660
47-48				20		20	60		10	20	100		150[f]	1,220	1,450
48-49				20		40	60		0	20	150		150[f]	1,080	1,370
49-50				20		50	60		10	20	200		150[f]	790	1,150
1950-51	10	30		20		60	80	20[d]	0		200		150[f]	590	1,010
51-52	10	30	10	20		60	90	30[d]	0		200		150[f]	430	880
52-53	20	30	10	20		50	80	60[d]	0		200		150[f]	180	640
53-54	10	30	10	20		40	80	70[d]	0		70		0	180	510
54-55	10	30	10	20	0	30	70	120[d]	10		240		0	40	580
1955-56	10	30	10	20	10	40	60	290[d]	30		230	0	0	10	730
56-57	10	30	10	20	10	20	80	490[d]	10		230	30[e]	0	30	940
57-58	10	30	10	20	10	40	90	620[d]	40		280	30[e]	0	0	1,140

a. Nonparty numbers are those referred to in the Report made pursuant to request made in Court on July 29, 1960. Nonparty numbers and names are tabulated below.
b. Determined from the records of Los Angeles Department of Water and Power employee Frank Carr, 1929 through 1949.
c. Total considered as all extractions but contains minor amounts of surface diversions.
d. Includes water extracted adjacent to and outside of the Upper Los Angeles River topographic boundary.
e. Included in amounts shown under nonparty No. 7.
f. Included in amounts shown under Defendant No. 54.

Nonparty number	Nonparty	Method of estimating extractions and diversions
1	Simi Hills Development Association	Production rate and hours of operation.
2	Chatsworth Lake Mutual Water Corporation	Production rate and hours of operation.
3	Twin Lakes Park Company	Use per capita.
4	Restland Memorial Park	Acres irrigated and duty of water.
5	Aqua Sierra Sportsman Club	Acres irrigated and duty of water.
6	Los Angeles County	Acres irrigated and duty of water
	A. Dexter Park	Pump test and kilowatt hours.
	B. Waterworks District No. 21	Pump test and kilowatt hours.
7	North American Aviation, Inc. Rocketdyne Division	Measured.
8	Louis J. Le Mesnager	Water sales.
9	United States of America	
	A. Veterans Hospital, Northeast of San Fernando	Extension of one year's measurements.
	C. Sepulveda Dam lease to Frank Ghiglia	Acres irrigated and duty of water.
	D. Ajacent to North American Aviation, Inc.	Measured.
	E. Adjacent to Lockheed Aircraft Corporation	Production rate and hours of operation.

Tables 12, 13 and 14 list the extractions and diversions within the Upper Los Angeles River area that have been made by entities who are parties and nonparties including known nonparty entities and taking by others whose individual identity is unknown. Total amounts extracted from the valley fill and hill and mountain areas, compiled from the data in Tables 12 and 14 and the records on private wells maintained by the City of Los Angeles Department of Water and Power, are shown in Table 15. Surface diversions for use on the valley floor are shown in Table 16.

The total amount of ground water extracted annually during the 29-year base period has increased generally with time, from approximately 70,000 acre-feet in the early 1930's to 150,000 acre-feet in the late 1950's. During the 29-year base period the minimum and maximum annual extractions were 67,333 and 163,270 acre-feet in 1932-33 and 1956-57, respectively.

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TABLE 15

GROUND WATER EXTRACTIONS[a]

In Acre-Feet

Year	Valley fill area			Hill and mountain area			Upper Los Angeles River area		
	Party (1)	Non-party (2)	Total (1)+(2) =(3)	Party (4)	Non-party (5)	Total (4)+(5) =(6)	Party (7)	Non-party (8)	Total (7)+(8) =(9)
1928-29	85,840	3,870	89,710	10		10	85,850	3,870	89,720
29-30	89,380	3,860	93,240	10		10	89,390	3,860	93,250
1930-31	92,620	3,780	96,400	10		10	92,630	3,780	96,410
31-32	65,930	3,480	69,410	10		10	65,940	3,480	69,420
32-33	62,770	4,540	67,310	20		20	62,790	4,540	67,330
33-34	87,450	4,490	91,940	20		20	87,470	4,490	91,960
34-35	74,210	4,630	78,840	20		20	74,230	4,630	78,860
1935-36	83,520	4,720	88,240	20		20	83,540	4,720	88,260
36-37	78,640	5,010	83,650	20		20	78,660	5,010	83,670
37-38	76,470	5,700	82,170	20	40[b]	60	76,490	5,740	82,230
38-39	78,120	6,080	84,200	20	30	50	78,140	6,110	84,250
39-40	80,860	5,460	86,320	20	40	60	80,880	5,500	86,380
1940-41	84,190	3,740	87,930	20	40	60	84,210	3,780	87,990
41-42	82,140	4,260	86,400	20	40	60	82,160	4,300	86,460
42-43	95,950	3,300	99,250	30	50	80	95,980	3,350	99,330
43-44	100,900	3,530	104,430	50	50	100	100,950	3,580	104,530
44-45	118,310	3,790	122,100	70	60	130	118,380	3,850	122,230
1945-46	130,420	2,700	133,120	80	70	150	130,500	2,770	133,270
46-47	135,450	1,570	137,020	90	90	180	135,540	1,660	137,200
47-48	136,310	1,370	137,680	110	80	190	136,420	1,450	137,870
48-49	136,580	1,260	137,840	130	110	240	136,710	1,370	138,080
49-50	139,890	1,030	140,920	130	120	250	140,020	1,150	141,170
1950-51	133,910	850	134,760	130	160	290	134,040	1,010	135,050
51-52	129,240	700	129,940	150	180	330	129,390	880	130,270
52-53	154,540	440	154,980	190	200	390	154,730	640	155,370
53-54	154,860	270	155,130	210	240	450	155,070	510	155,580
54-55	150,730	360	151,090	250	220	470	150,980	580	151,560
1955-56	153,670	330	154,000	260	400	660	153,930	730	154,660
56-57	162,050	330	162,380	280	610	890	162,330	940	163,270
57-58	146,080	380	146,460	300	760	1,060	146,380	1,140	147,520
29-Year Average 1929-57	108,790	2,950	111,740	80	100	180	108,870	3,040	111,920

a. Does not include extractions returned directly to ground water without loss.
b. Extractions unknown prior to 1937-38.

TABLE 16

SURFACE WATER DIVERSION

In Acre-Feet

Year	Valley fill (1)	Hill and mountain (2)	Total (3)
1928-29	500	140	640
29-30	500	130	630
1930-31	500	110	610
31-32	500	250	750
32-33	270	210	480
33-34	440	150	590
34-35	240	230	470
1935-36	120	280	400
36-37	160	440	600
37-38	140	510	650
38-39	180	620	800
39-40	250	510	760
1940-41	310	760	1,070
41-42	110	910	1,020
42-43	140	1,080	1,220
43-44	160	1,310	1,470
44-45	230	1,000	1,230
1945-46	140	710	850
46-47	140	640	780
47-48	180	550	730
48-49	120	440	560
49-50	0	430	430
1950-51	0	350	350
51-52	0	500	500
52-53	0	490	490
53-54	0	440	440
54-55	0	250	250
1955-56	0	200	200
56-57	0	160	160
57-58	0	270	270
29-Year Average 1929-57	180	480	660

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Land Development and Use

The San Fernando Valley is a prime example of the transformation of agricultural land into a modern suburban area. Prior to 1915, the Upper Los Angeles River area had been devoted mainly to nonirrigated agriculture. In 1928-29, irrigated agriculture occupied 47 percent of the valley floor and by 1957-58 constituted only 13 percent of the valley floor. On the other hand, residential, commercial and industrial acreage has tripled during the period 1928-29 through 1957-58 (see Figure 1). Accompanying this rapid change in land use has been a population growth of from 203,000 persons in 1930 to 850,000 in 1956. Land use in the area has been classified in four general types based on the varying influence of each on water supply and disposal. These general culture types are as follows:

1. Dry farm and native crops
2. Irrigated crops
3. Residential
4. Commercial and industrial

The areal extent of lands occupied by the major culture types requiring water (i.e., residential, commercial and industrial and irrigated crops) during the years 1928, 1949, 1955 and 1958 is depicted on Plates 22, 23, 24 and 25 respectively. These plates are based on land use surveys made in 1932, 1942, 1949, 1954 and 1958; aerial photographs taken in 1928 and 1956; crop records for the period 1925 through 1958; and censuses for the years 1930, 1940, 1950 and 1956 (see Appendix K).

Land Use

Extent of the four major culture types within the valley fill area for each year of the base period is summarized in Table 17. The variation of acreages in the dry farm and native group, irrigated crops, residential, and commercial and industrial uses during the period 1928-29 through 1957-58 is illustrated graphically on Figure 1, which indicates the general trend of land use from agricultural to urban during the last thirty years.

A detailed discussion of the data available and the methods utilized to determine the areal culture for each of the years in the 1928-29 through 1957-58 period for each of the hydrologic subareas is contained in Appendix K.

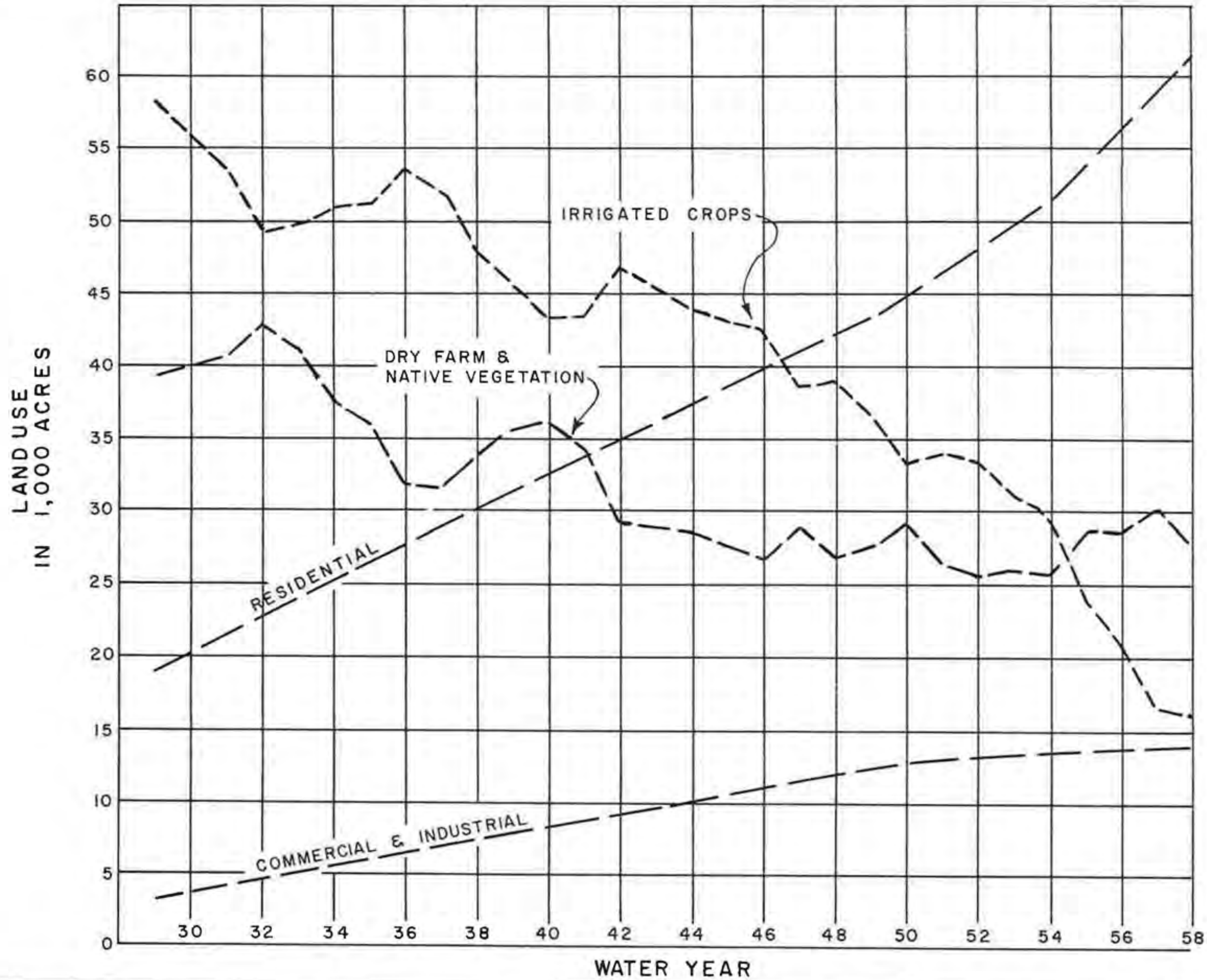
TABLE 17

LAND USE WITHIN BOUNDARY OF VALLEY FILL

(Total Valley Fill Area = 123,400 Acres)

In Acres and Percent of Total Area

Year	Irrigated crops		Residential		Commercial and industrial		Dry farm and native vegetation		Miscellaneous, riparian and water surface	
	Acres	Percent of total area	Acres	Percent of total area	Acres	Percent of total area	Acres	Percent of total area	Acres	Percent of total area
1928-29	58,380	47	19,040	15	3,010	2	39,150	32	3,820	3
29-30	55,720	45	20,260	16	3,480	3	40,120	32	3,820	3
1930-31	53,610	43	21,480	17	3,940	3	40,550	33	3,820	3
31-32	49,240	40	22,700	18	4,410	4	43,230	35	3,820	3
32-33	49,660	40	23,920	19	4,880	4	41,120	33	3,820	3
33-34	50,940	41	25,140	20	5,350	4	37,790	31	4,180	3
34-35	51,130	41	26,350	21	5,810	5	35,930	29	4,180	3
1935-36	53,550	43	27,570	22	6,280	5	31,820	26	4,180	3
36-37	52,050	42	28,790	23	6,750	5	31,630	26	4,180	3
37-38	47,910	39	30,010	24	7,210	6	34,090	28	4,180	3
38-39	45,530	37	31,230	25	7,680	6	35,560	29	3,400	3
39-40	43,350	35	32,450	26	8,150	7	36,190	29	3,260	3
1940-41	43,310	35	33,670	27	8,610	7	34,430	28	3,380	3
41-42	46,870	38	34,890	28	9,080	7	29,180	24	3,380	3
42-43	45,460	37	36,110	29	9,550	8	28,900	23	3,380	3
43-44	44,070	36	37,330	30	10,020	8	28,600	23	3,380	3
44-45	43,280	35	38,540	31	10,480	8	27,720	22	3,380	3
1945-46	42,710	35	39,760	32	10,950	9	26,450	21	3,530	3
46-47	38,400	31	40,980	33	11,420	9	29,070	24	3,530	3
47-48	38,890	31	42,200	34	11,890	10	26,890	22	3,530	3
48-49	36,340	29	43,410	35	12,350	10	27,770	23	3,530	3
49-50	33,230	27	44,990	36	12,550	10	29,100	24	3,530	3
1950-51	34,090	28	46,570	38	12,760	10	26,450	21	3,530	3
51-52	33,300	27	48,150	39	12,960	10	25,460	21	3,530	3
52-53	30,910	25	49,730	40	13,170	11	26,060	21	3,530	3
53-54	29,570	24	51,310	42	13,370	11	25,620	21	3,530	3
54-55	23,770	19	53,900	44	13,470	11	28,730	23	3,530	3
1955-56	20,960	17	56,490	46	13,570	11	28,740	23	3,640	3
56-57	16,370	13	59,070	48	13,670	11	30,250	25	4,040	3
57-58	16,170	13	61,660	50	13,770	11	27,740	22	4,060	3



SAN FERNANDO VALLEY REFERENCE

LAND USE — VALLEY FILL AREA

FIGURE 1

STATE WATER RIGHTS BOARD

Coincident with urbanization of the area there has been an increase in the proportion of the residential lot (including street rights of way) that is impervious and an increase in the miles of natural channels and washes that have been replaced by lined channels or conduits. From 1928 to 1958 the increase of impervious area occurring in privately held and publicly held areas that make up the residential lot was as follows:

Period	Percent of impervious area in a typical residential lot
1928-29 through 1944-45	35
1946-47 through 1949-50	40
1950-51 through 1954-55	45
1955-56 through 1957-58	50

Channel Improvements

The increased area of impervious lands has caused larger amounts of runoff to be discharged into the drainage system of the area. The quantity of runoff which becomes recharge to the ground water reservoir is limited by the pervious area over which the runoff flows. The need for flood control has resulted in the improvement of most of the Los Angeles River Channel and many of the tributary washes and channels. The urbanization of the area and present channel improvements have the combined effect of reducing the opportunity of native waters to recharge the ground water reservoir. The extent of channel improvements since 1928 is shown in Table 18 by a listing of the main wash and channel improvements having a constructed bottom width of 10 feet or greater and their cumulative length in relation to the total length of main channels. The locations of major improved channel reaches as well as the major storm drains existing as of 1958 are shown on Plate 12.

TABLE 18

WASH AND CHANNEL IMPROVEMENTS[a]

Year	Name of channel	Length of channel improvement, in miles	Total channels, in miles	Channels improved to date Miles	Channels improved to date Percent
1929-30	Verdugo Wash	0.32	137.6	0.3	0.2
1931-32	Pacoima Wash	1.32			
	Sycamore Canyon	4.97			
	Verdugo Wash	0.17	137.6	6.8	4.9
1932-33	Verdugo Wash	0.50	137.6	7.3	5.3
1933-34	Verdugo Wash	1.29	137.6	8.6	6.2
1934-35	Pickens Canyon	2.51			
	Verdugo Wash	0.64	137.6	11.7	8.5
1935-36	Dunsmuir Canyon	1.78			
	Eagle Canyon	1.86			
	Halls Canyon	2.04	137.6	17.4	12.6
1937-38	Haines Canyon	3.80			
	Verdugo Wash	1.84	137.6	23.0	16.7
1938-39	Burbank Western Storm Drain	0.65			
	Los Angeles River[b] (Station 24.3 - 33.6)	9.26	137.6	33.0	23.9
1939-40	Los Angeles River (Station 24.1 - 24.3)	0.20	137.6	33.2	24.1
1940-41	Los Angeles River[c] (Station 42.4 - 45.4)	2.92	137.6	36.1	26.2
1941-42	Aliso Canyon Wash[d]	2.60	137.6	38.7	28.1
1947-48	Los Angeles River (Station 33.6 - 35.3)	1.71	137.6	40.4	29.3
1948-49	Los Angeles River (Station 35.3 - 37.6)	2.31	137.6	42.7	31.0
1949-50	Tujunga Wash	2.08	137.6	44.8	32.5
1950-51	Los Angeles River (Station 37.6 - 39.6)	2.04	137.6	46.8	34.0
1951-52	Burbank Western Storm Drain	1.62			
	Cooks Canyon	1.27			
	Los Angeles River (Station 39.6 - 41.3)	1.65			
	Tujunga Wash	7.39	128.4	58.7	45.7
1952-53	Aliso Canyon Wash	1.96			
	Browns Canyon Wash[c]	1.32			
	Bull Canyon Wash[e]	4.36			
	Pacoima Diversion Channel	2.31			
	Pacoima Wash	1.71			
	Los Angeles River (Station 41.3 - 42.4)	1.15	125.2	71.6	57.1
1953-54	Pacoima Wash	1.86	125.2	73.4	58.6
1954-55	Bull Canyon Wash	2.26			
	Los Angeles River (Station 45.4 - 47.0)	1.67	125.2	77.3	61.8
1955-56	Bull Canyon Wash	1.52	125.2	78.9	63.0
1956-57	Los Angeles River (Station 47.0 - 48.8)	1.80	125.2	80.7	64.4
1957-58	Los Angeles River (Station 48.8 - 50.8)	2.00	125.2	82.7	66.0

a. Only washes and channels having an improved bottom width of 10 feet or greater.
b. Includes 7.72 miles of open bottom channel.
c. Open bottom channel.
d. Includes 1.07 miles of open bottom channel.
e. Includes 0.50 miles of open bottom channel.

Stations in parentheses for the Los Angeles River represents the stream miles system starting with station 24.1 at Gage F-57 and increasing upstream.

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Place and Character of Water Use

The major portion of the water delivered within the Upper Los Angeles River area is served by six agencies: the Cities of Burbank, Glendale, San Fernando and Los Angeles; the Crescenta Valley County Water District; and the La Canada Irrigation District. The service area to which each of these agencies delivers or serves water within the area of investigation is shown on Plate 19. In all but two of these service areas the water delivered is a mixture of imported water and local ground water. These exceptions are the Owens River service area of the City of Los Angeles where only imported Owens River water is delivered and the City of San Fernando where the sole source of supply is local ground water.

The place of use (service area) of each of the remaining parties serving water in the area, including 77 individuals, corporations, and water companies, is shown on Plate 20. The separate location of each is identified by the defendant number used in the complaint and as listed in Table 11. Additional sources of supply may be available to the service areas of individual parties through the distribution systems of cities or districts in which the service area is located.

The character of water use or uses of each party is set forth in Table 11. The definition of each of the six general types of use reported therein is as follows:

1. Domestic - Use for residences, including incidental irrigated garden and orchard.
2. Industrial - Use by a manufacturing or service industry which requires water to be used directly in the manufacturing process or service.

3. Commercial - Use by dry manufacturing and other commercial establishments whose primary water requirement is the lavatory needs of employees and clients and includes incidental irrigation of ornamental plants.
4. Irrigation - Use for irrigated agriculture including incidental stock-water and domestic use.
5. Recreation - Use for swimming, boating, hunting or fishing.
6. Municipal - Use for domestic, industrial, commercial, irrigation and recreation purposes including appurtenant fire protection and use for other municipal functions of entities serviced by a municipality, public utility or district.

Ground and Surface Water Exports From the Upper Los Angeles River Area

Waters derived from ground and surface water sources within the Upper Los Angeles River area have been exported therefrom by the City of Los Angeles and the La Canada Irrigation District. During the 1928-29 through 1957-58 period ground water export has been made every year by the City of Los Angeles. Both ground and surface waters were exported by the La Canada Irrigation District from 1928-29 through 1949-50.

Ground water extracted by the City of Los Angeles from the Los Angeles River System, comprised of the North Hollywood, Erwin, Whitnall, Verdugo, Deep Gallery, Headworks, Crystal Springs and Pollock well fields, is all measured and is transported to reservoirs outside the Upper Los Angeles River area (see Plate 21). A portion of this water is returned to the area to meet part of the water requirement in the City of Los Angeles Narrows service area. The difference between these amounts is equal to the ground water exported by the City of Los Angeles and is shown in Table 19.

Forty-two percent of the La Canada Irrigation District service area is located within the Upper Los Angeles River area. The District obtains its supply from surface and ground water sources in the area and from outside sources. Export by this entity has been evaluated as the amount that its extractions and diversions within the Upper Los Angeles River area have exceeded 42 percent of the total amount delivered within the District boundaries. Export occurred under these conditions during 1928-29 through 1949-50 and the amounts so determined are tabulated in Table 19. Derivation of these values is contained in Appendix M.

TABLE 19

EXPORT OF GROUND WATER[a]
FROM UPPER LOS ANGELES RIVER AREA

In Acre-Feet

Year	Exportation by City of Los Angeles (1)	Exportation by La Canada Irrigation District (2)	Total (3)
1928-29	54,810	20	54,830
29-30	57,190	80	57,270
1930-31	59,390	70	59,460
31-32	34,220	100	34,320
32-33	31,910	100	32,010
33-34	54,060	80	54,140
34-35	42,820	80	42,900
1935-36	49,510	90	49,600
36-37	44,270	160	44,430
37-38	38,550	210	38,760
38-39	36,260	230	36,490
39-40	37,860	230	38,090
1940-41	40,700	270	40,970
41-42	33,330	300	33,630
42-43	43,930	340	44,270
43-44	47,300	340	47,640
44-45	61,900	300	62,200
1945-46	68,030	210	68,240
46-47	73,170	280	73,450
47-48	67,810	280	68,090
48-49	66,890	190	67,080
49-50	72,740	50	72,790
1950-51	66,380	0	66,380
51-52	63,040	0	63,040
52-53	81,980	0	81,980
53-54	83,510	0	83,510
54-55	80,170	0	80,170
1955-56	84,000	0	84,000
56-57	90,750	0	90,750
57-58	83,280	0	83,280
29-Year Mean 1929-57	57,460	140	57,600

a. Includes a minor amount of surface water exported by La Canada Irrigation District

Source and derivation of values by column numbers:

1. Net export of ground water from Table M-6.
2. Export from Table M-7 rounded off to nearest 10 acre-feet.
3. Sum of columns 1 and 2.

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Delivered Water

The total amount of water made available to water systems in the Upper Los Angeles River area through importation, ground water extractions, surface diversions and including minor amounts of precipitation on and runoff into surface water supply reservoirs has been considered as the gross delivered water in the area. The "gross available for distribution" has been taken as the gross delivered water less the evaporative loss in surface water supply reservoirs. Gross amounts supplied to distribution systems serving hill and mountain areas and valley fill areas have been determined separately as have the amounts of water from each basic source (i.e., import, ground water and surface diversion) which comprise the gross water available for distribution in each hydrologic subarea.

Net deliveries for use have been taken as the total of all waters delivered to agricultural, residential, commercial and industrial areas and are based primarily on the amounts of metered sales to customers. Use of water for operational spills and spreading operations and loss of water in the water system have been evaluated separately.

Gross Delivered Water in the Upper Los Angeles River Area

Annual amounts of gross delivered water have been determined for each year of the 1928-29 through 1957-58 period as the sum of the total import shown in Table 8, local ground water extractions shown in Table 15, and local surface diversions shown in Table 16, less net exportations of ground water shown in Table 19. The net effect of precipitation and local runoff inflow plus water withdrawn from storage in San Fernando, Chatsworth and Encino reservoirs, have been added to the foregoing to evaluate the gross delivered water listed in Table 20.

Gross Delivered Water on Valley Fill and Hill and Mountain Areas. The annual amounts of delivered water served to acreages in the hill and mountain areas were estimated on the basis of the acreage served and the duty of water as set forth in Appendixes J and K. Gross delivered water on the valley fill area is the total gross water delivered within the Upper Los Angeles River area less gross deliveries to the hill and mountain areas. Delivered water derived from each of the basic sources (i.e., the import, extractions and diversions) was determined for portions of the major water service areas contained in each hydrologic subarea (see Appendix J). Delivered water derived from each of these basic sources was determined for each hydrologic subarea as the sum of the above portions. Gross delivered water on the valley fill area thus determined for each hydrologic subarea is set forth in Table 21.

Gross Available for Distribution

The gross delivered water and gross available for distribution are identical for hill and mountain areas. In the valley fill area the gross delivered exceeds the gross available for distribution by the amount of the reservoir evaporation from the three major water supply reservoirs of the City of Los Angeles located around the edge of the valley fill. The historic variation in gross available for distribution on the valley fill area is shown on Figure 2, page 140. Annual amounts of gross water available for distribution on the valley fill area are shown by ordinates on Figure 2 and are tabulated in column 18, Table 20.

TABLE 20

SUMMARY OF GROSS DELIVERED WATER AND GROSS AVAILABLE FOR DISTRIBUTION

In Acre-Feet

Upper Los Angeles River Area								
Year	Ground water extractions (1)	Ground water export (2)	Ground water remaining (1)-(2)=(3)	Surface water diversions (4)	Import (5)	Gross delivered water (3)+(4)+(5)=(6)	Reservoir evaporation (7)	Gross available for distribution (6)-(7)=(8)
1928-29	89,720	54,830	34,890	640	105,750	141,280	5,270	136,010
29-30	93,250	57,270	35,980	630	113,010	149,620	5,350	144,270
1930-31	96,410	59,460	36,950	610	118,290	155,850	5,990	149,860
31-32	69,420	34,320	35,100	750	124,820	160,670	4,600	156,070
32-33	67,330	32,010	35,320	480	118,610	154,410	5,390	149,020
33-34	91,960	54,140	37,820	590	104,950	143,360	5,240	138,120
34-35	78,860	42,900	35,960	470	103,650	140,080	4,290	135,790
1935-36	88,260	49,600	38,660	400	124,910	163,970	4,830	159,140
36-37	83,670	44,430	39,240	600	99,270	139,110	4,700	134,410
37-38	82,230	38,760	43,470	650	93,240	137,360	4,500	132,860
38-39	84,250	36,490	47,760	800	104,350	152,910	4,940	147,970
39-40	86,380	38,090	48,290	760	86,000	135,050	4,800	130,250
1940-41	87,990	40,970	47,020	1,070	78,100	126,190	4,170	122,020
41-42	86,460	33,630	52,830	1,020	118,850	172,700	4,740	167,960
42-43	99,330	44,270	55,060	1,220	131,400	187,680	4,720	182,960
43-44	104,530	47,640	56,890	1,470	113,580	171,940	4,540	167,400
44-45	122,230	62,200	60,030	1,230	118,700	179,960	4,440	175,520
1945-46	133,270	68,240	65,030	850	131,170	197,050	4,560	192,490
46-47	137,200	73,450	63,750	780	139,810	204,340	4,720	199,620
47-48	137,870	68,090	69,780	730	145,660	216,170	4,970	211,200
48-49	138,080	67,080	71,000	560	144,110	215,670	4,690	210,980
49-50	141,170	72,790	68,380	430	142,750	211,560	4,620	206,940
1950-51	135,050	66,380	68,670	350	166,430	235,450	4,570	230,880
51-52	130,270	63,040	67,230	500	150,480	218,210	4,550	213,660
52-53	155,370	61,960	73,390	490	168,740	242,620	4,760	237,860
53-54	155,580	83,510	72,070	440	166,470	238,980	4,280	234,700
54-55	151,560	80,170	71,390	250	166,630	238,270	4,680	233,590
1955-56	154,660	84,000	70,660	200	164,680	235,540	4,050	231,490
56-57	163,270	90,750	72,520	160	180,900	253,580	4,630	248,950
57-58	147,520	83,280	64,240	270	175,420	239,930	4,800	235,130
29-Year Average 1929-57	111,920	57,600	54,320	660	128,460	183,430	4,750	178,690

Source and derivation of values by column numbers:

Column No.

1. Table 15, Column 9.
2. Table 19, Column 3.
4. Table 16, Column 3.
5. Table 8, Column 3 minus annual change in reservoir storage, Table M-1, Column 4, Appendix M plus rain on reservoirs and runoff into reservoir, Table M-1, Columns 5 and 6, Appendix M.
7. Table M-1, Column 11, Appendix M.

TABLE 20

SUMMARY OF GROSS DELIVERED WATER AND GROSS AVAILABLE FOR DISTRIBUTION
(continued)

In Acre-Feet

Year	Hill areas: Import (9)	Hill areas: Ground water: Extracted in hills (10)	Hill areas: Ground water: Delivered from valley floor (11)	Hill areas: Gross delivered water (9)+(10)+(11)= (12)	Valley Fill Area: Import (13)	Valley Fill Area: Rain and runoff to reservoir (14)	Valley Fill Area: Ground water extractions (15)	Valley Fill Area: Surface diversion (16)	Valley Fill Area: Gross delivered water (13)+(14)+(15)+(16)=(17)	Gross Available for Distribution (17)-(7)=(18)
1928-29	0	10	2,290	2,300	104,770	980	32,590	640	138,980	133,710
29-30	0	10	3,640	3,650	112,060	950	32,330	630	145,970	140,620
1930-31	20	10	4,340	4,370	117,140	1,130	32,600	610	151,480	145,490
31-32	30	10	4,530	4,570	120,880	3,910	30,560	750	156,100	151,500
32-33	50	20	4,650	4,720	117,440	1,120	30,650	480	149,690	144,300
33-34	60	20	4,630	4,710	103,190	1,700	33,170	590	138,650	133,410
34-35	80	20	4,410	4,510	101,910	1,660	31,530	470	135,570	131,280
1935-36	90	20	4,890	5,000	123,210	1,610	33,750	400	158,970	154,140
36-37	110	20	5,430	5,560	94,020	5,140	33,790	600	133,550	128,850
37-38	130	60	6,140	6,330	86,390	6,730	37,270	650	131,040	126,540
38-39	140	50	6,790	6,980	101,760	2,450	40,920	800	145,930	140,990
39-40	160	60	6,920	7,140	84,190	1,650	41,310	760	127,910	123,110
1940-41	190	60	6,470	6,720	68,770	9,140	40,490	1,070	119,470	115,300
41-42	220	60	7,420	7,700	117,110	1,520	45,350	1,020	165,000	160,260
42-43	280	80	6,580	6,940	127,150	3,970	48,400	1,220	180,740	176,020
43-44	320	100	6,620	7,040	109,870	3,390	50,170	1,470	164,900	160,360
44-45	440	130	6,590	7,160	116,750	1,510	53,310	1,230	172,800	168,360
1945-46	750	150	7,980	8,880	129,280	1,140	56,900	850	188,170	183,610
46-47	910	180	6,290	7,380	137,650	1,240	57,280	780	196,960	192,240
47-48	1,160	190	4,420	5,770	143,930	570	65,170	730	210,400	205,430
48-49	1,350	240	4,840	6,430	142,150	610	65,920	560	209,240	204,550
49-50	1,820	250	7,320	9,390	139,990	940	60,810	430	202,170	197,550
1950-51	2,530	290	6,930	9,750	163,120	780	61,450	350	225,700	221,130
51-52	3,170	330	7,020	10,520	143,210	4,100	59,880	500	207,690	203,140
52-53	3,750	390	7,360	11,500	163,920	1,070	65,640	490	231,120	226,360
53-54	5,310	450	6,600	12,360	160,030	1,130	65,020	440	226,620	222,340
54-55	6,960	470	6,410	13,840	158,580	1,090	64,510	250	224,430	219,750
1955-56	7,630	660	6,380	14,670	155,500	1,550	63,620	200	220,870	216,820
56-57	9,140	890	6,560	16,590	170,730	1,030	65,070	160	236,990	232,360
57-58	11,020	1,060	5,840	17,920	160,820	3,580	57,340	270	222,010	217,210
29-Year Average 1929-57	1,610	180	5,880	7,670	124,650	2,200	48,260	660	175,760	171,020

Source and derivation of values by column numbers:

Column No.

9. Table J-13, Appendix J.
10. Table 15, Column 6.
11. Delivered ground water to hill areas, Table J-13 minus Column 10.
13. Table 8, Column 3 minus change in reservoir storage, Table M-1, Column 4, Appendix M minus Column 9 herein. Column 13 equals Column 5 minus Columns 9 and 14.
14. Sum of Columns 5 and 6, Table M-1, Appendix M.
15. Column 3 minus Columns 10 and 11.
16. Table 16, Column 3.

TABLE 21

GROSS DELIVERED WATER BY HYDROLOGIC SUBAREAS

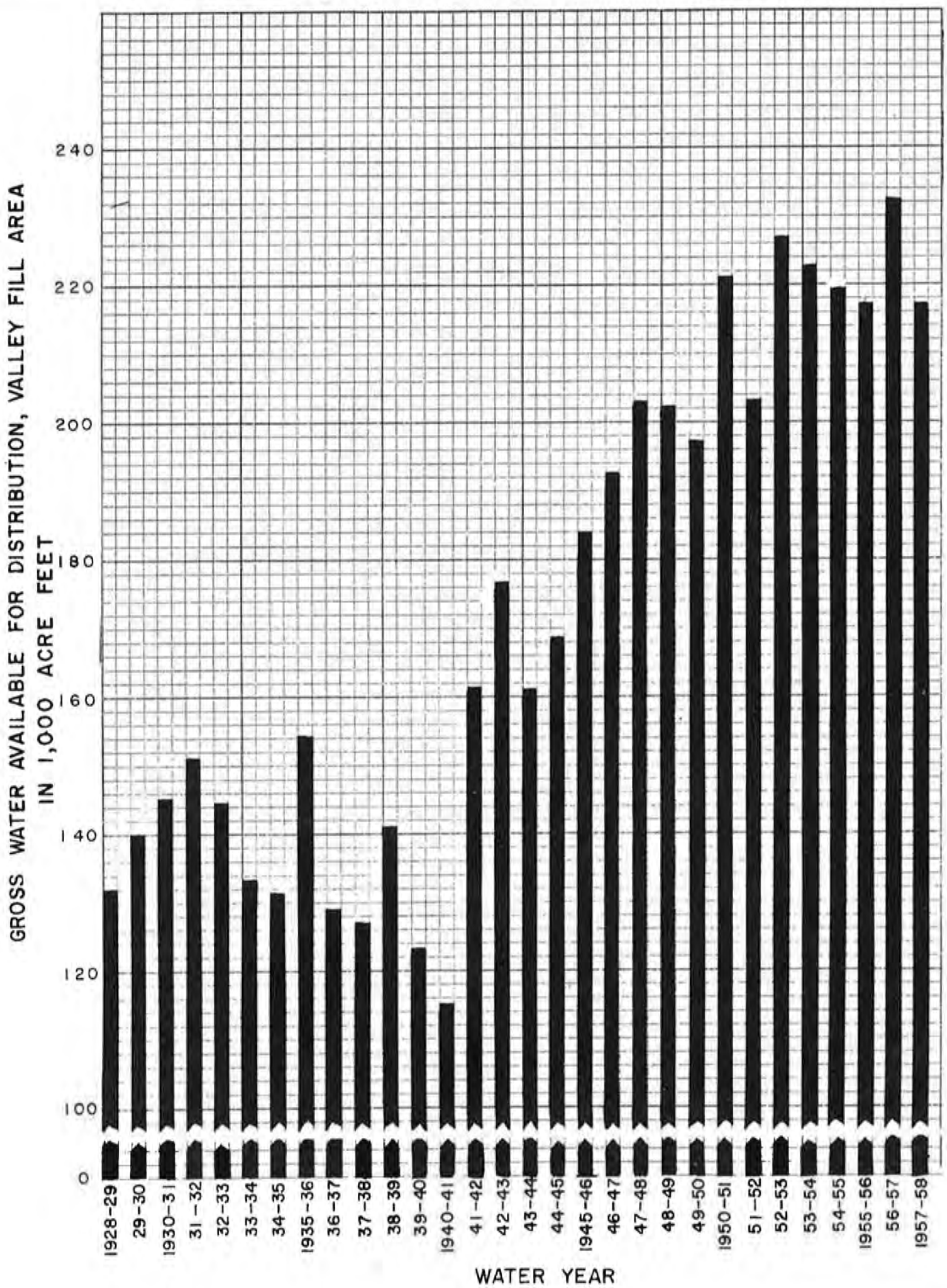
In Acre-Feet

Year	San Fernando and Eagle Rock Subareas				Sylmar Subarea				Verdugo Subarea[a]				Total gross delivered water
	Import[b]	Ground water	Surface diversion	Total	Import	Ground water	Surface diversion	Total	Import	Ground water	Surface diversion	Total	
1928-29	101,990	30,370	0	132,360	3,760	940	500	5,200	0	1,280	140	1,420	138,980
29-30	109,800	30,000	0	139,800	3,210	950	500	4,660	0	1,380	130	1,510	145,970
1930-31	115,260	30,180	0	145,440	3,010	950	500	4,460	0	1,470	110	1,580	151,480
31-32	122,300	28,140	120	150,560	2,490	950	500	3,940	0	1,460	140	1,600	156,100
32-33	115,170	28,010	100	143,280	3,390	1,060	270	4,720	0	1,580	110	1,690	149,690
33-34	101,910	30,060	70	132,040	2,980	1,100	440	4,520	0	2,010	80	2,090	138,550
34-35	100,610	28,830	90	129,530	2,960	1,040	240	4,240	0	1,660	140	1,800	135,570
1935-36	120,740	30,940	90	151,770	4,080	1,050	120	5,250	0	1,770	180	1,950	158,970
36-37	95,770	30,830	120	126,720	3,390	1,190	160	4,740	0	1,770	320	2,090	133,550
37-38	90,550	33,700	100	124,350	2,570	1,740	140	4,450	0	1,830	410	2,240	131,040
38-39	101,130	37,730	220	139,080	3,080	1,190	180	4,450	0	2,000	400	2,400	145,930
39-40	83,160	37,560	130	120,850	2,680	1,510	250	4,440	0	2,250	370	2,620	127,910
1940-41	75,110	36,930	260	112,300	2,800	1,590	310	4,700	0	1,970	500	2,470	119,470
41-42	115,040	41,020	440	156,500	3,590	1,900	110	5,600	0	2,430	470	2,900	165,000
42-43	126,740	44,090	440	171,270	4,380	1,820	140	6,340	0	2,490	640	3,130	180,740
43-44	108,730	45,820	560	155,110	4,530	1,780	160	6,470	0	2,560	760	3,320	164,900
44-45	113,470	48,800	490	162,760	4,790	1,690	230	6,710	0	2,820	510	3,330	172,800
1945-46	125,130	51,410	330	176,870	5,290	1,810	140	7,240	0	3,680	380	4,060	188,170
46-47	132,740	51,490	210	184,440	6,160	1,760	140	8,060	0	4,020	440	4,460	196,960
47-48	138,000	58,760	140	196,900	6,500	1,740	180	8,420	0	4,670	410	5,080	210,400
48-49	136,350	59,540	110	196,000	6,410	1,860	120	8,390	0	4,520	330	4,850	209,240
49-50	135,140	54,230	130	189,500	5,790	1,830	0	7,620	0	4,740	310	5,050	202,170
1950-51	157,680	54,640	80	212,400	5,990	1,840	0	7,830	240	4,960	270	5,470	225,700
51-52	142,060	53,610	120	195,790	5,120	1,530	0	6,650	130	4,750	370	5,250	207,690
52-53	158,440	58,370	100	216,910	6,150	1,250	0	7,400	400	6,010	400	6,810	231,120
53-54	155,370	57,050	70	212,490	5,350	1,240	0	6,590	440	6,730	370	7,540	226,620
54-55	153,060	57,060	50	210,170	5,650	1,280	0	6,930	960	6,170	200	7,330	224,430
1955-56	149,760	55,860	30	205,650	5,480	1,320	0	6,800	1,810	6,450	160	8,420	220,870
56-57	163,390	56,810	30	220,230	6,530	1,270	0	7,800	1,840	6,980	150	8,970	236,990
57-58	157,340	48,350	70	205,760	5,620	1,200	0	6,820	1,440	7,790	200	9,430	222,010
29-Year Average 1929-57	122,230	43,510	160	165,900	4,420	1,420	180	6,020	200	3,320	320	3,840	175,760

Note: Amounts shown are the summation of gross amounts of delivered water shown in Tables J-3, J-4 and J-5 less the amounts of water delivered to hill areas as shown in Table J-13.

a. Includes the portion of Monk Hill Basin within the Upper Los Angeles River Area.

b. Includes annual change in storage, rain on and runoff into reservoirs.



SAN FERNANDO VALLEY REFERENCE

GROSS WATER AVAILABLE FOR DISTRIBUTION
VALLEY FILL AREA

STATE WATER RIGHTS BOARD

Spread Import

Owens River water delivered by the Los Angeles Aqueduct is the only import supply of which a part is spread for direct recharge of the ground water. The City of Los Angeles commenced this operation in 1928-29 with the experimental spreading of 589 acre-feet in the vicinity of Vanowen Street and Whitsett Avenue near Tujunga Wash during that year. Including the 1928-29 experimental work, the City has spread water at its Tujunga Wash and Gravel Pits spreading grounds during 20 years of the base period. In addition to direct spreading the City rediverts Owens River water from the Los Angeles River Channel to the Headworks spreading grounds for infiltration to an underground gallery (Deep Gallery). Water collected by this gallery is then extracted through well 3884G.

The location and description of the spreading grounds and Deep Gallery are shown in Table 22 and on Plates 12 and 21. Annual amounts of Owens River water spread for direct recharge of the ground water at the Tujunga and Gravel Pits spreading grounds along with the amounts diverted to the Headworks spreading grounds from the Los Angeles River are shown in Table 23. It should be noted that the amounts of river water diverted to the Headworks spreading ground are comprised primarily of Owens River water which has been released, spilled or returned thereto from the Owens River distribution system including return from the early operation (i.e., prior to 1940) of the Los Angeles Department of Water and Power Coldwater Canyon Power Plant, line blowoff, and operational spills from reservoirs. The amounts of these diversions are included in the ground water extractions by the City of Los Angeles in Table 13.

TABLE 22

LOCATION AND DESCRIPTION OF SPREADING GROUNDS FOR OWENS IMPORT

Item	Grounds: Los Angeles Department of Water and Power, Tujunga Wash	Grounds: Los Angeles River Headworks Spreading Grounds	Grounds: Los Angeles Department of Water and Power, Gravel Pits
Type	Shallow basins	Shallow basins	Pit
Season first used	1931-32	1938-39	1930-31
Gross area, acres	180±	50±	Unknown
Wetted area, acres	25±	39.9	Unknown
Location	San Fernando Valley, east side of Tujunga Wash at Roscoe Boulevard.	San Fernando Valley, south of Los Angeles River above Mariposa Street.	Vicinity of Hansen Dam.
Source of water	Los Angeles City's Owens Valley Aqueduct.	Los Angeles River, partially controlled by various dams. Releases of Owens Valley water from Chatsworth Reservoir.	Los Angeles City's Owens Valley Aqueduct.
Remarks	Owned and operated by the Los Angeles Department of Water and Power. Prior to 1938 flood the wetted area of these grounds was 80 acres of Tujunga Wash. Tujunga Channel on westerly side of these grounds was paved in 1950.	Owned and operated by the Los Angeles Department of Water and Power. Spread at infiltration area, and pumped out from collecting galleries under area.	Operated by City of Los Angeles Department of Water and Power prior to construction of Hansen Dam in 1940.

TABLE 23

OWENS IMPORT SPREAD

In Acre-Feet

Year	Headworks[a]	Spread for recharge		
		Tujunga	Gravel Pits	Total[b]
	(1)	(2)	(3)	(4)
1928-29	See Table 22	See Table 22	See Table 22	590[c]
29-30				0
1930-31			7,280	7,280
31-32		20,337	11,406	31,740
32-33		26,873	6,556	33,430
33-34		20,855	0	20,860
34-35		24,774	6,030	30,800
1935-36		19,309	3,407	22,720
36-37		8,736	571	9,310
37-38		5,731	1,584	7,320
38-39	9,662	12,259	2,652	14,910
39-40	10,977	3,022	385	3,410
1940-41	11,001	3,446	See Table 22	3,450
41-42	13,258	11,290		11,290
42-43	14,289	12,131		12,130
43-44	19,861	3,191		3,190
44-45	21,028	0		0
1945-46	21,141	0		0
46-47	18,738	1,687		1,690
47-48	19,016	0		0
48-49	6,451	0		0
49-50	7,691	762		760
1950-51	4,917	2,354		2,350
51-52	1,524	7,281		7,280
52-53	7,424	0		0
53-54	6,648	0		0
54-55	10,867	0		0
1955-56	6,553	1,610		1,610
56-57	4,784	0		0
57-58	6,278	0		0

a. Diversions to Headworks Spreading Grounds are composed primarily of Owens River water released, spilled or otherwise tributary to the Los Angeles River. Amounts pumped from the gallery under the spreading grounds are included in ground water extractions of City of Los Angeles.

b. Rounded off to nearest 10 acre-feet.

c. Experimental spreading in the vicinity of Vanowen Street and Whitsett Avenue during 1928-29 only.

Operational Releases, Net Deliveries and Water System Losses

Operational releases of Owens River import, comprised of spills from reservoirs, return from power plant operations and line blowoff, are indicated in Table 24 under the caption, Operational Releases.

The net amounts of water delivered to the valley fill area have been primarily determined from metered water sales to customers when the water is transported to the customer through a distribution system. For systems comprised of a single well and for small companies where the distribution system is not extensive and sales records were not available, the gross amounts and net amounts have been taken as identical since in these instances the water system loss is minor. Net delivered water does not include water spread or spilled.

Water system loss is composed of leakage from the distribution system, unmetered water (including sewer flushing water) and meter slippage, and is equal to the gross amount of water available for distribution minus net water delivered, water spread and water spilled. The annual amounts of the foregoing items and the resulting water system loss for the Upper Los Angeles River area are shown in Table 24. The water system loss is also shown therein (column 7) as a percent of the gross water available for distribution.

The percent water system loss was assumed to apply equally to valley fill and hill areas. The total water system loss was split between the valley fill and hill areas on the basis of the gross amounts of water available for distribution in each area (see Table 20). The net delivered water on the valley fill area (Table 24) is the gross available for distribution less water spread, spilled and system loss for the valley fill area.

TABLE 24

NET DELIVERED WATER, OPERATIONAL RELEASES
SPREAD IMPORT AND WATER SYSTEM LOSS

In Acre-Feet

Year	Upper Los Angeles River area: Gross available for distribution (1)	Operational releases (2)	Spread import (3)	Net delivered (4)	Operational releases, spread, net delivered (2)+(3)+(4)=(5)	Water system loss: Acre-Feet (1)-(5)=(6)	Water system loss: Percent (7)	Valley fill area: Gross available for distribution (8)	Water system loss (7)x(8)=(9)	Net delivered (8)-(2)-(3)-(9)=(10)
1928-29	136,010	8,250	590	126,320	135,160	850	0.06	133,710	800	124,070
29-30	144,270	11,480	0	130,480	141,960	2,310	1.60	140,620	2,250	126,890
1930-31	149,860	4,680	7,280	127,440	139,400	10,460	6.98	145,490	10,160	123,370
31-32	156,070	3,290	31,740	103,960	138,990	17,080	10.94	151,500	16,570	99,900
32-33	149,020	1,920	33,430	107,910	143,260	5,760	3.87	144,300	5,580	103,370
33-34	138,120	2,010	20,860	115,230	138,100	20	0.01	133,410	10	110,530
34-35	135,790	490	30,800	105,560	136,850	- 1,060	- 0.78	131,280	- 1,020	101,010
1935-36	159,140	560	22,720	130,040	153,320	5,820	3.66	154,140	5,640	125,220
36-37	134,410	1,920	9,310	121,640	132,870	1,540	1.15	128,850	1,480	116,140
37-38	132,860	1,760	7,320	114,920	124,000	8,860	6.67	126.540	8,440	109,020
38-39	147,970	3,420	14,910	126,210	144,540	3,430	2.32	140,990	3,270	119,390
39-40	130,250	760	3,410	117,800	121,970	8,280	6.36	125,110	7,830	111,110
1940-41	122,020	0	3,450	112,210	115,660	6,360	5.21	115,300	6,010	105,840
41-42	167,960	6,270	11,290	138,000	155,560	12,400	7.38	160,260	11,830	130,850
42-43	182,960	8,700	12,130	150,920	171,750	11,210	6.13	176,020	10,790	144,400
43-44	167,400	2,860	3,190	150,470	156,520	10,880	6.50	160,360	10,420	143,890
44-45	175,520	1,310	0	158,680	159,990	15,530	8.85	168,360	14,900	152,150
1945-46	192,490	7,870	0	172,340	180,210	12,280	6.38	183,610	11,710	164,030
46-47	199,620	7,680	1,690	175,460	184,830	14,790	7.41	192,240	14,240	168,630
47-48	211,200	2,940	0	187,490	190,430	20,770	9.83	205,430	20,190	182,300
48-49	210,980	1,460	0	193,100	194.560	16.420	7.78	204,550	15,910	187,180
49-50	206,940	1,340	760	187,260	189,360	17,580	8.50	197,550	16,790	178,660
1950-51	230,880	3,940	2,350	203,780	210,070	20,810	9.01	221,130	19,920	194,920
51-52	213,660	2,830	7,280	189,630	199,740	13,920	6.52	203,140	13,240	179,790
52-53	237,860	5,410	0	211,040	216,450	21,410	9.00	226,360	20,370	200,580
53-54	234,700	3,180	0	209,280	212,460	22,240	9.48	222,340	21,080	198,080
54-55	233,590	7,860	0	203.450	211,310	22,280	9.54	219,750	20,960	190,930
1955-56	231,490	4,000	1,610	205,670	211,280	20,210	8.73	216,820	18,930	192,280
56-57	248,950	1,560	0	227,290	228,850	20,100	8.07	232,360	18,750	212,050
57-58	235,130	90	0	216,540	216,630	18,500	7.87	217,210	17,090	200,030
29-Year Average 1929-57	178,690	3,780	7,800	155,300	166,880	11,830	6.11	171,020	11,280	148,160

Source and derivation of values by column numbers:

Column No.

1. Table 20, Column 8.
2. Table M-1, Column 8, Appendix M, occur only on the valley fill area.
3. Table M-1, Column 9, Appendix M, occur only on the valley fill area.
4. Sum of net delivered water, Table J-3, J-4, J-5, Appendix J.
7. Column 6 divided by Column 1 times 100.
8. Table 20, Column 17 minus Table 20, Column 7.

Sewage and Waste

All of the sewage exported from the Upper Los Angeles River area, with the exception of occasional overflows and discharges into the Los Angeles River, is conveyed through the City of Los Angeles sewerage system to the city's treatment plant. Small amounts of ground water that infiltrate the sewer mains are also exported through the sewerage system as are minor amounts of delivered water used to flush the sewer lines. A large number of individual local sewage disposal systems, mainly cesspools and septic tanks, have been and still are in use in the area. The effluent from these represent a significant source of recharge to the ground water reservoir; also, industrial waste and sewage that have been discharged into the Los Angeles River result in minor amounts of recharge in the river channel. The methods of determining sewage export from the major water service areas within the Upper Los Angeles River area are listed in Table 25. The methods of estimating cesspool recharge in these areas is also shown in Table 25.

TABLE 25

METHODS OF DETERMINING SEWAGE EXPORT AND CESSPOOL RECHARGE

Area	Cesspool recharge	Sewage export
CITY OF LOS ANGELES		
West of Burbank	Unit sewage discharge per cesspool.	Measured.
Owens Service Area in Sylmar Subarea	Total sewage based on 45 percent of delivered water* minus measured sewage export.	Measured.
Sunland-Tujunga Service Area	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	Total measured sewage export for the City of Los Angeles west of Burbank minus measured sewage export from the Owens Service Area in Sylmar. The remaining sewage is split by the areal extent of sewered areas within each service area.
Mission Wells Service Area	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	
Owens Service Area in San Fernando Subarea	Total cesspool recharge in Los Angeles west of Burbank minus the sum of the three areas above.	
Narrows Service Area	None.	Estimated, based on unit sewage discharge per house connection.
CITY OF SAN FERNANDO	Unit sewage discharge per cesspool.	Measured.
In San Fernando Subarea	Split by areal extent of the City in each subarea.	Split by areal extent of sewered area.
In Sylmar Subarea	Split by areal extent of the City in each subarea.	Split by areal extent of sewered area.
CITY OF GLENDALE	Unit sewage discharge per cesspool.	Measured.
In Verdugo Subarea	Total sewage based on 45 percent of delivered water* minus estimated sewage export.	Split by areal extent of sewered area.
In San Fernando Subarea	Total cesspool recharge for the City less recharge in Verdugo Subarea.	Split by areal extent of sewered area.
CITY OF BURBANK	Unit sewage discharge per cesspool.	Measured.
LA CANADA IRRIGATION DISTRICT	Total sewage based on 45 percent of delivered water.*	None.
CRESCENTA VALLEY COUNTY WATER DISTRICT	Total sewage based on 45 percent of delivered water.*	None.

* Residential and commercial delivered water only.

Export of Sewage

The City of Los Angeles North Outfall Sewer (Plate 26) which was placed in operation in 1926 was the first trunk sewer conveying sewage out of the Upper Los Angeles River area and initially served the Cities of Burbank, Glendale and the portion of Los Angeles south of Glendale. Commencing in 1929, portions of the City of Los Angeles west of Burbank were connected to the North Outfall Sewer. The City of San Fernando operated its own treatment plant and discharged the effluent into Pacoima Wash until 1952 at which time its sewerage system was connected to the City of Los Angeles system.

Rapid growth of the San Fernando Valley caused a rapid increase in the amounts of sewage being exported. The capacity of the North Outfall Sewer was exceeded in 1952-53 and small amounts of sewage overflowed into the Los Angeles River at a point downstream from its confluence with the Verdugo Wash. The Valley Settling Basin was constructed on the south bank of the Los Angeles River south of the City of Burbank in 1954 to provide storage during peak sewage flows. On brief occasions when the capacities of the trunk sewer and the Valley Settling Basin were both exceeded, the stored sewage was chlorinated and discharged into the Los Angeles River. The amounts of sewage overflowing or discharged into the Los Angeles River are listed in Table 26.

The San Fernando Valley Relief Sewer Tunnel (Plate 26) was completed in June 1956. The amount of sewage conveyed through this sewer trunk is not measured; therefore, export of sewage from the Upper Los Angeles River area for the period 1955-56 through 1957-58 was estimated on the basis of the number of sewer connections and the expected sewage flow per connection (see Appendix N).

The amount of flow through sewer mains leaving the Upper Los Angeles River area is based on the records of sewage gaging stations of the City of Los Angeles. Location of these stations is indicated on Plate 26. Although the sewage gaging stations operate for only one week per month, the weekly measured flow has been accepted by the cities as being the average weekly flow for the month. Amounts of sewage overflowing into the Los Angeles River are estimated from partial records of the State Department of Public Health. Discharges from the Valley Settling Basin, shown in Table 26, are based on operational records of the City of Los Angeles.

Estimated Cesspool Recharge and Sewage from Hill Areas

In areas that were not completely sewered, sewage export and cesspool recharge were separated by determining the sewage discharge per house connection or the percent of delivered water becoming sewage. Studies detailed in Appendix N show that 45 percent of the delivered water becomes sewage and the sewage flows per house connection varied from 0.17 acre-foot in 1928-29 to 0.28 acre-foot in 1957-58 and averaged 0.20 during the 29-year base period. Neither of the above values include infiltration of water into the sewers. The methods utilized to determine the amounts of sewage export and cesspool recharge in each area are discussed in Appendix N. Amounts of cesspool recharge and sewage from hill areas so estimated are shown in Table 26.

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Export of Sewer Infiltration and Flushing Water

The amounts of water entering the sewer mains as infiltration were determined by comparison of the trends in sewage per connection for each of the gaged areas (see Appendix N). The amount thus determined for the City of Glendale was the sum of infiltration and flushing water. The amounts of unmetered delivered water discharged into the City of Glendale's sewers as flushing water constitute a portion of the city's water system loss. The water flowing through the flushing devices amounted to 25.3 percent of the gross deliveries in 1954-55. The city commenced removing the flushing devices in 1957 with the result that the water system loss was reduced to 7.2 percent in 1958-59. A comparison of the water distribution systems of the City of Burbank, which does not provide sewer flushing water, and the City of Glendale indicates that the two systems are otherwise comparable and that their water losses should therefore be approximately the same. The amounts of flushing water in the City of Glendale sewer mains were estimated by first comparing the water system loss in Glendale with the average water system loss for Burbank (see Appendix N) and then comparing this amount with the combined quantity of infiltration and flushing water previously estimated. Estimated amounts of sewer infiltration and flushing water exported in the sewer trunks are shown in Table 26.

TABLE 26

SUMMARY OF SEWAGE EXPORT AND CESSPOOL RECHARGE ,
VALLEY FILL AREA

In Acre-Feet

Year	Sewage export U.L.A.R. (1)	Estimated sewage from hill areas (2)	Estimated sewer infiltration (3)	Net export of sewage from valley fill (4)=1-2-3	Estimated sewer flushing water (5)	Sewage discharged to river (6)	Estimated cesspool recharge (7)	Total sewage (8)=4-5+6+7
1928-29	6,320	870	340	5,110	0	0	4,940	10,050
29-30	7,100	880	170	6,050	320	0	4,920	10,650
1930-31	8,490	900	430	7,160	490	0	4,930	11,600
31-32	9,900	910	880	8,110	810	0	4,560	11,860
32-33	9,970	920	430	8,620	610	0	4,160	12,170
33-34	10,340	940	310	9,090	700	0	4,030	12,420
34-35	11,850	960	1,700	9,190	450	0	3,950	12,690
1935-36	12,450	970	1,570	9,910	560	0	4,030	13,380
36-37	13,230	990	1,860	10,380	200	0	4,570	14,750
37-38	14,360	1,060	2,170	11,130	350	0	5,060	15,840
38-39	16,470	1,080	3,280	12,110	300	0	5,790	17,600
39-40	17,440	1,090	3,250	13,100	250	0	6,480	19,330
1940-41	21,630	1,170	6,290	14,170	150	0	7,290	21,310
41-42	21,910	1,190	5,730	14,990	170	0	7,920	22,740
42-43	22,470	1,200	5,780	15,490	0	0	8,100	23,590
43-44	23,470	1,220	6,110	16,140	0	0	7,950	24,090
44-45	23,780	1,320	5,310	17,150	90	0	8,400	25,460
1945-46	24,030	1,350	4,000	18,680	500	0	9,040	27,220
46-47	27,080	1,450	5,260	20,370	1,230	0	10,800	29,940
47-48	28,880	1,500	4,040	23,340	1,900	0	11,220	32,660
48-49	30,340	1,570	2,320	26,450	2,290	0	11,160	35,320
49-50	31,950	1,840	1,240	28,870	1,320	0	11,510	39,060
1950-51	35,660	2,160	1,170	32,330	1,520	0	13,500	44,310
51-52	39,950	2,540	2,090	35,320	2,530	0	14,600	47,390
52-53	41,590	2,890	950	37,750	2,090	10	15,400	51,070
53-54	47,260	3,470	1,840	41,950	2,620	190	17,150	56,670
54-55	45,670	4,100	1,950	39,620	2,240	4,840	18,630	60,850
1955-56	51,860	4,860	2,970	44,030	3,660	4,540	19,850	64,760
56-57	60,060	5,540	3,290	51,230	3,270	60	20,550	68,570
57-58	63,960	6,550	2,330	55,080	1,650	240	20,150	73,820
29-Year Average 1929-57	24,670	1,760	2,650	20,270	1,060		9,330	28,870

Source and derivation of values by column number:

Column No.

1. Column entitled "Total sewage export out of Upper Los Angeles River area" in Table N-8, Appendix N.
2. Column entitled "Total", Table N-9, Appendix N.
3. Column entitled "Total", Table N-5, Appendix N.
5. Column entitled "Sewer flushing Glendale", Table N-5, Appendix N.
6. Table N-10, Column 4, Appendix N.
7. Sum of the cesspool recharge for each service area in Table N-7, Appendix N.

Industrial and Sanitary Wastes

Industrial wastes discharged into the Los Angeles River were computed for the 1946-47 through 1957-58 period from permits issued by the City of Los Angeles, and for the years 1939-40 through 1946-47 by extrapolation. Industrial wastes discharged into the Burbank-Western storm drain were estimated from low flow measurements for the 1951-52 through 1957-58 period and by extrapolation back to 1939-40. Sewage discharged from the North Outfall Sewer and Valley Settling Basin and the total industrial wastes discharged into the Los Angeles River are shown in Table 26A. Waste discharges are discussed further in Appendix N. Industrial waste from the City of Los Angeles Valley Steam Plant is spread on adjacent land and is included as deep percolation on commercial and industrial land use areas (see Appendix L).

TABLE 26A

ESTIMATED WASTE DISCHARGES
TO THE STREAM SYSTEM

In Acre-Feet

Year	Industrial wastes (1)	Sewage (2)	Total wastes (3)	Industrial wastes in total wastes, in percent (4)
1939-40	0		0	
1940-41	540		540	100.00%
41-42	1,090		1,090	100.00%
42-43	1,640		1,640	100.00%
43-44	2,190		2,190	100.00%
44-45	2,740		2,740	100.00%
1945-46	3,290		3,290	100.00%
46-47	3,840		3,840	100.00%
47-48	4,090		4,090	100.00%
48-49	4,660		4,660	100.00%
49-50	4,740		4,740	100.00%
1950-51	4,810		4,810	100.00%
51-52	5,280		5,280	100.00%
52-53	6,080	10	6,090	99.84%
53-54	5,980	190	6,170	96.92%
54-55	6,350	4,840	11,190	56.75%
1955-56	5,880	4,540	10,420	56.43%
56-57	5,580	60	5,640	98.94%
57-58	5,750	240	5,990	95.99%

Source and derivation of values by column numbers:

Column No.

1. Table N-10, Column 3, estimated to be nil prior to 1940-41.
2. Table N-10, Column 4, estimated to be nil prior to 1952-53.
3. Table N-10, Column 5.
4. Column 1 divided by Column 3, expressed in percent.

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Surface Runoff

The drainage basin of the Upper Los Angeles River area is comprised of 329,137 acres of which 205,709 acres are hill and mountain lands. The surface flow in the streams in the area originates as storm runoff from hill and mountain areas, storm runoff from impervious areas on the valley floor, operational spills of imported water, industrial and sanitary waste discharges and rising water in the Los Angeles River.

The drainage system of the area is made up of the Los Angeles River and its tributaries. The important changes that have taken place in the drainage system in the past 30 years have previously been noted in Table 18. The changes that have occurred from the period when the area was essentially undeveloped to its present urbanized state may be readily seen by comparing the drainage system of 1893 as depicted on Plate 11 with that of 1958 as shown on Plate 12. As was noted in the discussion of channel improvement, the reduction in the length of pervious channels has been large.

The gaging stations at which surface flows in the drainage system are measured are shown on Plate 9 and listed as to location and length of record in Table 27. Surface outflow from the area has been measured by Los Angeles County Flood Control District at gaging station F-57 by a continuous water stage recorder, beginning in December 1929. In the period January to August 1929, only weekly measurements were available. During the remaining months, October 1928 to December 1929, no precipitation and therefore no storm runoff occurred. Various published references have been made as to the amount of water flowing in the Los Angeles River from 1898 to 1929. Some references as to the amount of water flowing in the Los Angeles River are found in the "Annual Reports" of the Los Angeles Department of Water and Power. However, the values presented in these publications lacked sufficient companion information to determine what these values represent. It is questionable as to whether they reflect the summer or average flow in the river or the amounts diverted or pumped. These were considered as incomplete data and were therefore not used.

Hydrographs of the surface flow of the Los Angeles River at gaging station F-57, prepared from daily records, were utilized to separate the surface flow into base low flow which is made up of rising water and waste discharges, and surface runoff which is composed of storm runoff and operational spills of Owens River water. The separation of the surface flow into its constituent parts is derived in Appendix O. The results of the study are presented in Table 28.

TABLE 27

MAIN STREAM GAGING STATIONS,
UPPER LOS ANGELES RIVER AREA

Station number*	Location	Period of record
2	Browns Canyon Wash at Devonshire Avenue, Chatsworth	December 1928 - September 1932 October 1936 - September 1939
5	Los Angeles River below Sepulveda Dam	December 1928 - March 1952
9	Verdugo Storm Drain at Glen Oaks Boulevard, Glendale	December 1928 - November 1933
15	Pacoima Wash at Van Nuys Boulevard	October 1952 - September 1958
16	Pacoima Wash at Parthenia Street	December 1928 - August 1952
19	Little Tujunga Wash at Foothill Boulevard	December 1928 - September 1958
43	Sycamore Canyon Channel above Solway Street	October 1938 - September 1958
44	Sycamore Canyon Channel at Adams Square	December 1927 - September 1935 October 1936 - April 1937 October 1938 - September 1958
57	Los Angeles River above Arroyo Seco	December 1929 - September 1958
105	Tujunga Wash at Magnolia Boulevard	August 1930 - February 1938 October 1938 - April 1948
105	Tujunga Wash below Moorpark Street	October 1950 - September 1958
106	Tujunga Wash - Central Branch at Magnolia Boulevard	August 1930 - February 1938 November 1941 - September 1958
110	Big Tujunga - Fox Creek, one-fourth mile above mouth	October 1930 - September 1937
111	Big Tujunga Creek below Mill Creek	December 1930 - September 1958
118	Pacoima Creek Flume below Pacoima Dam	March 1916 - September 1958
149	Limekiln Creek at Devonshire Street	November 1939 - September 1957
152	Aliso Wash below Nordhoff Street	November 1939 - August 1947 September 1948 - September 1958
168	Big Tujunga Creek below Big Tujunga Dam	December 1931 - October 1932 January 1938 - September 1958
213	Big Tujunga Creek above Gold Canyon	October 1932 - September 1958
244	Verdugo Channel at Don Carlos Street	December 1934 - September 1936
252	Verdugo Channel at Estelle Avenue	April 1936 - September 1958
266	Los Angeles River at Mariposa Street	December 1938 - September 1958
270	Calabasas Creek at Ventura Boulevard	February 1940 - November 1950
287	La Tuna Creek below Debris Basin	October 1946 - September 1958
299	Los Angeles River at Radford Avenue	February 1950 - September 1958
300	Los Angeles River at Tujunga Avenue	May 1950 - September 1958
305	Pacoima Diversion at Branford Street	October 1953 - September 1958
E-5-C	Los Angeles River below Sepulveda Dam	May 1943 - September 1958
E-20-C	Tujunga Wash above Glen Oaks Boulevard	May 1932 - February 1938 August 1940 - September 1958
E-285	Burbank-Western Storm Drain at Riverside Drive	October 1950 - September 1958
U-12	Haines Creek above mouth of canyon	February 1917 - September 1934 October 1935 - September 1958

* LACFCD gaging station number. See Plate 9 for location.

TABLE 28

SEPARATION OF SURFACE FLOW AT GAGE F-57

In Acre-Feet

Year	Base low flow			Surface runoff		Measured
	Rising water	Waste discharges		Owens River water	Net storm runoff	Outflow
		Industrial	Sewage			
	(1)	(2)	(3)	(4)	(5)	(6)
1928-29	0	0	0	650	2,950	3,600*
29-30	0	0	0	330	1,330	1,660
1930-31	0	0	0	260	3,710	3,970
31-32	60	0	0	1,550	13,630	15,240
32-33	440	0	0	0	10,200	10,640
33-34	1,670	0	0	1,750	26,400	29,820
34-35	760	0	0	440	11,350	12,550
1935-36	720	0	0	560	4,490	5,770
36-37	1,430	0	0	1,770	21,270	24,470
37-38	7,740	0	0	1,690	123,210	132,640
38-39	14,490	0	0	2,940	24,930	42,360
39-40	14,050	0	0	760	24,780	39,590
1940-41	25,770	200	0	0	138,990	164,960
41-42	28,600	410	0	5,160	20,630	54,800
42-43	25,490	620	0	8,680	89,600	124,390
43-44	26,500	830	0	2,850	79,650	109,830
44-45	16,610	1,040	0	1,210	18,130	36,990
1945-46	10,500	1,250	0	4,100	20,040	35,890
46-47	9,700	1,460	0	5,960	14,210	31,330
47-48	7,270	1,670	0	0	5,950	14,890
48-49	2,440	1,880	0	710	12,580	17,610
49-50	0	2,090	0	0	8,670	10,760
1950-51	0	1,890	0	1,080	4,870	7,840
51-52	3,110	1,750	0	1,430	101,750	108,040
52-53	0	1,400	0	1,650	15,430	18,480
53-54	0	930	30	290	19,750	21,000
54-55	0	880	670	0	16,720	18,270
1955-56	0	1,350	1,040	0	33,500	35,890
56-57	0	820	10	0	24,060	24,890
57-58	0	1,220	50	0	89,750	91,020
29-Year Average						
1929-57	6,810	710	60	1,580	30,790	39,940

* Partially estimated.

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Native Water Spread

Early protection from flood waters was provided by the construction of Pacoima and Big Tujunga Reservoirs in 1929 and 1931, respectively, by the Los Angeles County Flood Control District. Subsequent additional flood protection was provided on the valley floor area by the construction of Hansen and Sepulveda flood control reservoirs by the U. S. Corps of Engineers in 1940 and 1941, respectively.

Pacoima, Big Tujunga and Hansen Reservoirs have been operated for water conservation as a secondary function along with flood control. The location of these reservoirs and the spreading grounds situated downstream thereof are depicted on Plate 12. During the base period controlled releases from these reservoirs have been spread to recharge ground water. Four spreading grounds with an aggregate area of 266 acres have been constructed and operated for this purpose since 1932-33. The locations and descriptions of these, namely, the Pacoima, Hansen, Lopez and Branford spreading grounds, are shown in Table 29. Annual amounts of native water spread to recharge the ground waters at each of these grounds during the period 1928-29 through 1957-58 are shown in Table 30.

TABLE 29

LOCATION AND DESCRIPTION OF SPREADING GROUNDS FOR NATIVE RUNOFF

Grounds	Type	Season first used	Area in acres		Capacities		Location	Source of water	Remarks
			Gross	Wetted	Intake, cfs	Storage, af			
Lopez	Shallow basins	1956-57	18	13	25	25	Southeasterly side of Pacoima Wash north-easterly of Foothill Boulevard.	Controlled flow from Pacoima Dam and Lopez Basin.	Owned and operated by the Los Angeles County Flood Control District. The flow is diverted from Lopez Basin via canal to the spreading grounds. Gross area includes 1.3 acres in easement, Edison Company and 3.26 acres streets, but excludes canal area northwesterly side of channel. Storage capacity to be increased by permittee excavation.
Pacoima	Shallow basins	1932-33	179	122	400	330	Both sides of old Pacoima Wash channel from Arleta Street southwesterly to Woodman Avenue.	Controlled flow from Pacoima Dam. Partially controlled flow from Lopez Basin. Uncontrolled flow between Lopez Basin and spreading grounds.	Owned and operated by the Los Angeles County Flood Control District. Diversion from Pacoima diversion channel placed in use April, 1954. Gross area excludes new channel, but includes old channel from Woodman Avenue to Sharp Avenue, yard area to Paxton Street and area for access to diversion headworks. New basins built in old Pacoima channel between old headworks and Woodman Avenue and storage increased during 1956.
Hansen	Shallow basins	1944-45	157	110	450	230	Northwesterly side of Tujunga Wash from above Glenoaks Boulevard southwesterly to San Fernando Road.	Controlled flow from Hansen Dam and Big Tujunga Dam.	Owned and operated by the Los Angeles County Flood Control District. Gross area includes all land northwesterly of line 50 feet± from and parallel to northwesterly channel wall.
Branford	Deep basin	1956-57	12		1,540		Southwesterly of Arleta Street above confluence of Tujunga channel and Pacoima diversion channel.	Uncontrolled flows from Branford Street-Cantara Street drain.	Owned and operated by the Los Angeles County Flood Control District. Pit under development, therefore, storage and percolating capacity not firm. Outlet capacity = 1,540 cfs.

TABLE 30

NATIVE RUNOFF SPREAD

In Acre-Feet

Year	Name of spreading ground				Total[a]
	Lopez	Pacoima	Hansen	Branford	
1932-33		26[b]			30
33-34		230			230
34-35		1,200			1,200
1935-36		2,000			2,000
36-37		4,680			4,680
37-38		3,844			3,840
38-39		363			360
39-40		907			910
1940-41		9,775			9,780
41-42		37			40
42-43		3,744			3,740
43-44		7,223			7,220
44-45		1,467	7,651[c]		9,120
1945-46		514	2,268		2,780
46-47		3,763	8,725		12,490
47-48		0	0		0
48-49		0	0		0
49-50		245	0		250
1950-51		0	0		0
51-52		6,121	16,780		22,900
52-53		1,651	1,271		2,920
53-54		1,891	1,014		2,910
54-55		205	0		210
1955-56	0	566	2	0	570
56-57	28[d]	475	0	38[d]	540
57-58	1,030	10,924	18,407	20	30,380

a. Rounded off to nearest 10 acre-feet.
b. First used in 1932-33.
c. First used in 1944-45.
d. First used in 1956-57.

Subsurface Flow

Subsurface flow leaves the Upper Los Angeles River area at two locations, one southerly through the Los Angeles Narrows (Gage F-57 on the Los Angeles River) and the other easterly across the topographic divide in the vicinity of Pickens Canyon.

Subsurface flow takes place through the relatively thin section of water-bearing material shown as Section L-L' on Plate 5D (in vicinity of Gage F-57). Computation of annual quantities of underflow at this point by the slope area method is discussed in Appendix P. Subsurface flow from the Verdugo area easterly to the Monk Hill Basin was estimated for high and low water table conditions at the narrowest section of the valley fill east of the Verdugo Subarea boundary (about midway between Pickens Canyon Wash and the topographic boundary). The annual flow values were then determined from these data and water level conditions as indicated by well hydrographs. The total estimated annual amounts of underflow leaving the Upper Los Angeles River area near gaging station F-57 and in the vicinity of Pickens Canyon are presented in Table 31.

Conditions limiting subsurface flow between hydrologic subareas have previously been described in Chapter III. Annual amounts of such flow are discussed in Appendix P and summarized in Table 32.

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TABLE 31

ESTIMATED SUBSURFACE OUTFLOW,
UPPER LOS ANGELES RIVER AREA

In Acre-Feet

Year	Near Gage F-57 (1)	East of Pickens Canyon* (2)	Total* (3)
1928-29	340	250	600
29-30	260	250	500
1930-31	210	250	450
31-32	340	250	600
32-33	450	250	700
33-34	450	250	700
34-35	500	250	750
1935-36	440	300	750
36-37	430	300	750
37-38	410	300	700
38-39	430	400	850
39-40	400	400	800
1940-41	350	400	750
41-42	360	400	750
42-43	330	400	750
43-44	340	400	750
44-45	350	400	750
1945-46	330	400	750
46-47	330	400	750
47-48	330	300	650
48-49	300	300	600
49-50	280	300	600
1950-51	320	250	550
51-52	280	250	550
52-53	290	300	600
53-54	260	250	500
54-55	300	250	550
1955-56	330	250	600
56-57	190	250	450
57-58	160	250	400
29-Year Average 1929-57	340	300	650

* Rounded off to nearest 50 acre-feet.

TABLE 32

ESTIMATED UNDERFLOW BETWEEN HYDROLOGIC SUBAREAS

In Acre-Feet

Year	Sylmar Subarea to San Fernando Subarea			Verdugo and Eagle Rock Subareas to San Fernando Subarea
	Pacoima Notch[a] (1)	Sylmar Notch (2)	Total[b] (3)	(4)
1928-29	160	Average 400 acre-feet per year	550	Estimated to be nil
29-30	160		550	
1930-31	160		550	
31-32	160		550	
32-33	150		550	
33-34	140		550	
34-35	200		600	
1935-36	120		500	
36-37	320		700	
37-38	250		650	
38-39	180		600	
39-40	150		550	
1940-41	300		700	
41-42	210		600	
42-43	290		700	
43-44	250		650	
44-45	200		600	
1945-46	200		600	
46-47	170		550	
47-48	110		500	
48-49	60		450	
49-50	40		450	
1950-51	20		400	
51-52	190		600	
52-53	90		500	
53-54	60		450	
54-55	80		500	
1955-56	80		500	
56-57	60		450	
57-58	150		550	
29-Year Average 1929-57	160	400	550	0

a. Values assume submerged dam impervious below elevation of 1,200 feet. For values under other assumptions see Appendix P.

b. Rounded off to nearest 50 acre-feet

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Changes in Ground Water Storage

Water in excess of other demands remains in the area, percolates to the water table and results in increased ground water in storage. Conversely, water must necessarily come from ground water storage if all demands in excess of other supplies are to be met. The resultant change of ground water in storage is indicated by rising ground water levels as water goes into storage and falling levels as water comes out of storage. Water in transit to the water table is not feasible of evaluation and on the average has been removed from consideration since both the start and end of the base period are preceded by dry years causing this unaccounted-for water to be relatively minor.

The volume of material saturated or drained is the product of the area and the mean change of ground water levels occurring therein. The resultant change in storage was evaluated as the product of this volume and the mean specific yield of the material. Methods of determining the specific yields utilized are discussed in Chapter III and Appendix D.

In general the change in storage computation procedure consisted of determining the change in each of 52 separate storage units selected so that each area contained homogeneous hydrologic and geologic characteristics. Change in storage within a hydrologic subarea was computed as the summation of the changes in the group of storage units contained therein. Details of this procedure are described in Appendix Q.

Water level data on a large number of wells were available for the area within the boundary of the valley fill. The locations of wells having water level measurements during at least a portion of the 29-year base period are shown on Plates 27 through 30. The elevations of the water surface of the ground water reservoir are shown by ground water contours for the years 1931, 1938, 1944 and 1958 on Plates 27, 28, 29 and 30, respectively. Areas on the foregoing plates labeled "area of no control", and where ground water contours are dashed, are areas in which a deficiency of water level record existed. Measurements for adjacent areas and isolated readings within the area were utilized to estimate the change in storage therein. The years 1931 and 1958 are the earliest and latest years for which sufficient reliable data were available. The maximum amount of ground water in storage during the 29-year base period occurred during 1943-44. The annual ground water levels are shown for selected wells in the hydrologic subareas on Plates 34A, 34B and 34C.

The fluctuations of water levels are shown on Plates 31, 32 and 33 for the respective periods, fall of 1931 to fall of 1958, fall of 1934 to fall of 1949 and fall of 1944 to fall of 1958. The change from 1931 to 1958, although not of the greatest magnitude during the base period, is of importance since it illustrates the large increase of extractions that has occurred in the eastern portion of the San Fernando Hydrologic Subarea. This shift of pumping from west to east is further illustrated by Plates 31A and 31B, which show the respective distribution of ground water extractions for 1930-31 and 1957-58. The period 1934 to 1949 is included since it is a period during which the net change in storage was at a minimum. The maximum change in water levels during the 1928-29 through 1957-58 period occurred in the 1944 to 1958 period (Plate 33).

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Ground water levels used for change in storage were generally measured in October of each year. The beginning of the water year was considered the best annual reference point because at this time the water surface had generally recovered from localized effects of heavy summer pumping and it was usually prior to winter rainfall which might cause abnormalities in the ground water surface. In several instances where measurements in October were not available, measurements in November and December were utilized resulting, in some cases, in the use of measurements taken after appreciable precipitation had occurred. In these cases, the computed change in storage may be in error for that year and subsequent hydrologic years because of the influence of rain on pumping draft and related water level effects. The error, however, will compensate over a period where comparable water levels were obtained; this is believed to be no greater than two years during the base period and is of major consequence only in the period 1955-56 through 1957-58.

Free ground water conditions are generally found to exist in the major portion of the valley fill including the San Fernando and Verdugo Hydrologic Subareas. Confined ground water conditions are indicated in the Eagle Rock and Sylmar Hydrologic Subareas; thus change in storage in these subareas was considered to have occurred only in the free water table or forebay portion thereof. A paucity of well data precluded a determination of the forebay extent in the Sylmar area and change in storage in this area was determined from water level changes and specific yields occurring throughout that subarea. It is believed that this approximation gives results which will not grossly affect the accuracy of the overall determination of change in storage in the combined subareas because of the relatively small specific yields used and the relatively moderate cyclic variation of water levels which has occurred in the Sylmar Subarea during the base period.

The Eagle Rock forebay area comprises 535 acres or 69 percent of that small hydrologic subarea. Specific yields for this area were obtained by correlation of existing geologic information with specific yield data determined for the neighboring valley fill in the vicinity of the City of Glendale.

Annual and cumulative amounts of change in storage in the valley fill material of the Upper Los Angeles River area thus determined are shown in Table 33.

TABLE 33

CHANGE IN GROUND WATER STORAGE IN THE VALLEY FILL OF THE UPPER LOS ANGELES RIVER AREA[a]

In Acre-Feet

Year	Hydrologic Subarea, Annual Amount: San Fernando (1)	Eagle Rock (2)	Sylmar (3)	Verdugo[c] (4)	Valley fill of Upper Los Angeles River area: Annual[b] (5)	Cumulative (6)
1928-29	- 41,510	- 93	- 65	-1,370	- 43,040	- 43,040
29-30	- 15,694	- 93	294	-1,370	- 16,860	- 59,900
1930-31	- 26,322	- 93	1,019	-1,431	- 26,830	- 86,730
31-32	67,033	278	2,458	67	69,840	- 16,890
32-33	26,637	- 93	- 524	- 261	25,760	8,870
33-34	- 28,558	- 93	- 76	1,611	- 27,120	- 18,250
34-35	38,038	0	-1,127	1,670	38,580	20,330
1935-36	996	- 93	- 732	341	510	20,840
36-37	30,663	185	1,377	4,016	36,240	57,090
37-38	66,424	185	1,868	7,944	76,420	133,510
38-39	- 12,545	-185	146	2,480	- 10,100	123,400
39-40	- 32,650	-185	-3,655	-2,116	- 38,610	84,800
1940-41	116,852	93	6,042	5,030	128,020	212,810
41-42	- 31,230	93	-1,609	-1,408	- 34,150	178,660
42-43	31,029	93	20	1,390	32,530	211,190
43-44	47,205	93	1,493	330	49,120	260,310
44-45	- 74,177	0	- 296	-2,673	- 77,150	183,170
1945-46	- 33,296	-185	966	-5,676	- 38,190	144,980
46-47	- 41,202	93	-1,526	-5,261	- 47,860	97,120
47-48	- 52,768	-185	-2,478	-6,682	- 62,110	35,010
48-49	- 56,360	-464	-4,274	-8,220	- 69,320	- 34,310
49-50	- 43,390	0	24	-2,251	- 45,620	- 79,930
1950-51	- 53,288	185	- 714	- 337	- 54,150	-134,080
51-52	33,725	278	3,938	9,421	47,360	- 86,720
52-53	- 68,276	- 93	-2,563	-1,597	- 72,530	-159,250
53-54	- 56,769	185	- 782	-3,148	- 60,510	-219,760
54-55	- 51,368	- 93	- 596	585	- 51,470	-271.240
1955-56	- 71,391	- 93	-2,275	2,342	- 71,420	-342,650
56-57	- 6,279	93	-1,505	3,934	- 3,760	-346,410
57-58	- 9,159	93	229	4,565	- 4,270	-350,680
29-Year Average 1929-57	- 11,675	- 6	- 178	- 91	- 11,950	

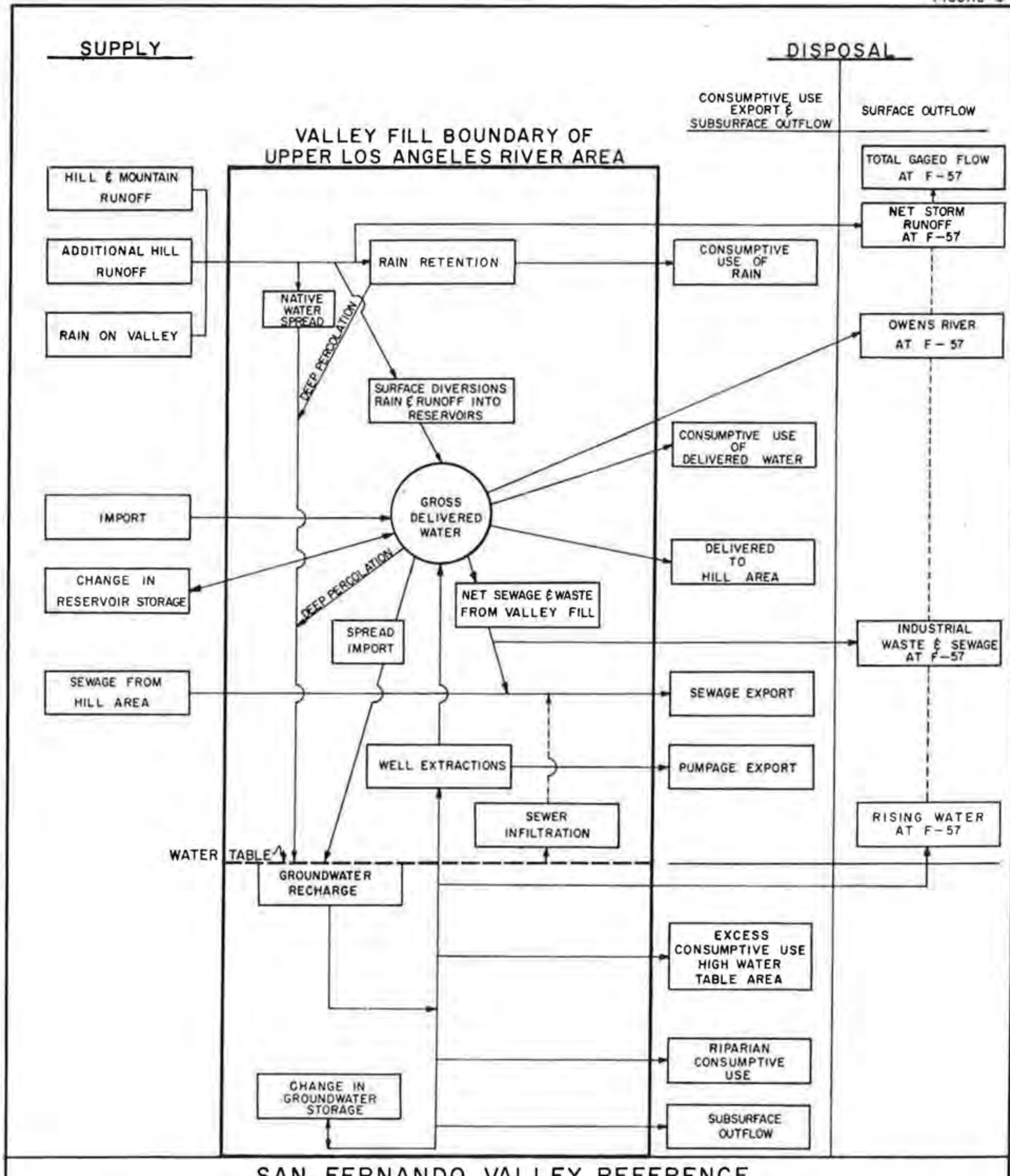
a. Values derived in Table Q-4. Minus indicates a reduction of water in storage and positive values indicate an increase in storage.
b. Rounded off to nearest 10 acre-feet from Table Q-4.
c. Includes portion of Monk Hill Basin within Upper Los Angeles River Area.

Determination of Consumptive Use by Inflow-Outflow Method

Consumptive use or disposal of water to the atmosphere through evapotranspiration accounts for a large portion of the water diminution in the Upper Los Angeles River area. It includes the amounts of water evaporated by natural or industrial processes, the water transpired by plants and the relatively minor quantities of water incorporated in plant fiber, industrial products and household uses.

Total consumptive use is computed in this chapter as the difference between already determined items of water supply and disposal by equating all such items in an inflow-outflow water inventory for the area. The various items of supply and disposal used are shown diagrammatically on Figure 3 to illustrate their physical relationship and composition. This procedure for determining consumptive use is called the Inflow-Outflow Method and the values derived by this method are shown in Table 34.

FIGURE 3



SAN FERNANDO VALLEY REFERENCE

DIAGRAM OF WATER SUPPLY AND DISPOSAL UPPER LOS ANGELES RIVER AREA

STATE WATER RIGHTS BOARD

TABLE 34

DETERMINATION OF CONSUMPTIVE USE ON VALLEY FILL AREA BY INFLOW-OUTFLOW METHOD

1,000 Acre-Feet

	Supply					Outflow							
						Ground water export			Outflow				
Year	Import, valley fill	Precipitation, valley fill	Runoff to valley fill	Surface diversion from hill areas	Total	Out of Upper Los Angeles River Area	To hill and mountain areas	Sewage and infiltration exported	Surface	Subsurface	Change in ground water storage	Total outflow and change in ground water storage	Consumptive use by inflow-outflow method
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1928-29	104.8	122.4	7.0	0.1	234.3	54.8	2.3	5.4	3.6	0.6	- 43.0	23.7	210.6
29-30	112.1	125.7	5.7	0.1	243.6	57.3	3.6	6.2	1.7	0.5	- 16.9	52.4	191.2
1930-31	117.1	155.8	4.4	0.1	277.4	59.5	4.3	7.6	4.0	0.5	- 26.8	49.1	228.3
31-32	120.9	207.4	58.9	0.3	387.5	34.3	4.5	9.0	15.2	0.5	69.8	133.4	254.1
32-33	117.4	133.5	13.6	0.2	264.7	32.0	4.7	9.0	10.6	0.7	25.8	82.8	181.9
33-34	103.2	150.0	20.3	0.2	273.7	54.1	4.6	9.4	29.8	0.7	- 27.1	71.5	202.2
34-35	101.9	207.1	24.3	0.2	333.5	42.9	4.4	10.9	12.6	0.8	38.6	110.2	223.3
1935-36	123.2	131.0	19.2	0.3	273.7	49.6	4.9	11.5	5.8	0.8	0.5	73.1	200.6
36-37	94.0	242.2	91.7	0.4	428.3	44.4	5.4	12.2	24.5	0.8	36.2	123.5	304.8
37-38	86.4	258.6	177.6	0.5	523.1	38.8	6.1	13.3	132.6	0.7	76.4	267.9	255.2
38-39	101.8	219.1	29.0	0.6	350.5	36.5	6.8	15.4	42.4	0.8	- 10.1	91.8	258.7
39-40	84.2	172.0	20.4	0.5	277.1	38.1	6.9	16.4	39.6	0.8	- 38.6	63.2	213.9
1940-41	68.8	409.8	191.4	0.8	670.8	41.0	6.5	20.5	165.0	0.8	128.0	361.8	309.0
41-42	117.1	137.7	22.1	0.9	277.8	33.6	7.4	20.7	54.8	0.8	- 34.2	83.1	194.7
42-43	127.2	259.0	166.5	1.1	553.8	44.3	6.6	21.3	124.4	0.8	32.5	229.9	323.9
43-44	109.9	254.3	124.6	1.3	490.1	47.6	6.6	22.2	109.8	0.8	49.1	236.1	254.0
44-45	116.8	148.5	37.7	1.0	304.0	62.2	6.6	22.5	37.0	0.8	- 77.2	51.9	252.1
1945-46	129.3	141.3	25.1	0.7	296.4	68.2	8.0	22.7	35.9	0.8	- 38.2	97.4	199.0
46-47	137.7	156.0	32.6	0.7	327.0	73.5	6.3	25.6	31.3	0.8	- 47.9	89.6	237.4
47-48	143.9	80.1	6.4	0.6	231.0	68.1	4.4	27.4	14.9	0.7	- 62.1	53.4	177.6
48-49	142.2	86.6	3.7	0.4	232.9	67.1	4.8	28.8	17.6	0.6	- 69.3	49.6	183.3
49-50	140.0	111.2	6.0	0.4	257.6	72.8	7.3	30.1	10.8	0.6	- 45.6	76.0	181.6
1950-51	163.1	89.9	3.5	0.4	256.9	66.4	6.9	33.5	7.8	0.6	- 54.2	61.0	195.9
51-52	143.2	315.0	116.8	0.5	575.5	63.0	7.0	37.4	108.0	0.6	47.4	263.4	312.1
52-53	163.9	118.9	16.0	0.5	299.3	82.0	7.4	38.7	18.5	0.6	- 72.5	74.7	224.6
53-54	160.0	138.4	17.3	0.4	316.1	83.5	6.6	43.8	21.0	0.5	- 60.5	94.9	221.2
54-55	158.6	142.9	10.0	0.3	311.8	80.2	6.4	41.6	18.3	0.6	- 51.5	95.6	216.2
1955-56	155.5	171.2	14.5	0.2	341.4	84.0	6.4	47.0	35.9	0.6	- 71.4	102.5	238.9
56-57	170.7	134.0	10.0	0.2	314.9	90.8	6.6	54.5	24.9	0.5	- 3.8	173.5	141.4
57-58	160.8	278.6	93.3	0.3	533.0	83.3	5.8	57.4	91.0	0.4	- 4.3	233.6	299.4
29-Year Average 1929-57	124.6	173.1	44.0	0.5	342.4	57.6	5.9	22.9	39.9	0.6	- 12.0	115.2	227.2

Source and derivation of values by column numbers:

Column number	
1.	Table 20, Column 13.
2.	Table 1.
3.	Table 3, Column 2.
4.	Table 16, Column 2.
5.	Sum of Columns 1, 2, 3 and 4, herein.
6.	Table 19, Column 3.
7.	Table 20, Column 11.

Column number	
8.	Table 26, sum of Columns 3 and 4.
9.	Table 28, Column 5.
10.	Table 31, Column 3.
11.	Table 33, Column 5.
12.	Sum of Columns 6, 7, 8, 9, 10 and 11, herein.
13.	Column 5 minus Column 12.

CHAPTER VI. HISTORIC GROUND WATER RECHARGE

To determine the effect of import on the safe yield of the ground water reservoir of the Upper Los Angeles River area, a determination of the amount of recharge to the reservoir originating from supplies imported to the area is required. In Table 34, page 169, an evaluation has been made of the disposal of the combined supply of native and imported water to the valley fill area. To identify the proportion or amount of the imported supplies which reaches the ground water reservoir as recharge, requires a breakdown of consumptive use quantities on the basis of whether the use was made from native or imported supplies and the proportion of the supply which contributed to recharge through deep percolation.

The "Integration Method" for determination of consumptive use provides the means of making the required breakdown and in addition provides a check on the combined consumptive use heretofore determined by the "Inflow-Outflow Method." The ground water reservoir of the Upper Los Angeles River area consists of water-bearing materials in the valley fill area as determined on Plate 5. The maximum water in storage within the range of water levels in materials watered and dewatered during the period 1928-29 through 1957-58 occurred in 1943-44. The minimum occurred in 1957-58.

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Consumptive Use by Integration Method

Annual amounts of consumptive use are determined by the Integration Method through the use of data on unit evapotranspiration or consumptive use of water for each culture type and on the acreage devoted to that culture. The total consumptive use occurring on the valley fill lands is determined by this method as the summation of the parts. These parts are the product of unit consumptive use and area of each type of land use, the consumptive use of water system losses and the excess consumptive use on high ground water areas. The sum of these parts, each of which is separately derived, is the total consumptive use on the valley fill area.

Computations of unit consumptive use have been made by determining the supply of native and delivered water available to the areas devoted to each culture type or land use class and computing the portions of the supply disposed of through evaporation, runoff, transpiration, deep percolation and storage in the soil.

Recognition of seasonal effect on consumptive use is made by computing the consumptive use by months for the winter season of October through April when the supply is largely uncontrolled rainfall, and as a lump sum for the summer months of May through September when the use is almost exclusively from delivered water to which a relatively uniform irrigation efficiency is applicable.

Unit values of consumptive use have been determined as described in Appendix L and separate computations of unit consumptive use for each year are summarized for each culture or land use class in Tables L-13, L-14 and L-15. Methods of computation are illustrated on Figures L-1 and L-2.

The areas of different types of vegetative cover and of land and water surface areas were determined for each year of the base period from aerial maps, photographs and field surveys as described in Appendix K.

Evaporation

Evaporation is a function of vapor pressure which varies with humidity, temperature and wind movement. The evaporation pan is sensitive to these factors and is commonly utilized to determine rates of evaporation from water surfaces. Moist surfaces, such as saturated soils and wet impervious areas, have been considered to have an evaporation rate equivalent to that of a water surface. Average daily rates of evaporation were determined for each month for days of rain and for days of no rain. The average daily rates of evaporation were applied separately to pervious and impervious areas with the maximum evaporation allowed being 0.60 and 0.50 of an inch, respectively, during and following each storm (see Appendix L).

Evaporation of Irrigation Water. The evaporation of irrigation water is estimated to be 15 percent of the delivered water and is included in the consumptive use.

Residual Rain on the Valley Fill Area. Precipitation falling on the pervious portions of the valley fill area is assumed to be either consumed or to percolate while precipitation falling on the impervious portions will either evaporate or become runoff. This runoff originating on impervious areas is termed residual rain. A portion of the residual rain percolates in transit to Gage F-57 and the remainder becomes part of the storm flow passing Gage F-57.

Irrigated, Native and Residential Land Use Areas

Computations of consumptive use for land use classes containing areas of vegetation were made for two separate periods: (1) the winter season of October 1 through April 30 and (2) the summer period May 1 through September 30. Two separate periods were used because of the different rate of plant growth and the variation in the amount of water available to the plant during the two periods. During the winter season large variations occur in the amounts of precipitation; therefore, the winter season computations were made monthly by first determining the water received by the soil, which was thus available for plant growth. This was taken as the sum of precipitation and delivered water reaching pervious areas less the evaporation of each. The water available, thus determined, was considered to be first utilized in satisfying the monthly transpiration requirements of the crop and secondly to satisfy any deficiency in the soil moisture within the root zone. The remainder was considered as deep percolation recharging the ground water.

Transpiration rates of the crops found in the area were determined from field investigations made in the San Fernando Valley by the Soil Conservation Service during the late 1940's or by transposing a value determined in another area similar to the Upper Los Angeles River area. The amount of soil moisture that could be held in storage within the root zone was determined from investigations made by the Soil Conservation Service and from published information on rooting depths and moisture-holding capacities of soils. In months when water available to the plant was less than the transpiration requirements, water was taken from storage within the root zone.

Consumptive use on irrigated lands during the summer season was determined by applying an irrigation efficiency for the particular crop to the known water deliveries. Depths of water delivered for each crop during the winter months and the summer growing season for each year of the base period are determined in Appendix J. The irrigation efficiency was based on work done by the Soil Conservation Service in the area and on discussions with Mr. H. F. Blaney who was in charge of the work. The consumptive use as determined for each of the periods was split into the parts derived from precipitation and delivered water in proportion to the amounts of each supply available. The sum of the consumptive use of each supply for the two periods is applicable to the net area of the land use and was adjusted to the gross area by weighting the net values for percent of each crop or impervious area included in a land use class. Unit values of consumptive use determined by the above methods for each of the hydrologic subareas are shown in Tables L-13, L-14 and L-15 in Appendix L, in which further details of the computations are set forth. Average annual consumptive use during the 29-year base period from irrigated agriculture and residential land use classes overlying the valley fill was 105,410 and 60,430 acre-feet, respectively.

Industrial and Commercial Land Use Areas

Consumptive use by industrial and commercial areas varies with the type of industrial process and was estimated on an annual basis. The annual depth of water consumed on industrial and commercial areas was based on values published in Bulletin 2, entitled "Water Utilization and Requirements of California", State Water Resources Board. Bulletin 2 gives values of 0.40 to 1.4 acre-feet per acre for consumptive use by industrial and commercial areas, based on total water delivered to this type of land use less sewage discharged into a sewerage system.

On the basis of the above values and 1958 land use data, the Referee selected the value of 0.85 acre-foot per acre as being representative of the difference between delivered water and sewage discharged to the sewerage system for industrial and commercial areas (see Appendix L). Therefore, the 0.85 acre-foot per acre represents consumptive use plus industrial wastes discharged to the stream system. Records of water sales indicate that defense industries in Burbank, Glendale and the Los Angeles Narrows used larger amounts of delivered water during the war years; therefore, the depth of consumptive use was increased during the war years (see Appendix L). Water sales records for the breweries and steam plant in the valley show that these plants used water greatly in excess of the amount estimated by the above method. The additional use by these plants after 1952-53 is estimated in Appendix L.

Deep percolation of water delivered to commercial and industrial areas occurs primarily from the discharge of industrial wastes in the channels of the stream system with minor amounts occurring on commercial and industrial land use areas. The amount occurring in the stream system are equal to the difference between industrial wastes discharged to the stream system (Table 26A, page 151b) and wastes passing Gage F-57 (Table 28, page 153). A relatively small amount of deep percolation has been found to occur in the area of use at the Valley Steam Plant of the City of Los Angeles (see Appendix L, page L-40).

The annual consumptive use by commercial and industrial areas averaged 6,710 acre-feet during the base period, comprising less than seven percent of the total average consumptive use of delivered water.

Excess Consumptive Use in High Water Table Areas

In areas where ground water is within 10 feet of the ground surface, an incremental evaporation occurs from moisture brought to the surface by capillary action in the soil and certain plants increase their transpirational use because of the more readily available supply.

Areas of high ground water have existed in the San Fernando Subarea and in the lower portion of the Sylmar Subarea. Extent of the high ground water area in the western portion of the San Fernando Subarea was determined from water level measurements at wells and piezometers observed for this purpose by the U. S. Soil Conservation Service in cooperation with the City of Los Angeles. The extent of the high ground water area in the fall of 1944 is shown on Plate 29. Due to the paucity of water level data in the western portion of the Sylmar Subarea, the extent of this area where excess consumptive use of ground water occurred was determined from the relative concentration of calcium carbonate existing in the soil. Using these data to limit the area, excess consumptive use during the base period was calculated by using water level observations at wells of the City of San Fernando, the Mission Well Field of the City of Los Angeles, and test hole data.

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Characteristics of soils and their relationship to past vegetative and water table conditions in the cienaga of the Sylmar Subarea were investigated by the Department of Water Resources in cooperation with the Referee. The Department's report is set forth in Appendix C and on Plates 7 and 8.

The depth of consumptive use in high ground water areas in excess of that which would normally occur was estimated as the difference between consumption based on high water table conditions and the normal consumption shown in Tables L-13 through L-15. Consumption under high ground water conditions is based on experiments in the Lower San Luis Rey Valley. The basic data and procedures utilized in these studies are set forth in Appendix L. The 29-year average annual consumptive use of ground water (excess consumptive use) in areas of high ground water is 2,640 acre-feet. (see Table L-22, page L-70).

Riparian Areas

Consumptive use by riparian vegetation, located in and adjacent to stream channels, has occurred during the base period mainly in the lower reaches of the Los Angeles River. The total annual depth of consumptive use for this type of vegetation was taken as equal to the annual transpiration rate for similar type growth in the Upper Santa Ana Valley, transposed by mean temperatures, plus the evaporation of rain. The annual depth of consumptive use of ground water was taken as the total annual depth of consumptive use less the precipitation and is shown in Tables L-13 and L-15 (see Appendix L). The average annual consumptive use of ground water on riparian areas during the base period is 2,000 acre-feet.

Consumptive Use of Water System Losses

Water system losses are comprised of sewer flushing water, distribution loss and other loss. Only the latter two items contain portions that may become consumptive use. The amount of sewer flushing water exported in sewer mains has been evaluated in Chapter V (see Table 26). Data available on comparable systems indicated that the maximum continuous pipe system leakage, or distribution loss, to be expected was approximately six percent, computed as a percentage of the gross available for distribution.

Foliage and plant growth along the roadways is estimated, on the average, to overhang approximately 20 percent of the paved area underlain by the pipes of the distribution system; thus, it is believed that the root system of this vegetation would have access to and transpire approximately the equivalent percentage of distribution losses.

The system loss in excess of sewer flushing and distribution loss is termed other loss and is comprised of meter slippage and unmetered deliveries. This portion of the system loss is taken as consumptively used in the same proportion as is water applied to the land use classes (i.e., net delivered water less sewage and wastes). The remainder of the system loss was considered as deep percolation. Negative values shown in Table 36 indicate that the amounts shown as available were less than the amounts shown as delivered. The negative values are retained in this and following tables to permit an accounting that is mathematically correct. During the base period consumptive use of water system losses averaged 3,250 acre-feet per year.

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Summary

The annual amount of consumptive use on the valley fill area is the summation of the annual amount occurring on land use class areas, excess consumptive use, and consumptive use of water system losses. The annual amount of consumptive use on land use classes and excess consumptive use are shown in Table 35. The consumptive use of water system losses is shown in Table 36. The total amount of consumptive use on the valley fill area is the total of the amounts in Tables 35 and 36 and is shown in Table 37.

During the 29-year base period, consumptive use on irrigated lands and on residential areas averaged 46 and 26 percent, respectively, of the average total consumptive use on the valley fill area. The effect of urbanization is shown by the averages for the base period and the 9-year period (1949-50 through 1957-58). During this latter period consumptive use on irrigated lands and on residential areas averaged 31 and 43 percent respectively.

TABLE 35

SUMMARY OF INTEGRATED CONSUMPTIVE USE AND DEEP PERCOLATION[a] ON LAND USE AREAS WITHIN BOUNDARY OF VALLEY FILL

In Acre-Feet

Year	Irrigated crops: Consumptive use: Rain (1)	Irrigated crops: Consumptive use: Delivered water (2)	Irrigated crops: Deep percolation: Rain (3)	Irrigated crops: Deep percolation: Delivered water (4)	Residential: Consumptive use: Rain (5)	Residential: Consumptive use: Delivered water (6)	Residential: Deep percolation: Rain (7)	Residential: Deep percolation: Delivered water (8)	Miscellaneous[b]: Consumptive use: Rain (9)	Miscellaneous[b]: Consumptive use: Delivered water (10)	Miscellaneous[b]: Deep percolation: Rain (11)
1928-29	55,830	76,910	260	17,940	15,350	14,750	450	1,340	42,470	4,390	0
29-30	53,010	77,860	2,220	17,020	14,520	15,740	2,040	2,630	44,070	4,410	0
1930-31	59,500	72,200	5,900	17,840	18,140	15,620	3,260	2,810	54,510	4,880	0
31-32	62,210	54,690	16,760	17,330	21,670	9,840	7,470	2,530	68,710	3,240	7,920
32-33	41,760	58,570	9,860	17,040	15,410	9,720	4,410	1,730	44,790	4,550	2,600
33-34	47,220	61,960	10,430	17,730	17,410	12,030	4,860	2,130	45,760	4,270	3,620
34-35	76,580	57,490	4,330	15,420	30,990	9,460	3,260	1,120	64,370	2,880	1,190
1935-36	49,490	74,600	4,670	19,200	20,330	11,230	2,660	1,460	37,000	3,840	690
36-37	71,590	62,030	25,560	21,290	30,960	10,670	12,220	1,830	57,220	2,990	11,240
37-38	61,170	53,570	34,000	19,320	29,870	11,670	17,780	2,820	56,060	2,840	22,500
38-39	60,970	58,780	16,910	19,040	35,100	15,000	7,320	2,900	62,620	3,520	3,960
39-40	50,480	52,130	8,010	14,640	29,970	15,950	5,350	2,380	52,550	3,650	550
1940-41	70,900	42,570	65,800	18,200	41,950	12,110	40,370	3,370	70,140	1,500	48,830
41-42	49,900	65,040	340	13,810	30,230	18,600	1,460	1,810	34,960	3,870	0
42-43	56,200	61,140	33,890	22,960	35,190	21,550	21,630	4,800	45,550	3,070	20,450
43-44	55,600	58,670	31,220	21,950	36,400	22,270	21,470	6,070	45,110	2,860	17,350
44-45	48,350	68,860	1,500	15,120	32,050	27,090	3,990	3,210	36,030	3,440	760
1945-46	42,580	70,670	4,520	16,660	29,660	31,580	5,180	7,500	32,050	3,590	480
46-47	41,640	68,930	4,850	15,870	31,980	38,070	7,420	6,210	39,300	3,670	770
47-48	24,100	76,240	30	11,560	20,950	46,330	490	3,850	19,210	4,440	0
48-49	24,350	74,510	130	11,270	24,260	49,090	1,000	4,350	21,890	4,080	0
49-50	27,260	62,730	1,770	11,570	29,490	49,870	2,600	5,070	29,000	3,750	0
1950-51	24,200	69,270	90	10,780	27,600	55,830	1,060	3,790	21,640	3,840	0
51-52	50,350	45,360	30,710	17,020	49,490	47,270	34,940	10,540	49,610	2,390	21,050
52-53	28,690	57,240	580	9,440	33,110	62,080	4,580	7,470	27,860	3,870	0
53-54	28,460	44,970	3,100	10,370	33,290	60,980	9,080	10,950	30,930	3,300	740
54-55	26,400	37,840	740	6,490	45,670	62,030	4,450	6,470	36,450	3,720	0
1955-56	25,110	30,190	2,910	6,860	40,230	63,020	12,930	9,660	42,420	2,740	100
56-57	15,660	32,230	1,550	7,160	36,520	75,200	8,700	9,570	35,560	3,700	0
57-58	24,440	24,410	11,160	8,710	60,280	66,180	31,830	8,170	55,850	2,650	12,750
29-Year Average 1929-57	45,850	59,560	11,130	15,200	29,580	30,850	8,700	4,500	43,030	3,560	5,680

a. Excludes deep percolation in the stream system.
b. Includes miscellaneous, dry farm and native vegetation, water surface evaporation and riparian vegetation.

Source and derivation of values by column numbers:

Column No.

1 through 11. Summation of the weighted unit values for each land use classification and respective subarea (Tables L-13, L-14 and L-15) multiplied by the respective acreage (Table K-6) except for water surface evaporation. Water surface evaporation computed as per Appendix L.

TABLE 35

SUMMARY OF INTEGRATED CONSUMPTIVE USE AND DEEP PERCOLATION
ON LAND USE AREAS WITHIN BOUNDARY OF VALLEY FILL
(continued)

In Acre-Feet

Year	Commercial and industrial: Consumptive use: Rain (12)	Commercial and industrial: Consumptive use: Delivered water (13)	Commercial and industrial: Deep percolation: Delivered water (14)	Valley fill area: Consumptive use: Rain (15)	Valley fill area: Consumptive use: Delivered water (16)	Valley fill area: Consumptive use: Other sources (17)	Valley fill area: Consumptive use: All sources (18)	Valley fill area: Deep percolation: Rain (19)	Valley fill area: Deep percolation: Delivered water (20)	Valley fill area: Deep percolation: All sources (21)	Consumptive use plus deep percolation[c]: Rain (22)	Consumptive use plus deep percolation[c]: Delivered water (23)
1928-29	1,270	2,550	0	114,920	98,600	5,850	219,370	710	19,280	19,990	115,600	117,900
29-30	990	2,950	0	112,590	100,960	5,190	218,740	4,260	19,650	23,910	116,800	120,600
1930-31	1,350	3,340	0	133,500	96,040	4,350	233,890	9,160	20,650	29,810	142,700	116,700
31-32	1,920	3,740	0	154,510	71,510	5,550	231,570	32,150	19,860	52,010	186,700	91,400
32-33	1,050	4,140	0	103,010	76,980	4,640	184,630	16,870	18,770	35,640	119,900	95,800
33-34	1,080	4,540	0	111,470	82,800	4,530	198,800	18,910	19,860	38,770	130,400	102,700
34-35	3,100	4,930	0	175,040	74,760	5,630	255,430	8,780	16,540	25,320	183,800	91,300
1935-36	2,340	5,330	0	109,160	95,000	6,590	210,750	8,020	20,660	28,680	117,200	115,700
36-37	3,330	5,730	0	163,100	81,420	5,120	249,640	49,020	23,120	72,140	212,100	104,500
37-38	3,120	6,130	0	150,220	74,210	6,130	230,560	74,280	22,140	96,420	224,500	96,400
38-39	2,860	6,520	0	161,550	83,820	4,540	249,910	28,190	21,940	50,130	189,700	105,800
39-40	3,350	6,930	0	136,350	78,650	3,930	218,930	13,910	17,020	30,930	150,300	95,700
1940-41	4,580	8,050	0	187,570	64,230	5,530	257,330	155,000	21,570	176,570	342,600	85,800
41-42	4,460	9,310	0	119,550	96,820	9,710	226,080	1,800	15,620	17,420	121,400	112,400
42-43	3,830	9,300	0	140,770	95,060	11,860	247,690	75,970	27,760	103,730	216,700	122,800
43-44	4,110	9,290	0	141,220	93,090	12,980	247,290	70,040	28,020	98,060	211,300	121,100
44-45	4,000	9,260	0	120,430	108,650	4,130	233,210	6,250	18,330	24,580	126,700	127,000
1945-46	4,060	7,630	0	108,350	113,470	4,150	225,970	10,180	24,160	34,340	118,500	137,600
46-47	4,820	5,860	0	117,740	116,530	3,090	237,360	13,040	22,080	35,120	130,800	138,600
47-48	3,350	6,010	0	67,610	133,020	3,360	203,990	520	15,410	15,930	68,100	148,400
48-49	4,720	5,840	0	75,220	133,520	3,190	211,930	1,130	15,620	16,750	76,400	149,100
49-50	4,660	5,930	0	90,410	122,280	3,340	216,030	4,370	16,640	21,010	94,800	138,900
1950-51	4,880	6,030	0	78,320	134,970	3,410	216,700	1,150	14,570	15,720	79,500	149,500
51-52	7,530	7,640	0	156,980	102,660	3,270	262,910	86,700	27,560	114,260	243,700	130,200
52-53	5,670	7,050	0	95,330	130,240	3,670	229,240	5,180	16,910	22,090	100,500	147,200
53-54	4,420	7,730	190	97,100	116,980	2,590	216,670	12,920	21,510	34,430	110,000	138,500
54-55	7,300	9,940	970	115,820	113,530	2,450	231,800	5,190	13,930	19,120	121,000	127,500
1955-56	5,430	10,890	1,700	113,190	106,840	2,000	222,030	15,940	18,240	34,180	129,100	125,100
56-57	4,440	11,930	1,960	92,180	123,060	1,930	217,170	10,250	18,690	28,940	102,400	141,800
57-58	7,460	11,900	1,920	148,030	105,140	1,640	254,810	55,740	18,800	74,540	203,800	123,900
29-Year Average 1929-57	3,720	6,710	170	122,180	100,680	4,920	227,780	25,510	19,870	45,380	147,700	120,600

c. Rounded off to nearest 100 acre-feet.

Source and derivation of values by column number:

Column No.

12. Commercial and industrial acreage in each subarea multiplied by their respective unit value (Tables L-13, L-14 and L-15).
13. Column 4, Table L-12.
14. Column 1 minus Column 4, Table L-12.
15. Column 1 plus Column 5 plus Column 9 plus Column 12 herein.
16. Column 2 plus Column 6 plus Column 10 plus Column 13 herein.
17. Sum of consumptive use of ground water (Table L-22) and consumptive use of runoff to Hansen Dam (Table L-22A).
18. Column 15 plus Column 16 plus Column 17 herein.
19. Column 3 plus Column 7 plus Column 11 herein.
20. Column 4 plus Column 8 plus Column 14 herein.
21. Column 19 plus Column 20 herein.
22. Column 15 plus Column 19 herein.
23. Column 16 plus Column 20 herein.

TABLE 36

DISPOSAL OF
WATER SYSTEM LOSSES WITHIN BOUNDARY OF VALLEY FILL

In Acre-Feet

Year	System loss (1)	System flushing water (2)	Distribution and other losses (3)	Distribution loss: Total (4)	Distribution loss: Consumptive use (5)	Distribution loss: Deep percolation (6)	Other losses: Total (7)	Other losses: Consumptive use (8)	Other losses: Deep percolation (9)	Total consumptive use (10)	Total deep percolation (11)
1928-29	800	0	800	800	160	640	0	0	0	160	640
29-30	2,250	320	1,930	1,930	390	1,540	0	0	0	390	1,540
1930-31	10,160	490	9,670	8,730	1,750	6,980	940	770	170	2,520	7,150
31-32	16,570	810	15,760	9,090	1,820	7,270	6,670	5,220	1,450	7,040	8,720
32-33	5,580	610	4,970	4,970	990	3,980	0	0	0	990	3,980
33-34	10	700	- 690	- 690	- 140	- 550	0	0	0	- 140	- 550
34-35	- 1,020	450	- 1,470	- 1,470	- 290	- 1,180	0	0	0	- 290	- 1,180
1935-36	5,640	560	5,080	5,080	1,020	4,060	0	0	0	1,020	4,060
36-37	1,480	200	1,280	1,280	260	1,020	0	0	0	260	1,020
37-38	8,440	350	8,090	7,590	1,520	6,070	500	380	120	1,900	6,190
38-39	3,270	300	2,970	2,970	590	2,380	0	0	0	590	2,380
39-40	7,830	250	7,580	7,390	1,480	5,910	190	150	40	1,630	5,950
1940-41	6,010	150	5,860	5,860	1,170	4,690	0	0	0	1,170	4,690
41-42	11,830	170	11,660	9,620	1,920	7,700	2,040	1,760	280	3,680	7,980
42-43	10,790	0	10,790	10,560	2,120	8,440	230	180	50	2,300	8,490
43-44	10,420	0	10,420	9,620	1,930	7,690	800	620	180	2,550	7,870
44-45	14,900	90	14,810	10,100	2,020	8,080	4,710	4,010	700	6,030	8,780
1945-46	11,710	500	11,210	11,020	2,210	8,810	190	160	30	2,370	8,840
46-47	14,240	1,230	13,010	11,530	2,310	9,220	1,480	1,240	240	3,550	9,460
47-48	20,190	1,900	18,290	12,320	2,460	9,860	5,970	5,350	620	7,810	10,480
48-49	15,910	2,290	13,620	12,270	2,450	9,820	1,350	1,210	140	3,660	9,960
49-50	16,790	1,320	15,470	11,850	2,370	9,480	3,620	3,180	440	5,550	9,920
1950-51	19,920	1,520	18,400	13,270	2,650	10,620	5,130	4,630	500	7,280	11,120
51-52	13,240	2,530	10,710	10,710	2,140	8,570	0	0	0	2,140	8,570
52-53	20,370	2,090	18,280	13,580	2,720	10,860	4,700	4,160	540	6,880	11,400
53-54	21,080	2,620	18,460	13,340	2,670	10,670	5,120	4,330	790	7,000	11,460
54-55	20,960	2,240	18,720	13,190	2,640	10,550	5,530	4,920	610	7,560	11,160
1955-56	18,930	3,660	15,270	13,010	2,600	10,410	2,260	1,930	330	4,530	10,740
56-57	18,750	3,270	15,480	13,940	2,790	11,150	1,540	1,340	200	4,130	11,350
57-58	17,090	1,650	15,440	13,030	2,610	10,420	2,410	2,050	360	4,660	10,780
29-Year Average 1929-57	11,280	1,060	10,220	8,400	1,680	6,720	1,830	1,570	260	3,250	6,970

Source and derivation of values by column number:

Column number

1. Table 24, Column 9.
2. Table 26, Column 5.
3. Column 1 minus Column 2.
4. Column 3 with a maximum of six percent of Table 24, Column 8.
5. Twenty percent of Column 4.
6. Column 4 minus Column 5.
7. Column 3 minus Column 4.
8. Consumptive use of other losses equals the total of other losses (Column 7) multiplied by the ratio of consumptive use of delivered water (Table 35) to the sum of consumptive use and deep percolation of delivered water (Table 35).
9. Column 7 minus Column 8.
10. Column 5 plus Column 8.
11. Column 6 plus Column 9.

Note: Negative values were retained for mathematical purposes.

TABLE 37

TOTAL CONSUMPTIVE USE ON VALLEY FILL AREA
BY INTEGRATION METHOD

In Acre-Feet

Year	Consumptive use		
	On land use classes (1)	Of water system losses (2)	Total (3)=(1)+(2)
1928-29	219,370	160	219,530
29-30	218,740	390	219,130
1930-31	233,890	2,520	236,410
31-32	231,570	7,040	238,610
32-33	184,630	990	185,620
33-34	198,800	- 140	198,660
34-35	255,430	- 290	255,140
1935-36	210,750	1,020	211,770
36-37	249,640	260	249,900
37-38	230,560	1,900	232,460
38-39	249,910	590	250,500
39-40	218,930	1,630	220,560
1940-41	257,330	1,170	258,500
41-42	226,080	3,680	229,760
42-43	247,690	2,300	249,990
43-44	247,290	2,550	249,840
44-45	233,210	6,030	239,240
1945-46	225,970	2,370	228,340
46-47	237,360	3,550	240,910
47-48	203,990	7,810	211,800
48-49	211,930	3,660	215,590
49-50	216,030	5,550	221,580
1950-51	216,700	7,280	223,980
51-52	262,910	2,140	265,050
52-53	229,240	6,880	236,120
53-54	216,670	7,000	223,670
54-55	231,800	7,560	239,360
1955-56	222,030	4,530	225,560
56-57	217,170	4,130	221,300
57-58	254,810	4,660	259,470
29-Year Average 1929-57	227,780	3,250	231,030

Source of values by column number:

Column No.

1. Table 35, Column 18.
2. Table 36, Column 10.

Comparison of Consumptive Use Values Determined by the Inflow-Outflow and Integration Methods

The annual and cumulative amounts of consumptive use as determined by the Inflow-Outflow Method (Table 34, page 169) and by the Integration Method (Table 37, page 184) are shown in Table 38. The average annual consumptive uses for the 29-year base period are 227,200 acre-feet (inflow-outflow) and 231,000 acre-feet (integration). The difference of 3,800 acre-feet between the two average values is approximately one and one-half percent of the average consumptive use and well within the accuracy of the data. The annual differences between the two consumptive use values are shown in column 5, Table 38. The annual consumptive use as determined by each method and the annual and cumulative differences are plotted on Figure 4.

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TABLE 38

COMPARISON OF CONSUMPTIVE USE AMOUNTS DETERMINED BY INFLOW-OUTFLOW AND INTEGRATION METHODS

In 1,000 Acre-Feet

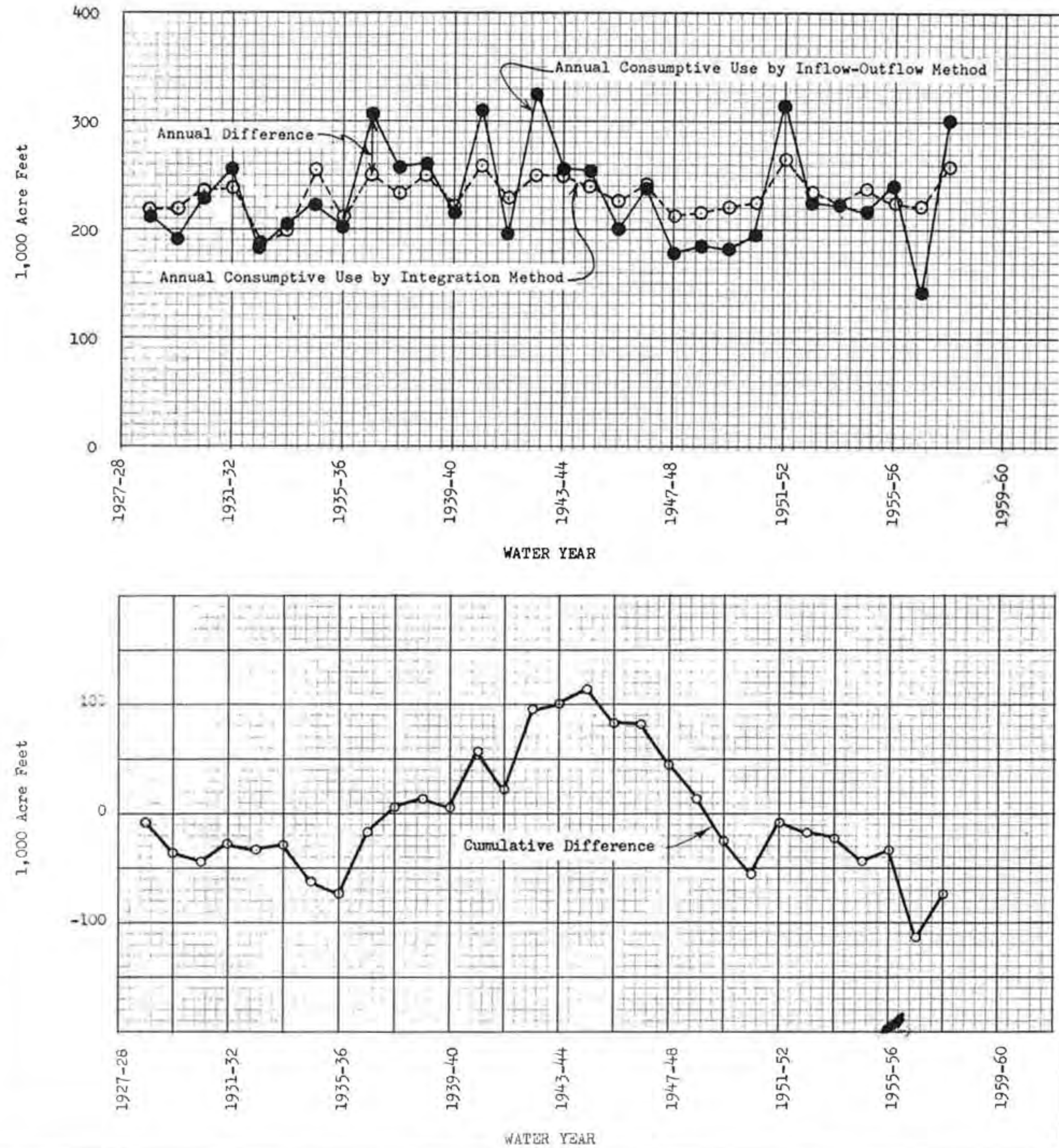
Year	Consumptive use				Difference	
	Inflow-outflow method		Integration method			
	Annual (1)	Cumulative (2)	Annual (3)	Cumulative (4)	Annual (1)-(3)=(5)	Cumulative (6)
1928-29	210.6	210.6	219.5	219.5	- 8.9	- 8.9
29-30	191.2	401.8	219.1	438.6	- 27.9	- 36.8
1930-31	228.3	630.1	236.4	675.0	- 8.1	- 44.9
31-32	254.1	884.2	238.6	913.6	15.5	- 29.4
32-33	181.9	1,066.1	185.6	1,092.2	- 3.7	- 33.1
33-34	202.2	1,268.3	198.7	1,297.9	3.5	- 29.6
34-35	223.3	1,491.6	255.1	1,553.0	- 31.8	- 61.4
1935-36	200.6	1,692.2	211.8	1,764.8	- 11.2	- 72.6
36-37	304.8	1,997.0	249.9	2,014.7	54.9	- 17.7
37-38	255.2	2,252.2	232.5	2,247.2	22.7	5.0
38-39	258.7	2,510.9	250.5	2,497.7	8.2	13.2
39-40	213.9	2,724.8	220.6	2,718.3	- 6.7	6.5
1940-41	309.0	3,033.8	258.5	2,976.8	50.5	57.0
41-42	194.7	3,228.5	229.8	3,206.6	- 35.1	21.9
42-43	323.9	3,552.4	250.0	3,456.6	73.9	95.8
43-44	254.0	3,806.4	249.8	3,706.4	4.2	100.0
44-45	252.1	4,058.5	239.2	3,945.6	12.9	112.9
1945-46	199.0	4,257.5	228.3	4,173,9	- 29.3	83.6
46-47	237.4	4,494.9	240.9	4,414.8	- 3.5	80.1
47-48	177.6	4,672.5	211.8	4,626.6	- 34.2	45.9
48-49	183.3	4,855.8	215.6	4,842.2	- 32.3	13.6
49-50	181.6	5,037.4	221.6	5,063.8	- 40.0	- 24.6
1950-51	195.9	5,233.3	224.0	5,287.8	- 28.1	- 54.5
51-52	312.1	5,545.4	265.0	5,552.8	47.1	- 7.4
52-53	224.6	5,770.0	236.1	5,788.9	- 11.5	- 18.9
53-54	221.2	5,991.2	223.7	6,012.6	- 2.5	- 21.4
54-55	216.2	6,207.4	239.4	6,252.0	- 23.2	- 44.6
1955-56	238.9	6,446.3	226.6	6,478.6	12.3	- 32.3
56-57	141.4	6,587.7	221.3	6,699.9	- 79.9	-112.2
57-58	299.4	6,887.1	259.5	6,959.4	39.9	- 72.3
29-Year Average 1929-57	227.2		231.0			

Source of values by column number:

Column No.

1. Table 34, Column 13.
3. Table 37, Column 3.

Note: Negative values indicate that values determined by integration method are in excess of values determined by the inflow-outflow method.



COMPARISON OF ANNUAL AMOUNTS OF CONSUMPTIVE USE ON THE VALLEY FILL AREA

DETERMINED BY INTEGRATION AND INFLOW-OUTFLOW METHODS

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Adjustment of Consumptive Use

The consumptive use shown in Table 34 and summarized in Table 38 is based on items of inflow, outflow and change in storage. The items of inflow and outflow are based directly or indirectly on measured items. Variations that could exist in the calculation of these items are small in comparison to the amount of the difference. The change in storage of surface reservoirs is measured indirectly and is small. Adjustment of the computed change in ground water storage would require an adjustment of water levels and/or specific yield values. Water levels are influenced, as discussed in Chapter V, by the change in pumping rate from year to year during the period water levels are being measured and by taking measurements at different times from year to year. Both of these possible variations in ground water measurements produce some differences in ground water calculations.

It appears from the above discussion that the difference between the two computations of consumptive use is more likely to be caused by inaccuracies in the integration method. The inflow-outflow method is used as a guide to make refinements in the integration method.

The trends of cumulative differences (Figure 4) are similar to the annual fluctuations of water levels (Plate 34A-C) and the mass diagram of precipitation (Plate 10). It is concluded that the item or items to be adjusted are related to precipitation. The consumptive use (plus the residual value, deep percolation) in the basin is large compared to any of the other disposal items (see Table 34) and is known to be responsive to wet and dry periods. The depths of consumptive use and deep percolation of precipitation, developed in Appendix L, were determined mainly by the use of average monthly winter transpiration rates and constant summer irrigation efficiencies. The use of average monthly transpiration rates rather than daily rates is necessary due to a lack of water supply data on a daily basis. This tends to cause the computed consumptive use to be high during dry periods and low during wet periods.

The relationship between precipitation on the valley fill and the difference between the consumptive use as determined by the two methods was ascertained as follows:

1. The amount that the annual precipitation on the entire valley fill area exceeded or was less than the annual average during the 29-year base period was computed in acre-feet for each year of that period.

2. The same computation was also made for precipitation occurring on the pervious portion of the valley fill area.

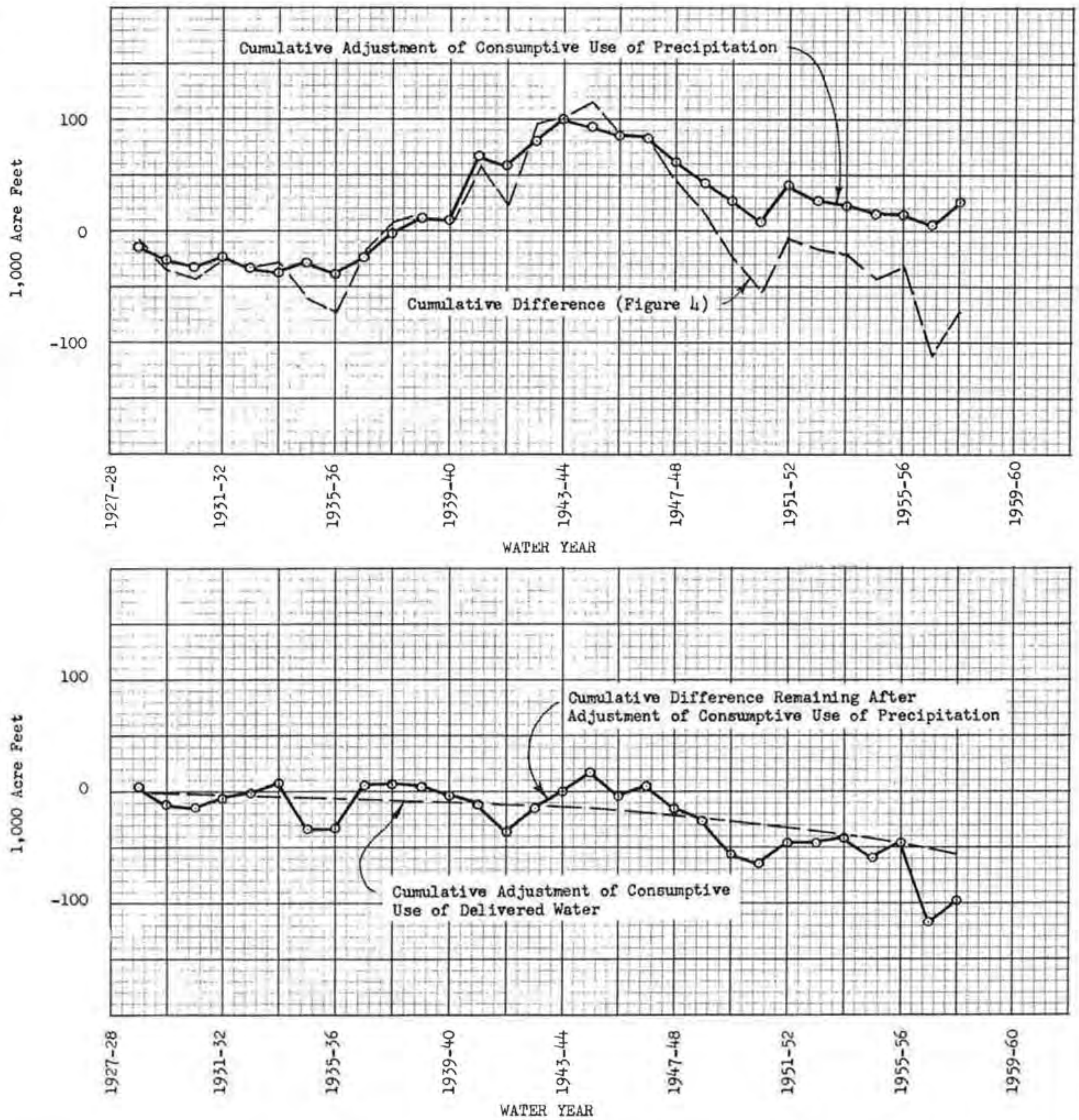
3. The cumulative amounts thus determined by each of these computations were compared with the cumulative difference in consumptive use determined by the Integration and Inflow-Outflow Methods.

From the foregoing it was found that trends in the differences in amount of consumptive use most closely approximated those indicated by abnormality of precipitation on the pervious portion of the valley fill found in Item 2 above. A value of 30 percent was selected as the parameter giving the closest match. The annual adjustment to the consumptive use of rain

(Table 39) may therefore be expressed as 30 percent of the difference between annual precipitation on the pervious valley fill area in acre-feet and the 29-year average precipitation thereon.

The effect of the consumptive use of rain adjustment is shown by cumulative curves on Figure 5. The magnitude of the remaining difference shown on Figure 5 is within the accuracy expected for a hydrologic study. There is, however, a slight trend indicating that the total adjusted consumptive use as determined by the Integration Method, still exceeds that of the Inflow-Outflow Method.

Since the adjustments to the consumptive use of rain did not fully correct the difference, it is assumed that adjustments in the consumptive use of delivered water may also be necessary. The consumptive use of irrigated crops was based on irrigation efficiency during the summer growing season and average transpiration rates during the winter season. Residential lawn grass on the other hand was based on experimental values developed in the Raymond Basin Reference. The lawn grass values were obtained under conditions of optimum moisture being available and would produce maximum consumptive use values. Therefore, it is assumed that the computed values for consumptive use of residential lawn grass are too high. The cumulative difference remaining, after the adjustment of the



CUMULATIVE ADJUSTMENTS TO THE CONSUMPTIVE USE OF PRECIPITATION
AND THE CONSUMPTIVE USE OF DELIVERED WATER

TABLE 39

ADJUSTMENT OF INTEGRATED CONSUMPTIVE USE

In 1,000 Acre-Feet

Year	Total difference		Consumptive use of rain adjustment		Difference		Consumptive use of delivered water adjustment		Total consumptive use adjustment		Remaining difference	
	Annual (1)	Cumulative (2)	Annual (3)	Cumulative (4)	Annual (5)	Cumulative (6)	Annual (7)	Cumulative (8)	Annual (9)	Cumulative (10)	Annual (11)	Cumulative (12)
1928-29	- 8.9	- 8.9	-13.5	-13.5	4.6	4.6	-0.8	- 0.8	-14.3	-14.3	5.4	5.4
29-30	-27.9	- 36.8	-12.5	-26.0	-15.4	- 10.8	-0.9	- 1.7	-13.4	-27.7	-14.5	- 9.1
1930-31	- 8.1	- 44.9	- 4.6	-30.6	- 3.5	- 14.3	-0.9	- 2.6	- 5.5	-33.2	- 2.6	-11.7
31-32	15.5	- 29.4	9.0	-21.6	6.5	- 7.8	-0.6	- 3.2	8.4	-24.8	7.1	- 4.6
32-33	- 3.7	- 33.1	-10.3	-31.9	6.6	- 1.2	-0.7	- 3.8	-10.9	-35.7	7.2	2.6
33-34	3.5	- 29.6	- 5.9	-37.8	9.4	8.2	-0.7	- 4.5	- 6.6	-42.3	10.1	12.7
34-35	-31.8	- 61.4	8.7	-29.1	-40.5	- 32.3	-0.5	- 5.0	8.2	-34.1	-40.0	-27.3
1935-36	-11.2	- 72.6	-10.7	-39.8	- 0.5	- 32.8	-0.6	- 5.6	-11.3	-45.4	0.1	-27.2
36-37	54.9	- 17.7	17.5	-22.3	37.4	4.6	-0.6	- 6.2	16.9	-28.5	38.0	10.8
37-38	22.7	5.0	21.2	- 1.1	1.5	6.1	-0.7	- 6.9	20.5	- 8.0	2.2	13.0
38-39	8.2	13.2	11.5	10.4	- 3.3	2.8	-0.9	- 7.8	10.6	2.6	- 2.4	10.6
39-40	- 6.7	6.5	- 0.3	10.1	- 6.4	- 3.6	-0.9	- 8.7	- 1.2	1.4	- 5.5	5.1
1940-41	50.5	57.0	58.2	68.3	- 7.7	- 11.3	-0.8	- 9.5	57.4	58.8	- 6.9	- 1.8
41-42	-35.1	21.9	- 8.6	59.7	-26.5	- 37.8	-1.0	-10.5	- 9.6	49.2	-25.5	-27.3
42-43	73.9	95.8	20.8	80.5	53.1	15.3	-1.3	-11.8	19.5	68.7	54.4	27.1
43-44	4.2	100.0	19.5	100.0	-15.3	0.0	-1.4	13.2	18.1	86.8	-13.9	13.2
44-45	12.9	112.9	- 5.9	94.1	18.8	18.8	-1.5	-14.7	- 7.4	79.4	20.3	33.5
1945-46	-29.3	83.6	- 7.4	86.7	-21.9	- 3.1	-2.0	-16.7	- 9.4	70.0	-19.9	13.6
46-47	- 3.5	80.1	- 3.9	82.8	0.4	2.7	-2.2	-18.9	- 6.1	63.9	2.6	16.2
47-48	-34.2	45.9	-21.3	61.5	-12.9	- 15.6	-2.5	-21.4	-23.8	40.1	-10.4	5.8
48-49	-32.3	13.6	-19.7	41.8	-12.6	- 28.2	-2.7	-24.1	-22.4	17.7	- 9.9	- 4.1
49-50	-40.0	- 24.6	-14.0	27.8	-26.0	- 54.2	-2.7	-26.8	-16.7	1.0	-23.3	-27.4
1950-51	-28.1	- 54.5	-18.2	9.6	- 9.9	- 64.1	-3.0	-29.8	-21.2	-20.2	- 6.9	-34.3
51-52	47.1	- 7.4	30.8	40.4	16.3	- 47.8	-2.9	-32.7	27.9	7.7	19.2	-15.1
52-53	-11.5	- 18.9	-11.7	28.7	0.2	- 47.6	-3.5	-36.2	-15.2	- 7.5	3.7	-11.4
53-54	- 2.5	- 21.4	- 7.4	21.3	4.9	- 42.7	-3.6	-39.8	-11.0	-18.5	8.5	- 2.9
54-55	-23.2	- 44.6	- 6.4	14.9	-16.8	- 59.5	-3.4	-43.2	- 9.8	-28.3	-13.4	-16.3
1955-56	12.3	- 32.3	- 0.4	14.5	12.7	- 46.8	-3.6	-46.8	- 4.0	-32.3	16.3	0.0
56-57	-79.9	-112.2	- 7.8	6.7	-72.1	-118.9	-4.8	-51.6	-12.6	-44.9	-67.3	-67.3
57-58	39.9	- 72.3	20.8	27.5	19.1	- 99.8	-3.7	-55.3	17.1	-27.8	22.8	-44.5

Source and derivation of values by column number:

Column No.

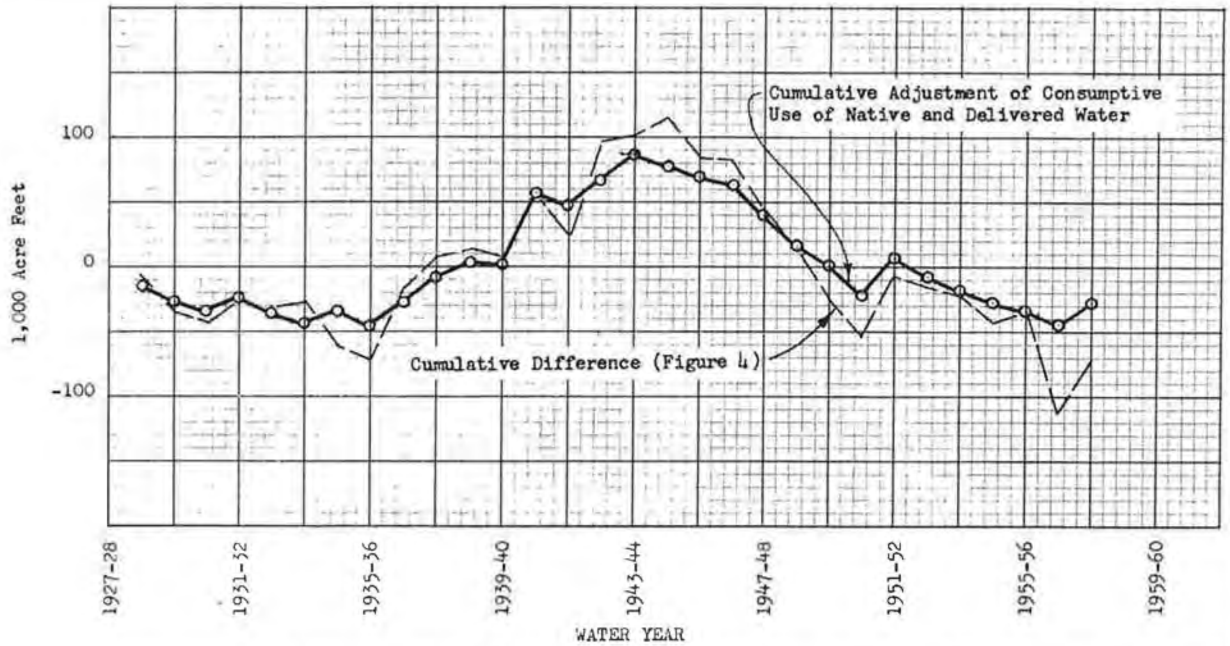
1. Table 38, Column 5.
3. 30 percent of annual precipitation above and below 29-year average falling on pervious areas.
5. Column 1 minus Column 3.
7. Five percent of the sum of Columns 6 and 8 in Table 35.
9. Column 3 plus Column 7.
11. Column 1 minus Column 9.

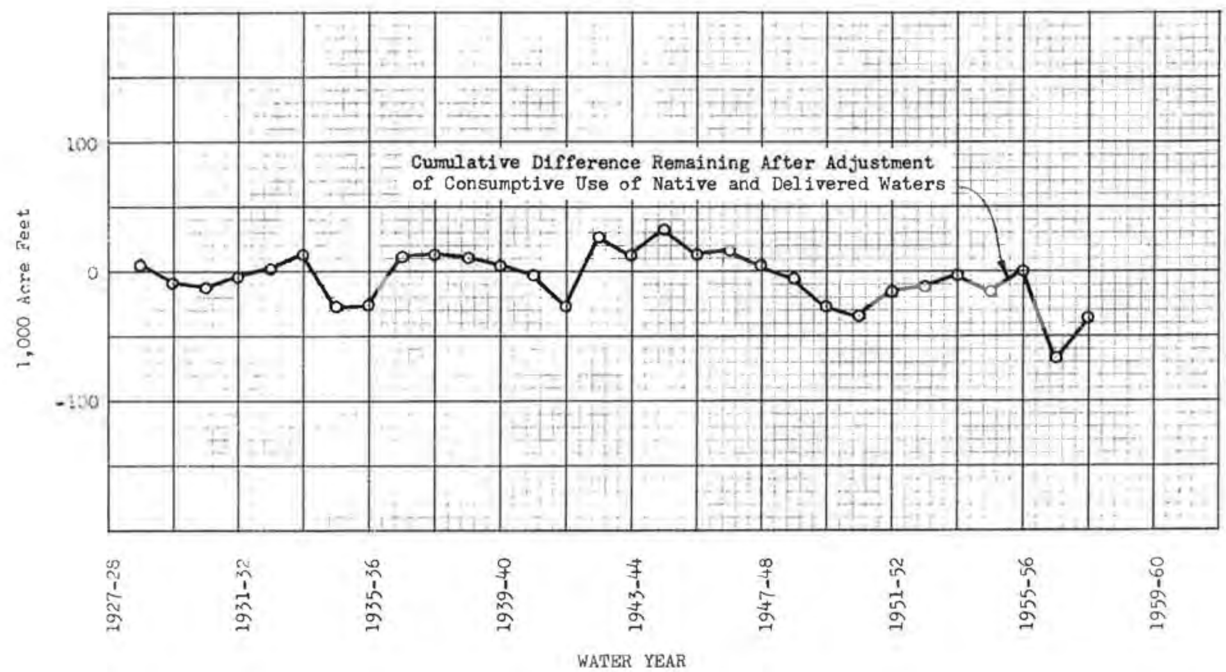
consumptive use of precipitation has been made (Figure 5), is an increasing function. The acreage put to residential use is also an increasing function while lands used for irrigated and nonirrigated crops have been decreasing. Both the method of determining consumptive use of residential lawn grass and the land use trends indicate that the adjustment of the consumptive use of delivered water is related to residential delivered water. An adjustment equal to five percent of residential delivered water applied to land areas (excluding sewage) was found to be the best match to the remaining difference and was adopted as the adjustment to the consumptive use of delivered water.

The annual and cumulative adjustments of the consumptive use of precipitation and delivered water and the sum of both are shown in Table 39. These adjustments are applied to the consumptive use as determined by the integration method. The effects of the adjustments are to increase the consumptive use of precipitation during wet years and to decrease it during dry years, and to decrease the consumptive use of delivered water for all years. The adjustments are transfers of water between the amounts of consumptive use and deep percolation computed by the integration method; therefore, the sum of consumptive use and deep percolation is unchanged.

The total cumulative adjustments to the integrated consumptive use and the cumulative difference remaining between the adjusted integrated consumptive use and Inflow-Outflow Method consumptive use are shown on Figure 6.

The cumulative difference curve which represents the chronological accumulation of all differences between the two values of consumptive use after adjustment shows that the adjustment formula are applicable throughout the range of precipitation influences and other effects concerning delivered water occurring throughout the base period.





CUMULATIVE ADJUSTMENT TO CONSUMPTIVE USE AND REMAINING DIFFERENCE

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Adjusted Consumptive Use of Precipitation and Delivered Water on the Valley Fill Area

The annual amounts of consumptive use of precipitation and of delivered water adopted by the Referee are shown in Table 40 and are equal to the amounts obtained by the Integration Method (Table 37, page 184) modified by the annual adjustments (Table 39, page 192). For the purposes of hydrologic inventories, the unit values of consumptive use of precipitation shown in Tables L-13, L-14 and L-15 must be used along with the adjustment to the consumptive use of precipitation (see page 190). The unit values of consumptive use of delivered water contained in Tables L-13 through L-15, with the exception of those for residential areas, may be used without adjustment. The unit values for consumptive use on residential land use areas must be decreased by five percent of the difference between residential delivered water and residential sewage (or five percent of consumptive use plus deep percolation). The above unit values are shown in Appendix R.

The total consumptive use adopted by the Referee is the sum of adjusted consumptive use of precipitation and delivered water, the consumptive use of ground water, and evaporation of runoff into Hansen Dam. The 29-year averages of adjusted consumptive use and their sources are as follows:

	1,000 acre-feet	Source
Adjusted consumptive use of precipitation	122.4	Page 197
Adjusted consumptive use of delivered water	102.2	Page 197
Consumptive use of ground water	4.6	Page L-70
Consumptive use of runoff (Hansen Dam)	0.3	Page L-71a
Total	229.5	

TABLE 40

ADJUSTED CONSUMPTIVE USE OF DELIVERED WATER AND PRECIPITATION
ON VALLEY FILL AREA

In 1,000 Acre-Feet

Year	Consumptive use of delivered water				Consumptive use of precipitation			Adjusted consumptive use of precipitation and delivered water
	On land use areas by integration	Water system loss	Consumptive use adjustment	Adjusted consumptive use of delivered water	By integration	Consumptive use adjustment	Adjusted consumptive use of precipitation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1928-29	98.6	0.2	-0.8	98.0	114.9	-13.5	101.4	199.4
29-30	101.0	0.4	-0.9	100.5	112.6	-12.5	100.1	200.6
1930-31	96.0	2.5	-0.9	97.6	133.5	- 4.6	128.9	226.5
31-32	71.5	7.0	-0.6	77.9	154.5	9.0	163.5	241.4
32-33	77.0	1.0	-0.6	77.4	103.0	-10.3	92.7	170.1
33-34	82.8	-0.1	-0.7	82.0	111.5	- 5.9	105.6	187.6
34-35	74.8	-0.3	-0.5	74.0	175.0	8.7	183.7	257.7
1935-36	95.0	1.0	-0.6	95.4	109.2	-10.7	98.5	193.9
36-37	81.4	0.3	-0.6	81.1	163.1	17.5	180.6	261.7
37-38	74.2	1.9	-0.7	75.4	150.2	21.2	171.4	246.8
38-39	83.8	0.6	-0.9	83.5	161.6	11.5	173.1	256.6
39-40	78.7	1.6	-0.9	79.4	136.4	- 0.3	136.1	215.5
1940-41	64.2	1.2	-0.8	64.6	187.6	58.2	245.8	310.4
41-42	96.8	3.7	-1.0	99.5	119.6	- 8.6	111.0	210.5
42-43	95.1	2.3	-1.3	96.1	140.8	20.8	161.6	257.7
43-44	93.1	2.5	-1.4	94.2	141.2	19.5	160.7	254.9
44-45	108.7	6.0	-1.5	113.2	120.4	- 5.9	114.5	227.7
1945-46	113.5	2.4	-2.0	113.9	108.3	- 7.4	100.9	214.8
46-47	116.5	3.6	-2.2	117.9	117.7	- 3.9	113.8	231.7
47-48	133.0	7.8	-2.5	138.3	67.6	-21.3	46.3	184.6
48-49	133.5	3.7	-2.7	134.5	75.2	-19.7	55.5	190.0
49-50	122.3	5.5	-2.7	125.1	90.4	-14.0	76.4	201.5
1950-51	135.0	7.3	-3.0	139.3	78.3	-18.2	60.1	199.4
51-52	102.7	2.1	-2.9	101.9	157.0	30.8	187.8	289.7
52-53	130.2	6.9	-3.5	133.6	95.3	-11.7	83.6	217.2
53-54	117.0	7.0	-3.6	120.4	97.1	- 7.4	89.7	210.1
54-55	113.5	7.6	-3.4	117.7	115.8	- 6.4	109.4	227.1
1955-56	106.8	4.5	-3.6	107.7	113.2	- 0.4	112.8	220.5
56-57	123.1	4.1	-4.8	122.4	92.2	- 7.8	84.4	206.8
57-58	105.1	4.7	-3.7	106.1	148.0	20.8	168.8	274.9
29-Year Average 1929-57	100.7	3.3	-1.8	102.2	122.2	0.2	122.4	224.6

Source and derivation of values by column number:

Column No.

1. Table 35, Column 16.
2. Table 36, Column 10.
3. Table 39, Column 7.
4. Sum of Columns 1, 2 and 3.
5. Table 35, Column 15.
6. Table 39, Column 3.
7. Sum of Columns 5 and 6.
8. Sum of Columns 4 and 7.

Historic Ground Water Recharge

The items comprising recharge to and draft on the ground water reservoir are shown on Figure 7. Recharge of delivered water is shown in Table 41 and is computed as surface supply to the valley fill area less consumptive use, exports and outflows of that supply. Recharge from native water is shown in Table 42 and is computed in three parts: that occurring on land use classes; that occurring in channels of the stream system; and that resulting from the spreading of native water. The first portion equals the precipitation on land use class areas on the valley fill area less consumptive use and residual rain (i.e., precipitation not retained on land use class areas). The second is the recharge from native water in transit across the valley fill to the point of surface escape and is equal to the amounts of native water tributary to the stream channel system less diversions for spreading and use and storm outflows at Gage F-57. Recharge of delivered water in the stream channels has been included in the total recharge of delivered water.

Ground Water Draft

The draft on the ground water reservoir, shown in Table 43, is composed of well extractions, for use on the valley fill area and for export, and natural depletions.

Ground Water Inventory

The basic equation for ground water inventory (Figure 7) is ground water supply minus ground water draft equals change in ground water storage. Since the difference between consumptive use determined by the inflow-outflow and integration methods was not completely removed by the adjustments made to the integrated consumptive use, the remaining imbalance (Table 39, column 10) must be added to the basic equation. The ground water inventory for the period 1928-29 through 1957-58 lists annual amounts of supply, disposal, change in storage and the remaining difference and is shown in Table 43.

The effects of urbanization on the average recharge of delivered water to the ground water reservoir are shown below by comparing the averages for two periods of average precipitation on the valley fill area; i.e., the 9-year period (1949-50 through 1957-58) and the 29-year base period.

In 1,000 Acre-feet

Item	9-year average (1)	29-year average (2)	Difference (3)=(1)-(2)
Gross delivered water[a]	222.0	175.8	46.2
Gross recharge of delivered water[a]	57.9	49.4	8.5
Gross recharge as a percent of delivered water	26.1%	28.1%	2.0%
Cesspool recharge[b]	16.8	9.3	7.5
Gross recharge of delivered water less cesspool recharge	41.1	40.1	1.0
Gross recharge of delivered water less cesspool rechargevas a percent of delivered water	18.5%	22.8%	4.3%

a. From Table 41.
b. From Table 26

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GROUND WATER RECHARGE =

- Deep percolation of delivered water. = Gross delivered water. − { Consumptive use of delivered water on land use class areas + Consumptive use of water system losses + Net sewage export + Industrial waste and sewage passing Gage F-57 + Operational spills passing Gage F-57. }

plus

- Deep percolation of precipitation on land use class areas. = Precipitation on valley fill areas. − { Consumptive use of precipitation on land use class areas + Residual rain. }

plus

- Deep percolation of native water in the stream system. = { Hill and mountain runoff + Residual rain on the valley fill areas. } − { Native water spread + Surface diversions on valley fill areas + Runoff to reservoirs + Net storm runoff passing Gage F-57 + Evaporation of runoff in Hansen Dam. }

plus

- Native water spread.

GROUND WATER DRAFT = { Well extractions (including export) + Subsurface outflow + Consumptive use of ground water + Sewer infiltration + Rising water passing Gage F-57. }

GROUND WATER RECHARGE − GROUND WATER DRAFT = CHANGE IN GROUND WATER STORAGE

HYDROLOGIC EQUATIONS FOR THE UPPER LOS ANGELES RIVER AREA GROUND WATER RESERVOIR SHOWING ITEMS OF RECHARGE AND DRAFT WITH REFERENCE TO THE GROUND WATER TABLE

FIGURE 7

TABLE 41

GROSS HISTORIC RECHARGE OF DELIVERED WATER TO THE GROUND WATER RESERVOIR

In 1,000 Acre-Feet

Year	Gross delivered water (1)	Precipitation on reservoirs (2)	Adjusted consumptive use of delivered water (3)	Net sewage export (4)	Outflows passing Gage F-57: Industrial waste and sewage (5)	Outflows passing Gage F-57: Owens (6)	Gross recharge of delivered water (7)
1928-29	139.0	0.9	98.0	5.1	0	0.7	34.3
29-30	146.0	0.9	100.5	6.1	0	0.3	38.2
1930-31	151.5	1.1	97.6	7.2	0	0.3	45.3
31-32	156.1	1.4	77.9	8.1	0	1.6	67.1
32-33	149.7	0.8	77.4	8.6	0	0	62.9
33-34	138.6	1.0	82.0	9.1	0	1.8	44.7
34-35	135.6	1.4	74.0	9.2	0	0.4	50.6
1935-36	159.0	1.0	95.4	9.9	0	0.6	52.1
36-37	133.5	1.7	81.1	10.4	0	1.8	38.5
37-38	131.0	1.7	75.4	11.1	0	1.7	41.1
38-39	145.9	1.4	83.5	12.1	0	2.9	46.0
39-40	127.9	1.2	79.4	13.1	0	0.8	33.4
1940-41	119.5	2.7	64.6	14.2	0.2	0	37.8
41-42	165.0	0.9	99.5	15.0	0.4	5.2	44.0
42-43	180.7	1.7	96.1	15.5	0.6	8.7	58.1
43-44	164.9	1.7	94.2	16.1	0.8	2.9	49.2
44-45	172.8	1.0	113.2	17.2	1.0	1.2	39.2
1945-46	188.2	1.0	113.9	18.7	1.3	4.1	49.2
46-47	197.0	1.1	117.9	20.4	1.5	6.0	50.1
47-48	210.4	0.5	138.3	23.3	1.7	0	46.6
48-49	209.2	0.6	134.5	26.5	1.9	0.7	45.0
49-50	202.2	0.9	125.1	28.9	2.1	0	45.2
1950-51	225.7	0.7	139.3	32.3	1.9	1.1	50.4
51-52	207.7	2.2	101.9	35.3	1.8	1.4	65.1
52-53	231.1	0.9	133.6	37.8	1.4	1.7	55.7
53-54	226.6	1.0	120.4	42.0	1.0	0.3	61.9
54-55	224.4	1.0	117.7	39.6	1.6	0	64.5
1955-56	220.9	1.3	107.7	44.0	2.4	0	65.5
56-57	237.0	0.9	122.4	51.2	0.8	0	61.7
57-58	222.0	2.2	106.1	55.1	1.3	0	57.3
29-Year Average 1929-57	175.8	1.2	102.2	20.3	0.8	1.6	49.8

Source and derivation of values by column number:

Column No.

1. Table 20, Column 17.
2. Table M-1, Column 6, Appendix M.
3. Table 40, Column 4.
4. Table 26, Column 4.
5. Table 28, Sum of Columns 2 and 3.
6. Table 28, Column 4.
7. Column 1 minus Columns 2 through 6 herein.

TABLE 42

GROSS HISTORIC RECHARGE OF NATIVE WATER TO THE GROUND WATER RESERVOIR

In 1,000 Acre-Feet

Year	Land use areas				Stream system									
	Precipitation valley fill (1)	Adjusted consumptive use of precipitation (2)	Residual rain (3)	Deep percolation of precipitation on land use areas (4)	Hill and mountain runoff (5)	Residual rain (6)	Native spread (7)	Surface diversion valley fill (8)	Runoff to reservoirs (9)	Evaporation of runoff (10)	Net storm runoff (11)	Deep percolation of native water in stream system (12)	Native spread (13)	Gross recharge (14)
1928-29	122.4	101.4	6.8	14.2	7.0	6.8	0	0.5	0.1	0	3.0	10.2	0	24.4
29-30	125.7	100.1	8.8	16.8	5.7	8.8	0	0.5	0	0	1.3	12.7	0	29.5
1930-31	155.8	128.9	13.2	13.7	4.4	13.2	0	0.5	0	0	3.7	13.4	0	27.1
31-32	207.4	163.5	20.7	23.2	58.9	20.7	0	0.5	2.6	0	13.6	62.9	0	86.1
32-33	133.5	92.7	13.6	27.2	13.6	13.6	0	0.3	0.3	0	10.2	16.4	0	43.6
33-34	150.0	105.6	19.6	24.8	20.3	19.6	0.2	0.4	0.7	0	26.4	12.2	0.2	37.2
34-35	207.1	183.7	23.3	0.1	24.3	23.3	1.2	0.2	0.3	0	11.4	34.5	1.2	35.8
1935-36	131.0	98.5	13.8	18.7	19.2	13.8	2.0	0.1	0.6	0	4.5	25.8	2.0	46.5
36-37	242.2	180.6	30.1	31.5	91.7	30.1	4.7	0.2	3.4	0	21.3	92.2	4.7	128.4
37-38	258.6	171.4	34.1	53.1	177.6	34.1	3.8	0.1	5.1	0	123.2	79.5	3.8	136.4
38-39	219.1	173.1	29.3	16.7	29.0	29.3	0.4	0.2	1.0	0	24.9	31.8	0.4	48.9
39-40	172.0	136.1	21.8	14.1	20.4	21.8	0.9	0.3	0.5	0	24.8	15.7	0.9	30.7
1940-41	409.8	245.8	67.2	96.8	191.4	67.2	9.8	0.3	6.5	0.2	139.0	102.8	9.8	209.4
41-42	137.7	111.0	16.3	10.4	22.1	16.3	0	0.1	0.7	0.5	20.6	16.5	0	26.9
42-43	259.0	161.6	42.2	55.2	166.5	42.2	3.7	0.1	2.3	0.4	89.6	112.6	3.7	171.5
43-44	254.3	160.7	43.0	50.6	124.6	43.0	7.2	0.2	1.7	0.4	79.7	78.4	7.2	136.2
44-45	148.5	114.5	21.8	12.2	37.7	21.8	9.1	0.2	0.5	0.5	18.1	31.1	9.1	52.4
1945-46	141.3	100.9	22.8	17.6	25.1	22.8	2.8	0.1	0.2	0.5	20.0	24.3	2.8	44.7
46-47	156.0	113.8	25.2	17.0	32.6	25.2	12.5	0.1	0.2	0.5	14.2	30.3	12.5	59.8
47-48	80.1	46.3	12.0	21.8	6.4	12.0	0	0.2	0	0.6	6.0	11.6	0	33.4
48-49	86.6	55.5	10.3	20.8	3.7	10.3	0	0.1	0	0.6	12.6	0.7	0	21.5
49-50	111.2	76.4	16.4	18.4	6.0	16.4	0.3	0	0.1	0.6	8.7	12.7	0.3	31.4
1950-51	89.9	60.1	10.4	19.4	3.5	10.4	0	0	0.1	0.6	4.9	8.3	0	27.7
51-52	315.0	187.8	71.4	55.8	116.8	71.4	23.0	0	1.9	0.4	101.8	61.1	23.0	139.9
52-53	118.9	83.6	18.4	16.9	16.0	18.4	2.9	0	0.2	0.6	15.4	15.3	2.9	35.1
53-54	138.4	89.7	28.3	20.4	17.3	28.3	2.9	0	0.2	0.5	19.8	22.2	2.9	45.5
54-55	142.9	109.4	21.9	11.6	10.0	21.9	0.2	0	0.1	0.5	16.7	14.4	0.2	26.2
1955-56	171.2	112.8	42.1	16.3	14.5	42.1	0.6	0	0.2	0.4	33.5	21.9	0.6	38.8
56-57	134.0	84.4	31.5	18.1	10.0	31.5	0.5	0	0.1	0.5	24.1	16.3	0.5	34.9
57-58	278.6	168.8	74.9	34.9	93.3	74.9	30.4	0	1.4	0.5	89.8	46.1	30.4	111.4
29-Year Average 1929-57	173.1	122.4	25.4	25.3	44.0	25.4	3.0	0.2	1.0	0.3	30.8	34.1	3.0	62.4

Source and derivation of values by column number:

Column No.

1. Table 1.
2. Table 40, Column 7.
3. Column 1 minus Table 35, Column 22.
4. Column 1 minus Columns 2 and 3, herein.
5. Table 3.
6. Same as Column 3 herein.
7. Table 30.
8. Table 16, Column 1.
9. Table F-10, Appendix F.
10. Table L-22A.
11. Table 28, Column 5.
12. Column 5 plus Column 6 minus Columns 7, 8, 9, 10 and 11.
13. Table 30.
14. Sum of Columns 4, 12 and 13, herein.

TABLE 43

HISTORIC HYDROLOGIC INVENTORY OF GROUND WATER RESERVOIR

In 1,000 Acre-Feet

Year	Supply: Gross recharge: Delivered water (1)	Supply: Gross recharge: Native water (2)	Supply: Total supply (3)	Disposal: Extractions (4)	Disposal: Subsurface outflow (5)	Disposal: Consumptive use of ground water (6)	Disposal: Sewer infiltration (7)	Disposal: Rising water passing Gage F-57 (8)	Disposal: Total disposal (9)	Change in ground water storage (10)	Supply minus disposal and change in storage (11)=(3)-(9)-(10)
1928-29	34.3	24.4	58.7	89.7	0.6	5.9	0.3	0	96.5	- 43.0	5.2
29-30	38.2	29.5	67.7	93.2	0.5	5.2	0.2	0	99.1	- 16.9	-14.5
1930-31	45.3	27.1	72.4	96.4	0.5	4.4	0.4	0	101.7	- 26.8	- 2.5
31-32	67.1	86.1	153.2	69.4	0.6	5.6	0.9	0.1	76.6	69.8	6.8
32-33	62.9	43.6	106.5	67.3	0.7	4.6	0.4	0.4	73.4	25.8	7.3
33-34	44.7	37.2	81.9	91.9	0.7	4.5	0.3	1.7	99.1	- 27.1	9.9
34-35	50.6	35.8	86.4	78.8	0.8	5.6	1.7	0.8	87.7	38.6	-39.9
1935-36	52.1	46.5	98.6	88.2	0.8	6.6	1.6	0.7	97.9	0.5	0.2
36-37	38.5	128.4	166.9	83.7	0.8	5.1	1.9	1.4	92.9	36.2	37.8
37-38	41.1	136.4	177.5	82.2	0.7	6.1	2.2	7.7	98.9	76.4	2.2
38-39	46.0	48.9	94.9	84.2	0.9	4.5	3.3	14.5	107.4	- 10.1	- 2.4
39-40	33.4	30.7	64.1	86.3	0.8	3.9	3.3	14.1	108.4	- 38.6	- 5.7
1940-41	37.8	209.4	247.2	87.9	0.8	5.3	6.3	25.8	126.1	128.0	- 6.9
41-42	44.0	26.9	70.9	86.4	0.8	9.2	5.7	28.6	130.7	- 34.2	-25.6
42-43	58.1	171.5	229.6	99.3	0.8	11.4	5.8	25.5	142.8	32.5	54.3
43-44	49.2	136.2	185.4	104.4	0.8	12.6	6.1	26.5	150.4	49.1	-14.1
44-45	39.2	52.4	91.6	122.1	0.8	3.6	5.3	16.5	148.4	- 77.2	20.4
1945-46	49.2	44.7	93.9	133.1	0.8	3.6	4.0	10.5	152.0	- 38.2	-19.9
46-47	50.1	59.8	109.9	137.0	0.8	2.6	5.3	9.7	155.4	- 47.9	2.4
47-48	46.6	33.4	80.0	137.7	0.7	2.7	4.0	7.3	152.4	- 52.1	-20.3
48-49	45.0	21.5	66.5	137.8	0.6	2.6	2.3	2.4	145.7	- 69.3	- 9.9
49-50	45.2	31.4	76.6	140.9	0.6	2.8	1.2	0	145.5	- 45.6	-23.3
1950-51	50.4	27.7	78.1	134.8	0.6	2.8	1.2	0	139.4	- 54.2	- 7.1
51-52	65.1	139.9	205.0	129.9	0.6	2.9	2.1	3.1	138.6	47.4	19.0
52-53	55.7	35.1	90.8	155.0	0.6	3.1	1.0	0	159.7	- 72.5	3.6
53-54	61.9	45.5	107.4	155.1	0.5	2.1	1.8	0	159.5	- 60.5	5.4
54-55	64.5	26.2	90.7	151.1	0.6	1.9	2.0	0	155.6	- 51.5	-13.4
1955-56	65.5	38.8	104.3	154.0	0.6	1.5	3.0	0	159.2	- 71.4	16.5
56-57	61.7	34.9	96 6	162.4	0.5	1.4	3.3	0	167.6	- 3.8	-67.2
57-58	57.3	111.4	168.7	146.5	0.4	1.2	2.3	0	150.4	- 4.3	22.6
29-Year Average 1929-57	49.8	62.4	112.2	111.7	0.7	4.6	2.6	6.8	126.5	-12.0	- 2.4

Source and derivation of values by column number:

Column No.

1. Table 41, Column 7.
2. Table 42, Column 13.
3. Sum of Columns 1 and 2 herein.
4. Table 15, Column 3.
5. Table 31, Column 3.
6. Table L-22
7. Table 26, Column 3.
8. Table 28, Column 1.
9. Sum of Columns 4 through 8.
10. Table 33, Column 5.
11. Amounts should agree with those in column 9, Table 39. Annual amounts differ by a maximum of 300 acre-feet. 29-year averages are identical.

CHAPTER VII. SAFE YIELD

This chapter contains the determination of the safe yield of the ground water reservoir of the Upper Los Angeles River area based on cultural conditions existing during the water years 1949-50, 1954-55 and 1957-58. The effect of the importation of foreign waters on the safe yield is also determined. These determinations are made to satisfy Paragraph I. 2, H. of the Order of Reference:

> "The safe yield, and the effect thereon of the importation of foreign waters, shall be determined for the water year immediately preceding the filing of the report for which data is available, and for the water years ending 1950 and 1955."

The safe yield of the ground water reservoir of the Upper Los Angeles River area is defined as the maximum average annual ground water extractions which can be continually withdrawn for useful purposes under a given set of conditions without causing an undesirable result. Conditions imposed herein for the determination of safe yield are summarized in Table 55, page 246b, and the maximum average annual ground water extractions which could be taken under these conditions without the undesirable occurrence of continued lowering of the ground water levels is determined as the safe yield.

Limitations and Factors Influencing Safe Yield

Analysis has been restricted to the two potential limitations on ground water yield which are believed pertinent within the scope of the reference. These are the amount of the ground water recharge from native and imported water sources under conditions imposed for determination of safe yield, and the ability of the ground water reservoir to regulate this supply under those conditions.

The amount of the safe yield is dependent upon the average amount of water which can be stored in and used from the ground water reservoir over a period of normal water supply under a given set of conditions. Thus, safe yield is related to factors which influence or control ground water recharge and to the amount of storage space available to carry over recharge occurring in years of above average supply to years of deficient supply.

Recharge, in turn, depends on the available surface water supply and the factors influencing the percolation of that supply to the water table. The 29-year base period, 1928-29 through 1956-57, has been adopted as representative of normal native water supply conditions because the magnitude and occurrence of annual water supply from precipitation is representative of the long-time mean. The major land use trend of the base period is from agricultural to urban development and has resulted in an increased proportion of impervious area affecting rain recharge to the ground water reservoir through increased runoff and reduced opportunity for consumptive use. Concurrent improvement of drainage channels has partially removed a major medium of ground water recharge from the native supply. Reduction in recharge from these changes has been offset to some extent by the construction and operation of spreading works during the base period to increase the native water recharge. Urbanization of the valley also has affected the ground water recharge from import supplies, mainly through increased sewage outflows and changes in potential consumptive use. The above conditions have been considered in the determination of safe yield.

The change in ground water storage in the valley fill of the Upper Los Angeles River area from 1943-44 to 1957-58 ground water levels was a reduction of 611,000 acre-feet (see Table 33, page 166). An operational study of the ground water reservoir, using the conditions under which safe yield is determined, indicates that a maximum of about 360,000 acre-feet of storage is required for regulation of supply over the 29-year base period. Under such operation, about 210,000 acre-feet of this maximum amount was found to be required above the 1957-58 levels and about 150,000 acre-feet was found to be required below these levels. The data available since 1957-58 indicate that a total of at least 150,000 acre-feet has been taken from storage below the 1957-58 levels. Therefore, the availability of ground water storage space is not a limitation on safe yield under the conditions adopted.

Conditions for Safe Yield Determination

Safe yield is determined herein by evaluation of the average net ground water recharge which would occur if the culture of the safe yield year and the average historic import and export for the safe yield year had existed each year over a period of normal native supply. The average gross recharge of average historic import is obtained by (1) determining the average delivered water required by the culture and conditions of the safe yield year; (2) calculating the average gross recharge therefrom as a percent of the average delivered water; and (3) applying this percentage to the average historic import. In evaluating the average amounts of each item of supply and disposal, consideration has been given not only to the historic variation of the item but also to the factors causing the variation.

Gross recharge from native sources occurs as percolation from precipitation on land use areas on the valley fill, percolation from runoff in the stream system and percolation of native spread water, and is determined under normal precipitation and runoff conditions with the culture existing during the safe yield year.

In order to determine safe yields on a comparable basis with regard to availability of regulatory storage capacity and items dependent thereon, such as rejected recharge and rising water, the ground water levels existing as of 1957-58 are used as a beginning point for basin operation in the evaluation of safe yield for each of the three years.

The annual depths of water delivered to land use classes (Tables J-8 and J-12) during the 1932-40 period are small when compared to the amounts delivered in the 1949-58 period, which includes the safe yield years. This difference in depths of delivered water is believed related to changing economic conditions and in particular to the economic depression of the early 1930's. To eliminate this economic effect from the safe yield computations, the determination of recharge from delivered water for items responsive to both precipitation and economics is based on the 9-year period from 1949-50 through 1957-58. Items dependent only on precipitation on the valley fill area are evaluated over the 29-year base period. This 9-year period compares favorably with the 29-year base period and has an average precipitation on the valley floor that differs from the normal by less than one percent. The remaining items are based on historic amounts for the safe yield year adjusted by use of trend curves. In all instances the amount derived is the best average for the stated condition; i.e., the culture of the safe yield year existing over a period of normal supply

Conditions Affecting Recharge from Delivered Water on Land Use Class Areas

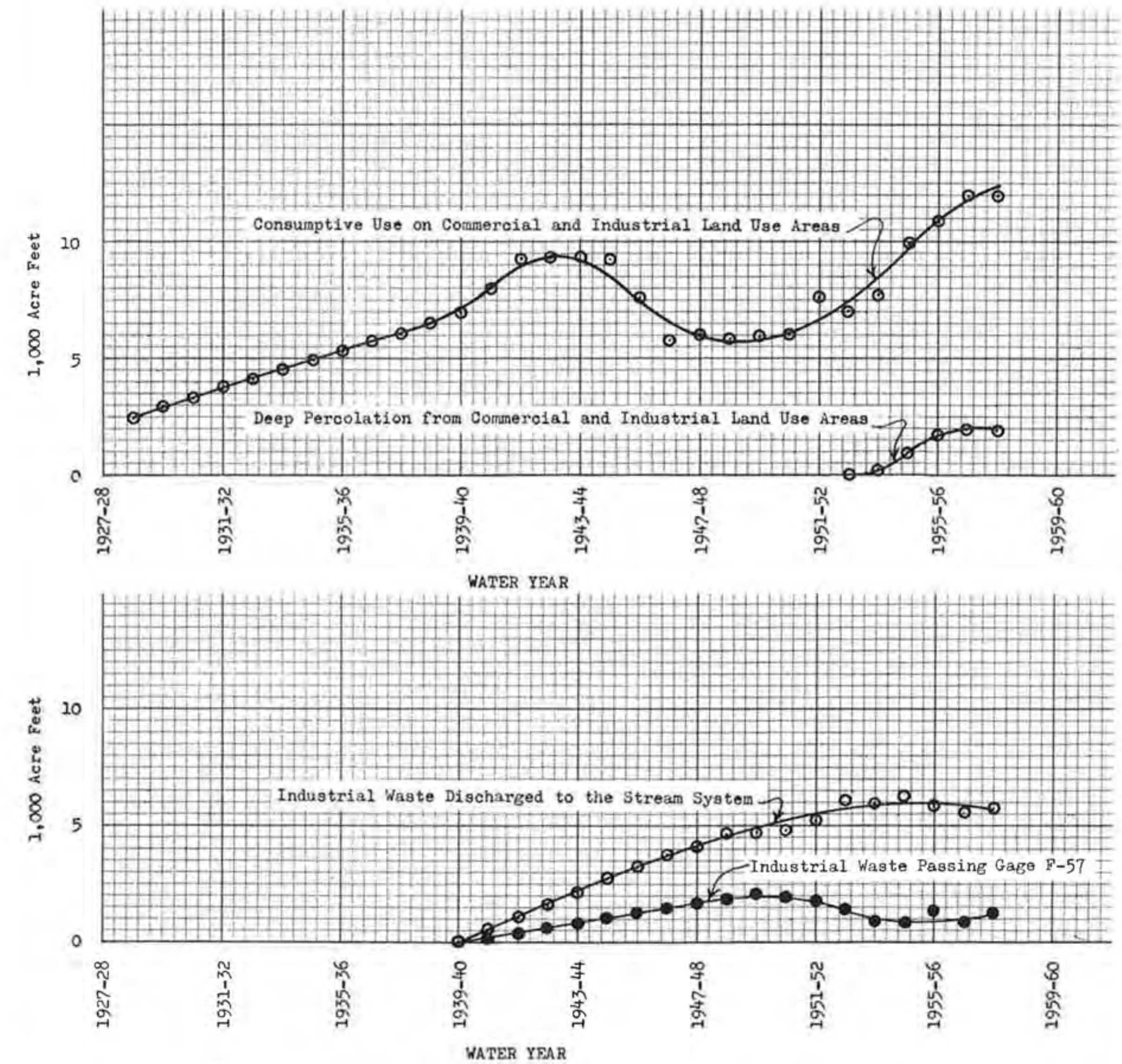
The annual amounts of water consumed and percolating on land use class areas (except commercial and industrial areas) are affected by, but not directly related to, the annual amounts of precipitation. The average amounts are therefore best obtained by averaging the historic amounts over a period of normal precipitation which contains the safe yield years, thus also including the effect of economic conditions. The 9-year period, 1949-50 through 1957-58, meets these requirements and is used to obtain average values of net recharge for all affected land use classes except as noted. The average adjusted depths of consumptive use and deep percolation for residential land use differ from the historic values in that they are adjusted to reflect the percent of the residential area that was pervious during the safe yield year. The average annual amounts of consumptive use and deep percolation for safe yield determination are therefore computed as the product of these adjusted 9-year average depths (see Table R-2) and the acreage of each type of land use existing during the safe yield year.

Commercial and industrial consumptive use is not affected by variations in precipitation. To obtain the average consumptive use and deep percolation on this land use class for the safe yield years, the annual amounts are plotted on Figure 8 and a trend curve drawn. The amounts for the safe yield years are then taken from the trend curve on Figure 8.

Evaporation from water system reservoirs (Table M-1) is dependent on climate and was computed for each year. The 29-year period average is used as representative of normal. The portion of this evaporation assigned to precipitation is taken as the 29-year average rain on the reservoirs (Table M-1). The remainder of the evaporation is taken to be imported water.

A summary of average amounts of consumptive use and deep percolation of delivered water on land use class areas thus determined is shown in Table 44 along with a reference to the source and derivation of the values.

FIGURE 8



TREND CURVES FOR CONSUMPTIVE USE, DEEP PERCOLATION AND WASTE DISCHARGE
OF WATER DELIVERED TO COMMERCIAL AND INDUSTRIAL LAND USE AREAS

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TABLE 44

AVERAGE AMOUNTS OF CONSUMPTIVE USE AND DEEP PERCOLATION OF DELIVERED WATER REQUIRED BY THE LAND USE OF THE VALLEY FILL AREA FOR THE SAFE YIELD YEARS

In Acre-Feet

Land use class	Safe yield year								
	1949-50			1954-55			1957-58		
	Consumptive use (1)	Deep percolation (2)	Total (3)=(1)+(2)	Consumptive use (4)	Deep percolation (5)	Total (6)=(4)+(5)	Consumptive use (7)	Deep percolation (8)	Total (9)=(7)+(8)
1. Deciduous	1,390	220	1,610	1,760	280	2,040	1,320	220	1,540
2. Citrus	17,020	3,980	21,000	12,840	3,010	15,850	7,480	1,750	9,230
3. Walnuts	6,120	1,070	7,190	4,200	730	4,930	1,670	290	1,960
4. Truck	9,430	3,230	12,660	7,450	2,510	9,960	6,470	2,180	8,650
5. Alfalfa	16,190	2,380	18,570	8,090	1,190	9,280	5,070	740	5,810
6. Vineyard	230	40	270	140	30	170	90	10	100
7. Lawn grass	5,040	1,130	6,170	5,280	1,190	6,470	5,960	1,340	7,300
8. Water supply reservoirs	3,560	0	3,560	3,560	0	3,560	3,560	0	3,560
9. Commercial and industrial	5,930	0	5,930	9,940	970	10,910	12,450	2,000	14,450
10. Residential	48,680	10,360	59,040	58,260	12,400	70,660	67,250	13,580	80,830
11. Total	113,590	22,410	136,000	111,520	22,510	133,830	111,320	22,110	133,430

Source and derivation of values by item number.

Item number

1 through 7 and 10. Average amounts of consumptive use and deep percolation of delivered water for these land use areas are the products of the 9-year average (1949-50 through 1957-58) mean weighted depths (Table R-2) and the acreage of each type of land use (Table K-6).

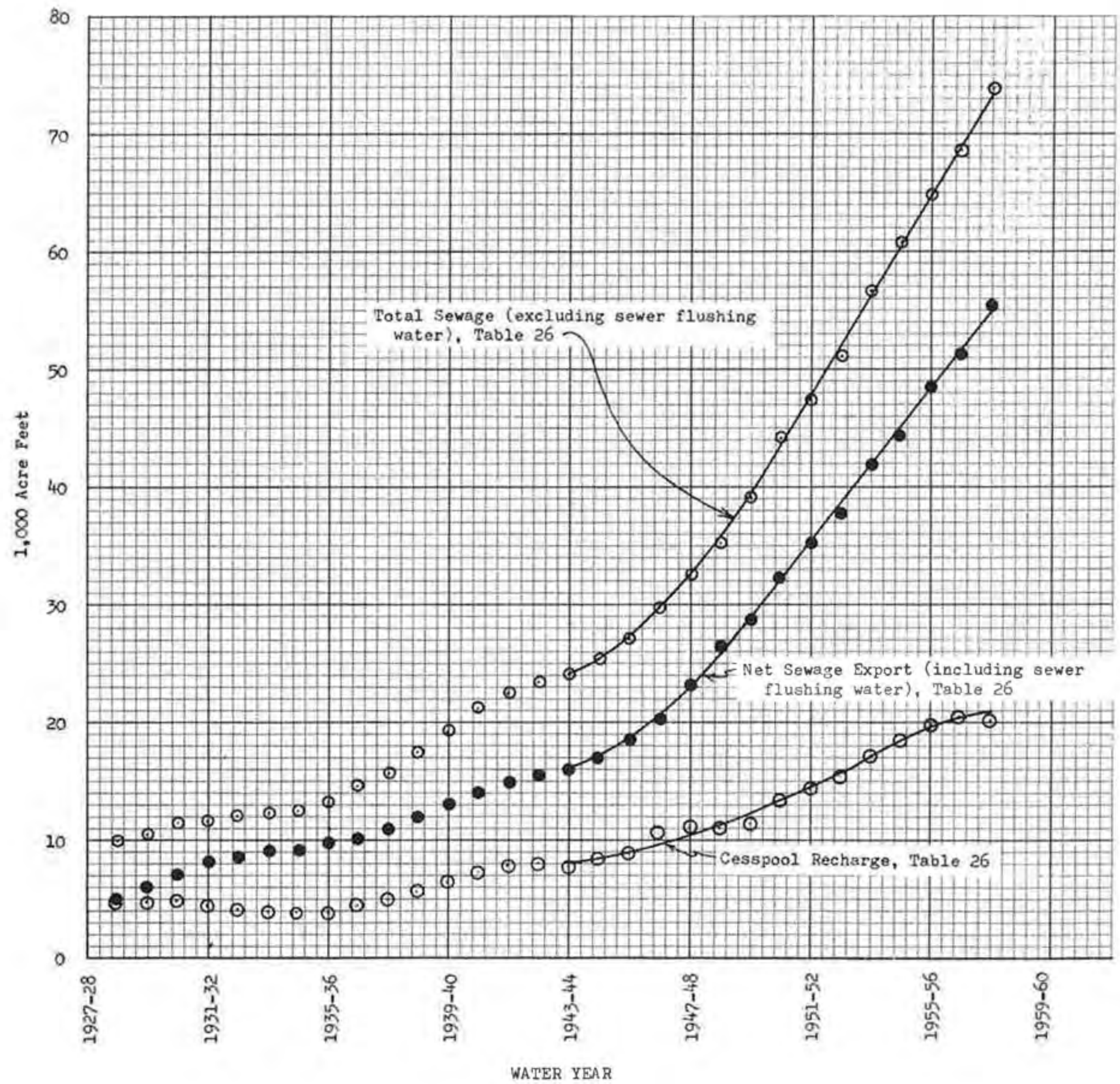
8. Average total consumptive use of delivered water in water supply reservoirs is the 29-year average total evaporation for water supply reservoirs (column 11, Table M-1) minus the 29-year average precipitation on the reservoirs (column 6, Table M-1).

9. Average amounts of consumptive use and deep percolation for industrial and commercial areas are from trend curves on Figure 8.

Industrial Wastes. Waste discharges from industrial plants to the stream channels vary annually. To obtain the average amount of industrial wastes discharged to the stream channels for each of the safe yield years, the annual amounts (Table 26A, page 151b) are plotted on Figure 8 and a trend curve drawn. The amounts of industrial waste discharged to the stream channels for each of the safe yield years are taken as the ordinate of the trend curve for that year.

Annual amounts of industrial wastes passing Gage F-57 are also plotted on Figure 8 and a trend curve drawn. Comparison of industrial wastes discharged and the amounts passing Gage F-57 shows that a larger portion of these wastes percolated during the years after 1949-50. For safe yield computations the amount of industrial waste passing Gage F-57 is taken as the ordinate of the trend curve for that year.

Total Sewage, Sewage Export and Cesspool Recharge. The total amounts of sewage discharged to sewer lines and to cesspools have increased with the urbanization of the area and are dependent on the population of the area. The historic variation in amounts of total sewage (Table 26) is plotted on Figure 9. The trend curve is a close approximation of the historic points and is used to determine the average amounts for the safe yield years. Annual amounts of cesspool recharge and sewage export (plus sewer flushing water) are also plotted on Figure 9 and trend curves constructed. Sewage discharged to the Los Angeles River is considered as a random occurrence that would not recur and these amounts are included in sewage export. Amounts of sewer infiltration and sewer flushing water are not included in total sewage but are treated separately.



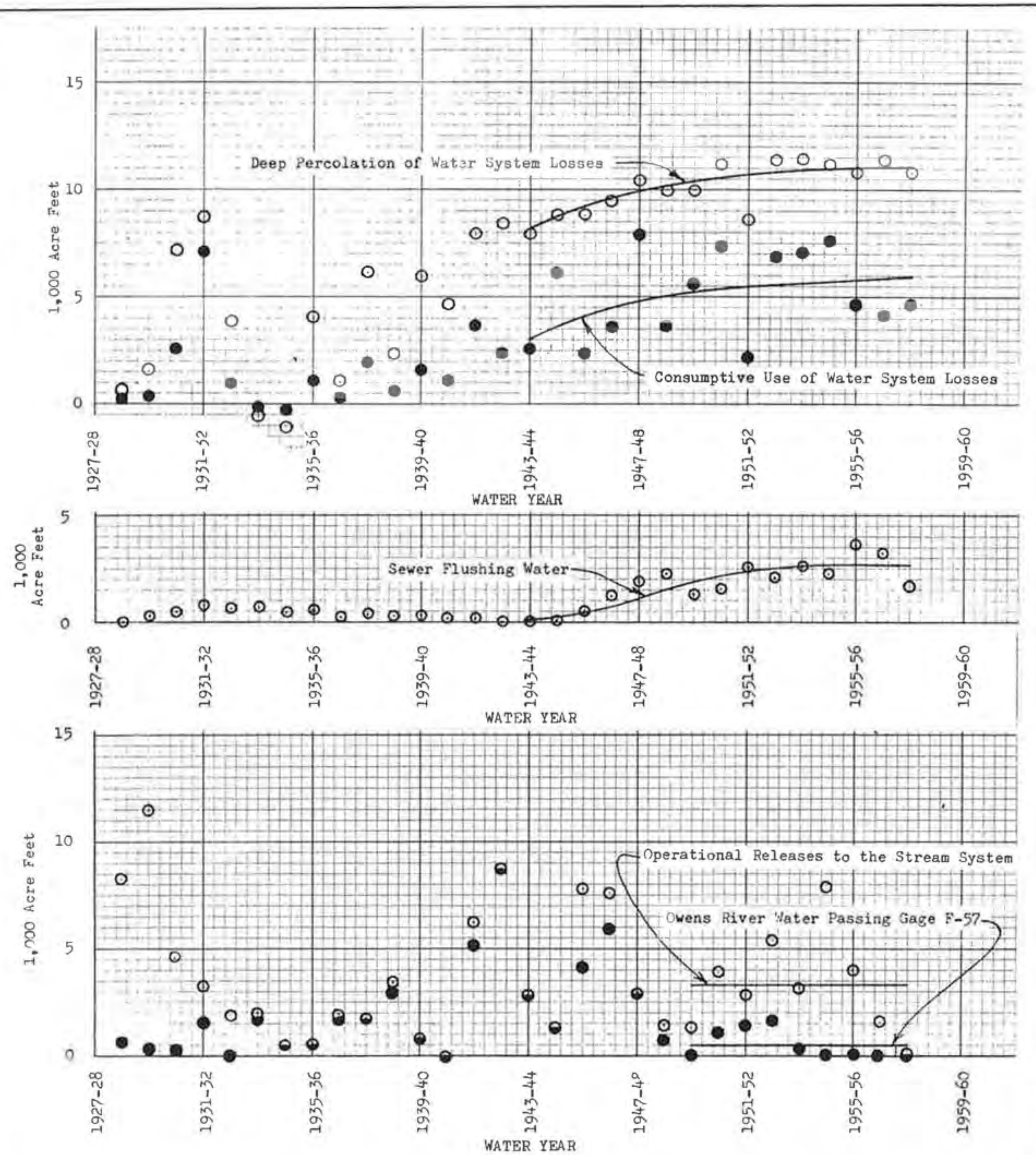
TREND CURVES FOR SEWAGE

Spread Import. Imported water has been spread only by the City of Los Angeles (Table 23, page 143). During the 9-year period, 1949-50 through 1957-58, the Los Angeles Aqueduct has operated at or near capacity with spreading occurring during four of the nine years. Spreading of import occurring during this period is considered to be caused by operational procedures; therefore, these amounts, which averaged 1,330 acre-feet per year, are included as an augmentation of operational releases, discussed hereafter, and the average amount of water imported for the purpose of spreading for each of the safe yield years is taken as zero.

Operational Releases. The annual amounts of operational releases of Owens River water to the stream system (Table 24, page 145) and the portion passing Gage F-57 (Table 28, page 155) are plotted on Figure 10. The annual variations were considered to be too irregular to permit use of a trend curve; therefore, the averages of these two items, based on a period of normal wetness (1949-50 through 1957-58) subsequent to the Los Angeles Aqueduct reaching capacity (circa 1949), are used. For the same reason the average amount of import spread due to operational procedures is also based on the 1949-50 through 1957-58 period. The average amount of operational release for each of the safe yield years is taken as the sum of average operational release of Owens River water (i.e., 3,300 acre-feet per year, Figure 10), and an additional operational release in lieu of spreading which averaged 1,330 acre-feet per year (i.e., average of annual import spread shown in Table 23, page 143, for the 9-year period 1949-50 through 1957-58).

Water System Loss. Water system loss for safe yield determination is computed as the sum of three parts; sewer flushing water, consumptive use of water system loss, and deep percolation of water system loss. The annual historic amounts of these items are shown in Table 36 and plotted on Figure 10. Trend curves were constructed to obtain average values and the amounts for safe yield conditions were obtained from ordinates of the curves for each safe yield year.

FIGURE 10



TREND CURVES FOR WATER SYSTEM LOSSES AND OPERATIONAL RELEASES

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Conditions Affecting Recharge From Precipitation on Land Use Areas

The amounts of water applied either through deliveries or rainfall and the percent of the area that is impervious have an affect on the consumptive use of rain. The percentage of residential land that is impervious has increased, while agricultural areas have remained unchanged in this respect during the base period. The type of use on pervious residential areas has also changed during the base period and has affected the residential use of delivered water and precipitation.

The mean depths of consumptive use for the land use class areas are shown for the 29-year and 9-year periods in Tables L-13 through L-15 and Table R-2 respectively. The 29-year average unit values of consumptive use of precipitation are approximately three percent greater than the 9-year average values for the land use classes that are predominantly pervious. Average unit values for residential areas for the 29 and 9-year periods cannot be compared due to the variation in percent pervious. The best approximation of recharge from precipitation on the valley fill area under safe yield conditions is obtained by the combination of normal precipitation from Table 1, 9-year average consumptive use of precipitation derived in Table 45, and the 29-year average residual rain shown in Table 45. The 9-year average unit consumptive use values are compatible with normal precipitation on the valley fill area and include the influence of changing amounts of delivered water on consumptive use. The 29-year average is used for unit residual rain values because residual rain is unaffected by economic conditions and to provide continuity with the computation of recharge in the stream system which is based on the 29-year average.

TABLE 45

AVERAGE AMOUNTS OF CONSUMPTIVE USE OF PRECIPITATION ON LAND USE AREAS AND RESIDUAL RAIN ON VALLEY FILL AREA FOR SAFE YIELD YEARS

In Acre-Feet

	Item	Safe yield year 1949-50	1954-55	1957-58
	Consumptive use by land use class			
1.	Deciduous	1,190	1,520	1,150
2.	Citrus	11,560	8,740	5,100
3.	Walnuts	4,670	3,220	1,280
4.	Truck	6,440	4,970	4,340
5.	Alfalfa	9,770	4,900	3,070
6.	Vineyard	230	150	90
7.	Lawn grass	2,040	2,130	2,410
8.	Dry farm and native	34,570	33,990	32,760
9.	Miscellaneous	1,890	1,920	2,350
10.	Riparian	470	400	320
11.	Commercial and industrial	5,420	5,820	5,950
12.	Residential	33,010	37,630	41,610
13.	Water Surface	1,320	1,320	1,320
14.	Total consumptive use of precipitation	112,580	106,710	101,750
15.	Residual rain	30,590	36,420	42,330
16.	Total of consumptive use and residual rain	143,170	143,130	144,080

Source and derivation of values by line number:

Line No.

1. through 12. Average amounts of consumptive use of precipitation for these land use areas are the products of the 9-year average (1949-50 through 1957-58) depths (Table R-2) and the acreage of land use (Table K-6).

13. The evaporation of precipitation is the 29-year mean precipitation on water supply reservoirs (Table M-1). and Hansen Dam Reservoir.

14. Sum of Items 1 through 13.

15. Summation of the products of the 29-year average depth of residual rain (Tables L-13 through L-15) and the impervious area for the safe yield year (Table R-5).

Conditions Affecting Native Recharge in the Stream System

Recharge of native waters in the stream system is based on the assumption that the condition of the stream system existing during the safe yield year prevailed over a period of normal runoff. The available data on supply to and recharge from the stream system are shown in Table 42, page 202, for the 1928-29 through 1957-58 period. These data are plotted on Figure 11 and the relationship between annual amounts of supply and recharge for each of the safe yield years is determined in the form of a curve. The average amount of recharge of native water in the stream system is based on the 29-year base period, since runoff from hill and mountain areas is normal for this period.

To ascertain the relationship between native supply to the river system and deep percolation therein, the annual amounts of native supply less amounts diverted and spread are plotted against annual amounts of deep percolation on Figure 11. The deep percolation, as plotted on Figure 11, shows a decrease with time and in general varies inversely with the amount of improvements made to channels. The historic improvements made to the main channels are summarized in Table 18, page 131. The decreasing percent of the total length of main channels remaining unpaved is an indication of the loss of percolation capacity of the stream system. In order to construct curves showing the relationship between native supply and deep percolation of that supply, the years are grouped on the basis of length of channel remaining unpaved as follows:

Period	Channels with paved bottoms		Percent with open bottom
	Miles	Percent	
1928-29 through 1936-37			
1929-30	0.3	0.2	99.8
31-32	6.8	4.9	95.1
32-33	7.3	5.3	94.7
33-34	8.6	6.2	93.8
34-35	11.7	8.5	91.5
35-36	17.4	12.6	87.4
1937-38 through 1950-51			
1937-38	23.0	16.7	83.3
38-39	25.9	18.8	81.2
39-40	26.1	18.9	81.1
40-41	26.1	18.9	81.1
41-47	27.6	20.1	79.9
47-48	29.3	21.3	78.7
48-49	31.6	23.0	77.0
49-50	33.7	24.5	75.5
50-51	35.8	26.0	74.0
1951-52 through 1954-55			
1951-52	47.7	34.7	65.3
52-53	58.7	42.7	57.3
53-54	60.5	44.0	56.0
54-55	64.5	46.9	53.1
1955-56 through 1957-58			
1955-56	66.0	48.0	52.0
56-57	67.8	49.3	50.7
57-58	69.8	50.7	49.3

The curves for the above periods are shown on Figure 11 and are constructed by plotting the data on both logarithmic and rectangular coordinates, drawing average trend curves, and spacing the curves on the basis of the amounts of unpaved channels remaining during the period. The resulting family of curves on Figure 11 all intersect a line representing 100 percent percolation of supply at decreasing values of supply for the more recent years and

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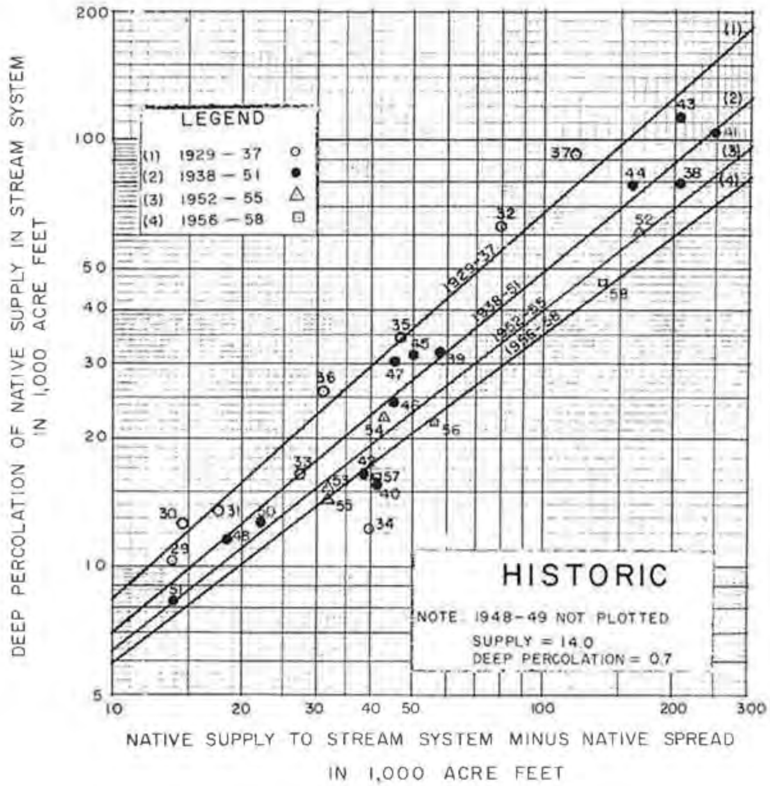
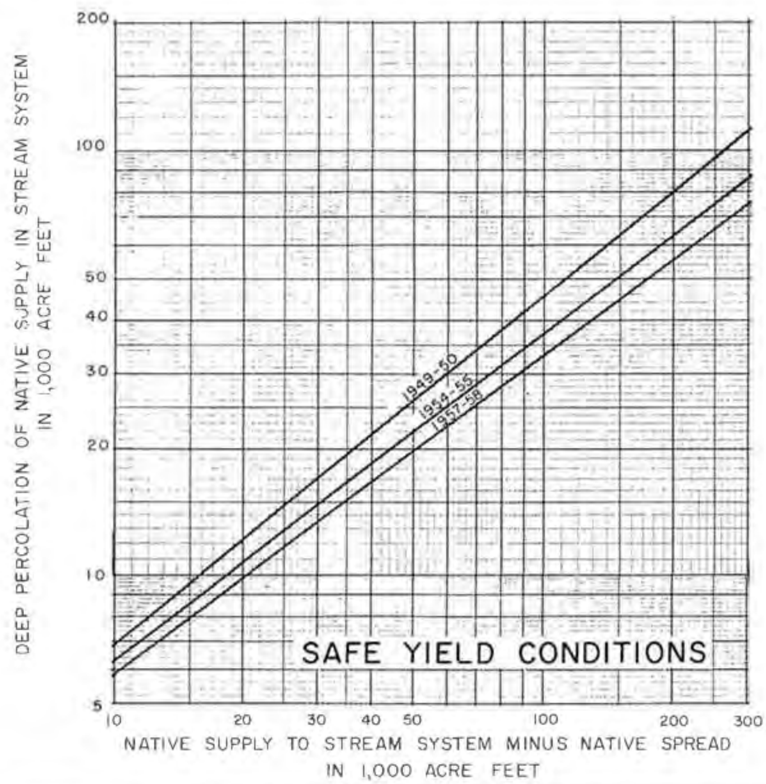
all diverge for increasing amounts of supply. The spacing of the curves indicates reduced percolation with reduced length of open bottom channels. The curves for the 1949-50 and 1954-55 safe yield years were drawn by interpolating between historic curves on the basis of the relative amounts of open bottom channels remaining during the safe yield year. The curve for 1957-58 is drawn in a similar manner by extrapolation.

The net supply to the stream system is the sum of hill and mountain runoff and residual rain draining off the valley fill area minus the runoff reaching water system reservoirs, native water spread, and surface diversions. Modifications of runoff items to conform to safe yield conditions are derived in Appendix R. These conditions differ from historic due to increased impervious areas in the hills and diversions works (constructed after 1941) which bypass runoff around water system reservoirs.

During the base period the amounts of surface water diverted on the valley fill area (Table 16, page 125) have not exceeded 500 acre-feet and have averaged 180 acre-feet per year. Surface diversions were not made during the 1949-50 through 1957-58 period. The amount of surface diversions on the valley fill area for each of the safe yield years has therefore been taken as zero. The amount of native water spread is that amount which would have been spread if the spreading grounds existing during the safe yield year (see Table 29, page 157) had existed over the period of normal supply (29-year period).





SAN FERNANDO VALLEY REFERENCE

RELATIONSHIP BETWEEN SUPPLY AND DEEP PERCOLATION IN THE STREAM SYSTEM

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STATE WATER RIGHTS BOARD

Conditions Affecting Natural Depletions from the Ground Water Reservoir

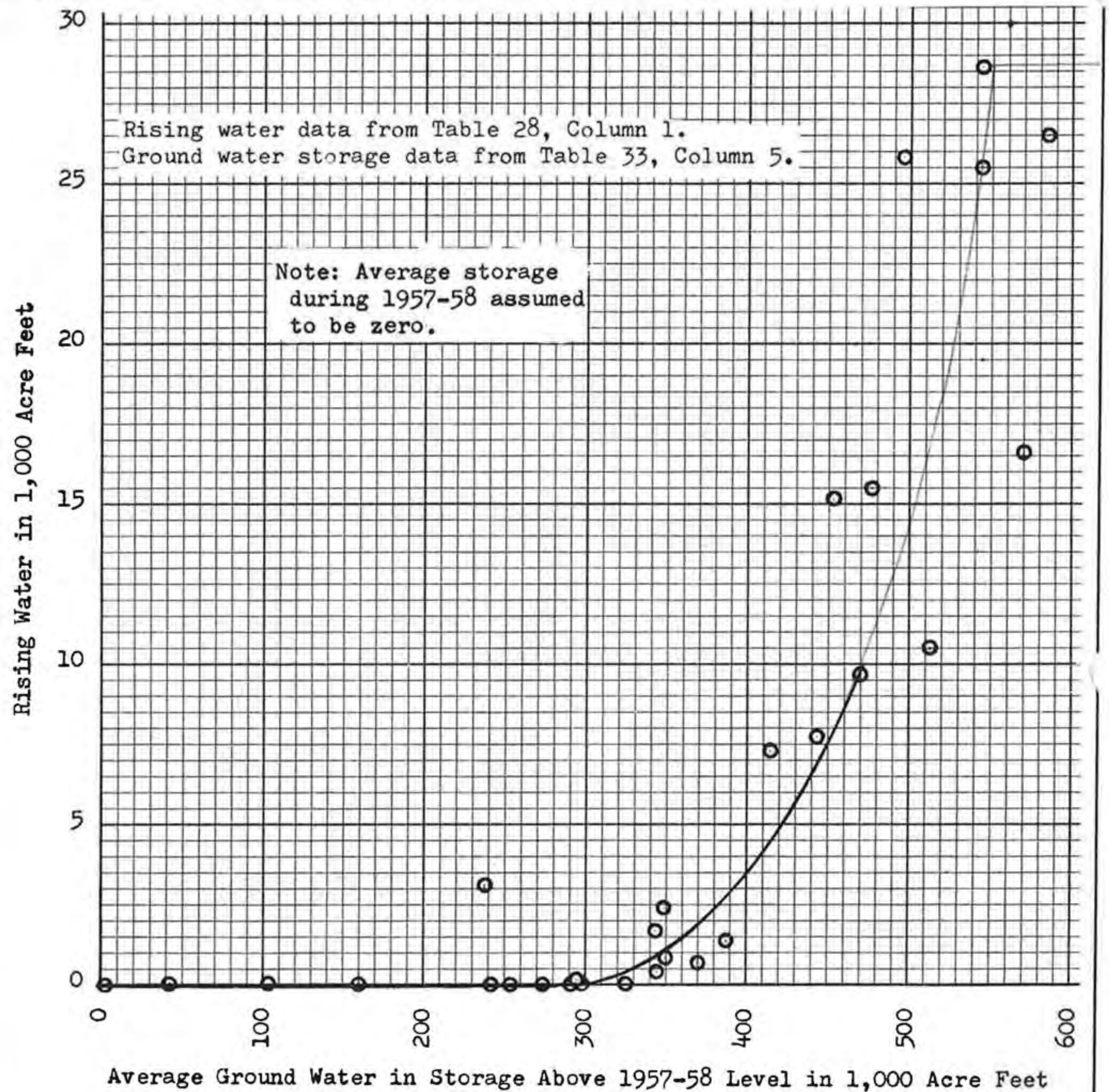
Natural depletions consist of rising water, subsurface outflows, sewer infiltration and direct consumption of ground water on land use areas (riparian and excess consumptive use). The average amounts of rising water passing Gage F-57 are controlled by the relative position of the stream channel invert and average ground water surface configuration. The latter is in turn dependent on basin operation. To provide a uniform basis for comparison of the safe yield for the three years, basin operation for each of the three years is assumed to commence with configuration of ground water levels the same as existed during 1957-58. Operation of the ground water reservoir under safe yield conditions requires a maximum of approximately 210,000 acre-feet of storage space above the 1957-58 water levels. This amount of storage space is required for the 1949-50 safe yield condition with the other two safe yield years requiring lesser amounts. Historic rising water passing Gage F-57 is plotted against storage above 1957-58 levels on Figure 12. This relationship indicates that the rising water outflow which would occur within the storage fluctuation noted above is nil; therefore, for the three safe yield years, average rising water has been taken as zero.

Subsurface outflows (Table 31) at Gage F-57 are plotted on Figure 13. The annual amounts have declined gradually from 500 acre-feet in 1934-35 to 160 acre-feet in 1957-58. The average amounts for the safe yield years have been taken from the curve. Estimated annual subsurface flows out of the Upper Los Angeles River area in the vicinity of Pickens Canyon have varied with the amount of natural supply and within a narrow range (250 to 400 acre-feet) during the 29-year period; therefore, the 29-year average has been used for the subsurface outflow in this vicinity.

Annual amounts of sewer infiltration (Table 26, page 151) are plotted on Figure 13 and the trend curve, drawn to represent average sewer infiltration, reflects the general decline in ground water levels during the 1940's and increase in length of sewer lines during the 1950's. For safe yield computations, average values were taken as the ordinate to the trend curve for the safe yield year.

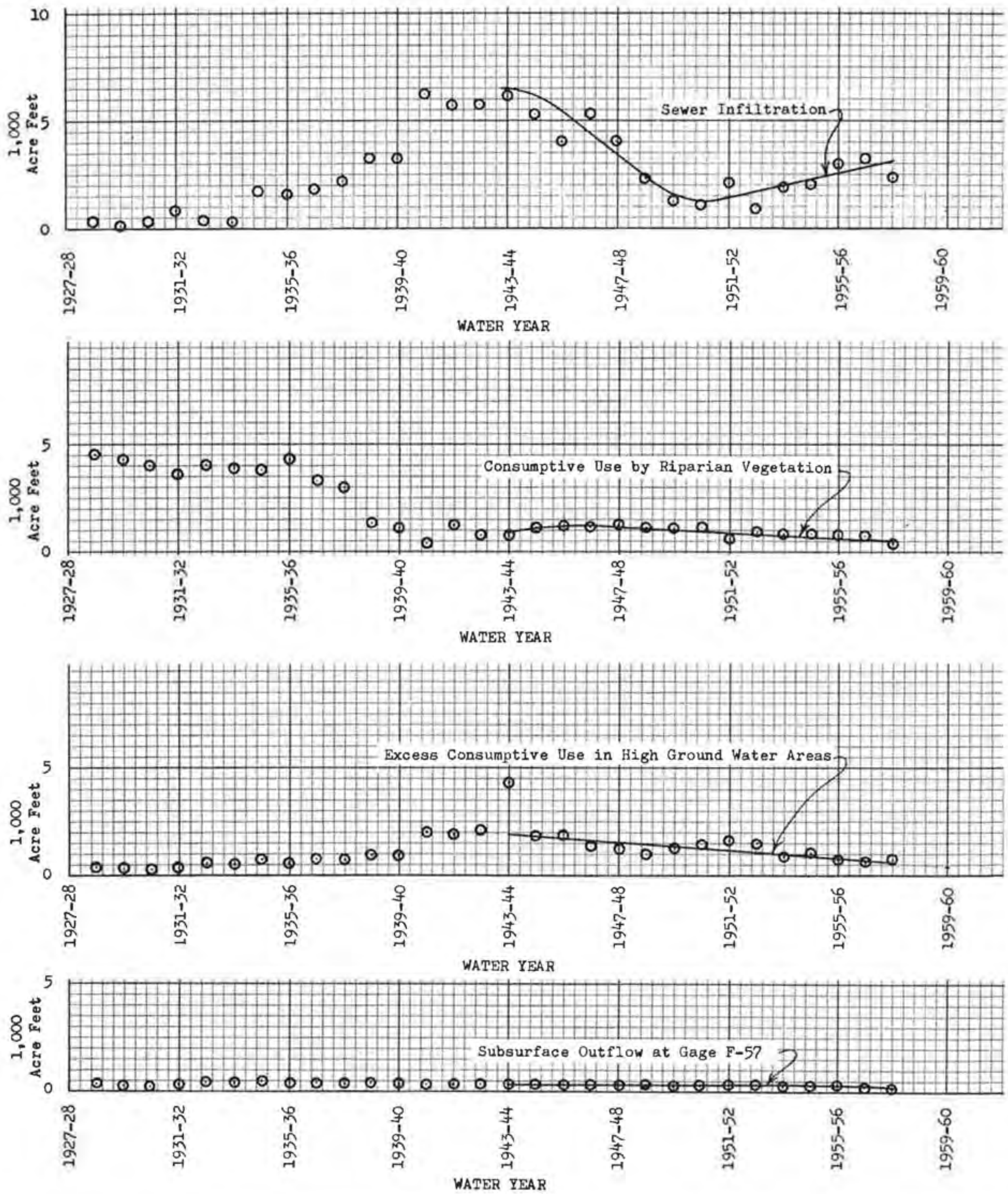
Improvement of channels made in 1938 through 1940 and the 1938 flood removed a large amount of riparian growth from the stream channels. The trend curve on Figure 13 from 1941 to 1947 shows a small increase in riparian use followed by a steady decline. The annual historic amounts of excess consumptive use presented in Table L-17 are for a depth to ground water interval of 0 to 10 feet. The area which had a depth to ground water of less than four feet is presently subdivided. It is believed that recurrence of a very high ground water table will be avoided since extensive damage to the homes would result. For this reason the trend curve for excess consumptive use shown on Figure 13 is based on the historic amounts for a depth to ground water interval of 4 to 10 feet. Average values for safe yield conditions were taken as the ordinate to the trend curve for the safe yield year.

FIGURE 12



RISING WATER AS A FUNCTION OF GROUND WATER IN STORAGE

FIGURE 13



TREND CURVES FOR NATURAL DEPLETIONS OF GROUND WATER

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Average Delivered Water Requirement
Under Safe Yield Conditions

Average delivered water required by the culture of the safe yield year over a period of normal native supply is the sum of average demands and uses of delivered water by the culture of the safe yield year. The conditions governing these average demands and uses of delivered water are discussed in the preceding sections of this chapter. The average amounts of the demands and uses along with their source and derivation are shown in Table 46.

The average delivered water requirement for the 1957-58 culture conditions is 34,000 acre-feet greater than for the 1949-50 conditions. This change results from urbanization of the area and is reflected in the increase in the total of sewage export and cesspool recharge shown in Table 46.

TABLE 46

AVERAGE DELIVERED WATER REQUIREMENT UNDER SAFE YIELD CONDITIONS

In 1,000 Acre-Feet

Item	Safe yield year 1949-50	1954-55	1957-58
1. Consumptive use plus deep percolation on land use class areas	136.0	133.8	133.4
2. Industrial wastes	4.9	6.0	5.7
3. Total sewage (sewage export plus cesspool recharge)	39.6	60.5	73.3
4. Operational releases	4.6	4.6	4.6
5. Spread import	0	0	0
6. Water system loss	17.5	19.4	19.5
7. Average delivered water requirement under safe yield conditions	202.6	224.3	236.5

Source and derivation of values by item number.

Item No.

1. Table 44, line 11, Columns 3, 6 and 9.
2. From industrial waste discharge trend curve, Figure 8.
3. From total sewage curve, Figure 9.
4. Average for 9-year period (1949-50 through 1957-58) of the sum of operational releases (Table 24, page 145) and spread import (Table 23, page 143).
5. There was no planned spreading in the 9-year period 1950-58.
6. Sum of amounts from trend curves for sewer flushing water, consumptive use of water system loss and deep percolation of water system loss, Figure 10.
7. Sum of Items 1 through 6.

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Ground Water Recharge Under Safe Yield Conditions

Gross ground water recharge under the safe yield conditions heretofore established has been evaluated as the supply from deliveries and native sources less consumptive use and outflows including sewage export. Net recharge has been determined as the gross recharge less natural ground water depletions under safe yield conditions. Gross recharge of the delivered water requirement is computed as a lump sum while gross recharge of native water is calculated in three parts: from land use areas, from the stream system and from native spread water.

Gross Recharge of Delivered Water Required by the Culture

The gross recharge from the average delivered water requirement under safe yield conditions is shown in Table 47 and is the difference between the average delivered water and its consumptive uses, outflows and exports.

TABLE 47

AVERAGE GROSS RECHARGE WITH SAFE YIELD
CULTURE WATER REQUIREMENT SATISFIED

In 1,000 Acre-Feet

Item	Safe yield year		
	1949-50	1954-55	1957-58
1. Average delivered water requirement for the safe yield year	202.6	224.3	236.5
2. Consumptive use on land use areas	113.6	111.5	111.3
3. Consumptive use of water system loss	5.2		5.9
4. Industrial waste passing Gage F-57	2.0	0.9	1.2
5. Owens River water passing Gage F-57	0.5	0.5	0.5
6. Sewage export (including sewer flushing water)	28.9	45.1	55.0
7. Total consumptive use and outflow	150.2	163.7	173.9
8. Gross recharge of average delivered water requirement	52.4	60.6	62.6
9. Gross recharge in percent of average delivered water requirement	25.9	27.0	26.5

Source and derivation of average values by item number:

Item No.

1. Gross delivered water is Item 7, Table 46.
2. Consumptive use of delivered water from Table 44, Item 11, columns 1, 4 and 7.
3. Consumptive use of water system loss is from curve, Figure 10.
4. Industrial waste passing Gage F-57 is from curve, Figure 8.
5. Operational release of Owens River water passing F-57 is the average of historic amounts in column 4, Table 28, page 155, for the 9-year period, 1949-50 through 1957-58 (also see Figure 10).
6. Sewage export (including sewer flushing water) is from curve, Figure 9.
7. Total consumptive use and outflow is the sum of Items 2 through 6.
8. Gross recharge of delivered water is the difference between Items 1 and 7.
9. Gross recharge in percent of average delivered water requirement is Item 8 divided by Item 1, times 100.

Gross Recharge of Precipitation on Land Use Areas

The gross recharge of precipitation on land use areas is the normal precipitation on the valley fill area (Table 1) minus the consumptive use and residual rain on the land use areas (Table 45). The average amounts of these items, their source, and the resulting gross recharge are listed in Table 48 for each of the three safe yield years.

TABLE 48

AVERAGE GROSS RECHARGE ON LAND USE AREAS FROM
NORMAL PRECIPITATION UNDER SAFE YIELD CONDITIONS

In 1,000 Acre-Feet

Item	Safe yield year		
	1949-50	1954-55	1957-58
1. Normal precipitation, valley fill area	167.7	167.7	167.7
2. Consumptive use of normal precipitation plus residual rain on the valley fill	143.2	143.1	144.1
3. Gross recharge of normal precipitation, valley fill area	24.5	24.6	23.6
4. Gross recharge in percent of normal precipitation	14.6%	14.7%	14.1%

Source and derivation of values by item number:

Item
Number

1. 85-year mean precipitation for valley fill Table 1.
2. Total of average consumptive use of precipitation and residual rain from Table 45, line 16.
3. Item 1 minus Item 2.
4. Item 3 divided by Item 1 times 100.

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Gross Recharge of Native Spread Water

The historic amounts of net water spread at the four spreading grounds operated by the Los Angeles County Flood Control District are shown in Table 49. The average amount of native water spread is the estimated amount of water that would have been spread if the spreading grounds existing during a safe yield year had operated during a period of normal supply. The 29-year base period is the only period of near normal precipitation and runoff having adequate records. The amount of surface runoff which may be spread at these basins is a function of the occurrence and intensities of rainfall and the operating procedures of Pacoima, Big Tujunga and Hansen flood control dams. Pacoima spreading grounds have the longest period of record, with operation commencing in 1932-33. Hansen spreading grounds were completed and began operation in 1944-45 with Lopez and Branford being completed in 1955-56. Urbanization has been minor in areas tributary to the spreading grounds; therefore, the amount of native water spread historically during a given year has been used as the amount which could have been spread during that year under safe yield conditions. Estimation of spreading during the remainder of the 29-year base period is based on the historic amounts spread.

Water spread at Pacoima spreading grounds from 1928-29 through 1931-32 was taken as equal to stream runoff at Gage 118 multiplied by the average ratio of the annual amounts of water spread for the period of record (1932-33 through 1957-58) to the annual amount of hill and mountain runoff from Pacoima Canyon, measured at Gage 118 (see Plate 9 and Table 27). The annual estimated amount which could have been spread at the Lopez

TABLE 49

ACTUAL AND COMPUTED NATIVE WATER SPREAD

In Acre-Feet

Year	Pacoima (1)	Hansen (2)	Lopez (3)	Branford (4)	Total (5)
1928-29	340*	710*	30*	10*	1,090*
29-30	380*	800*	30*	20*	1,230*
1930-31	340*	710*	30*	10*	1,090*
31-32	3,300*	6,900*	260*	130*	10,590*
32-33	30	50*	0*	0*	80*
33-34	230	480*	20*	10*	740*
34-35	1,200	2,500*	100*	50*	3,850*
1935-36	2,000	4,200*	160*	80*	6,440*
36-37	4,680	9,800*	370*	190*	15,040*
37-38	3,840	8,100*	310*	150*	12,400*
38-39	360	760*	30*	10*	1,160*
39-40	910	1,900*	70*	40*	2,920*
1940-41	9,780	20,400*	780*	390*	31,350*
41-42	40	80*	0*	0*	120*
42-43	3,740	7,900*	300*	150*	12,090*
43-44	7,220	15,000*	580*	290*	23,090*
44-45	1,470	7,650	120*	60*	9,300*
1945-46	510	2,270	40*	20*	2,840*
46-47	3,760	8,730	300*	150*	12,940*
47-48	0	0	0*	0*	0*
48-49	0	0	0*	0*	0*
49-50	250	0	20*	10*	280*
1950-51	0	0	0*	0*	0*
51-52	6,120	16,780	490*	240*	23,630*
52-53	1,650	1,270	130*	70*	3,120*
53-54	1,890	1,010	150*	80*	3,130*
54-55	210	0	20*	10*	240*
1955-56	570	0	0	0	570
56-57	480	0	30	40	550
57-58	10,920	18,410	1,030	20	30,380
29-Year Average 1929-57	1,907	4,069	151	76	6,203

* Estimated amounts of runoff which would have been spread had spreading grounds been constructed and operated during these years.

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grounds was taken as equal to the amount spread at Pacoima (as extended) multiplied by the average ratio of water spread at Lopez to the amount spread at Pacoima, both taken over the period of concurrent records. Estimated amounts spread at Hansen and Branford were computed in a similar manner. Amounts of spreading, both estimated and of record, at the four spreading grounds are shown in Table 49. Comparison of amounts of runoff available for spreading with the amounts estimated as spread indicates that sufficient supply for the estimated spreading was historically available. In determining the amounts of native water spread under safe yield conditions, only the estimated amounts spread at Pacoima and Hansen spreading grounds were included in the 1949-50 and 1954-55 safe yield years. In the 1957-58 safe yield year, the estimated amounts for all four spreading grounds were utilized. The average amounts of native water spread for the safe yield years are listed in Table 50.

TABLE 50

ESTIMATED AVERAGE NATIVE WATER
SPREAD UNDER SAFE YIELD CONDITIONS

Item	Safe yield year		
	1949-50	1954-55	1957-58
Spreading grounds	Pacoima Hansen	Pacoima Hansen	Pacoima Hansen Lopez Branford
Estimated average annual amount spread, in 1,000 acre-feet	6.0	6.0	6.2

Gross Recharge of Native Waters From the Stream System of the Valley Fill Area

The supply to the stream system is made up of hill and mountain runoff and residual rain from valley fill areas. The net supply available for recharge from the stream system on the valley fill area is the total supply minus amounts spread, diverted and flowing into water system reservoirs. The annual amounts resulting in the net supply are shown in Table 51 for each of the three safe yield years. The residual rain is based on the 29-year average depth of residual rain for impervious areas (Tables L-13 through L-15) multiplied by the impervious area for the safe yield year. Hill and mountain runoff is the historic annual amount adjusted to reflect the culture of the safe yield year. Runoff to reservoirs is the annual historic amount corrected for the effect of drainage channels constructed around water supply reservoirs to bypass runoff. Evaporation of runoff at Hansen Dam cannot be accurately estimated for each year under safe yield conditions but can be estimated as an average value based on the 1949 through 1958 period (9-year average = 490 acre-feet).

The average recharge in the stream system is the average of the sum of the annual amounts of recharge for the 29-year base period. The annual amounts of recharge are obtained by entering the annual amounts of net supply and using the appropriate curve for the safe yield year on Figure 11. Average amounts of recharge in the stream system thus obtained for each of the safe yield years are shown as the 29-year average deep percolation in Table 51 and after correction for evaporation at Hansen Dam are 31,200, 27,900 and 26,700 acre-feet for the respective safe yield years of 1949-50, 1954-55 and 1957-58.

TABLE 51

DEEP PERCOLATION IN STREAM SYSTEM

Safe yield year 1949-50

In 1,000 Acre-Feet

Year	Residual rain (1)	Hill and mountain runoff (2)	Additional hill and mountain runoff (3)	Sub-total (4)	Runoff to reservoirs (5)	Native spread (6)	Sub-total (7)	Net supply (8)	Deep percolation in stream system (9)
1928-29	17.7	6.6	1.0	25.3	0	1.1	1.1	24.2	14.4
29-30	22.8	5.3	0.9	29.0	0	1.2	1.2	27.8	16.1
1930-31	28.0	3.9	1.2	33.1	0	1.1	1.1	32.0	17.9
31-32	37.8	58.3	1.4	97.5	1.0	10.2	11.2	86.3	40.1
32-33	26.6	13.1	1.2	40.9	0.2	0	0.2	40.7	21.9
33-34	30.6	19.6	1.7	51.9	0.3	0.7	1.0	50.9	26.2
34-35	34.3	23.6	1.6	59.5	0.1	3.7	3.8	55.7	28.1
1935-36	20.7	18.7	1.0	40.4	0.3	6.2	6.5	33.9	18.8
36-37	44.7	90.9	1.6	137.2	1.4	14.5	15.9	121.3	53.6
37-38	51.0	176.7	1.7	229.4	2.2	11.9	14.1	215.3	85.0
38-39	43.2	28.2	1.6	73.0	0.5	1.1	1.6	71.4	34.5
39-40	30.0	19.8	1.0	50.8	0.3	2.8	3.1	47.7	24.9
1940-41	85.2	190.0	2.7	277.9	2.8	30.2	33.0	244.9	95.0
41-42	18.6	21.8	0.7	41.1	0.3	0.1	0.4	40.7	21.8
42-43	51.8	165.7	1.6	219.1	2.3	11.6	13.9	205.2	82.0
43-44	50.4	123.8	1.5	175.7	1.7	22.2	23.9	151.8	64.0
44-45	24.7	37.1	1.0	62.8	0.5	9.1	9.6	53.2	27.2
1945-46	23.6	24.3	1.2	49.1	0.2	2.8	3.0	46.1	24.4
46-47	25.5	31.2	1.8	58.5	0.2	12.5	12.7	45.8	24.1
47-48	10.9	6.0	0.5	17.4	0	0	0	17.4	10.9
48-49	9.4	3.2	0.5	13.1	0	0	0	13.1	8.6
49-50	16.1	5.2	0.8	22.1	0.1	0.3	0.4	21.7	13.0
1950-51	10.4	2.9	0.5	13.8	0.1	0	0.1	13.7	8.8
51-52	60.3	113.7	2.2	176.2	1.9	22.9	24.8	151.4	64.0
52-53	16.5	15.0	0.6	32.1	0.2	2.9	3.1	29.0	16.6
53-54	24.1	15.3	1.1	40.5	0.2	2.9	3.1	37.4	20.5
54-55	19.2	8.3	0.8	28.3	0.1	0.2	0.3	28.0	16.1
1955-56	30.0	11.1	1.5	42.4	0.2	0.6	0.8	41.6	22.1
56-57	23.2	6.8	1.1	31.1	0.1	0.5	0.6	30.5	17.2
29-Year Average 1929-57	30.6	43.0	1.2	74.8	0.6	6.0	6.6	68.2	31.7-0.5*=31.2

DEEP PERCOLATION IN STREAM SYSTEM
(continued)

Safe yield year 1954-55

In 1,000 Acre-Feet

Year	Residual rain (1)	Hill and mountain runoff (2)	Additional hill and mountain runoff (3)	Sub-total (4)	Runoff to reservoirs (5)	Native spread (6)	Sub-total (7)	Net supply (8)	Deep percolation in stream system (9)
1928-29	21.1	6.6	2.2	29.9	0	1.1	1.1	28.8	14.4
29-30	27.1	5.3	2.0	34.4	0	1.2	1.2	33.2	16.2
1930-31	33.3	3.9	2.5	39.7	0	1.1	1.1	38.6	18.0
31-32	45.0	58.3	3.0	106.3	1.0	10.2	11.2	95.1	35.9
32-33	31.7	13.1	2.4	47.2	0.2	0	0.2	47.0	21.0
33-34	36.5	19.6	3.7	59.8	0.3	0.7	1.0	58.8	24.9
34-35	40.8	23.6	3.3	67.7	0.1	3.7	3.8	63.9	26.4
1935-36	24.7	18.7	2.2	45.6	0.3	6.2	6.5	39.1	18.1
36-37	53.3	90.9	3.4	147.6	1.4	14.5	15.9	131.7	46.0
37-38	60.7	176.6	3.6	241.0	2.2	11.9	14.1	226.9	69.0
38-39	51.5	28.2	3.4	83.1	0.5	1.1	1.6	81.5	31.9
39-40	35.7	19.8	2.2	57.7	0.2	2.8	3.1	54.6	23.6
1940-41	101.3	190.0	5.7	297.0	2.8	30.2	33.0	264.0	78.0
41-42	22.2	21.8	1.4	45.4	0.3	0.1	0.4	45.0	20.3
42-43	61.6	165.7	3.3	230.6	2.3	11.6	13.9	216.7	67.0
43-44	60.0	123.8	3.1	186.9	1.7	22.2	23.9	163.0	54.0
44-45	29.4	37.1	2.2	68.7	0.5	9.1	9.6	59.1	25.0
1945-46	28.1	24.3	2.3	54.7	0.2	2.8	3.0	51.7	22.5
46-47	30.4	31.2	3.7	65.3	0.2	12.5	12.7	52.6	22.9
47-48	13.0	6.0	1.1	20.1	0	0	0	20.1	10.9
48-49	11.2	3.2	1.1	15.5	0	0	0	15.5	8.8
49-50	19.2	5.2	1.7	26.1	0.1	0.3	0.4	25.7	13.1
1950-51	12.4	2.9	0.9	16.2	0.1	0	0.1	16.1	9.1
51-52	71.8	113.7	4.7	190.2	1.9	22.9	24.8	165.4	54.5
52-53	19.6	15.0	1.2	36.9	0.2	2.9	3.1	33.8	16.2
53-54	28.7	15.3	2.3	46.3	0.2	2.9	3.1	43.8	19.9
54-55	22.8	8.3	1.7	32.8	0.1	0.2	0.3	32.5	15.9
1955-56	35.7	11.1	2.7	49.5	0.2	0.6	0.8	48.7	21.6
56-57	27.6	6.8	2.2	36.6	0.1	0.5	0.6	36.0	17.1
29-Year Average 1927-57	36.4	43.0	2.6	82.0	0.6	6.0	6.6	75.6	28.4-0.5*=27.9

TABLE 51

DEEP PERCOLATION IN STREAM SYSTEM
(continued)

Safe yield year 1957-58

In 1,000 Acre-Feet

Year	Residual rain (1)	Hill and mountain runoff (2)	Additional hill and mountain runoff (3)	Sub-total (4)	Runoff to reservoirs (5)	Native spread (6)	Sub-total (7)	Net supply (8)	Deep percolation in stream system (9)
1928-29	24.5	6.6	3.5	34.6	0	1.1	1.1	33.5	14.8
29-30	31.5	5.3	3.2	40.0	0	1.2	1.2	38.8	16.4
1930-31	38.7	3.9	4.1	46.7	0	1.1	1.1	45.6	18.5
31-32	52.4	58.3	4.8	115.5	1.0	10.6	11.6	103.9	34.1
32-33	36.8	13.1	3.9	53.8	0.2	0	0.2	53.6	20.8
33-34	42.4	19.6	5.9	67.9	0.3	0.7	1.0	66.9	24.9
34-35	47.4	23.6	5.4	76.3	0.1	3.9	4.0	72.3	26.1
1935-36	28.6	18.7	3.5	50.8	0.3	6.4	6.7	44.1	18.1
36-37	61.9	90.9	5.6	158.4	1.4	15.0	16.4	142.0	43.5
37-38	70.6	176.7	5.8	253.1	2.2	12.4	14.6	238.5	63.0
38-39	59.8	28.2	5.5	93.5	0.5	1.2	1.7	91.8	31.0
39-40	41.5	19.8	3.5	64.8	0.2	2.9	3.1	61.7	23.1
1940-41	117.8	190.0	9.3	317.1	2.8	31.4	34.2	282.9	72.0
41-42	25.8	21.8	2.2	49.8	0.3	0.1	0.4	49.4	19.8
42-43	71.7	165.7	5.4	242.8	2.3	12.1	14.4	228.4	61.0
43-44	69.8	123.8	5.1	198.7	1.7	23.1	24.8	173.9	49.5
44-45	34.2	37.1	3.5	74.8	0.5	9.3	9.8	65.0	24.1
1945-46	32.7	24.3	3.7	60.7	0.2	2.8	3.0	57.7	22.0
46-47	35.4	31.2	6.0	72.6	0.2	12.9	13.1	59.5	22.5
47-48	15.1	6.0	1.8	22.9	0	0	0	22.9	11.0
48-49	13.0	3.2	1.8	18.0	0	0	0	18.0	9.1
49-50	22.2	5.2	2.8	30.2	0.1	0.3	0.4	29.8	13.3
1950-51	14.4	2.9	1.5	18.8	0.1	0	0.1	18.7	9.3
51-52	83.4	113.7	7.6	204.7	1.9	23.6	25.5	179.2	51.0
52-53	22.8	15.0	2.0	39.8	0.2	3.1	3.3	36.5	15.6
53-54	33.4	15.3	3.7	52.4	0.2	3.1	3.3	49.1	19.6
54-55	26.5	8.3	2.7	37.5	0.1	0.2	0.3	37.2	15.9
1955-56	41.5	11.1	4.4	57.0	0.2	0.6	0.8	56.2	21.8
56-57	32.1	6.8	3.6	42.5	0.1	0.6	0.7	41.8	17.2
29-Year Average 1929-57	42.3	43.0	4.2	89.5	0.6	6.2	6.8	82.7	27.2-0.5*=26.7

Source and derivation of values by column number:

Column No.

1. Residual rain from Table R-5.
2. Hill and mountain runoff under conditions of native culture from Table F-7.
3. Additional hill and mountain runoff from Table R-6.
4. Total of columns 1, 2 and 3.
5. Runoff to reservoirs is sum of columns 2, 3 and 4 from Table F-10.
6. Native spread from Table 49.
7. Total of columns 5 and 6.
8. Net supply is column 4 minus column 7.
9. Deep percolation from curve for safe yield year on Figure 12.

* Correction for evaporation of runoff at Hansen Dam (Table L-22A).

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Natural Depletions from the Ground Water Reservoir

The average annual amounts of natural ground water depletions over a period of normal supply, along with their source and derivation, are shown in Table 52. Average amounts of natural depletions consisting of subsurface outflows, rising water, sewer infiltration and consumptive use of ground water are, with the exception of average subsurface outflow in the vicinity of Pickens Canyon (29-year average), based on the trend curves. The conditions governing these items are discussed in preceding portions of this chapter.

TABLE 52

NATURAL GROUND WATER DEPLETION UNDER SAFE YIELD CONDITIONS

In 1,000 Acre-Feet

Items of depletion	Safe yield year		
	1949-50	1954-55	1957-58
1. Subsurface outflow, passing Gage F-57	0.3	0.3	0.2
2. Subsurface outflow, vicinity of Pickens Canyon	0.3	0.3	0.3
3. Consumptive use of ground water by riparian vegetation	1.0	0.7	0.5
4. Consumptive use of ground water in high ground water areas	1.4	0.9	0.6
5. Rising water passing Gage F-57	0.0	0.0	0.0
6. Sewer infiltration	1.6	2.3	3.1
7. Total natural ground water depletion	4.6	4.5	4.7

Source and derivation of values by item number:

Item No.

1. Subsurface outflow at Gage F-57 from trend curve, Figure 13.
2. Subsurface outflow in vicinity of Pickens Canyon taken as the 29-year average from Table 31, page 160.
3. Consumptive use of ground water by riparian vegetation from trend curve, Figure 13.
4. Consumptive use of ground water in high ground water areas from trend curve, Figure 13.
5. Rising water from curve on Figure 12. Maximum increase in storage above 1957-58 level under safe yield conditions over a period of normal native supply is 200,000 acre-feet.
6. Sewer infiltration from trend curve, Figure 13.
7. Total of columns 1 through 6.

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Net Recharge of Native and Delivered Waters

The net recharge from normal native supply and average delivered water requirement is determined in Table 53 and is equal to the difference between the gross recharge and natural ground water depletion. The determination of net recharge demonstrates the effect of urbanization on recharge. The average gross recharge of native water was approximately 5,000 acre-feet greater for 1949-50 safe yield conditions than for the 1957-58 conditions. The average gross recharge of the delivered water requirement was approximately 10,000 acre-feet less for 1949-50 conditions than for 1957-58 conditions. The decrease in recharge of native water is primarily due to improvement of the drainage system. The increase in recharge of delivered water is due to the increase in cesspool recharge which has accompanied urbanization of the area. The average natural depletions are approximately the same for the three safe yield years. The resulting average net recharge for 1954-55 safe yield conditions is approximately 5,000 acre-feet greater than for the 1949-50 conditions and has remained about the same for 1957-58 conditions. The increase in recharge of delivered water has therefore kept pace with the decrease in recharge of native supply. It should be noted that if the entire area were connected to the sewer system the recharge of delivered water would be considerably less.

TABLE 53

NET RECHARGE FROM NORMAL NATIVE SUPPLY
AND AVERAGE REQUIRED DELIVERED WATER

In 1,000 Acre-Feet Per Annum

Item	Safe Yield Year 1949-50	1954-55	1957-58
1. Average gross recharge from precipitation on land use areas	24.5	24.6	23.6
2. Average gross recharge from native spread water	6.0	6.0	6.2
3. Average gross recharge from native water in the stream system on the valley fill area	31.2	27.9	26.7
4. Average gross recharge of native waters (total native except runoff to reservoirs)	61.7	58.5	56.5
5. Average gross recharge from average delivered water	52.4	60.6	62.6
6. Average gross recharge of delivered and native waters	114.1	119.1	119.1
7. Average natural depletions of ground water	4.6	4.5	4.7
8. Average net recharge of native and delivered waters	109.5	114.6	114.4

Source and derivation of values by item number:

Item No.

1. From Table 48, Item 3.
2. From Table 50.
3. From Table 51, Column 9 (29-year average).
4. Total of Items 1, 2 and 3.
5. From Table 47, Item 8.
6. Total of Items 4 and 5.
7. From Table 52, Item 7.
8. Item 6 minus Item 7.

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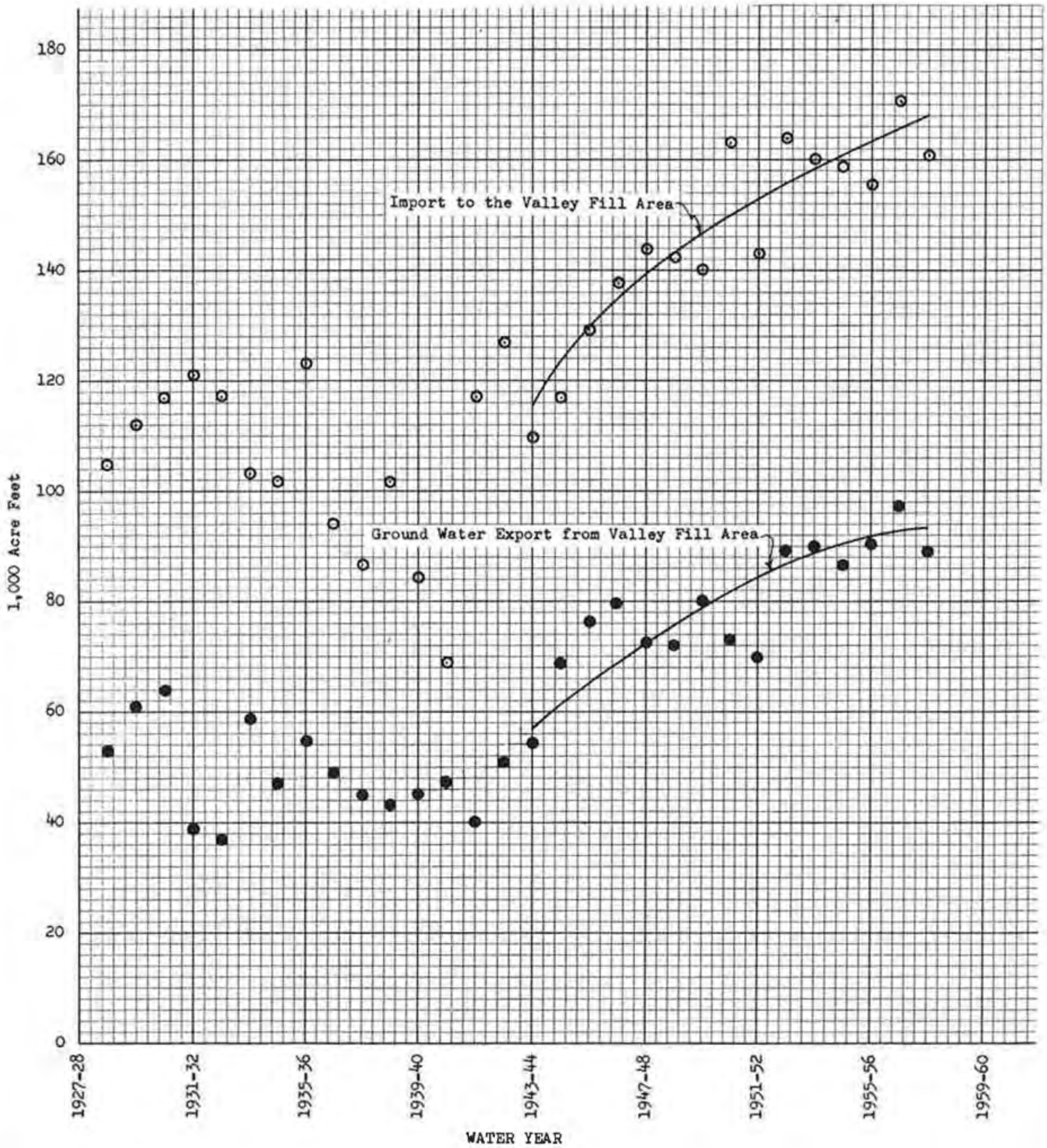
Evaluation of Safe Yield

The average net recharge from normal native supply and from average delivered water requirement can be the safe yield only if the delivered water requirement of, and export from, the valley fill area is met by import and ground water yield of imported and native waters. Thus, the amount of safe yield is affected by both the import and export conditions adopted for its determination.

Import and Export Conditions

Since the Order of Reference requires a determination of the effect of import on safe yield, and since export is related to import and also to the use of water in the City of Los Angeles outside the valley fill, the average historic amounts of import and export are used as a safe yield condition. The historic amounts of import to and export from the valley fill area are plotted on Figure 14 and trend curves representing the averages drawn. The ground water export (sum of columns 6 and 7, Table 34) includes amounts exported to hill and mountain areas and to areas outside the Upper Los Angeles River area. The annual amounts of import (column 1, Table 34) plotted on Figure 14 are those amounts available on the valley fill area after correction for changes in reservoir storage and do not include amounts of rain and runoff entering the water supply reservoirs (column 13, Table 20). It is apparent from Figure 14 that the historic amounts of each are influenced by both precipitation and operational procedures of municipal water supply systems. The average amounts of import and export taken from Figure 14 and the difference betweeen them are shown in Table 54.

FIGURE 14



TREND CURVES FOR IMPORT TO AND EXPORT FROM
THE VALLEY FILL AREA

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TABLE 54

AVERAGE IMPORT AND EXPORT
CONDITIONS FOR SAFE YIELD DETERMINATION

In 1,000 Acre-Feet

Item		Safe yield year 1949-50	1954-55	1957-58
1.	Import (Figure 14)	146.8	161.0	168.0
2.	Export (Figure 14)	79.5	90.5	93.5
3.	Import minus export	67.3	70.5	74.5

Safe Yield

Computation of safe yield first requires the evaluation of net recharge from native and imported water under safe yield conditions. Net recharge from these sources is the gross recharge less natural ground water depletions. Net recharge has been thus derived under Item 9 of Table 55. Since there is no return from ground water pumped for exportation, the total safe yield is equal to export plus the remaining net recharge converted to equivalent pumpage. Amounts of safe yield thus derived in Table 55 are 100,800, 100,400 and 97,600 acre-feet for 1949-50, 1954-55 and 1957-58 respectively. The safe yield of normal native supply and of average historic import are shown in Table 55 and have been determined by splitting the total safe yield in the ratio of gross recharge from both sources with the recharge from runoff to reservoirs being included under native supply.

TABLE 55

SAFE YIELD

In 1,000 Acre-Feet

Item	Safe yield year 1949-50	Safe yield year 1954-55	Safe yield year 1957-58
AVERAGE GROSS GROUND WATER RECHARGE OVER A PERIOD OF NORMAL NATIVE SUPPLY			
1. Gross recharge of average import	38.0	43.5	44.5
Determined from:			
a. Average import	146.8	161.0	168.0
b. Percent of delivered water becoming gross recharge	25.9%	27.0%	26.5%
2. Gross recharge of runoff to reservoirs	0.2	0.2	0.2
Determined from:			
a. Average runoff to reservoirs	0.6	0.6	0.6
b. Percent of delivered water becoming gross recharge	25.9%	27.0%	26.5%
3. Gross recharge of normal native supply exclusive of runoff to reservoirs	61.7	58.5	56.5
4. Total average gross ground water recharge	99.9	102.2	101.2
AVERAGE GROUND WATER DRAFT OVER A PERIOD OF NORMAL NATIVE SUPPLY			
5. Average natural ground water depletions	4.6	4.5	4.7
6. Average ground water export from the valley fill area	79.5	90.5	93.5
7. Subtotal - ground water depletions and export	84.1	95.0	98.2
8. Net recharge remaining for use as delivered water on valley fill	15.8	7.2	3.0
9. Net recharge remaining (Item 8) converted to pumpage	21.3	9.9	4.1
Determined from:			
a. Percent consumed or leaving valley fill area exclusive of ground water export	74.1%	73.0%	73.5%
SAFE YIELD			
10. Safe yield of average import and normal native supply	100.8	100.4	97.6
Prorated into:			
a. Safe yield derived from average import	38.7	42.7	42.9
b. Safe yield derived from normal native supply	62.1	57.7	54.7

Source and derivation of amounts shown on following page.

TABLE 55

SAFE YIELD
(continued)

Source and derivation of amounts by item number:

1.	Product of Items 1a and 1b.
1a.	Trend curve on Figure 14, page 245.
1b.	Item 9, Table 47, page 231.
2.	Product of Items 2a and 2b.
2a.	29-year average in Column 5, Table 51, page 238.
2b.	Item 9, Table 47, page 231.
3.	Item 4, Table 53, page 243.
4.	Sum of Items 1, 2 and 3.
5.	Item 7, Table 52, page 241.
6.	Trend curve on Figure 14, page 245.
7.	Sum of Items 5 and 6.
8.	Item 4 minus Item 7.
9.	Item 8 divided by Item 9a and multiplied by 100.
9a.	100 percent minus Item 1b.
10.	Sum of Items 6 and 9.
10a.	Item 1 multiplied by Item 10 and divided by Item 4.
10b.	Item 10 less Item 10a.

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Water Requirement and Supply
Under Safe Yield Conditions

The relationship between delivered water required under safe yield conditions and the delivered water available under the same conditions is set forth in Table 56. The water requirements are those determined in Table 46 plus the export of ground water from the valley fill area. The available water is the sum of native surface water diversion, imported water, and pumped ground water which is limited to the safe yield. Since the available water is less than the required water, it is apparent that under the import and export conditions set forth, a greater amount of ground water has historically been extracted than was replenished by recharge from normal native supply and average import. The result of this condition has been a progressive annual reduction of ground water in storage. To eliminate the deficiency that would exist between the water requirements under safe yield conditions and water supply under safe yield conditions, it would be necessary to adopt one or a combination of the following:

1. A reduction in extractions for export in the amount of Item 12, Table 56, while meeting average import and delivered water requirements.

2. An additional import in the amount of Item 12, Table 56, while meeting average export and delivered water requirements.

3. A reduction in extractions for delivery to the valley fill area in the amount of Item 10, Table 56, while meeting average import and export requirements.

TABLE 56

RELATIONSHIP BETWEEN WATER REQUIREMENTS
AND WATER SUPPLY UNDER SAFE YIELD CONDITIONS

In 1,000 Acre-Feet

Item	Safe yield year 1949-50	1954-55	1957-58
WATER REQUIREMENTS			
1. Average delivered water requirement, valley fill area	202.6	224.3	236.5
2. Average export from valley fill area	79.5	90.5	93.5
3. Total water requirement	282.1	314.8	330.0
WATER SUPPLY			
4. Surface diversion	0.0	0.0	0.0
5. Runoff to reservoirs	0.6	0.6	0.6
6. Safe yield derived from native sources	62.1	57.7	54.7
7. Average import	146.8	161.0	168.0
8. Safe yield derived from average import	38.7	42.7	42.9
9. Total water available to satisfy average delivered water requirement and average export	248.2	262.0	266.2
DEFICIENCY			
10. Portion of the total water requirement not satisfied by total water available	33.9	52.8	63.8
11. Percent of delivered water consumed or leaving valley fill area exclusive of ground water export	74.1%	73.0%	73.5%
12. Water requirement deficiency expressed as delivered water consumed or leaving valley fill area exclusive of ground water export	25.2	38.5	46.8

Source and derivation of amounts by item number:

Item No.

1. Item 7, Table 46, page 229.
2. Trend curve, Figure 14, page 245.
3. Sum of Items 1 and 2.
4. Assumed to be zero (see page 222).
5. 29-year average in column 5, Table 51, page 238.
6. Item 10b, Table 55, page 246b.
7. Trend curve, Figure 14, page 245.
8. Item 10a, Table 55, page 246b.
9. Sum of Items 4 through 8.
10. Item 3 minus Item 9.
11. Item 9a, Table 55, page 246b.
12. Item 10 multiplied by Item 11.

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That the foregoing amounts represent a consumptive demand that would not be satisfied under conditions of average import and export, is shown in the following example for the 1949-50 safe yield year be comparing the consumptive use and outflows of delivered water and ground water to the water available to satisfy these demands.

The consumptive demand consists of:

Average consumptive use and outflows of delivered water of 150,200 acre-feet (Item 7, Table 47, page 231).
Average natural depletions of ground water of 4,600 acre-feet (Item 7, Table 52, page 241).
Average export of ground water of 79,500 acre-feet (Item 2, Table 54, page 246).
For a total consumptive demand of 234,300 acre-feet.

The water available to satisfy the above demand consists of:

Average gross recharge of native waters of 61,700 acre-feet (Item 3, Table 55, page 246b).
Average runoff to reservoirs of 600 acre-feet (29-year average in Column 5, Table 51, page 238).
Average import to the valley fill area of 146,800 acre-feet (Item 1, Table 54, page 246).
For a total available water of 209,100 acre-feet.

The excess of consumptive demand over available water amounts to 25,200 acre-feet and is equivalent to the 25,200 acre-feet determined as Item 12 in Table 56.

Effect of Import on Safe Yield

Importation of foreign waters increased the safe yield of the ground water reservoir by 38,700, 42,700 and 42,900 acre-feet for the respective safe yield years of 1949-50, 1954-55 and 1957-58. As a result there was a decrease in deficiency of supply to meet the water requirements of the culture existing during the safe yield years to less than the deficiency which would have occurred had local sources been the sole supply.

CHAPTER VIII. THE USE OF WATER BY THE CITY OF LOS ANGELES AND ITS INHABITANTS

The scope of this chapter is limited to an evaluation of the gross water use from all sources by the City of Los Angeles and its inhabitants within the territory of the original Pueblo (since 1948) and within its expanded boundaries, and of the amounts of water distributed by the City of Los Angeles for use outside its boundaries, and satisfies the requirements of Paragraph I-5 and I-6 of the Order of Reference.

Use of Water by the City of Los Angeles Within the Territory of the Original Pueblo

The original Los Angeles Pueblo area contained four square leagues, the Spanish equivalent of 17,756 acres. However, the title of the land given to the City as a successor to the Pueblo, as surveyed in 1858, was only 17,172. The boundaries of the original Pueblo are delineated and recorded in the Book of Patents Number 3, pages 64 and 65.

The amount of water delivered by the City of Los Angeles for use within the original Pueblo boundary, as shown on Plate 36, has been determined by the City of Los Angeles for the period from 1949-50 through 1957-58. These values, including both measured and estimated amounts, consist of metered sales to customers, water pumped by the City Department

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of Recreation and Parks for irrigation of Elysian Park, and unaccounted-for water consisting of pipeline leakage and other minor losses. These values, tabulated in Table 57, do not include reservoir evaporation of approximately 175 acre-feet per year and a minor amount of pumpage from private wells within the pueblo area.

TABLE 57

USE OF WATER BY THE CITY OF LOS ANGELES WITHIN THE TERRITORY OF THE ORIGINAL PUEBLO*

Hydrologic year	Deliveries, in acre-feet
1949-50	73,533
1950-51	65,445
51-52	65,802
52-53	68,914
53-54	66,771
54-55	62,564
1955-56	63,673
56-57	64,368
57-58	60,692

* As per Patent 3, pages 64 and 65, encompassing 17,172 acres.

By applying the water requirements given in State Water Resources Board Bulletin No. 24 to the acreage of the various types of culture as determined in 1955 by the Department of Water Resources, the values determined by the City of Los Angeles appear reasonable. The existing culture is predominantly residential and industrial and commercial and includes a small amount of irrigated agriculture.

Use of Water by the City of Los Angeles Within its Expanded Boundaries

The total use of water by the City of Los Angeles within its expanded boundaries, including the original Pueblo, is considered to be that quantity of water which has been delivered to its distribution system to supply demands for all uses within the boundary in existence at that time. The present boundary of the City of Los Angeles and the changes in the boundary that have occurred from time to time are shown on Plate 36. In addition to consumer deliveries, use includes operational losses and use by the several city departments. Records of ground water pumpage by all private parties for use within the city's boundaries are not readily available and therefore are not included in the values of total use presented herein. Water distributed for use outside the city boundaries is discussed subsequently and included in the total use.

Water delivered to the City of Los Angeles distribution system includes the major portion of Owens-Mono Basin import measured in San Fernando Valley, Colorado River water measured at the several connections to Metropolitan Water District feeders and all local extractions by the several city departments in the Coastal Plain and in San Fernando Valley. Owens-Mono Basin water which is spread in San Fernando Valley and that which is spilled into the Los Angeles River were not considered to be in the distribution system and were subtracted from the measured import. Exchange of water between the City of Los Angeles and The Metropolitan Water District has occurred in several instances where the city supplies other agencies and is reimbursed with Colorado River water. That quantity has been subtracted from the city's Colorado River import. Measured change in storage in the surface reservoirs within the city's boundaries has also been included in the determination of total use.

Table 58 shows the water use within the expanded boundaries of the City of Los Angeles along with the items of supply to the distribution system and the modifications that were made in arriving at the use values.

A portion of the water used by the City of Los Angeles is extracted from the ground water supply of Central and West Coast Basins in the Coastal Plain. There exists, however, a state of overdraft in each basin (References: State Water Resources Board, "Central Basin Investigation", Bulletin No. 8, March, 1952; Department of Public Works, Draft of Report of Referee, West Coast Basin Reference, February, 1952).

The amounts of ground water extracted by the City of Los Angeles from areas outside the Upper Los Angeles River area and used by the City of Los Angeles within its boundaries, are listed in Table 59.

TABLE 58

USE OF WATER BY THE CITY OF LOS ANGELES WITHIN THE CITY BOUNDARIES

In Acre-Feet

Year	Import: Owens-Mono Basin (1)	Import: Owens-Mono Basin water spread (2)	Import: Owens-Mono Basin water spilled into Los Angeles River (3)	Import: Net Owens-Mono Basin (1)-(2)-(3)=(4)	Import: Colorado River (5)	Import: Subtotal (4)+(5)=(6)	Local ground water extractions by City Departments: Water and power (7)	Local ground water extractions by City Departments: Parks (8)	Local ground water extractions by City Departments: Airports (9)	Local ground water extractions by City Departments: Harbor (10)	Local ground water extractions by City Departments: Subtotal (7)+(8)+(9)+(10)=(11)	Subtotal (6)+(11)=(12)	Change in reservoir storage (13)	Water used by the City (12)+(13)=(14)
1928-29	190,103	590	No record	189,513	0	190,103	79,567	1,750	9	830	82,156	271,669	- 2,222	273,891
29-30	198,127	0	No record	198,127	0	198,127	84,832	1,750	9	830	87,421	285,548	- 2,985	288,533
1930-31	215,747	7,280	No record	208,467	0	208,467	83,525	2,450	9	830	86,814	295,281	10,563	284,718
31-32	238,195	31,743	0	206,452	0	206,452	50,308	2,370	9	830	53,517	259,969	5,100	254,869
32-33	228,432	33,429	0	195,003	0	195,003	47,333	2,440	9	821	50,603	245,606	140	245,466
33-34	185,579	20,855	0	164,724	0	164,724	70,296	2.360	8	832	73,496	238,220	- 3,230	241,450
34-35	194,924	30,804	0	164,120	0	164,120	59,485	2,030	8	759	62,282	226,402	- 1,590	227,992
1935-36	236,945	22,716	0	214,229	0	214,229	59,219	2,520	7	896	62,642	276,871	5,240	271,631
36-37	206,673	9,307	0	197,366	0	197,366	53,687	2,990	8	842	57,527	254,893	- 1,330	256,223
37-38	209,081	7,315	0	201,766	0	201,766	49,246	3,540	4	758	52,548	254,314	- 1,970	256,284
38-39	237,254	14,911	0	222,343	0	222,343	46,385	4,030	6	915	51,336	273,679	170	273,509
39-40	217,158	3,407	0	213,751	0	213,751	47,464	3,800	3	1,087	52,354	266,105	2,580	263,525
1940-41	200,976	3,446	0	197,530	331	197,861	50,364	3,470	2	1,008	54,844	252,705	5,270	247,435
41-42	246,350	11,290	6,268	228,792	526	229,318	44,477	3,000	2	514	47,993	277,311	- 5,160	282,471
42-43	264,396	12,130	8,702	243,564	227	243,791	56,021	3,020	2	170	59,213	303,004	- 5,750	308,754
43-44	274,495	3,191	2,862	268,442	245	268,687	60,485	2,740	6	103	63,334	332,021	5,630	326,391
44-45	267,238	0	1,305	265,933	1,620	267,553	77,069	2,920	5	0	79,994	347,547	- 5,640	353,187
1945-46	283,968	0	7,869	276,099	7,190	283,289	86,141	4,390	6	79	90,616	373,905	- 1,920	375,825
46-47	291,015	1,687	7,683	281,645	9,294	290,939	90,825	2,820	3	110	93,758	384,697	- 890	385,587
47-48	306,458	0	2,935	303,523	14,888	318,411	85,460	3,220	4	499	89,183	407,594	3,030	404,564
48-49	298,462	0	1,463	296,999	15,378	312,377	84,019	3,390	552	228	88,189	400,566	- 5,169	405,735
49-50	305,398	762	1,337	303,299	5,155	308,454	92,437	3,430	551	367	96,785	405,239	7,611	397,628
1950-51	317,374	2,354	3,942	311,078	13,697	324,775	89,854	3,440	4	367	93,665	418,440	- 7,114	425,554
51-52	316,568	7,281	2,834	306,453	15,597	322,050	90,126	2,930	54	367	93,477	415,527	1,947	413,580
52-53	320,924	0	5,408	315,516	15,973	331,459	119,556	2,920	54	367	122,897	454,386	- 2,121	456,507
53-54	318,589	0	3,176	315,413	18,671	334,084	113,202	2,780	27	262	116,271	450,355	- 1,893	452,248
54-55	316,319	0	7,863	308,456	28,966	337,422	105,781	2.780	0	262	108,823	446,245	860	445,385
1955-56	321,256	1,610	4,003	315,643	29,303	344,946	109,487	2,440	0	262	112,189	457,135	6,010	451,125
56-57	318,389	0	1,565	316,824	36,007	352,831	116,107	2 720	0	262	119,089	471,920	- 5,714	477,634
57-58	325,387	0	90	325,297	28.768	354,065	106,327	2,131	0	48	108,506	462,571	3,225	459,346
29-year (1929-57) Average	259,531	7,797	2,387	249,347	7,347	256,694	75,957	2,912	47	533	79,414	336,109	- 19	336,128

Source and derivation of amounts by column numbers.

Column No.

1. Column 1, Table M-1.
2. Sum of Columns 2 and 3, Table 23.
3. Column 8, Table M-1 for years 1940-41 through 1957-58. Does not include discharge from River Power Plant.
5. City of Los Angeles.
7. City of Los Angeles.
8. City of Los Angeles. Year 1945-46 includes Department of Public Works extraction of 1,325 acre-feet.
9. City of Los Angeles.
10. City of Los Angeles.
13. Column 4, Table M-1.

TABLE 59

GROUND WATER EXTRACTED BY CITY OF LOS ANGELES FROM AREAS OUTSIDE THE UPPER LOS ANGELES RIVER AREA

In Acre-Feet

Year	Ground water extractions outside Upper Los Angeles River area		
	Department of Water and Power[a]	Other departments[b]	Total
1928-29	17,984	839	18,823
29-30	18,960	839	19,799
1930-31	15,567	839	16,406
31-32	8,410	839	9,249
32-33	8,531	830	9,361
33-34	9,805	840	10,645
34-35	10,583	767	11,350
1935-36	3,591	903	4,494
36-37	2,983	850	3,833
37-38	3,423	762	4,185
38-39	2,482	921	3,403
39-40	2,195	1,090	3,285
1940-41	2,392	1,010	3,402
41-42	2,785	516	3,301
42-43	3,633	172	3,805
43-44	4,552	109	4,661
44-45	6,524	5	6,529
1945-46	9,113	85	9,198
46-47	8,394	113	8,507
47-48	8,413	503	8,916
48-49	7,800	780	8,580
49-50	10,496	918	11,414
1950-51	14,597	371	14,968
51-52	14,881	421	15,302
52-53	24,141	421	24,562
53-54	19,430	289	19,719
54-55	18,035	262	18,297
1955-56	16,798	262	17,060
56-57	17,172	262	17,434
57-58	16,436	48	16,484

a. From wells owned and operated by the City of Los Angeles and their predecessors in Central, West Coast and West Coastal Plain-North Basins.
b. Airports and Harbors (see Table 51).

Water Distributed by the City of Los Angeles for Use Outside Its Boundaries

Records of water distributed by the City of Los Angeles for use outside its boundaries, but not including unmeasured distribution along the Los Angeles Aqueduct or exchange water supplied to others for The Metropolitan Water District, are readily available only for the period from 1950-51 through 1954-55 and for the year 1959-60. The water so distributed during the 1950-51 through 1954-55 period is grouped into four categories: (1) acquired services are those served by a water company purchased by the City, (2) governmental services are either Federal, State, County or City agencies, (3) miscellaneous services are those in unincorporated areas and (4) reciprocal services are those in adjacent incorporated municipalities and in County Water Works District No. 3 supplied by the City and, in return, the City of Los Angeles is given a like amount by the entity in which the services are located. The water distributed during 1959-60 is shown as a total of these groups.

Amounts of water delivered by the City of Los Angeles for use to parcels partially outside and to parcels completely outside its boundaries for the 5-year period from 1950-51 through 1954-55 are shown in Table 60. The total amount served to both types of parcels is also shown in Table 60 for the period 1950-51 through 1959-60.

TABLE 60

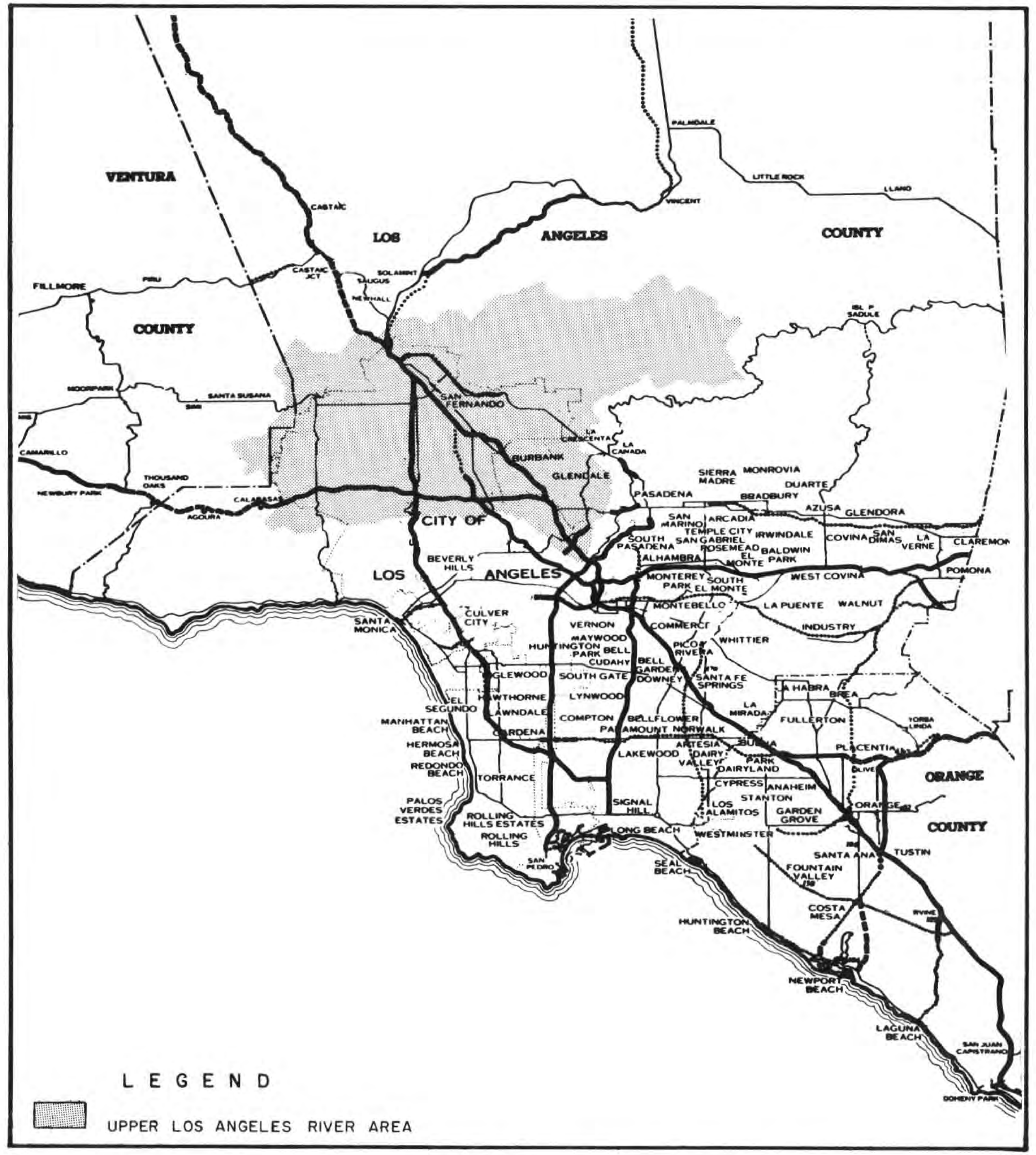
WATER DISTRIBUTED BY THE CITY OF LOS ANGELES TO AREAS OUTSIDE AND PARTIALLY OUTSIDE ITS BOUNDARIES

In Acre-Feet

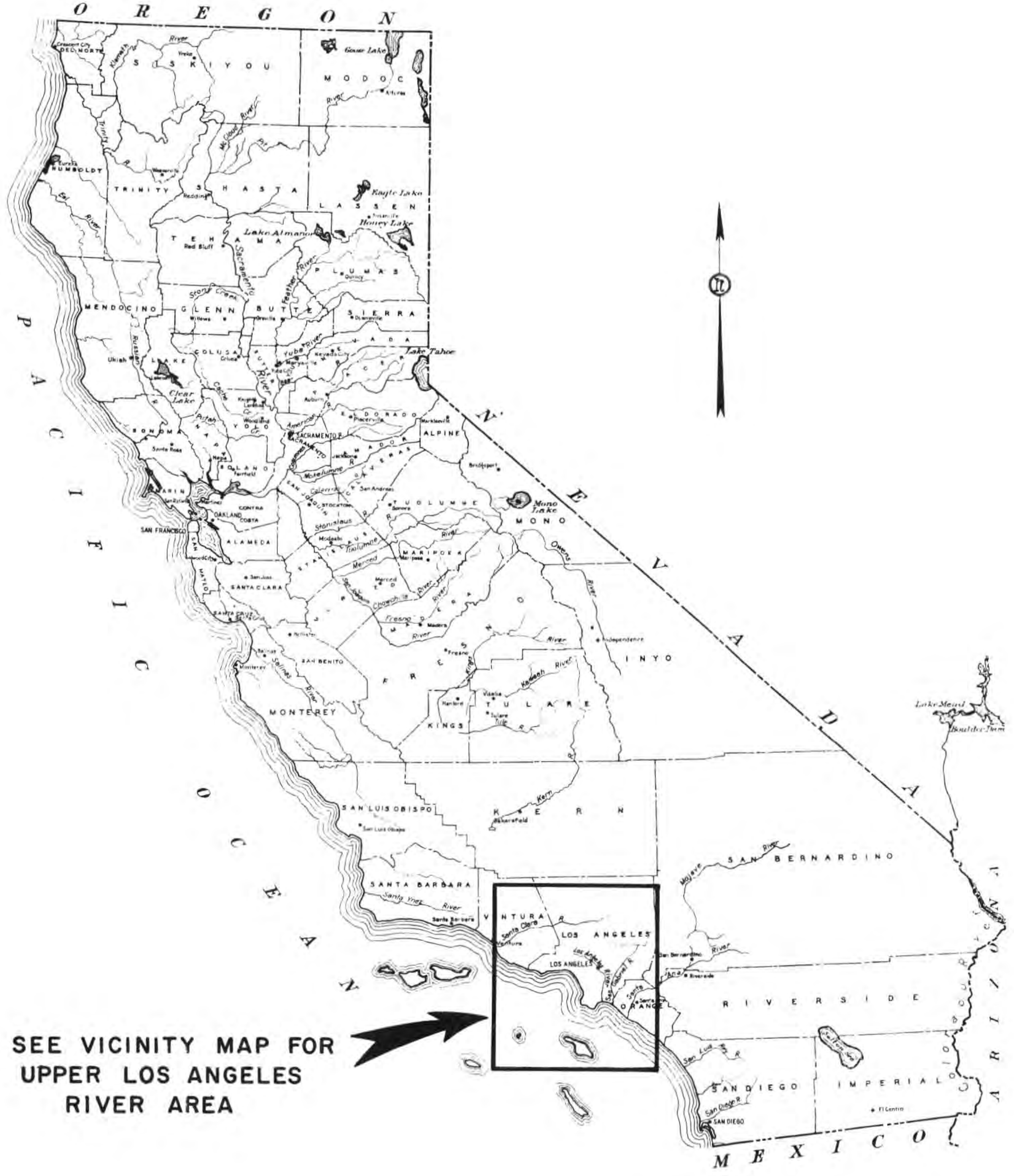
Year	Distributed to parcels outside city boundary	Distributed to parcels partially outside city boundary[a]	Distributed to parcels wholly and partially outside city boundary[a]
1950-51	4,316	1,489	5,805
1951-52	4,865	1,469	6,334
1952-53	5,260	1,801	7,061
1953-54	5,386	1,865	7,251
1954-55	5,362	2,044	7,406
1955-56	--	--	7,699[b]
1956-57	--	--	7,993[b]
1957-58	--	--	8,286[b]
1958-59	--	--	8,580[b]
1959-60	--	--	8,873

a. Includes water delivered within the city boundary.
b. No data available, amounts estimated by interpolation between 1954-55 and 1959-60

72252-C 9-62 350 SPO



VICINITY MAP
SCALE
0 5 10 15 Miles



LOCATION MAP

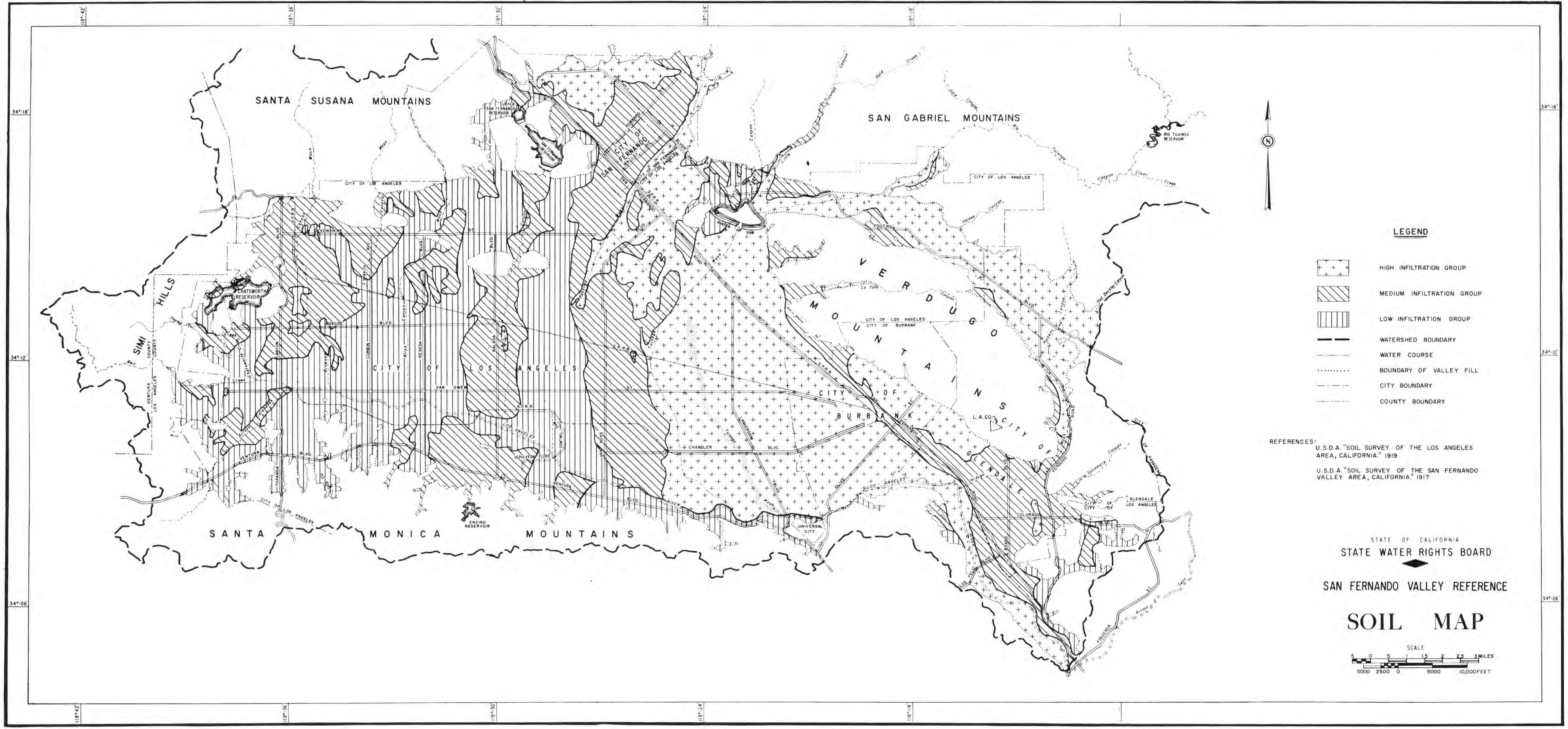
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

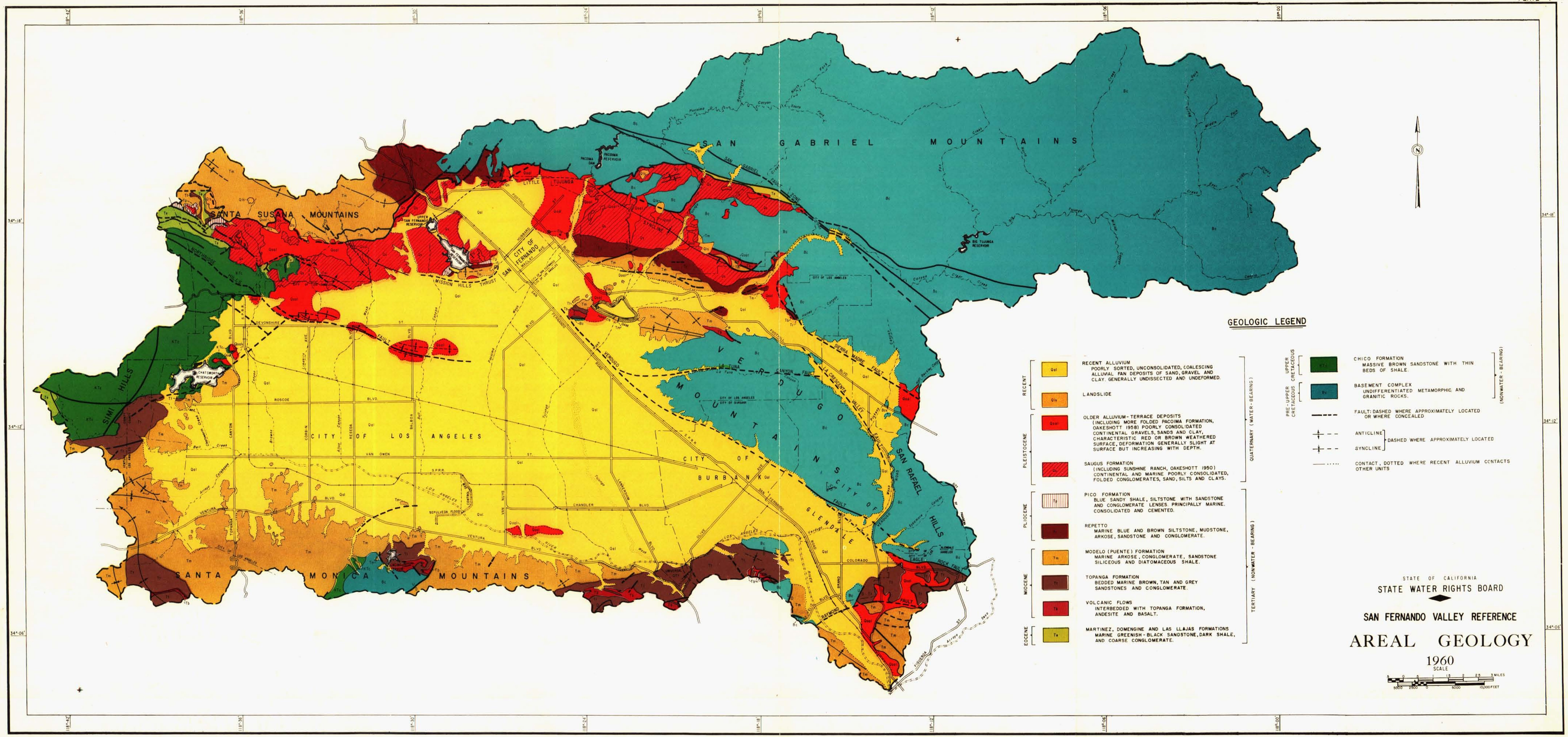
VICINITY & LOCATION MAPS

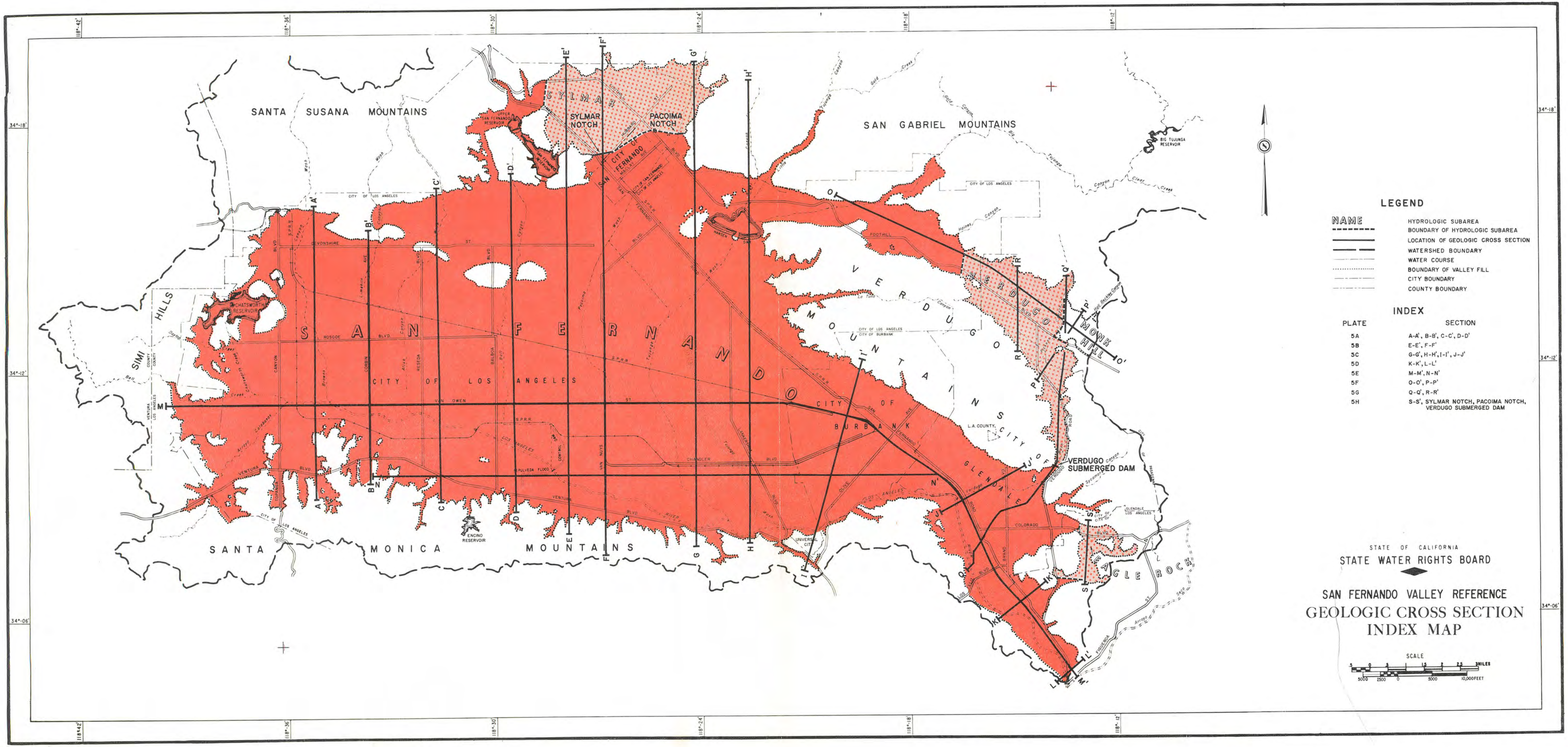
PLATE 2

MAGIC MTN.
ELEV. 4880
GLEASON MTN.
ELEV. 6532
PACIFICO MTN.
ELEV. 7124
UNNAMED PEAK
ELEV. 6192
UNNAMED PEAK
ELEVATION 3670
OAT MTN. LOOKOUT
ELEV. 3747
SAN GABRIEL MOUNTAINS
SANTA SUSANA MOUNTAINS
MISSION HILLS
SAN FERNANDO
CITY OF SAN FERNANDO
SANTA SUSANA PASS
CHATSWORTH PEAK
ELEV. 2314
BURRO FLATS
PACOIMA HILLS
CITY OF LOS ANGELES
STRAWBERRY PEAK
ELEV. 6164
BARLEY FLATS
UNNAMED PEAK
ELEV. 5410
UNNAMED PEAK
ELEV. 4306
SUNLAND-LA CRESCENTA PIEDMONT SLOPE
VERDUGO MOUNTAINS
NORTHRIDGE HILLS
SIMI HILLS
CHATSWORTH HILLS
DEVONSHIRE
ROSCOE BLVD.
VAN OWEN ST.
CITY OF LOS ANGELES
VAN NUYS PLAIN AND ASSOCIATED FEATURES
CITY OF BURBANK
BURBANK PIEDMONT SLOPE
SAN RAFAEL HILLS
LASKEY MESA
WOODLAND HILLS
CHALK HILLS
VENTURA BLVD.
SEPULVEDA FLOOD CONTROL
CHANDLER BLVD.
GLENDALE
EAGLE ROCK
COLORADO
SANTA MONICA MOUNTAINS
SAN RAFAEL HILLS
UNIVERSAL CITY
CAHUENGA PEAK
ELEV. 1825
UNNAMED PEAK
ELEV. 1689
SAN VINCENTE MTN.
ELEV. 1961
ELYSIAN HILLS
REPETTO HILLS
LOS ANGELES RIVER
L.A.C.F.C.D. GAGE F-57
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL ELEVATION OF GROUND SURFACE
REFERENCE: CONTOURS BASED ON U.S.G.S. QUADS
DATUM IS MEAN SEA LEVEL
CONTOUR INTERVALS 50, 200 AND 400 FEET
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
PHYSIOGRAPHY MAP
SCALE
118°42'
118°36'
118°30'
118°24'
118°18'
118°12'
118°06'
118°00'
34°18'
34°12'
34°06'


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
SIMI HILLS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
SAN FERNANDO RESERVOIR
UNIVERSAL CITY
LEGEND
HIGH INFILTRATION GROUP
MEDIUM INFILTRATION GROUP
LOW INFILTRATION GROUP
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
REFERENCES:
U.S.D.A. "SOIL SURVEY OF THE LOS ANGELES AREA, CALIFORNIA." 1919
U.S.D.A. "SOIL SURVEY OF THE SAN FERNANDO VALLEY AREA, CALIFORNIA." 1917
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
SOIL MAP
SCALE
5 0 .5 1 1.5 2 2.5 3 MILES
5000 2500 0 5000 10,000 FEET
118°-42'
118°-36'
118°-30'
118°-24'
118°-18'
34°-18'
34°-12'
34°-06'

175


SAN GABRIEL MOUNTAINS
SANTA SUSANA MOUNTAINS
SIMI HILLS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
SAN RAFAEL HILLS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
MISSION HILLS THRUST
PACOIMA RESERVOIR
BIG TUJUNGA RESERVOIR
CHATSWORTH RESERVOIR
GEOLOGIC LEGEND
RECENT
PLEISTOCENE
PLIOCENE
MIOCENE
EOCENE
Qal RECENT ALLUVIUM POORLY SORTED, UNCONSOLIDATED, COALESCING ALLUVIAL FAN DEPOSITS OF SAND, GRAVEL AND CLAY. GENERALLY UNDISSECTED AND UNDEFORMED.
Qls LANDSLIDE
Qoal OLDER ALLUVIUM-TERRACE DEPOSITS (INCLUDING MORE FOLDED PACOIMA FORMATION, OAKESHOTT 1958) POORLY CONSOLIDATED CONTINENTAL GRAVELS, SANDS AND CLAY, CHARACTERISTIC RED OR BROWN WEATHERED SURFACE, DEFORMATION GENERALLY SLIGHT AT SURFACE BUT INCREASING WITH DEPTH.
Qs SAUGUS FORMATION (INCLUDING SUNSHINE RANCH, OAKESHOTT 1950) CONTINENTAL AND MARINE POORLY CONSOLIDATED, FOLDED CONGLOMERATES, SAND, SILTS AND CLAYS.
QUATERNARY (WATER-BEARING)
Tp PICO FORMATION BLUE SANDY SHALE, SILTSTONE WITH SANDSTONE AND CONGLOMERATE LENSES. PRINCIPALLY MARINE. CONSOLIDATED AND CEMENTED.
Tr REPETTO MARINE BLUE AND BROWN SILTSTONE, MUDSTONE, ARKOSE, SANDSTONE AND CONGLOMERATE.
Tm MODELO (PUENTE) FORMATION MARINE ARKOSE, CONGLOMERATE, SANDSTONE SILICEOUS AND DIATOMACEOUS SHALE.
Tt TOPANGA FORMATION BEDDED MARINE BROWN, TAN AND GREY SANDSTONES AND CONGLOMERATE.
Tb VOLCANIC FLOWS INTERBEDDED WITH TOPANGA FORMATION, ANDESITE AND BASALT.
Te MARTINEZ, DOMENGINE AND LAS LLAJAS FORMATIONS MARINE GREENISH-BLACK SANDSTONE, DARK SHALE, AND COARSE CONGLOMERATE.
TERTIARY (NONWATER-BEARING)
UPPER CRETACEOUS
PRE-UPPER CRETACEOUS
KTc CHICO FORMATION MASSIVE BROWN SANDSTONE WITH THIN BEDS OF SHALE.
Bc BASEMENT COMPLEX UNDIFFERENTIATED METAMORPHIC AND GRANITIC ROCKS.
(NONWATER-BEARING)
FAULT: DASHED WHERE APPROXIMATELY LOCATED OR WHERE CONCEALED
ANTICLINE
SYNCLINE
DASHED WHERE APPROXIMATELY LOCATED
CONTACT, DOTTED WHERE RECENT ALLUVIUM CONTACTS OTHER UNITS
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
AREAL GEOLOGY
1960
SCALE
3 MILES
10,000 FEET


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SYLMAR
SYLMAR NOTCH
PACOIMA NOTCH
CITY OF SAN FERNANDO
SAN FERNANDO
CITY OF LOS ANGELES
CHATSWORTH RESERVOIR
SIMI HILLS
VERDUGO MOUNTAINS
VERDUGO
MONK HILL
CITY OF BURBANK
CITY OF GLENDALE
VERDUGO SUBMERGED DAM
EAGLE ROCK
SANTA MONICA MOUNTAINS
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
LEGEND
NAME HYDROLOGIC SUBAREA
BOUNDARY OF HYDROLOGIC SUBAREA
LOCATION OF GEOLOGIC CROSS SECTION
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
INDEX
PLATE SECTION
5A A-A', B-B', C-C', D-D'
5B E-E', F-F'
5C G-G', H-H', I-I', J-J'
5D K-K', L-L'
5E M-M', N-N'
5F O-O', P-P'
5G Q-Q', R-R'
5H S-S', SYLMAR NOTCH, PACOIMA NOTCH, VERDUGO SUBMERGED DAM
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GEOLOGIC CROSS SECTION
INDEX MAP
SCALE
3 MILES
10,000 FEET

LEGEND

- CLAY
- SAND
- GRAVEL
- SAND AND GRAVEL
- SEDIMENTARY NONWATER-BEARING ROCKS

WATER-BEARING

- Qal — RECENT ALLUVIUM
- Qoal — OLDER ALLUVIUM - TERRACE DEPOSITS
- Qs — SAUGUS FORMATION

NONWATER-BEARING

- Qsm — SAUGUS FORMATION - MARINE FACIES
- Tp — PICO FORMATION
- Tr — REPETTO FORMATION
- Tm — MODELO (PUENTE) FORMATION
- Tt — TOPANGA FORMATION
- T? — UNDIFFERENTIATED TERTIARY
- Bc — BASEMENT COMPLEX

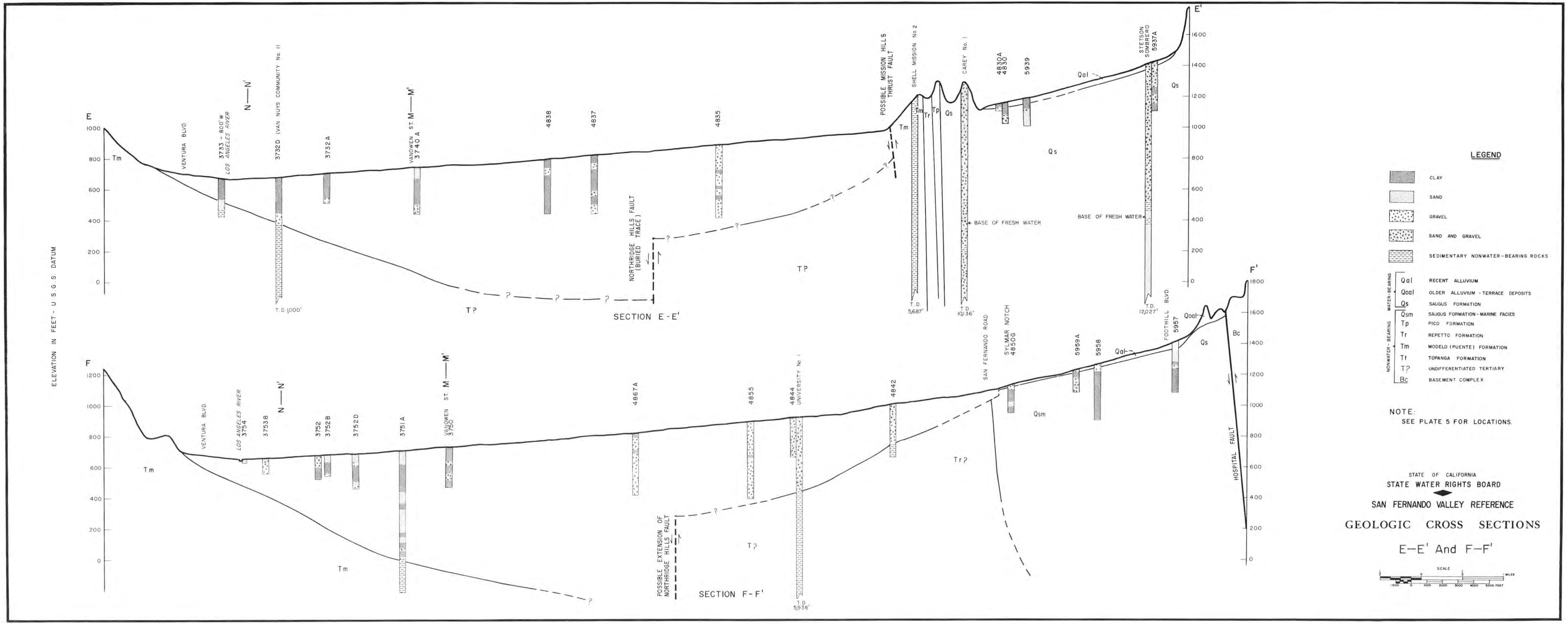
NOTE:
SEE PLATE 5 FOR LOCATIONS.

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

GEOLOGIC CROSS SECTIONS
A–A', B–B', C–C', And D–D'

SCALE



STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

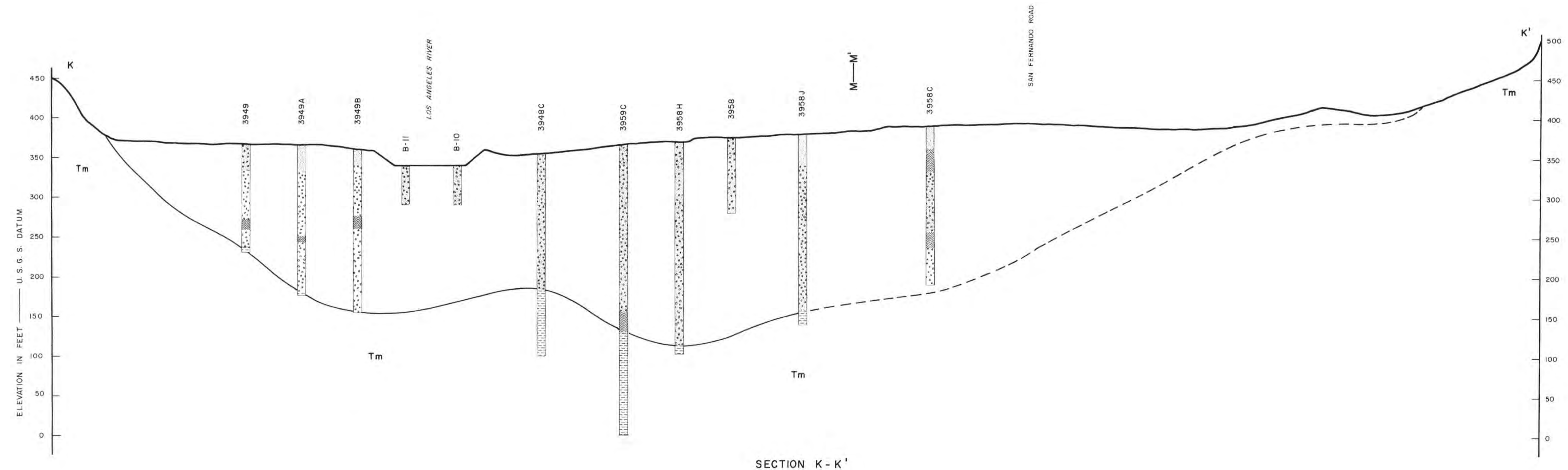
SAN FERNANDO VALLEY REFERENCE

GEOLOGIC CROSS SECTIONS

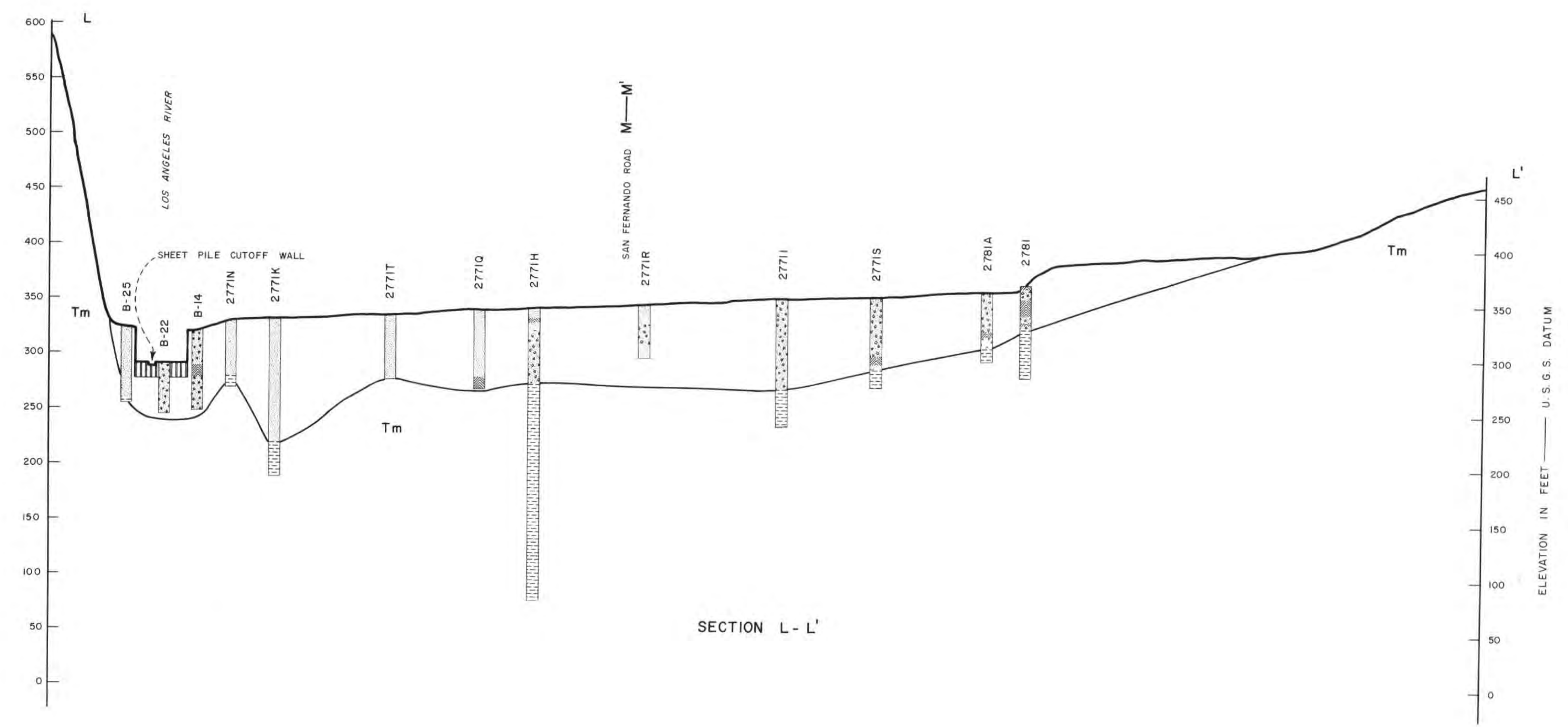
E—E' And F—F'

PLATE 5C


ELEVATION IN FEET - U.S.G.S. DATUM
SECTION G-G'
VENTURA BLVD.
LOS ANGELES RIVER
CHANDLER BLVD.
LANKERSHIM BLVD.
VANOWEN ST
SAN FERNANDO RD.
FOOTHILL BLVD.
PACOIMA CREEK
VERDUGO FAULT
PACOIMA HILLS FAULT
SECTION H-H'
TUJUNGA WASH
HANSEN DAM
GRAVEL PIT
BARTHOLOMAUS FAULT
LOPEZ FAULT
SECTION I-I'
TOLUCA LAKE
SECTION J-J'
BRAND BLVD.
EAGLE ROCK FAULT
LEGEND
CLAY
SAND
GRAVEL
SAND AND GRAVEL
SEDIMENTARY NONWATER-BEARING ROCKS
WATER-BEARING
Qal RECENT ALLUVIUM
Qoal OLDER ALLUVIUM - TERRACE DEPOSITS
Qs SAUGUS FORMATION
NONWATER-BEARING
Tp PICO FORMATION
Tr REPETTO FORMATION
Tm MODELO (PUENTE) FORMATION
Tt TOPANGA FORMATION
T? UNDIFFERENTIATED TERTIARY
Bc BASEMENT COMPLEX
NOTE:
SEE PLATE 5 FOR LOCATIONS.
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GEOLOGIC CROSS SECTIONS
G-G', H-H', I-I', And J-J'
SCALE



SECTION K-K'



SECTION L-L'

LEGEND

- CLAY
- SAND
- GRAVEL
- SAND AND GRAVEL
- SEDIMENTARY NONWATER-BEARING ROCKS

WATER-BEARING

- Qal RECENT ALLUVIUM
- Qoal OLDER ALLUVIUM - TERRACE DEPOSITS
- Qs SAUGUS FORMATION

NONWATER-BEARING

- Tp PICO FORMATION
- Tr REPETTO FORMATION
- Tm MODELO (PUENTE) FORMATION
- Tt TOPANGA FORMATION
- Bc BASEMENT COMPLEX

NOTE:
SEE PLATE 5 FOR LOCATIONS.

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

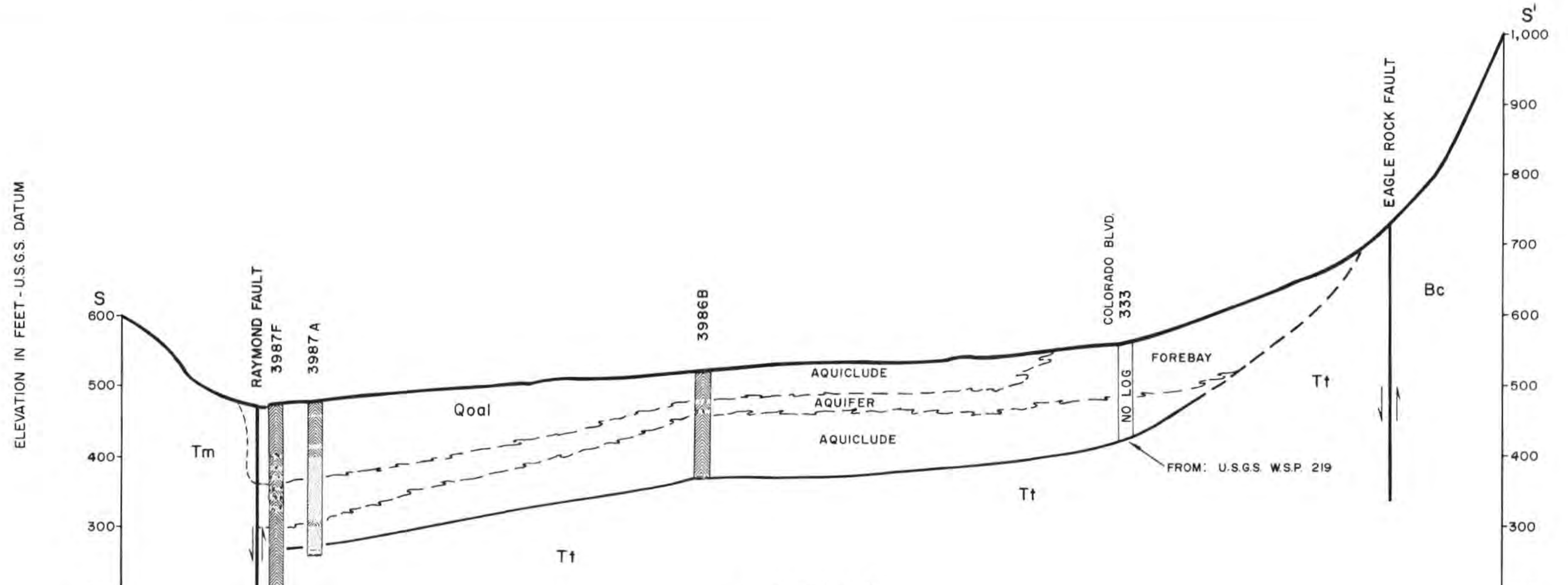
GEOLOGIC CROSS SECTIONS
K-K' And L-L'

SCALE
200 0 200 400 600 FEET


ELEVATION IN FEET - U.S.G.S. DATUM
SECTION ALONG VANOWEN STREET
SECTION M - M'
SECTION ALONG SOUTHERN PACIFIC RIGHT OF WAY
MATCH LINE
LOS ANGELES RIVER
POSSIBLE EXTENSION OF EAGLE ROCK FAULT
INFERRED RAYMOND FAULT
SECTION ALONG SOUTHERN PACIFIC RIGHT OF WAY
SECTION M - M'
(CONTINUED)
SECTION N-N'
SECTION ENDS AT M-M'
TUJUNGA FLOOD CONTROL CHANNEL
LEGEND
CLAY
SAND
GRAVEL
SAND AND GRAVEL
SEDIMENTARY NONWATER-BEARING ROCKS
WATER-BEARING
Qal RECENT ALLUVIUM
Qoal OLDER ALLUVIUM - TERRACE DEPOSITS
Qs SAUGUS FORMATION
NONWATER - BEARING
Tp PICO FORMATION
Tr REPETTO FORMATION
Tm MODELO (PUENTE) FORMATION
Tt TOPANGA. FORMATION
Bc BASEMENT COMPLEX
NOTE:
SEE PLATE 5 FOR LOCATIONS.
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GEOLOGIC CROSS SECTIONS
M-M' And N-N'
SCALE
1000 0 1000 2000 3000 4000 5000 FEET
1 MILES

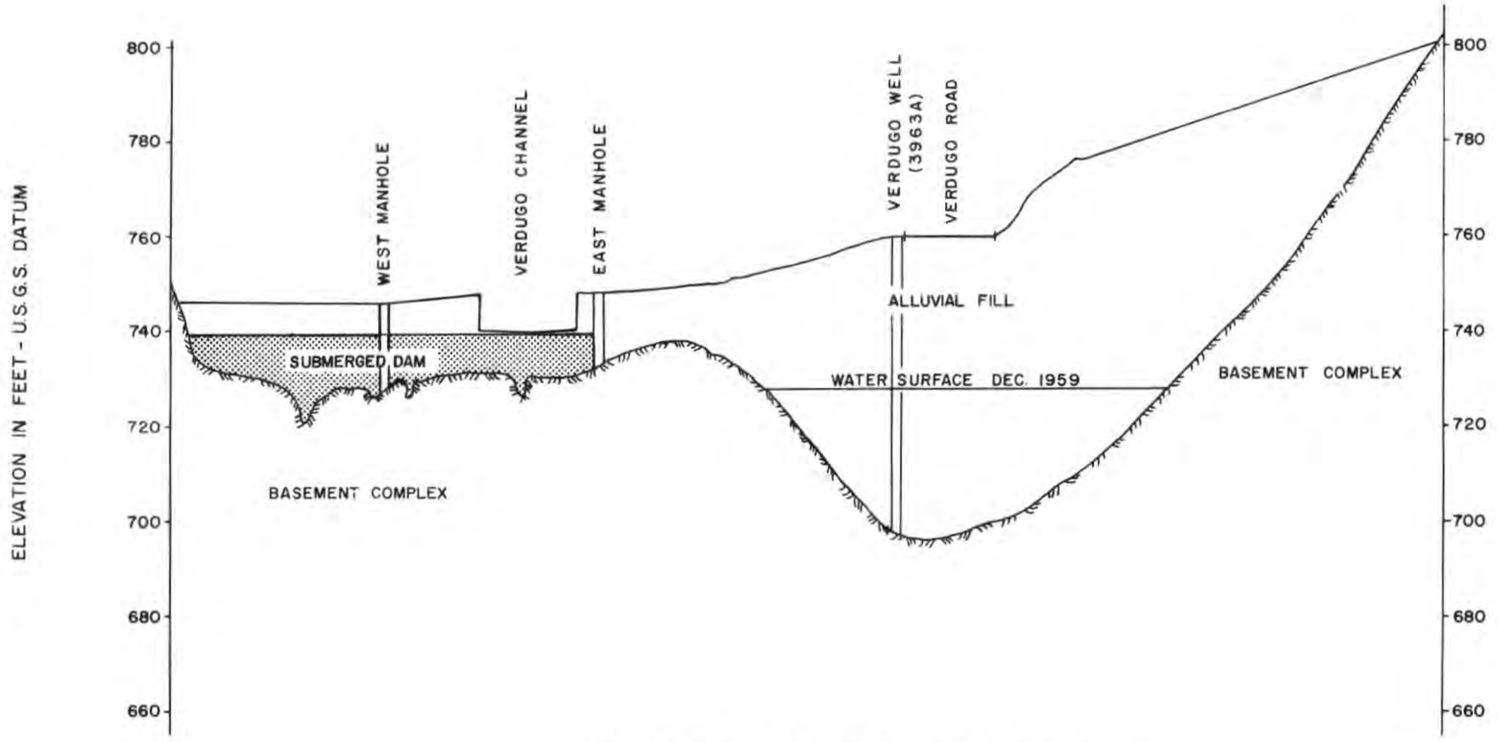

PLATE 5F
O
O'
P
P'
ELEVATION IN FEET - U.S.G.S. DATUM
BIG TUJUNGA WASH
4983E 225' SOUTH OF SECTION
4983J 850' SOUTH OF SECTION
4993 150' SOUTH OF SECTION
5014 500' SOUTH OF SECTION
HAINES CANYON CHANNEL
TOPOGRAPHIC DIVIDE
5035 2100' SOUTH OF SECTION
5046 3700' SOUTH OF SECTION
5056 1400' SOUTH OF SECTION
5066A 1800' NORTH OF SECTION
5066 200' NORTH OF SECTION
MONK HILL BASIN
PICKENS CANYON CHANNEL
5077 300' SOUTH OF SECTION
5077A 1200' NORTH OF SECTION
5078C 1900' SOUTH OF SECTION
5078A 1500' SOUTH OF SECTION
5078 2900' SOUTH OF SECTION
Q—Q'
P—P'
TOPOGRAPHIC DIVIDE
5099A
Qal
Tm
Tr?
Bc
?
SECTION O-O'
SECTION PARALLEL TO AND APPROXIMATELY 2000' NORTH OF FOOTHILL BLVD.
5069
5069G
5069D
5069H
INFERRED LA CRESCENTA VALLEY FAULT
FOOTHILL BLVD
5078
Q—Q'
5078A - 350' E
O—O'
5077A
INFERRED SIERRA MADRE FAULT ZONE
SECTION P-P'
SECTION NEAR HALLS CANYON CHANNEL
LEGEND
CLAY
SAND
GRAVEL
SAND AND GRAVEL
GRANITIC NONWATER-BEARING ROCKS
WATER-BEARING
Qal RECENT ALLUVIUM
Qoal OLDER ALLUVIUM - TERRACE DEPOSITS
Qs SAUGUS FORMATION
NONWATER-BEARING
Tp PICO FORMATION
Tr REPETTO FORMATION
Tm MODELO (PUENTE) FORMATION
Tt TOPANGA FORMATION
Bc BASEMENT COMPLEX
NOTE:
SEE PLATE 5 FOR LOCATIONS
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GEOLOGIC CROSS SECTIONS
O-O' And P-P'
SCALE


Q
Q'
R
R'
ELEVATION IN FEET — U.S.G.S. DATUM
MATCH LINE
LOS ANGELES RIVER
3927A
3926C
SAN FERNANDO ROAD
3936
3935-1500'N
BRAND BLVD.
3945-1750'N
3954
EAGLE ROCK FAULT
Tm
Tm?
Tt?
3963
NO LOG
VERDUGO FAULT
SUBMERGED DAM
3971
3971C
3970
INFERRED LA CRESCENTA VALLEY FAULT ZONE
VERDUGO ROAD
5069H-1500'W
5079-450'E
FOOTHILL BLVD.
5078C
5077-650'W
P—P'
O—O'
INFERRED SIERRA MADRE FAULT ZONE
PICKENS CANYON
5076-750'W
Bc
SECTION Q-Q'
VERDUGO WASH
5058H
5057
FOOTHILL BLVD.
5056
300' W
SECTION R-R'
LEGEND
CLAY
SAND
GRAVEL
SAND AND GRAVEL
SEDIMENTARY NONWATER-BEARING
GRANITIC NONWATER-BEARING ROCKS
WATER-BEARING
Qal RECENT ALLUVIUM
Qoal OLDER ALLUVIUM-TERRACE DEPOSITS
Qs SAUGUS FORMATION
NONWATER-BEARING
Tp PICO FORMATION
Tr REPETTO FORMATION
Tm MODELO (PUENTE) FORMATION
Tt TOPANGA FORMATION
Bc BASEMENT COMPLEX
NOTE:
SEE PLATE 5 FOR LOCATIONS.
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GEOLOGIC CROSS SECTIONS
Q-Q' And R-R'
SCALE
1000 0 1000 2000 3000 FEET



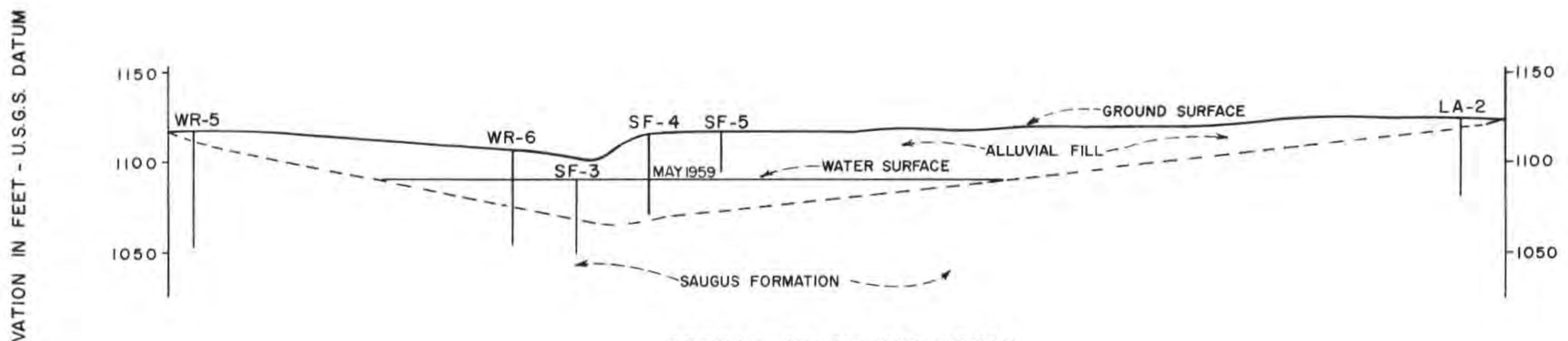
SECTION S-S'

HORIZONTAL SCALE
0 500 1,000 FEET



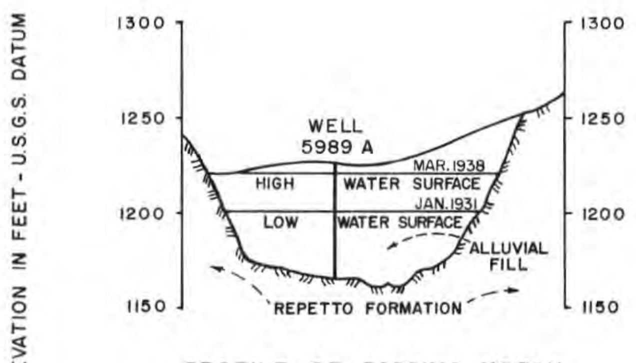
PROFILE AT VERDUGO SUBMERGED DAM

HORIZONTAL SCALE
0 80 100 FEET



PROFILE OF SYLMAR NOTCH

HORIZONTAL SCALE
0 200 400 FEET



PROFILE OF PACOIMA NOTCH

HORIZONTAL SCALE
0 200 400 FEET

LEGEND

- CLAY
- SAND
- GRAVEL
- SAND AND GRAVEL

WATER-BEARING
- Qal RECENT ALLUVIUM
- Qoal OLDER ALLUVIUM - TERRACE DEPOSITS
- Qs SAUGUS FORMATION

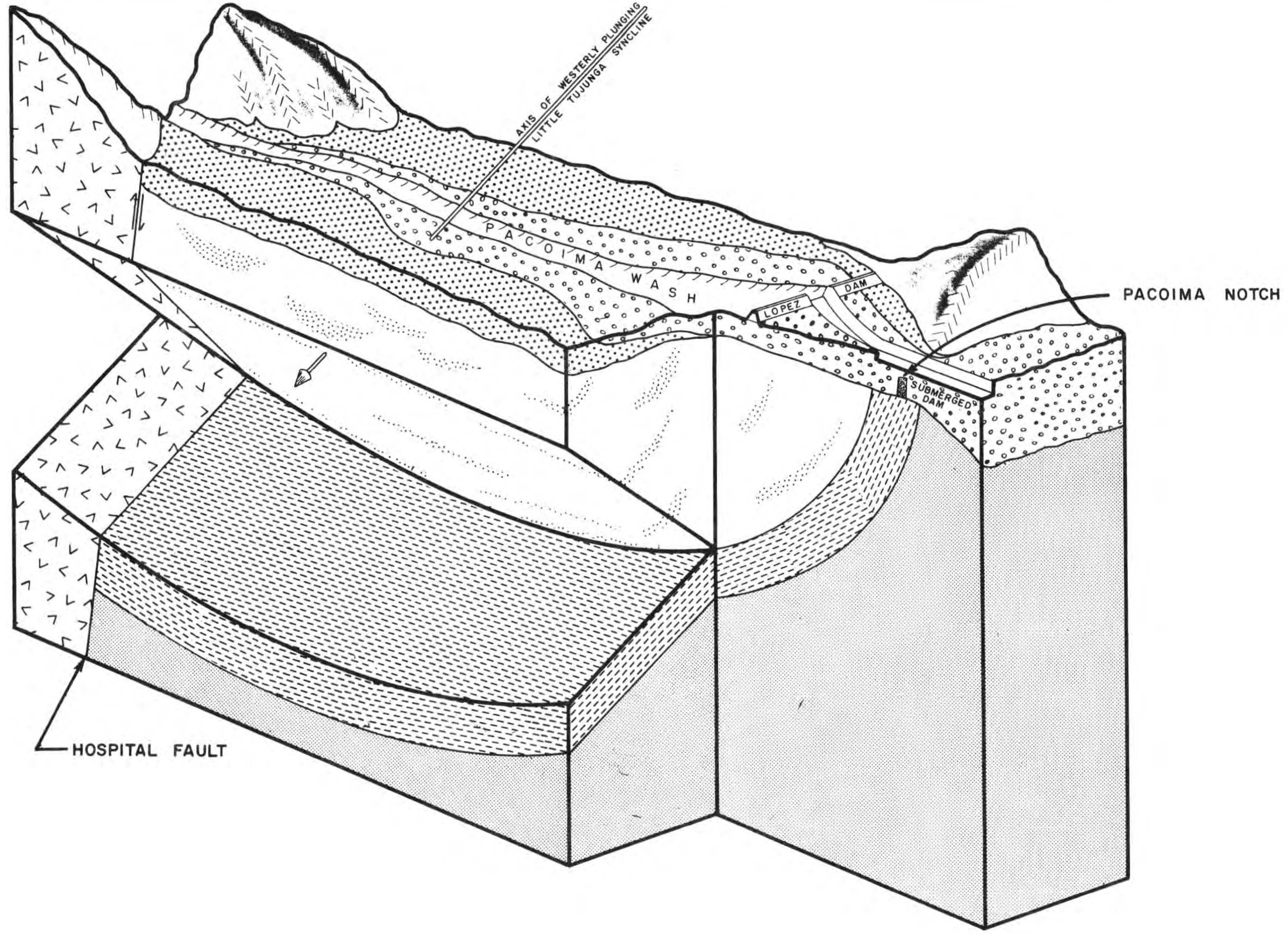
NONWATER-BEARING
- Tp PICO FORMATION
- Tr REPETTO FORMATION
- Tm MODELO (PUENTE) FORMATION
- Tt TOPANGA FORMATION
- Bc BASEMENT COMPLEX

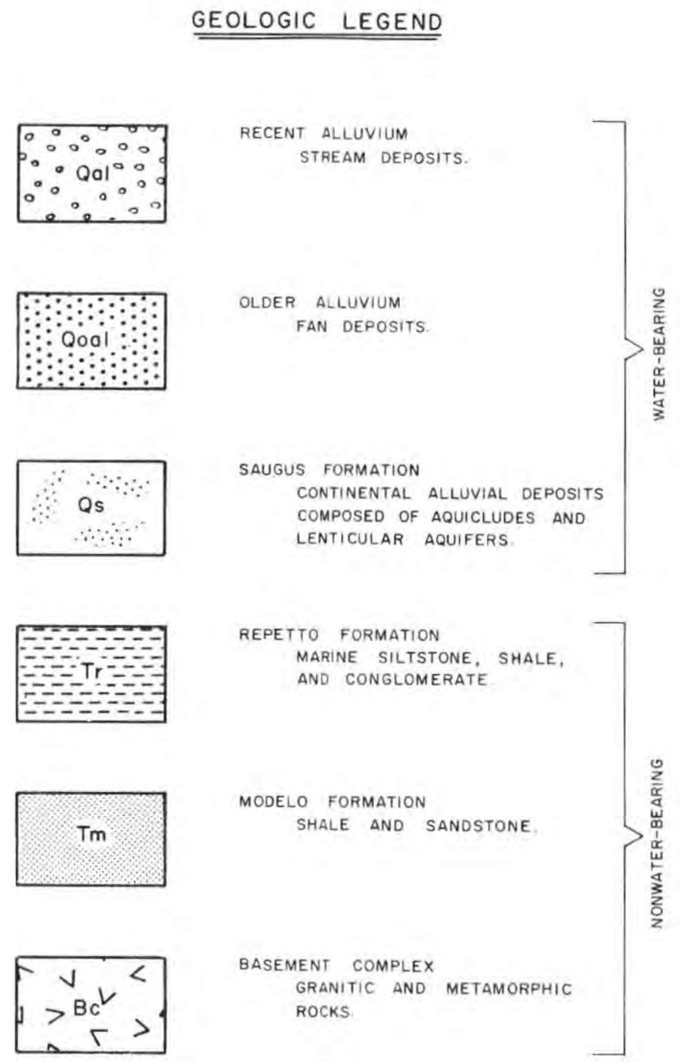
NOTE:
SEE PLATE 5 FOR LOCATIONS

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

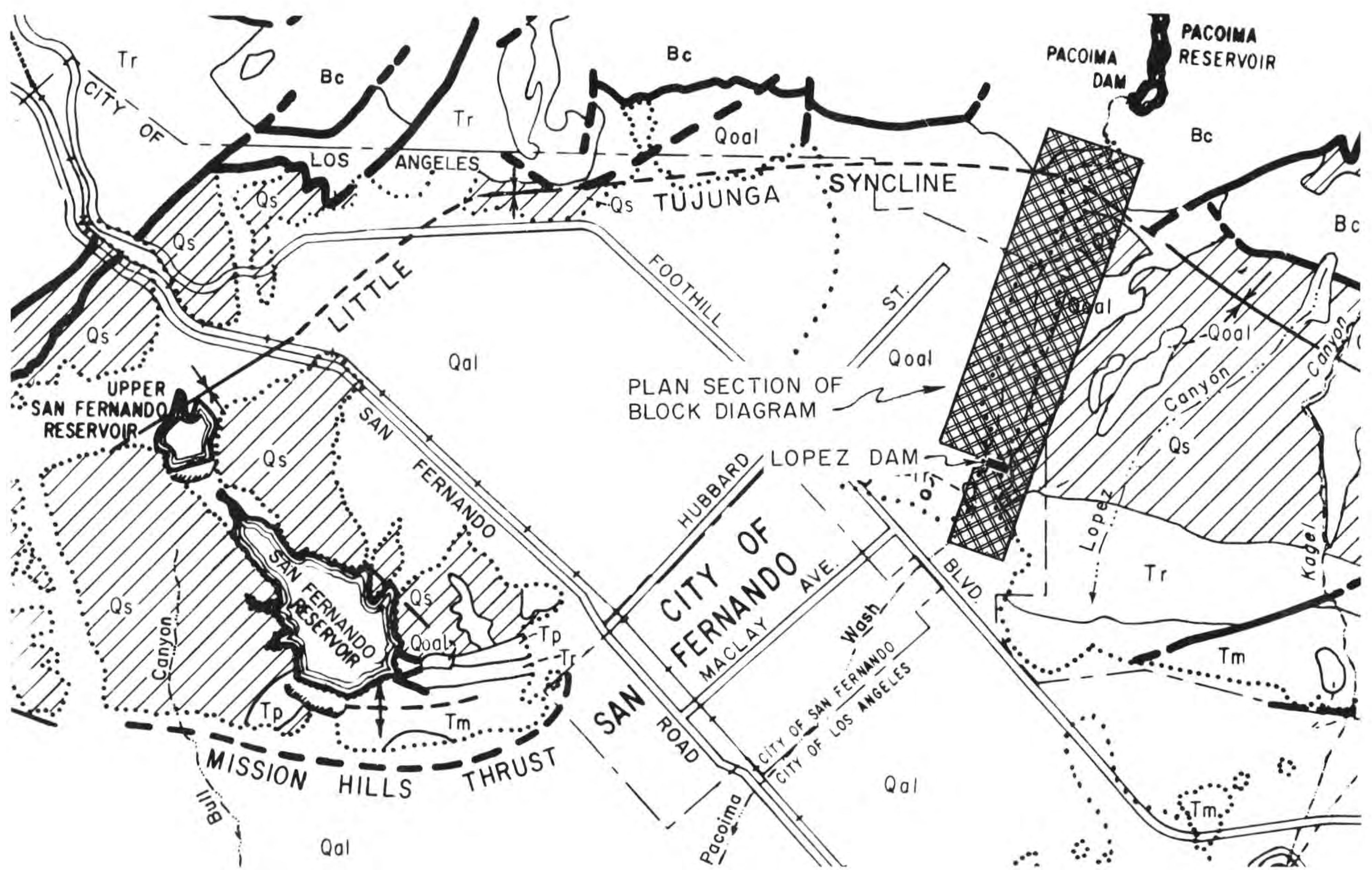
SAN FERNANDO VALLEY REFERENCE

GEOLOGIC CROSS SECTIONS
S-S', VERDUGO SUBMERGED DAM, SYLMAR NOTCH & PACOIMA NOTCH



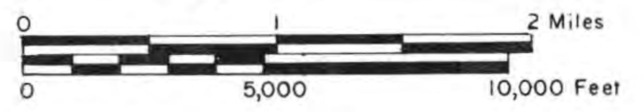


DIAGRAMMATIC BLOCK DIAGRAM ILLUSTRATING THE LITTLE TUJUNGA SYNCLINE IN SYLMAR HYDROLOGIC SUBAREA



LOCATION MAP

SCALE



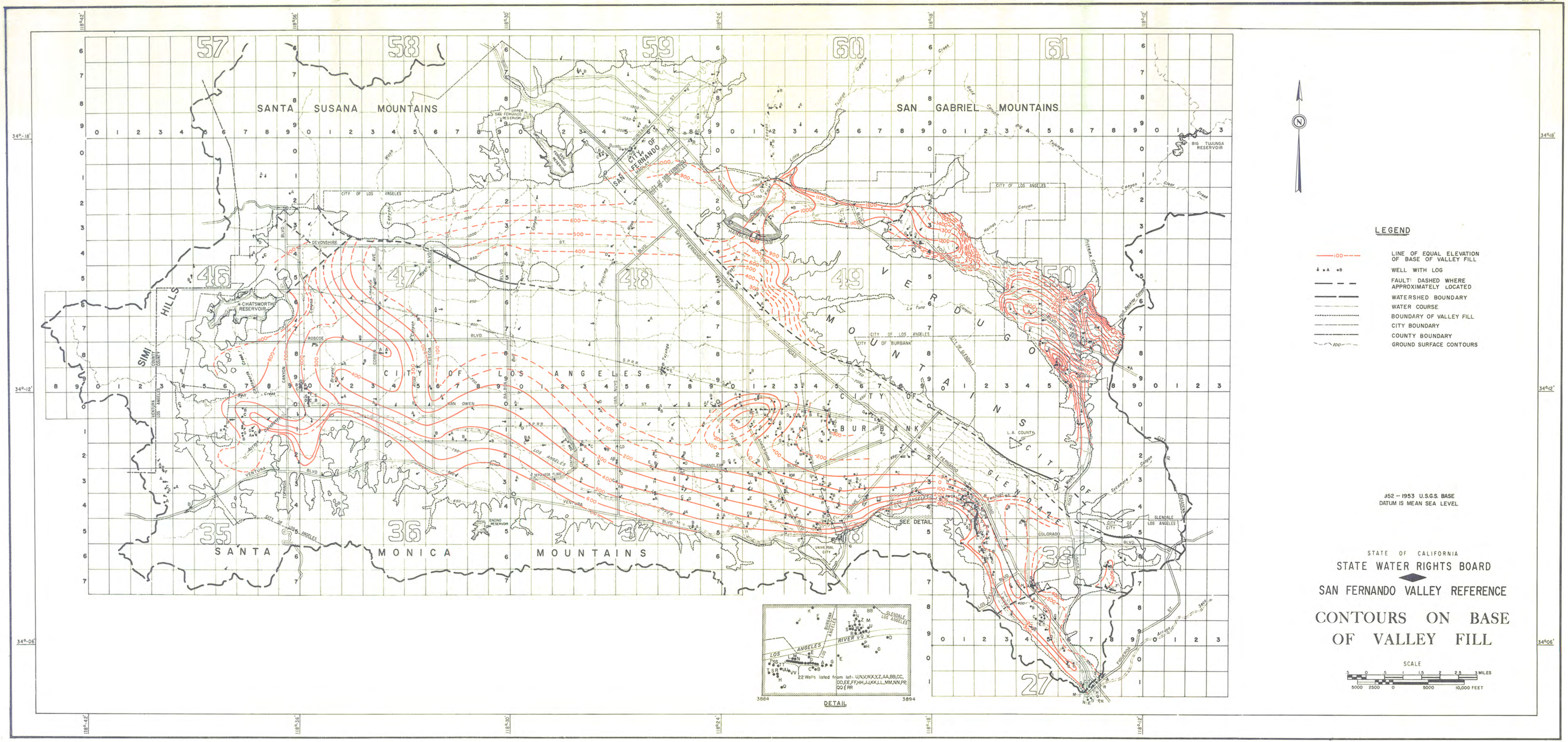
NOTE: FOR IDENTIFICATION AND DECRIPTION OF GEOLOGIC SYMBOLS SHOWN ON THE LOCATION MAP SEE "GEOLOGIC LEGEND" ON PLATE 4.

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

GEOLOGIC CROSS SECTION

BLOCK DIAGRAM
of
LITTLE TUJUNGA SYNCLINE

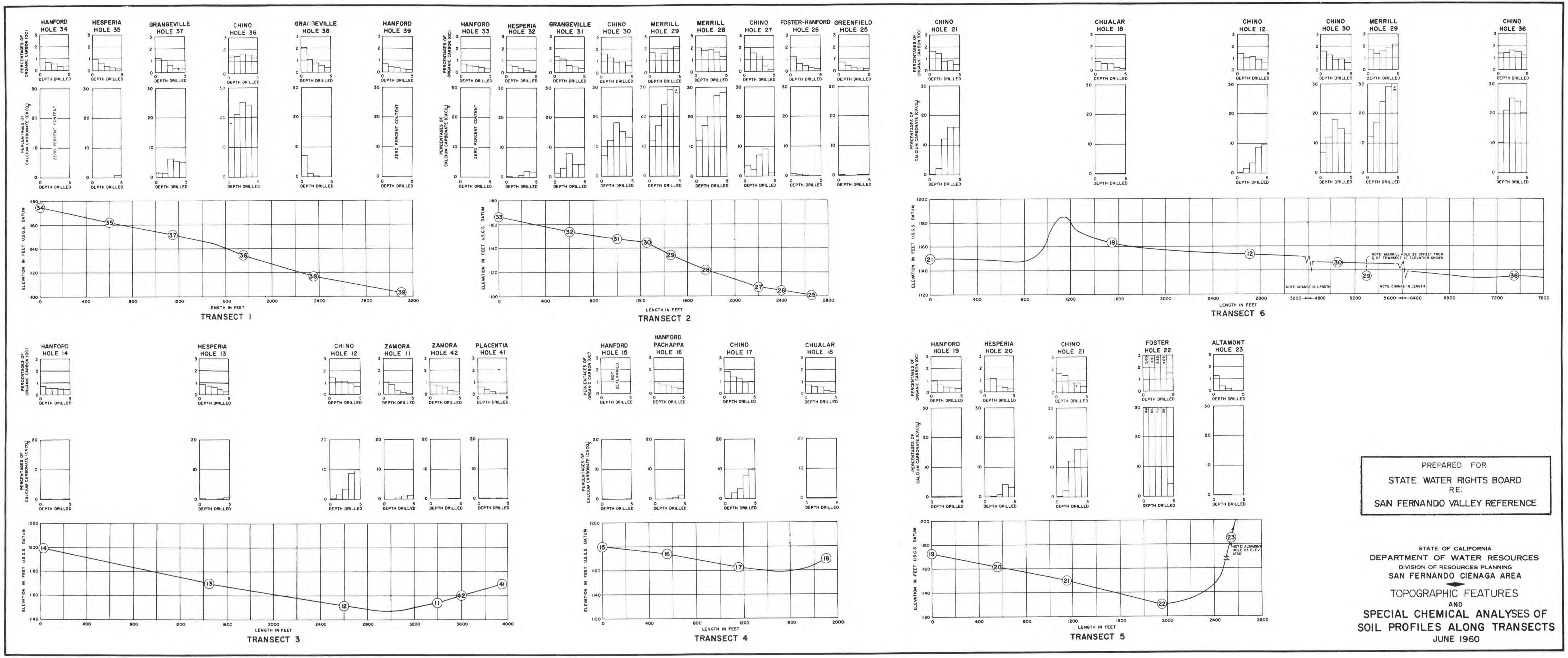


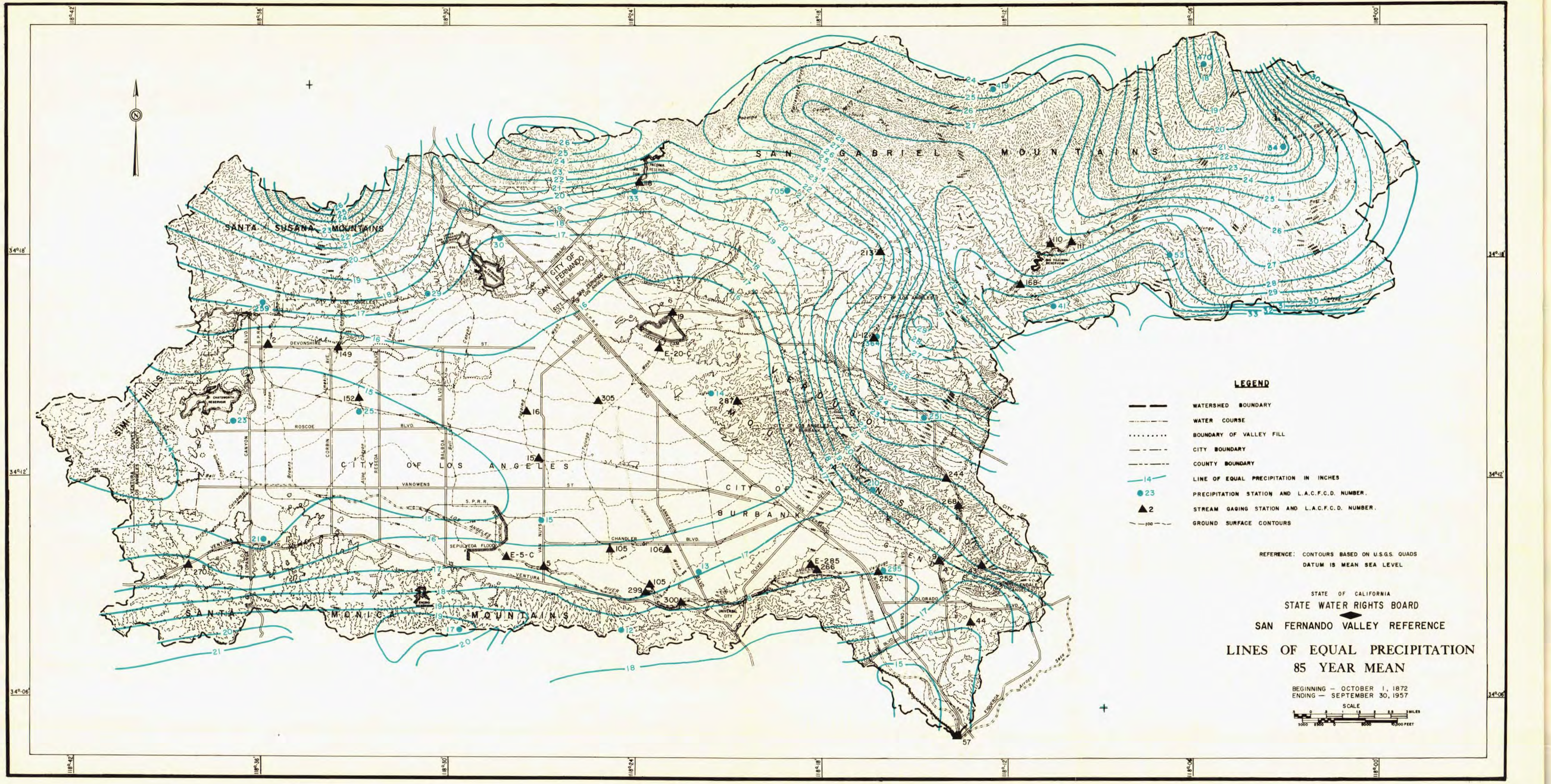
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

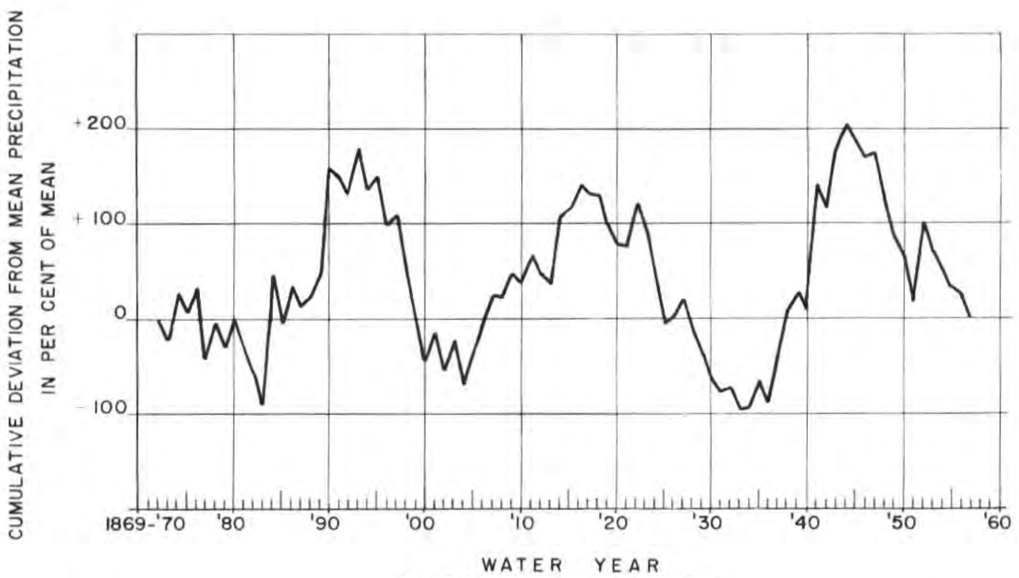
SAN FERNANDO VALLEY REFERENCE

CONTOURS ON BASE OF VALLEY FILL


LEGEND
B – SOILS MOST STRONGLY AFFECTED BY HIGH WATER TABLE.
B1 – CHINO FINE SANDY LOAM
B2 – MERRILL FINE SANDY LOAM
B3 – FOSTER SANDY LOAM
SB – SOILS SOMEWHAT LESS STRONGLY AFFECTED BY HIGH WATER TABLE.
SB1 – GRANGEVILLE FINE SANDY LOAM
T – TRANSITION AREA BETWEEN HIGH WATER TABLE SOILS AND RELATED WELL DRAINED ALLUVIAL FAN SOILS. AFFECTED TO A SMALL DEGREE BY WATER TABLE.
T1 – HESPERIA FINE SANDY LOAM (INCLUDES SMALL AREAS OF OTHER SOILS OF SIMILAR NATURE)
F – WELL DRAINED ALLUVIAL FAN SOILS UNAFFECTED BY WATER TABLE. RELATED TO ADJACENT CIENAGA SOILS IN SOURCE OF MATERIAL AND GENERAL AGE.
F1 – HANFORD SANDY LOAM
F2 – GREENFIELD SANDY LOAM
U – SOILS IN THE SURROUNDING AREA THAT ARE UNRELATED IN GENERAL AGE, PARENT MATERIAL, OR MODE OF FORMATION TO CIENAGA SOILS. NOT AFFECTED BY WATER TABLE.
U1 – ZAMORA LOAM
U2 – CHUALAR SANDY LOAM AND RAMONA SANDY LOAM
U3 – PLACENTIA SANDY LOAM
U4 – ALTAMONT SANDY LOAM
U5 – DIABLO SANDY LOAM AND LOAM
SYMBOLS
1 THROUGH 42 SOIL SAMPLE LOCATIONS
SOILS BOUNDARIES
PREPARED FOR
STATE WATER RIGHTS BOARD
RE:
SAN FERNANDO VALLEY REFERENCE
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
SAN FERNANDO CIENAGA AREA
SOIL SURVEY
AND
LOCATION OF TRANSECTS
JUNE 1960
SCALE OF FEET
0 500 1000
TRANSECT 1
TRANSECT 2
TRANSECT 3
TRANSECT 4
TRANSECT 5
TRANSECT 6
END OF PROFILE
SAN FERNANDO RD
S.P.R.R.
SEPULVEDA BLVD.
SAN FERNANDO RES.
GLENOAKS BLVD
GROVE ST
ORANGE ST
BRADLEY AVE
RALSTON AVE
HUBBARD ST

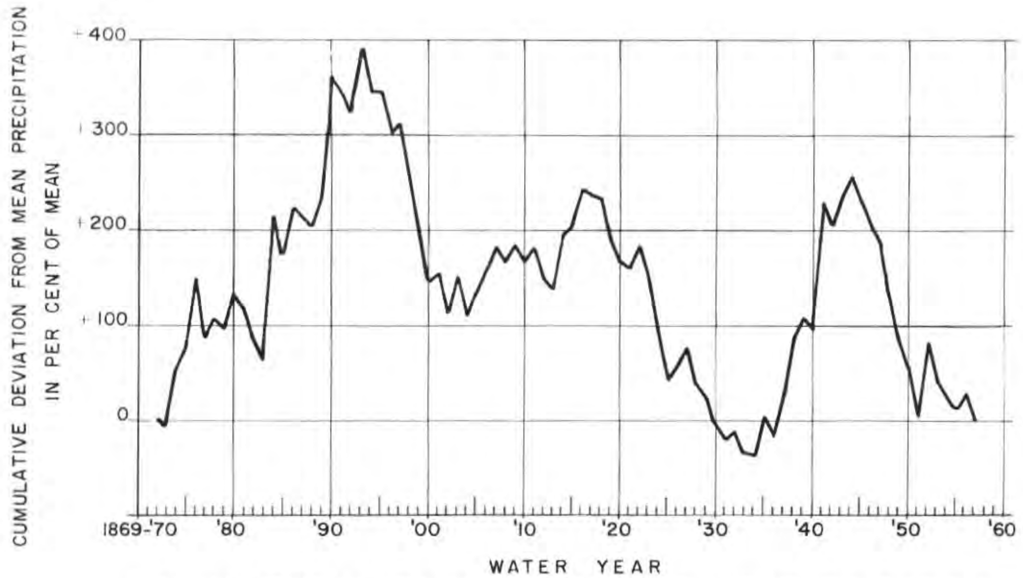

HANFORD HOLE 34
HESPERIA HOLE 35
GRANGEVILLE HOLE 37
CHINO HOLE 36
GRANGEVILLE HOLE 38
HANFORD HOLE 39
HANFORD HOLE 33
HESPERIA HOLE 32
GRANGEVILLE HOLE 31
CHINO HOLE 30
MERRILL HOLE 29
MERRILL HOLE 28
CHINO HOLE 27
FOSTER-HANFORD HOLE 26
GREENFIELD HOLE 25
CHINO HOLE 21
CHUALAR HOLE 18
CHINO HOLE 12
CHINO HOLE 30
MERRILL HOLE 29
CHINO HOLE 36
PERCENTAGES OF ORGANIC CARBON (OC)
PERCENTAGES OF CALCIUM CARBONATE (CACO3)
DEPTH DRILLED
ZERO PERCENT CONTENT
ELEVATION IN FEET U.S.G.S. DATUM
LENGTH IN FEET
TRANSECT 1
TRANSECT 2
NOTE: MERRILL HOLE 29 OFFSET FROM ℄ OF TRANSECT AT ELEVATION SHOWN.
NOTE CHANGE IN LENGTH
TRANSECT 6
HANFORD HOLE 14
HESPERIA HOLE 13
CHINO HOLE 12
ZAMORA HOLE 11
ZAMORA HOLE 42
PLACENTIA HOLE 41
HANFORD HOLE 15
HANFORD PACHAPPA HOLE 16
CHINO HOLE 17
CHUALAR HOLE 18
NOT DETERMINED
HANFORD HOLE 19
HESPERIA HOLE 20
CHINO HOLE 21
FOSTER HOLE 22
ALTAMONT HOLE 23
NOTE: ALTAMONT HOLE 23 ELEV. 1250
TRANSECT 3
TRANSECT 4
TRANSECT 5
PREPARED FOR
STATE WATER RIGHTS BOARD
RE:
SAN FERNANDO VALLEY REFERENCE
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
SAN FERNANDO CIENAGA AREA
TOPOGRAPHIC FEATURES
AND
SPECIAL CHEMICAL ANALYSES OF
SOIL PROFILES ALONG TRANSECTS
JUNE 1960


SAN GABRIEL MOUNTAINS
SANTA SUSANA MOUNTAINS
SIMI HILLS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
CITY OF SAN FERNANDO
CITY OF LOS ANGELES
CITY OF BURBANK
DEVONSHIRE ST
ROSCOE BLVD.
VANOWENS ST
CHANDLER BLVD.
VENTURA BLVD.
COLORADO
SEPULVEDA FLOOD
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL PRECIPITATION IN INCHES
PRECIPITATION STATION AND L.A.C.F.C.D. NUMBER.
STREAM GAGING STATION AND L.A.C.F.C.D. NUMBER.
GROUND SURFACE CONTOURS
REFERENCE: CONTOURS BASED ON U.S.G.S. QUADS
DATUM IS MEAN SEA LEVEL
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
LINES OF EQUAL PRECIPITATION
85 YEAR MEAN
BEGINNING — OCTOBER 1, 1872
ENDING — SEPTEMBER 30, 1957
SCALE



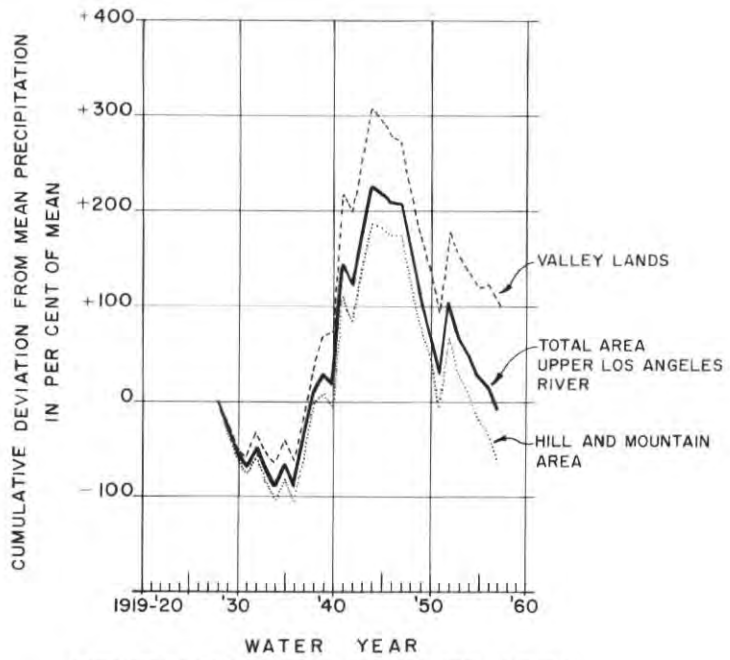
PASADENA CITY HALL

85 YEAR MEAN ANNUAL PRECIPITATION = 20.19 INCHES, ELEVATION 864 FEET



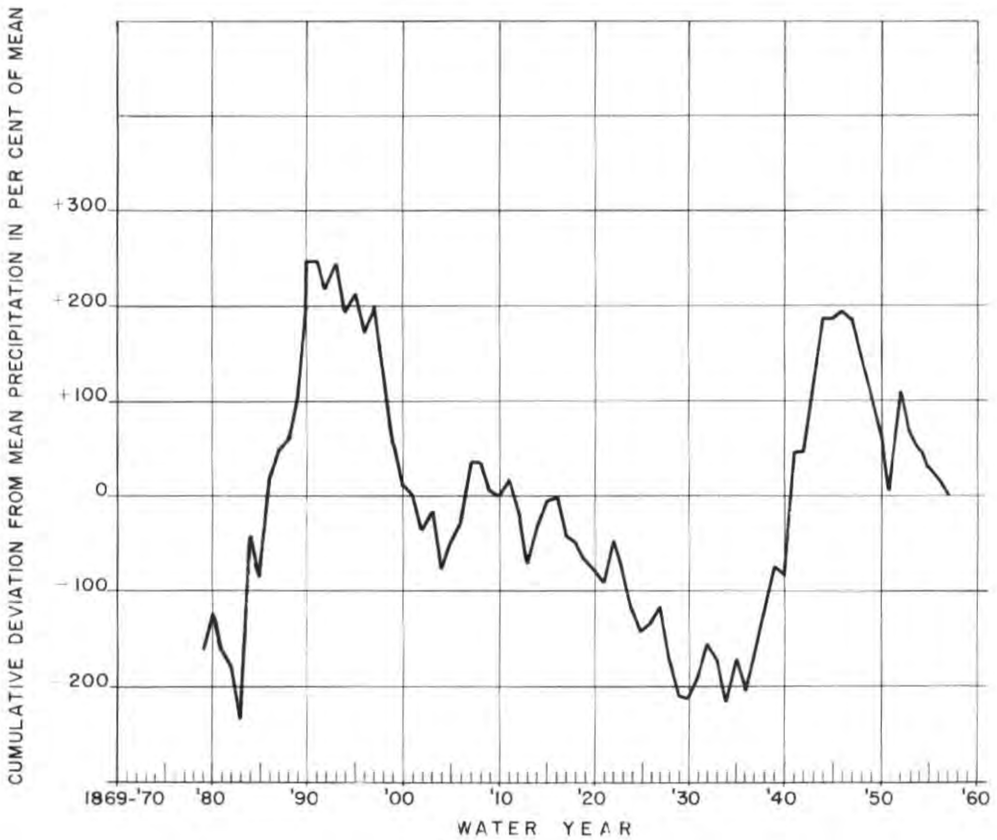
LOS ANGELES, CITY (UNITED STATES WEATHER BUREAU)

85 YEAR MEAN ANNUAL PRECIPITATION = 15.26 INCHES, ELEVATION 282 FEET



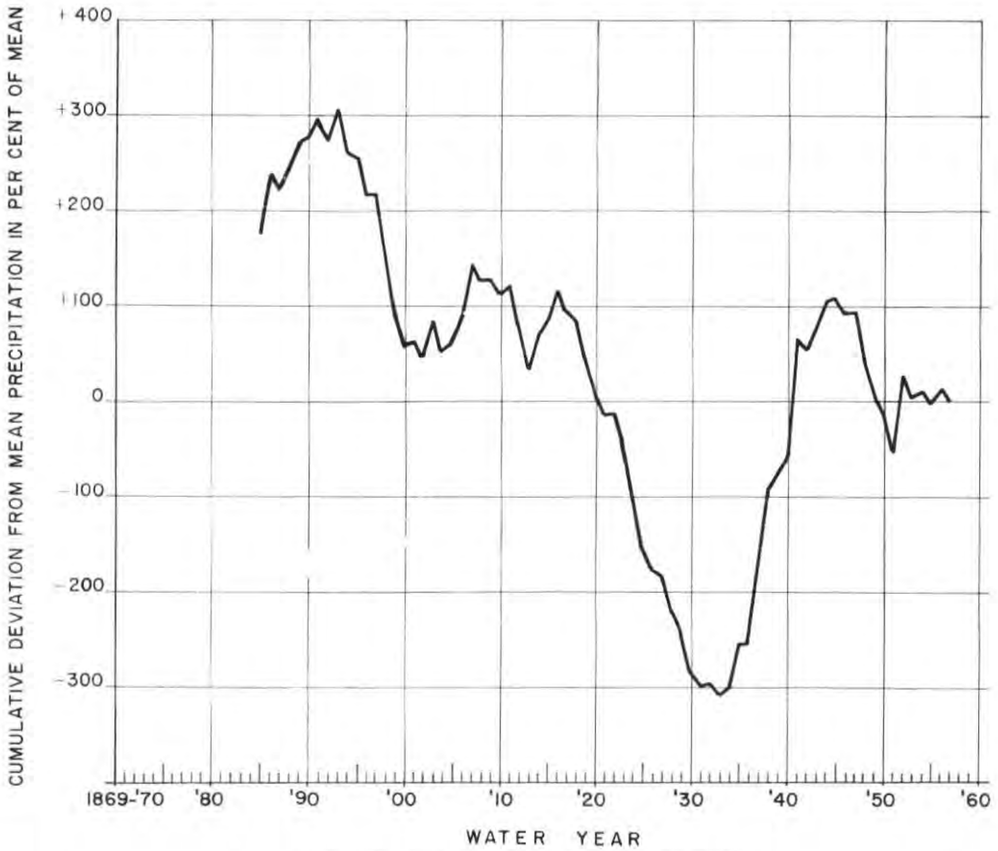
UPPER LOS ANGELES RIVER AREA

1928-'29 THROUGH 1956-'57



ACTON ESCONDIDO CANYON

85 YEAR MEAN ANNUAL PRECIPITATION = 10.10 INCHES, ELEVATION 2,920 FEET

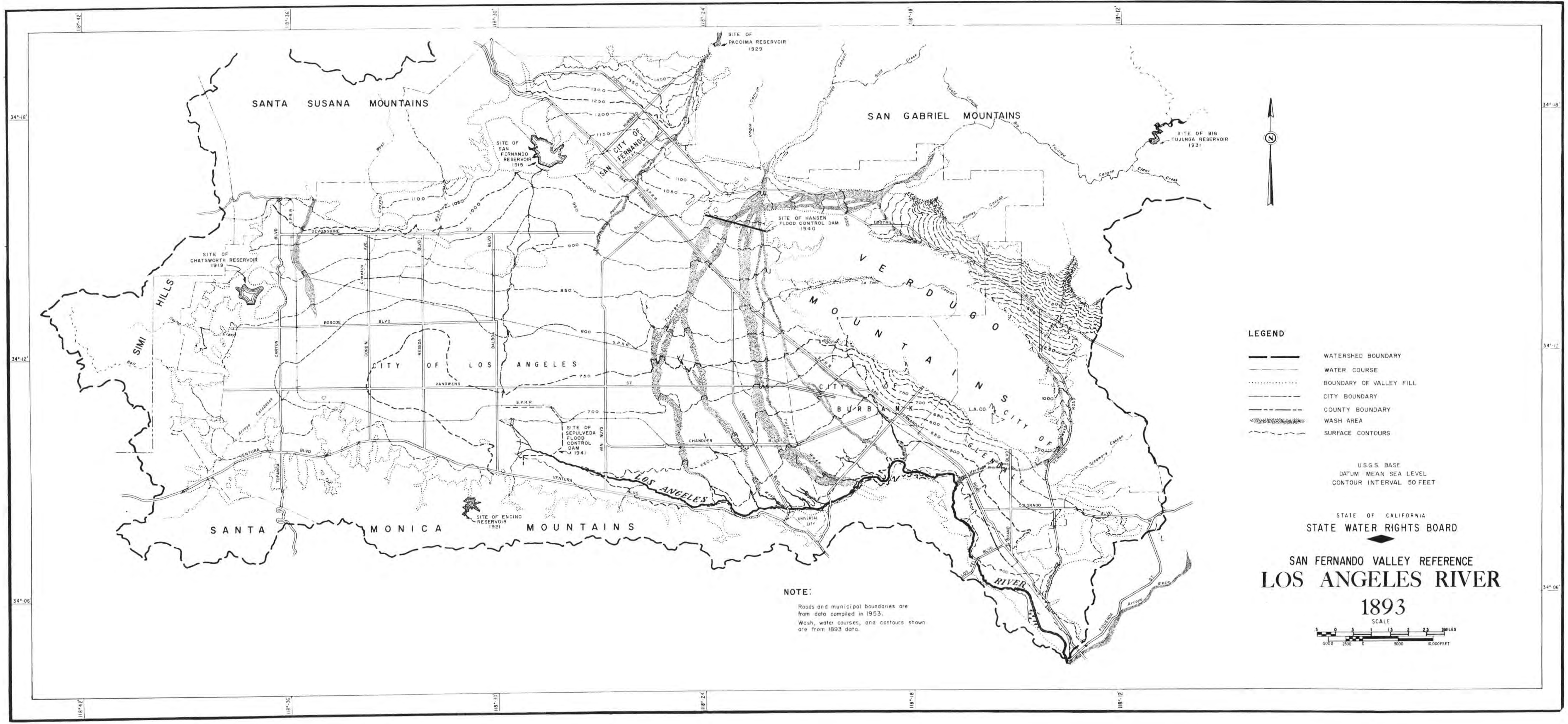


SAWTELLE SOLDIERS HOME

85 YEAR MEAN ANNUAL PRECIPITATION = 15.22 INCHES, ELEVATION 230 FEET

SAN FERNANDO VALLEY REFERENCE
CUMULATIVE DEVIATION FROM 85 YEAR MEAN PRECIPITATION
OCTOBER, 1872 THROUGH SEPTEMBER, 1957

STATE WATER RIGHTS BOARD


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
CITY OF SAN FERNANDO
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
SITE OF PACOIMA RESERVOIR 1929
SITE OF SAN FERNANDO RESERVOIR 1915
SITE OF CHATSWORTH RESERVOIR 1919
SITE OF HANSEN FLOOD CONTROL DAM 1940
SITE OF BIG TUJUNGA RESERVOIR 1931
SITE OF SEPULVEDA FLOOD CONTROL DAM 1941
SITE OF ENCINO RESERVOIR 1921
UNIVERSAL CITY
LOS ANGELES RIVER
DEVONSHIRE ST
ROSCOE BLVD
VANOWENS ST
VENTURA BLVD
CHANDLER BLVD
COLORADO BLVD
S.P.R.R.
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
WASH AREA
SURFACE CONTOURS
U.S.G.S. BASE
DATUM MEAN SEA LEVEL
CONTOUR INTERVAL 50 FEET
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
LOS ANGELES RIVER
1893
SCALE
NOTE:
Roads and municipal boundaries are from data compiled in 1953.
Wash, water courses, and contours shown are from 1893 data.

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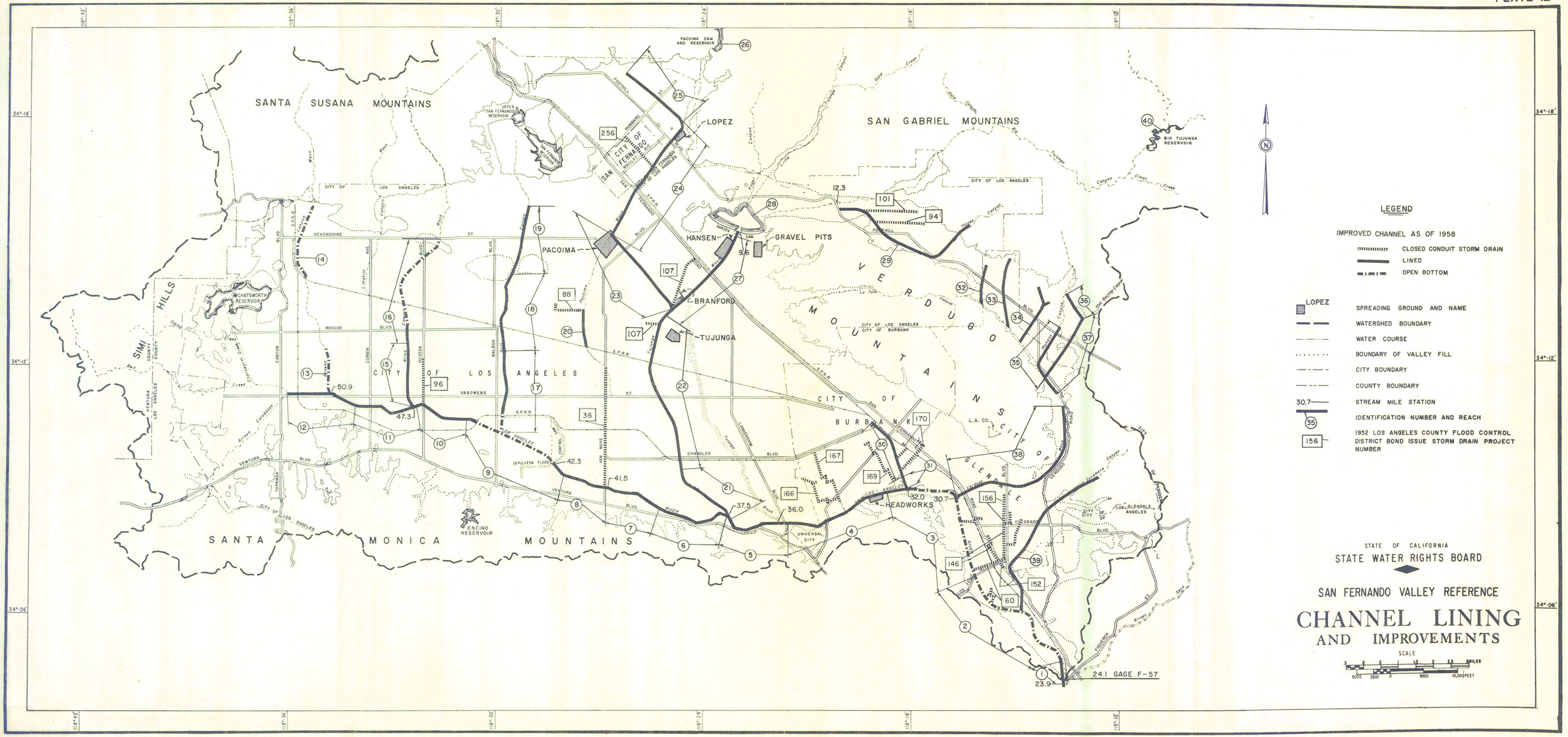
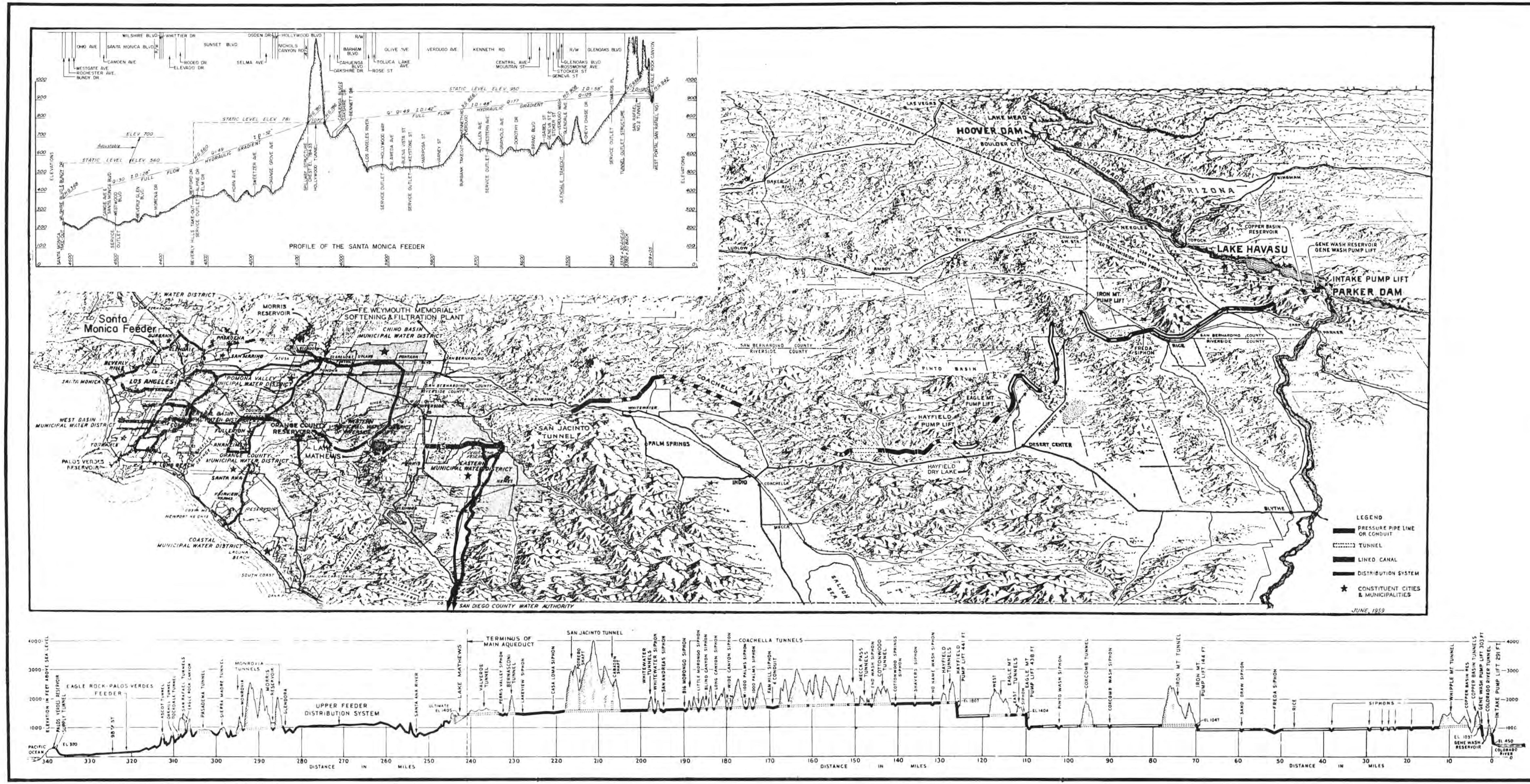

SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
PACOIMA DAM AND RESERVOIR
UPPER SAN FERNANDO RESERVOIR
SAN FERNANDO RESERVOIR
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
LOPEZ
PACOIMA
HANSEN
GRAVEL PITS
BRANFORD
TUJUNGA
HEADWORKS
UNIVERSAL CITY
SEPULVEDA FLOOD CONTROL
24.1 GAGE F-57
LEGEND
IMPROVED CHANNEL AS OF 1958
CLOSED CONDUIT STORM DRAIN
LINED
OPEN BOTTOM
SPREADING GROUND AND NAME
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
STREAM MILE STATION
IDENTIFICATION NUMBER AND REACH
1952 LOS ANGELES COUNTY FLOOD CONTROL DISTRICT BOND ISSUE STORM DRAIN PROJECT NUMBER
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
CHANNEL LINING AND IMPROVEMENTS
SCALE



REFERENCE:

Schematic map showing Colorado River Aqueduct and Santa Monica Feeder per The Metropolitan Water District of Southern California
June, 1959

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

COLORADO RIVER AQUEDUCT

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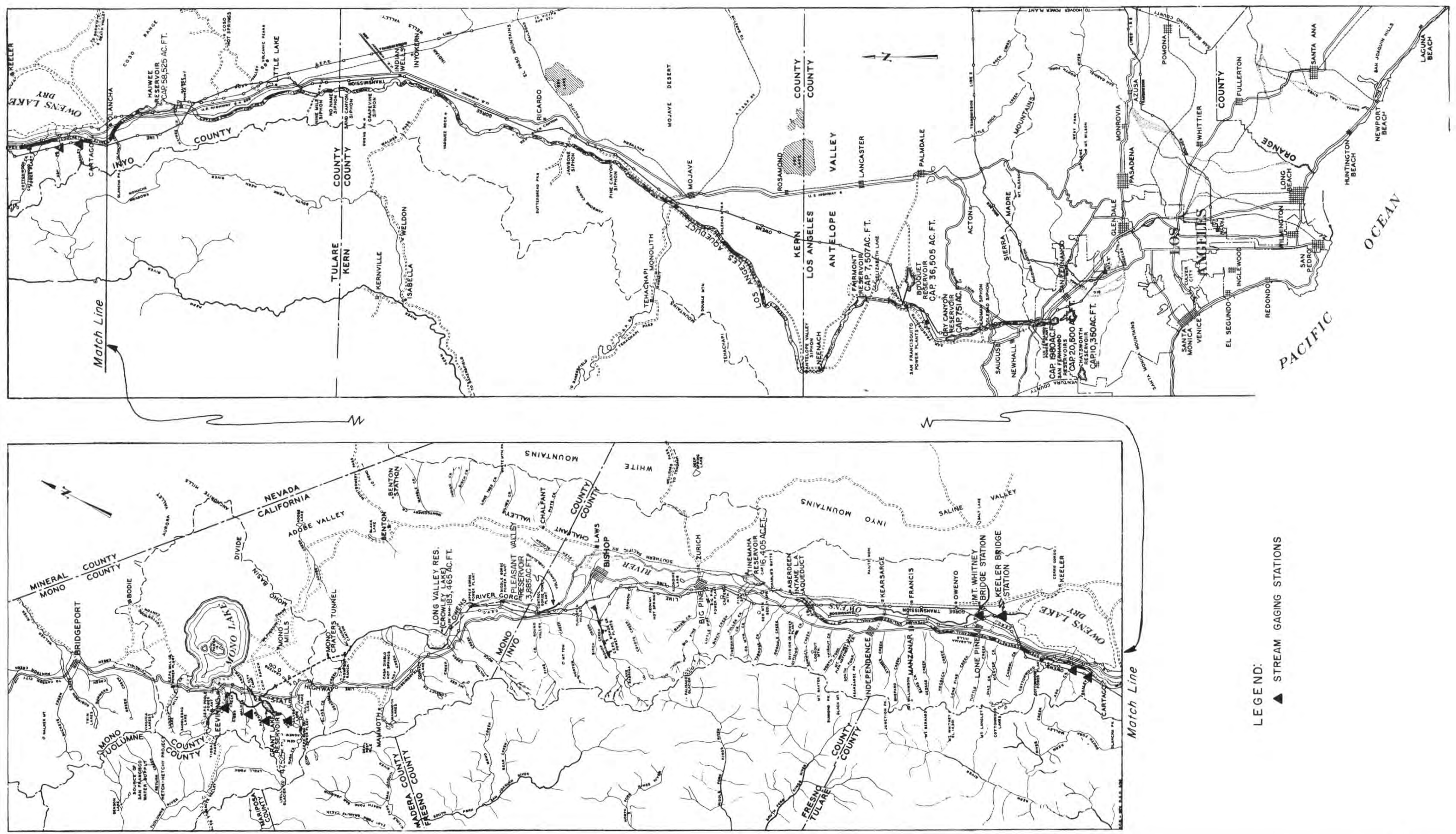
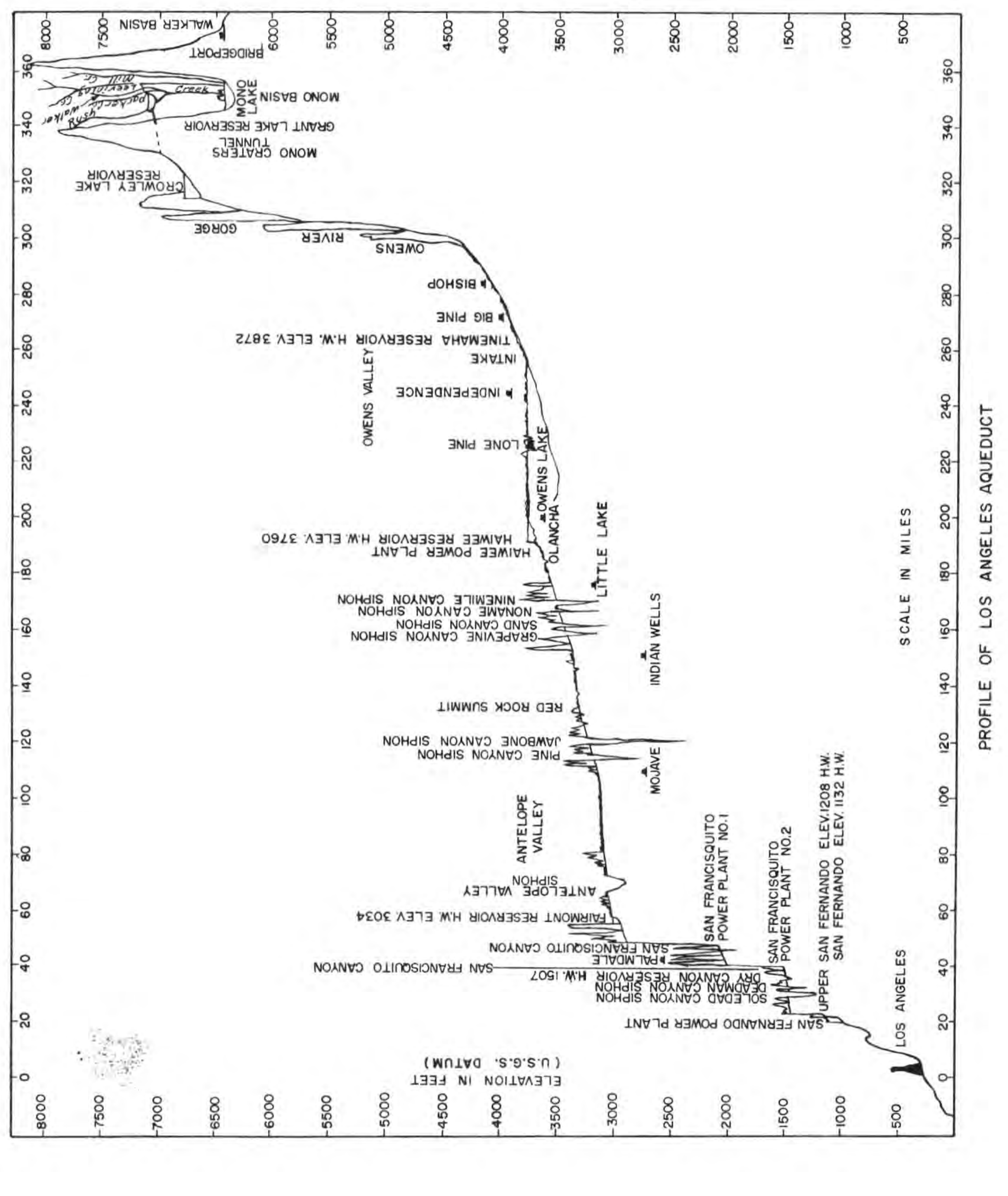


LEGEND:
▲ STREAM GAGING STATIONS



REFERENCE:
Map showing Los Angeles Aqueduct and Mono Basin Extension based on Department of Water and Power, City of Los Angeles. Map dated 1962.

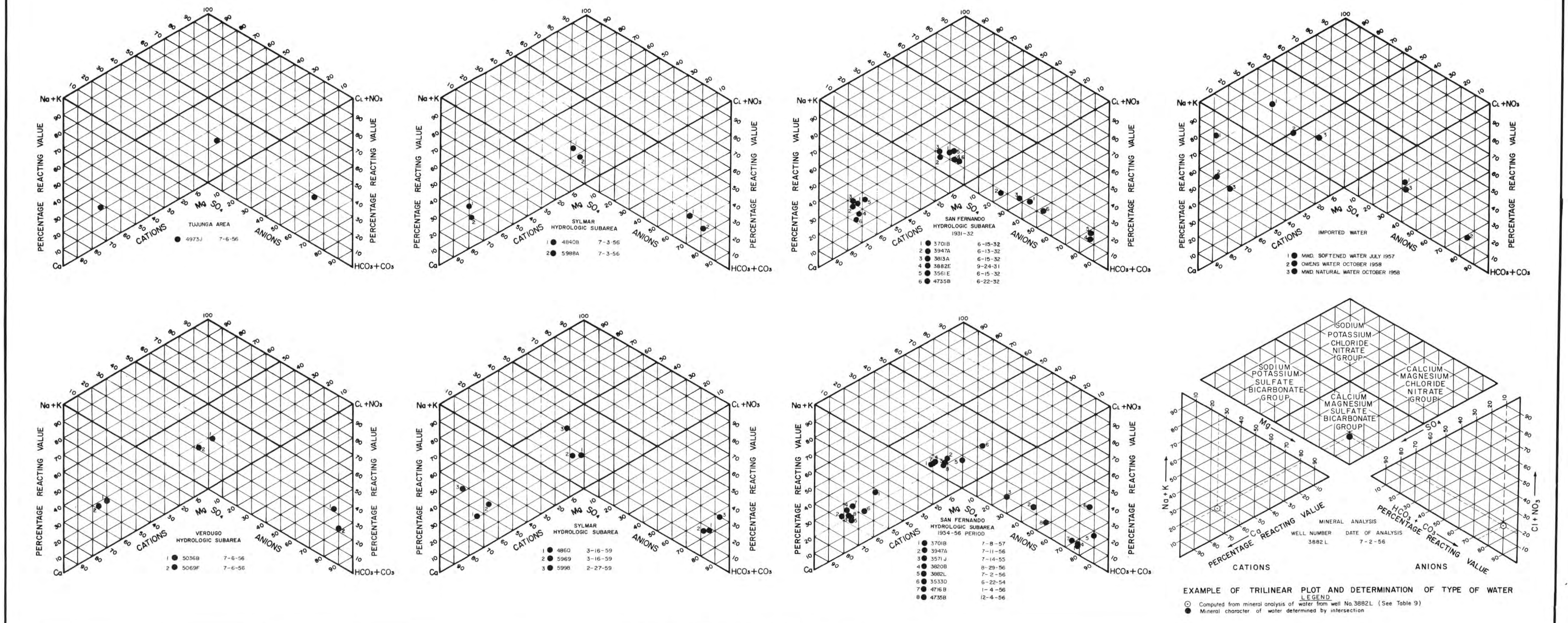
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

LOS ANGELES AQUEDUCT

SCALE

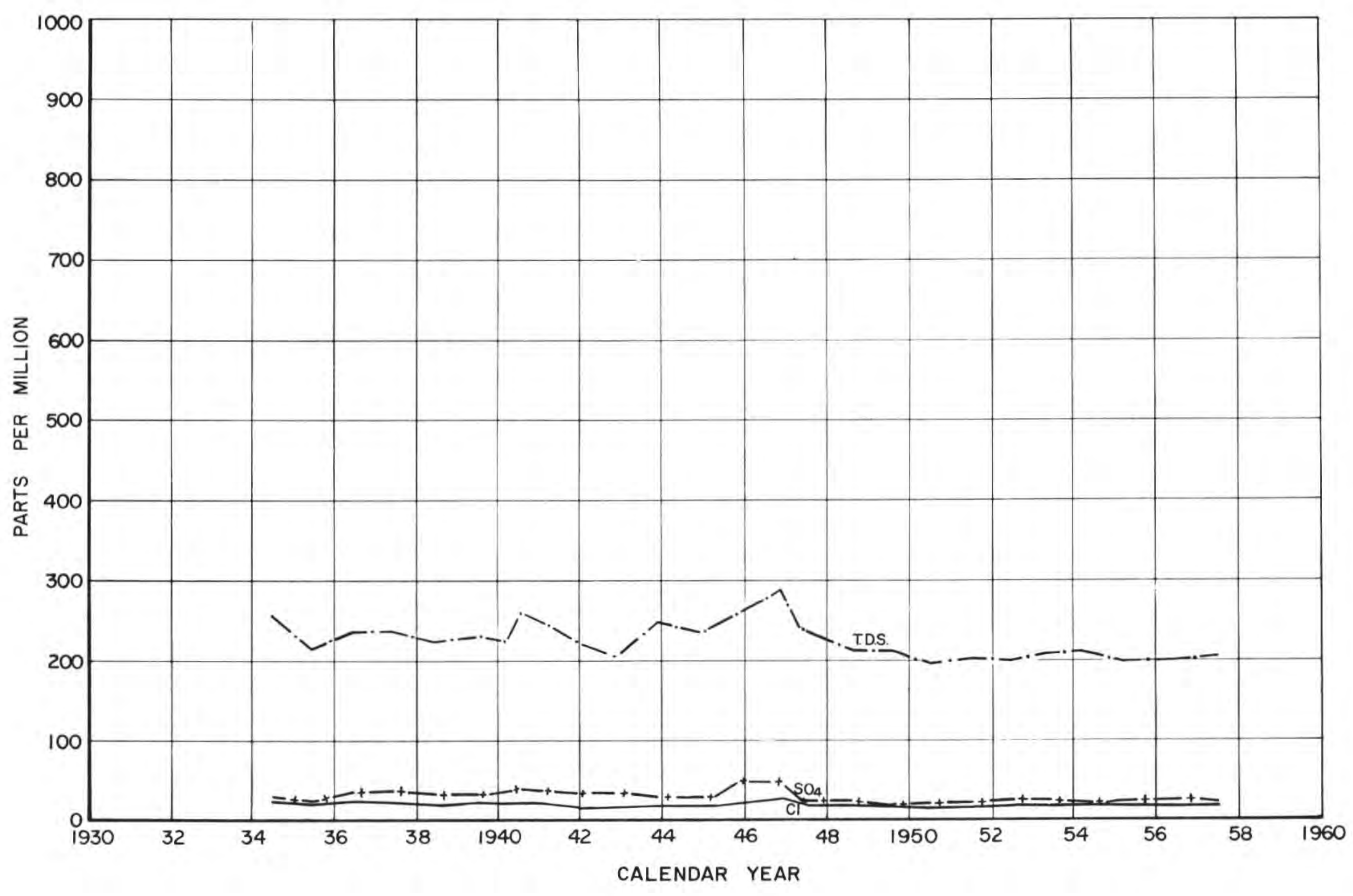
PLATE 15



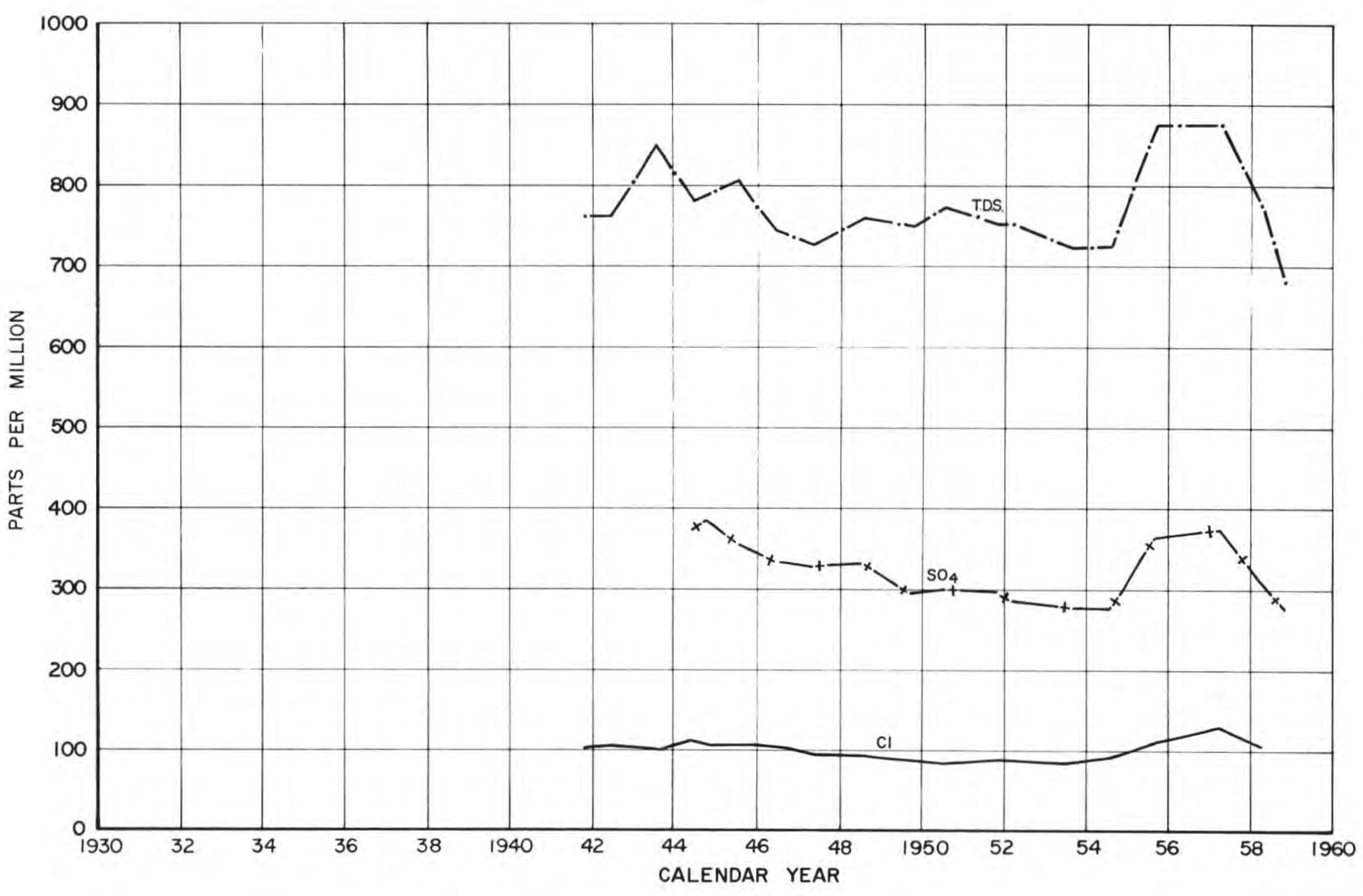
SAN FERNANDO VALLEY REFERENCE

MINERAL CHARACTER OF IMPORTED AND GROUND WATER

STATE WATER RIGHTS BOARD



OWENS RIVER WATER
AT UPPER SAN FERNANDO RESERVOIR INLET



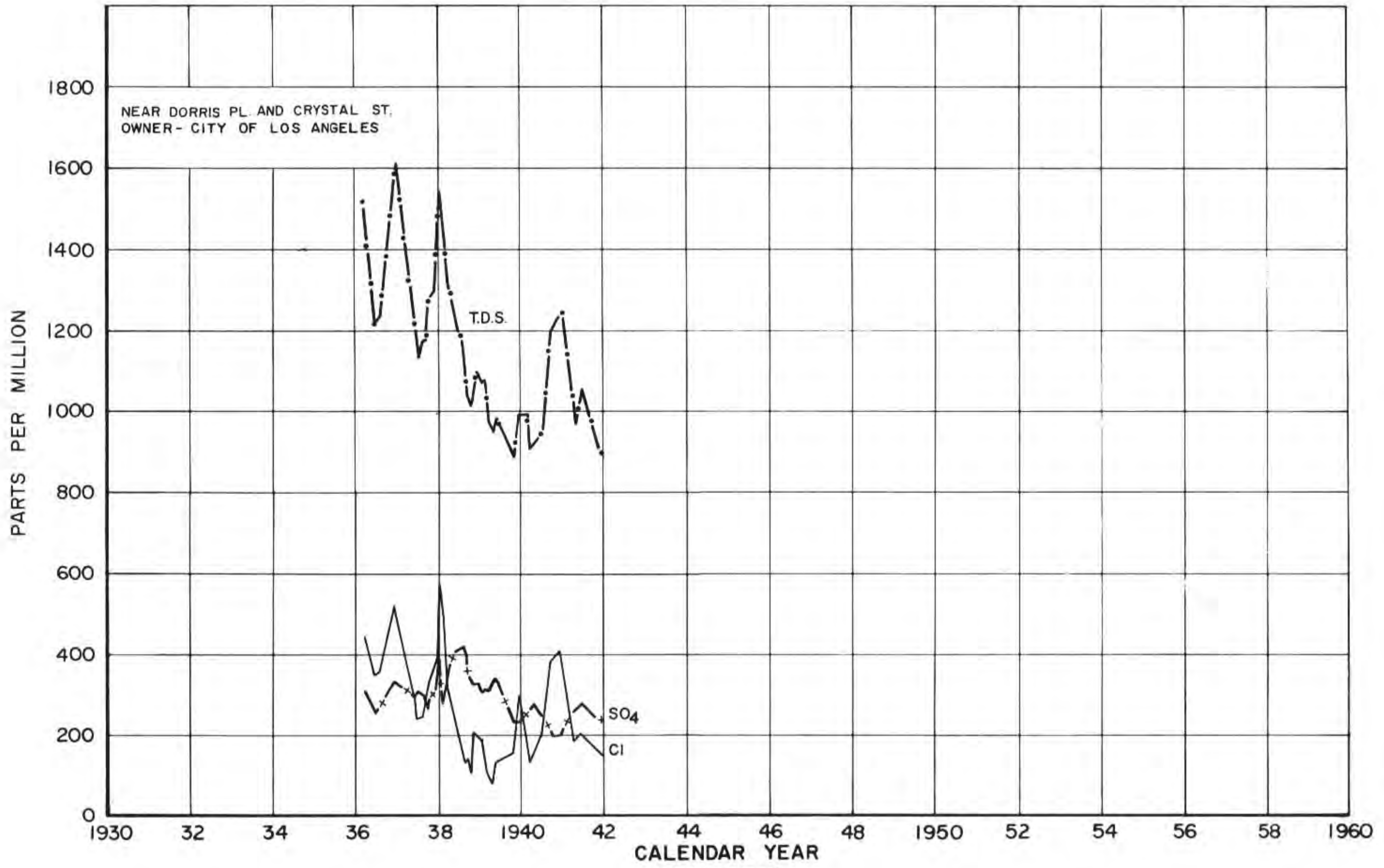
SOFTENED COLORADO RIVER WATER FROM METROPOLITAN WATER DISTRICT
AT CITY OF BURBANK

SAN FERNANDO VALLEY REFERENCE

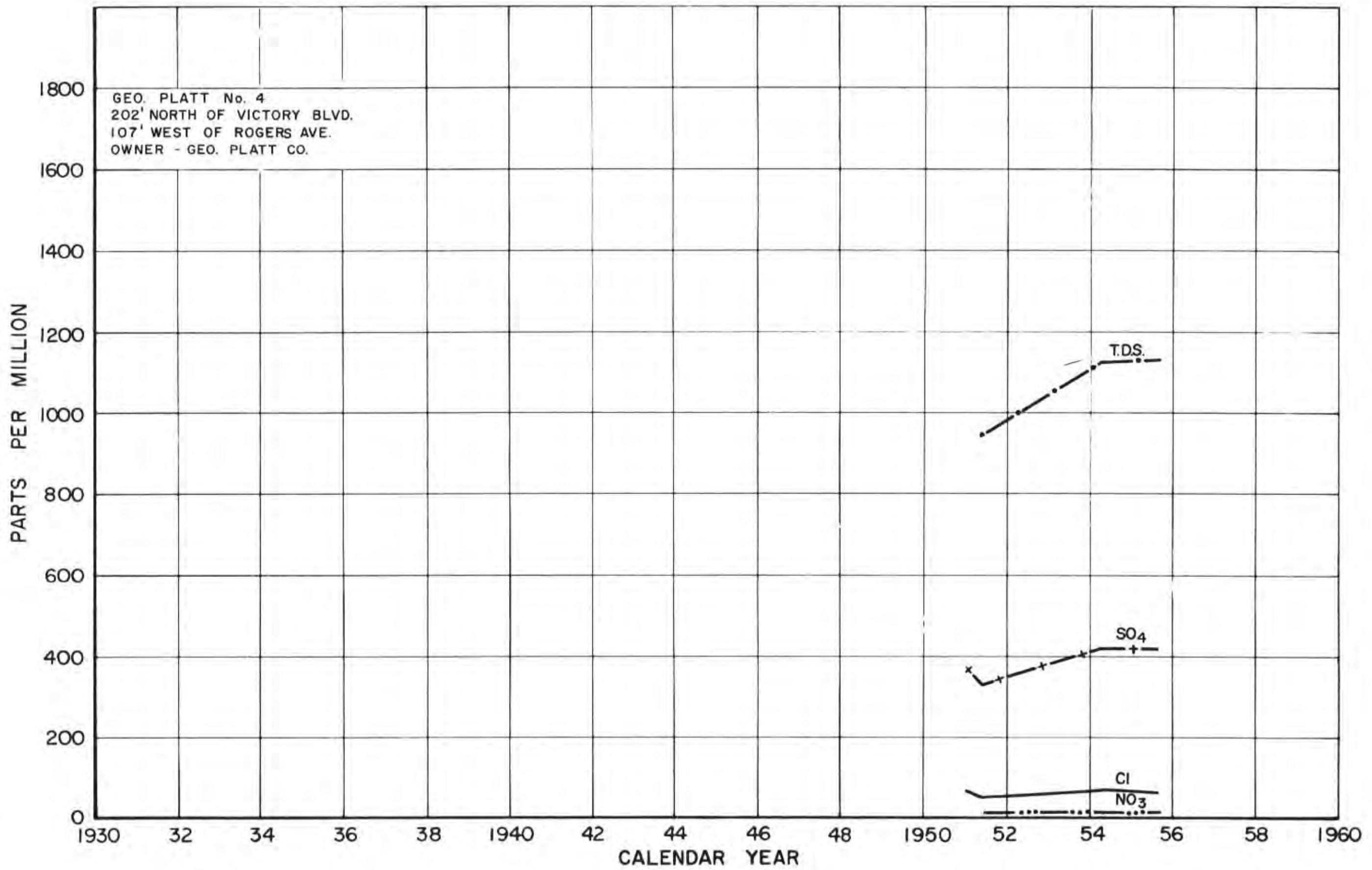
TOTAL DISSOLVED SOLIDS, SULFATE AND CHLORIDE CONTENT OF IMPORTED WATER

STATE WATER RIGHTS BOARD

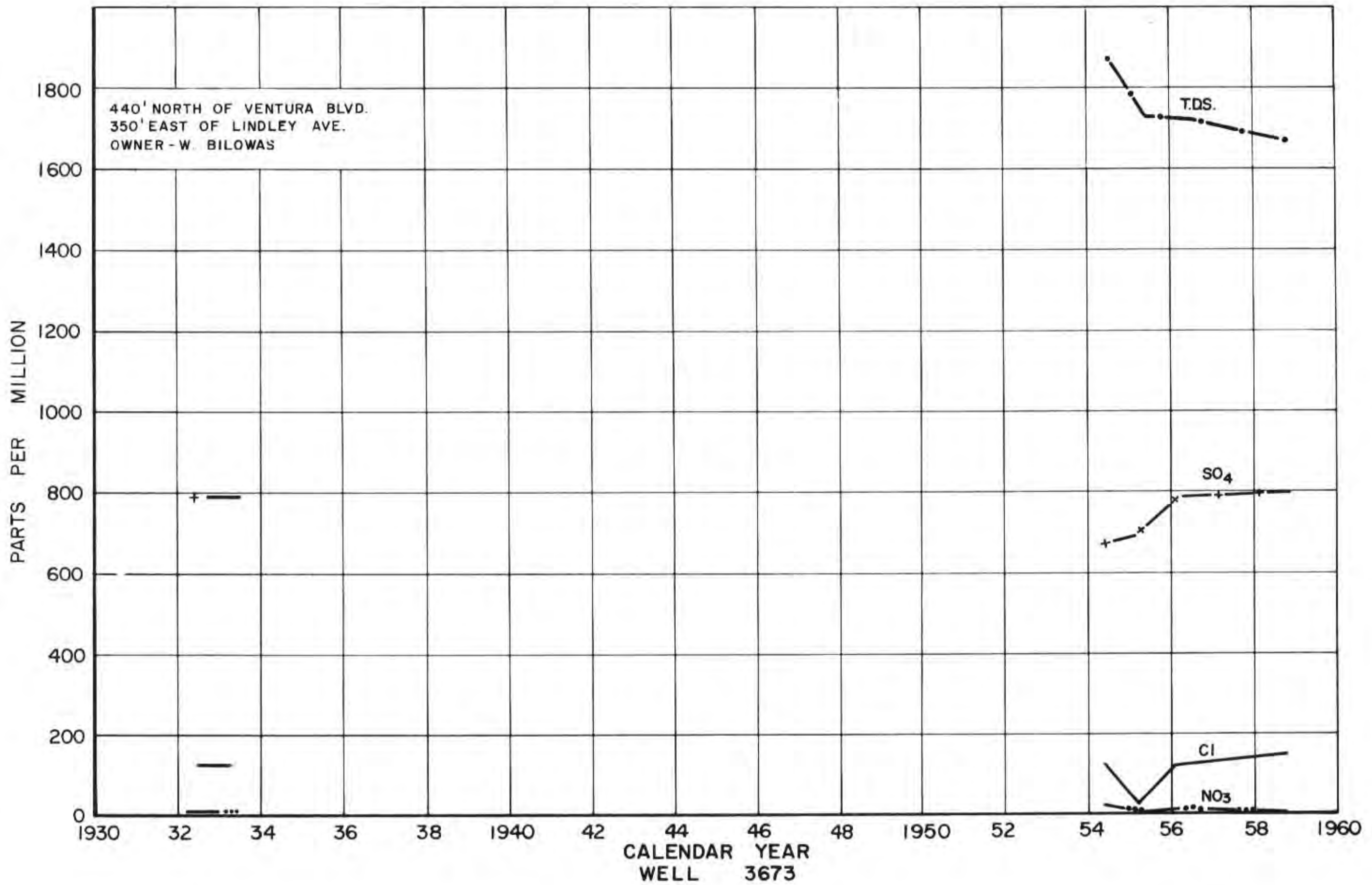
SAN FERNANDO HYDROLOGIC SUBAREA



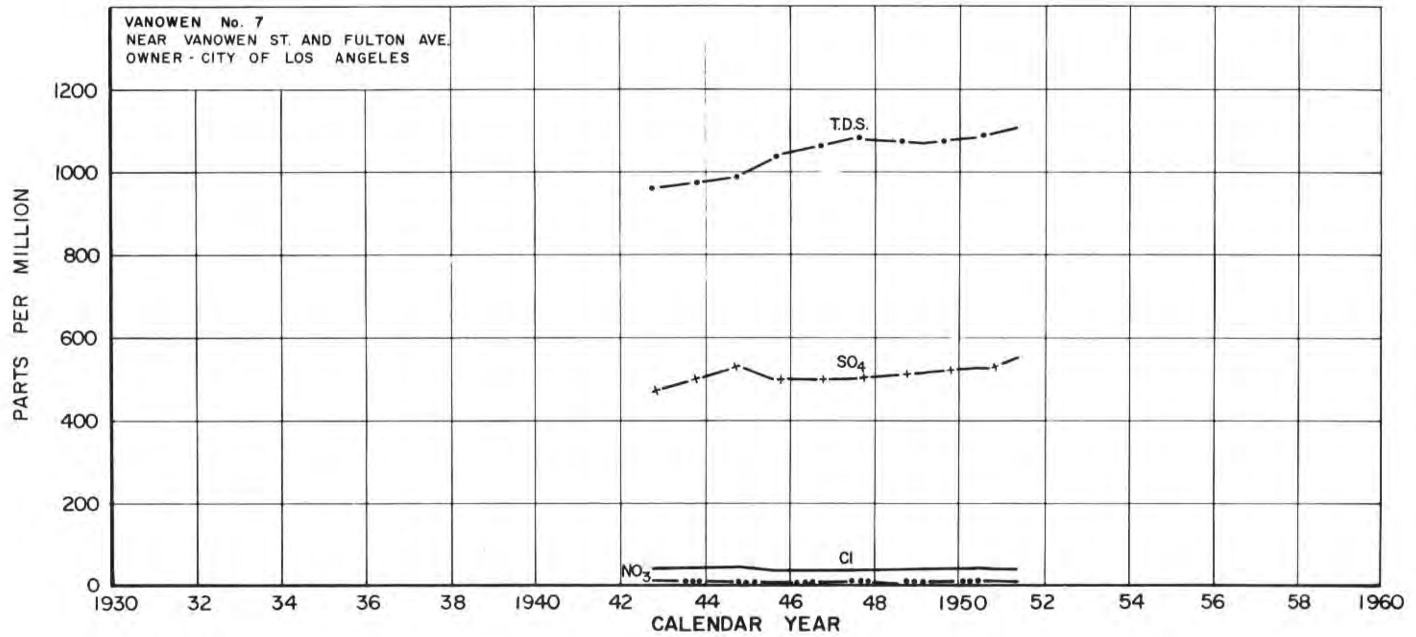
WELL 2760



WELL 3571J



WELL 3673



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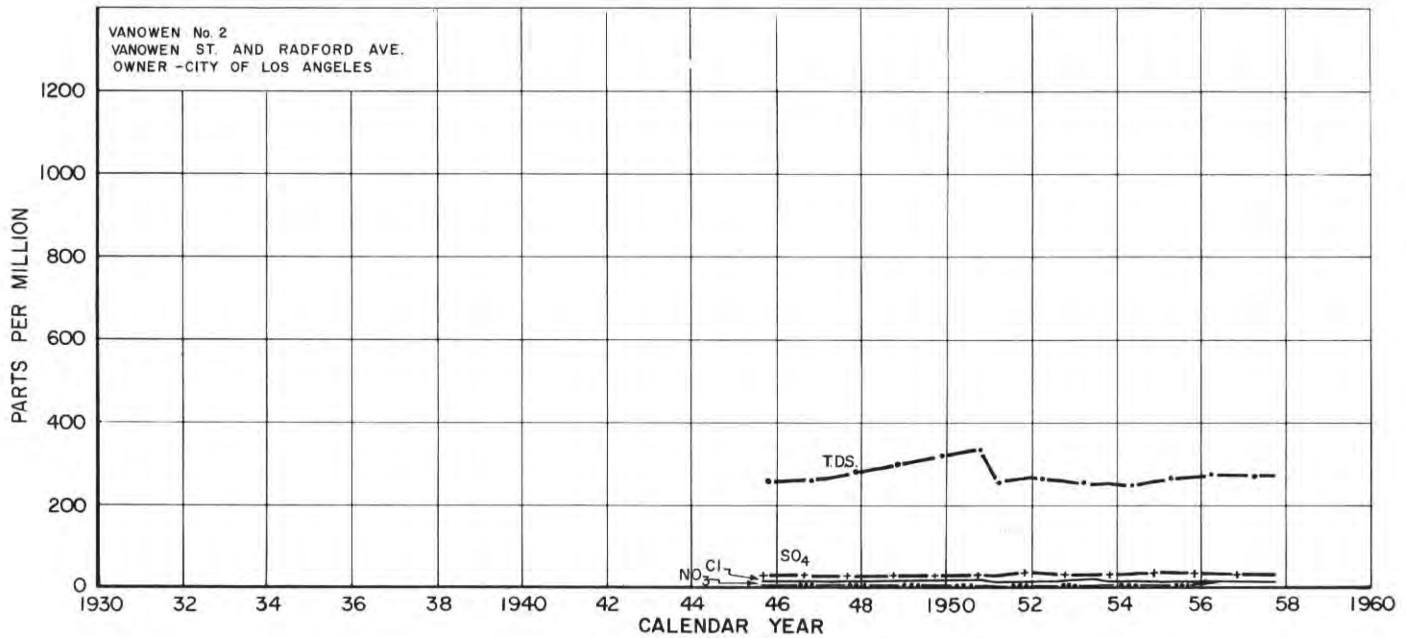

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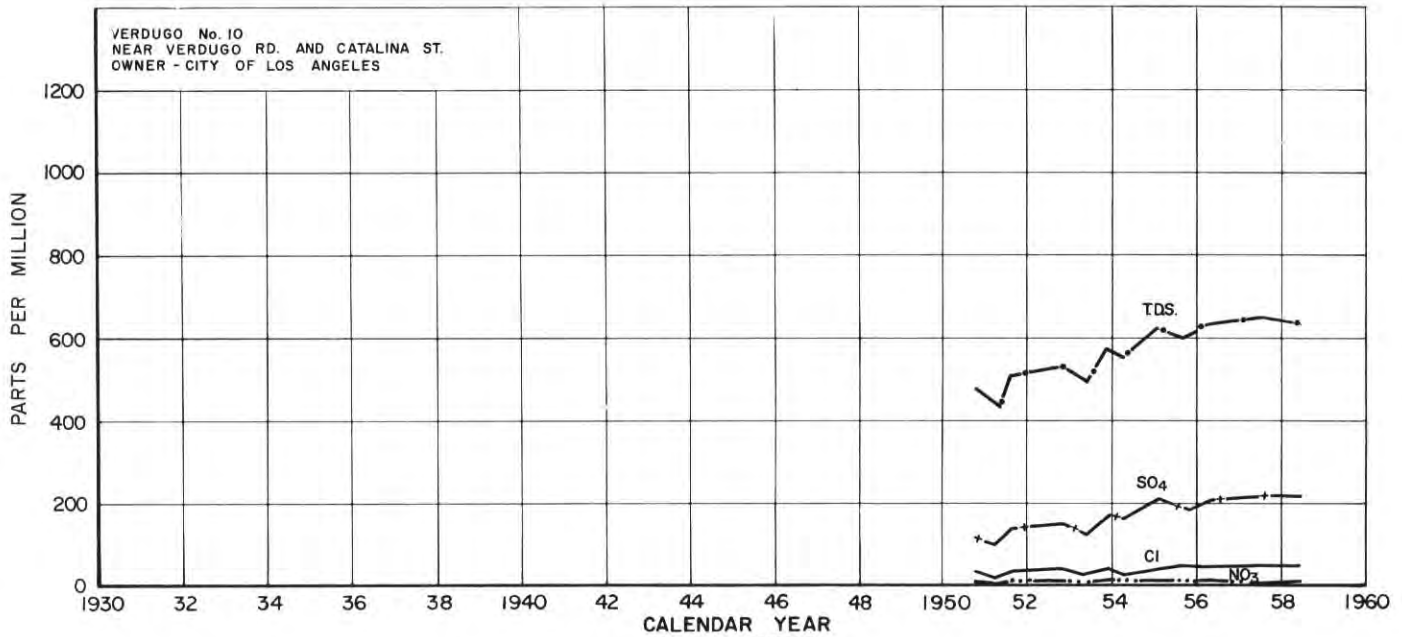


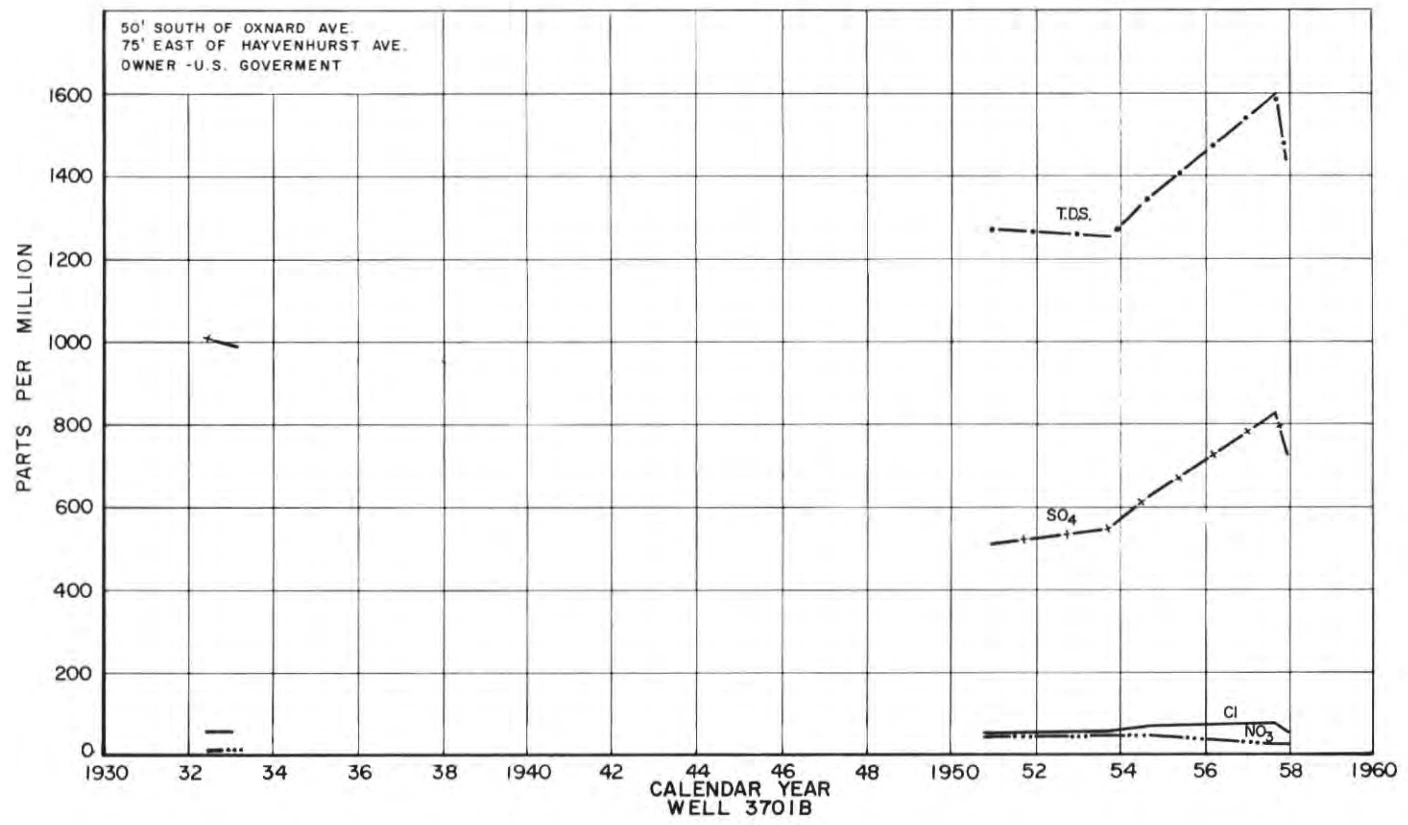
WELL 3863K

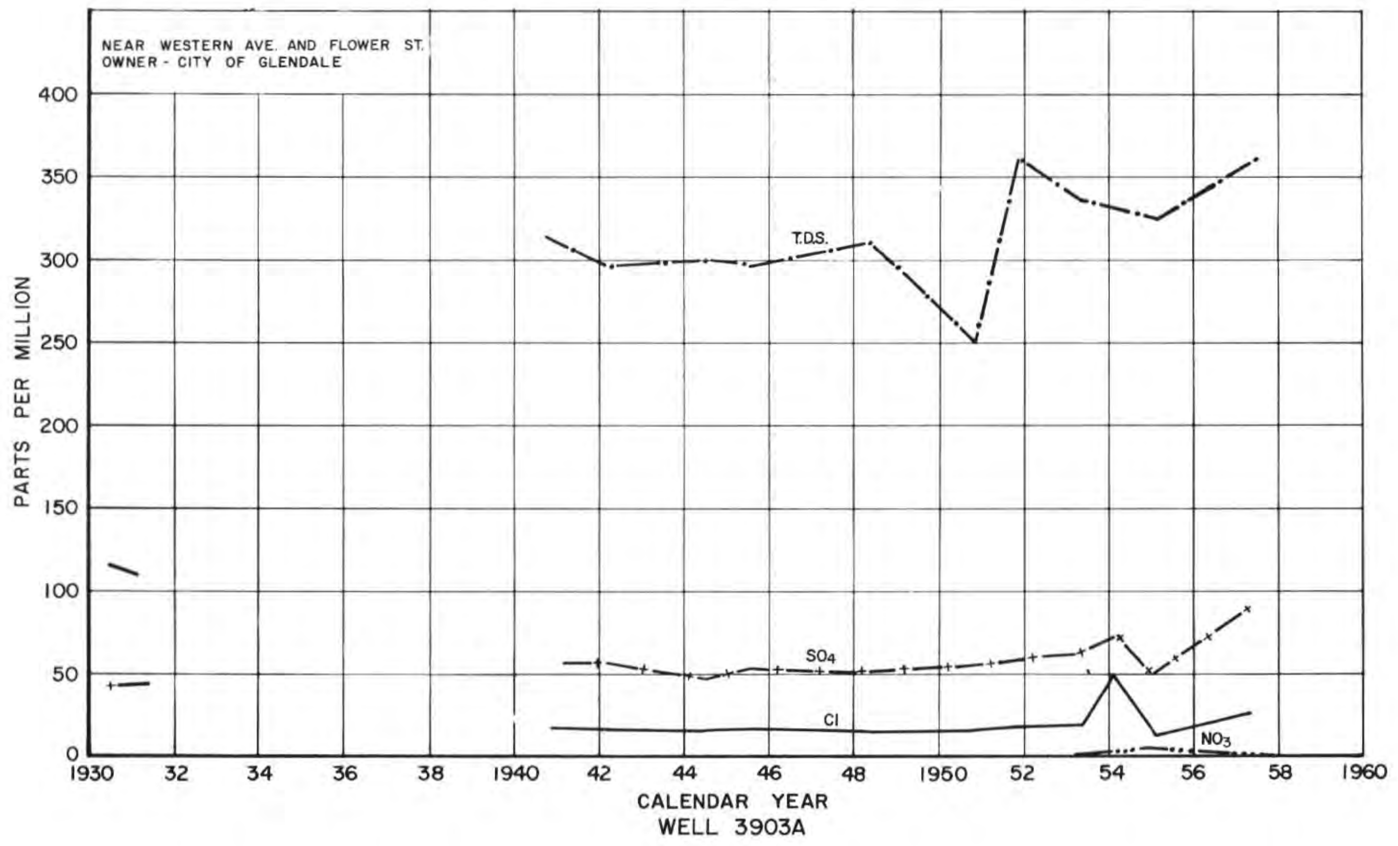
SAN FERNANDO VALLEY REFERENCE

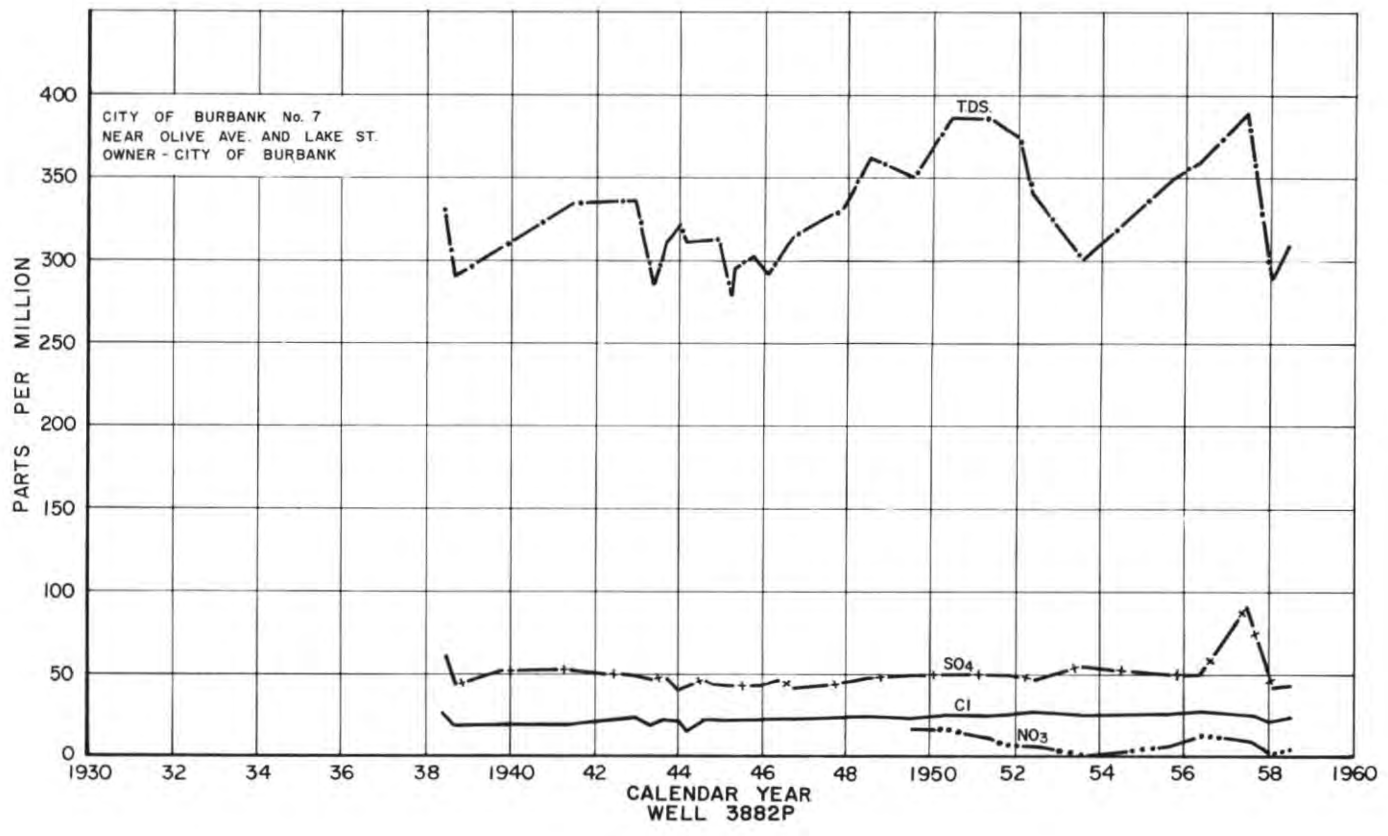
TOTAL DISSOLVED SOLIDS, SULFATE AND CHLORIDE CONTENT OF WELL WATER

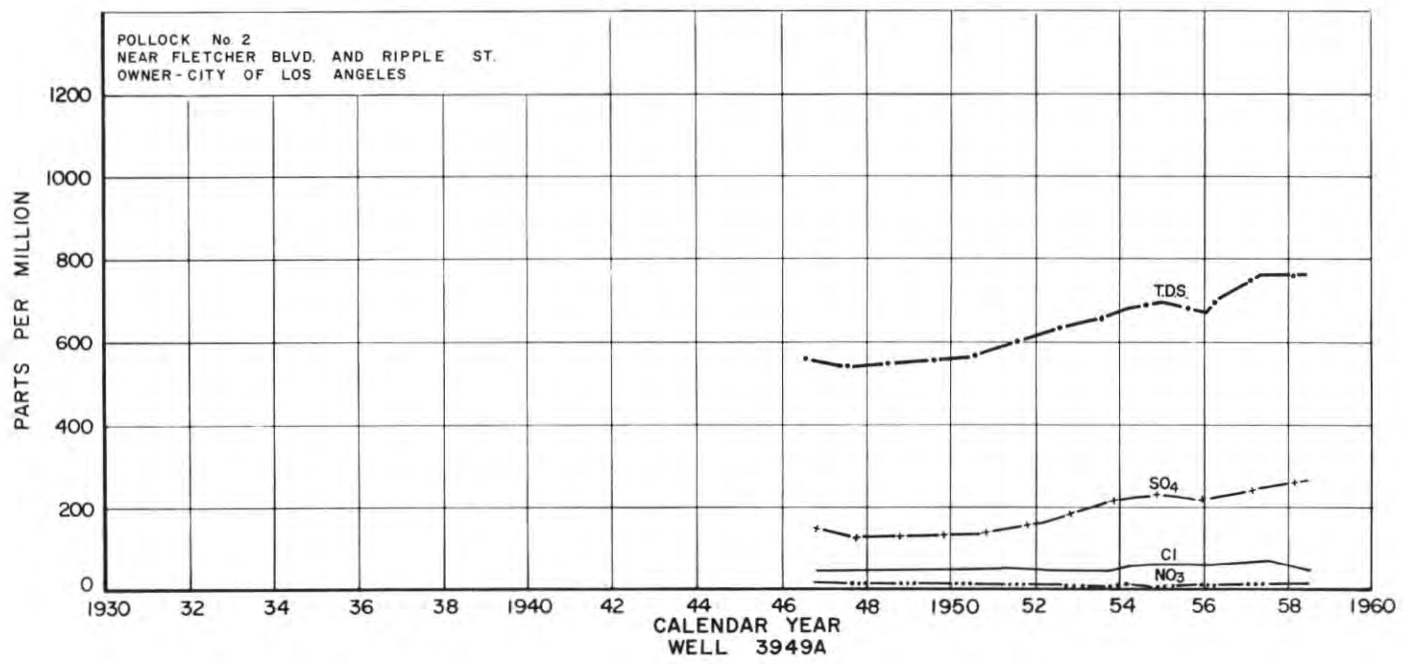
STATE WATER RIGHTS BOARD

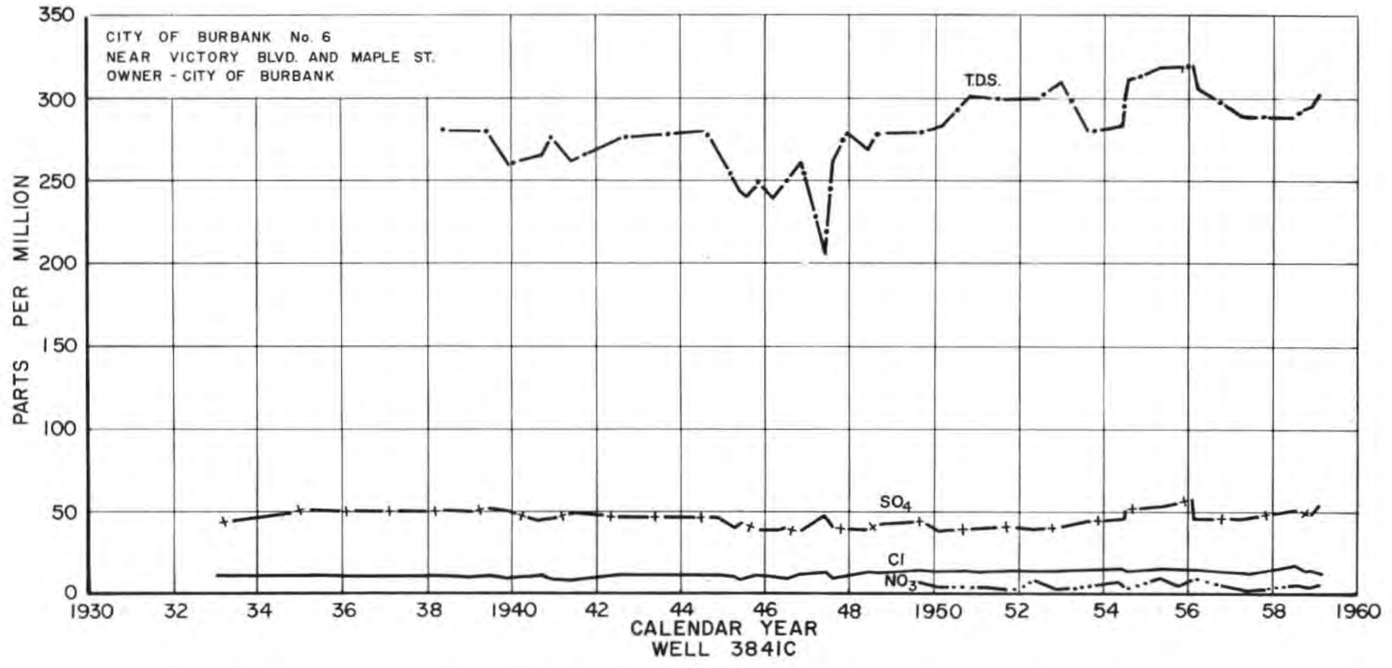
SAN FERNANDO HYDROLOGIC SUBAREA











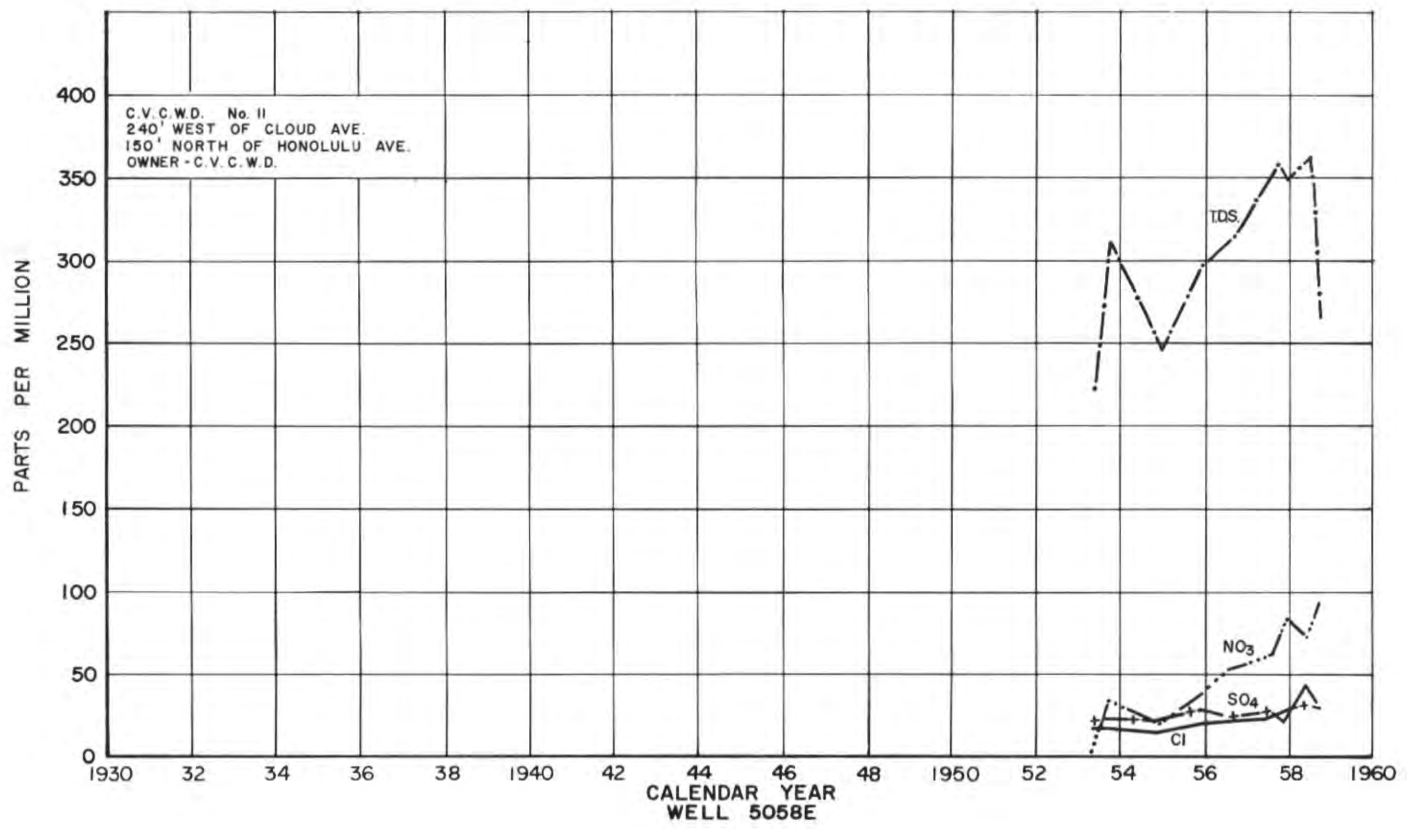
199

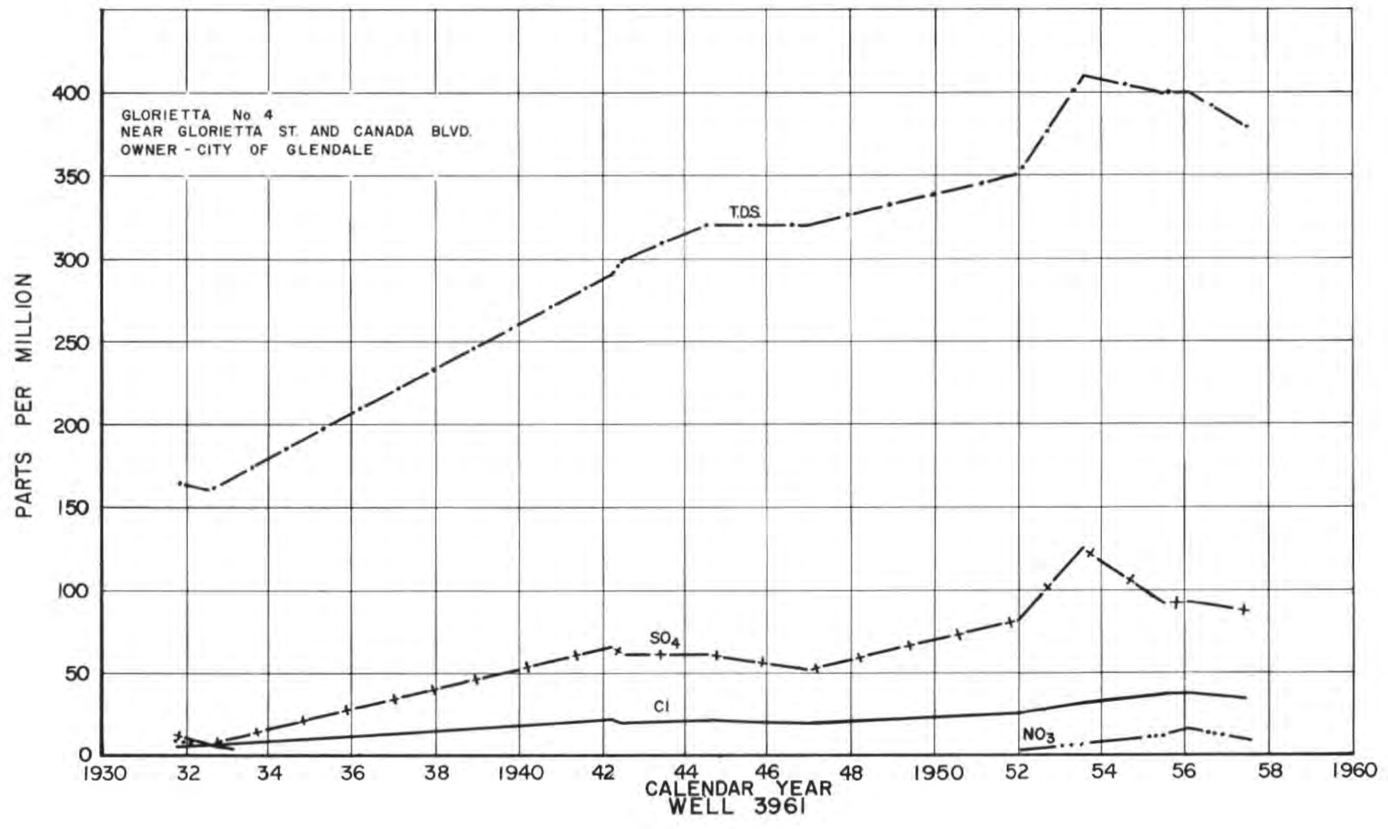
SAN FERNANDO VALLEY REFERENCE

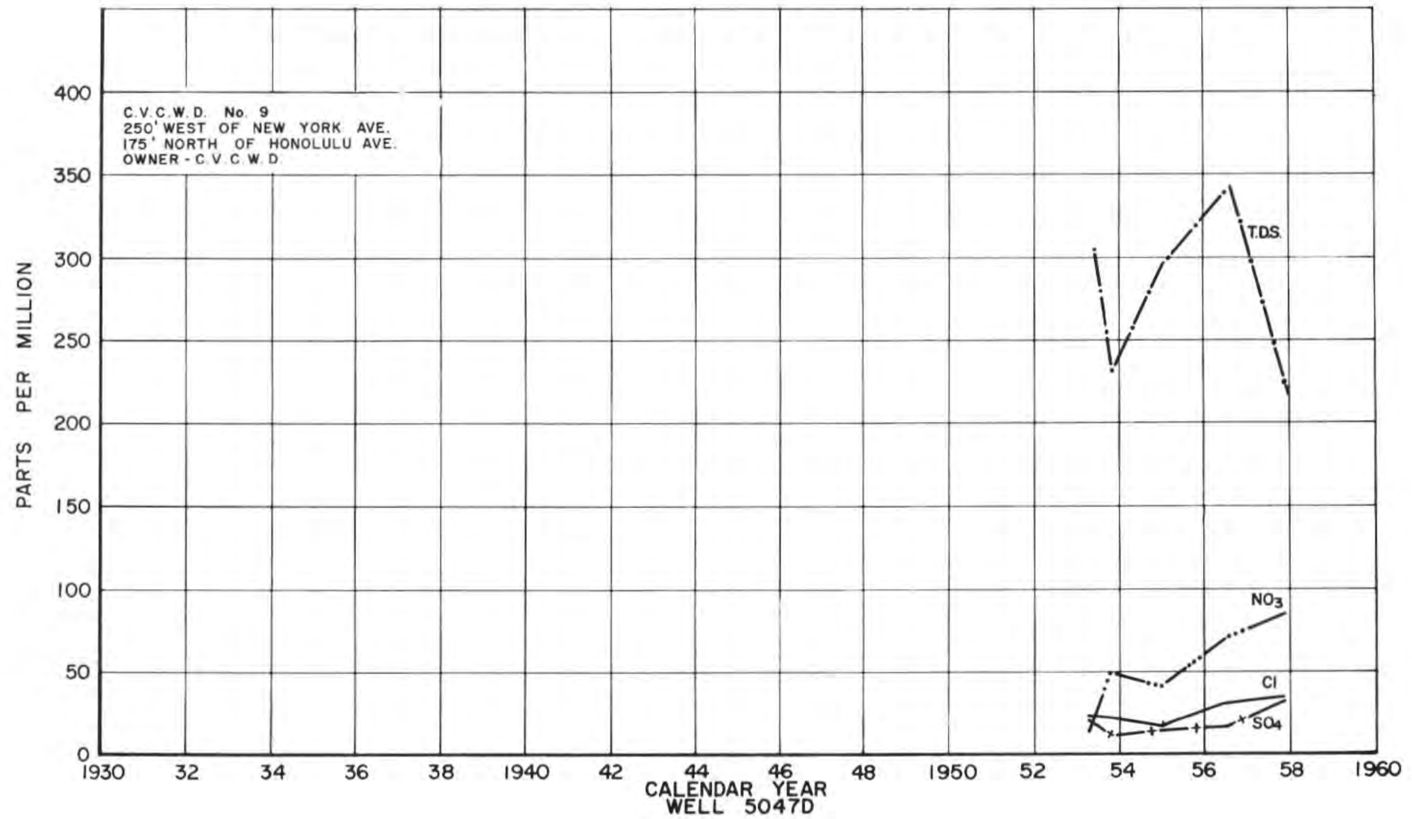
TOTAL DISSOLVED SOLIDS, SULFATE AND CHLORIDE CONTENT OF WELL WATER

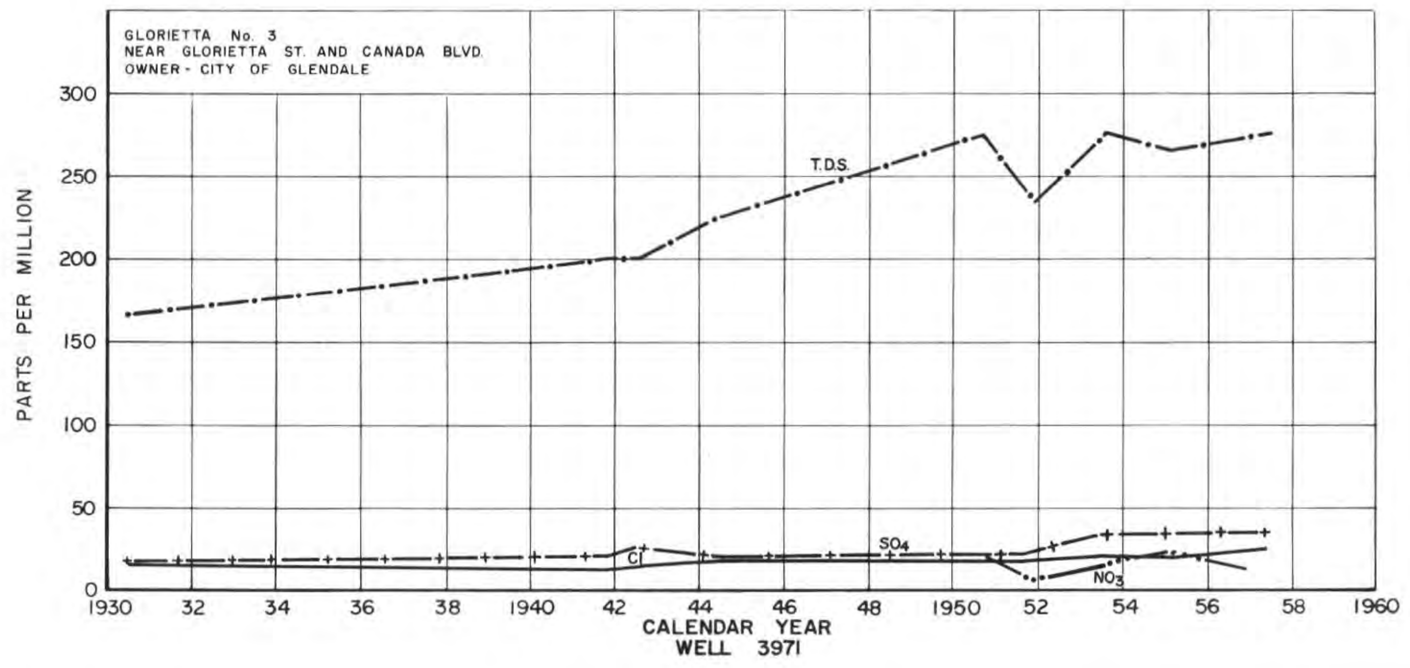
STATE WATER RIGHTS BOARD

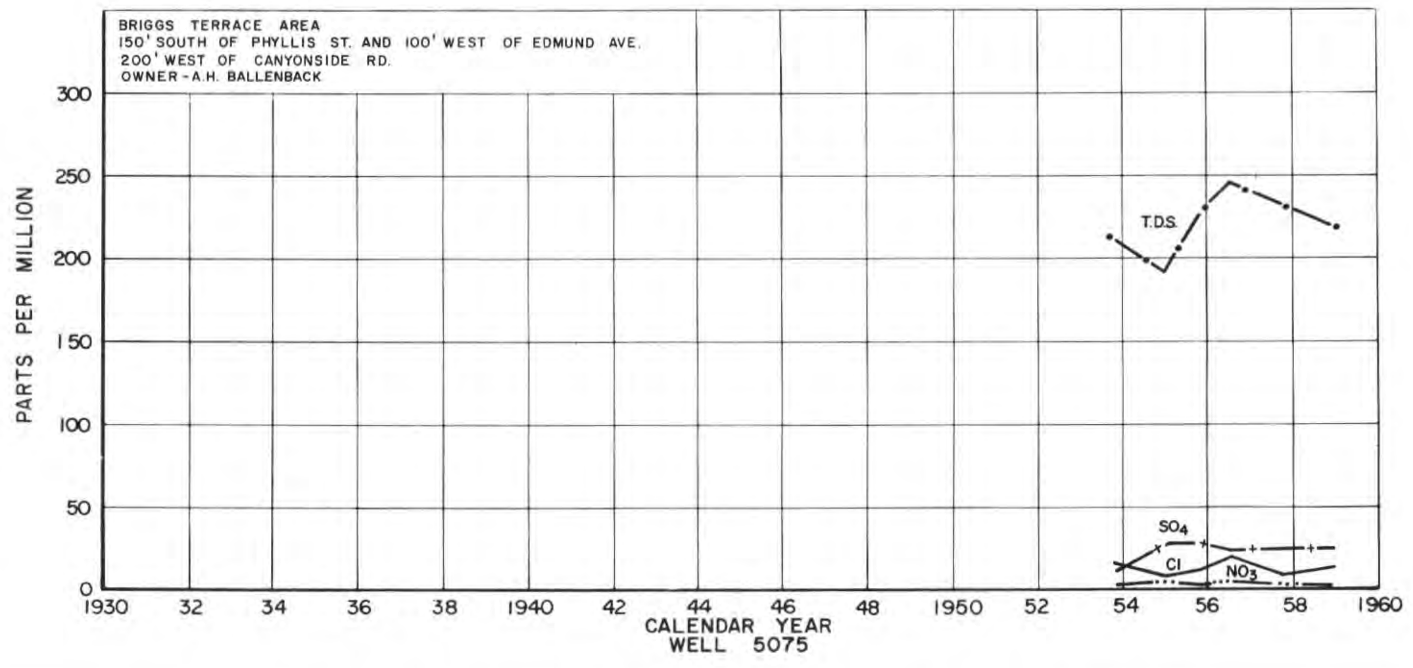
VERDUGO HYDROLOGIC SUBAREA

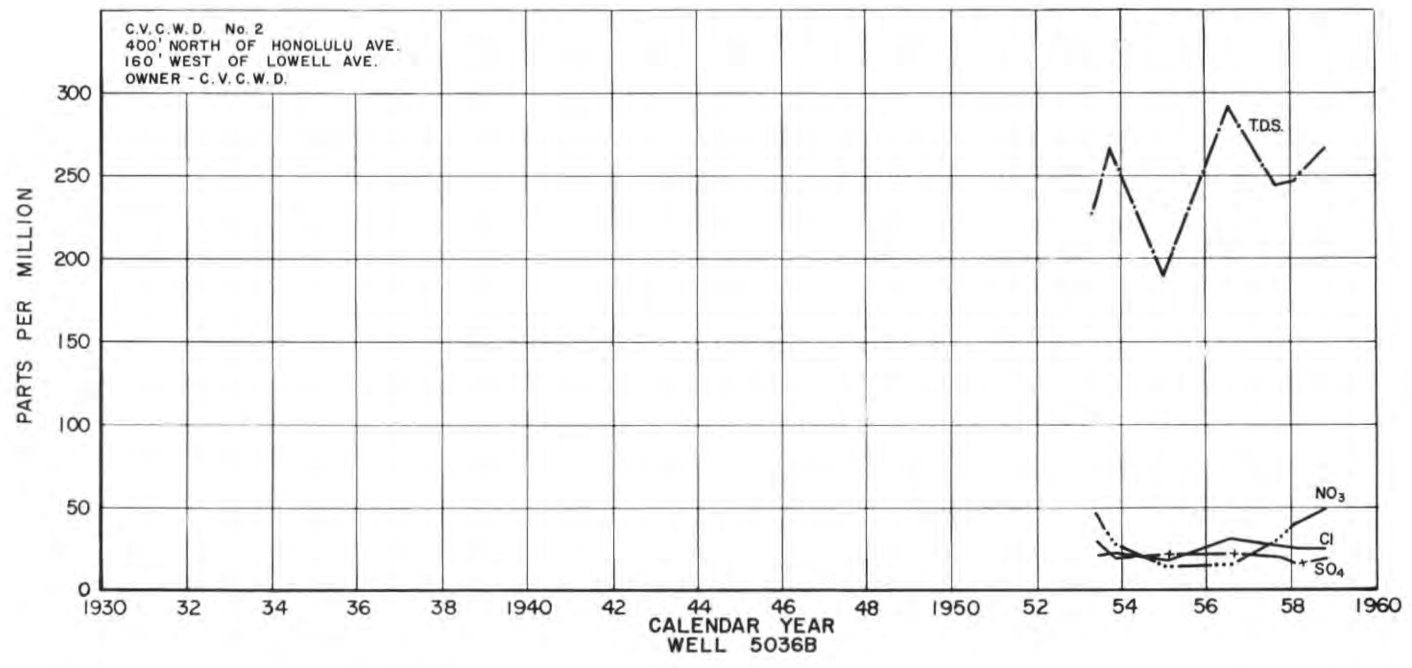








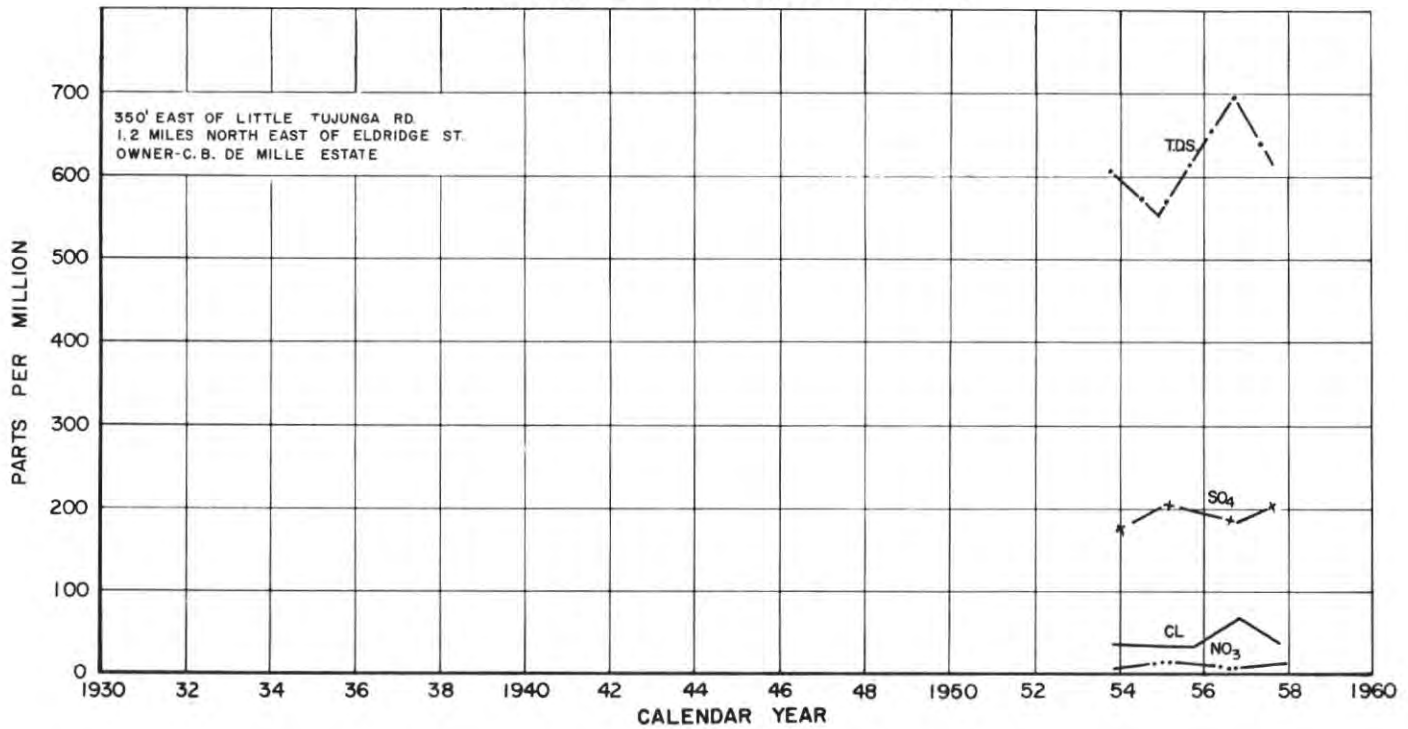




SAN FERNANDO VALLEY REFERENCE

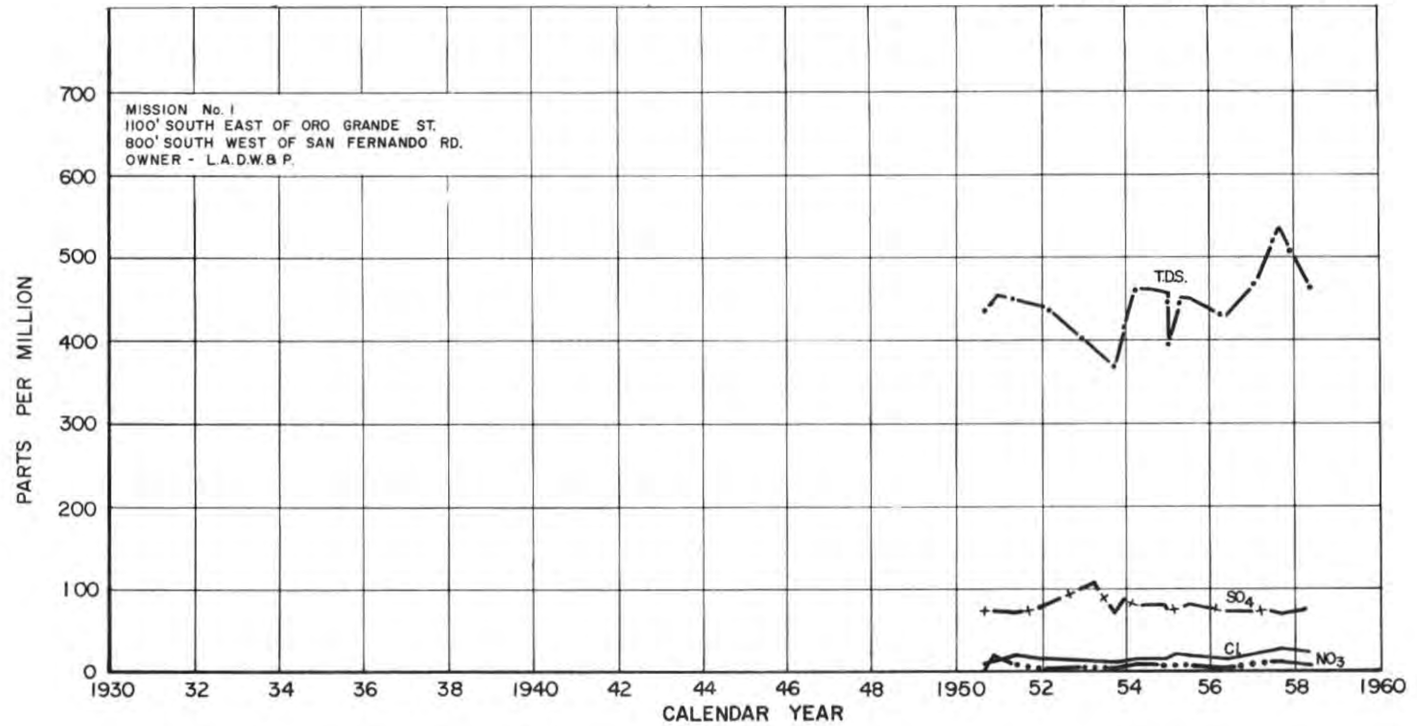
TOTAL DISSOLVED SOLIDS, SULFATE AND CHLORIDE CONTENT OF WELL WATER

LITTLE TUJUNGA AREA

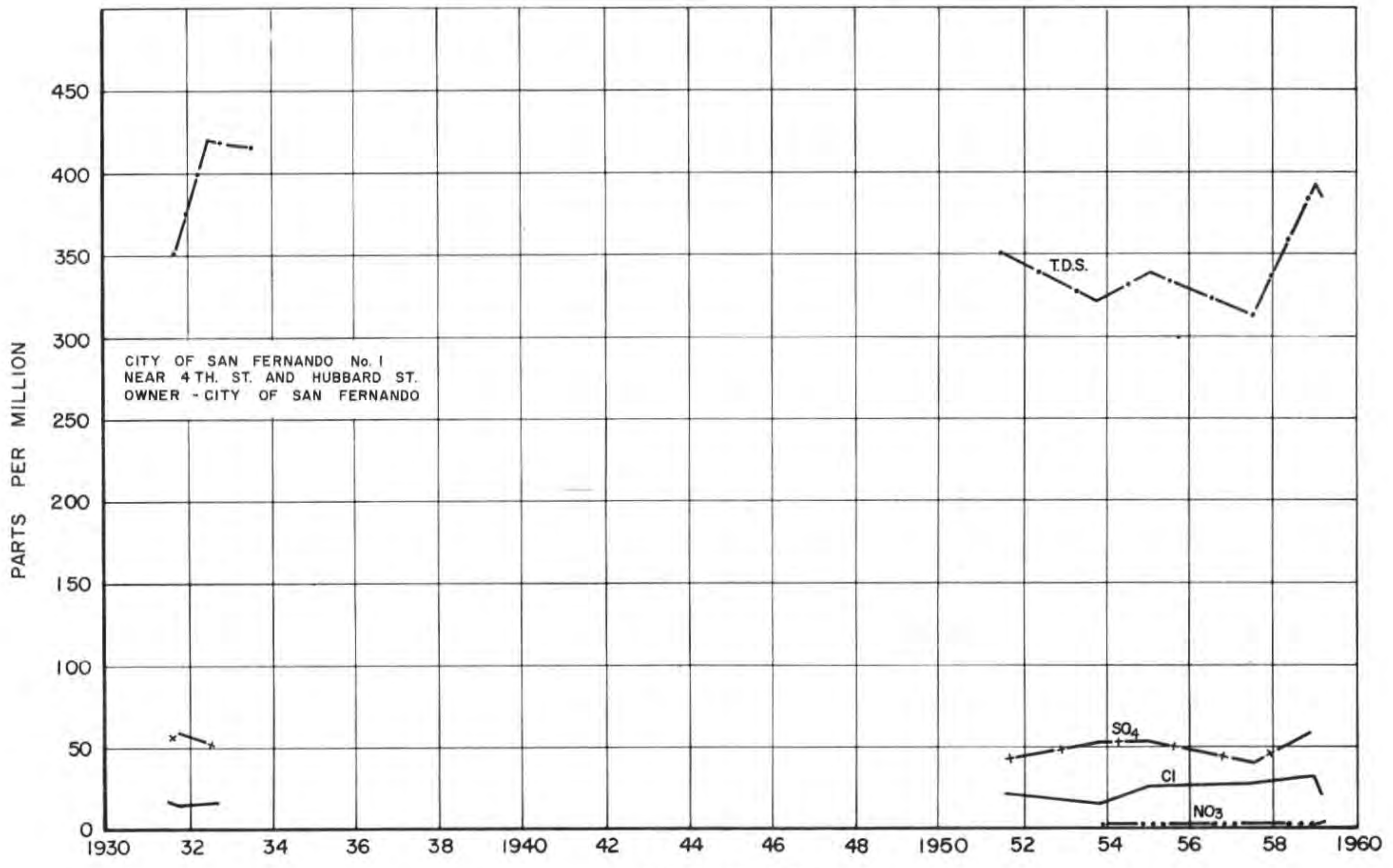


WELL 4931

SYLMAR HYDROLOGIC SUBAREA

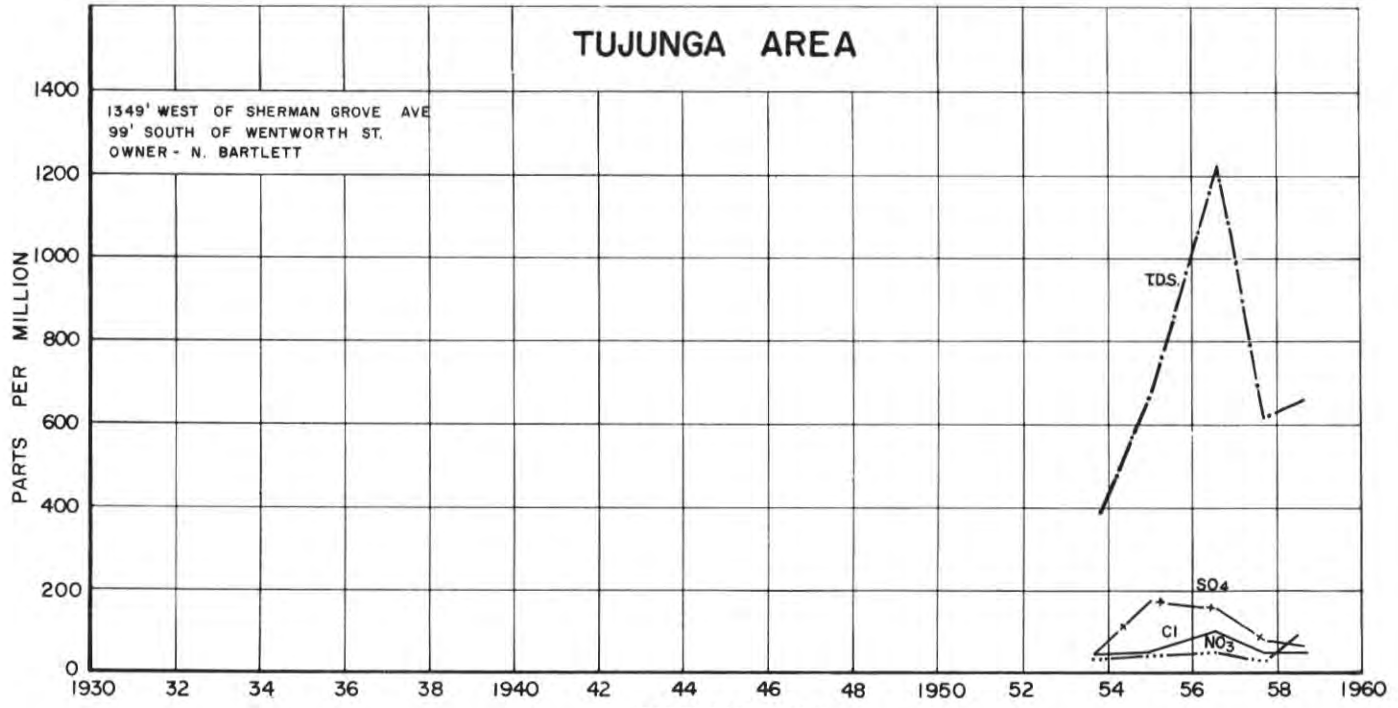


WELL 4840A

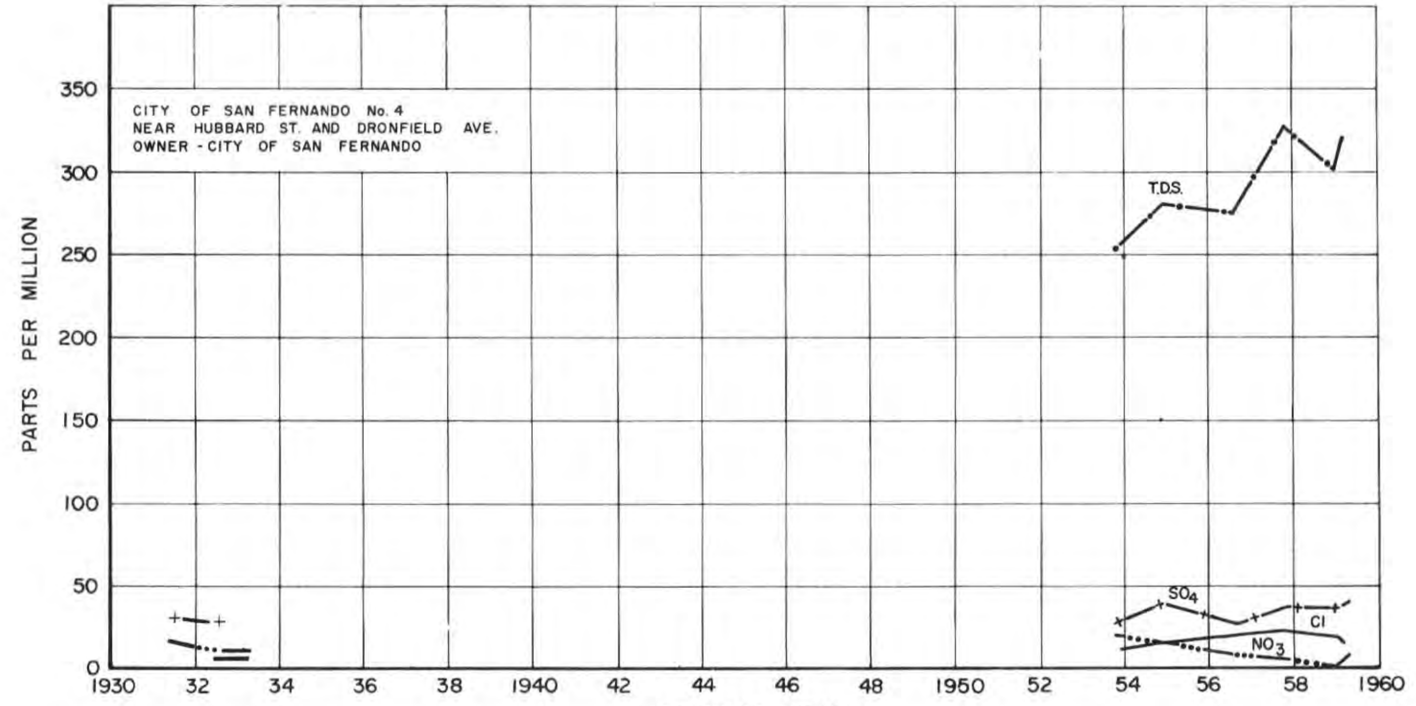


WELL 4850B

TUJUNGA AREA



WELL 4973J

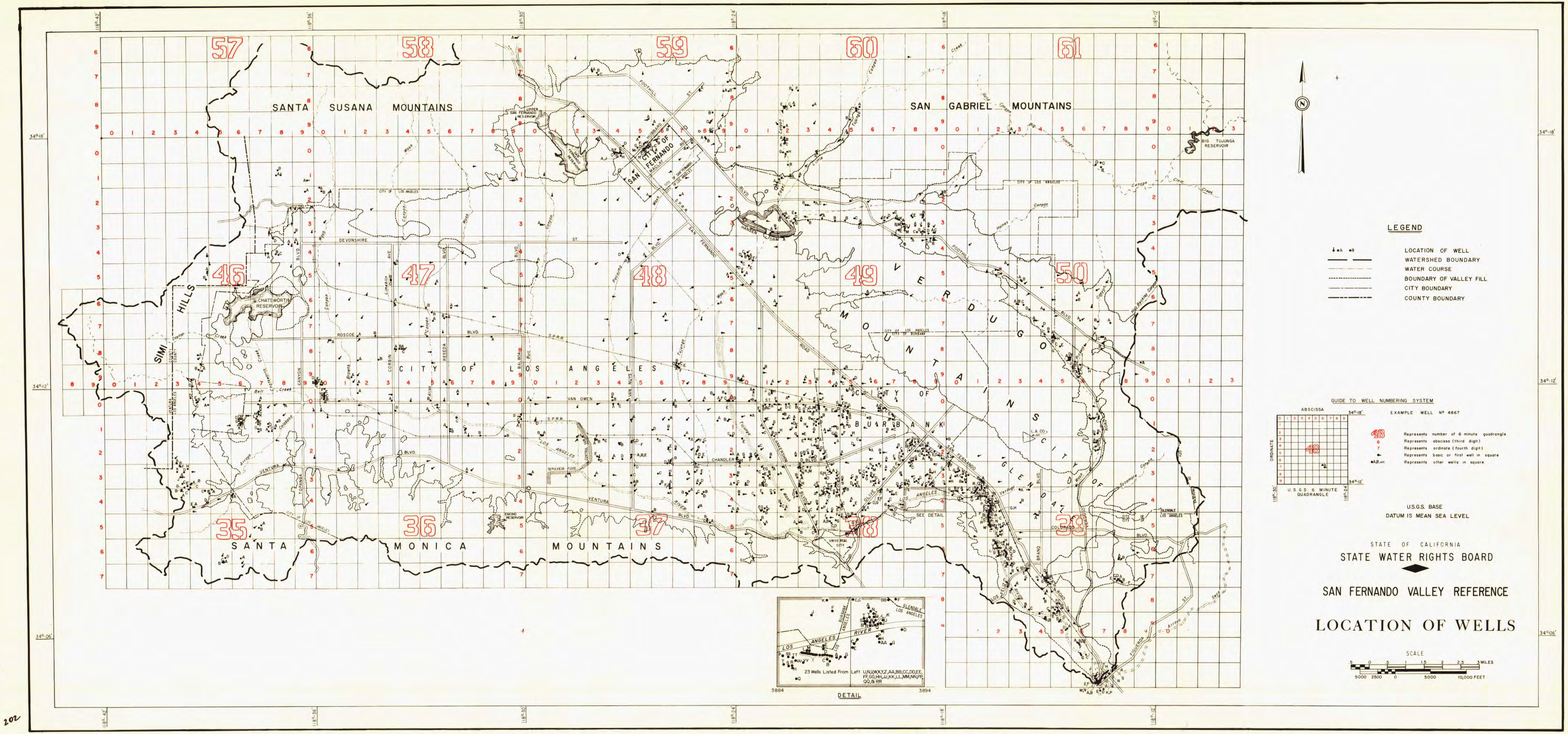


WELL 5969

SAN FERNANDO VALLEY REFERENCE

TOTAL DISSOLVED SOLIDS, SULFATE AND CHLORIDE CONTENT OF WELL WATER

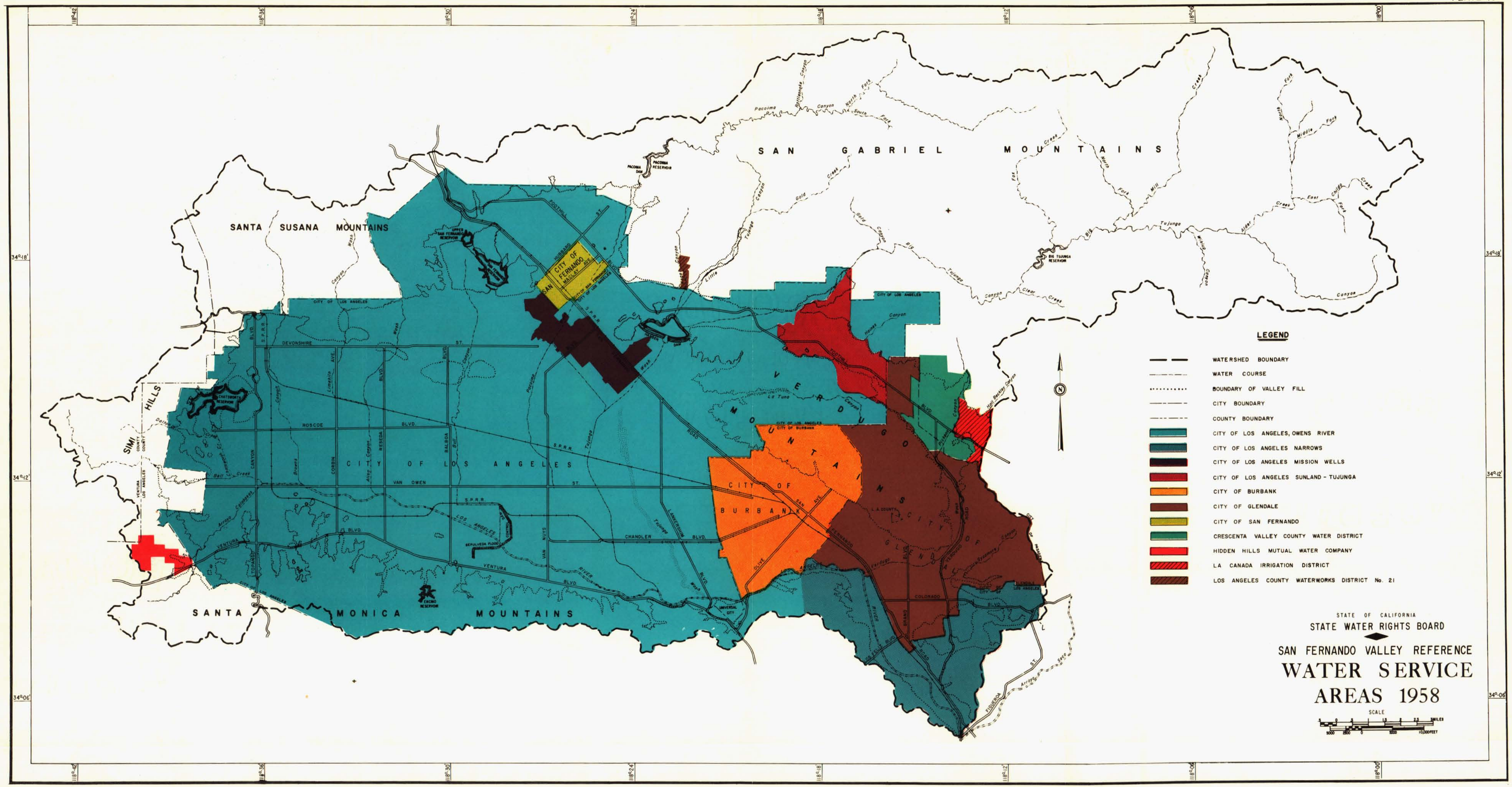
STATE WATER RIGHTS BOARD



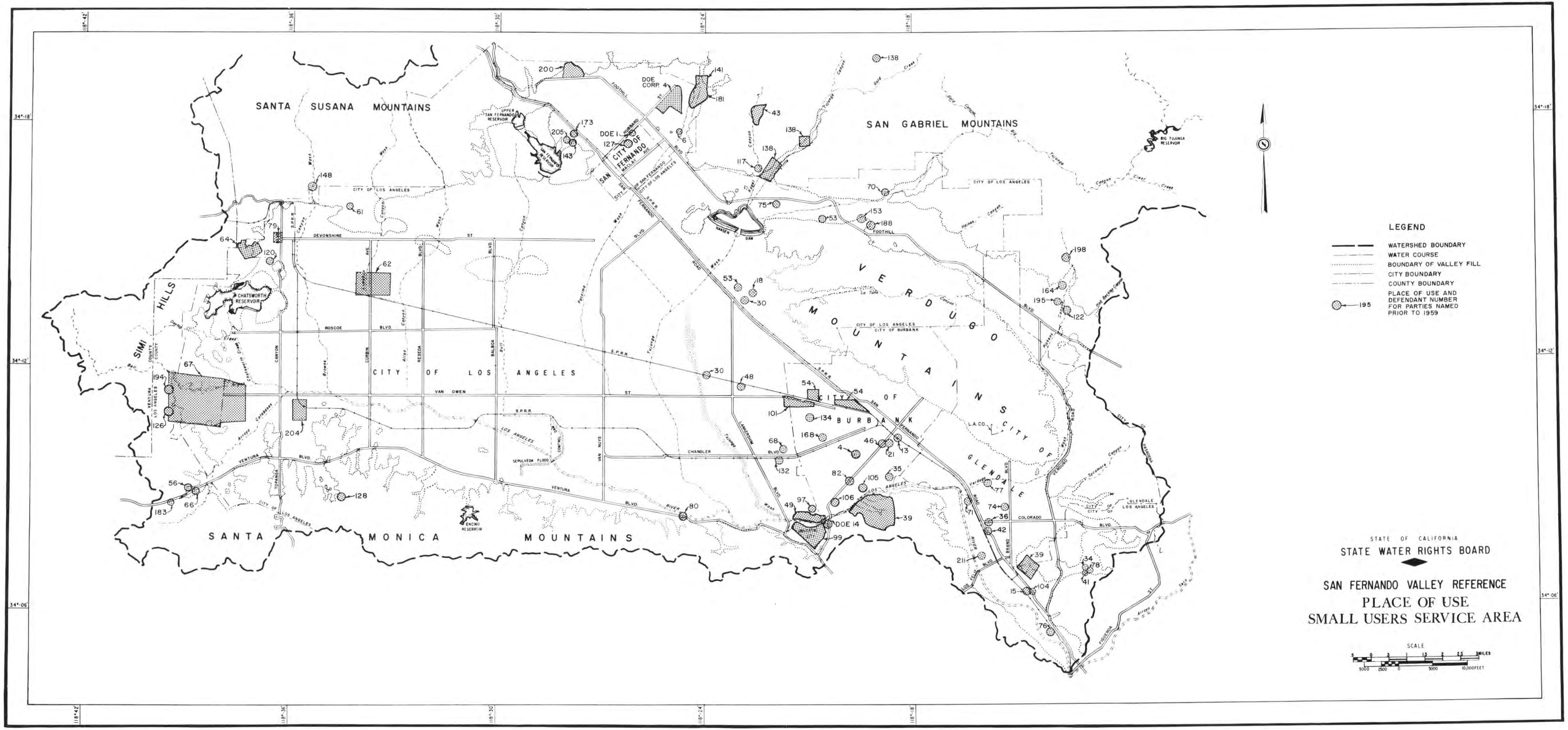
SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
SANTA MONICA MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
CHATSWORTH RESERVOIR
HANSEN DAM
BIG TUJUNGA RESERVOIR
UPPER SAN FERNANDO RESERVOIR
ENCINO RESERVOIR
UNIVERSAL CITY
DEVONSHIRE ST
ROSCOE BLVD.
VAN OWEN
VENTURA BLVD.
FOOTHILL BLVD.
SAN FERNANDO ROAD
LOS ANGELES RIVER
S.P.R.R.
LEGEND
LOCATION OF WELL
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
GUIDE TO WELL NUMBERING SYSTEM
ABSCISSA
ORDINATE
EXAMPLE WELL Nº 4867
Represents number of 6 minute quadrangle
Represents abscissa (third digit)
Represents ordinate (fourth digit)
Represents basic or first well in square
Represents other wells in square
U.S.G.S. 6 MINUTE QUADRANGLE
U.S.G.S. BASE
DATUM IS MEAN SEA LEVEL
SEE DETAIL
DETAIL
23 Wells Listed From Left: U,N,W,X,Y,Z,AA,BB,CC,DD,EE, FF,GG,HH,JJ,KK,LL,MM,NN,PP, QQ,& RR
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
LOCATION OF WELLS
SCALE
MILES
5000 2500 0 5000 10,000 FEET

202

PLATE 19

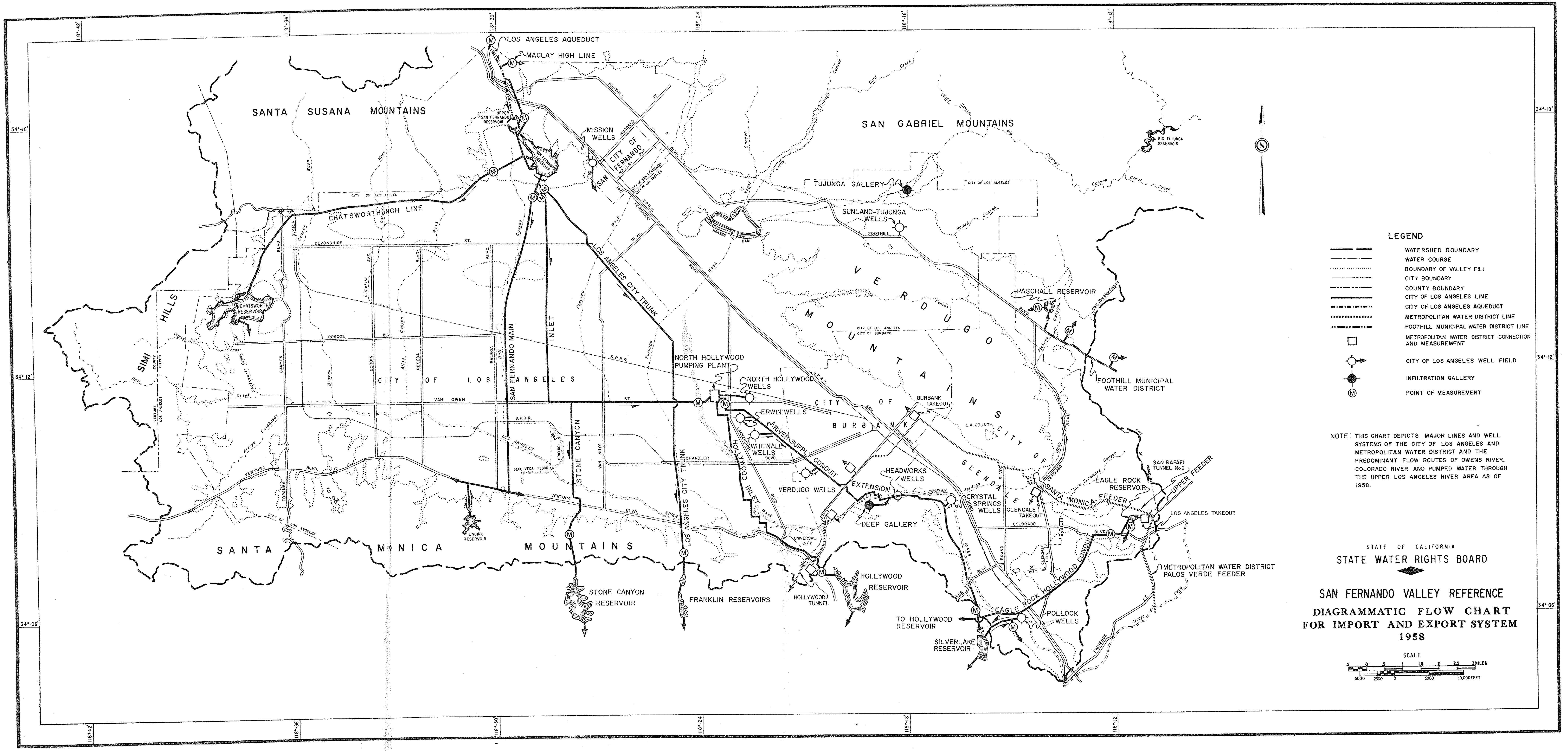

SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
SAN FERNANDO
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
CITY OF LOS ANGELES, OWENS RIVER
CITY OF LOS ANGELES NARROWS
CITY OF LOS ANGELES MISSION WELLS
CITY OF LOS ANGELES SUNLAND - TUJUNGA
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
CRESCENTA VALLEY COUNTY WATER DISTRICT
HIDDEN HILLS MUTUAL WATER COMPANY
LA CANADA IRRIGATION DISTRICT
LOS ANGELES COUNTY WATERWORKS DISTRICT No. 21
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
WATER SERVICE
AREAS 1958
SCALE

203



SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
SIMI HILLS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
UPPER SAN FERNANDO RESERVOIR
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
HANSEN DAM
SEPULVEDA FLOOD CONTROL
DEVONSHIRE
ROSCOE BLVD.
VAN OWEN ST.
VENTURA BLVD.
CHANDLER BLVD.
FOOTHILL BLVD.
COLORADO BLVD.
LOS ANGELES RIVER
S.P.R.R.
VENTURA COUNTY
LOS ANGELES COUNTY
DOE 1
DOE 14
DOE CORP. 4
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
PLACE OF USE AND DEFENDANT NUMBER FOR PARTIES NAMED PRIOR TO 1959
195
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
PLACE OF USE
SMALL USERS SERVICE AREA
SCALE
MILES
FEET

204

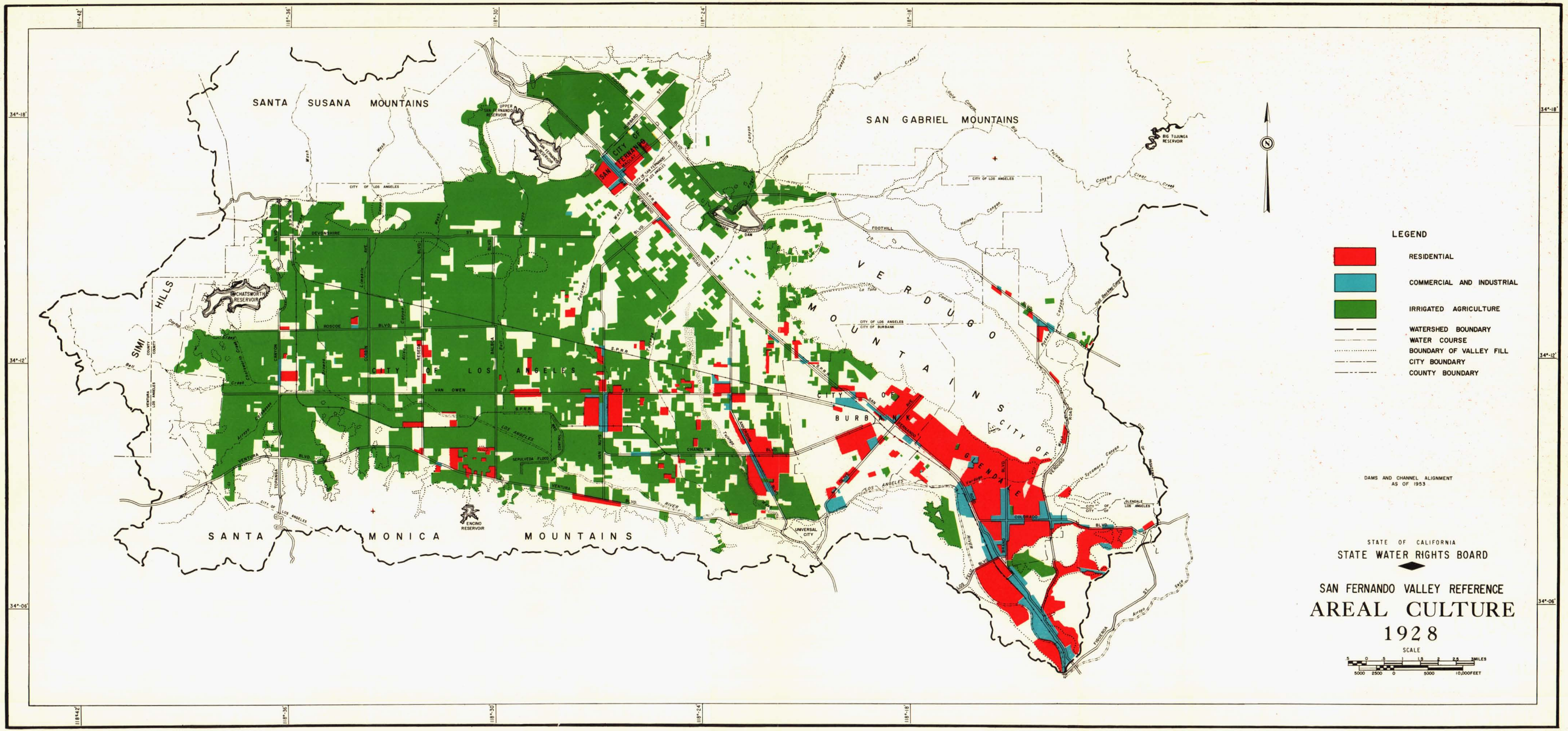


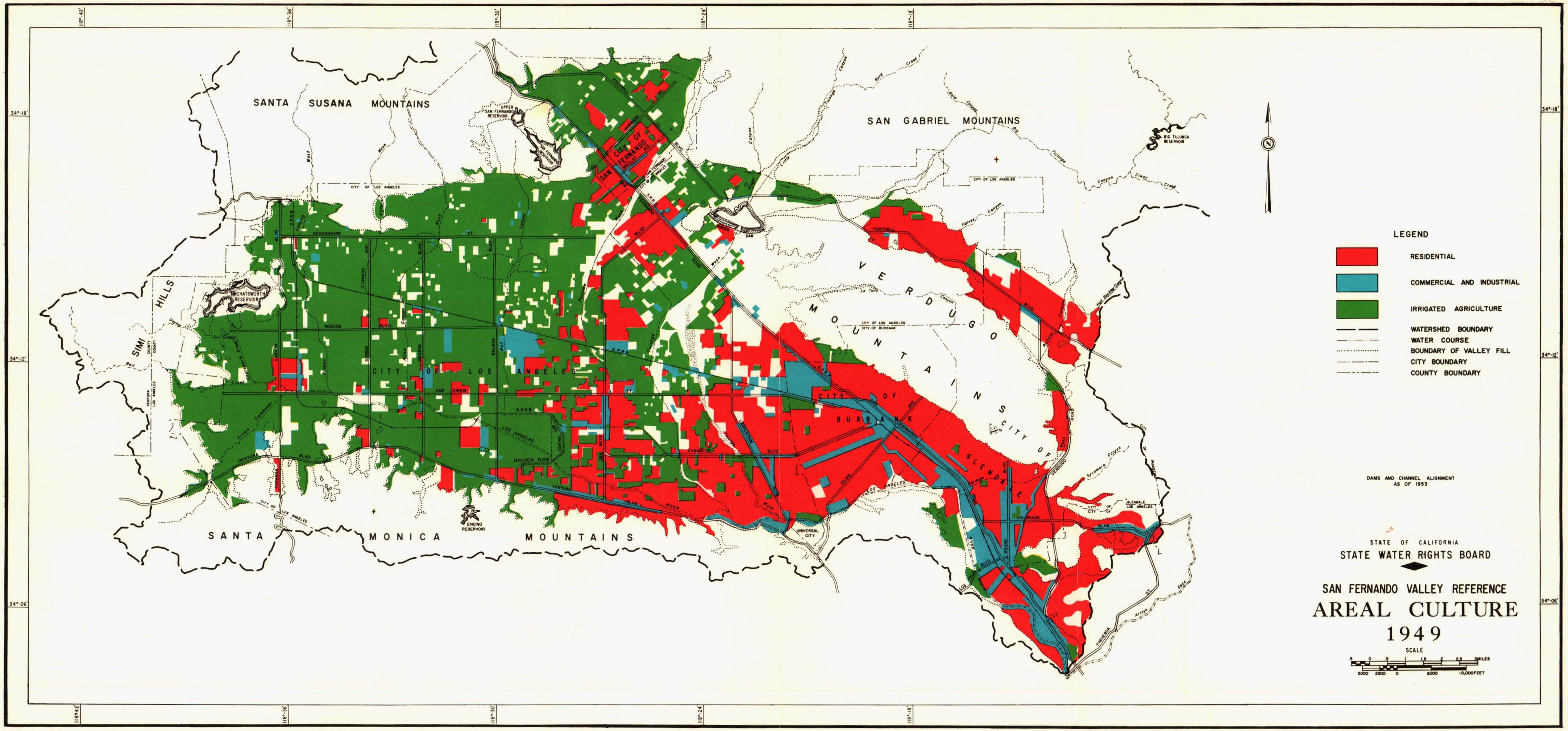
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

DIAGRAMMATIC FLOW CHART FOR IMPORT AND EXPORT SYSTEM 1958

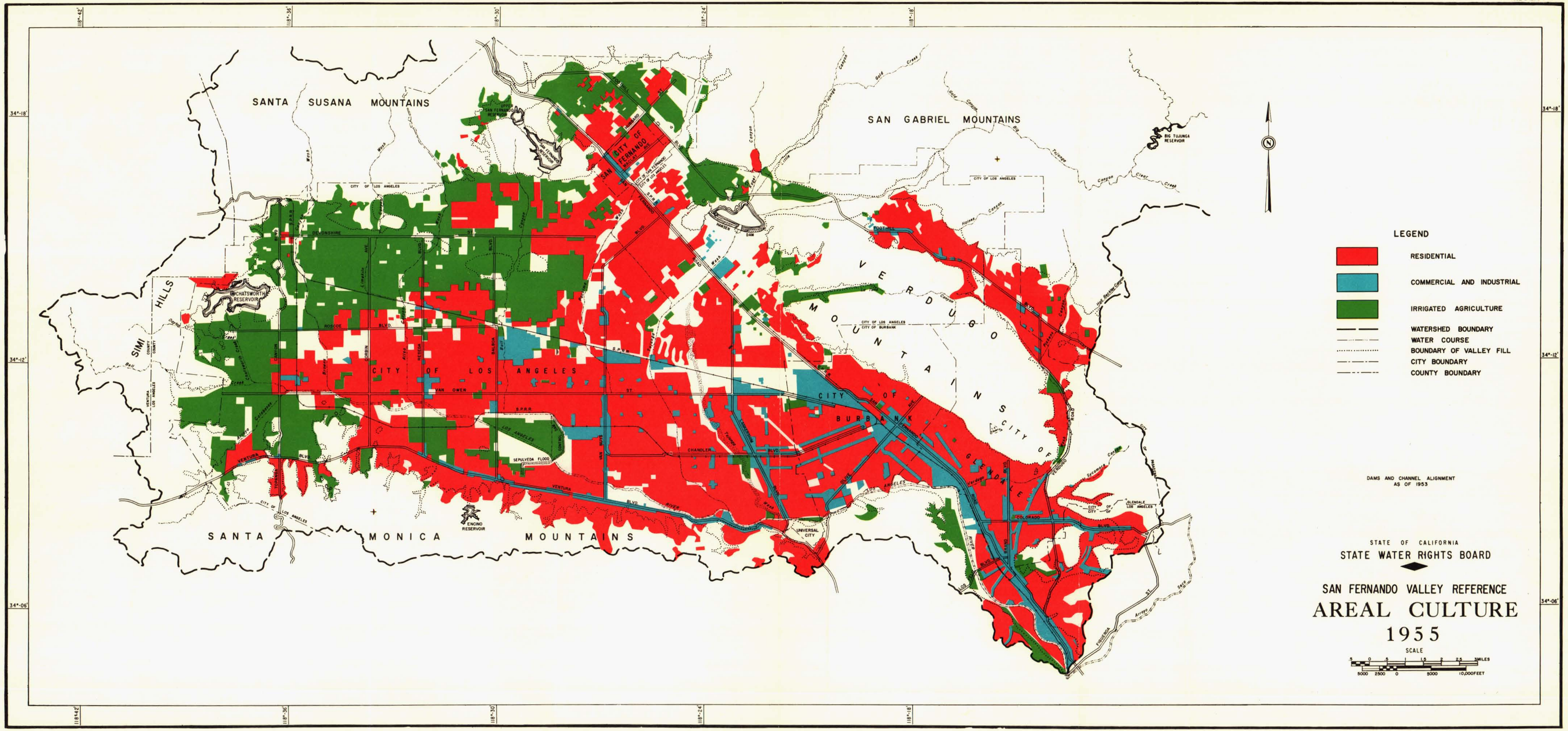
PLATE 22

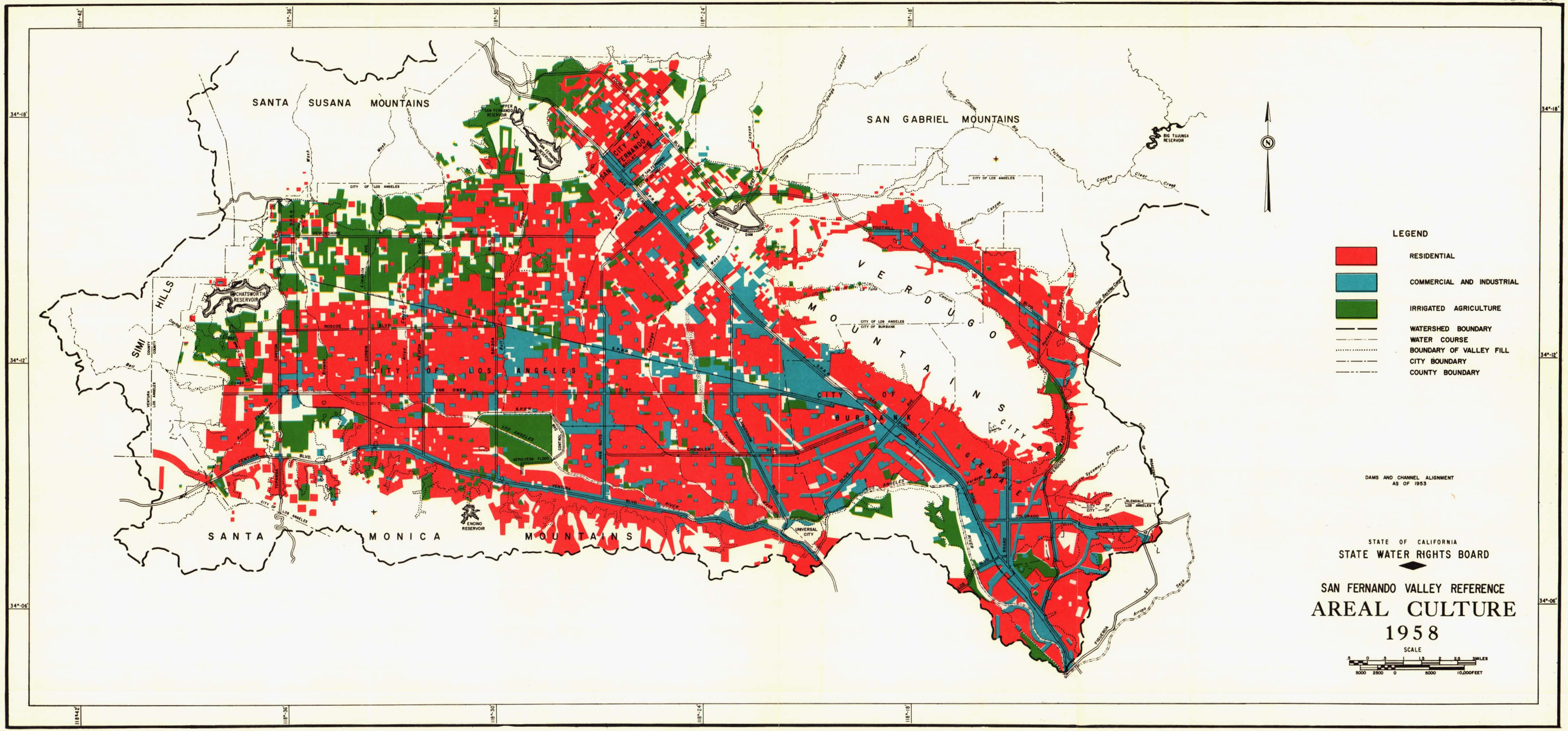

SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
SANTA MONICA MOUNTAINS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
UNIVERSAL CITY
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
UPPER SAN FERNANDO RESERVOIR
BIG TUJUNGA RESERVOIR
LEGEND
RESIDENTIAL
COMMERCIAL AND INDUSTRIAL
IRRIGATED AGRICULTURE
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
DAMS AND CHANNEL ALIGNMENT AS OF 1953
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
AREAL CULTURE
1928
SCALE

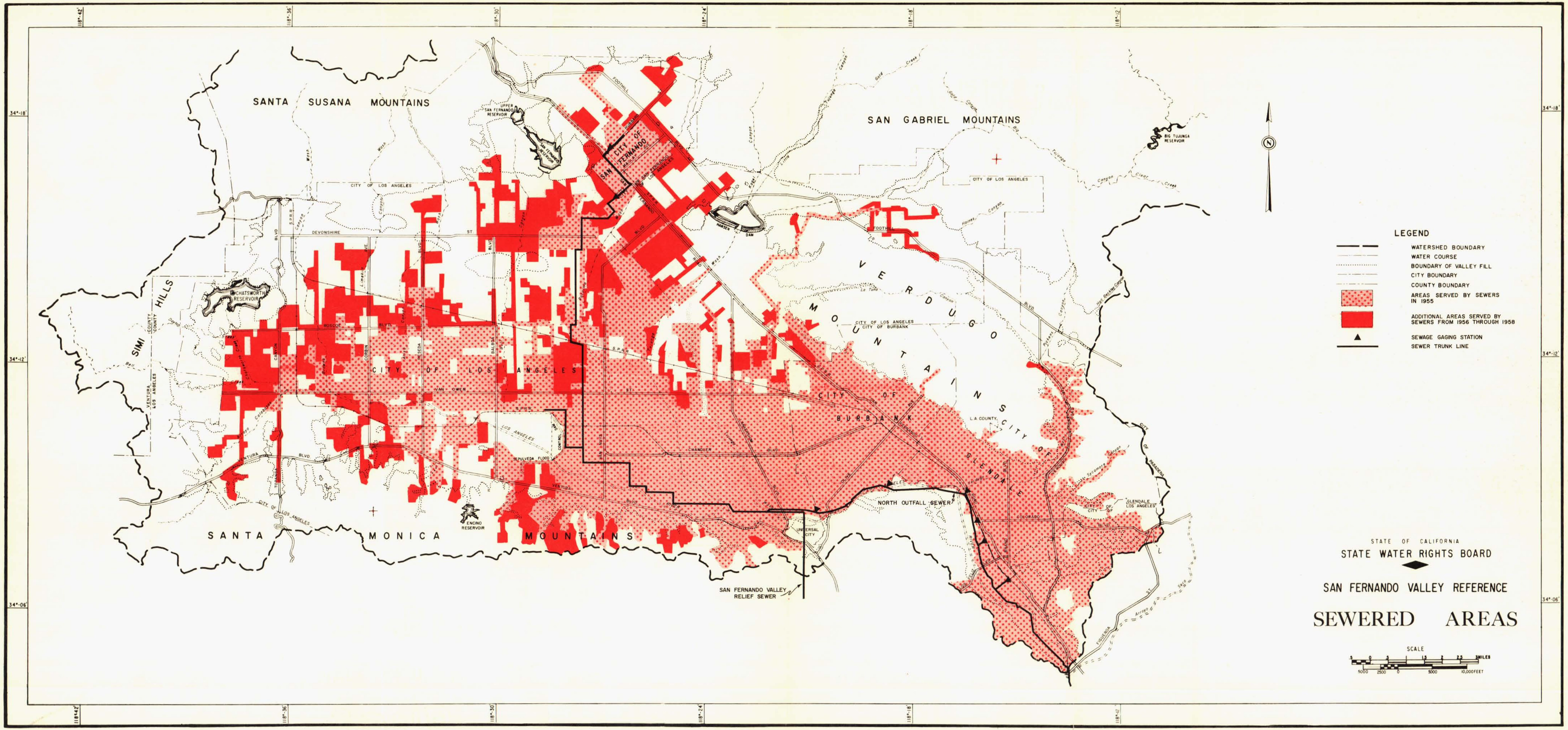


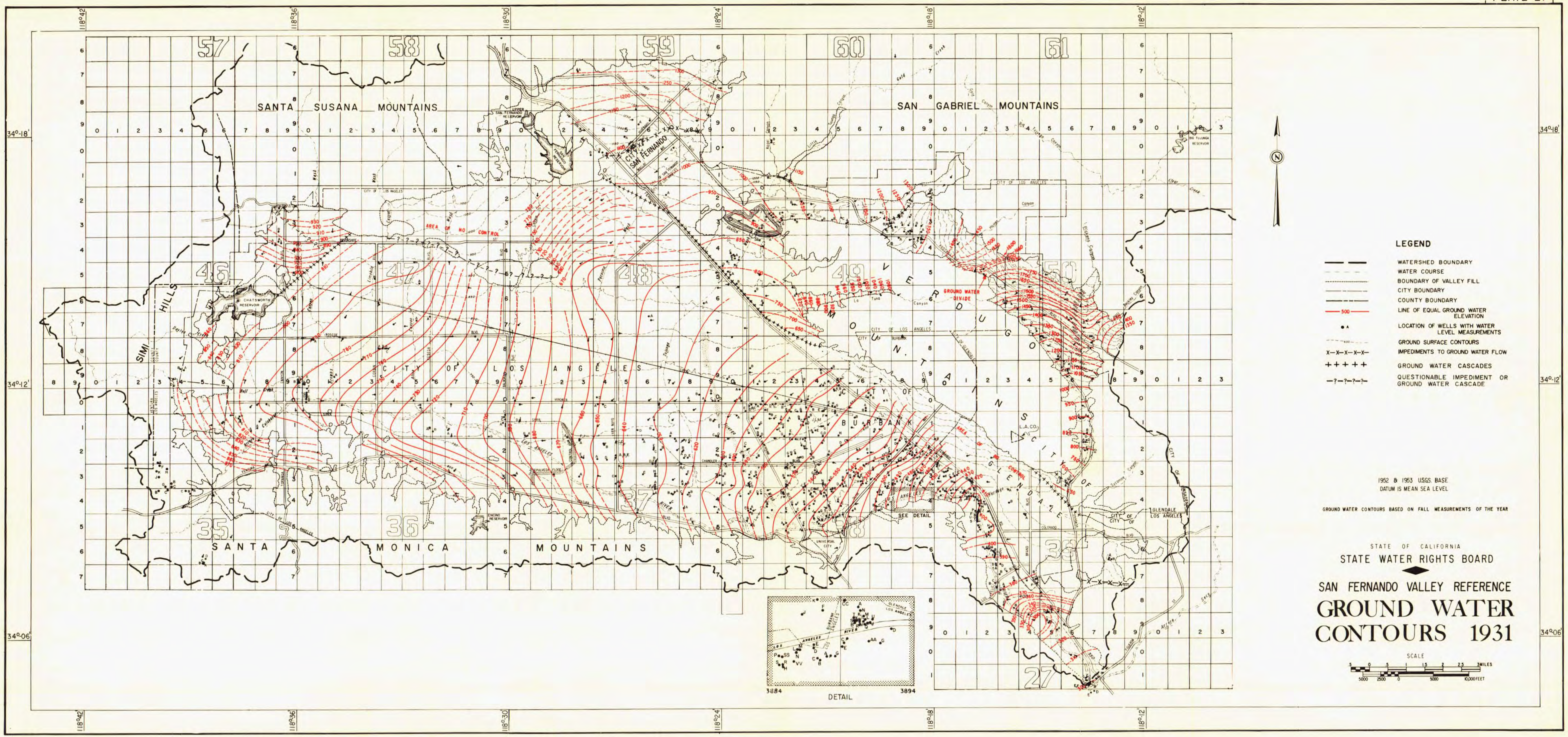
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE
AREAL CULTURE
1949


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
SANTA MONICA MOUNTAINS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
HANSEN DAM
SEPULVEDA FLOOD
UNIVERSAL CITY
DEVONSHIRE ST
ROSCOE BLVD.
VAN OWEN ST
VENTURA BLVD.
CHANDLER BLVD.
FOOTHILL BLVD.
COLORADO BLVD.
LEGEND
RESIDENTIAL
COMMERCIAL AND INDUSTRIAL
IRRIGATED AGRICULTURE
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
DAMS AND CHANNEL ALIGNMENT AS OF 1953
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
AREAL CULTURE
1955
SCALE
5000 2500 0 5000 10,000 FEET


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
CHATSWORTH RESERVOIR
UPPER SAN FERNANDO RESERVOIR
BIG TUJUNGA RESERVOIR
ENCINO RESERVOIR
HANSEN DAM
SEPULVEDA FLOOD CONTROL BASIN
UNIVERSAL CITY
LEGEND
RESIDENTIAL
COMMERCIAL AND INDUSTRIAL
IRRIGATED AGRICULTURE
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
DAMS AND CHANNEL ALIGNMENT AS OF 1953
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
AREAL CULTURE
1958
SCALE
MILES
FEET

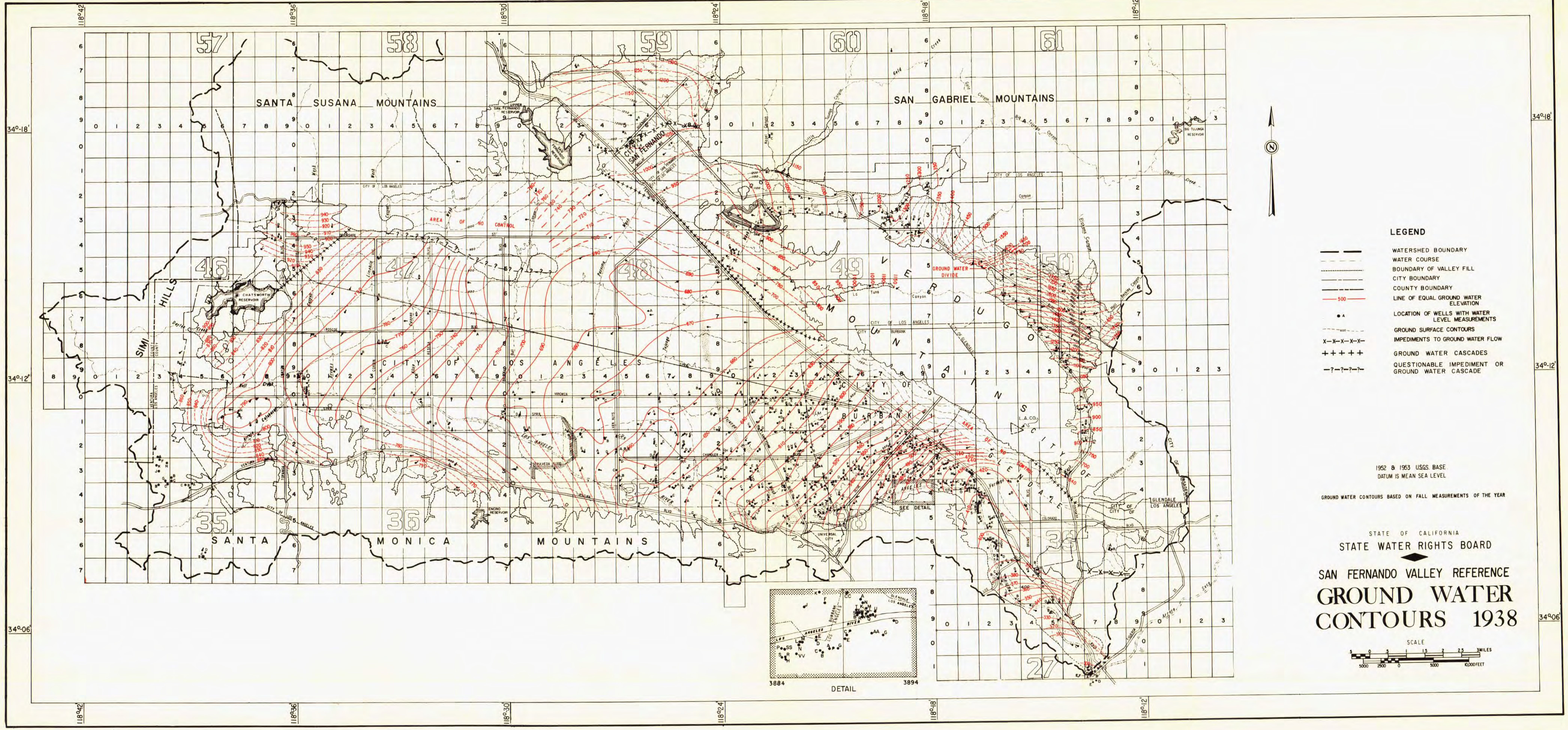

SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
VERDUGO MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
UPPER SAN FERNANDO RESERVOIR
HANSEN DAM
UNIVERSAL CITY
NORTH OUTFALL SEWER
SAN FERNANDO VALLEY RELIEF SEWER
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
AREAS SERVED BY SEWERS IN 1955
ADDITIONAL AREAS SERVED BY SEWERS FROM 1956 THROUGH 1958
SEWAGE GAGING STATION
SEWER TRUNK LINE
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
SEWERED AREAS
SCALE

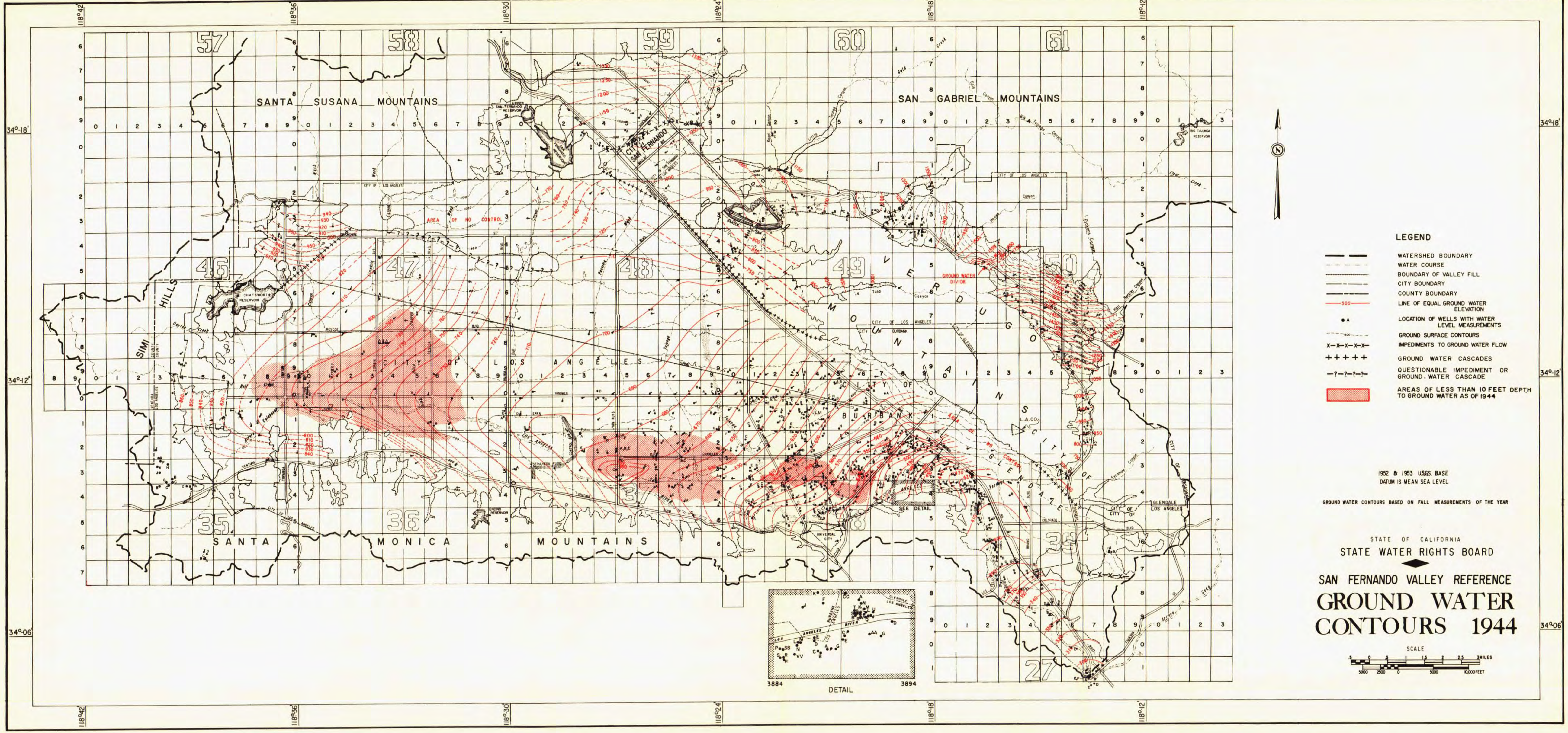


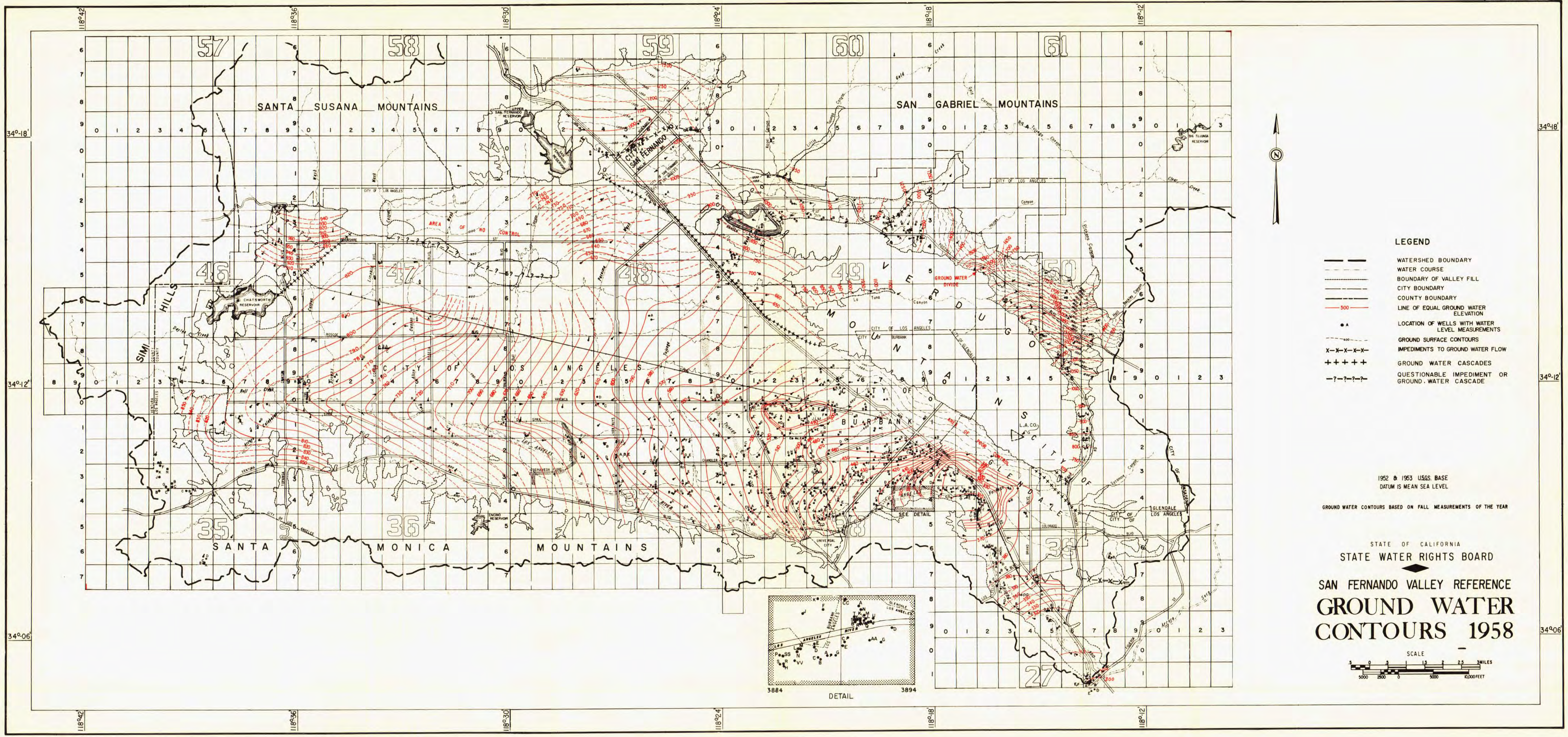
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

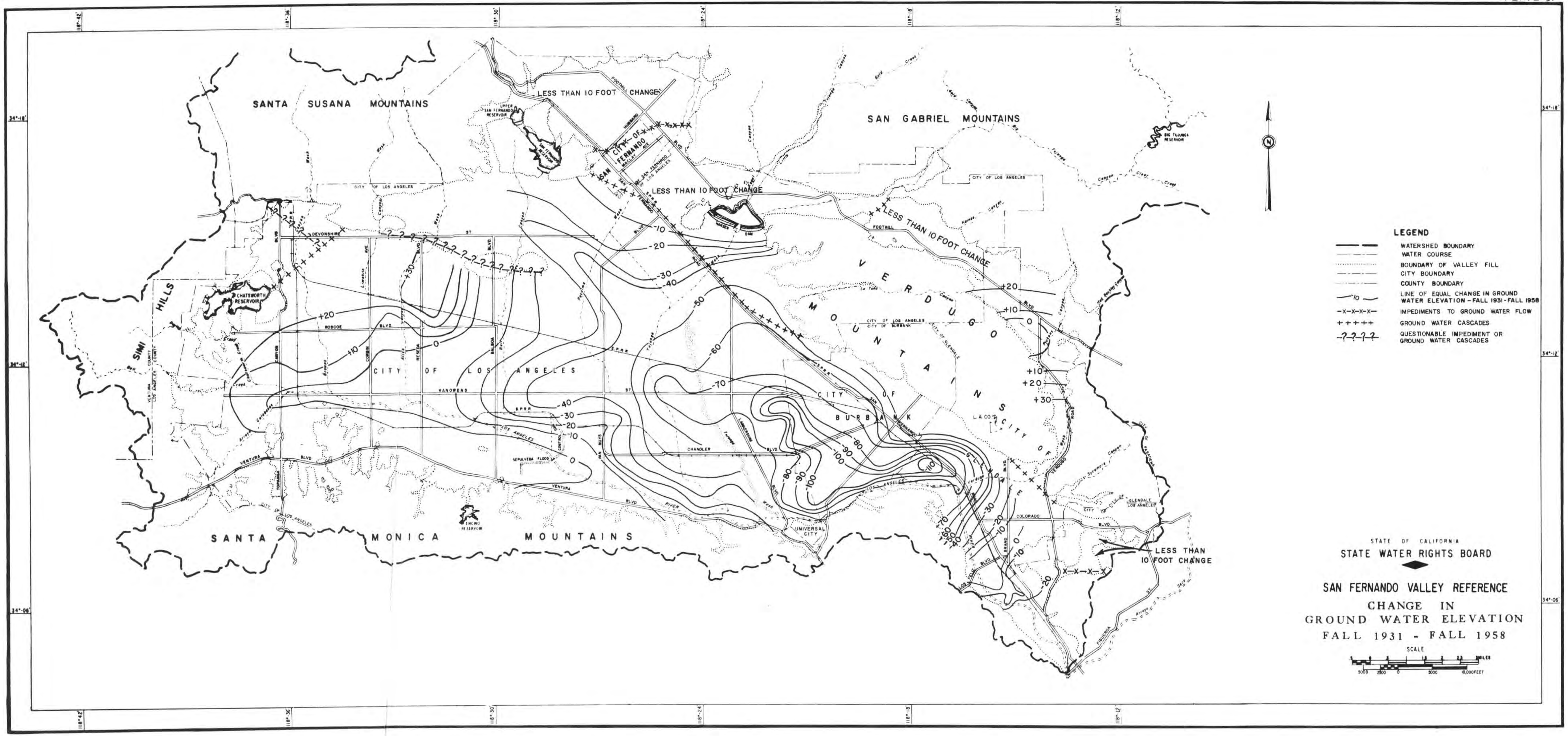
GROUND WATER CONTOURS 1931

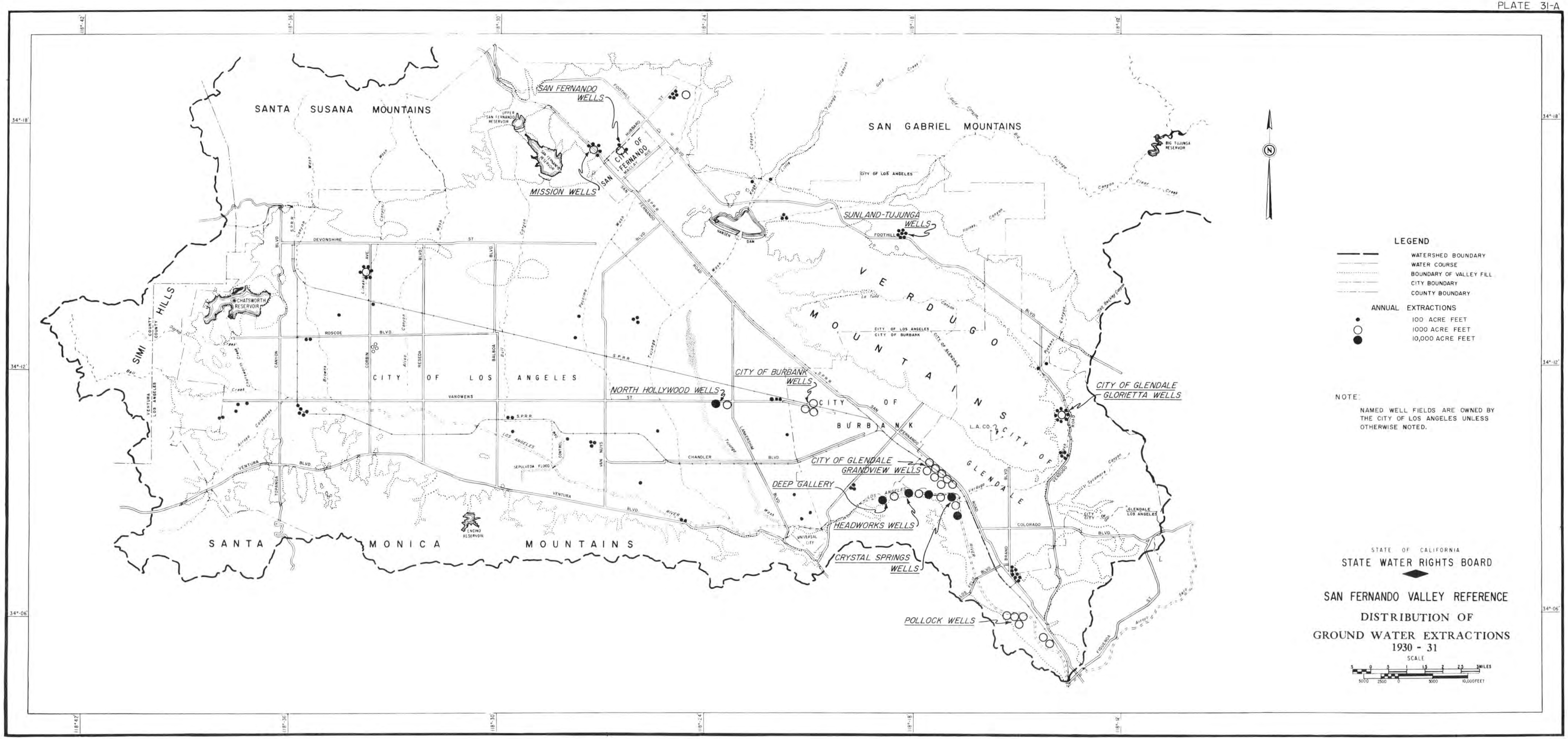

SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
SANTA MONICA MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
CHATSWORTH RESERVOIR
AREA OF NO CONTROL
GROUND WATER DIVIDE
DETAIL
SEE DETAIL
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL GROUND WATER ELEVATION
LOCATION OF WELLS WITH WATER LEVEL MEASUREMENTS
GROUND SURFACE CONTOURS
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND WATER CASCADE
1952 & 1953 USGS. BASE
DATUM IS MEAN SEA LEVEL
GROUND WATER CONTOURS BASED ON FALL MEASUREMENTS OF THE YEAR
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GROUND WATER CONTOURS 1938
SCALE
MILES
FEET
118°42'
118°36'
118°30'
118°24'
118°18'
118°12'
34°18'
34°12'
34°06'


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
CHATSWORTH RESERVOIR
AREA OF NO CONTROL
GROUND WATER DIVIDE
SEE DETAIL
DETAIL
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL GROUND WATER ELEVATION
LOCATION OF WELLS WITH WATER LEVEL MEASUREMENTS
GROUND SURFACE CONTOURS
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND-WATER CASCADE
AREAS OF LESS THAN 10 FEET DEPTH TO GROUND WATER AS OF 1944
1952 & 1953 U.S.G.S. BASE
DATUM IS MEAN SEA LEVEL
GROUND WATER CONTOURS BASED ON FALL MEASUREMENTS OF THE YEAR
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GROUND WATER CONTOURS 1944
SCALE


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF SAN FERNANDO
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
AREA OF NO CONTROL
GROUND WATER DIVIDE
CHATSWORTH RESERVOIR
SEE DETAIL
DETAIL
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL GROUND WATER ELEVATION
LOCATION OF WELLS WITH WATER LEVEL MEASUREMENTS
GROUND SURFACE CONTOURS
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND. WATER CASCADE
1952 & 1953 U.S.G.S. BASE
DATUM IS MEAN SEA LEVEL
GROUND WATER CONTOURS BASED ON FALL MEASUREMENTS OF THE YEAR
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
GROUND WATER CONTOURS 1958
SCALE
MILES
FEET

214


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF SAN FERNANDO
CITY OF GLENDALE
UNIVERSAL CITY
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
HANSEN DAM
SEPULVEDA FLOOD CONTROL BASIN
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
DEVONSHIRE ST
ROSCOE BLVD
VANOWENS ST
CHANDLER BLVD
VENTURA BLVD
FOOTHILL BLVD
COLORADO BLVD
LOS ANGELES RIVER
VENTURA COUNTY
LOS ANGELES COUNTY
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL CHANGE IN GROUND WATER ELEVATION - FALL 1931 - FALL 1958
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND WATER CASCADES
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
CHANGE IN GROUND WATER ELEVATION
FALL 1931 - FALL 1958
SCALE
5000 2500 0 5000 10,000 FEET


SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
SAN FERNANDO WELLS
MISSION WELLS
SUNLAND-TUJUNGA WELLS
NORTH HOLLYWOOD WELLS
CITY OF BURBANK WELLS
CITY OF GLENDALE GLORIETTA WELLS
CITY OF GLENDALE GRANDVIEW WELLS
DEEP GALLERY
HEADWORKS WELLS
CRYSTAL SPRINGS WELLS
POLLOCK WELLS
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
UPPER SAN FERNANDO RESERVOIR
HANSEN DAM
UNIVERSAL CITY
DEVONSHIRE ST
ROSCOE BLVD
VANOWENS ST
CHANDLER BLVD
VENTURA BLVD
FOOTHILL BLVD
COLORADO BLVD
SAN FERNANDO ROAD
S.P.R.R.
LOS ANGELES RIVER
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
ANNUAL EXTRACTIONS
100 ACRE FEET
1000 ACRE FEET
10,000 ACRE FEET
NOTE:
NAMED WELL FIELDS ARE OWNED BY THE CITY OF LOS ANGELES UNLESS OTHERWISE NOTED.
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
DISTRIBUTION OF
GROUND WATER EXTRACTIONS
1930 - 31
SCALE
5000 2500 0 5000 10,000 FEET
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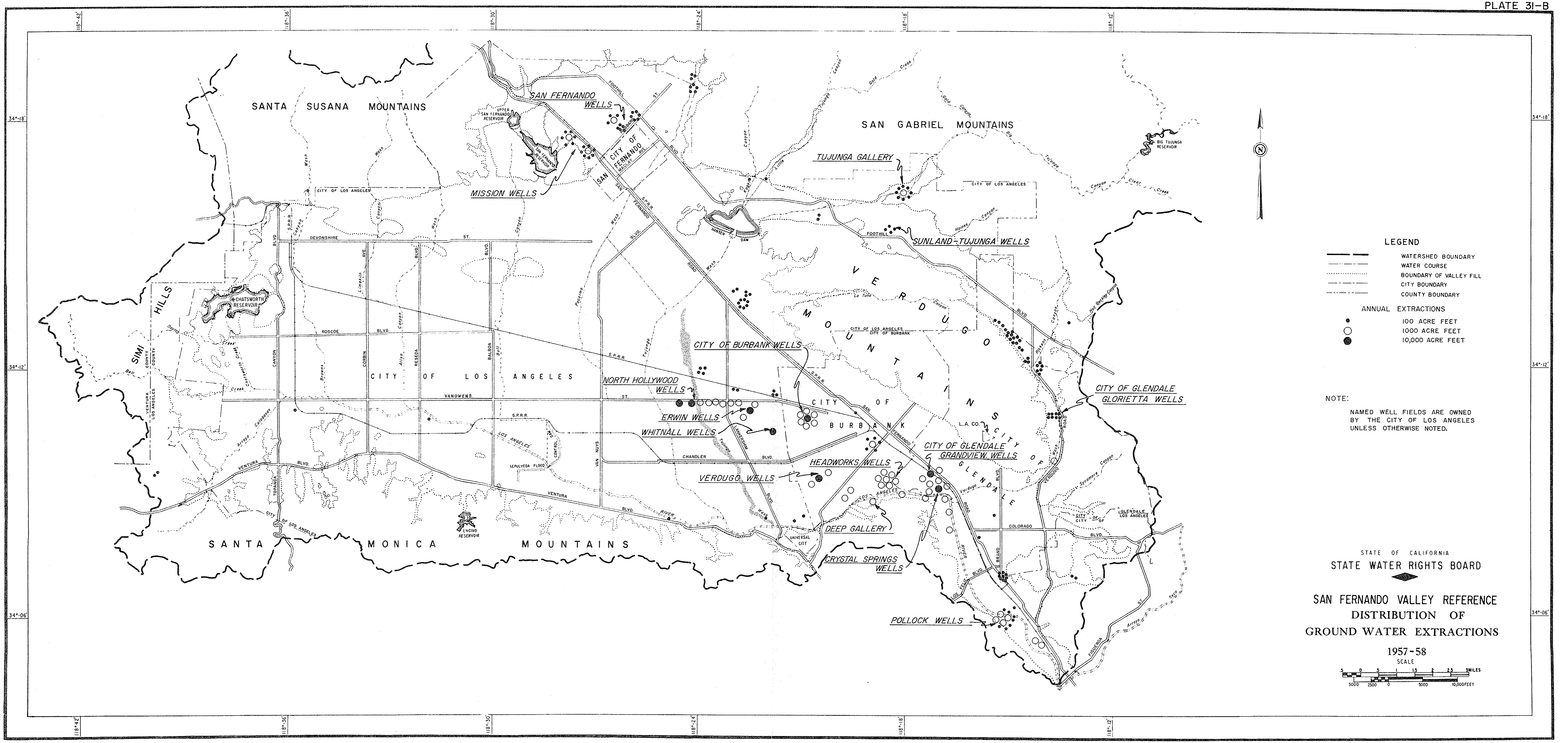
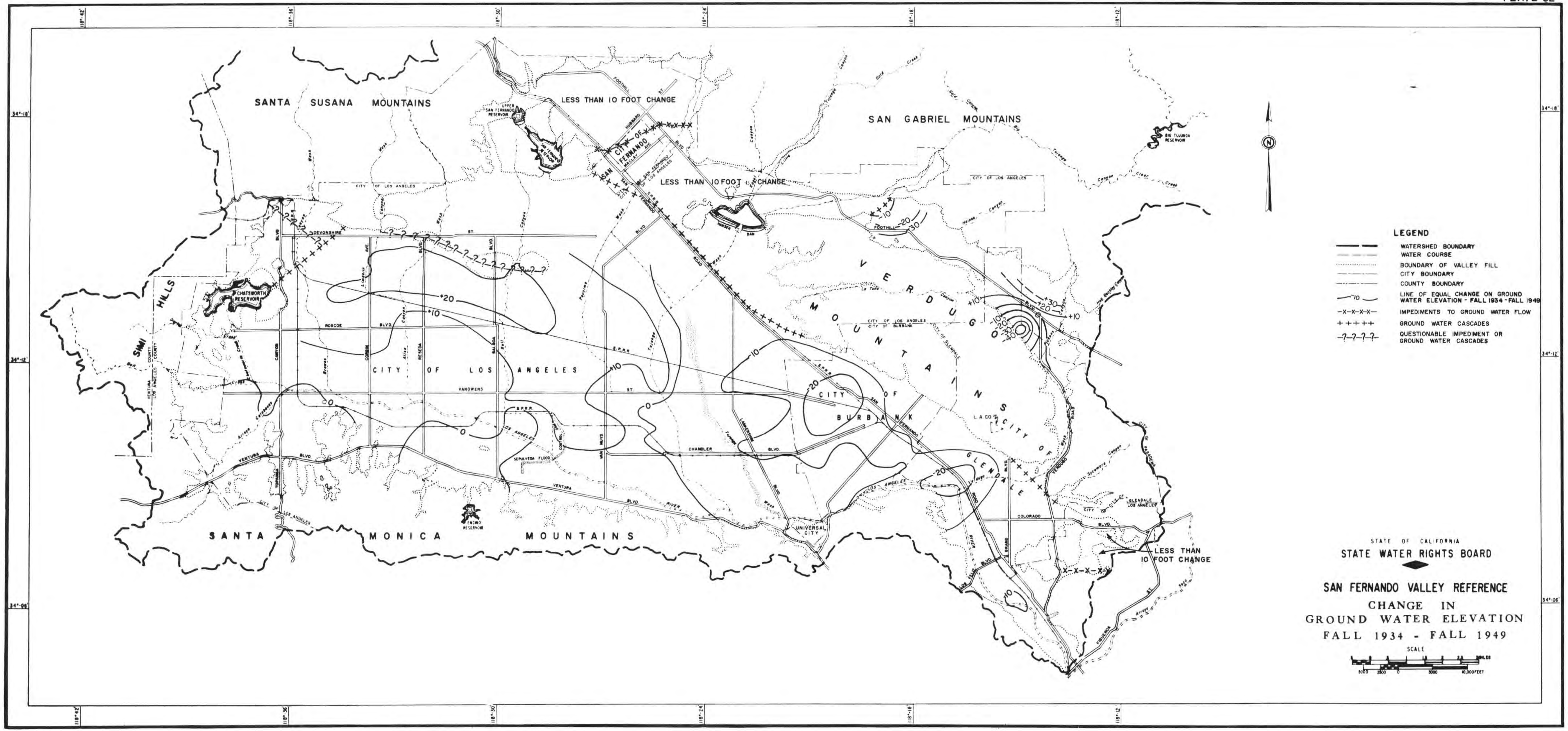
118°36'
118°30'
118°24'
118°18'
118°12'
34°18'
34°12'
34°06'



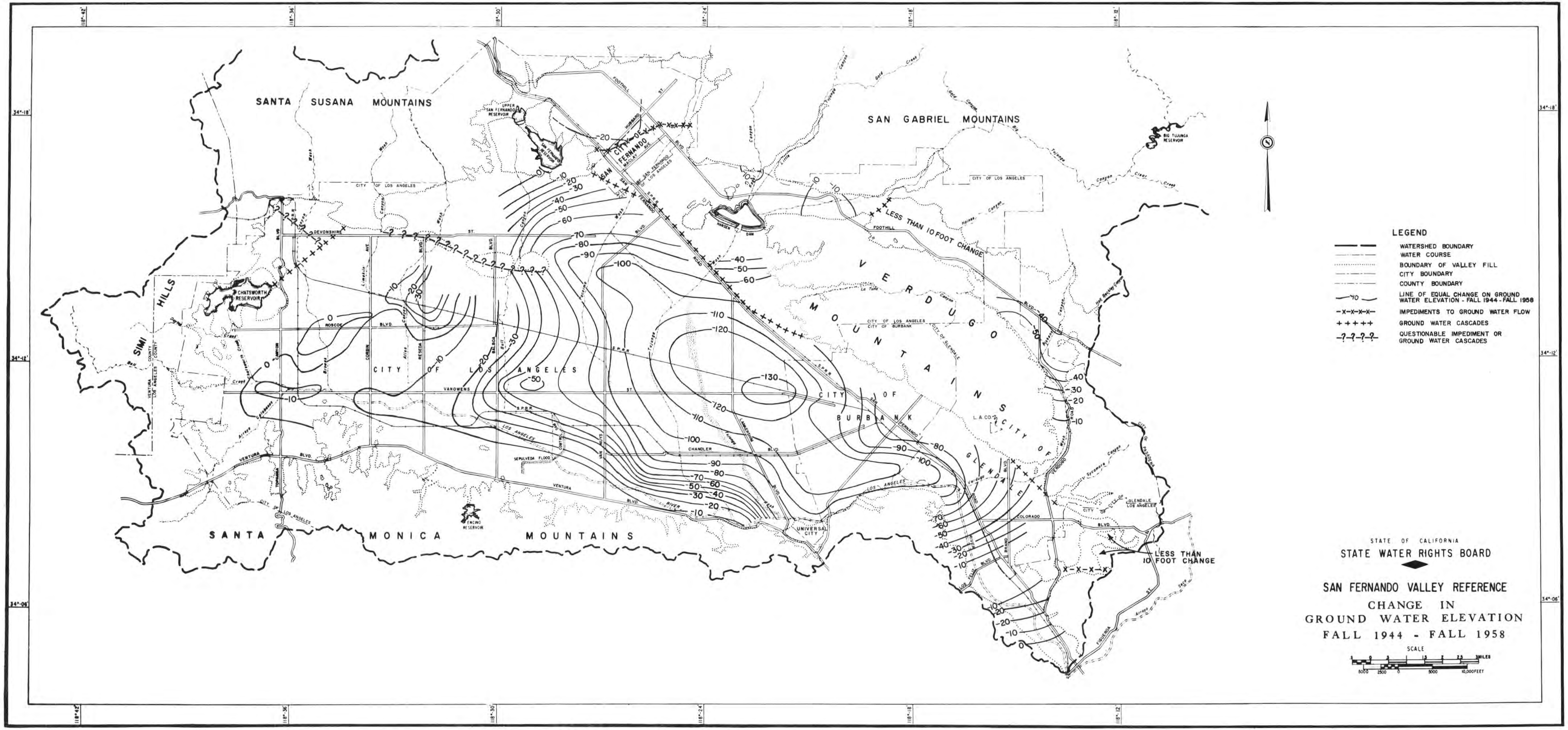
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE
DISTRIBUTION OF GROUND WATER EXTRACTIONS
1957-58

SCALE

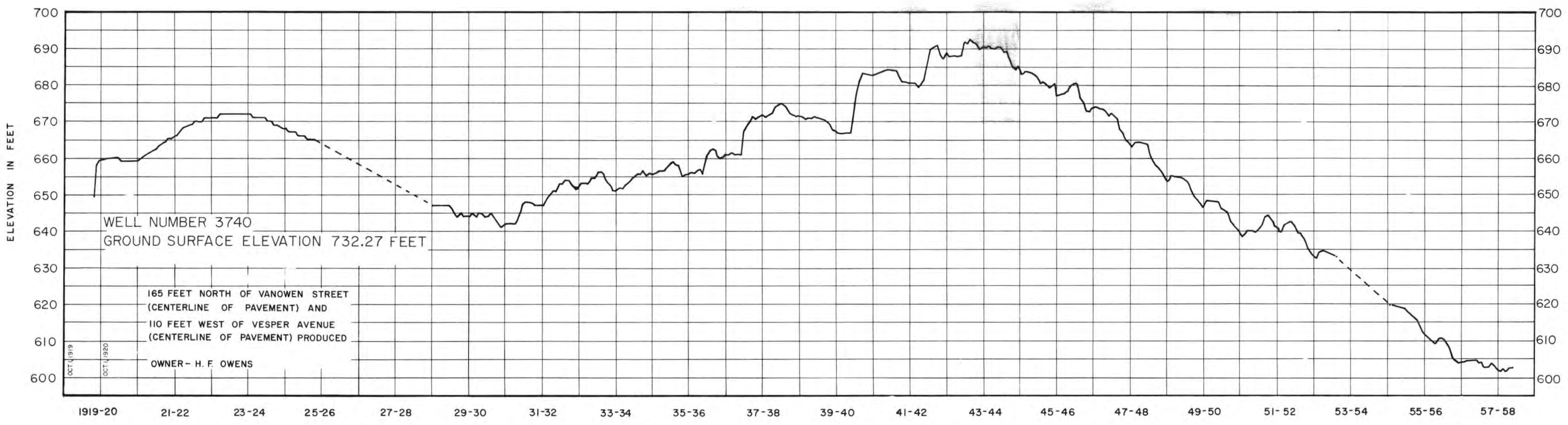


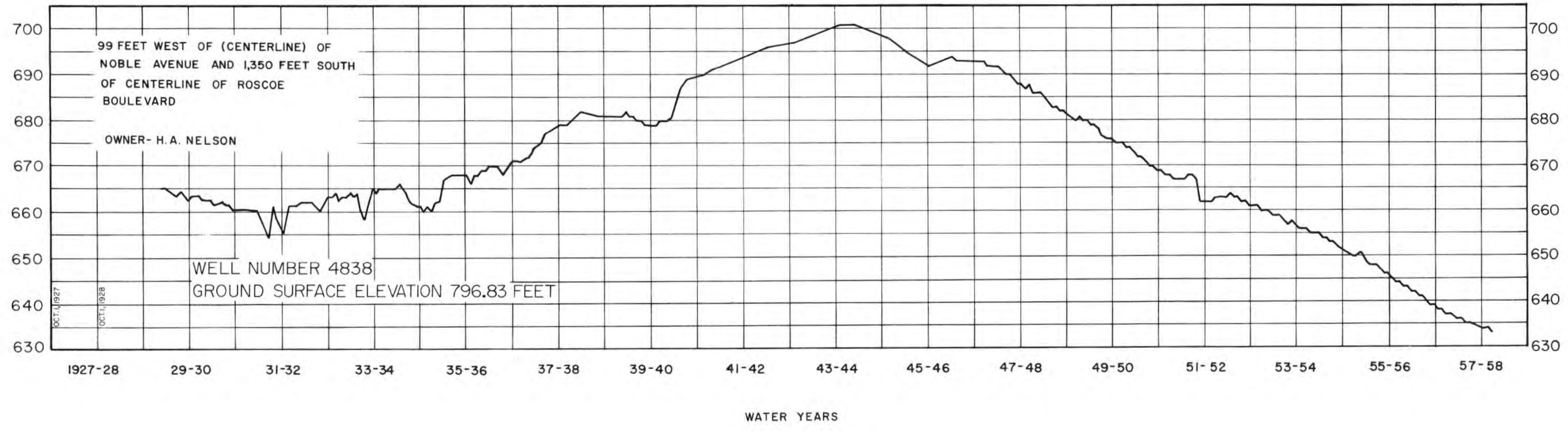
SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
VERDUGO MOUNTAINS
SIMI HILLS
CITY OF LOS ANGELES
CITY OF BURBANK
CITY OF GLENDALE
CITY OF SAN FERNANDO
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
CHATSWORTH RESERVOIR
UPPER SAN FERNANDO RESERVOIR
BIG TUJUNGA RESERVOIR
ENCINO RESERVOIR
HANSEN DAM
UNIVERSAL CITY
DEVONSHIRE
ROSCOE BLVD
VANOWENS
CHANDLER BLVD
VENTURA BLVD
FOOTHILL BLVD
COLORADO BLVD
LOS ANGELES RIVER
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL CHANGE ON GROUND WATER ELEVATION - FALL 1934 - FALL 1949
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND WATER CASCADES
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
CHANGE IN
GROUND WATER ELEVATION
FALL 1934 - FALL 1949
SCALE
5000 2500 0 5000 10,000 FEET

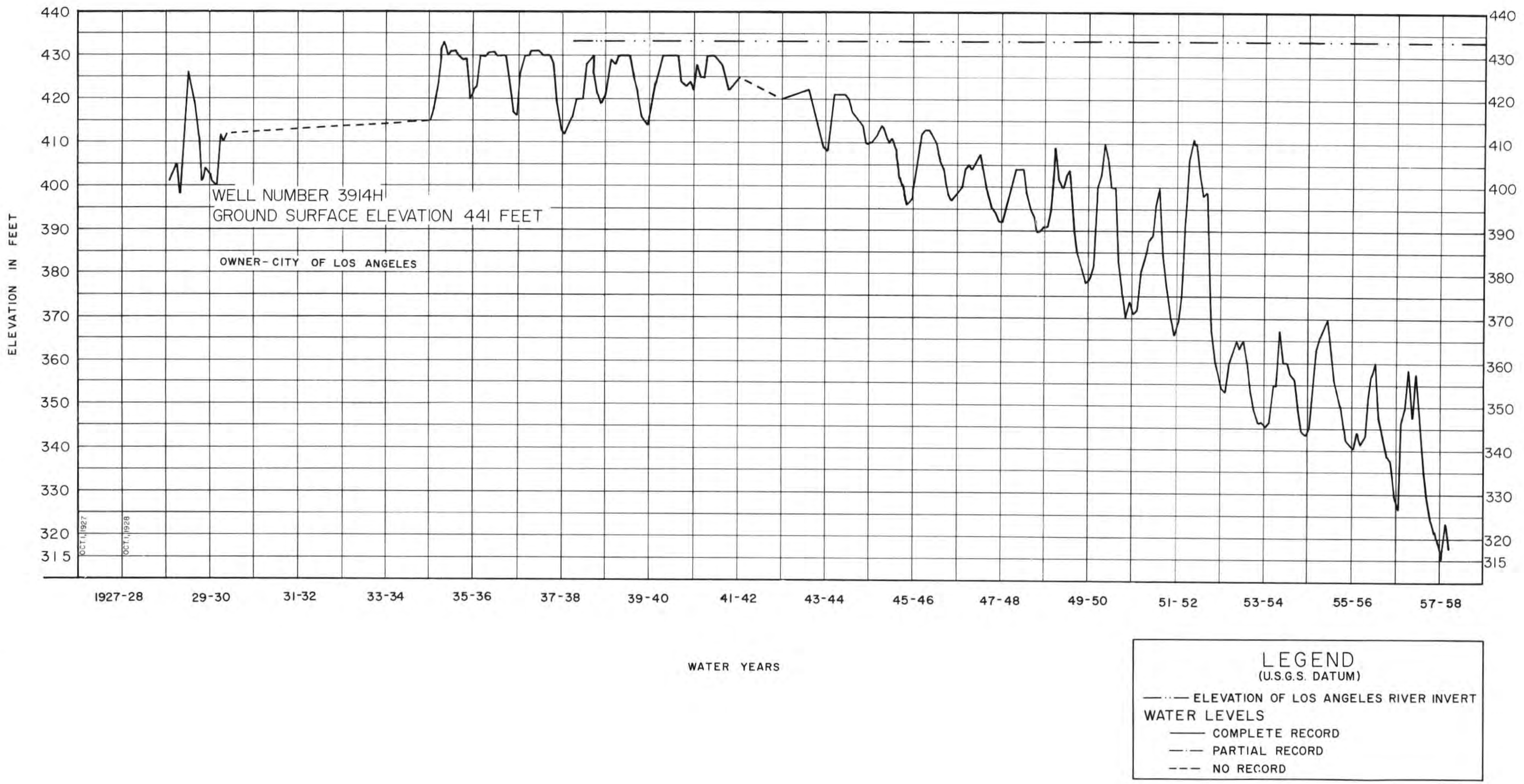

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD
SAN FERNANDO VALLEY REFERENCE
CHANGE IN
GROUND WATER ELEVATION
FALL 1944 - FALL 1958
SCALE
LEGEND
WATERSHED BOUNDARY
WATER COURSE
BOUNDARY OF VALLEY FILL
CITY BOUNDARY
COUNTY BOUNDARY
LINE OF EQUAL CHANGE ON GROUND WATER ELEVATION - FALL 1944-FALL 1958
IMPEDIMENTS TO GROUND WATER FLOW
GROUND WATER CASCADES
QUESTIONABLE IMPEDIMENT OR GROUND WATER CASCADES
SANTA SUSANA MOUNTAINS
SAN GABRIEL MOUNTAINS
SANTA MONICA MOUNTAINS
SIMI HILLS
VERDUGO MOUNTAINS
CITY OF LOS ANGELES
CITY OF SAN FERNANDO
CITY OF BURBANK
CITY OF GLENDALE
UNIVERSAL CITY
CHATSWORTH RESERVOIR
ENCINO RESERVOIR
BIG TUJUNGA RESERVOIR
UPPER SAN FERNANDO RESERVOIR
SAN FERNANDO RESERVOIR
HANSEN DAM
SEPULVEDA FLOOD
LESS THAN 10 FOOT CHANGE
LESS THAN 10 FOOT CHANGE
DEVONSHIRE ST
ROSCOE BLVD.
VANOWENS ST
CHANDLER BLVD.
VENTURA BLVD.
FOOTHILL BLVD.
COLORADO BLVD.
LOS ANGELES RIVER
VENTURA COUNTY
LOS ANGELES COUNTY
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0

SAN FERNANDO VALLEY REFERENCE

SAN FERNANDO SUBAREA WELL HYDROGRAPHS



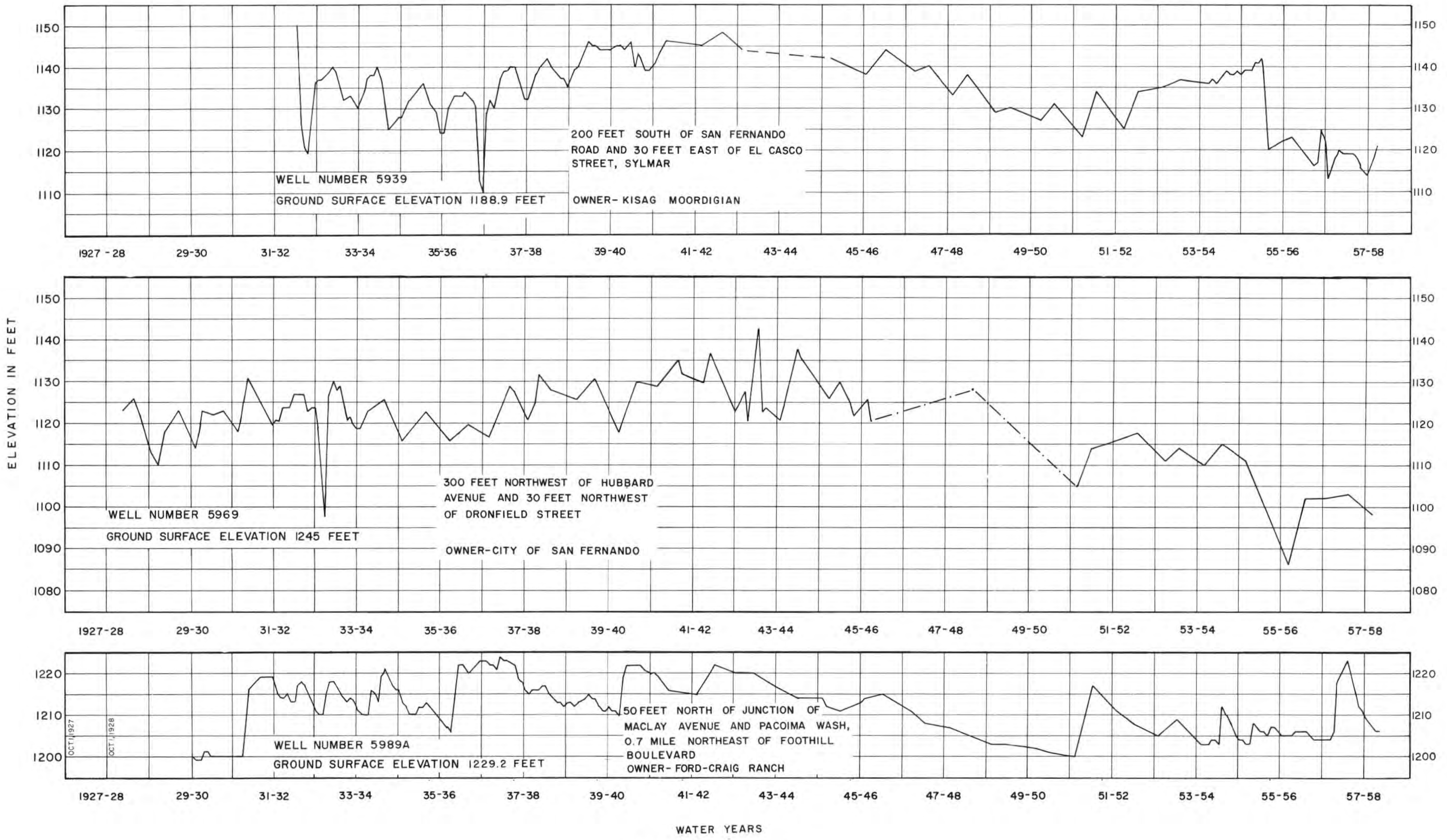




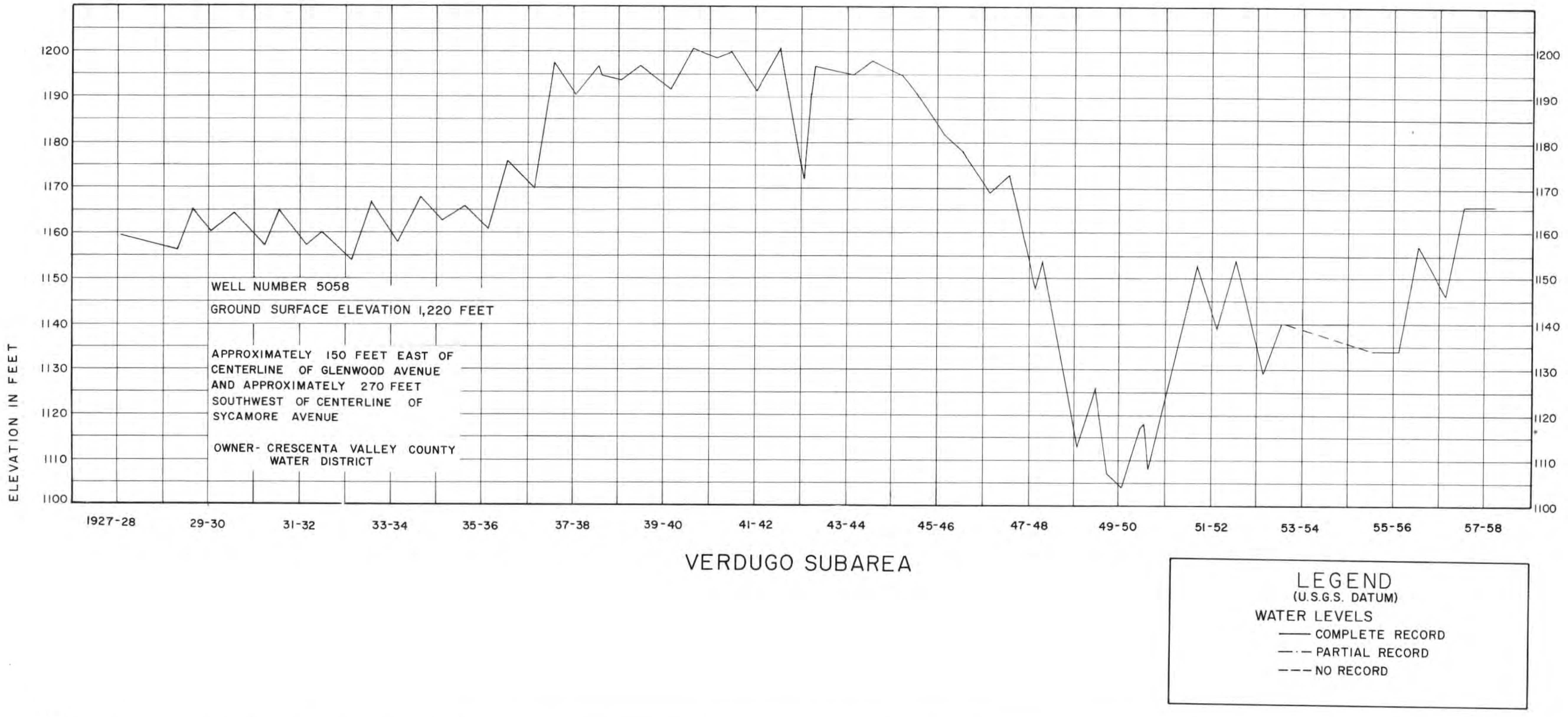
SAN FERNANDO VALLEY REFERENCE

SAN FERNANDO SUBAREA WELL HYDROGRAPHS

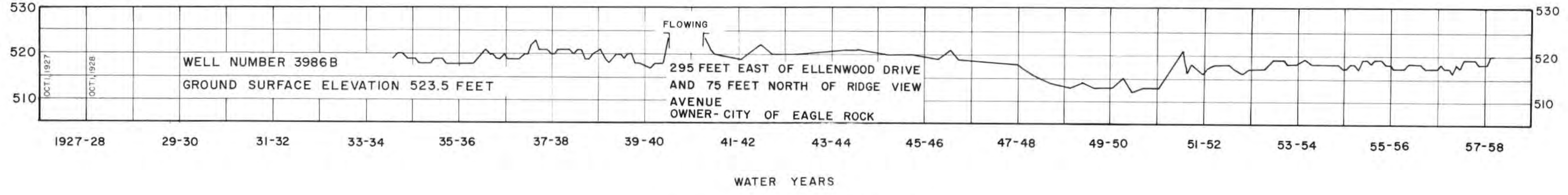
STATE WATER RIGHTS BOARD



SYLMAR SUBAREA



VERDUGO SUBAREA

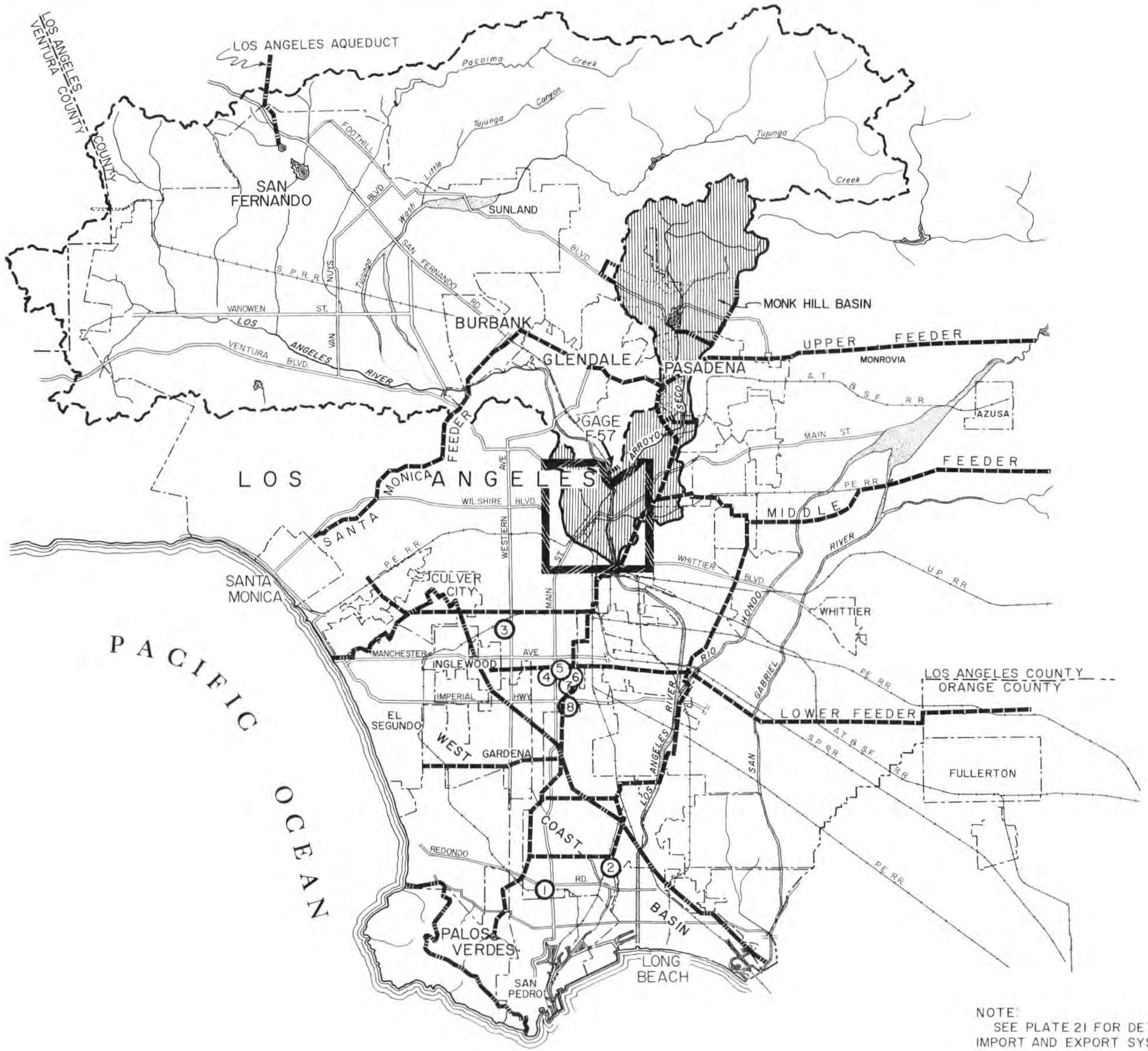


EAGLE ROCK SUBAREA

SAN FERNANDO VALLEY REFERENCE

SYLMAR, EAGLE ROCK AND VERDUGO SUBAREA WELL HYDROGRAPHS

STATE WATER RIGHTS BOARD



LEGEND

- WATERSHED BOUNDARY OF UPPER LOS ANGELES RIVER AREA
- CITY BOUNDARY
- COUNTY BOUNDARY
- PUEBLO BOUNDARY
- SURFACE DRAINAGE BOUNDARY OF LOS ANGELES RIVER BETWEEN SOUTH BOUNDARY OF PUEBLO AND STREAM GAGE F-57 AND GROUND WATER BOUNDARIES
- DISTRIBUTION SYSTEM OF THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

CITY OF LOS ANGELES WELL FIELDS ACTIVE IN 1959:

WEST COAST BASIN
- (1) LOMITA WELLS
- (2) HARBOR DEPARTMENT WELLS

CENTRAL COASTAL BASIN
- (3) MANHATTAN FIELD WELLS
- (4) COLDEN WELLS
- (5) TOWNE WELLS
- (6) 99th. STREET WELLS
- (7) AVALON WELLS
- (8) DEL MAR WELLS

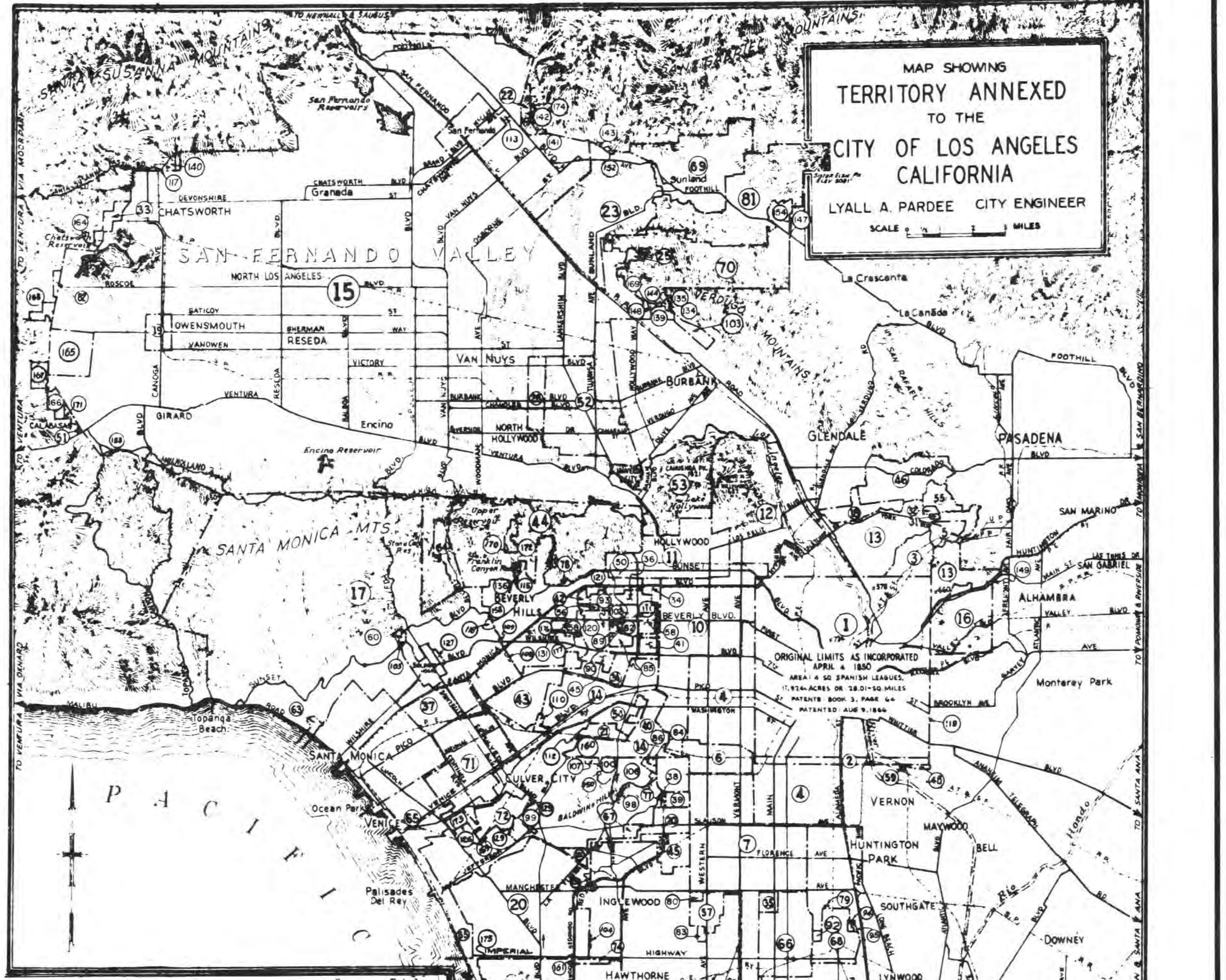
NOTE:
SEE PLATE 21 FOR DETAILED IMPORT AND EXPORT SYSTEM IN UPPER LOS ANGELES RIVER AREA.

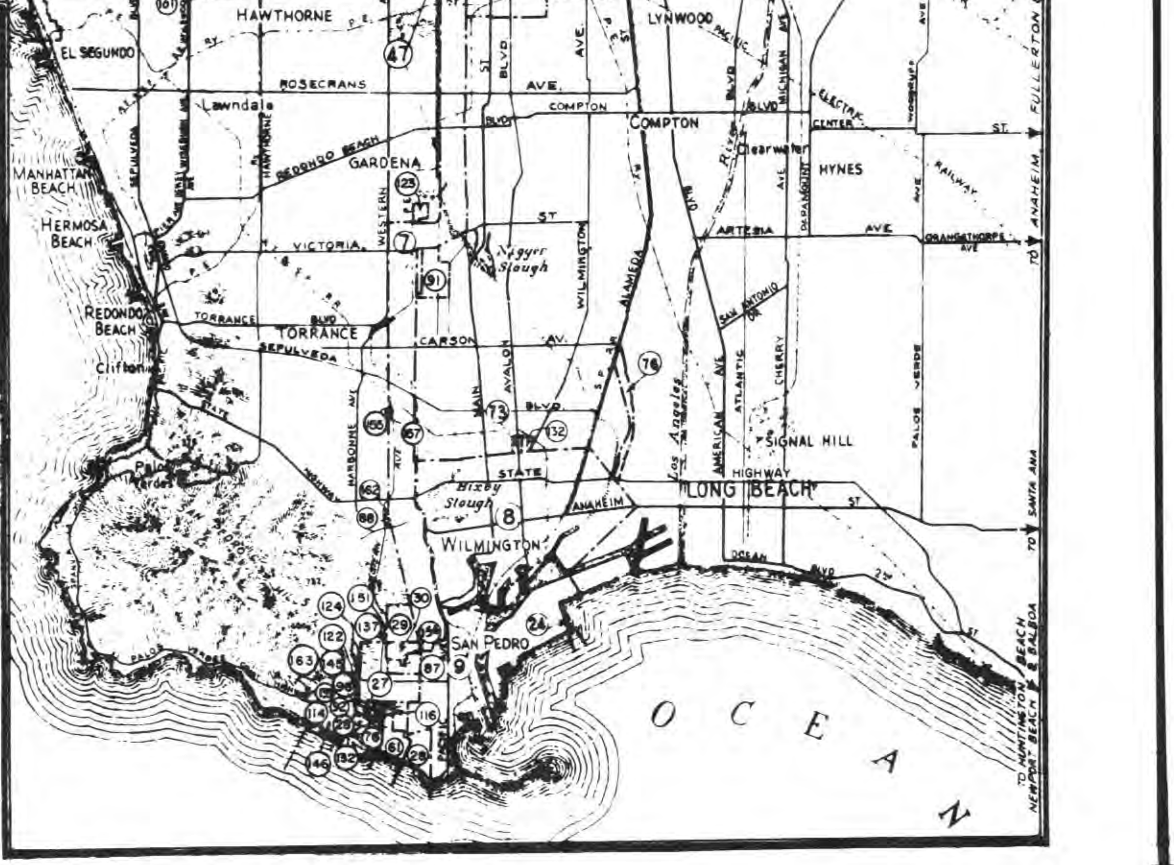
STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

WATERSHED BOUNDARY AND OTHER SOURCES OF SUPPLY

SCALE
0 1 2 3 4 5 MILES





No.	Date	Name	How Obtained	Sq. Miles	Total Sq. Mi.
1	1781 - Grant	Original City	Spanish Grant	28.01	28.01
2	August 29, 1859	Southern Extension	Annexation	1.20	29.21
3	October 18, 1895	Highland Park	Annexation	1.41	30.62
4	April 2, 1896	Southern and Western	Annexation	10.18	40.80
5	June 12, 1899	Garvanza	Annexation	0.69	41.49
6	June 12, 1899	University	Annexation	1.77	43.26
7	December 26, 1906	Shoestring	Annexation	18.64	61.90
8	August 28, 1909	Wilmington	Consolidation	9.93	71.83
9	August 28, 1909	San Pedro	Consolidation	4.61	76.44
10	October 27, 1909	Colgrove	Annexation	8.72	85.16
11	February 7, 1910	Hollywood	Consolidation	4.45	89.61
12	February 28, 1910	East Hollywood	Annexation	11.11	100.72
13	February 9, 1912	Arroyo Seco	Annexation	6.90	107.62
14	May 22, 1915	Palms	Annexation	7.30	114.92
15	May 22, 1915	San Fernando	Annexation	169.89	284.81
16	June 10, 1915	Bairdstown	Annexation	3.40	288.21
17	June 14, 1916	Westgate	Annexation	48.67	336.88
18	June 14, 1916	Occidental	Annexation	1.04	337.92
19	February 26, 1917	Owensmouth	Annexation	0.773	338.70
20	June 15, 1917	West Coast	Annexation	12.41	351.11
21	February 13, 1918	West Adams	Annexation	0.59	351.70
22	February 16, 1918	Griffith Ranch	Annexation	0.23	351.93
23	April 11, 1918	Hansen Heights	Annexation	8.30	360.23
24	July 11, 1918	Ostend	Annexation		360.23
25	November 13, 1918	Orange Cove	Annexation	0.23	360.46
26	June 17, 1919	West Lankershim	Annexation	1.17	361.63
27	July 23, 1919	Dodson	Annexation	1.05	362.68
28	August 6, 1919	Fort McArthur	Annexation	0.56	363.24
29	September 10, 1919	Peck	Annexation	0.45	363.69
30	September 25, 1919	Harbor View	Annexation	0.175	363.87
31	February 26, 1920	St. Francis	Annexation	0.05	363.92
32	September 10, 1920	Hill	Annexation	0.11	364.03
33	November 19, 1920	Chatsworth	Annexation	0.34	364.37
34	February 28, 1922	La Brea	Annexation	1.53	365.90
35	March 2, 1922	Manchester	Annexation	0.33	366.23
36	June 16, 1922	Melrose	Annexation	0.67	366.90
37	July 13, 1922	Sawtelle	Consolidation	1.82	368.72
38	July 27, 1922	Angeles Mesa	Annexation	0.99	369.71
39	October 5, 1922	Angeles Mesa No. 2	Annexation	0.34	370.05
40	October 5, 1922	Rimpau	Annexation	0.14	370.19
41	January 18, 1923	Hancock	Annexation	0.26	370.45
42	January 18, 1923	Evans	Annexation	0.13	370.58
43	May 16, 1923	Ambassador	Annexation	2.62	373.21
44	May 16, 1923	Laurel Canyon	Annexation	13.57	386.78
45	May 17, 1923	Hyde Park	Consolidation	1.20	387.98
46	May 17, 1923	Eagle Rock	Consolidation	3.17	391.15
47	May 17, 1923	Vermont	Annexation	0.025	391.18
48	May 17, 1923	Laguna	Annexation	0.08	391.26
49	May 17, 1923	Carthay	Annexation	0.38	391.64
50	December 20, 1923	Rosewood	Annexation	0.62	392.26
51	December 20, 1923	Agoure	Annexation	0.02	392.28
52	December 29, 1923	Lankershim	Annexation	7.64	399.92
53	February 4, 1924	Providencia	Annexation	4.82	404.74
54	February 13, 1924	Cienega	Annexation	0.93	405.67
55	February 21, 1924	Annandale	Annexation	0.68	406.35
56	May 31, 1924	Clinton	Annexation	0.05	406.40
57	September 8, 1924	Wagner	Annexation	0.94	407.34
58	September 8, 1924	Fairfax	Annexation	1.88	409.22
59	January 3, 1925	Holabird	Annexation	0.01	409.23
60	January 8, 1925	Danziger	Annexation	0.123	409.36
61	January 30, 1925	Hamilton	Annexation	0.44	409.80
62	April 28, 1925	Martell	Annexation	0.23	410.03
63	April 28, 1925	Santa Monica Canyon	Annexation	0.17	410.20
64	October 26, 1925	Beverly Glen	Annexation	0.81	411.01
65	November 25, 1925	Venice	Consolidation	4.105	415.12
66	March 18, 1926	Green Meadows	Annexation	3.57	418.69
67	May 10, 1926	Buckler	Annexation	0.20	418.89
68	May 29, 1926	Watts	Consolidation	1.69	420.58
69	August 4, 1926	Sunland	Annexation	6.01	426.59
70	November 18, 1926	Tuna Canyon	Annexation	7.67	434.26
71	March 5, 1927	Mar Vista	Annexation	4.984	439.25
72	April 11, 1927	Barnes City	Consolidation	1.81	441.06
73	June 11, 1927	Brayton	Annexation	0.075	441.14
74	February 10, 1928	Wiseburn	Annexation	0.14	441.28
75	November 27, 1928	White Point	Annexation	0.01	441.29
76	February 17, 1930	Classification Yard	Annexation	0.41	441.70
77	April 17, 1930	Viewpark	Annexation	0.02	441.72
78	August 1, 1930	Sentney	Annexation	0.01	441.73
79	December 22, 1930	Tobias	Annexation	0.01	441.74
80	June 17, 1931	Cole	Annexation	0.09	441.83
81	March 7, 1932	Tujunga	Consolidation	8.70	450.53
82	January 31, 1933	Lakeside Park Addition	Annexation	0.13	450.66
83	March 14, 1935	Western Avenue Highlands	Annexation	0.12	450.78
84	August 15, 1940	Crenshaw Manor	Annexation	0.054	450.834
85	July 29, 1941	Fairfax Addition No. 2	Annexation	0.263	451.097
86	August 14, 1941	Crenshaw Manor Addition No. 2	Annexation	0.093	451.190
87	September 17, 1941	Woodland Heights Addition	Annexation	0.014	451.204
88	April 13, 1942	Palos Verdes Addition	Annexation	0.013	451.217
89	April 15, 1942	Fairfax Addition No. 3	Annexation	0.015	451.232
90	December 11, 1942	Fairfax Addition No. 4	Annexation	0.031	451.263
91	April 30, 1943	Domingues Addition	Annexation	0.445	451.708
92	January 7, 1944	Florence Addition	Annexation	0.075	451.783
93	September 25, 1944	Fairfax Addition No. 5	Annexation	0.024	451.807
94	December 1, 1944	Florence Addition No. 2	Annexation	0.057	451.864
95	December 1, 1944	Florence Addition No. 3	Annexation	0.024	451.888
96	August 27, 1945	Lomita Addition	Annexation	0.017	451.905
97	July 19, 1946	Lomita Addition No. 2	Annexation	0.008	451.913
98	September 18, 1946	Mesa Addition No. 3	Annexation	0.056	451.969
99	November 6, 1946	Mar Vista Addition No. 2	Annexation	0.062	452.031
100	January 24, 1947	Angeles Mesa Addition No. 4	Annexation	0.409	452.440
101	January 29, 1947	Mar Vista Addition No. 3	Annexation	0.205	452.645
102	October 14, 1947	Fairfax Addition No. 6	Annexation	0.073	452.718
103	March 1, 1948	Burbank Detachment	Detachment	0.446	452.272
104	April 6, 1948	Wiseburn Addition No. 2	Annexation	0.002	452.274
105	April 13, 1948	Danziger Addition No. 2	Annexation	0.003	452.277
106	April 22, 1948	Angeles Mesa Addition No. 5	Annexation	0.990	453.267
107	July 23, 1948	Angeles Mesa Addition No. 6	Annexation	0.065	453.332
108	December 28, 1948	Beverly Hills Detachment No. 1	Detachment	0.0096	453.322
109	December 28, 1948	Beverly Hills Detachment No. 2	Detachment	0.0002	453.322

No.	Date	Name	How Obtained	Sq. Miles	Total Sq. Mi.
110	July 26, 1949	Arnaz Addition	Annexation	0.1458	453.468
111	November 4, 1949	Fairfax Addition No. 7	Annexation	0.0106	453.479
112	December 16, 1949	Culver City Exclusion	Exclusion	0.0064	453.473
113	January 21, 1950	San Fernando Detachment	Detachment	0.0517	453.421
114	May 3, 1950	Lomita Addition No. 4	Annexation	0.0809	453.502
115	October 9, 1950	Beverly Hills Detachment No. 3	Detachment	0.0041	453.498
116	November 15, 1950	Lomita Addition No. 3	Annexation	0.0021	453.500
117	December 20, 1950	Chatsworth Addition No. 2	Annexation	0.0109	453.511
118	January 12, 1951	Beverly Hills Detachment No. 4	Detachment	0.0134	453.498
119	October 22, 1951	Belvedere Addition	Annexation	0.0031	453.501
120	October 24, 1951	Fairfax Addition No. 8	Annexation	0.0058	453.507
121	October 24, 1951	Melrose Addition No. 2	Annexation	0.0027	453.510
122	November 7, 1951	Lomita Addition No. 5	Annexation	0.0063	453.516
123	June 4, 1952	Norman Addition	Annexation	0.0822	453.598
124	June 11, 1952	Lomita Addition No. 6	Annexation	0.0152	453.613
125	August 28, 1952	Culver City Detachment No. 1	Detachment	0.013	453.600
126	October 14, 1952	Mar Vista Addition No. 4	Annexation	0.0076	453.608
127	January 7, 1953	Westgate Addition No. 2	Annexation	0.0631	453.671
128	June 3, 1953	Rolling Hills Addition	Annexation	0.1197	453.791
129	June 17, 1953	Mar Vista Addition No. 5	Annexation	0.0101	453.801
130	August 14, 1953	Inglewood Detachment No. 1	Detachment	0.0270	453.774
131	September 15, 1953	Fairfax Addition No. 9	Annexation	0.0019	453.776
132	September 28, 1953	Keystone Addition No. 1	Annexation	0.0724	453.848
133	October 26, 1953	Rolling Hills Addition No. 2	Annexation	0.0543	453.902
134	December 21, 1953	Burbank Detachment No. 2	Detachment	0.0087	453.893
135	April 26, 1954	Glenoaks Addition	Annexation	0.0047	453.898
136	June 25, 1954	Beverly Hills Detachment No. 5	Detachment	0.0074	453.891
137	August 10, 1954	Rolling Hills Addition No. 4	Annexation	0.0013	453.892
138	August 11, 1954	Rolling Hills Addition No. 3	Annexation	0.2852	454.177
139	August 19, 1954	Burbank Exclusion No. 1	Exclusion	0.1266	454.050
140	May 9, 1955	Chatsworth Addition No. 3	Annexation	0.0868	454.137
141	June 15, 1955	Sunland Addition No. 2	Annexation	0.0336	454.1714
142	June 23, 1955	Sunland Addition No. 3	Annexation	0.0101	454.1815
143	July 11, 1955	Sunland Addition No. 4	Annexation	0.0142	454.1957
144	August 16, 1955	Burbank Detachment No. 3	Detachment	0.0189	454.1768
145	August 24, 1955	Rolling Hills Addition No. 6	Annexation	0.1985	454.3753
146	September 21, 1955	Rolling Hills Addition No. 7	Annexation	0.2590	454.6343
147	October 5, 1955	Tuna Canyon Addition No. 2	Annexation	0.0145	454.6488
148	October 19, 1955	Burbank Detachment No. 4	Detachment	0.0112	454.6376
149	February 16, 1956	Arroyo Seco Addition No. 2	Annexation	0.0011	454.639
150	May 9, 1956	Angeles Mesa Addition No. 7	Annexation	0.0356	454.675
151	July 23, 1956	Rolling Hills Addition No. 8	Annexation	0.0004	454.675
152	September 13, 1956	Sunland Addition No. 5	Annexation	0.0450	454.720
153	December 12, 1956	Calabasas Addition	Annexation	0.0259	454.746
154	December 17, 1956	Tuna Canyon Addition No. 3	Annexation	0.0048	454.751
155	January 4, 1957	Torrance Detachment No. 1	Detachment	0.0017	454.749
156	April 17, 1957	La Rambla Addition	Annexation	0.0035	454.752
157	May 1, 1957	Torrance Addition No. 1	Annexation	0.0017	454.754
158	September 13, 1957	Beverly Hills Detachment No. 6	Detachment	0.0116	454.742
159	October 9, 1957	Mar Vista Addition No. 6	Annexation	0.0639	454.806
160	October 14, 1957	Culver City Detachment No. 2	Detachment	0.0030	454.803
161	May 19, 1958	Wiseburn Addition No. 3	Annexation	0.0017	454.805
162	May 22, 1958	Palos Verdes Addition No. 2	Annexation	0.0009	454.806
163	September 12, 1958	Lomita Addition No. 7	Annexation	0.0005	454.807
164	October 28, 1958	Calabasas Addition No. 5	Annexation	0.0609	454.868
165	November 6, 1958	Calabasas Addition No. 6	Annexation	1.7439	456.612
166	February 4, 1959	Calabasas Addition No. 2	Annexation	0.2696	456.882
167	February 4, 1959	Calabasas Addition No. 3	Annexation	0.3971	457.279
168	February 4, 1959	Calabasas Addition No. 4	Annexation	0.2766	457.556
169	February 4, 1959	Burbank Detachment No. 5	Detachment	0.0548	457.501
170	February 25, 1959	Laurel Canyon Addition No. 3	Annexation	0.0008	457.502
171	March 9, 1959	Calabasas Addition No. 7	Annexation	0.0956	457.598
172	March 11, 1959	Laurel Canyon Addition No. 2	Annexation	0.0170	457.615
173	April 1, 1959	Mar Vista Addition No. 7	Annexation	0.2512	457.866
174	September 14, 1959	Sunland Addition No. 6	Annexation	0.0952	457.961
175	December 11, 1959	El Segundo Detachment	Detachment	0.0413	457.920
176	February 29, 1960	Fairfax Addition No. 10	Inclusion	0.0015	457.921
177	February 29, 1960	Beverly Hills Detachment No. 8	Exclusion	0.0014	457.920

NO. SHOWN ON MAP IN CIRCLE	DATE OF BOUNDARY CHANGE	NAME OF BOUNDARY CHANGE	TYPE OF CHANGE	AREA INVOLVED	TOTAL AREA WITHIN CITY BOUNDARY AFTER CHANGE

EXPLANATION OF ABOVE PRINTED DATA

STATE OF CALIFORNIA
STATE WATER RIGHTS BOARD

SAN FERNANDO VALLEY REFERENCE

TERRITORY ANNEXED
TO THE
CITY OF LOS ANGELES

REFERENCE:
From Map No. A-5910 prepared by the City Engineer of Los Angeles.