EXHIBIT 12

PART 2

APPENDIX C

CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP TO PAST VEGETATIVE AND WATER TABLE CONDITIONS IN SAN FERNANDO CIENAGA AREA

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP TO PAST VEGETATIVE AND WATER TABLE CONDITIONS IN SAN FERNANDO CIENAGA AREA

SAN FERNANDO, CALIFORNIA

November, 1960

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(Plates are bound at the end of Volume I)

CHARACTERISTICS OF SOILS AND THEIR RELATIONSHIP
TO PAST VEGETATIVE AND WATER TABLE CONDITIONS
IN SAN FERNANDO CIENAGA AREA

Authorization for Investigation

This report was prepared by the Department of Water Resources in response to a request for technical assistance from the State Water Rights Board. This request, outlined in State of California Interagency Agreement No. 60-SWRB-23 dated December 11, 1959, calls for the following:

1. Accomplish the necessary field and laboratory work required to ascertain existence and extent of old swamp conditions in Sylmar Subarea in vicinity of City of San Fernando, as evidenced by determinations of proportionate amounts of carbonaceous material and other soils information pertaining to such a condition in said vicinity.

2. Methods and procedures used and scope of work done under the agreement to be approved by representatives of the State Water Rights Board.

3. Results of investigation to be set forth in a report to the State Water Rights Board including copies of all pertinent measurements and observations.

Purpose and Scope of Report

This report describes the investigation made to determine the past location and extent, and probable vegetative and water table conditions in an old "cienaga"* occurring near the westerly corner of the

* Cienaga--a term, probably of Spanish origin, indicating a limited area showing growth of water-loving plants in otherwise arid surroundings, occasionally giving rise to flowing springs. As discussed throughout this report, the term "cienaga" is used to include all areas or soils apparently affected by a water table. See "Glossary of Geology and Related Sciences" published by the American Geological Institute, 1957.

City of San Fernando (Figure C-1). Soil formation and development processes are discussed as they relate to morphology of soils found in the general area. The investigation included a detailed soil survey of the general area to a 5-foot depth, supplemented by a limited study of deeper strata to a 14-foot depth. Also included is a discussion and interpretation of the results of some 1,700 laboratory determinations made on 200 soil samples taken in the investigational area. The analyses are included in the basic data section of this report.

In addition, 20 holes drilled in a geological investigation of the area were logged by the State Water Rights Board and were available for study. These data are not included here, but are available in the Basic Data filed with the Report of Referee.

Soil Formation, Development, and Morphology in Relation to the Investigational Area

In order to interpret the significance of findings of the soil survey of the investigational area, it is helpful to review the basic concepts concerning soil formation and morphology which are pertinent to analysis of soil characteristics revealed in the study.

The character of a natural soil is determined by six broad influences. These are: (1) parent material from which the soil is formed, (2) climate, (3) relief (particularly as this influences erosion and deposition), (4) vegetative and animal life, (5) depth of water table, and (6) the length of time these factors have been acting together. To these six factors, in the case of the San Fernando cienaga area, a seventh must be added--the effects of man's activities.

The total effect of these influences varies with depth and this tends to produce differences within the soil. Such differences give rise to layers called "horizons" and the sequence of horizons taken together is called the "soil profile" to any specified depth. Very young soils have had too little time to develop horizons, but as they become older their horizons become increasingly distinct. A significant aspect of soil horizon formation is that it is a <u>developmental</u> process, requiring a considerable time duration under the particular physical, chemical, and biological conditions occurring at a site. This developmental process may occur either on rock material weathered in place or upon materials that have been transported by water or otherwise and deposited at some new location. Soils too youthful to have developed horizons may be highly stratified (layered) due to the depositional process by which they were laid down. True horizons are distinguished from such layers by structural and chemical features associated with soil developmental processes. Thus, while depositional strata may strongly affect moisture, fertility, tillage, and other characteristics, they do not reveal the trend of soil forming forces with time.

In the formation of the surface horizon, referred to as the "A" horizon, the accumulation of plant remains tends to enrich the mineral soil in organic matter. At the same time, weathering forces are apt to be most active at the surface. Mineral matter is weathered into clay and soluble material which, in turn, is leached downward by rain or flood water. The subsoil or "B" horizon is formed by accumulation of material leached from the surface and added to any clay that may have formed at this depth. Beneath the subsoil are horizons of partially weathered ("C" horizon) and unweathered parent material.

Characteristics of the horizons thus depend upon factors such as the rate of formation and decomposition of organic material, the amount and depth of leaching, and the type and solubility of the mineral parent material. Downward leaching is reduced or prevented where the ground water table is shallow. If the water table is close to the surface, upward water movement caused by evaporative forces may far exceed downward movement due to rainfall. The exact depth to water table at which upward movement begins to exceed downward movement varies with the climate and the soil profile but in general, under conditions similar to those in the cienaga area, may be expected to occur at about 4 to 6 feet. Vegetation may considerably increase this depth by root extraction of water from the moist soil, thereby increasing the upward hydraulic gradient as well as by consumptively using rainfall before it has a chance to leach downward to the water table.

Salts of various kinds accumulate in the soil above the water table when upward movement exceeds downward leaching, affecting both chemical and physical characteristics. The amount and kind of salts that accumulate depend upon the quality of ground water, the depth to water, the length of time the high water conditions persist, and the amount of downward leaching that occurs from time to time by rainfall.

In warm humid climates weathering is intense and wherever drainage is not limiting, soils are leached to great depths at a relatively rapid rate, leaving only the least soluble and generally less fertile material behind. In arid climates, weathering is slow and soils are leached only a few inches in depth unless excess water from sources other than rainfall happens to be present.

The San Fernando Valley falls between the two climatic extremes. Weathering is relatively slow and only the very oldest soils in the valley have been leached extensively. Under this climate, natural vegetation is rather sparse and organic matter decomposes rapidly so that the soils are normally low in humus. Where moisture conditions are such as to permit more lush growth, organic matter (humus) accumulates in the soil. The darker colors commonly associated with soils in the moist areas in a dry climate zone are due to increased humus. It should be pointed out, however, that the accumulation of humus in soils under natural conditions takes many years since by far the greater portion of all plant remains decomposes into gases, water, or soluble material and thus disappears. More detailed discussion of various aspects of soil formation and morphological processes can be found in reference 6 through 11 at the end of this report.

A consideration of soil formation and developmental processes in the investigational area would be incomplete without reference to man's activities. During the period of agricultural use some minor leveling of the soil surface by cuts and fills occurred in areas which were irrigated. Development of the area as an urban site increased cutting and filling activity and has permanently obscured an important fraction of the soil surface area with buildings, streets and railroads. Fill material from outside the investigational area has been spread over or mixed with the surface soil in a few places. Frequent and liberal use of fertilizers and soil amendments of every description, applied by owners of small plots and yards, has unquestionably affected chemical soil characteristics in some places. Finally, soil moisture conditions in the investigational area have been altered by a lowering of the water table. As discussed later in this report, the influence of some of these activities could explain certain variations in the data.

The Soil Survey

Soil surveys classify soils into "soil series" on the basis of their profile characteristics. A soil series is a group of soils alike in position, mode of formation, parent material, sequence of horizons, age, degree of development, color, and all other morphological features except surface texture. Texture refers to the proportion of sand, silt, and clay that occurs in the soil. Variations that occur in the surface texture within the series are separated as "types". On the map, delineations are made on the basis of soil types, each different separation having a combination name giving the series and type, as "Chino (series) fine sandy loam (type)", "Hanford sandy loam", or "Diablo loam".

Methods

The soil survey was made by examining the soil profile to a five-foot depth, at a large number of locations, by hand boring with an orchard type auger. Sites for borings were selected to reduce as far as possible effects of cuts, fills, and other unnatural circumstances. Simple field tests for texture, structure, color, presence of calcium carbonate, etc., were applied to each auger full of soil. Information thus gained was interpreted in terms of soil series and types and was plotted on a large scale (1"=400') aerial photograph. The investigation shows that many of the soil profiles in the vicinity are closely similar to soil series already established and described as occurring under similar sites in California by soil correlation staffs of the University of California and the U. S. Department of Agriculture.

In addition to the large number of holes studied to determine the soil series characteristics and the soil boundaries, 33 special holes were drilled for collection of soil samples for laboratory studies. These holes were located to form a series of approximately straight lines or transects* across those parts of the investigational area that appeared to have been most strongly affected by a high water table. Location of these transects is shown on Plate 7. Plate 8 indicates the surface elevation

* Transect--a line drawn across any chosen area, along which, at intervals, any soil property is measured and graphically presented. See Reference No. 6, Page 29 (C-33).

profile of each transect, with a graphical presentation of significant chemical data plotted above each hole location. Logs of these holes and the laboratory data on the samples are included in the basic data section of this report. Logs of several deeper holes drilled during a preliminary reconnaissance of the area are also included in the basic data section.

The limits of the survey were arbitrarily fixed by determining which areas appeared to have been affected by a water table and then extending the mapping far enough into adjacent unaffected areas to establish relationships between the soils.

Description and Extent of Soils in the Cienaga Area

Plate 7 is the soil survey map and shows the major separate soil bodies as delineated in the field investigation. Table C-1 summarizes the data on the soils shown on Plate 7. From examination of the profiles and consideration of topographic relationships, it is apparent that the cienaga area soils are predominantly derived from granitic alluvium washed in from higher-lying deposits to the northwest, north, and northeast.

The normal soils developed up-slope on this alluvium are deep, well-drained, and show little or no profile development. Too little time has elapsed for the relatively stable minerals to break down due to weathering and thus there is no accumulation of any physical or chemical weathering products at any place in the profile. Because a water table has not been close to the surface, soluble minerals have not accumulated from that source. Under the climatic conditions prevailing, natural vegetation consists of a relatively sparse cover of grasses and shrubs.

TABLE C-1

CHARACTERISTICS OF SOILS IN
THE SAN FERNANDO CIENAGA AREA

Soil type	Approximate acreage	Characteristics
Soils strongly affected by a water table		
Chino fine sandy loam	190	Calcareous throughout, very strong $CaCO_3$ in subsoil, high in organic carbon, dark color, dominant soil within cienaga area, strongly affected by water table.
Merrill fine sandy loam	2.3	Calcareous throughout, $CaCO_3$ hardpan in subsoil, high in organic carbon, dark in color, represents a further stage of Chino development, strongly affected by water table.
Foster sandy loam	3.2	Calcareous throughout, $CaCO_3$ variable in amount, several bodies too small to map, dark color, represents more recent deposits in the cienaga area, strongly affected by water table.
Grangeville fine sandy loam	93	Calcareous throughout, $CaCO_3$ usually less than in Chino, little accumulation of $CaCO_3$ in subsoil, relatively high in organic carbon, dark color, moderately to strongly affected by water table.
Subtotal	288	Strongly affected by water table.
Transitional soils, slightly affected by a water table		
Hesperia	157	Slightly to moderately calcareous in subsoil, little or no organic carbon accumulation beyond that in Hanford, light color, slightly affected by water table.
TOTAL Acreage	445	

Natural organic matter is thus low. They are mapped as typical Hanford series soils, light brown to light grayish brown in color and neutral throughout in reaction. The map symbol (Plate 7) is "F-1". The Hanford soils extend for considerable distances in all directions around the cienaga area, with the exception of the area occupied by the Mission Hills, and no attempt was made to map a particular area or acreage.

The dominant soils within the area considered to have been affected most prominently by a high water table are of the Chino series. This series, as established by the correlation staffs of the University of California and the U. S. Department of Agriculture, is described as occupying a semibasin or gently sloping position and belonging to the Wiesenboden Great Soil Group. Wiesenboden, or gley, soils owe their distinctive characteristics to the presence of a ground water table at or near the surface. Accumulation of calcareous material occurs in the profile due to the upward movement of water and precipitation of the salts as evaporation or evapotranspiration by plants takes place.

The Chino soils in the cienaga area have a dark gray or dark brownish gray surface which is basic or slightly calcareous. They are slightly developed, the subsoil or "B" horizon having been enriched in clay by action of water. This accumulation of clay changes the texture of the "B" horizon at most by only one textural class from that of the surface. Structure of the subsoil usually changes from granular to subangular blocky. The "B" horizon is gray and has a strong accumulation of carbonates. Carbonate concretions are common in the lower portion of this horizon.

Three separate bodies of Chino soils are delineated on Plate 7, each being indicated by the symbol "B-1". The main body covers about 173 acres and extends all the way from the vicinity of the Mission well field to San Fernando Reservoir, indicating that in times past a high water table extended from the so-called "east" cienaga to the "west" cienaga. This includes several small areas of Foster soils (see below).

The second and much smaller area of Chino soils occurs near Fourth and Hubbard Streets and covers approximately 13 acres.

A third (3.7 acres) body of Chino occurs just south of the southeast corner of the main Chino area. This is separated from the main body by recent deposits of Foster-like soils along San Joaquin Ravine.

The Foster soils occur in association with the Chino soils. They are found in and near the water courses where relatively recent deposition has occurred. In this area some bodies are so small and thin that sites were noted but no effort was made to delineate the extent. The Foster series is recent granitic alluvium having a dark gray basic surface and dark brownish gray calcareous subsoil. It is also classed as Wiesenboden, or gley, soil. The single body delineated, 3.2 acres in extent, is located at the southeast edge of the main Chino body and is indicated by the symbol "B-3".

A small area of the Merrill series, about 2.3 acres in extent, occurs near the large drainage which crosses San Fernando Road about one-fourth of a mile north of Hubbard Street. The mapping symbol is "B-2". These soils are similar to the Chino soils, but are more strongly developed

Ab

and have a calcium-magnesium carbonate hardpan. This pan probably was formed slightly above the top of a high water table by precipitation of $CaCO_3$ and $MgCO_3$ as a result of capillary rise of water containing calcium, magnesium, and bicarbonate ions.

Along the northeastern edge of the main body of Chino soils is an area of soils with characteristics similar to the Grangeville series. The Grangeville soils are recent alluvial deposits from granitic sources which are light gray to light brownish gray in color, and have developed under restricted drainage conditions. The color and presence of carbonates in the profile indicate that this land was moist for considerable periods due to capillary rise of water occurring beneath it, although apparently it was less strongly affected by the water table than the Chino soils. The single body, carrying the symbol "SB-1" on Plate 2, covers approximately 93 acres.

Running across the entire northern edge of the cienaga there is a transitional strip of land between the well-drained Hanford soils lying up-slope, and the Chino-Grangeville body. Soils in this strip are the Hesperia, Pachappa, Hanford over Chino, and Hanford over Pachappa. This group has a common characteristic, in that the surface soils do not contain carbonates, whereas carbonates are found in the subsoils or "B" horizons (horizon of accumulation) at depths less than five feet. On the map they are indicated as "Tl". The Hesperia soils differ from the Hanford soils in that there is a slight accumulation of carbonates found in the subsoil. Pachappa soils represent a stage development slightly greater than the Hesperia.

The transition zone was influenced by the flow of underground water to the degree that capillary rise resulted in the precipitation and accumulation of carbonates below the surface of the soil but above a depth of 60 inches. The main body of these transition soils covers approximately 150 acres. A smaller body of similar soil occurs near Second and Hubbard Streets and includes about seven and a half acres.

In contrast to this transition zone north of the cienaga is the situation to the south along San Fernando Ravine and Hubbard Street at the railroad. Here there is an abrupt change from the soils developed under wet conditions to the Hanford or Greenfield soils. There is also an abrupt change in the depth to water as determined by drilling investigations and in wells. The deep deposit of coarse material, south of what geological studies by the Referee have indicated, is in effect, a constriction of the alluvium, allows water to penetrate to such depths that surface soils are well-drained and free of carbonates. Hanford soils are mapped with the symbol "F1" and Greenfield with "F2". No effort was made to find the areal extent of these soils.

Unrelated Soils Adjacent to the Cienaga

Immediately south and west of the study area the Mission Hills rise abruptly above the alluvial fill that comprises the cienaga. These hills have contributed a few small alluvial bodies lying above the basin, but only a little material has washed into the cienaga area itself. The hills are largely occupied by residual soils formed in place on the Saugus formation or by elevated old terrace soils. None of these soils show any close relation to soils in the cienaga. Although the different series are separated on the map, the soil bodies were not closed off so that areal extent was not determined.

The residual soils on sedimentary material are the Altamont and Diablo soils. They are similar to each other, but Diablo soils (symbol "U5") have a dark gray surface and Altamont (symbol "U4") have brown surfaces. The parent material sometimes contains carbonates but not consistently. Both soils are free of carbonates in the surface.

Zamora soils are found on small alluvial fans deposited by drainage from the Altamont soils. These soils are dull brown in color, slightly developed and generally free of carbonates. However, occasional profiles do contain small carbonate concentrations in the lower portion of the "B" horizon due to weathering of the soft, occasionally calcareous, parent materials and increased leaching by runoff from surrounding hills. They are mapped as "U1".

Chualar soils, indicated by "U2" on the soil survey, are dark brown, moderately developed on older granitic alluvium, and are found in terrace positions between the residual Altamont and Diablo soils and the lower-lying cienaga. Included are some areas of Ramona soils, similar to the Chualar but with a slightly redder color. All are free of carbonates. On one or two of the higher terraces Placentia soils were found. These represent an older, more advanced, stage of weathering than the Chualar-Ramona, and have a strong clay accumulation in the "B" horizon and occasionally some calcium carbonate beneath the "B". Their symbol is "U3".

Laboratory Studies

Physical Analyses

Physical analyses of soil samples in the laboratory were confined to tests of particle size distribution (mechanical analyses). Table C-2 summarizes the limited data obtained. Detailed data are contained in the basic data section of this report. There is a definite tendency for the well-drained soils (Hanford and Greenfield) and the most recent deposits in the wet area (Foster) to have a higher proportion of coarser fractions, while the Chino, Merrill, and Grangeville soils tend to be higher in fines. This interpretation is consistent with field observations and is also apparent when the data are analyzed in conjunction with field logs. It is probable that some of these textures have been artifically modified through activities such as cutting, filling, or incorporating fill material from outside the area. The data are too limited to be in any sense conclusive and serve principally to support the numerous field tests which established the trends mentioned.

It may be pointed out, that in theory, the wet area soils might be expected to be slightly finer than related Hanford, Hesperia, or Greenfield soils because of the tendency for soils that are more or less moist and carry a heavy vegetative cover to "weather" and break down at a more rapid rate. However, during the limited period that these soils have been in place, not enough time has elapsed for the rather stable granite minerals to break down very extensively.

TABLE C-2

MECHANICAL ANALYSES OF REPRESENTATIVE SOILS
IN THE CIENAGA AREA

(in percent of total dry weight)

Soil series	Sample hole number	Depth	Particle size in microns: More than 39	Less than 39	Less than 18	Less than 5	Less than 2	Less than 1	Texture designation
Chino	4	0-2.5'	25	75	57	37	21	14	Silt loam
		4-5	48	52	39	26	17	14	Loam
		7-9	21	79	46	49	33	27	Silty clay loam
		12.3-12.7	17	83	72	55	40	33	Silty clay
		12.7-13.8	69	31	18	10	7	5	Sandy loam
Hanford	8	0-1'	67	33	16	11	8	8	Sandy loam
		1-3.5	75	25	17	12	8	8	Sandy loam
		3.5-5.5	75	25	15	10	7	6	Sandy loam
		5.5-7.5	69	31	20	13	9	9	Sandy loam
Chino	9	0-6'	47	53	38	25	14	10	Loam
		6-9.5	51	49	31	19	13	9	Loam
		9.5-11.2	52	48	44	30	22	17	Sandy clay loam
		12.5-13	47	53	41	32	27	25	Sandy clay loam
Greenfield	25	0-1'	66	34	21	13	10	7	Sandy loam
		1-2	67	33	21	13	10	8	Sandy loam
		2-3	68	32	22	14	11	10	Sandy loam
		3-4	67	33	23	17	12	12	Sandy loam
		4-5	66	34	22	16	12	11	Sandy loam
Foster Hanford	26	0-1'	66	34	23	15	10	9	Sandy loam
		1-2	71	29	19	13	9	8	Sandy loam
		2-3	75	25	18	12	9	8	Sandy loam
		3-4	74	26	17	12	9	8	Sandy loam
		4-5	76	24	16	11	7	6	Sandy loam
Chino	27	0-1'	59	41	30	20	14	10	Sandy loam
		1-2	57	43	31	21	15	11	Sandy loam
		2-3	58	42	31	20	14	10	Sandy loam
		3-4	71	29	21	15	11	9	Sandy loam
		4-4.5	78	22	15	11	7	7	Sandy loam
Merrill	28	0-1'	55	45	26	13	7	6	Sandy loam
		1-2	53	47	27	13	7	4	Sandy loam
		2-3	50	50	32	16	9	5	Loam
		3-4.2	40	60	45	25	12	9	Loam
		4.2-5	41	59	51	27	16	11	Loam
Merrill	29	0-1'	59	41	25	12	8	5	Sandy loam
		1-2	53	47	29	13	8	6	Sandy loam
		2-3	44	56	39	22	13	8	Loam
		3-3.5	41	59	42	25	15	9	Loam
		3.5-4	47	53	39	23	14	8	Loam
		4-5	41	59	45	26	16	10	Loam
Chino	30	0-1'	75	25	24	13	8	6	Sandy loam
		1-2	58	42	26	13	8	5	Sandy loam
		2-3	51	49	34	21	13	9	Loam
		3-4	56	44	32	21	13	9	Sandy loam
		4-5	61	39	28	17	11	8	Sandy loam
Grangeville	31	0-1'	57	43	27	15	11	9	Sandy loam
		1-2	56	44	29	18	12	9	Sandy loam
		2-3	56	44	32	21	15	11	Sandy loam
		3-4	57	43	31	19	14	12	Sandy loam
		4-5	58	42	29	18	13	11	Sandy loam
Hesperia	32	0-1'	70	30	19	11	8	8	Sandy loam
		1-2	67	33	22	13	10	9	Sandy loam
		2-3	61	39	26	16	12	10	Sandy loam
		3-4	64	36	22	14	11	10	Sandy loam
		4-5	66	34	22	15	11	10	Sandy loam
Hanford	33	0-1'	77	23	13	7	5	5	Sandy loam
		1-2	70	30	20	13	9	7	Sandy loam
		2-3	66	34	23	15	11	9	Sandy loam
		3-4	68	32	22	15	11	9	Sandy loam
		4-5	68	32	22	15	11	9	Sandy loam

Chemical Analyses

Laboratory chemical determinations were made on samples from 35 profiles. Analyses included organic carbon, calcium carbonate, cation exchange capacity, and determination of principal cations and anions in saturated extracts. Organic carbon was determined by the wet combustion process described by Allison (Reference 1) using the "direct" procedure. Calcium carbonate was determined by the manometric pressure method described by D. E. Williams (Reference 12). Other determinations were made by standard methods described in Agriculture Handbook 60 (Reference 11). Detailed data are included in the basic data section of this report.

Study of the above data indicated that the organic carbon, calcium carbonate, and total salt concentration in the saturation extract showed several important relationships between the soil groups. Table C-3 summarizes most of the data in such a manner that significant differences and similarities between the various soil groups are readily apparent.

The laboratory method of determining the organic content of the soil gives results in terms of organic carbon expressed as a percentage of dry soil weight. These results may be converted to terms of total organic material (a method of expression sometimes used) by multiplying by the constant 1.8.

Discussion and Interpretation of Soil Survey and Laboratory Studies

Analyses of data presented in Table C-3 brings out important differences between the Chino-Merrill-Grangeville soils and the related alluvial soils up-slope and down-slope from the cienaga area.

Significance of Organic Carbon

As previously mentioned in this report, organic matter in soil comes chiefly from decomposition of plants that once grew on the land. Plant cover and density depend largely on moisture, temperature, and soil characteristics. If conditions for vegetative growth improve, organic matter gradually accumulates until it reaches a constant value with decomposition equaling accumulation. If, however, the vegetative cover is removed (for example by plowing, or removal of the moisture supply) the bulk of organic material decomposes very rapidly, compared to the time required for its accumulation. After the initial rapid decline the more stable fractions, often called "humus", will continue to decompose at a much slower rate. It would take a very long time for these latter fractions to completely disappear even if no new material were added.

Comparison of the organic carbon content in Chino, Merrill, Grangeville, and Foster samples with that in samples from adjacent soils, indicates that at one time plant cover was considerably more lush in the cienaga area than in surrounding areas. Accruals of organic material to these cienaga area soils for the past few years approximate those to adjacent Hanford soils and are thus too small to cause or maintain their

TABLE C-3

SUMMARY OF SIGNIFICANT CHEMICAL ANALYSES DATA ON SOIL SAMPIES
TAKEN IN THE SAN FERNANDO CIENAGA INVESTIGATION AREA

Sample depth, in inches	Soil series and hole number			Soil series and hole number			Soil series and hole number			Soil series and hole number			Soil series and hole number		
	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]	$CaCO_3$ in percent	Organic carbon[a]	Electrical conductivity[b]
Soils strongly affected by water table															
	Merrill (28)			Merrill (29)			Foster (22)			Foster-Hanford (26)			Chino (12)		
0-12	12	2.06	0.58	12	1.74	0.55	40	5.80	0.97	0.8	1.18	1.37	0.1	1.40	0.74
12-24	17	1.82	0.51	17	1.45	0.60	66	4.41	1.03	0.4	0.61	0.52	1.7	1.09	0.88
24-36	20	1.84	0.59	24	1.66	0.65	72	5.35	1.20	0.1	0.40	0.45	3.5	1.11	0.56
36-48	27	1.67	1.06	29	1.96	0.73	38	4.09	2.64	0.0	0.26	0.42	8.7	0.90	0.57
48-60	28	1.27	1.23	34	2.20	0.94	4.1	1.55	5.04	0.0	0.16	0.43	9.7	0.66	0.64
	Chino (17)			Chino (21)			Chino (27)			Chino (30)			Chino (36)		
0-12	0.2	1.85	0.49	0.1	1.65	0.57	3.5	1.95	0.67	7.1	1.64	0.76	10	1.40	0.66
12-24	2.1	1.38	0.57	2.2	1.46	0.54	2.2	1.53	0.60	12	1.29	1.89	21	1.42	0.78
24-36	3.4	1.19	0.35	12	0.75	0.75	7.1	1.28	0.65	18	0.90	1.00	25	1.67	1.72
36-48	7.9	0.87	0.41	16	0.81	0.54	9.0	0.44	0.51	35	0.96	0.72	24	1.54	2.67
48-60	10	0.96	0.42	16	0.51	0.48	0.9	0.15	0.50	13	0.66	0.64	20	1.30	3.71
	Grangeville (31)			Grangeville (37)			Grangeville (38)								
0-12	1.4	1.28	0.66	1.4	1.17	0.68	7.1	2.01	1.30						
12-24	2.9	1.09	0.47	1.3	0.95	1.40	1.1	1.07	0.87						
24-36	7.7	0.54	0.42	6.1	0.58	0.78	0.2	0.77	0.84						
36-48	3.9	0.44	0.40	5.5	0.31	0.61	0.0	0.59	0.87						
48-60	3.9	0.34	0.39	4.8	0.27	0.55	0.0	0.39	0.95						
Transitional soils, slightly affected by water table															
	Hesperia (13)			Hesperia (20)			Hesperia (32)			Hesperia (35)			Hanford-Pachappa (16)		
0-12	0.1	0.93	No data	0.2	1.12	No data	0.1	0.60	0.35	0.0	0.97	No data	0.0	0.87	No data
12-24	0.0	0.73	No data	0.1	1.10	No data	0.0	0.51	0.29	0.0	0.63	No data	0.0	0.78	No data
24-36	0.0	0.65	No data	0.7	0.45	No data	0.5	0.32	0.44	0.0	0.35	No data	0.1	0.61	No data
36-48	0.1	0.43	No data	4.2	0.34	No data	1.9	0.18	0.35	0.0	0.25	No data	0.6	0.52	No data
48-60	0.5	0.25	No data	3.3	0.22	No data	1.7	0.11	0.35	0.6	0.18	No data	1.4	0.39	No data
Related soils, unaffected by water table															
	Hanford (14)			Hanford (15)			Hanford (19)			Hanford (33)			Hanford (34)		
0-12	0.2	0.68	No data	0.1	No data	No data	0.1	0.95	No data	0.0	0.71	0.60	0.0	0.98	No data
12-24	0.1	0.56	No data	0.0	No data	No data	0.2	0.70	No data	0.0	0.52	0.51	0.0	0.67	No data
24-36	0.0	0.50	No data	0.0	No data	No data	0.2	0.44	No data	0.0	0.50	0.74	0.0	0.52	No data
36-48	0.0	0.47	No data	0.0	No data	No data	0.1	0.36	No data	0.0	0.38	0.42	0.0	0.31	No data
48-60	0.1	0.43	No data	0.1	No data	No data	0.2	0.30	No data	0.0	0.29	0.54	0.0	0.38	No data
	Hanford (39)			Greenfield (25)											
0-12	0.0	0.68	No data	0.1	0.74	2.38									
12-24	0.0	0.48	No data	0.0	0.47	2.50									
24-36	0.0	0.39	No data	0.0	0.30	1.06									
36-48	0.0	0.27	No data	0.1	0.20	0.66									
48-60	0.0	0.22	No data	0.1	0.15	0.53									
Unrelated soils, unaffected by water table															
	Zamora (11)			Zamora (24)			Zamora (42)			Chualar (18)			Placentia (10)		
0-12	0.0	1.05	1.12	0.1	No data	No data	0.0	0.77	0.49	0.2	0.72	No data	0.1	No data	No data
12-24	0.0	0.81	0.45	0.1	No data	No data	0.0	0.68	0.35	0.1	0.54	No data	0.1	No data	No data
24-36	0.1	0.31	0.66	0.0	No data	No data	0.0	0.57	0.32	0.1	0.52	No data	0.1	No data	No data
36-48	0.9	0.14	1.13	0.2	No data	No data	0.1	0.29	0.61	0.1	0.21	No data	0.4	No data	No data
48-60	1.2	0.06	0.89	No data	No data	No data	0.1	0.21	0.82	0.2	0.12	No data	0.0	No data	No data
	Placentia (41)			Altamont (23)			Diablo (40)								
0-12	0.1	0.58	0.80	0.1	1.23	0.49	0.0	2.31	0.55						
12-24	0.1	0.40	0.26	0.1	0.39	0.30	0.1	1.56	0.48						
24-36	0.1	0.23	0.26	0.1	0.19	0.34	0.1	0.97	0.37						
36-48	0.1	0.11	0.34	---	---	---	14	0.75	0.46						
48-60	0.1	0.11	0.35	---	---	---	15	0.36	0.52						

a. Organic carbon in percent.
b. Electrical conductivity in millimhos per cubic centimeter of saturation extract.

relatively high organic content. For this reason, it can only be a fraction of what was present at one time.

The distribution of the organic material with depth in the Chino and Merrill (and to a lesser extent in the Grangeville) soils may also be considered indicative of a difference in moisture source to the vegetation when compared with the depth distribution in Hanford-Greenfield soils. The average surface foot organic content in Chino and Merrill is 1.71 percent while from two to three feet it is 1.30 percent or 76 percent of the surface amount. In the Hanford-Greenfield soils the surface foot averaged only 0.81 percent and the two to three foot depth only 0.44 percent or 54 percent of the surface content. The greater actual and relative abundance of organic carbon in the deeper layers of Chino-Merrill soils indicates that the plants were probably getting water from a water table, while water for plant use on the well-drained soils probably penetrated from the surface downward following rainfall or overland flow.

Significance of Calcium Carbonate

Under the prevailing climate in the San Fernando Valley, calcium carbonate could accumulate in the soil profile under only three types of natural processes. These are: (1) weathering of calcium-bearing parent materials; (2) periodic flooding of soil with calcium-bearing waters followed by transpiration and evaporation; and (3) precipitation resulting from transpiration and evaporation of calcium-bearing water from a high water table. A fourth possible process, not a natural one, is addition through man's activities. However, the nature, amount, and distribution of the material eliminates this method as a major cause within the cienaga area.

The first process, in granitic alluvium, requires long periods of time during which other soil morphological changes occur. These include accumulations of clay size particles and development of pronounced "B" horizons and structural patterns. Neither the parent material, the soil morphology, nor the age of material in the cienaga area indicate that such a process caused an appreciable part of the calcium carbonate found there.

The second process that might cause accumulation of calcium carbonate is flooding the soil periodically with calcium-bearing waters, followed by evaporation. Salts more soluble than calcium carbonate, which would also accumulate in this process, could be leached from the soil by subsequent rainfall. This process may account for a small part of the accumulation, but is not a major factor for the following reasons: (1) areas up-slope and down-slope from the cienaga which were also subject to such flooding should have accumulated calcium carbonate, but both field and laboratory tests show this did not occur; (2) surface slopes in the cienaga area are not flat enough to trap surface water flowing down from above, so that this factor could not have caused appreciable increases in the amount of water entering the soil; and (3) the accumulation in many places is so large that very great quantities of water were required to supply the calcium carbonate. A high flood frequency over long ages would be required for this process, and other features of the soil morphology as well as the physiographic relief would have been considerably modified under such conditions.

The preponderance of evidence indicates that the calcium carbonate present in these soils must have accumulated principally by the third process mentioned, evaporation or transpiration from a high water table. The conclusion that such a water table existed is further substantiated by the historical record of springs and artesian wells in the area.

Since evaporation and transpiration are greatest near the soil surface, maximum salt accumulation also may be expected in the surface zone. However, the vertical distribution pattern of $CaCO_3$, shown for cienaga area soils in Table C-3, indicates higher concentrations in the subsoil than in the surface. This pattern may be related to the tendency of this salt to precipitate from solution because of small pH or concentration changes. Such changes result from normal activity of roots at depths where samples were secured. In addition, downward leaching probably occurred intermittently during wet periods and may have caused part of the subsoil accumulation. During the years the water table has been at considerable depth a small additional amount of leaching also has occurred.

While quantitative data on accumulation below the 5-foot depth are not available, some qualitative observations made during the study are shown in Table C-4. It is evident that considerable accumulation did occur below 5 feet in at least part of the area.

Variations in chemical and physical characteristics within the same soil body, as well as between the different bodies, suggest that water table depth and depth fluctuations were not consistent throughout the area. In some places, such as the vicinity of the old San Fernando Mission water gathering works, where it may be assumed that the water table must have been close to surface, calcium carbonate accumulations below the surface foot are negligible because free water was always present. The first twelve inches in that location, obviously modified to an indeterminate extent by man's activities, is very high in calcium carbonate. That the accumulation is still not as great as occurs in some other places is probably due to more frequent leaching, either upwards or downwards in this very wet location. Thus if an attempt was made to correlate calcium carbonate content and evapo-transpiration, it would be necessary to evaluate such local conditions separately before deriving averages.

Soluble Salts

Soluble salts also tend to accumulate while calcium carbonate is building up. However, the electrical conductivity of saturation extracts (recognized as a basic measure of soil salinity) of samples from 14 of the profiles shows values in the range for normal soil unaffected by salts (Table C-3). This is explained in part by the much greater tendency of calcium carbonate to precipitate from solution because of its low solubility. It is probable, however, that these more soluble salts did accumulate in the soil during the periods these soils were subjected to

TABLE C-4

SUMMARY OF CHEMICAL DATA OBTAINED ON SOIL SAMPLES FROM DEEP HOLES IN THE SAN FERNANDO CIENAGA AREA

Soil series and hole number	Depth, in feet	$CaCO_3$, in percent	Electrical conductivity*	Remarks
Chino Hole No. 1	0-1	12	1.94	
	2-3	0.2	1.12	
	3-4.5	0.6	1.26	
	6.5-8	0.2	2.87	Limonite mottlings.
	10.8-12.3	0.0	0.99	Sand, limonite mottlings.
	13-14.5	1.2	1.43	Saugus formation, limonite mottlings.
Chino Hole No. 4	0-2.5	18	1.05	
	4-5	18	3.72	
	7-9	25	2.40	
	12.3-12.7	0.2	No data	Some limonite mottlings.
	12.7-13.7	0.8	3.98	Saugus formation, limonite mottlings.
Chino Hole No. 6	0-10.5	Calcareous	No data	Strong $CaCO_3$ by field test. No laboratory test.
	10.5-13.5	Noncalcareous	No data	
	13.5-14	Noncalcareous	No data	Saugus formation, limonite mottlings.
Chino Hole No. 9	0-6	14	1.09	
	7-9.5	0.4	1.33	Some limonite mottlings.
	9.5-11.2	0.2	0.80	Very slight limonite mottlings.
	12.5-13.0	0.4	0.55	Saugus formation, limonite mottlings.
Hanford Hole No. 5	0-1	0.2	0.79	Little or no calcium carbonate or limonite mottlings in this profile by field tests.
	1-2.3	0.2	0.71	
	2.3-5.5	0.2	0.45	
	7-10	0.4	0.37	
	10-11.5	0.4	0.31	
	12-14.5	0.0	0.31	Saugus formation, limonite mottlings.
Hanford Hole No. 8	0-1	0.0	0.30	Some gravels in profile. Appears recent deposit coarser with depth.
	1-3.5	0.0	0.42	
	3.5-5.5	0.0	0.32	
	5.5-7.5	0.0	0.51	Stopped by gravels - hand auger.

* Electrical conductivity of saturation extract in millimhos per centimeter.

high water table conditions and varied in concentration in accordance with any fluctuation of the water table. These highly soluble salts were subsequently leached away during periods of above normal surface water supplies following a lowering of the water table. Some surface salts would be washed away by surface flows down San Fernando Ravine while the majority would be leached and removed by underflow through the Sylmar Notch. In an unpublished report by the Soil Conservation Service, in 1941 (Reference 4), mention is made of the fact that a few small saline spots were noted in this vicinity. Apparently these spots have been leached free of salts since they were not found in this investigation.

At the request of the Referee a comparison was made of the chemical data obtained on cienaga soils with similar data on samples taken from a nearby presently high water table area. The comparison area, Elizabeth Lake, is an intermittently flooded dry lake bed about 30 miles northeast of San Fernando. Climate is reasonably similar to that in San Fernando and the water table is believed to have been within a few feet of the surface for many years.

Soil samples were taken both in the dry lake bed and on an adjacent alluvial fan where the water table was influenced by the lake, but has probably seldom been within five feet of the surface of the soil. Analyses of these samples are included in Table C-5.

TABLE C-5

SUMMARY OF CHEMICAL DATA OBTAINED ON ELIZABETH LAKE SOIL SAMPLES AND SELECTED COMPARATIVE SAMPLES FROM SAN FERNANDO CIENAGA

Depth in feet	$CaCO_3$	Organic carbon[a]	Electrical conductivity[b]	Sodium adsorption ratio	
Elizabeth Lake Fan - 80 feet from Dry Lake Bed					
0-2	7.2	0.78	1.21	4.1	Bermuda and salt grass pasture.
2.5-3.5	7.0	0.61	0.94	10	No salinity or alkali problem to this depth.
4-5	15	0.75	15.6	27	Very severe saline alkali problem at this depth.
Elizabeth Lake Dry Bed - Lake Intermittently Flooded					
0-1	21	1.23	45.4	74	White salt surface crust - no vegetation.
1-2.5	20	1.45	27.5	65	
2.5-4	22	1.28	25.8	60	Free water seeping through this layer.
4-5	22	1.46	24.9	61	Very heavy clay - restricted permeability at this depth.
San Fernando Cienaga Area Foster Soil - Hole 22					
0-1	40	5.8	0.97	0.4	Profile influenced by fluctuating level of San Fernando Reservoir. Also receives runoff from above.
1-2	66	4.41	1.03	0.4	
2-3	72	5.35	1.20	1.1	
3-4	38	4.09	2.64	3.2	
4-5	4.1	1.55	5.04	5.0	
San Fernando Cienaga Area Chino Soil - Hole 36					
0-1	10	1.40	0.66	0.5	
1-2	21	1.42	0.78	2.8	
2-3	25	1.67	1.72	4.3	
3-4	24	1.54	2.67	2.3	

a. Organic carbon in percent.
b. Electrical conductivity in millimhos per centimeter.

Due to the high water table conditions and lack of subsurface outflow, leaching has not removed the highly soluble salts from the dry lake bed. On the alluvial fan, leaching from rainfall (and probably some irrigation) has moved the soluble salts into the subsoil. Because subsurface outflow at the lower end of the alluvial fan adjacent to the lake, where the samples were taken, is also limited, considerable soluble salt has accumulated at the greatest depth sampled. Calcium carbonate content in the dry lake samples is similar to that found in the subsoils of several of the Chino and Merrill profiles so that the concentrations of this salt found in the cienaga area are believed to be representative of values found under extreme conditions of evaporation from a high water table.

Included in Table C-5 are results of analyses of samples from cienaga area hole No. 22. This hole was drilled near the margin of San Fernando Reservoir and represents the extreme values of both $CaCO_3$ and organic carbon found in the investigation area. The values found are so extreme that it is possible some additional unknown causative factor is involved. Additional samples would be necessary to determine whether the values shown are representative of a mapable area.

<u>Transects</u>

Areal distribution of soil series in the cienaga area has been shown on the soil survey map (Plate 7). Topographic relationships are indicated on Plate 8 showing a series of profiles or transects across the area. Soil sampling holes were chosen along the transects, and data on organic carbon and $CaCO_3$ from these samples were plotted above each sample hole located on the transect. Plate 8 graphically illustrates the degree to which different areas were affected by the water table and the topographic relationships among these areas.

Conclusions

1. As a result of a soil survey described herein, 445 acres of soils located near the City of San Fernando, in the Sylmar Subarea of the Upper Los Angeles River area, were found to have appreciable accumulation of calcium carbonate as compared with surrounding areas which were practically devoid of calcium carbonate accumulations.

2. A relatively high concentration of organic carbon was also found in soils having a high concentration of calcium carbonate, indicating that a high vegetative density existed within this area.

3. The large amount of calcium carbonate found in the soils of this area resulted from evaporation and transpiration of calcium-bearing water from a high ground water table.

4. An area of 445 acres in the Sylmar Subarea of the Upper Los Angeles River area has been affected at some time and to some extent by a high ground water table as evidenced by appreciable accumulation of calcium carbonate and organic carbon not found in soils of surrounding areas.

5. Included in the total area of 445 acres of soils which have been affected at some time and to some extent by a high water table, there are 288 acres which have been strongly affected, as evidenced by a relatively larger accumulation of calcium carbonate and organic carbon therein.

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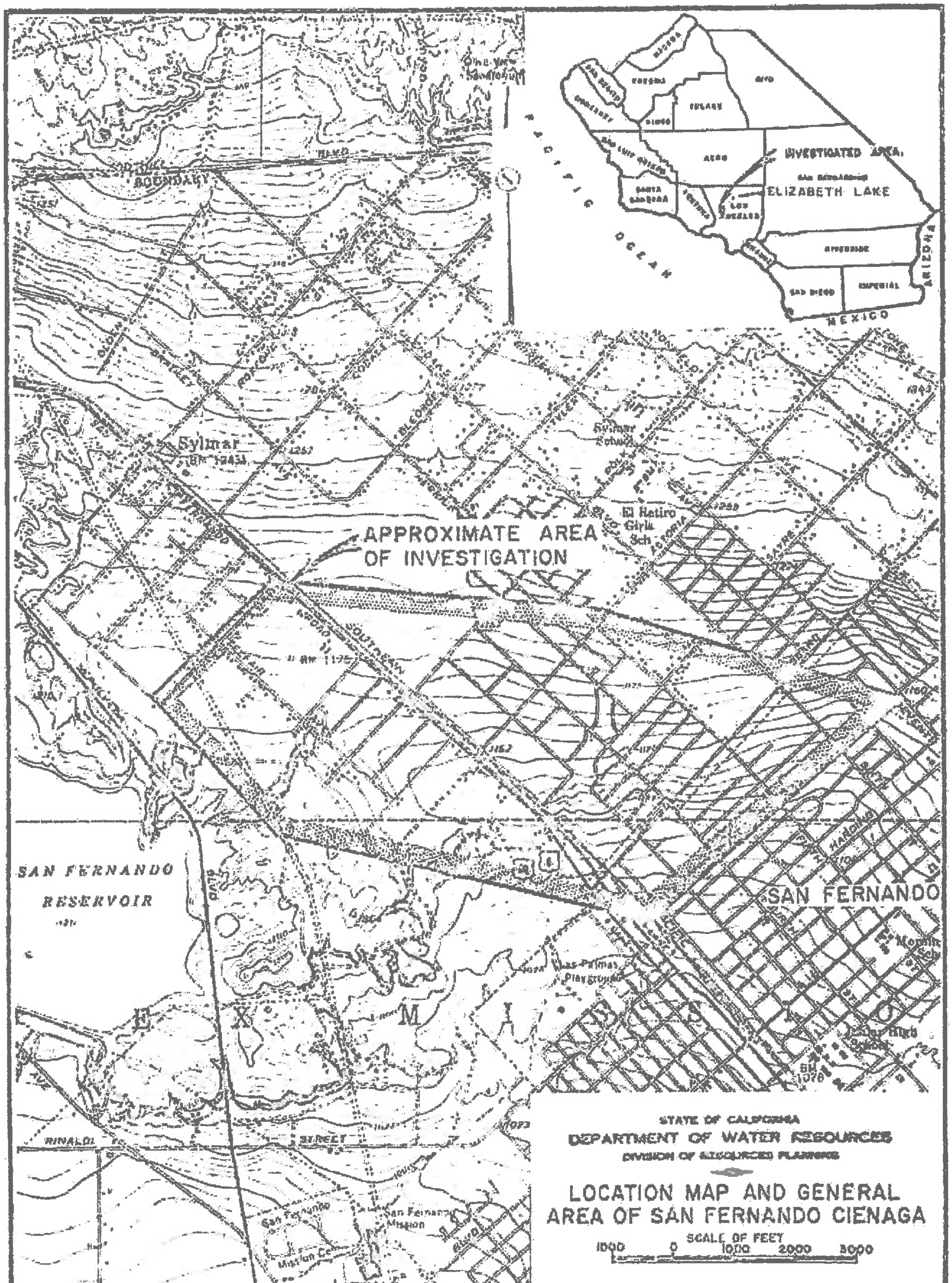

STATE WATER RIGHTS BOARD

APPENDIX D

SELECTION OF SPECIFIC YIELD VALUES

APPENDIX D

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TABLE

APPENDIX D

SELECTION OF SPECIFIC YIELD VALUES

To select specific yield values applicable to the various materials described in driller's logs in the area of investigation, the Referee made a detailed study of previous investigations. To show the reasons for and data considered in the selection of the specific yield values for computing change in storage, this appendix is broken into three sections: Definitions, Previous Determinations and Selection of Specific Yield Values for the San Fernando Valley area. The application of specific yield in evaluating change in storage is discussed in detail in Appendix Q.

Definitions

The specific yield of a rock or soil is defined herein 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 after the saturated material is drained will be retained by it against the force of gravity to the total volume of such material.

Previous Determinations

The following are extracts of information concerning evaluation of specific yield as determined in previous investigations.

Basic information concerning the various types of water-bearing material must be derived from well logs in which the materials encountered are described by the driller. Because of the variety of individuals involved and the fact that the driller in many instances is primarily interested in the relative permeability of the materials penetrated, there results a great number of descriptions for similar types of materials. These circumstances, when combined with the paucity of measurements of specific yield, require that considerable judgment be experienced in the evaluation of the extent and storage capacity of equivalent types of water-bearing materials.

The purpose in presenting the following information concerning other investigations is to set forth the scope and circumstances of those in which specific yield has been measured and to indicate the various categories to which measured values have been applied. Thus, by comparison, the degree of judgment exercised by the Referee in selection and application of the specific yield values utilized in this report will be apparent.

South Coastal Basin Investigation[1/]

The South Coastal Basin of California includes the coastal plain areas of Los Angeles and Orange Counties, together with the inland drainage areas of the Los Angeles, San Gabriel and Santa Ana Rivers, exclusive of the San Jacinto River drainage area which is tributary to the Santa Ana River.

The geological investigation included several lines of study. These are outlined briefly as follows:

1. Experimental Work - Several hundred samples of typical gravels, sands and clays of the South Coastal Basin were dug from surface exposures and obtained from post hole borings. About 2,000 samples of similar materials were collected from wells as they were being drilled. Porosity determinations were made of the samples taken in place and of those which came intact from wells. Further experimental work was done to determine the water-yielding capacity of various materials. The coarser sediments were classified by mechanical analysis.

2. Subsurface Studies - About 5,000 well logs from all parts of the South Coastal Basin were collected. Nearly 300 wells were observed as they were being drilled. The well logs were grouped and the materials classified with the aid of notes from wells observed during drilling. Thus by grouping the well logs and averaging the materials, the vertical and horizontal distribution of water-bearing materials was estimated. Combining this information with yield values obtained by the experimental work, storage capacities of the basins were computed.

The unaltered materials upon the alluvial cone surfaces were studied in detail. Distribution of the various types (sands, gravels and clays) was noted, and the water-yielding properties were estimated by field and laboratory investigation. The water-yielding properties of these unaltered materials were classified according to coarseness, the maximum 10 percent grade size being used as an index of coarseness.

The nature and amount of alteration by weathering that the water-producing deposits have undergone was studied, and the effect of this alteration upon the specific yield was evaluated. All subsurface materials were considered to have undergone some alteration.

The specific yields of weathered altered materials could not be successfully classified from measurements on actual samples because of the nature of variation. Therefore, specific yields were assigned by making an arbitrary divsion according to the degree of alteration. Tight gravel was given a yield value of two-thirds that of unweathered subsurface gravel and gravelly clay one-third the specific yield value of unweathered surface gravel. Probably the typical residual clay which does not occur in this area has a yield of zero, but since it is highly variable in composition it undoubtedly contains streaks of more permeable materials that will yield small quantities of water. It was, therefore, assigned a specific yield of one to indicate a probable slight yield throughout the well section. These yields are set forth in Table D-1

TABLE D-1

ESTIMATED SPECIFIC YIELD VALUES FOR SEDIMENTS
OF THE SOUTH COASTAL BASIN

(After Table 5)[1/]

		Percent yield, gravel				Percent yield, sand		Percent yield, clay	
		256+ mm., boulders	64-256 mm., coarse	16-64 mm., medium	8-16 mm., fine	1/2-8 mm., coarse-medium	1/8-1/2 mm., fine	Sandy	Clay
Unweathered-									
Surface alluvial	(1)	13.6	14.2	20.5	26.5	30.9	21.2	10	1
Subsurface alluvial	(2)	13	14	20	25	28	16	5	1
Weathered subsurface-									
Tight[a]	(3)	9	9	13	17	16			
Clayey[b]	(4)	4	5	7	8	5			
Residual clay[c]	(5)	1	1	1	1	1		1	

a. Lime cemented gravels are included in tight gravels.
b. Lime cemented sands are included in clayey sand.
c. The yield of one makes allowance for small sandy or gravelly streaks.

In the San Fernando Valley area, contours of specific yield for a zone averaging 100 feet thick for 50 feet above and 50 feet below the water of January, 1933, show the highest yields to be in the eastern and southeastern parts of the basin where a peak of about 16 percent is reached. The yield decreases to about three percent along the south and west margins, and to seven and eight percent along the north and northwest margins of the basin.

Mokelumne Area Investigation[2/]

In the Mokelumne investigation, intensive field studies were undertaken to determine the specific yield of water-bearing materials.

Two methods were used to determine specific yield. In the first method, the volume of material saturated and unwatered by alternate addition and withdrawal of measured volumes of water from columns of undisturbed soil was determined for materials from 13 localities. This is a direct volumetric method for determining specific yield. In the second method, the difference between the porosity and the specific retention of undisturbed material was determined on 16 samples, in duplicate, after drainage periods as long as 390 days. This is an indirect method similar to those employed by Eckis[1/]. In general, these averages agree with the values obtained for the specific yield of valley fill in the South Coastal Basin,[1/] although that intensive study dealt chiefly with coarser materials. The specific yield values for three general classes of material obtained by the foregoing methods and the averages for the two methods are set forth in Table D-2.

TABLE D-2

SPECIFIC YIELD
MOKELUMNE INVESTIGATION

Material	Specific yield in percent		
	Direct method	Indirect method	Average
Gravel and coarse sand	35	34.5	34.8
Medium and fine sand	26	22.6	24.2
Very fine sand, silt and clay	3.5	5.0	4.2

Salinas Basin Investigation[3/]

The indicated average specific yield for a change in ground water storage of 50,000 acre-feet in the free ground water areas at the water levels prevailing 1944-45 is approximately 13.8 percent.

Sacramento Valley Investigation[4/]

On the basis of the South Coastal Basin Investigation[1/] and Mokelumne Area Investigation,[2/] together with less detailed studies by others, the specific yield values shown in Table D-3 were assigned to the five groups of material classified in the well logs of the Sacramento Valley.

TABLE D-3

SPECIFIC YIELDS OF SEDIMENTS
IN SACRAMENTO VALLEY

Material	Specific yield (percent)
Gravel	25
Sand	20
Fine sand	10
Clay and gravel	5
Clay, silt, sandy clay, lava rock	3

Ventura County Investigation[5]

With slight variations, the values determined in the South Coastal Basin Investigation[1] were used. Estimated weighted average specific yields by basins are: Piru Basin, 16.7 percent; Fillmore Basin, 12.2 percent; Santa Paula Basin, 10.0 percent; Oxnard Forebay Basin, 16.5 percent. The specific yield values utilized in the Ventura County Investigations are listed in Table D-4.

TABLE D-4

SPECIFIC YIELDS OF SEDIMENTS IN VENTURA COUNTY

(After Table B-1)[5]

Material	Specific yield (percent)
Soil, including silty clay	3
Clay, including adobe and hard pan	0
Clayey sand, including sandy silt	5
Clayey gravel	7
Sand	25
Tight sand, including cemented sand	18
Gravel, including gravel and sand	21
Tight gravel, including cemented gravel	14

Santa Margarita River Investigation[6]

The values of specific yield assigned are those set forth in Table D-5 and were derived largely from the laboratory investigations of the South Coastal Basin Investigation.[1]

TABLE D-5

ASSIGNED SPECIFIC YIELD VALUES,
SANTA MARGARITA INVESTIGATION
(After Table B-4)[6/]

Type	Description of material		Specific yield value assigned
Clay	Carbonaceous-silt Decomposed granite Hill formation	Hard pan Adobe	1
Soil	Loam	Lake bed	4
Clay-sand	Sand and clay Muck Sea mud and packed sand Silty clay	Clay with lime rocks Cemont Sandy clay Cemented sediment	5
Silt	Sandy soil		10
Sand	Fine sand Coarse sand	Quicksand	28
Tight sand	Sandy-soil Silty-sand Unsorted angular sand Sand with trace of clay	Sand and mud Cemented sand Dirty sand	16
Gravel	Gravel and sand Boulders	Cobbles and sand Fill	22
Tight gravel	Cemented gravel Gravel with clay layers Dirty gravel	Sandy clay with gravel Packed sand with rocks	15
Gravel-clay	Conglomerate (partially cemented) Clay and boulders		7

Tia Juana Basin Report[7]

Specific yield values have been assigned to the sediments in the Tia Juana Basin based upon previous studies of similar materials in South Coastal Basin.[1] A direct determination of specific yield was made by the drainage of core samples within essentially homogenous materials of the Tia Juana Basin in order to ascertain the degree of correlation existing between the samples taken and those of the South Coastal Basin[1] sediments based on maximum ten percent grade sizes. Two indirect determinations of specific yield were also made in this investigation by pumped well methods, the results of which compared fairly well with the direct determinations. Although the origin and mode of deposition of sediments in Tia Juana and South Coastal Basins differ, the specific yields of sediments sampled in Tia Juana Basin were found to be only slightly higher than those in the South Coastal Basin. Values so selected are indicated in Table D-6

TABLE D-6

SPECIFIC YIELD VALUES
APPLIED TO SEDIMENTS IN TIA JUANA BASIN
(After Table C-2)[7]

Differentiated description of material	Average specific yield, in percent[a]	Undifferentiated description of material[b]	Average specific yield value used, in percent
Clay	1	Clay	1
Sandy clay	5	Sandy clay	5
Silt	10	Silt	10
Very fine sand	17	Fine sand	21
Fine sand	25		
Medium sand	30		
Coarse sand	32	Sand	30
Very coarse sand	31		
Gravelly sand	28		
Fine gravel	26		
Medium gravel	23	Gravel	22
Coarse gravel	18		
Very coarse gravel and boulders	14	Boulders	14

a. Determined from maximum 10 percent grade size of cored samples.
b. As contained in drillers' logs.

San Joaquin Valley Investigation[8]

Data collected by the Geological Survey on the character of materials underlying the San Joaquin Valley include drillers' logs of nearly 6,000 water wells that were field located, geologists' logs and core records of 64 Bureau of Reclamation test holes, and more than 1,000 electric logs of water wells and oil wells. The logs were used for two important purposes; a study of the geology of the materials penetrated by the wells, and classification of the materials according to their specific yields for the purpose of estimating ground water storage capacity.

A total of 300 drillers' terms were grouped into five principal classes and one minor class of material for use in the storage estimate. A distinction between ill-sorted gravelly material and ill-sorted sand was important at many places in the geologic studies, although the specific yields of the two types of materials were considered sufficiently similar so that they could be combined in a single category in the storage study.

Facilities were not available in this investigation for making either aquifer-rating (pumping) tests or field or laboratory drainage tests of samples to determine specific yield. As in the Sacramento Valley and in most other ground water basins in California where storage studies have been made by the Geological Survey, it was necessary to assign estimated specific yields to the various classes of materials reported in well logs. The values chosen for specific yield were based largely on previous work by other investigators in California, with certain rational modifications to fit conditions in the San Joaquin Valley.

The grouping of drillers' terms into the five major and one minor specific yield categories are listed in Table D-7.

TABLE D-7

GROUPING OF DRILLERS' TERMS USED IN ESTIMATING SPECIFIC YIELD
(After Table 3)[8]

Crystalline Bedrock (fresh)

Specific yield zero

Granite
Hard boulders
Hard granite
Hard rock
Graphite and rocks
Rock (if in area of known crystalline rocks)

Clay and Related Materials

Specific yield 3 percent

Adobe
Brittle clay
Caving clay
Cement
Cement ledge
Choppy clay
Clay
Clay, occasional rock
Crumbly clay
Cube clay
Decomposed granite
Dirt
Good clay
Gumbo clay
Hard clay
Hardpan (H.P.)
Hardpan shale
Hard shale
Hard shell
Joint clay
Lava
Loose shale
Muck
Mud
Packed clay
Poor clay
Shale
Shell
Slush
Soapstone
Soapstone float
Soft clay
Squeeze clay
Sticky
Sticky clay
Tiger clay
Tight clay
Tule mud
Variable clay
Volcanic rock

Clay and Gravel, Sandy Clay, and Similar Materials

Specific yield 5 percent

Cemented gravel (cobbles)
Cemented gravel and clay
Cemented gravel, hard
Cement and rocks (cobbles)
Clay and gravel (rock)
Clay and boulders (cobbles)
Clay, pack sand, and gravel
Cobbles in clay
Conglomerate
Dry gravel (below water table)
Gravel and clay
Gravel (cement)
Gravel and sandy clay
Gravel and tough shale
Gravelly clay
Rocks in clay
Rotten cement
Rotten concrete mixture
Sandstone and float rock
Silt and gravel
Soil and boulders

Clay and sandy clay
Clay and silt
Clay, cemented sand
Clay, compact loam and sand
Clay to coarse sand
Clay, streaks of hard packed sand
Clay, streaks of sandy clay
Clay, water
Clay with sandy pocket
Clay with small streaks of sand
Clay with some sand
Clay with streaks of fine sand
Clay with thin streaks of sand
Porphyry clay
Quicksandy clay
Sand--clay
Sand shell
Shale and sand
Solid clay with strata of cemented sand
Sticky sand and clay
Tight muddy sand
Very fine tight muddy sand

Cemented sand
Cemented sand and clay
Clay sand
Dry hard packed sand
Dry sand (below water table)
Dry sand and dirt
Fine muddy sand
Fine sand, streaks of clay
Fine tight muddy sand
Hard packed sand, streaks of clay
Hard sand and clay
Hard set sand and clay
Muddy sand and clay
Packed sand and clay
Packed sand and shale
Sand and clay mix
Sand and tough shale
Sand rock
Sandstone
Sandstone and lava
Set sand and clay
Set sand, streaks of clay
Cemented sandy clay
Hard sandy clay (tight)
Sandy clay
Sandy clay with small sand streaks, very fine
Sandy shale
Set sandy clay
Silty clay
Soft sandy clay
Clay and fine sand
Clay and pumice streaks

Dry sandy silt
Fine sandy loam
Fine sandy silt
Ground surface
Loam
Loam and clay
Sandy clay loam
Sediment
Silt
Silt and clay
Silty clay loam
Silty loam
Soft loam
Soil
Soil and clay
Soil and mud
Soil and sandy shale
Surface formation
Top hardpan soil
Topsoil
Topsoil and sandy silt
Topsoil--silt

Decomposed hardpan
Hardpan and sandstone
Hardpan and sandy clay
Hardpan and sandy shale
Hardpan and sandy stratas
Hard rock (alluvial)
Sandy hardpan
Semi-hardpan
Washboard

Clay and Gravel, Sandy Clay, and Similar Materials (continued)

Ash
Caliche
Chalk
Hard lava formation
Hard pumice
Porphyry
Seepage soft clay
Volcanic ash

Fine Sand, Tight Sand, Tight Gravel, and Similar Materials

Specific yield 10 percent

Sand and clay
Sand and clay strata (traces)
Sand and dirt
Sand and hardpan
Sand and hard sand
Sand and lava
Sand and pack sand
Sand and sandy clay
Sand and soapstone
Sand and soil
Sand and some clay
Sand, clay, and water
Sand crust
Sand-little water
Sand, mud, and water
Sand (some water)
Sand streaks, balance clay
Sand, streaks of clay
Sand with cemented streaks
Sand with thin streaks of clay

Coarse, and sandy
Loose sandy clay
Medium sandy
Sandy
Sandy and sandy clay
Sandy clay, sand, and clay
Sandy clay--water bearing
Sandy clay with streaks of sand
Sandy formation
Sandy muck
Sandy sediment
Very sandy clay

Boulders, cemented sand
Cement, gravel, sand, and rocks
Clay and gravel, water bearing
Clay and rock, some loose rock
Clay, sand, and gravel
Clay, silt, sand, and gravel
Conglomerate, gravel, and boulders
Conglomerate, sticky clay, sand and gravel
Dirty gravel
Fine gravel, hard
Gravel and hardpan strata
Gravel, cemented sand
Gravel with streaks of clay
Hard gravel
Hard sand and gravel
Packed gravel
Packed sand and gravel
Quicksand and cobbles
Rock sand and clay
Sand and gravel, cemented streaks
Sand and silt, many gravel
Sand, clay, streaks of gravel
Sandy clay and gravel
Set gravel
Silty sand and gravel (cobbles)
Tight gravel

Sandy loam
Sandy loam, sand, and clay
Sandy silt
Sandy soil
Surface and fine sand

Cloggy sand
Coarse pack sand
Compacted sand and silt
Dead sand
Dirty sand
Fine pack sand
Fine quicksand with alkali streaks
Fine sand
Fine sand, loose
Hard pack sand
Hard sand
Hard sand and streaks of sandy clay

Hard sand rock and some water sand
Hard sand, soft streaks
Loamy fine sand
Medium muddy sand
Milk sand
More or less sand
Muddy sand
Pack sand
Poor water sand
Powder sand
Pumice sand
Quicksand
Sand, mucky or dirty
Set sand
Silty sand
Sloppy sand
Sticky sand
Streaks fine and coarse sand
Surface sand and clay
Tight sand

Brittle clay and sand
Clay and sand
Clay, sand, and water
Clay with sand
Clay with sand streaks
More or less clay, hard sand and boulders
Mud and sand
Mud, sand, and water
Sand and mud with chunks of clay
Silt and fine sand
Silt and sand
Soil, sand, and clay
Topsoil and light sand
Water sand sprinkled with clay

Float rock (stone)
Laminated
Pumice
Seep water
Soft sandstone
Strong seepage

Gravel, Sand, Sand and Gravel, and Similar Materials

Specific yield 25 per cent

Boulders
Coarse gravel
Coarse sand
Cobbles
Cobble stones
Dry gravel (if above water table)
Float rocks
Free sand
Gravel
Loose gravel
Loose sand
Rocks
Water gravel
Gravel and sand
Gravel and sandrock
Medium sand
Rock and gravel
Running sand
Sand
Sand, water
Sand and boulders
Sand and cobbles
Sand and fine gravel
Sand and gravel
Sandy gravel

San Luis Obispo County Investigation[9/]

With slight variations, the values determined in Bulletin No. 45 were adopted for computing the change of storage estimates in this area.

The task of assigning specific yield values to the sediments appearing in drill logs was simplified by dividing all basin sediments into eight general categories. These included soil, clay, clay and sand, clay and gravel, tight sand, tight gravel and gravel. Sand, gravel, and clay which constitute the bulk of the basin sediments were generally found to be well differentiated on the drillers' logs. Combinations of these materials, however, were frequently described by such unique or local terms as "ooze", "muck", "cement", etc. Materials so described were placed, based on the judgment of a geologist, into one of the above eight categories. The Paso Robles formation is generally more compacted and weathered than the alluvium and some specific yield values were lowered accordingly. Estimated weighted mean specific yield of the Paso Robles formation and alluvium is eight percent. The specific yield of the alluvium of the Salinas River is estimated to average 15 percent.

The specific yield values assigned to the general categories of material encountered are shown in Table D-8.

TABLE D-8

SPECIFIC YIELDS OF SEDIMENTS
(After Table B-2)[2]

Material	Specific yield (percent) Alluvium	Specific yield (percent) Paso Robles formation
Soil, including silty clay	5	5
Clay, including adobe and hard pan	3	3
Clay and sand, including sandy silt	5	5
Clay and gravel	7	7
Sand	25	20
Tight sand, including cemented sand	18	15
Gravel, including gravel and sand	21	18
Tight gravel, including cemented gravel	14	13

Selection of Specific Yield Values

Review by the Referee of the results of prior investigations and consultation with the Engineering Advisory Committee resulted in an agreement to base the specific yield values on data presented in Bulletin 45, South Coastal Basin Investigation,[1] and the work sheets used in preparation of that bulletin. The specific yield values so selected by the Referee are shown in Table D-9 and are based on results of the Bulletin 45 investigation with the following modifications:

Ground water inventories such as developed in Bulletin 12, Ventura County Investigation,[5] utilizing the specific yield values as published in Bulletin 45, have been found to be out of balance with insufficient water going in and out of storage for corresponding fluctuation of the water surface. The lack of balance indicates that the specific yield may be too small.

TABLE D-9

SPECIFIC YIELD VALUES SELECTED FOR USE
IN SAN FERNANDO VALLEY REFERENCE

0 Percent

Hard granite rock
Soil rock

3 Percent

Adobe
Boulders in clay
Cemented clay
Clay
Clay loam
Decomposed shale
Dirt
Granite clay
Hard clay
Hard pan
Hard sandy shale
Hard shell
Muck
Sandy clay loam
Shale
Shaley clay
Shell rock
Soapstone

5 Percent

Cemented sand
Clay and gravel
Clayey sand
Clayey silt
Conglomerate
Decomposed granite
Gravelly clay
Loam
Rotten conglomerate
Rotten granite
Sand rock
Sandstone
Sand and clay
Sandy clay
Sandy silt
Sediment
Shaley gravel
Silt
Silty clay
Silty loam
Soil
Soft sand

10 Percent

Cemented boulders
Cemented gravel
Cemented sand and gravel
Dead gravel
Dead sand
Dirty pack sand
Hard gravel
Hard sand
Heavy rocks
Sandy loam
Soft sandstone
Tight boulders
Tight coarse gravel

14 Percent

Boulders
Broken rocks
Coarse gravel
Cobbles and gravel
Gravel and boulders
Large gravel
Rocks
Sand and gravel, silty
Tight fine gravel
Tight medium gravel

16 Percent

Fine sand
Heaving sand
Quicksand
Sand and boulders
Tight sand

19 Percent

Sand and gravel

21 Percent

Dry gravel
Gravel
Gravelly sand
Loose gravel
Medium gravel
Sand
Water gravel

26 Percent

Coarse sand
Fine gravel
Medium sand

Based on the foregoing indications and the fact that specific yield for fine materials suggested by Bulletin 45 were not supported by experimental data, the Referee has utilized a higher value of three percent for clay as being more appropriate than the value of one percent used in the prior investigation.

The value of sand and gravel, not mentioned in Bulletin 45, was set at 19 percent through a trial and error method. This method consisted of utilizing a series of assumed values for the specific yield of sand and gravel and working out the average specific yield values for well groups identical with those of the work sheets of Bulletin 45, until the average of the reworked groups closely approximated the average specific yield values indicated by the Bulletin 45 studies. During this work it was noted that in numerous places on the Bulletin 45 work sheets pertaining to the San Fernando Valley the value of sand and gravel was arbitrarily assigned a value of 19 percent. Study of these same work sheets also noted that the majority of gravel strata mentioned were reduced from 25 percent specific yield to values of 19, 20 and 22 percent. No explanation of this devaluation was found in the work sheets and the text of the bulletin does not reflect such a change.

The values for medium and coarse sand were reduced from 28 percent to 21 and 26 percent, respectively, since it was felt that a 28 percent value was more applicable to poorly graded or more uniform sediments found in the lower basins of the South Coastal area. The sediments in the lower basins were subject to a better degree of sorting over the longer distance of travel from the source area, while the sediments in the San Fernando Valley area show a better gradation allowing the finer particles to fit between the coarse ones, thus reducing the amount of voids with a resultant decrease in specific yield.

Slichter's classical study of the Theoretical Investigation of the Motion of Ground Water,[10/] points out that when dealing with uniform spheres arranged in a cubic fashion, which is considered loose packing, the porosity is equal to 47.64 percent. When the same spheres are arranged in a rhombohedron in the most compact or tightly packed condition, the porosity is reduced to 25.95 percent. Observation of a great number of samples taken from wells and in deep cuts indicates that well-graded fairly compact materials are the most prevalent in the San Fernando Basin.

During the investigation of storage capacity reported in Bulletin 45, there were 350 samples procured and analyzed primarily from shallow surface pits; about 29 of these were obtained in the San Fernando Valley. Mean specific yield was determined at 34 well groups from about 200 well logs. Data gathered for the present investigation comprise 560 usable well logs which were utilized in 52 well groups or storage units. A comparison of mean specific yield values for three typical well groups computed, using the Bulletin 45 values and the values used in the San Fernando Valley Reference, show very little difference as indicated in Table D-10.

TABLE D-10

COMPARISON OF MEAN SPECIFIC YIELD VALUES
FOR SELECTED WELL GROUPS

Well group	Mean Specific Yield Bulletin 45 Work Sheets in Percent	Mean Specific Yield San Fernando Reference in Percent
3600	5.72	6.57
3800	12.58	12.23
3752	6.70	6.96

It should be noted that in Well Group 3600 the mean specific value increased from 5.72 percent to 6.57 percent. This is due primarily to the increase in specific yield of clay materials from one percent to three percent. A comparision of the specific yield values selected by the Referee with those utilized in other investigations is shown in Table D-11.

TABLE D-11

COMPARISON OF SPECIFIC YIELD VALUES SELECTED BY REFEREE WITH PREVIOUS INVESTIGATIONS

Material	DWR Bulletin 45, 1934	U.S.G.S. WSP 780, 1939	State Water Resources Board Bulletin 1, 1951	DWR Bulletin 12, 1956	DWR Bulletin 57, 1956	State Water Rights Board: Tia Juana, 1956	U.S.G.S. San Joaquin, 1957	DWR Bulletin 18, 1958	Referee San Fernando Valley Reference, 1960
Clay	1	4	3	0	1	1	3	3	3
Silty clay	1	4	3	3	5	5	5	5	5
Clayey sand	5	4	3	5	5	5	5	5	5
Fine sand	16	24	10	25	28	25	10	25	16
Medium sand	28	24	20	25	28	30	25	25	21
Coarse sand	28	34	20	25	28	32	25	25	26
Fine gravel	25	34	25	21	22	26	25	21	26
Medium gravel	20	34	25	21	22	23	25	21	21
Coarse gravel	14	34	25	21	22	18	25	21	14

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APPENDIX E

PRECIPITATION

APPENDIX E

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TABLES

APPENDIX E

PRECIPITATION

Quantities of precipitation on the valley fill and on the hill and mountain areas were evaluated separately. The valley fill area was divided into three sections, referred to as the San Fernando, Sylmar and Verdugo Hydrologic Subareas and the precipitation was evaluated separately for each subarea. Precipitation on the hill and mountain areas was evaluated separately for the watersheds of Big Tujunga, Pacoima Creek and Sycamore Canyon, for which runoff records are available, and for each of 12 subdivisions of the remaining hill and mountain areas (see Appendix F). Each of the latter units is comprised of small watersheds having one or more outlets at the edge of the valley fill.

Precipitation Stations and Records

The 85-year Isohyetal Map of Los Angeles County, prepared by the Los Angeles County Flood Control District for the period 1872-73 through 1956-57, is based on 130 master precipitation stations, of which 37 are within or are immediately adjacent to the Upper Los Angeles River area. Three factors were considered in the selection of master stations; (1) length of record, (2) location and (3) accuracy of record. The minimum length of record of the valley fill stations used was 20 seasons and of the mountain area stations 14 seasons. Master stations were also selected to give representative areal distribution of precipitation on the entire county. The 85-year isohyets, derived from the records of these stations are shown on Plate 9.

The Los Angeles and Pasadena precipitation stations are the only stations that have continuous records for the 85-year period. The records of the other master stations have been extended by the Los Angeles County Flood Control District to 85 years, based on indices of selected longer record stations, taking the stations in descending order of their length of record.

The extended 85-year rainfall of a station was computed by a direct proportion, using the indices of wetness of a known master station for the corresponding years of unknown record at the station being extended. The formula used is as follows:

$$R = \frac{B}{8{,}500 - A} \times 8{,}500$$

where: R = estimated total rainfall for 85-year period at station being extended.

A = sum of indices of wetness of longer record station for unknown period of station being extended.

B = Sum of rainfall for period of record of station being extended.

When more than one station was used to extend a record, the indices of wetness used were either averaged or weighted inversely with respect to the distance of each from the station being extended.

Table E-1 lists 37 of a county-wide total of 130 master stations which are within or adjacent to the Upper Los Angeles River area along with

TABLE E-1

LOS ANGELES COUNTY FLOOD CONTROL DISTRICT MASTER RAINFALL STATIONS
WITHIN OR ADJACENT TO SAN FERNANDO VALLEY

Los Angeles County Flood Control District station number	Name	Period of record	Station used for extension of record[a]
715	Los Angeles	1872-58	
610	Pasadena	1872-58	
32	Newhall-Soledad Division Headquarters	1876-58	Los Angeles
28	San Fernando Lemon Association	1877-58	Los Angeles (0.66)
185	Glendora - west	1880-58	Pasadena
634	Santa Monica - City Hall	1885-58	Los Angeles
394	Highland Park	1897-58	Pasadena (0.36) and Los Angeles (0.15)
179	Sierra Madre	1889-58	Pasadena (0.36) and Glendora (0.15)
261	Acton-Escondido Canyon	1896-58	Average of Pasadena and Newhall
119	Sawtelle - Soldier's Home	1896-58	Average of Los Angeles and Santa Monica City Hall
250	Acton Camp	1879-99 1929-32 1933-37 1938-58	Acton-Escondido Canyon
53[b]	Colby's Ranch	1897-58	Average of Pasadena, Sierra Madre and Haines Canyon - Lower
13[b]	North Hollywood	1906-58	Average of Los Angeles and San Fernando Lemon Association
517	Andersen Ranch	1909-32 1942-58	Valyermo
295[b]	Glendale	1909-58	Average of Los Angeles and Highland Park
478	Valyermo	1911-58	Acton-Escondido Canyon
177	La Canada	1912-58	Pasadena
21[b]	Brant Rancho-Girard	1912-58	Average of Los Angeles and San Fernando Lemon Association
33[b]	Pacoima Dam	1915-58	San Fernando Lemon Association
364[b]	Haines Canyon - Lower	1917-58	Los Angeles (0.17), San Fernando Lemon Association (0.10) and Pasadena (0.19)
373	Briggs Terrace	1915-16 1918-58	Average of La Canada and Haines Canyon - Lower
54[b]	Loomis Ranch - Alder Creek	1917-19 1920-22 1923-58	Colby's Ranch
155	Little Rock Creek	1920-22 1928-58	Average of Valyermo and Acton Camp
25[b]	Northridge-Andrews	1920-58	Average of San Fernando Lemon Association and Brant Ranch
259[b]	Chatsworth Patrol Station	1929-58	Northridge
23[b]	Chatsworth Reservoir	1925-58	Average of Brant Ranch and Northridge
15[b]	Van Nuys - City warehouse	1925-58	Average of North Hollywood and Northridge
46	Big Tujunga Dam	1917-21	Average of Haines Canyon-Lower and Colby's
14[b]	Roscoe-Merrill	1927-58 1927-58	Average of North Hollywood, San Fernando Lemon Association and Pacoima Dam
11	Upper Franklin Reservoir	1927-58	Sawtelle (0.20) and North Hollywood (0.25)
213[b]	Brand Park	1928-58	Glendale
17[b]	Sepulveda Canyon	1928-58	Upper Franklin Reservoir
395	Olive View Sanitorium	1934-58	Average of Pacoima Dam and San Fernando Lemon Association
695	Tujunga Canyon - Vogel Flat	1935-58	Big Tujunga Dam
405	Soledad Canyon-Eckles	1936-58	Average of Acton-Escondido Canyon and Acton Camp
423	Acton-Aliso Canyon	1937-58	Average of Mount Gleason, Acton Camp and Little Rock Creek
419[b]	Santa Clara Ridge Mount Gleason	1937-58	Average of Big Tujunga Dam, Pacoima Dam and Soledad Canyon

The following stations used by the Referee as controlling stations are not Master Rainfall Stations, as designated by the Los Angeles County Flood Control District, but the 85-year mean precipitation was computed for each by the District for use in deriving the 55-year Isohyetal Map.

12[b]	Franklin Canyon	1927-58	Sawtelle (0.17) and North Hollywood (0.33)
29[b]	Granada Pump Plant	1927-58	Average of San Fernando Lemon Association and Chatsworth Patrol Station
30[b]	Sylmar	1919-58	Average of San Fernando Lemon Association and Olive View Sanitorium
47[b]	Clear Creek-City School	1927-58	Big Tujunga Dam
251[b]	La Crescenta	1929-58	Briggs Terrace
470[b]	Tujunga-Mill Creek	1941-58	Average of Loomis Ranch and Acton-Aliso Canyon
705[b]	Alder Creek-Paradise Ranch	1942-58	Average of Loomis Ranch and Acton-Aliso Canyon

a. Numbers in parenthesis are weighted coefficients used by Los Angeles County Flood Control District to determine indices of wetness for the unknown record of the station.

b. Controlling stations used by the Referee in computing quantities of precipitation.

the stations which were used to extend the record of the master stations. Seven additional stations, utilized by the Referee in computing the annual amounts of precipitation, are also listed in Table E-1 along with the master stations of the Los Angeles County Flood Control District heretofore mentioned.

In computing mean annual precipitation for the Upper Los Angeles River area, 22 precipitation stations, all located within the watershed, were utilized in conjunction with the 85-year isohyets of the Los Angeles County Flood Control District. These stations are identified in Table E-1 and their locations shown on Plate 9. These stations were selected to reflect areal distribution as well as representative depth of precipitation. The minimum length of record for stations on the valley fill was 29 seasons (through 1957-58) and 16 seasons (through 1957-58) in the hill and mountain areas. Table E-2 gives the elevation, period of record, 85-year mean precipitation, and the recorded maximum and minimum precipitation of the 22 stations utilized.

Quantity of Precipitation

In computing the 85-year mean seasonal precipitation, the Isohyetal Method was used within polygons of a Thiessen network. The Thiessen network determined the area of influence of each controlling station and was used to facilitate annual precipitation computations. It was constructed by locating the stations on a map and drawing the perpendicular bisectors to the lines connecting the stations. The polygons thus formed around each station are the boundaries of the area considered controlled by its station

TABLE E-2

MEAN, MAXIMUM AND MINIMUM SEASONAL PRECIPITATION
OF CONTROLLING STATIONS USED BY THE REFEREE

Los Angeles County Flood Control District station number	Station name	Elevation, in feet[a]	Period of record	Computed [illegible]-year mean seasonal precipitation, in inches	Recorded maximum and minimum	
					Season	Inches
12	Franklin Canyon	1,100	1927-28 1957-58	18.71	1940-41 1947-48	46.15 8.85
13	North Hollywood	593	1906-07 1957-58	16.90	1940-41 1947-48	39.68 7.40
14	Roscoe-Morrill	1,050	1927-28 1957-58	14.61	1940-41 1947-48	35.99 7.25
15	Van Nuys Warehouse	675	1925-26 1957-58	15.20	1940-41 1950-51	39.77 7.07
17	Sepulveda Canyon	1,425	1928-29 1957-58	19.22	1940-41 1947-48	47.9[illegible] 8.36
21	Brant Ranch-Girard	891	1912-13 1957-58	14.38	1940-41 1947-48	36.29 6.57
23	Chatsworth Reservoir	865	1925-26 1957-58	14.12	1940-41 1947-48	36.65 6.68
25	Northridge-Andrews	795	1920-21 1957-58	14.59	1940-41 1923-24	38.34 6.69
29	Granada Pump Plant	1,150	1927-28 1957-58	17.10	1940-41 1948-49	40.55 6.47
30	Sylmar	1,250	1919-20 1957-58	16.70	1940-41 1948-49	38.77 8.17
33	Pacoima Dam	1,500	1915-16 1957-58	18.94	1940-41 1947-48	40.41 9.46
47	Clear Creek-City School	3,200	1927-28 1957-58	32.41	1940-41 1950-51	61.72 10.53
53	Colby's Ranch	3,675	1897-98 1957-58	30.13	1921-22 1898-99	51.75 [illegible].13
54	Loomis Ranch - Alder Creek	4,320	1917-18 1957-58	20.90	1940-41 1950-51	40.5[illegible] 8.75
210	Brand Park	1,250	1928-29 1957-58	19.15	1940-41 1947-48 1950-51	43.[illegible]6 8.91 8.91
251	La Crescenta	1,565	1929-30 1957-58	23.64	1940-41 1947-48	48.14 10.62
259	Chatsworth Patrol	1,254	1929-30 1957-58	17.77	1940-41 1948-49	42.02 8.77
295	Glendale	530	1917-18 1957-58	17.93	1940-41 1923-24	41.63 8.04
364	Haines Canyon-Lower	2,450	1917-18 1957-58	24.30	1940-41 1947-48	53.07 11.12
419	Santa Clara Ridge-Mount Gleason	5,450	1937-38 1957-58	24.48	1940-41 1950-51	52.98 10.15
470	Tujunga-Mill Creek	4,600	1941-42 1957-58	17.63	1951-52 1950-51	28.99 8.00
705	Alder Creek-Paradise Ranch	2,330	1942-43 1957-58	20.70	1951-52 1950-51	35.55 10.26

a. As of September 1958.

because any point in such a polygon is closer to the controlling station than to any other station.

The 85-year mean seasonal isohyets were superimposed on the Thiessen network and the Isohyetal Method was then applied to each polygon in computing the mean seasonal precipitation. The area between successive isohyets in each polygon was determined with a planimeter. The areas of each subarea or watershed were kept separate and designated by station number and letter when more than one existed within the polygon. The area in acres between two isohyets multiplied by their weighted precipitation in feet gave the quantity of mean precipitation on the area between the two isohyets in acre-feet. The weighted value used was the average of the boundary isohyets except in the few instances where the area was controlled by the previously noted arbitrary boundaries. The summation of all these increments within a polygon or portion thereof was taken as the 85-year mean seasonal precipitation in the polygon or portion thereof. The area and mean seasonal precipitation of each polygon are presented in Table E-3 and of each hydrologic subarea and drainage unit in Table E-4.

The precipitation for a specific season in a polygon was computed by multiplying the 85-year mean seasonal precipitation of the polygon or a portion of the polygon by the index of wetness of the controlling station for the specific year. The indices of wetness for each controlling station are presented in Table E-5. To arrive at the annual precipitation in subareas of the valley fill and in hill and mountain watersheds, the precipitation in the appropriate polygons or portion of polygons were

TABLE E-3

85-YEAR MEAN PRECIPITATION BY THEISSEN POLYGONS

L.A.C.F.C.D. number for controlling station in polygon	85-year mean precipitation, in acre-feet	Area, in acres	Precipitation by polygon		L.A.C.F.C.D. 85-year mean precipitation, in inches
			Feet	Inches	
12	6,452	4,238	1.52	18.27	18.71
13	17,562	12,720	1.38	16.57	16.90
14	32,155	24,110	1.33	16.00	14.61
15	29,083	22,262	1.31	15.68	15.20
17	9,593	6,231	1.54	18.47	19.22
21	32,774	24,462	1.34	16.08	14.38
23	12,281	10,331	1.19	14.26	14.12
25	30,126	23,609	1.28	15.31	14.59
29	10,619	6,673	1.59	19.10	17.10
30	28,691	19,455	1.47	17.70	16.70
33	23,934	14,812	1.62	19.39	18.94
47	31,403	12,852	2.44	29.32	32.41
53	36,388	15,726	2.31	27.77	30.13
54	38,096	17,925	2.13	25.50	20.90
210	14,763	9,021	1.64	19.64	19.15
251	11,086	5,709	1.94	23.30	23.64
259	21,898	13,898	1.58	18.91	17.77
295	35,534	24,559	1.45	17.36	17.93
364	27,867	13,791	2.02	24.25	24.30
419	37,448	16,616	2.25	27.04	24.48
470	13,378	7,694	1.74	20.86	17.63
705	43,715	22,443	1.95	23.37	20.70
TOTAL	544,846	329,137			

TABLE E-4

85-YEAR MEAN PRECIPITATION
BY SUBAREAS AND DRAINAGE UNITS

Unit	Area, in acres	85-year mean precipitation, in acre-feet
Hydrologic Subarea		
San Fernando and Eagle Rock	112,854	149,884
Sylmar	5,565	8,149
Verdugo[a]	5,009	9,706
Subtotal	123,428	167,739
Drainage Unit[b]		
Lower Tujunga	21,833	37,085
Big Tujunga	68,111	151,059
Pacoima	18,090	38,714
Unit I	19,238	28,520
Unit II	6,446	9,336
Unit III	17,594	23,573
Unit IV	17,582	27,892
Unit V	5,873	10,639
Unit VI	1,786	2,587
Haines Canyon	971	2,115
Sycamore Canyon	1,733	2,890
Unit VII	13,104	19,042
Unit VIII	4,928	7,057
Unit IX	1,391	2,418
Unit X	7,029	14,180
Subtotal	205,709	377,107
TOTAL	329,137	544,846

a. Includes precipitation on the portion of Monk Hill Basin within the Upper Los Angeles River Area.
b. See Appendix F for description of drainage units.

TABLE E-5

ANNUAL PERCENT OF 85-YEAR MEAN PRECIPITATION
OF CONTROLLING STATIONS

Year	Los Angeles County Flood Control District number										
	17 Franklin Canyon	13 North Hollywood	14 Roscoe-Merrill	15 Van Nuys	17 Sepulveda Canyon	21 Brant. Ranch	23 Chatsworth Reservoir	25 Northridge-Andrews	29 Granada pump plant	30 Sylmar	33 Pacoima Dam
1928-29	60	67	69	68	79	70	79	75	79	81	69
29-30	62	71	69	73	71	76	78	78	82	90	82
1930-31	96	90	93	102	101	95	101	91	94	101	97
31-32	123	120	135	126	129	120	119	123	128	126	128
32-33	87	91	84	88	84	72	78	72	69	76	82
33-34	105	115	81	84	100	67	90	81	86	88	87
34-35	127	130	126	119	117	115	135	125	119	125	133
1935-36	82	72	70	65	86	78	87	83	86	92	94
36-37	153	141	144	144	153	150	161	114	116	152	155
37-38	171	163	147	157	176	152	154	151	142	149	172
38-39	117	121	131	136	137	136	118	142	130	135	116
39-40	93	94	110	104	97	110	105	111	104	104	96
1940-41	247	236	246	261	250	252	260	263	237	232	213
41-42	85	83	90	87	77	86	80	80	78	79	77
42-43	153	151	157	159	161	148	145	155	149	153	160
43-44	133	129	165	154	135	164	162	172	145	147	148
44-45	86	75	95	74	83	95	92	93	87	92	97
1945-46	83	78	87	81	88	86	87	85	85	89	89
46-47	95	80	103	93	85	82	89	.87	88	99	110
47-48	47	44	50	51	43	46	47	47	50	49	50
48-49	53	45	56	47	53	47	50	47	54	59	63
49-50	65	59	60	57	65	66	78	69	78	80	74
1950-51	56	50	53	47	44	51	65	57	69	67	62
51-52	189	192	180	188	194	187	194	192	186	197	193
52-53	76	61	68	73	71	74	84	79	80	80	69
53-54	83	78	76	81	89	83	94	85	86	87	84
54-55	76	84	85	89	78	90	93	88	84	84	76
1955-56	97	96	93	94	84	115	114	111	119	121	94
56-57	70	76	84	79	76	73	88	83	83	83	83
57-58	146	141	151	156	153	204	212	190	194	184	161
29-year TOTAL	2,990	2,895	3,007	2,981	3,006	2,986	3,127	3,069	3,023	3,117	3,053
29-Year Average 1929-57	103.1	99.8	103.7	102.8	103.7	103.0	107.8	105.8	104.2	107.5	105.3

ANNUAL PERCENT OF 85-YEAR MEAN PRECIPITATION
OF CONTROLLING STATIONS
(continued)

Year	Los Angeles County Flood Control District number										
	47 Clear Creek-City School	53 Colby's Ranch	54 Loomis Ranch-Alder Creek	210 Brand Park	251 La Crescenta	259 Chatsworth Patrol	295 Glendale	364 Haines Canyon-Lower	419 Santa Clara Ridge	470 Tujunga-Mill Creek	705 Alder Creek-Paradise Ranch
1928-29	65	58	63	82	75[a]	78[b]	82	69	65[c]	65[c]	65[c]
29-30	66	63	86	65	67	81	67	66	73[c]	73[c]	73[c]
1930-31	77	61	80	87	74	89	66	75	78[c]	78[c]	78[c]
31-32	102	102	109	115	114	134	117	121	112[c]	112[c]	112[c]
32-33	85	55	66	78	76	70	76	90	76[c]	76[c]	76[c]
33-34	75	69	56	105	105	98	110	82	74[c]	74[c]	74[c]
34-35	120	121	116	128	129	132	116	120	122[c]	122[c]	122[c]
1935-36	83	61	58	81	82	84	83	70	73[c]	73[c]	73[c]
36-37	151	135	139	139	145	159	134	143	145[c]	145[c]	145[c]
37-38	158	137	155	150	174	160	148	155	193	155[c]	155[c]
38-39	98	91	108	117	112	105	114	114	109	105[c]	105[c]
39-40	73	63	73	81	88	99	83	84	94	78[c]	78[c]
1940-41	190	185	194	229	204	236	232	218	216	200[c]	200[c]
41-42	60	67	72	77	74	72	71	71	81	84	69[a]
42-43	152	165	165	145	178	167	137	164	162	141	148
43-44	121	137	147	122	124	140	125	150	175	154	154
44-45	80	94	96	89	102	98	86	85	106	102	98
1945-46	90	89	94	78	83	90	82	95	110	88	88
46-47	107	93	103	94	102	87	98	112	121	94	99
47-48	48	47	57	47	45	49	47	46	59	58	52
48-49	65	45	49	50	61	57	53	61	65	67	59
49-50	64	62	53	55	77	79	67	72	61	55	69
1950-51	32	34	42	47	50	63	48	48	41	45	50
51-52	162	153	143	191	177	185	186	183	151	164	172
52-53	49	43	55	70	57	83	61	56	48	64	55
53-54	85	76	70	76	95	92	79	75	83	79	78
54-55	65	62	65	78	73	88	79	79	60	79	76
1955-56	79	62	64	87	93	113	95	86	75	77	84
56-57	71	64	60	74	75	83	77	79	58	66	70
57-58	167	156	142	146	152	202	141	165	148	144	150
29-year TOTAL	2,673	2,494	2,638	2,837	2,911	3,071	2,839	2,869	2,886	2,773	2,776
29-Year Average 1929-57	92.2	86.0	91.0	97.8	100.4	105.9	97.9	98.9	99.5	95.6	95.7

a. Average index of Stations 14, 30, 33 and 295.
b. Average index of Stations 23, 25 and 29.
c. Average index of Stations 33, 47, 53, 54 and 364.

totaled. The annual amounts of precipitation derived in this manner are tabulated by year in Chapter IV of this report. Percent of normal precipitation on the valley fill, hill and mountain areas and entire watershed for each year of the base period are also shown in Chapter IV.

Monthly precipitation was computed only for the San Fernando, Sylmar and Verdugo Hydrologic Subareas on the valley fill and shown in Table E-6. The product of the monthly recorded precipitation in percent of the seasonal record at each controlling station and the annual precipitation in its respective polygon, resulted in the monthly precipitation used for each polygon. The monthly amounts of precipitation in each polygon were totaled by subareas and converted to average depths of monthly precipitation in inches.

TABLE E-6

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	San Fernando and Eagle Rock Subareas								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.3	1.6	2.2	1.7	1.8	1.6	1.9	0.6	11.7
29-30	0.1	0	0	5.6	0.7	4.3	0.1	1.2	12.0
1930-31	0.2	2.0	0.2	3.6	5.0	0.3	2.6	1.1	15.0
31-32	0.2	2.7	6.1	2.1	7.5	0.1	0.7	0.4	19.8
32-33	0.2	0	1.3	9.8	0.4	0.1	0.5	0.6	12.9
33-34	0.2	0.2	4.8	6.0	2.3	0.2	0	0.5	14.2
34-35	1.6	2.4	4.6	3.3	1.8	3.4	2.1	0.4	19.6
1935-36	0.2	1.2	0.3	0.6	7.5	1.3	0.9	0.1	12.1
36-37	1.5	0.3	6.8	3.0	6.2	4.6	0.3	0.2	22.9
37-38	0	0	3.2	1.2	8.7	10.3	0.8	0.3	24.5
38-39	0.1	0	9.5	3.6	1.2	1.5	0.3	5.0	21.2
39-40	0.1	0.2	0.7	6.0	6.2	1.5	1.7	0.2	16.6
1940-41	1.3	0.3	8.2	2.7	12.7	10.0	3.8	0.6	39.6
41-42	1.8	0.1	5.2	0.6	1.0	1.3	2.4	0.7	13.1
42-43	1.0	0.3	1.2	13.1	3.5	4.5	0.9	0	24.5
43-44	0.3	0.2	8.1	0.9	11.1	3.0	0.7	0.3	24.6
44-45	0.1	4.8	0.7	0.5	4.1	3.4	0.2	0.1	13.9
45-46	0.6	0.6	5.7	0.3	1.4	3.8	0.9	0.2	13.5
46-47	0.7	7.5	3.9	0.5	0.4	1.2	0.3	0.2	14.8
47-48	0.1	0	1.7	0	1.4	3.1	0.7	0.5	7.5
48-49	0.2	0	2.8	2.2	1.0	1.2	0	0.7	8.1
49-50	0	1.1	2.8	2.6	1.8	0.8	0.9	0.5	10.5
1950-51	0.3	1.5	0.1	3.1	1.1	0.6	1.3	0.6	8.6
51-52	0.6	1.4	5.6	12.2	0.3	8.2	1.7	0.1	30.1
52-53	0	4.3	4.0	1.3	0	0.4	1.3	0.3	11.6
53-54	0	1.2	0.2	4.9	2.9	3.2	0.7	0	13.1
54-55	0	1.7	1.2	4.8	1.2	0.9	1.7	2.4	13.9
1955-56	0	1.4	1.9	6.9	1.0	0	3.9	1.2	16.3
56-57	0.3	0	0.1	6.3	2.0	1.6	1.2	1.2	12.7
57-58	1.9	0.5	4.9	1.8	7.4	5.3	4.4	0.4	26.6

TABLE E-6
(continued)

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	Sylmar Subarea								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.4	1.9	2.6	1.9	2.1	1.6	2.3	0.6	13.4
29-30	0.1	0	0	6.7	1.1	5.3	0.6	1.4	15.2
1930-31	0.8	2.9	0.5	4.1	5.4	0	2.4	1.3	17.4
31-32	0.2	3.0	6.4	2.6	7.9	0.3	1.4	0.4	22.2
32-33	0.1	0	1.5	9.6	0.4	0.3	0.8	1.1	13.8
33-34	0.2	0.6	7.6	3.3	2.7	0.2	0	0.9	15.5
34-35	2.1	2.6	6.0	3.5	2.0	3.7	2.2	0.4	22.5
1935-36	0.5	1.2	0.3	0.9	10.6	1.9	0.9	0.1	16.4
36-37	1.6	0.3	7.5	3.8	7.6	4.8	0.6	0.6	26.8
37-38	0	0	4.7	1.6	9.1	10.2	1.4	0.8	27.8
38-39	0.2	0	11.3	3.8	1.4	1.7	0.3	3.5	22.2
39-40	0.2	0.2	1.0	6.6	6.1	1.5	2.2	0.1	17.9
1940-41	1.4	0.2	7.6	3.4	12.7	9.3	4.2	0.7	39.5
41-42	1.9	0.1	5.2	0.8	0.9	1.1	3.0	0.7	13.7
42-43	1.1	0.9	1.2	13.7	4.3	5.3	1.0	0	27.5
43-44	0.2	0.3	7.5	1.4	10.9	4.0	1.0	0.5	25.8
44-45	0.4	4.7	1.1	0.2	5.1	4.1	0.4	0.6	16.6
1945-46	0.8	1.0	6.4	0.3	1.3	4.8	0.9	0.3	15.8
46-47	1.6	7.8	5.3	0.6	0.2	1.4	0.6	0.5	18.0
47-48	0.3	0	1.6	0	1.6	3.3	1.5	0.5	8.8
48-49	0.2	0	3.1	2.8	1.5	1.6	0.1	1.5	10.8
49-50	0	1.9	3.3	2.9	2.4	1.1	1.1	1.0	13.7
1950-51	0.7	1.9	0.2	4.3	0.9	0.7	1.9	0.8	11.4
51-52	0.7	2.0	7.8	12.0	0.5	8.8	2.2	0.3	34.3
52-53	0	4.4	3.9	1.8	0.2	0.9	1.8	0.3	13.3
53-54	0	1.0	0.2	6.4	2.7	3.8	0.9	0.1	15.1
54-55	0	1.6	1.3	4.3	1.4	0.8	2.1	2.8	14.3
1955-56	0	1.9	2.7	7.5	1.3	0	4.7	1.3	19.4
56-57	0.7	0	0.2	6.3	1.9	2.4	1.3	1.9	14.7
57-58	2.3	0.6	6.0	2.4	7.6	5.9	5.5	0.4	30.7

TABLE E-6
(continued)

MONTHLY PRECIPITATION ON VALLEY FILL AREA

In Inches

Year	Verdugo Subarea[a]								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May through Sept.	Total
1928-29	0.7	2.3	3.4	2.5	2.6	2.6	2.7	0.7	17.5
29-30	0.1	0	0	6.1	0.7	5.1	0.3	3.2	15.5
1930-31	0.1	2.9	0.2	3.9	4.8	0	4.0	1.5	17.4
31-32	0.3	3.3	7.9	1.9	11.3	0	1.4	0.4	26.5
32-33	0.1	0	1.7	13.5	0.4	0.2	0.6	1.2	17.7
33-34	0.2	0.7	11.5	7.5	3.7	0.3	0.1	0.5	24.5
34-35	2.4	2.9	7.2	4.7	3.4	4.0	4.0	1.2	29.8
1935-36	0.5	1.5	0.3	0.7	12.5	2.1	1.2	0.2	19.0
36-37	2.4	0.5	10.3	4.4	8.6	6.4	0.3	0.5	33.4
37-38	0	0	4.9	1.9	13.9	16.9	1.6	0.8	40.0
38-39	0.3	0	9.8	4.4	1.3	3.0	0.5	6.8	26.1
39-40	0.3	0.2	1.0	6.7	7.9	1.8	2.4	0.2	20.5
1940-41	1.7	0.7	6.6	3.2	17.2	11.7	6.0	0.8	47.9
41-42	2.7	0.1	6.6	0.3	1.7	1.6	3.0	1.2	17.2
42-43	1.2	0.5	1.3	23.7	6.1	7.1	1.0	0	40.9
43-44	0.2	0.1	8.4	1.0	13.5	3.8	1.0	0.8	28.8
44-45	0	8.0	1.8	0	7.5	5.1	0.5	0.5	23.4
1945-46	0.6	0.7	9.0	0.2	2.2	5.5	0.9	0.3	19.4
46-47	2.5	10.4	6.4	0.8	0.6	1.9	0.3	0.8	23.7
47-48	0	0	2.3	0	2.2	4.1	1.6	0.3	10.5
48-49	0.4	0	3.6	3.5	2.2	2.7	0.1	1.7	14.2
49-50	0.2	3.1	4.5	3.3	2.6	1.8	1.1	1.1	17.7
1950-51	0.5	2.0	0	3.8	1.7	0.8	2.2	0.7	11.7
51-52	1.5	2.1	8.2	16.2	0.9	9.1	2.8	0.5	41.3
52-53	0	4.2	4.6	1.5	0.1	1.2	1.3	0.3	8.6
53-54	0	1.4	0.3	9.1	5.0	5.1	0.8	0.1	21.8
54-55	0	2.0	1.4	6.0	1.2	1.2	2.9	2.3	17.0
1955-56	0	1.6	1.9	10.3	1.3	0	4.9	1.6	21.6
56-57	0.6	0	0.2	7.1	3.2	1.5	1.6	3.2	17.4
57-58	2.6	0.8	5.8	3.1	9.6	6.7	6.1	0.4	35.1

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