Riverside County Flood Control
and Water Conservation District

HYDROLOGY MANUAL

April 1978

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ACKNOWLEDGEMENTS

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Grateful acknowledgment is also extended to the many other individuals too numerous to name who provided invaluable assistance in the development of this Manual.

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SECTION A

INTRODUCTION

INTRODUCTION

Purpose and Scope - The purpose of this manual is to document design hydrology methods and criteria currently used by the Riverside County Flood Control and Water Conservation District (District). The District covers an area of 2,736 square miles, comprising essentially the western one-half of Riverside County as shown on Plate A-l.

The materials contained in this manual are intended for the use of both District personnel and engineers submitting hydrologic computations to the District. The methods presented are considered applicable to the hydrologic design of underground storm drains, open channels, retention basins, dams and debris basins, as well as subdivision review and flood plain mapping.

Runoff Determination Methods - The two primary methods used by the District to determine design discharges are the Rational method and the Synthetic Unit Hydrograph method. Before attempting to use these methods it is essential that the engineer become thoroughly familiar with the rainfall and infiltration material in Sections B and C of this report.

The Rational method is generally intended for use on small watersheds of less than 300 to 500-acres while the Synthetic Unit Hydrograph method is intended for use on watersheds in excess of these limits. These methods are discussed in detail in Sections D and E, respectively of this report.

Debris Determination Methods - Little observational data is available for debris production on watersheds in the District, however, several methods of estimating debris production have been developed for San Gabriel Mountain watersheds. These methods and their applicability to the District are discussed briefly in Section F of this report.

Adequacy of Estimates - In studies of larger watersheds a review should always be made of available stream flow records. Comparisons should be made between flows developed by the methods in this manual, and frequency analysis of recorded and historical discharges. Where sufficient rainfall and runoff records are available it is desirable to test the model developed by the Synthetic Unit Hydrograph method by reproducing hydrographs resulting from major flood events.

Discharges computed by experienced engineers, using the methods outlined in this report, are considered to be reasonable for design of hydraulic structures in the District. All hydrology submittals to the District are subject to review, and the District's judgment regarding design discharges must be considered final.

Flood Protection Levels and Criteria -

Development Criteria - Since 1955, the Riverside County Subdivision Ordinance (Number 460) has required protection of all new subdivisions from the 100-year flood event. More recently, the National Flood Insurance Program has adopted this protection level nationally, and most financial institutions are now required by Federal regulations to enforce this criteria. It is District policy to recommend 100-year flood protection for all dwelling units, including those not covered under Ordinance Number 460, such as mobile home developments. A brief overview of general District policy with respect to flood protection levels is summarized and illustrated on Plate A-2.

Dams and Reservoirs - The District receives numerous inquiries with respect to the construction of dams or storage reservoirs. The District has no authority to approve or disapprove construction of dams built by others, except through its limited advisory role on those facilities required within new developments. Dams which exceed certain height or storage criteria fall under the jurisdiction of the State Division of Safety of Dams. Dams which do not fall into this category are controlled only by the Riverside County Subdivision or Grading Ordinances, and permits for their construction are obtained through the Riverside County Department of Building and Safety. These criteria are illustrated on Plate A-3, along with appropriate excerpts from the 1970 California Administrative Code. Any persons or agency contemplating construction of a dam of any sort should secure the services of a competent professional engineer to prepare the design, and should also contact the State Division of Safety of Dams to ensure these statutes have not been revised.

Spillway hydrology submittals for dams under State jurisdiction are subject to review by the State's Dam Safety Division. The State does not specify storage capacity or the degree of protection required for the dam, however, it typically rejects spillway designs believed to be inadequate. The District's experience indicates that the minimum spillway design flood acceptable to the State is the 1,000-year flood routed through the reservoir, while the most severe requirement would be the probable maximum flood. In either case, the reservoir is assumed full to spillway crest at the beginning of the storm. The design flood acceptable to the State typically lies between these two extremes depending on the degree of risk or damage anticipated if failure of the structure should occur.

An enveloping curve of historical and recorded peak discharges can be a valuable tool in evaluating the adequacy of spillway design discharges. Enveloping curves of peak discharges for the Southern California area are shown on Plate A-4.

Physiographic Characteristics -

Topography - The District encompasses portions of three major river basins: the Santa Ana, the Santa Margarita and the Whitewater. The entire San Jacinto River Basin, a 768 square mile tributary of the Santa Ana River, is located within District boundaries. The San Jacinto River is regulated by natural storage in Lake Elsinore, and rarely contributes flow to the Santa Ana River, the last occurrence being in 1916. The boundaries of these basins are shown on Plate A-l.

Major topographic features in the area include the Santa Ana, San Jacinto, San Bernardino and Little San Bernardino Mountains. The Santa Ana Mountain range trends southeasterly along the western border of Riverside County, and has a maximum elevation of 5,687 feet at Santiago Peak. The Santa Anas form a barrier between the Pacific Ocean and the inland valleys of Riverside County. The major orographic barrier in the region lies approximately 50 miles to the east. It is comprised of the San Bernardino and San Jacinto Mountain ranges, which also trend southeasterly across Riverside County with maximum elevations of 10,804 feet at San Jacinto Peak and 11,502 feet at San Gorgonio Mountain. The San Gorgonio Pass near the northerly boundary of Riverside County constitutes a major breach of this barrier with elevations dropping to about 2,600 feet.

Between the Santa Ana and the San Bernardino-San Jacinto barriers, lies an area of broken topography including valleys, plateaus and minor mountain ranges.

Easterly of the San Jacinto-San Bernardino barrier lies the desert regions of the District. To the northeast is the upper Coachella Valley and beyond it, in the extreme northeasterly portion of the District, are the Little San Bernardino Mountains. Elevations in this region of the District range from below 500 feet to a maximum of 5,575 feet. The topographic features discussed above are shown on Plate A-l.

<u>Geology and Soils</u> - The extremely varied topography in the region is a result of extensive fault systems crossing the area and erosive weathering. The mountain ranges are essentially a product of this faulting and run roughly parallel to one another, and to the largest fault zones. The three major fault zones are the Elsinore, San Jacinto and San Andreas. The Elsinore fault parallels the northeasterly toe of the Santa Ana Mountains, while the San Jacinto and San

Andreas faults lie at the southwesterly toe of the San Jacinto and Little San Bernardino Mountains, respectively.

In mountainous areas soil depths are extremely shallow, and on many of the steepest slopes soil cover is virtually non-existent with bedrock exposed. Infiltration capacity is extremely limited in such areas. In the valley areas alluvial soils predominate, but extreme variations do exist in the depth and nature of the alluvial deposits. In general, the alluvial cones or fans near canyon mouths are coarse and extremely porous. The materials further downstream tend to become finer and less porous with distance from the source. Some valley areas have extremely low infiltration rates due to high clay content in the alluvium.

<u>Land Use</u> - Historically the inland valleys have been devoted primarily to agriculture. Over the past decade, however, urbanization has steadily increased, and development is now taking place at unprecedented rates in many areas of the county. A wide variety of agricultural cover still exists including citrus, fruit and nut orchards; row crops such as sugar beets and potatoes; and both irrigated and dry pastureland. Pastureland is the predominate cover in the inland valley areas.

In the desert regions of the District virtually no agriculture has ever existed. This is due to the lack of a suitable water supply, soil type and the extreme winds which occur in the area. Rapid urbanization is taking place in some portions of the desert, especially in the Palm Springs and Desert Hot Springs areas.

Most of the mountainous regions of the District lie either in the Cleveland or San Bernardino National Forests. A woodland cover of pines and other conifers occurs in these mountains above elevations of 4,000 feet. Mingled with the conifers but extending to lower points on the slopes are live oaks and walnuts. Sycamores, birches, maples, willows and cottonwoods are found in the sheltered areas where sufficient moisture is available. Chaparral and grasses are the predominate cover on the lower slopes of the mountains, and also in the foothill regions.

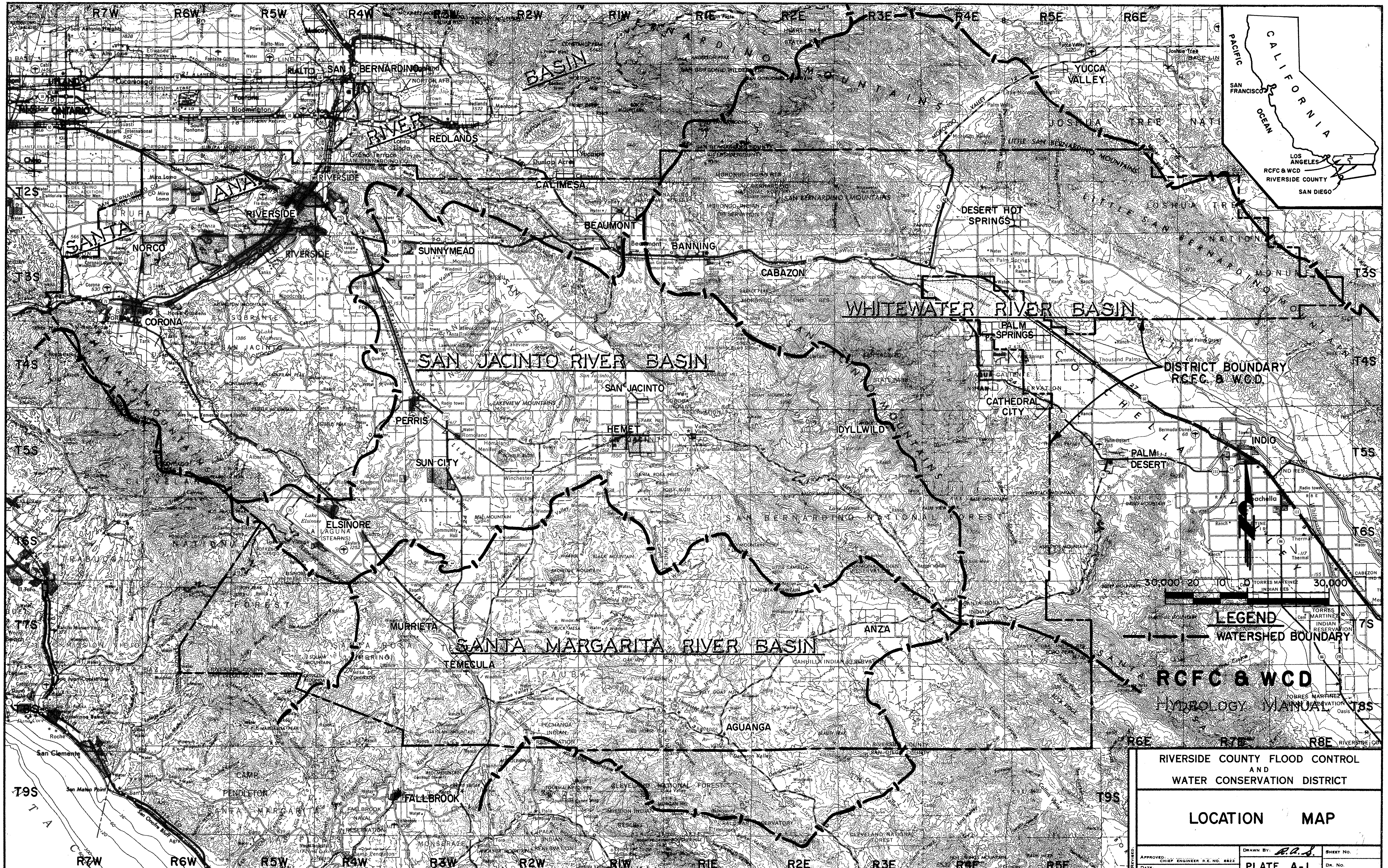
Hydrometeorological Characteristics - Climate in the District varies from humid to arid, according to elevation and distance from the ocean. The inland valley and desert areas are extremely hot and dry during summer months, with moderate temperatures occurring during winter. This contrasts with the mountainous areas where temperatures are moderate during the summer months and low during the winter. Snow commonly occurs in the upper reaches of the San Bernardino and San Jacinto Mountains in winter. Some snow usually remains well into the spring months, and often remains until early summer at higher elevations. Mean seasonal precipitation ranges from a low of three inches in the eastern desert regions to highs of thirty-five to forty inches in the San Bernardino and San Jacinto Mountains.

The three types of storms which can occur over the District are general winter storms, general summer storms and high intensity thunderstorms. Most precipitation results from the general winter storms which normally occur in the late fall or winter months and may have durations of several days. General winter storms occur when, as the result of extratropical cyclones, warm moisture laden Pacific air masses move inland over Southern California. Orographic lifting and cooling of the air masses results in increasing precipitation as they move eastward over the coastal plain and Santa Ana Mountains. Precipitation rates decrease over the inland valleys, but as the air masses are subjected to more extensive lifting upon rising over the major interior mountain ranges high rates of precipitation occur. As the storm continues eastward beyond the mountains little moisture remains and precipitation decreases rapidly over the desert areas.

Although most precipitation over the District results from general winter storms, thunderstorms can occur at any time of the year causing extremely high rates of precipitation for relatively short durations. Thunderstorms can occur either during general storms or as an isolated phenomena, but are most common from July through September when moist unstable air subject to convective lifting may cover the Southern California area.

General summer storms, although rare, occur normally in the months from July through September and result from an influx of tropical, moisture-laden air originating over the Gulf of Mexico or the South Pacific Ocean. Although these type storms are uncommon, they can result in heavy precipitation and have durations of several days.

Streamflow Characteristics - Streamflow is intermittent on foothill and valley streams in the District, although perennial flow occurs on many mountain area tributaries. During major storms, after initial wetting, periods of intense rainfall result in rapid increases of stream flow in steep foothill and mountainous areas. Flood flows collecting in unimproved valley watercourses often exceed the natural channel capacity and flow overland causes major flood damage in many urban and agricultural regions. Debris laden flows discharging from mountain watersheds onto alluvial cones are especially dangerous as they may follow a new course in each storm or even change course during a major storm.

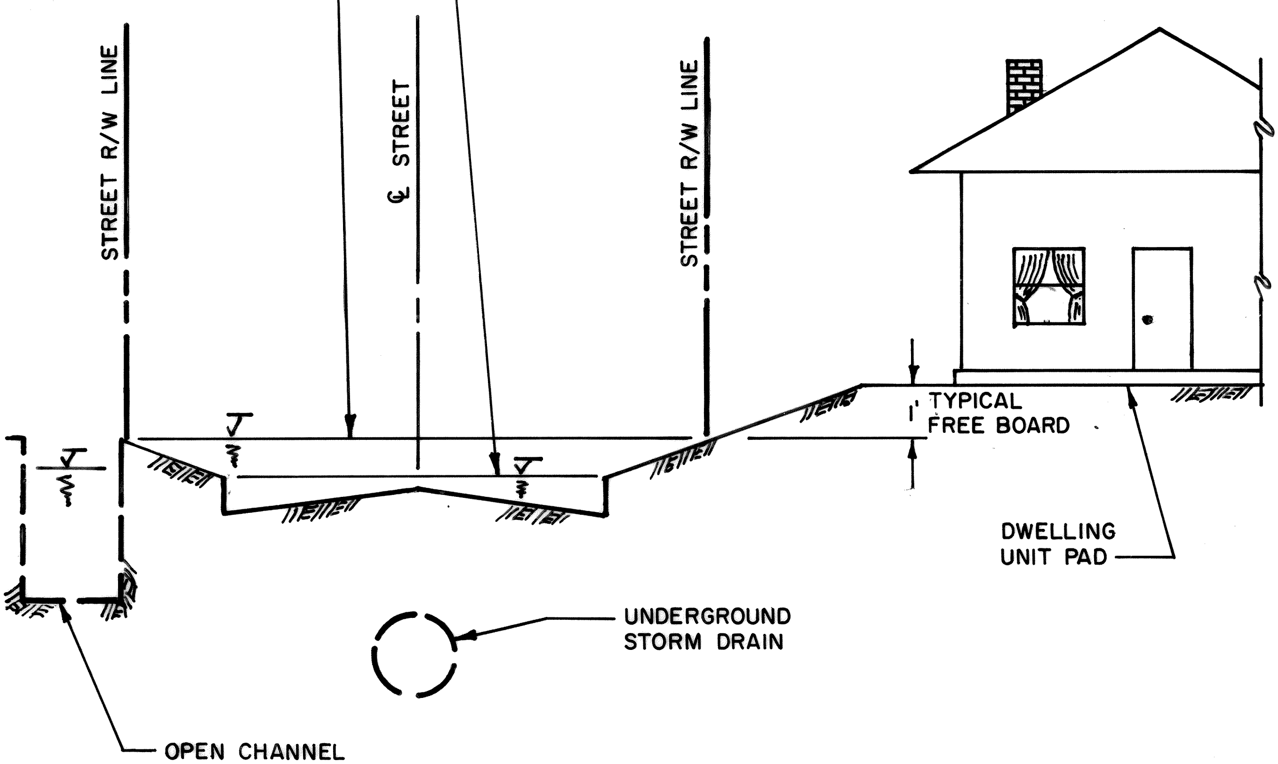


SAN JACINTO RIVER BASIN
WHITEWATER RIVER BASIN
SANTA MARGARITA RIVER BASIN
SANTA ANA RIVER BASIN
DISTRICT BOUNDARY RCFC & WCD
LEGEND
WATERSHED BOUNDARY
30,000 20 10 0 30,000
RCFC & WCD
HYDROLOGY MANUAL
PACIFIC OCEAN
CALIFORNIA
SAN FRANCISCO
LOS ANGELES
RCFC & WCD
RIVERSIDE COUNTY
SAN DIEGO
SAN BERNARDINO
RIVERSIDE
REDLANDS
CALIMESA
BEAUMONT
BANNING
CABAZON
DESERT HOT SPRINGS
YUCCA VALLEY
PALM SPRINGS
CATHEDRAL CITY
PALM DESERT
INDIO
NORCO
CORONA
SUNNYMEAD
PERRIS
SAN JACINTO
HEMET
IDYLLWILD
SUN CITY
ELSINORE
MURRIETA
TEMECULA
ANZA
AGUANGA
FALLBROOK
ONTARIO
RIALTO
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E
T2S T3S T4S T5S T6S T7S T8S T9S
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
LOCATION MAP
PLATE A-1

The 100-Year flood shall be contained within street R/W limits.

The 10-Year flood shall be contained within the Top of curbs.

Initiate a storm drain or channel when either condition is exceeded.



NOTES:

Protection criteria shown are the Districts typical minimum requirments. Special conditions, or other authorities may require stricter controls; ie; for reasons of traffic or pedestrian safety, maintenance problems behind curbs, etc., lower maximum depths of flow in streets may be required. Also see Riv. Co. Ord. No. 460.

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FLOOD PROTECTION CRITERIA

STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources
Division of Safety of Dams

STATUTES AND REGULATIONS PERTAINING TO SUPERVISION OF DAMS AND RESERVOIRS 1970*

CALIFORNIA ADMINISTRATIVE CODE

Title 23. Waters

Chapter 2. Department of Water Resources

Subchapter 1. Dams and Reservoirs

Article 1. General Provisions

301. Definitions. As used in these regulations, the terms listed below shall have the meanings noted:

(a) Department. "Department" means the Department of Water Resources of the State of California.

(b) Dam. "Dam" means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (a) is or will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest elevation of the outside limit of the barrier, as determined by the department, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or (b) has or will have an impounding capacity of 50 acre-feet or more.

Any such barrier which is or will not be in excess of 6 feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of 15 acre-feet, regardless of height, shall not be considered a dam.

No obstruction in a canal used to raise or lower water therein or divert water therefrom, no levee, including but not limited to a levee on the bed of a natural lake the primary purpose of which levee is to control floodwaters, no railroad fill or structure, and no road or highway fill or structure, no circular tank constructed of steel or concrete or of a combination thereof, no tank elevated above the ground, and no barrier which is not across a stream channel, watercourse, or natural drainage area and which has the principal purpose of impounding water for agricultural use shall be considered a dam. In addition, no obstruction in the channel of a stream or watercourse which is 15 feet or less in height from the lowest elevation of the obstruction and which has the single purpose of spreading water within the bed of the stream or watercourse upstream from the obstruction for percolation underground shall be considered a dam.

(c) Reservoir. "Reservoir" means any reservoir which contains or will contain the water impounded by a dam.

(d) Owner. "Owner" includes any of the following who own, control, operate, maintain, manage, or propose to construct a dam or reservoir:

(1) The State and its departments, institutions, agencies, and political subdivisions.

(2) Every municipal or quasi-municipal corporation.

(3) Every public utility.

(4) Every district.

(5) Every person.

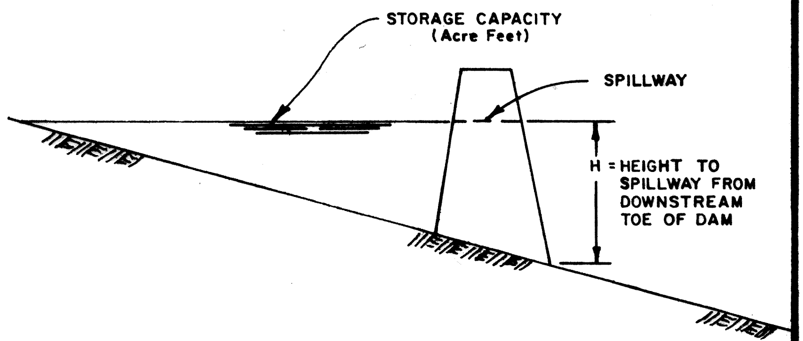
(6) The duly authorized agents, lessees, or trustees of any of the foregoing.

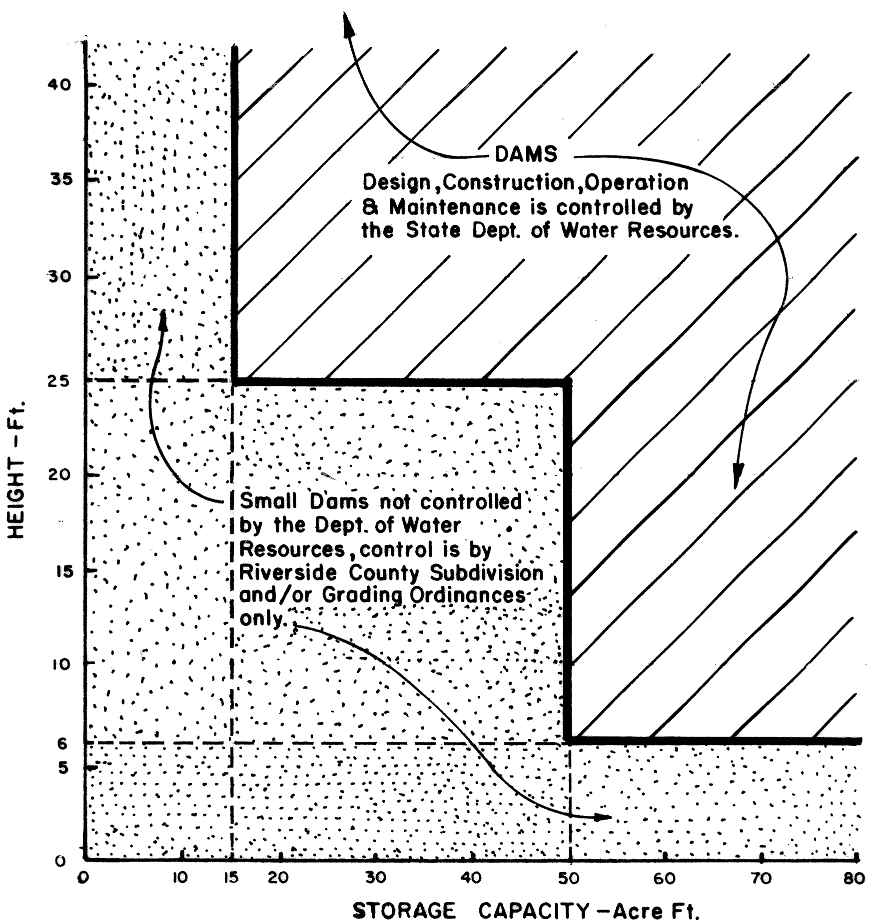
(7) Receivers or trustees appointed by any court for any of the foregoing.

"Owner" does not include the United States. (Sections 6002-6005, Water Code)

302. Purpose and Effect of Regulations. These regulations are adopted for the purpose of carrying out the provisions of Part 1 of Division 3 of the Water Code. Under no circumstances, and in no particular case, shall these regulations, or any of them, be construed as a limitation or restriction upon the exercise of any proper discretion that is vested in the department, nor shall they in any event be construed to deprive the department of any exercise of powers, duties and jurisdiction conferred by law, nor to limit or restrict the amount or character of data or information which may be required for the proper administration of the law. (Section 6078, Water Code)

* USERS SHOULD ASCERTAIN IF STATUTES HAVE BEEN REVISED.





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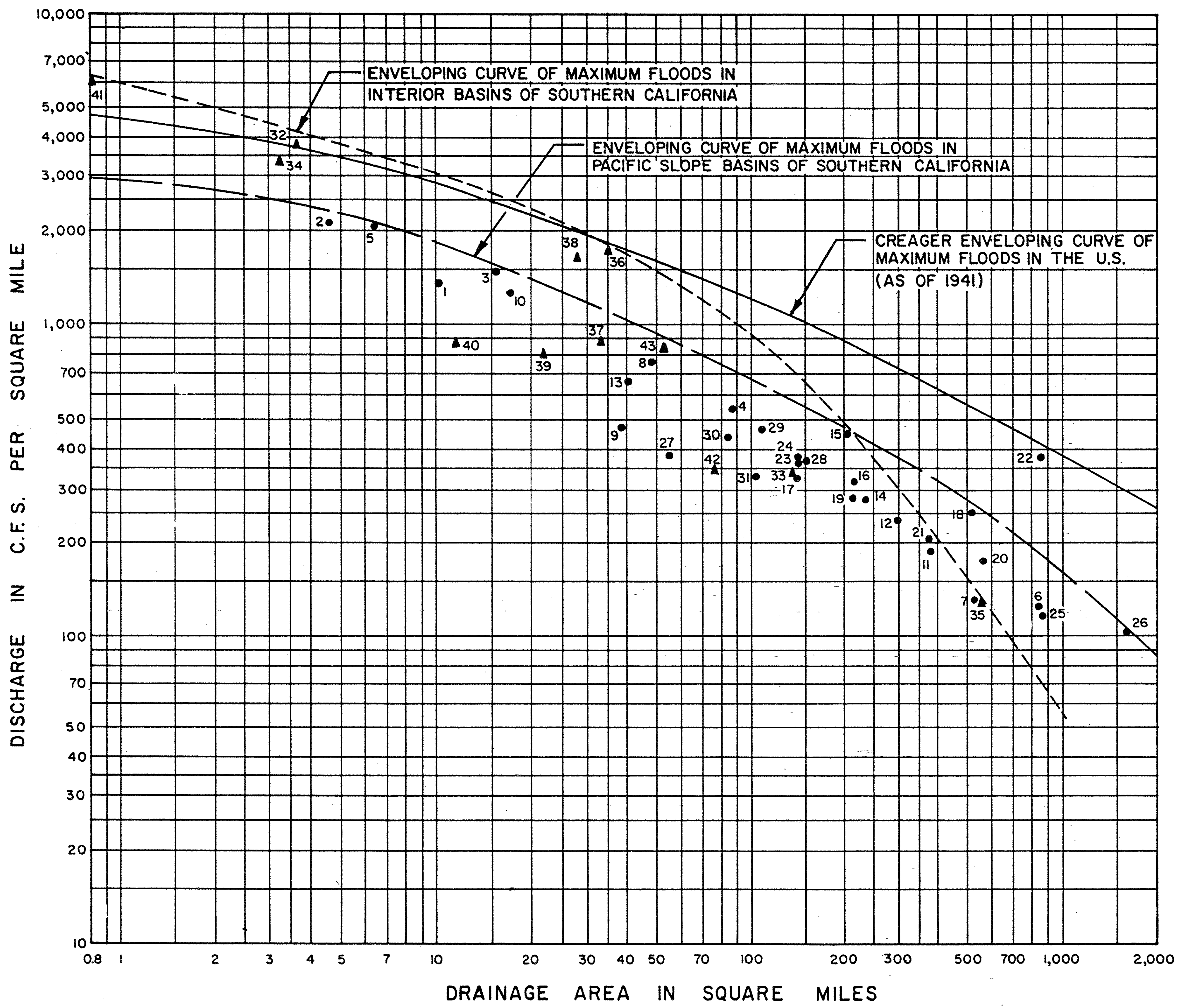
DAMS & IMPOUNDMENT RESERVOIRS UNDER STATE CONTROL



RECORDED OR ESTIMATED PEAK DISCHARGES OF RECORD

	STREAM & LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGE (INCLUDES DEBRIS) C.F.S.	DATE
● —	SOUTHERN CALIF.-PACIFIC SLOPE BASINS			
1	CUCAMONGA CREEK NEAR UPLAND	10.1	14,100	25 JAN 1969
2	DAY CREEK NEAR ETIWANDA	4.6	9,450	25 JAN 1969
3	DEVIL'S CANYON ABOVE COGSWELL DAM	15.4	23,000	2 MAR 1938
4	EAST FORK SAN GABRIEL RIVER NEAR CAMP BONITA	88.2	46,000	2 MAR 1938
5	FISH CREEK NEAR DUARTE	6.4	13,000	25 JAN 1969
6	LOS ANGELES RIVER AT LONG BEACH	832	102,000	25 JAN 1969
7	LOS ANGELES RIVER AT LOS ANGELES	514	67,000	3 MAR 1938
8	LYTLE CREEK NEAR FONTANA	47.9	35,900	25 JAN 1969
9	MILL CREEK NEAR YUCAIPA	38.1	18,100	2 MAR 1938
10	SAN ANTONIO CREEK NEAR CLAREMONT	16.9	21,400	2 MAR 1938
11	SAN DIEGO RIVER NEAR SANTEE	377	70,200	27 JAN 1916
12	SAN DIEGUITO RIVER NEAR BERNARDO	299	72,100	27 JAN 1916
13	SAN GABRIEL RIVER AT COGSWELL DAM	40.4	26,900	2 MAR 1938
14	SAN GABRIEL RIVER AT FOOTHILL BLVD	230	61,800	2 MAR 1938
15	SAN GABRIEL RIVER AT SAN GABRIEL DAM	202	90,000	2 MAR 1938
16	SAN GABRIEL RIVER BELOW MORRIS DAM	211	65,700	2 MAR 1938
17	SAN JACINTO RIVER BELOW NORTH FORK NEAR SAN JACINTO	141	45,000	16 FEB 1927
18	SAN LUIS REY RIVER AT BONSALL	512	128,000	23 FEB 1891
19	SAN LUIS REY RIVER NEAR MESA GRANDE	209	58,600	27 JAN 1916
20	SAN LUIS REY RIVER AT OCEANSIDE	557	95,600	27 JAN 1916
21	SAN LUIS REY RIVER NEAR PALA	373	75,300	27 JAN 1916
*22	SANTA ANA RIVER AT AGUA MANSA	855	320,000	22 JAN 1862
23	SANTA ANA RIVER NEAR MENTONE	144	52,300	2 MAR 1938
24	SANTA ANA RIVER NEAR MENTONE	144	53,700	23 FEB 1891
25	SANTA ANA RIVER AT RIVERSIDE NARROWS	858	100,000	2 MAR 1938
26	SANTA CLARA RIVER NEAR SATICOY	1595	165,000	25 JAN 1969
27	SANTA YSABEL CREEK NEAR MESA GRANDE	53.9	21,100	27 JAN 1916
28	TUJUNGA CREEK BELOW HANSEN DAM	150	54,000	3 MAR 1938
29	TUJUNGA CREEK NEAR SUNLAND	106	50,000	3 MAR 1938
30	TUJUNGA CREEK AT TUJUNGA DAM (INFLOW)	81.4	35,000	3 MAR 1938
31	WEST FORK SAN GABRIEL RIVER AT CAMP RINCON	102	34,000	2 MAR 1938
▲ —	SOUTHERN CALIF.-INTERIOR BASINS			
32	CAMERON CREEK NEAR TEHACHAPI	3.59	13,500	30 SEP 1932
33	DEEP CREEK NEAR HESPERIA	137	46,600	2 MAR 1938
34	LITTLE SAN GORGONIO CREEK NEAR BEAUMONT	3.23	11,000	25 FEB 1969
35	MOJAVE RIVER NEAR VICTORVILLE	530	70,600	2 MAR 1938
36	PINE TREE CANYON 12 MILES NORTH OF MOJAVE	35	59,500	12 AUG 1931
37	PINE TREE CREEK NEAR MOJAVE	33.5	30,000	23 AUG 1961
38	SACRAMENTO WASH NEAR NEEDLES	27	43,000	17 AUG 1939
39	SAN GORGONIO RIVER NEAR BANNING	21.2	17,000	2 MAR 1938
40	SNOW CREEK NEAR PALM SPRINGS	11	9,500	FEB 1927
41	UPPER WILLOW SPRINGS CANYON NEAR MOJAVE	0.81	4,900	30 SEP 1932
42	WEST FORK MOJAVE RIVER NEAR HESPERIA	74.8	26,100	2 MAR 1938
43	WHITEWATER RIVER ABOVE WHITEWATER	51.4	42,000	2 MAR 1938

NOTES:

*1. Because of the extreme variation of this value from the other data, this point was disregarded in construction of the enveloping curve for California.

2. References for flow estimates are USGS Water Supply Papers and Bibliography item No. 13.

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RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

ENVELOPING CURVES OF PEAK DISCHARGES IN SOUTHERN CALIFORNIA

REVISED | APPROVED CHIEF ENGINEER R.E. NO. | DATE | DRAWN BY: R.a.S. | PLATE A-4 | SHEET NO. | DR. NO.

SECTION B

PRECIPITATION

PRECIPITATION

General - The types of storms occurring over the District are general winter storms, general summer storms and local thunderstorms. The characteristics and origins of these storm types are discussed in detail in Section A of this report. In District design hydrology the 3 and 6-hour duration storms are taken as representative of local thunderstorms, while the 24-hour storm is characteristic of general storms.

Point Precipitation -

Design Storm Isohyetal Maps - Isohyetal maps of point precipitation for the 2 and 100-year 1, 3, 6 and 24-hour storms, are shown on Plates D-4.3, D-4.4 and E-5.l through E-5.6, respectively. The 1-hour maps of Section D are intended for use in developing intensity duration curves for the Rational method. The 3, 6 and 24-hour maps are intended for use with the Synthetic Unit Hydrograph method.

The 6 and 24-hour duration maps are from "NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume XI-California" (NOAA Atlas 2), published by the National Weather Service (NWS) in 1973. The 1 and 3-hour duration maps were developed by the District using data from the 6 and 24-hour duration maps, and equations presented in NOAA Atlas 2. Point rainfall values were developed for a basic 5-minute grid of latitude and longitude. These values were supplemented with points on a 2½-minute grid in mountainous regions. Isohyetals were drawn using the computed point values and the basic patterns on the 6-hour maps.

Point precipitation for other return periods can be developed using the return period diagrams on Plates D-4.5 or E-5.7. The return period diagrams are based on NOAA Atlas 2 and are identical except for vertical scale.

Spillway Storm Precipitation - As discussed in the Introduction Section of this report, spillway design is normally for something between the 1,000-year and the probable maximum precipitation (PMP) storm. In development of spillway hydrology all available rainfall records in and near the watershed should be analyzed. For preliminary planning purposes only, spillway precipitation amounts can be estimated using 100-year precipitation times the factors in the following tabulation:

Spillway Precipitation Factors

Return Period (Std. Deviations*)	Ratio to the 100-Year Event: Santa Ana River Basin	Ratio to the 100-Year Event: Santa Margarita River Basin	Ratio to the 100-Year Event: Whitewater River Basin
l,000-Year (5.1 to 5.9)	1.35	1.37	1.45
l0,000-Year (6.9 to 8.2)	1.68	1.73	1.89
10 Std. Deviations (10)	2.27	2.22	2.24
PMP (15)	3.22	3.15	3.21

*Approximate number of standard deviations above the mean. See DWR Bulletin Number 195.

The tabulated factors above are based on methods presented in Department of Water Resources (DWR) Bulletin Number 195, "Rainfall Analysis for Drainage Design", dated October 1976. It should be emphasized that these factors are suitable for preliminary planning purposes only, and selection of design precipitation values for spillways requires an in-depth analysis of all available records and the pertinent literature.

District Frequency Analyses - The District has prepared frequency analyses for records of all available precipitation stations in and near the District. These analyses are based on methods described by DWR in Bulletin Number 195. In most areas District analyses support the National Weather Service maps in NOAA Atlas 2. However, in some regions, particularly in mountainous areas where data is often lacking, there is significant variation between District analysis and NWS isohyetal maps. The resolution of these variations may require the accumulation of many years of rainfall data and studies well beyond the scope of this report. It is expected, however, that apparent conflicts between these two sources of rainfall data will be resolved, and revised maps will be published by the District through its ongoing data collection and hydrologic studies programs. Until this is accomplished, users of this manual should consult the District's frequency analyses computations for additional information before selecting point rainfall values on studies of large mountainous watersheds.

Precipitation Depth - Area Adjustment - For use with the Synthetic Unit Hydrograph method, point rainfall values can be adjusted for a real effect using the curves on Plate E-5.8. The upper set of curves are from NOAA Atlas 2 and should be used for all storms except the PMP storm. The lower set of curves are for PMP storms only. The PMP curves are based on NWS information published in the Corps of Engineers report "Interim Report on Survey for Flood Control, Tahquitz Creek, California", dated June 20, 1963.

Precipitation Intensity Pattern - Tabulations of rainfall patterns are given on Plate E-5.9 for use with the Synthetic Unit Hydrograph method. The rainfall patterns used in development of 3 and 6-hour thunderstorm flood hydrographs are from the Indio storm of September 24, 1939, the largest thunderstorm of record in the Whitewater River basin. The pattern used for development of 24-hour general storm flood hydrographs is based on the storm of March 2nd through March 3rd of 1938 as recorded in the San Gabriel Mountains at Opid's Camp, Camp Baldy and Crystal Lake. This storm resulted in high rates of runoff and major flooding in western Riverside County. The patterns presented herein are considered to represent a reasonable distribution of rainfall which will cause critical runoff conditions during major storm events.

Intensity-Duration Curves - Intensity-duration data is required for use with the Rational method. This data is usually presented in the form of curves of rainfall intensity in inches per hour versus storm duration in minutes. Intensity-duration data for durations under 3-hours tends to plot in a straight line on Log-Log paper, and the curves for various return periods tend to run parallel to one another.

Standard intensity-duration curves have been published in master plan studies for many areas of the District. In areas where these curves are still applicable they should be used in the interest of consistency. A tabular presentation of current intensity-duration data for many of the population centers throughout the District are presented on Plate D-4 .1. The reader should be aware that hydrologic variations caused by terrain, etc., require caution in transposing these curves onto adjacent areas without clearly determining their applicability.

For areas where standard curves are not presented herein the District recommends using the 1-hour point precipitation and the intensity curve slope to develop design intensity-duration curves. Isohyetal maps of the maximum 2-year - 1-hour and 100-year - 1-hour precipitation are shown on Plates D-4.3 and D-4.4, respectively. One-hour point rain for intermediate return periods can be determined from Plate D-4.5. The slope of the intensity-duration curve can be obtained from Plate D-4.6. Intensity duration curves for a particular area can be easily developed using Plate D-4.7, plotting the 1-hour point rain value for the desired return period and drawing a straight line through the 1-hour value parallel to the required slope. The isohyetal maps and return period diagram are based on NOAA Atlas 2 as discussed previously. The map of intensity-duration curve slope is based on District analysis of all available recording rain gauge records in and near the District. The slope used is from a best-fit curve (straight line on a Log-Log plot) of the average of recorded annual maximum intensities for durations of 5-minutes through 3-hours.

SECTION C

INFILTRATION

INFILTRATION

General - Infiltration is the process of water entering the soil surface. In District design hydrology, infiltration is expressed as the rate in inches per hour at which precipitation enters the soil surface and is stored in the subsurface structure. Among the many factors affecting infiltration or loss rates, three of the most important are: soil surface and profile characteristics, soil cover or vegetation type, and antecedent moisture conditions. During a storm event loss rates tend to decrease with time, although in design hydrology a constant average loss rate is often assumed.

In the following paragraphs major factors affecting infiltration are discussed in detail, and methods are described for estimating loss rates for use in District design hydrology. The methods described are based on general information, and therefore are intended only as a guide in estimating loss rates; however, it is believed that when properly applied by experienced engineers and hydrologists they will yield reasonable results. In the final analysis the best estimate of loss rates would come from analysis of recorded rainfall-runoff relationships during major flood events on the area under study, but such information is usually not available. It should be noted that all hydrology submittals to the District are subject to review, and the District's evaluation of infiltration rates, as well as other factors affecting hydrologic results will be considered final.

Hydrologic Soil Groups - The major factor affecting infiltration is the nature of the soil itself. The soils surface characteristics, ability to transmit water through subsurface layers and total storage capacity are all major factors in the infiltration capabilities of a particular soil. The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has investigated the hydrologic characteristics of soils as related to runoff potential, and has developed a system useful to the District to classify soils into four hydrologic soils groups as follows:

Group A — Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B — Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C — Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D — High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

In some cases a dual soil designation such as "B-C" has been assigned to an area. This indicates the infiltration characteristics are too variable either geographically or with time, to assign the soil to a single classification. In such cases the more conservative value is recommended for design hydrology.

The SCS and U. S. Forest Service (USFS) have mapped soil types and assigned hydrologic soils classifications in many areas of the District. Using this information the District has compiled generalized hydrologic soils classification maps. These maps are shown on Figures C-l.01 through C-l.66. In areas which have not yet been mapped, SCS or USFS personnel may be able to supply generalized soils information. The District will update the soils maps as additional information becomes available.

<u>Soil Cover Type</u> - The type of vegetation or ground cover on a watershed, and the quality or density of that cover, have a major impact on the infiltration capacity of a given soil. In consideration of cover type and quality the District uses a system developed by the SCS, whose studies on the affect of cover type on runoff potential are believed to represent the most

comprehensive information available for this region. Detailed descriptions of these cover types grouped in three broad classifications (Natural, Urban, and Agricultural) are given on Plate C-2. Definitions of cover quality are as follows:

Poor Heavily grazed or regularly burned areas. Less than 50 percent of the ground surface is protected by plant cover or brush and tree canopy.

Fair Moderate cover with 50 percent to 75 percent of the ground surface protected.

Good Heavy or dense cover with more than 75 percent of the ground surface protected.

In most cases cover type and quality can be readily determined by a field review of a study watershed. USFS personnel may also be helpful in determining such information in remote mountainous areas of the District.

Antecedent Moisture Conditions - Antecedent moisture condition (AMC) has a major effect on the runoff potential of a particular soil-cover complex. AMC can be defined as the relative wetness of a watershed just prior to a flood producing storm event. AMC is sometimes expressed as the amount of rainfall occurring in a specific period of time prior to a major storm. Such evaluations are crude at best due to the importance of the time distribution of rainfall within the antecedent period, etc. For this reason the District uses the following generalized definitions of AMC levels:

AMC I Lowest runoff potential. The watershed soils are dry enough to allow satisfactory grading or cultivation to take place.

AMC II Moderate runoff potential, an intermediate condition.

AMC III Highest runoff potential. The watershed is practically saturated from antecedent rains.

In rainfall based hydrology methods it is normally true that a low AMC index (high loss rates) should be used in developing short return period storms (2-5 year); and a moderate to high AMC index (low loss rates) should be used in developing longer return period storms (10 - 100 year). For the purposes of design hydrology using District methods, AMC II should normally be assumed for both the 10 year and 100 year frequency storm. In the case of spillway hydrology for dams or debris basins, a condition between AMC II and AMC III should be assumed depending on the degree of risk involved in failure of the structure.

Impervious Areas - Discussion in the previous paragraphs has dealt entirely with infiltration for pervious surfaces. In analyzing developed areas the effect of impervious surfaces on the average infiltration rate over the entire watershed must be considered. Estimated ranges of impervious percentages for various types of development are given on Plate D-5.6 or E-6.3 (identical Plates). Values given are for the actual percentage of area covered by impervious surfaces; however, studies have shown that effective impervious area is generally smaller than actual impervious area. A number of reasons for this difference can be cited, i.e., an impervious surface discharging onto a pervious surface where infiltration may take place, evaporation from local depression storage, pervious area under the overhang of rooftop eaves, etc. The difference between effective and actual impervious area generally is larger for short return period storms (2 - 5 year), and smaller for longer return period storms (10 - 100 year). To account for the difference between actual and effective impervious areas in District hydrology, actual impervious area is assumed to be 90 percent effective during design storms. This adjustment is made in the computation of runoff coefficients for the Rational method, and in the computation of adjusted loss rates for the Synthetic Unit Hydrograph method. This is discussed in detail in the sections covering the two methods.

In District design hydrology, ultimate development of the watershed must normally be assumed since watershed urbanization is reasonably likely within the expected life of most hydraulic facilities serving the valley areas. Long range master plans for the County and incorporated cities should be reviewed to insure that reasonable land use assumptions are made.

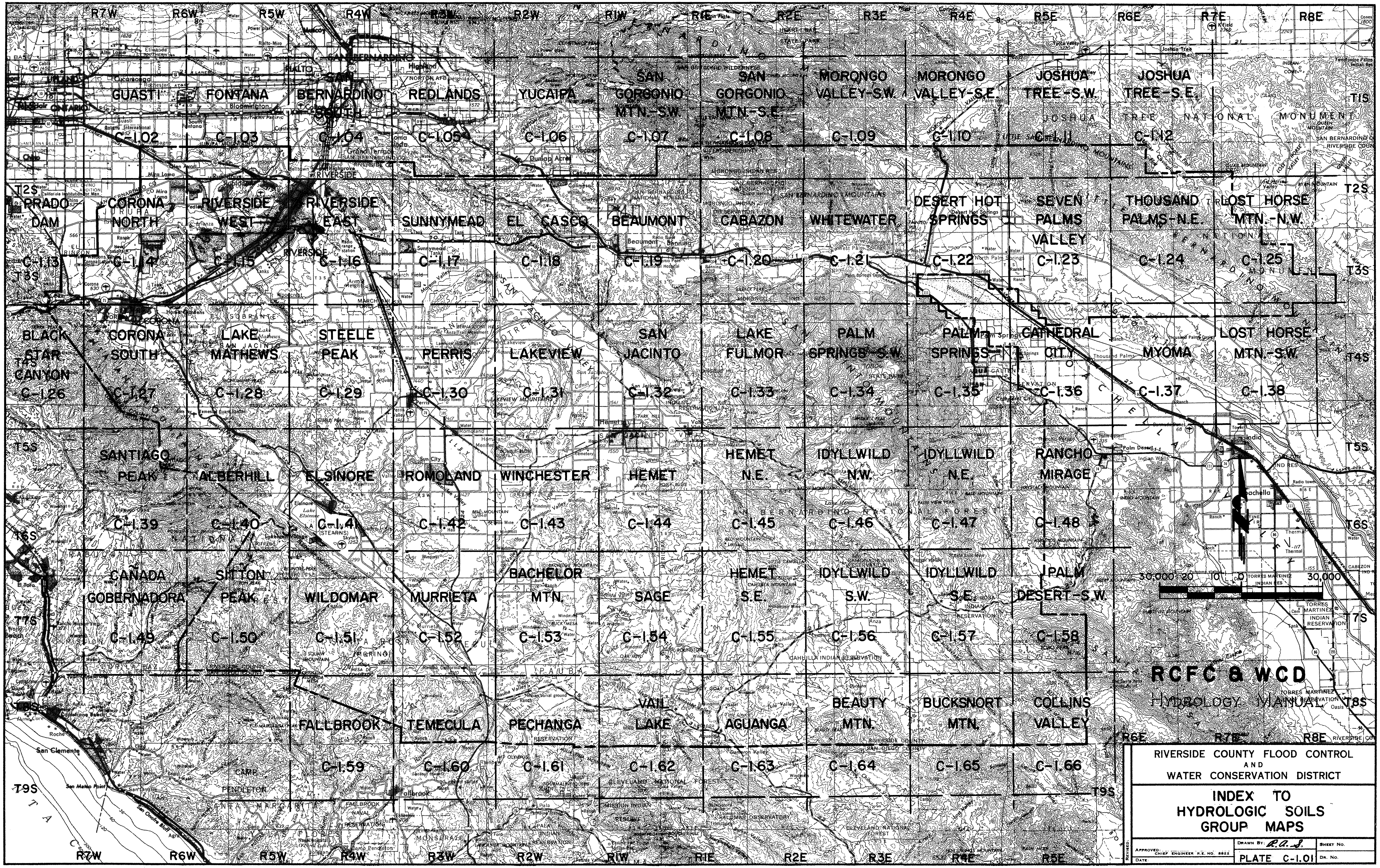
A field review should also be made. Particular attention should be paid to landscape practices, as it is common in some areas (primarily desert and retirement communities) to use ornamental gravels underlain by impervious plastic materials in place of lawns and shrubs. Appropriate actual impervious percentages can then be selected from Plate D-5.6 or E-6.3. It should be noted that the recommended values on these Plates are for average conditions, and therefore subject to adjustment in application.

Estimation of Infiltration Rates - In estimating infiltration rates for District design hydrology, an index of runoff potential or "runoff index" 1 (RI) is determined for each soil-cover complex within a study watershed. The RI scale has a range of zero to 100, where a low RI number indicates low runoff potential (high infiltration), and a high RI number indicates high runoff potential (low infiltration). Selection of an RI number takes into account the previously discussed major factors affecting infiltration on pervious surfaces including hydrologic soils group, cover type and quality and antecedent moisture condition. RI numbers for typical soil-cover complexes in the District are given on Plates D-5.5 or E-6.l (identical Plates) for antecedent moisture condition II. The RI index values on these Plates are based on studies of runoff potential by the SCS, and are synonymous with the "runoff curve" numbers used by that agency.

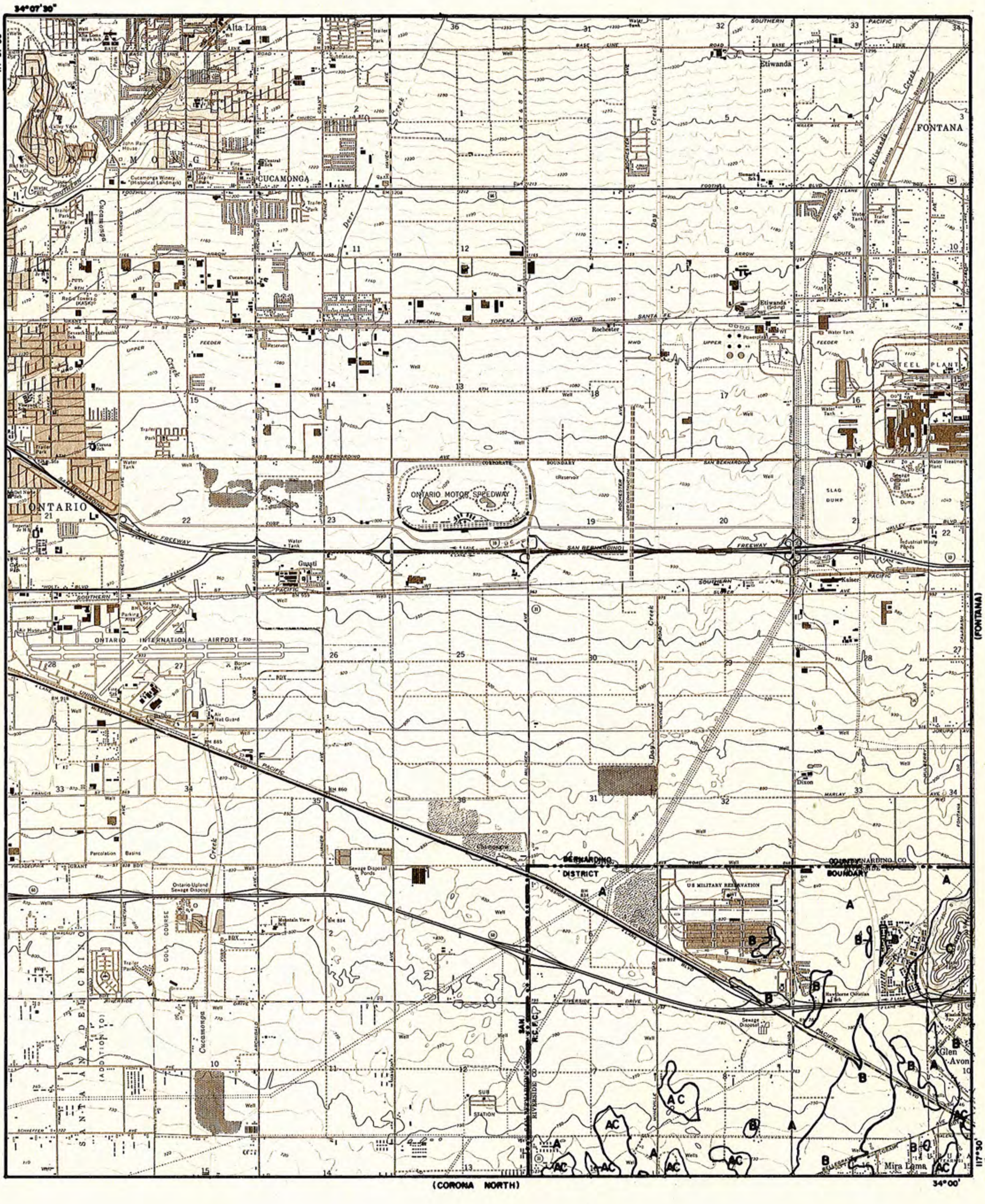
Once an RI number has been selected, infiltration rates can be estimated for pervious areas by use of Plate E-6.2 on studies requiring the use of the Synthetic Unit Hydrograph method. The fact that this loss rate is for the pervious area only should be clearly understood, as the engineer is really interested in a composite loss rate which represents both the pervious and impervious surfaces in the study watershed. Adjustment of the loss rate for impervious surfaces is discussed in Section E on the Synthetic Unit Hydrograph method.

The RI number versus infiltration relationships are based on rainfall - runoff relationships developed from SCS studies of numerous flood events. The District has determined that these relationships are in good agreement with the results of field infiltrometer studies run in the Southern California area.

Estimation of Runoff Coefficient Curves - Runoff coefficient curves can be developed for any runoff index number using loss rates for pervious areas (derived as discussed in the previous paragraph) and the relationships presented in Section D of this manual. In practice it is not necessary for the engineer to make these computations, as runoff coefficient curve data has been tabulated by the District on Plate D-5.7 for the normal working range of runoff index numbers. Runoff coefficient curves can be developed for any combination of conditions by simply plotting the data from Plate D-5.7 on Plate D-5.8. In addition, for the common case of urban landscaping type cover, runoff coefficient curves have been plotted on Plates D-5.l through D-5.4.



GUASTI C-1.02
FONTANA C-1.03
SAN BERNARDINO SOUTH C-1.04
REDLANDS C-1.05
YUCAIPA C-1.06
SAN GORGONIO MTN.-S.W. C-1.07
SAN GORGONIO MTN.-S.E. C-1.08
MORONGO VALLEY-S.W. C-1.09
MORONGO VALLEY-S.E. C-1.10
JOSHUA TREE-S.W. C-1.11
JOSHUA TREE-S.E. C-1.12
PRADO DAM C-1.13
CORONA NORTH C-1.14
RIVERSIDE WEST C-1.15
RIVERSIDE EAST C-1.16
SUNNYMEAD C-1.17
EL CASCO C-1.18
BEAUMONT C-1.19
CABAZON C-1.20
WHITEWATER C-1.21
DESERT HOT SPRINGS C-1.22
SEVEN PALMS VALLEY C-1.23
THOUSAND PALMS-N.E. C-1.24
LOST HORSE MTN.-N.W. C-1.25
BLACK STAR CANYON C-1.26
CORONA SOUTH C-1.27
LAKE MATHEWS C-1.28
STEELE PEAK C-1.29
PERRIS C-1.30
LAKEVIEW C-1.31
SAN JACINTO C-1.32
LAKE FULMOR C-1.33
PALM SPRINGS-S.W. C-1.34
PALM SPRINGS C-1.35
CATHEDRAL CITY C-1.36
MYOMA C-1.37
LOST HORSE MTN.-S.W. C-1.38
SANTIAGO PEAK C-1.39
ALBERHILL C-1.40
ELSINORE C-1.41
ROMOLAND C-1.42
WINCHESTER C-1.43
HEMET C-1.44
HEMET N.E. C-1.45
IDYLLWILD N.W. C-1.46
IDYLLWILD N.E. C-1.47
RANCHO MIRAGE C-1.48
CAÑADA GOBERNADORA C-1.49
SITTON PEAK C-1.50
WILDOMAR C-1.51
MURRIETA C-1.52
BACHELOR MTN. C-1.53
SAGE C-1.54
HEMET S.E. C-1.55
IDYLLWILD S.W. C-1.56
IDYLLWILD S.E. C-1.57
PALM DESERT-S.W. C-1.58
FALLBROOK C-1.59
TEMECULA C-1.60
PECHANGA C-1.61
VAIL LAKE C-1.62
AGUANGA C-1.63
BEAUTY MTN. C-1.64
BUCKSNORT MTN. C-1.65
COLLINS VALLEY C-1.66
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E
T1S T2S T3S T4S T5S T6S T7S T8S T9S
30,000 20 10 0 30,000
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
INDEX TO HYDROLOGIC SOILS GROUP MAPS
DRAWN BY: R.A.S.
APPROVED: CHIEF ENGINEER R.E. NO. 8822
PLATE C-1.01



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HYDROLOGIC SOILS GROUP MAP FOR GUASTI

PLATE C-1.02

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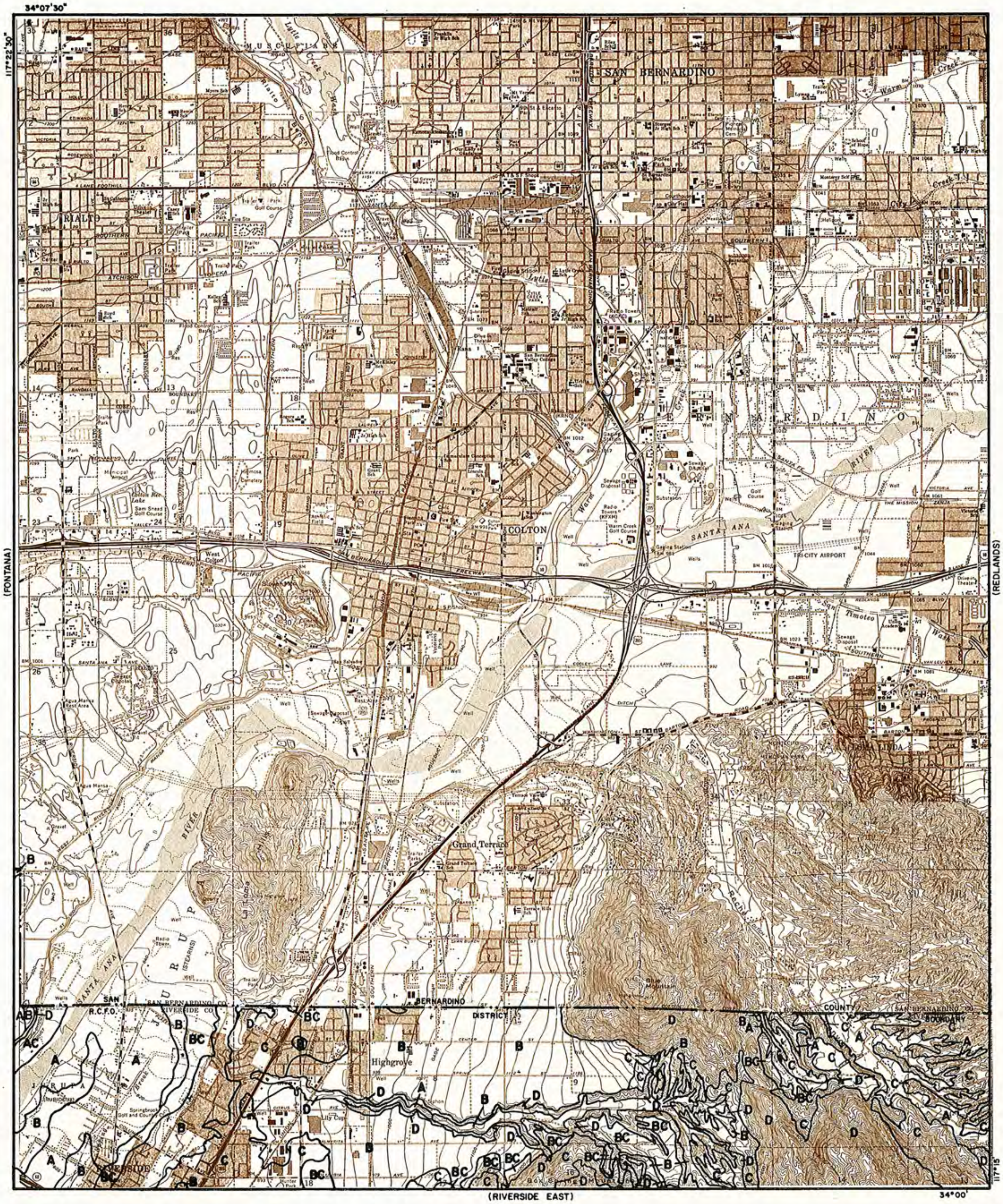
HYDROLOGIC SOILS GROUP MAP FOR FONTANA



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HYDROLOGIC SOILS GROUP MAP FOR SAN BERNARDINO-SOUTH

PLATE C-1.04

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HYDROLOGIC SOILS GROUP MAP FOR REDLANDS

PLATE C-1.05

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HYDROLOGIC SOILS GROUP MAP FOR YUCAIPA

PLATE C-1.06

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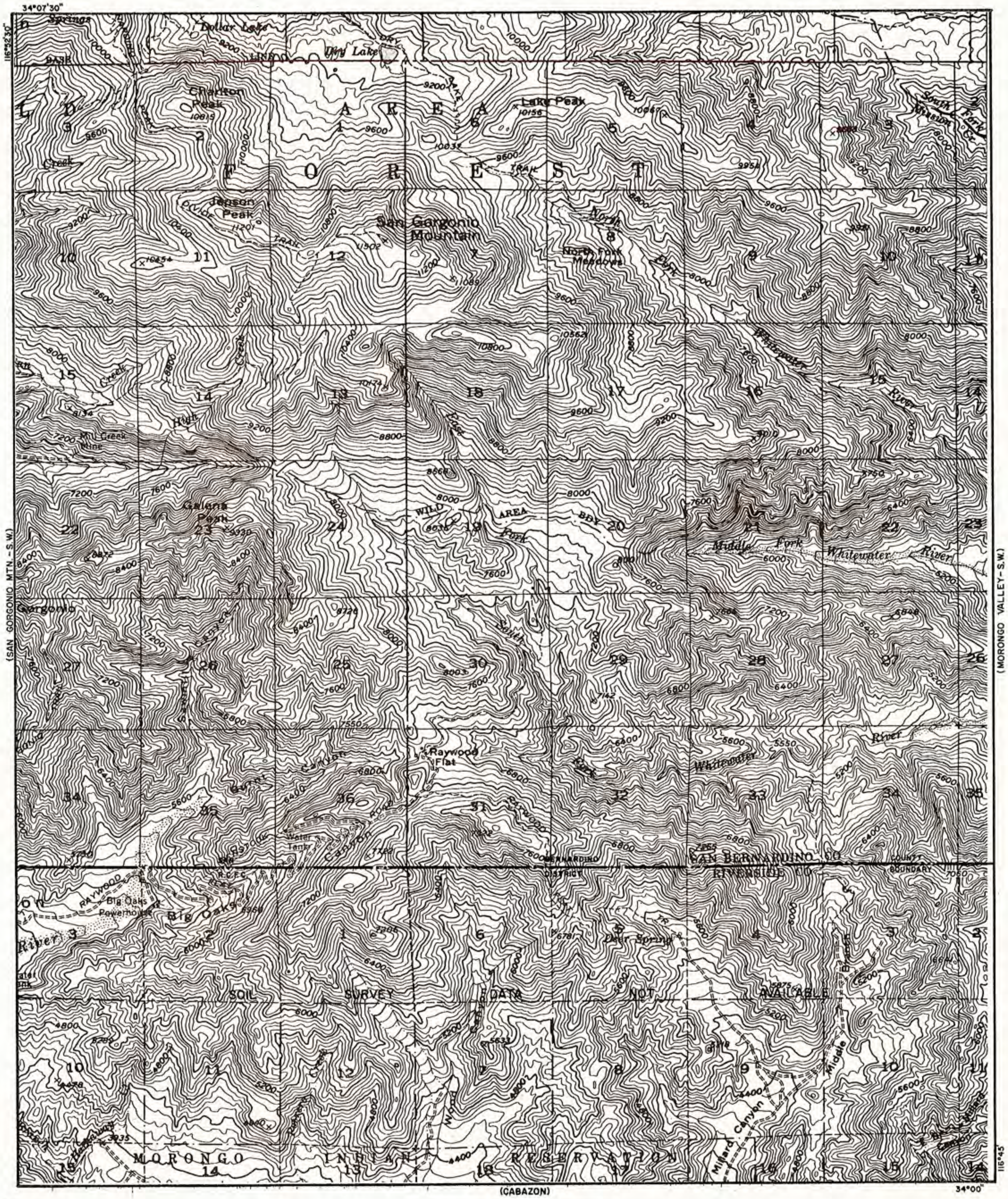
HYDROLOGIC SOILS GROUP MAP FOR SAN GORGONIO MTN.-S.W.

PLATE C-1.07



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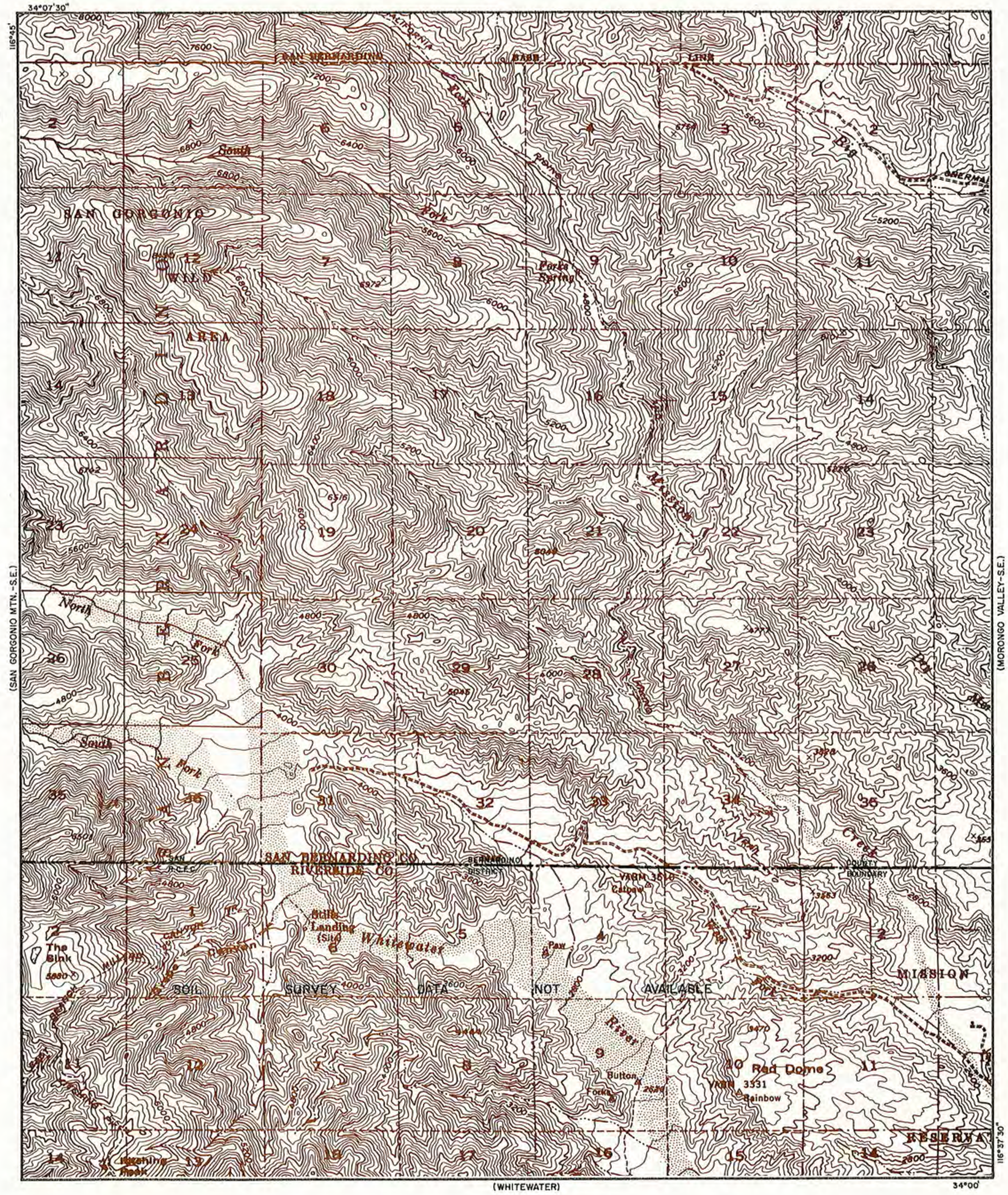
HYDROLOGIC SOILS GROUP MAP FOR SAN GORGONIO MTN.-S.E.

PLATE C-1.08



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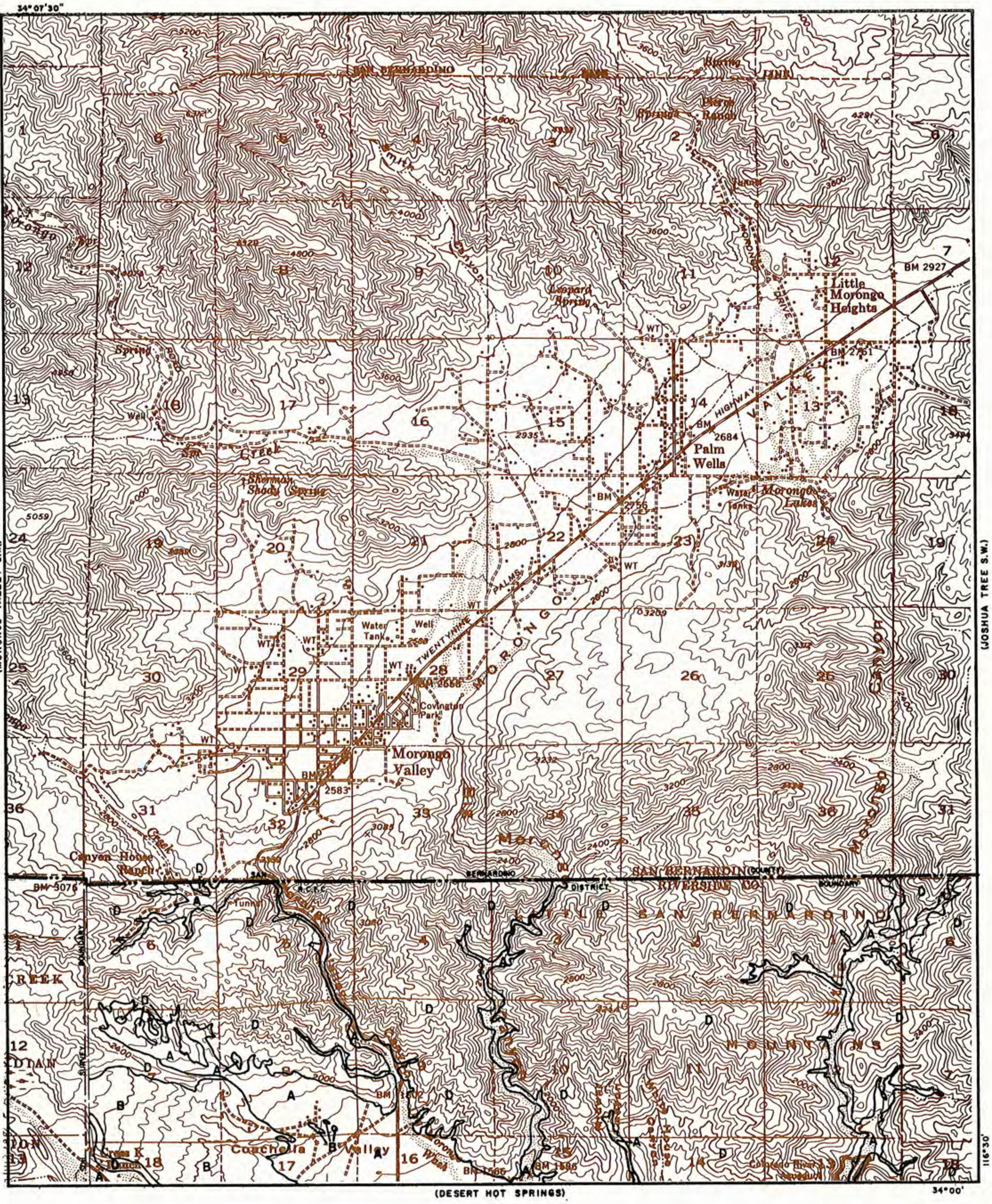
HYDROLOGIC SOILS GROUP MAP FOR MORONGO VALLEY—S.W.

PLATE C—1.09



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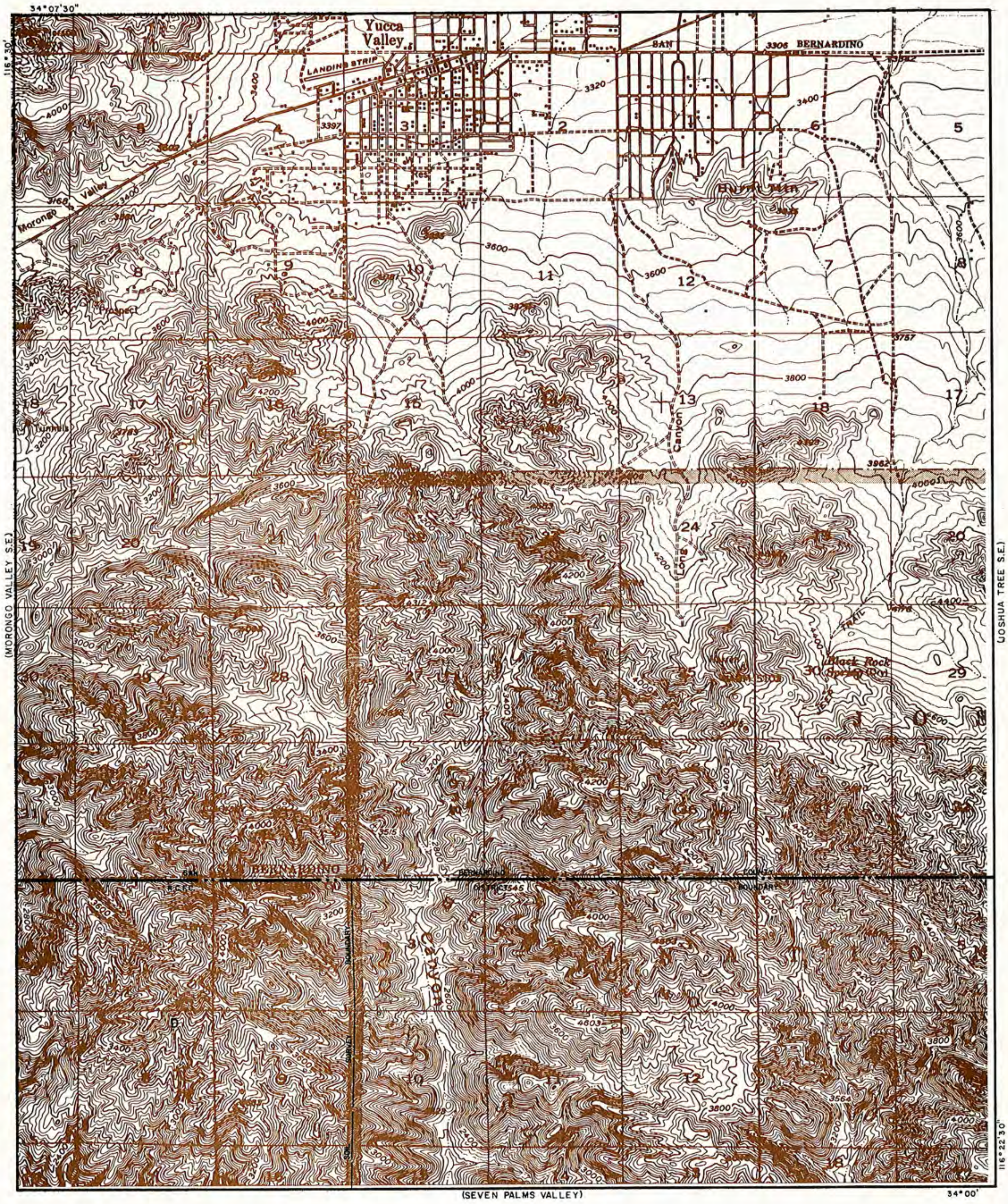
HYDROLOGIC SOILS GROUP MAP FOR MORONGO VALLEY-S.E.

PLATE C-1.10



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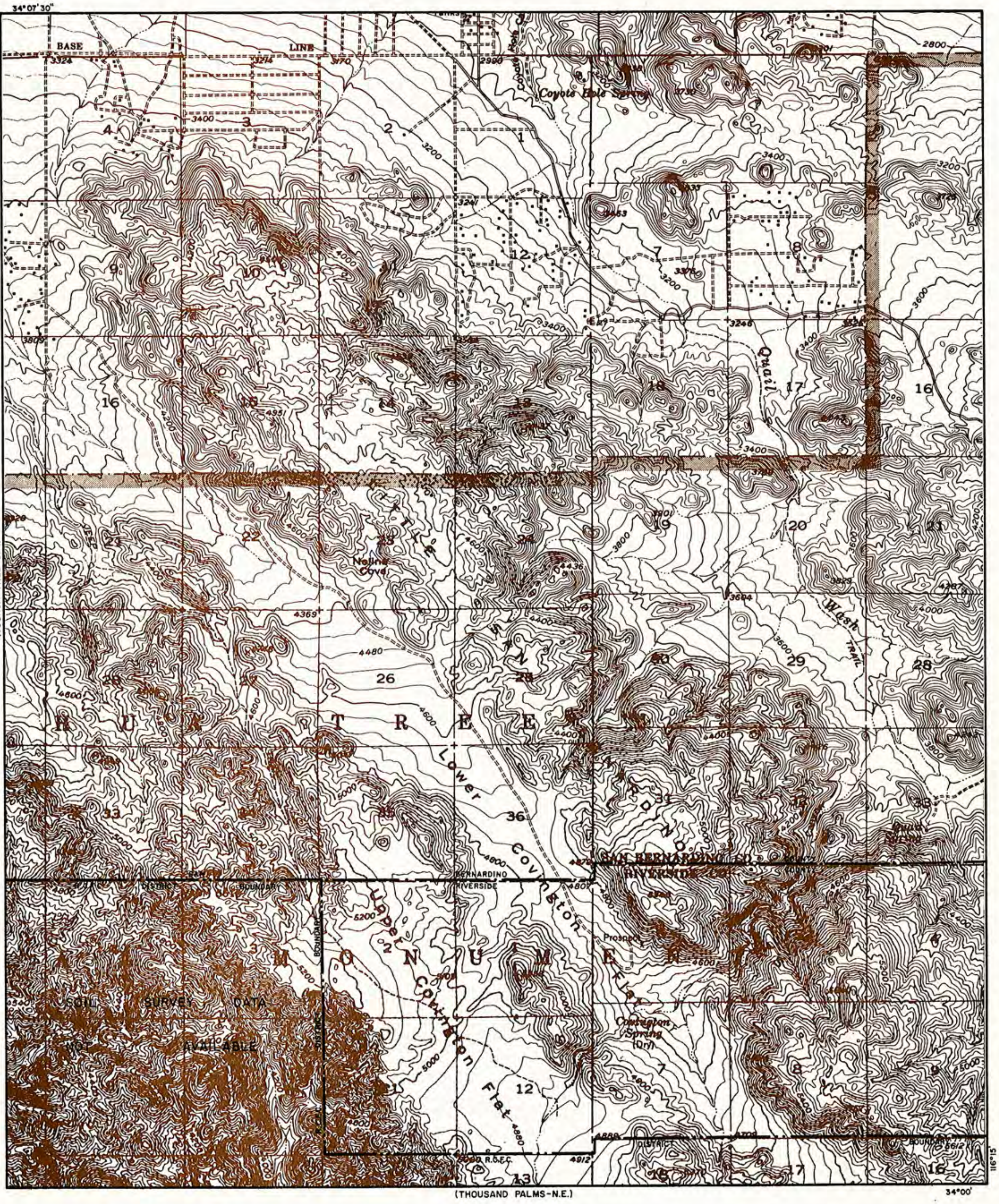
HYDROLOGIC SOILS GROUP MAP FOR JOSHUA TREE-S.W.

PLATE C-1.11



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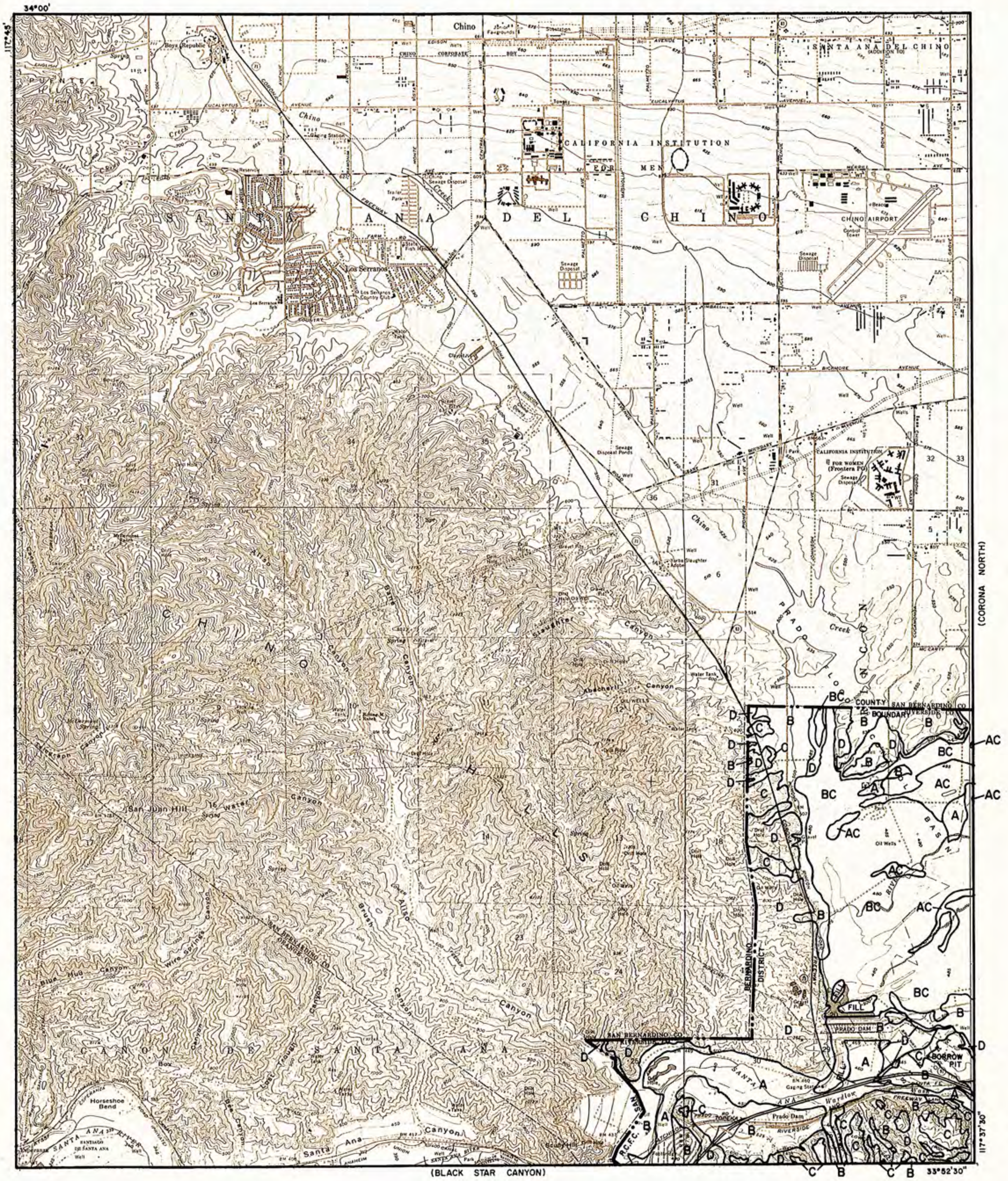
HYDROLOGIC SOILS GROUP MAP FOR JOSHUA TREE–S.E.

PLATE C-1.12



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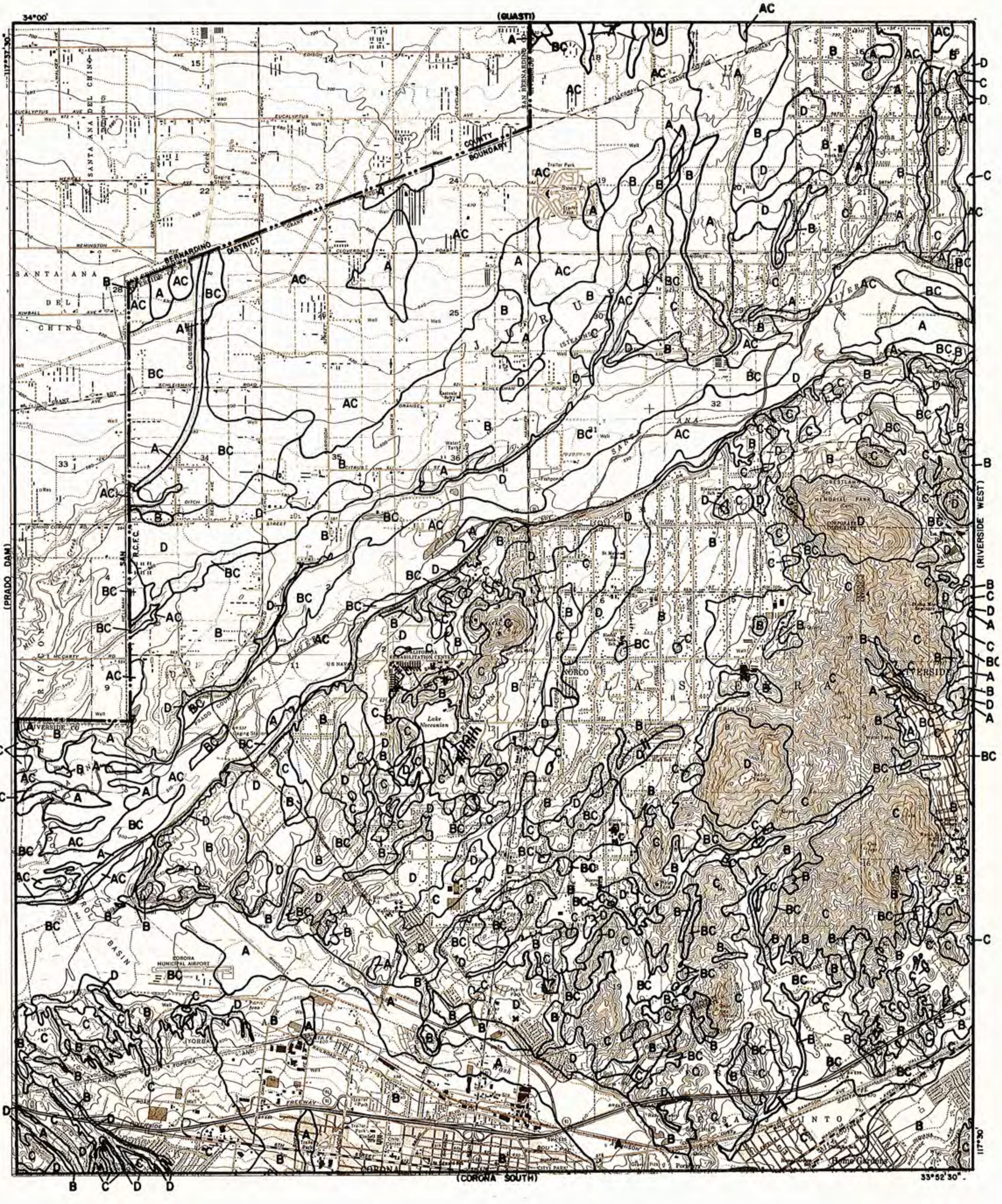
HYDROLOGIC SOILS GROUP MAP FOR PRADO DAM

PLATE C-1.13



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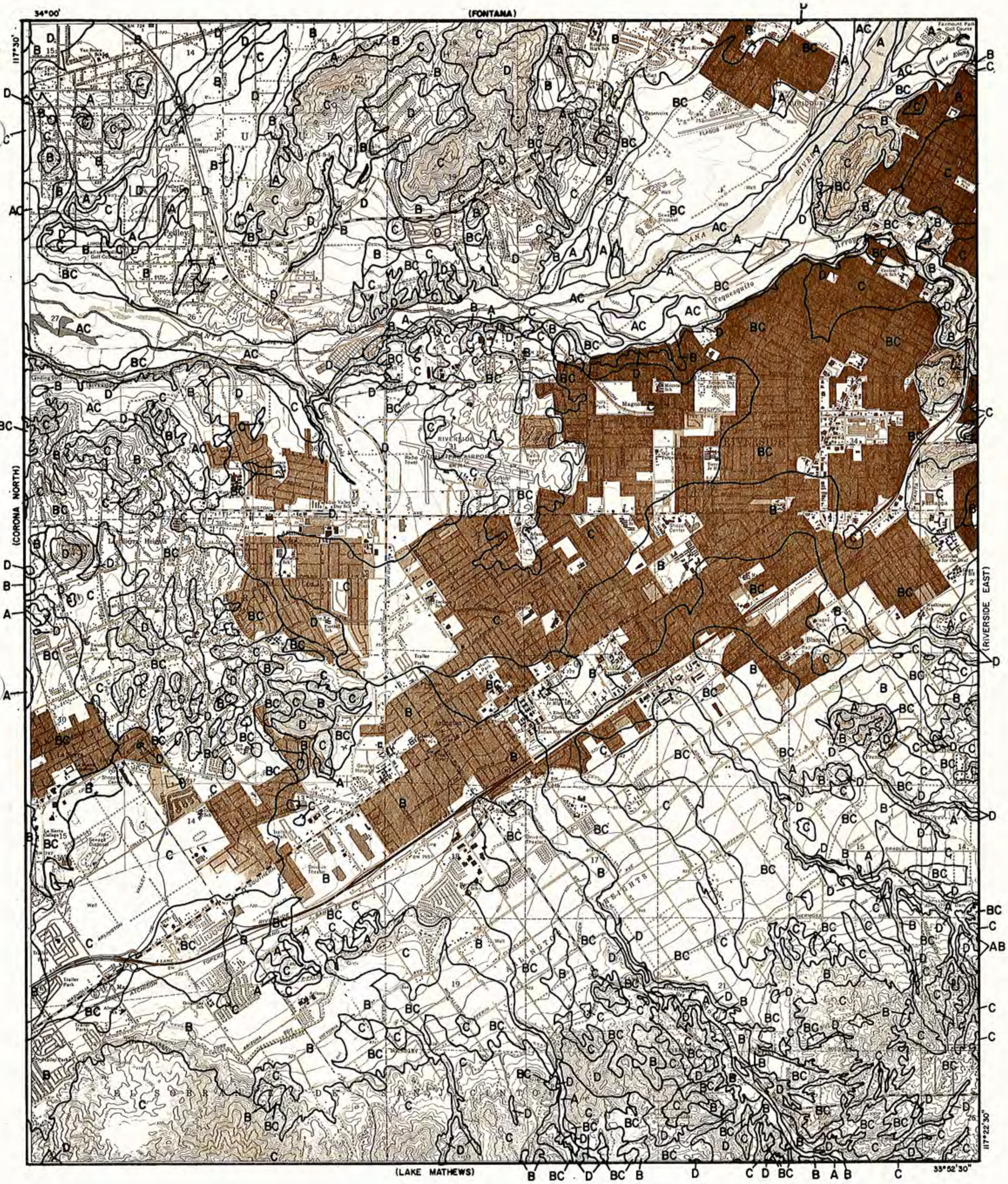
HYDROLOGIC SOILS GROUP MAP FOR CORONA-NORTH

PLATE C-1.14



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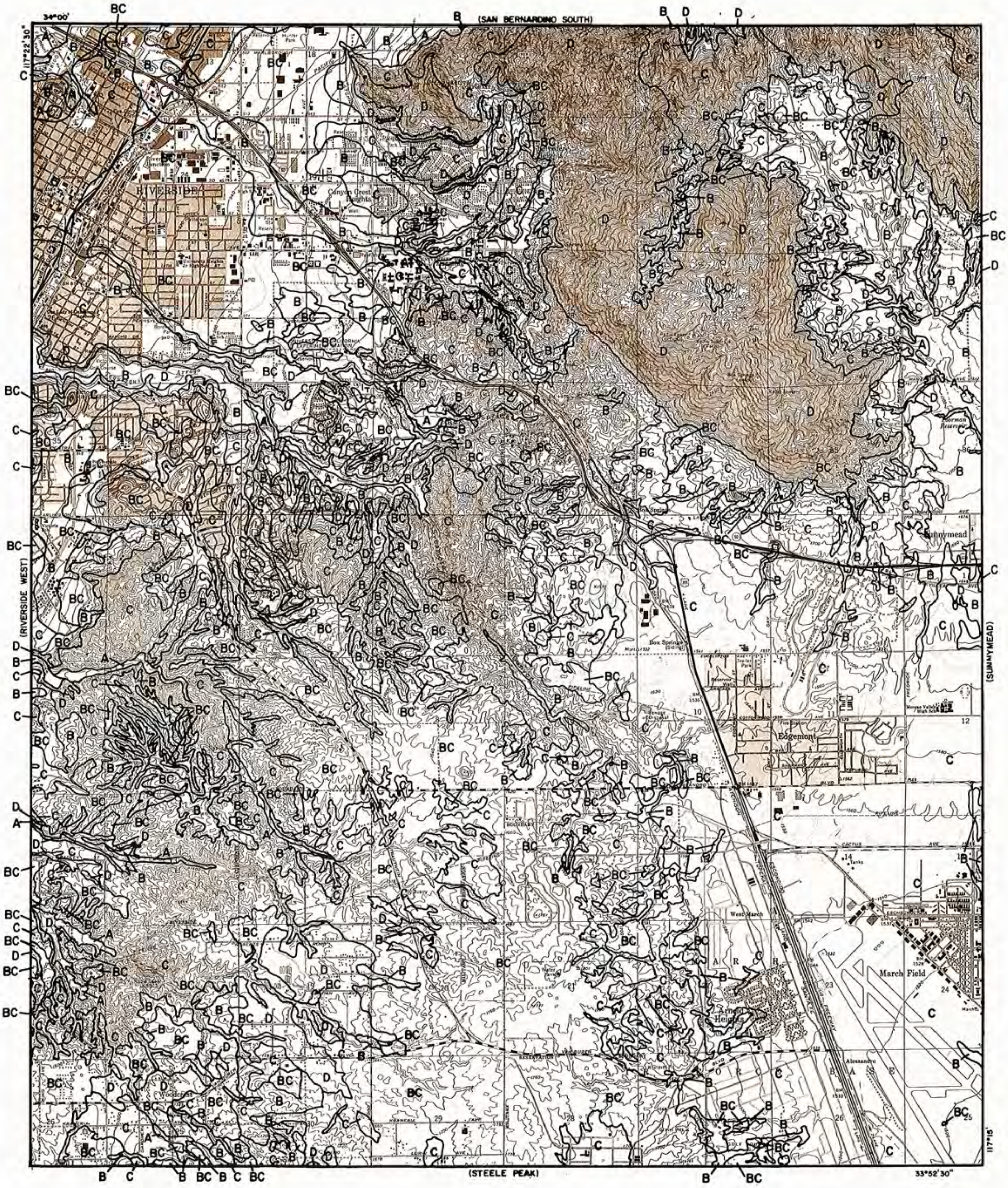
HYDROLOGIC SOILS GROUP MAP FOR RIVERSIDE—WEST

PLATE C—1.15



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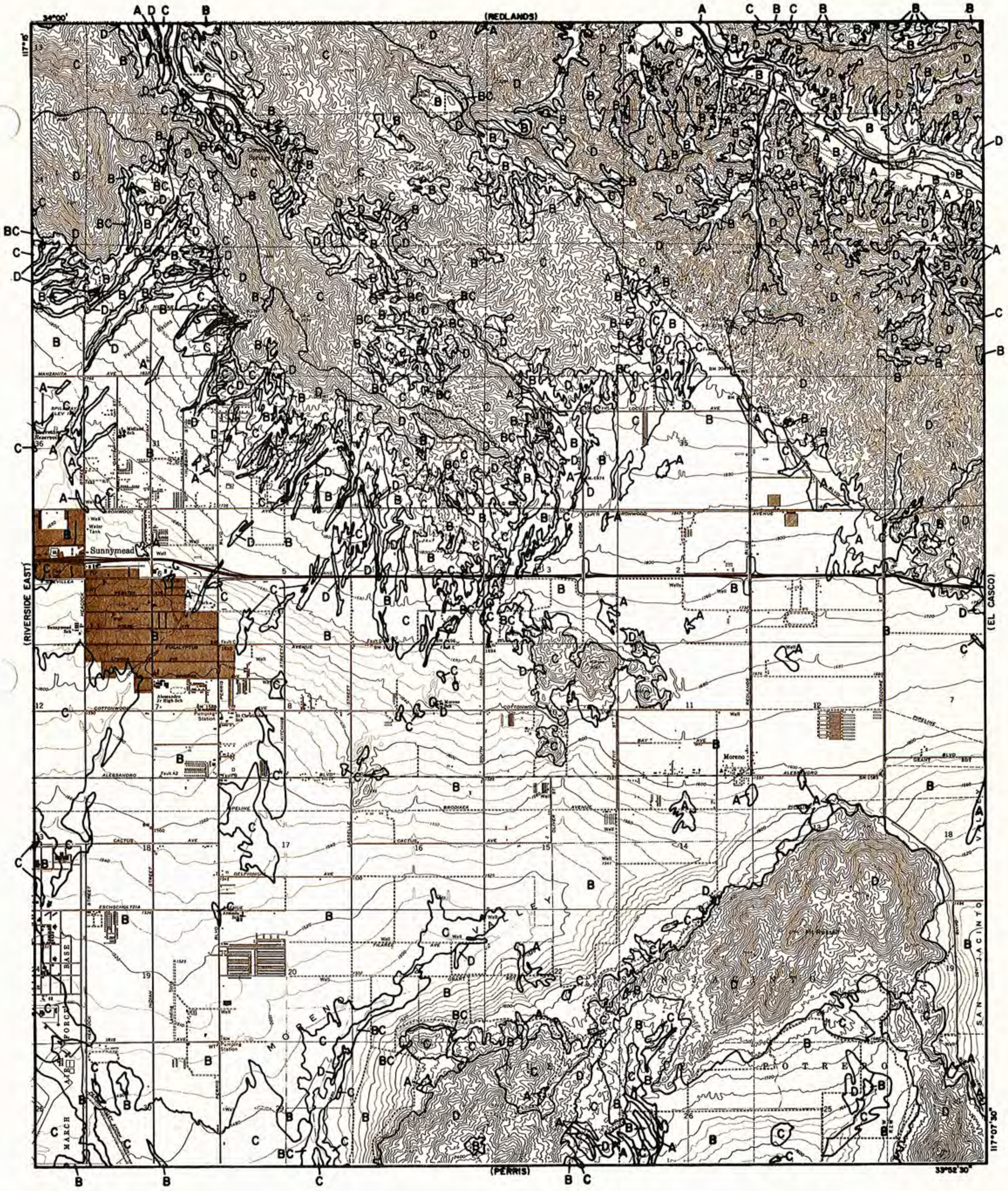
HYDROLOGIC SOILS GROUP MAP FOR RIVERSIDE-EAST



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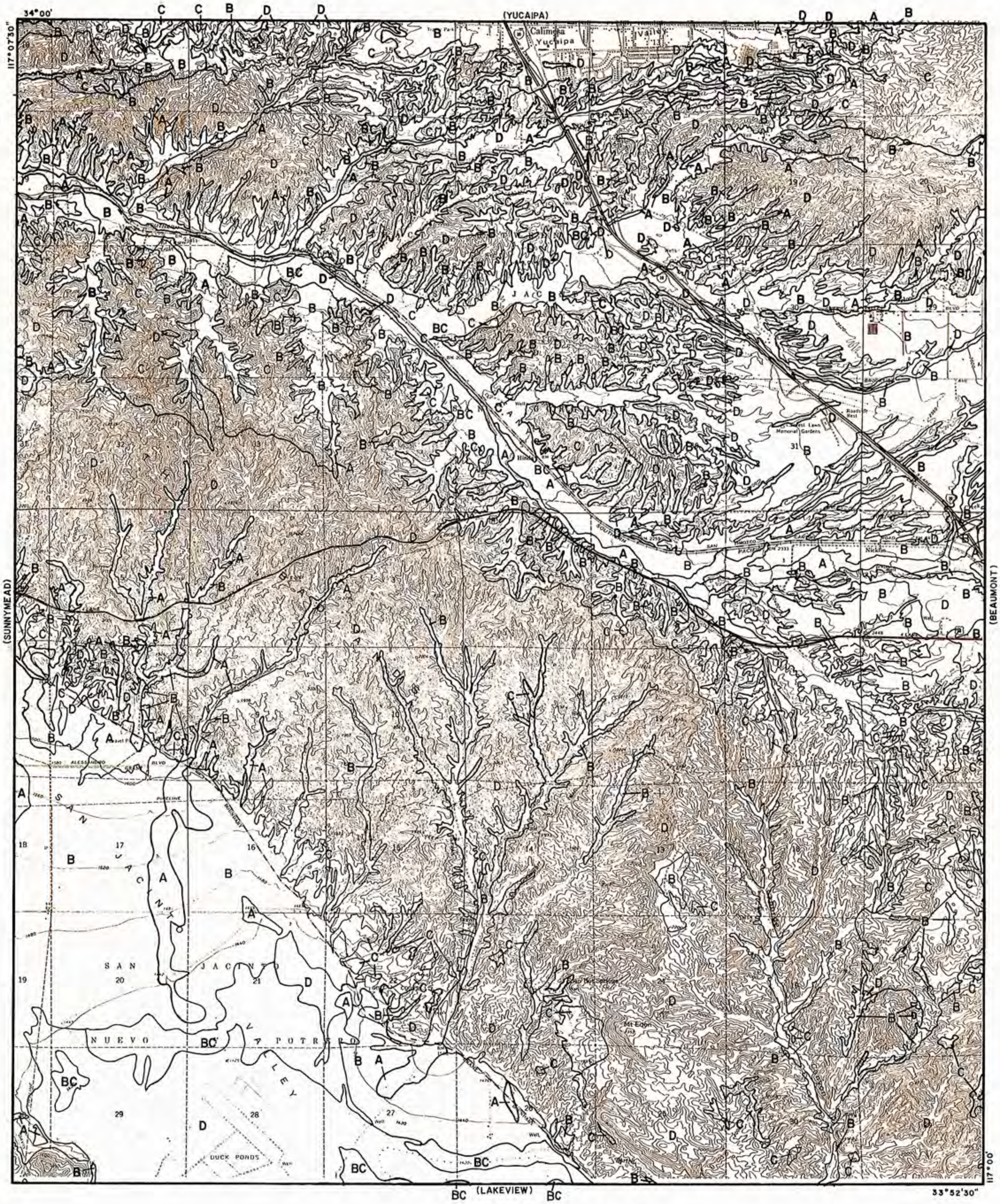
HYDROLOGIC SOILS GROUP MAP FOR SUNNYMEAD



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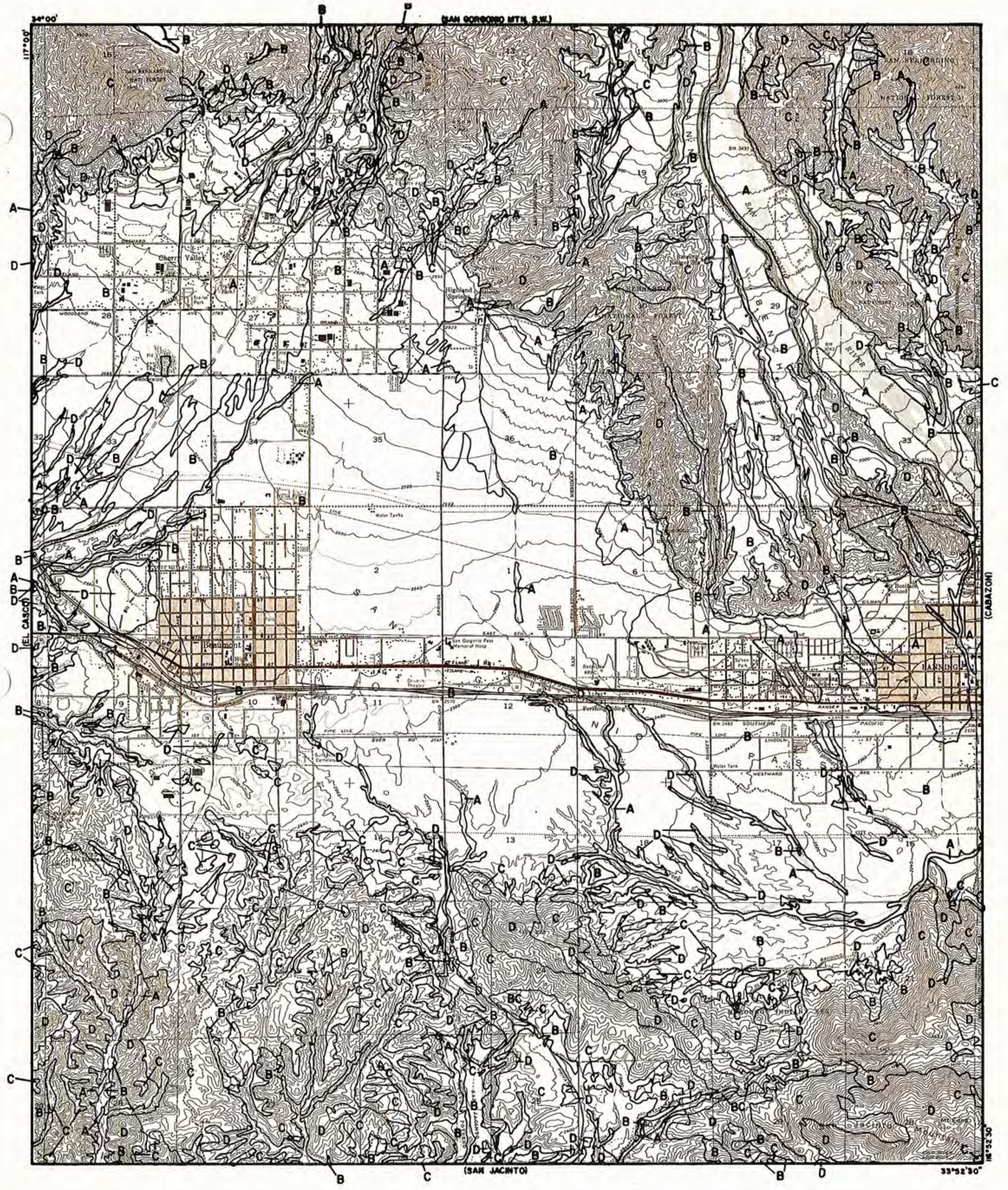
HYDROLOGIC SOILS GROUP MAP FOR EL CASCO

PLATE C-1.18



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HYDROLOGIC SOILS GROUP MAP FOR BEAUMONT

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HYDROLOGIC SOILS GROUP MAP FOR CABAZON

PLATE C-1.20

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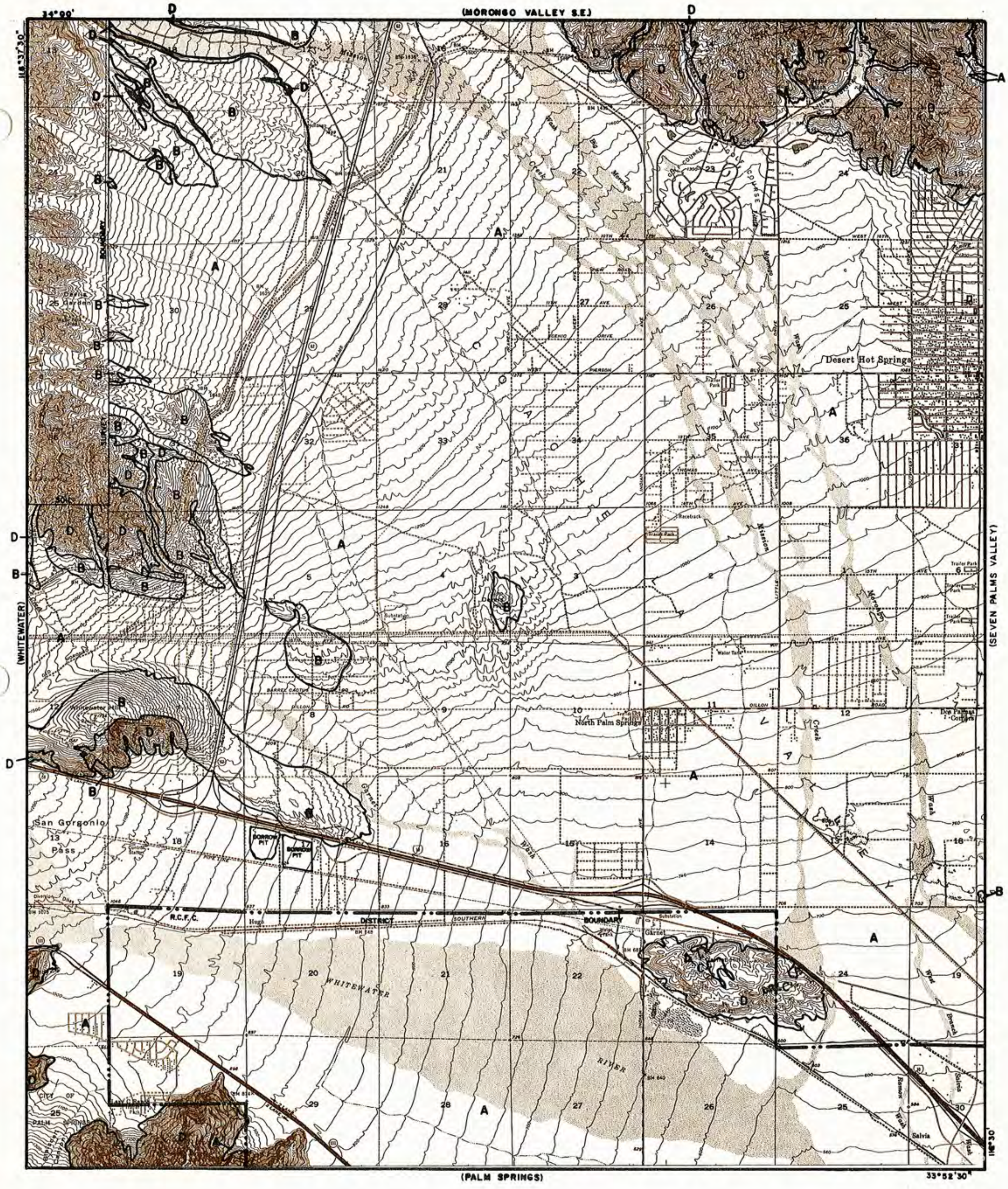
HYDROLOGIC SOILS GROUP MAP FOR WHITEWATER



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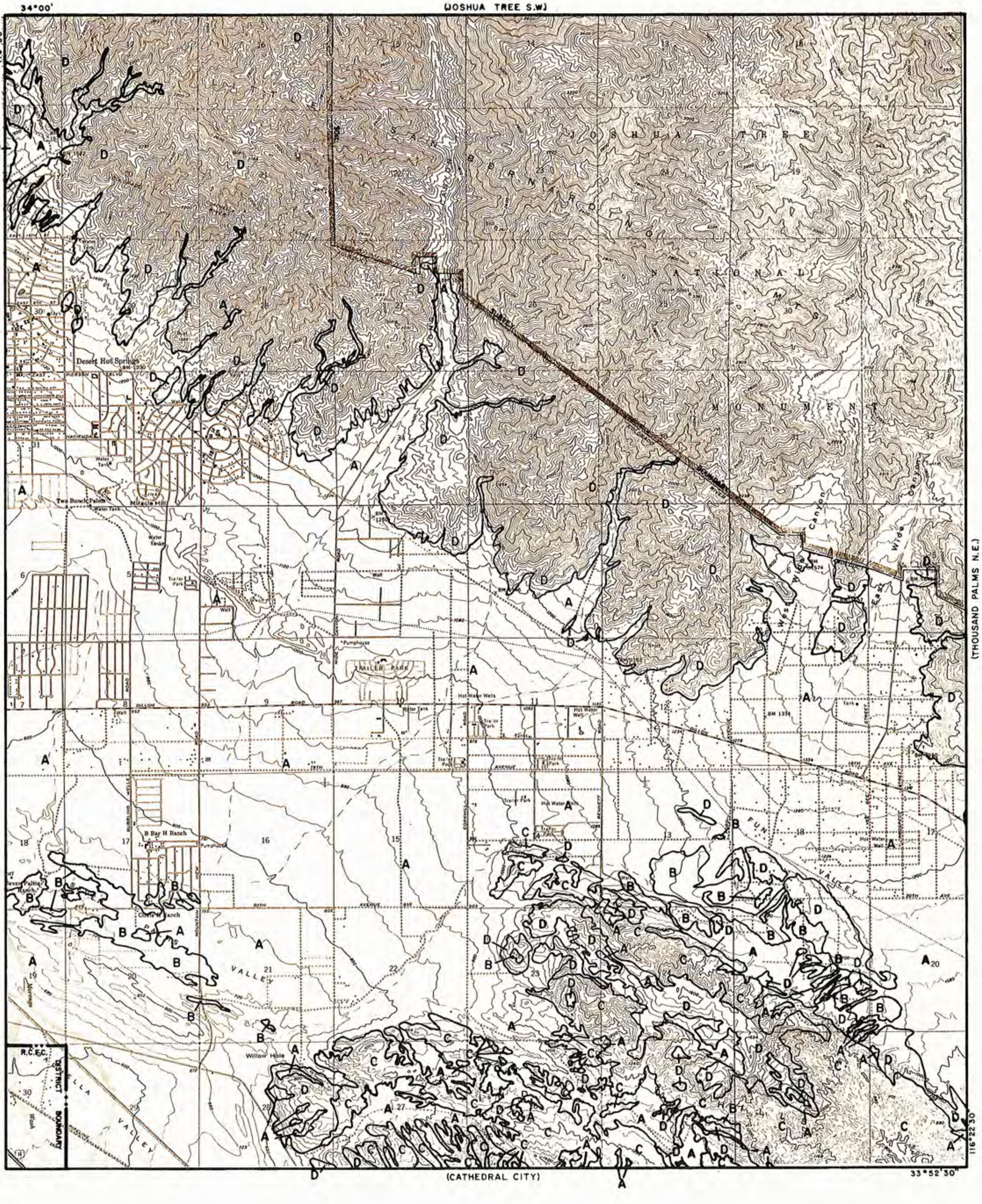
HYDROLOGIC SOILS GROUP MAP FOR DESERT HOT SPRINGS

PLATE C-1.22



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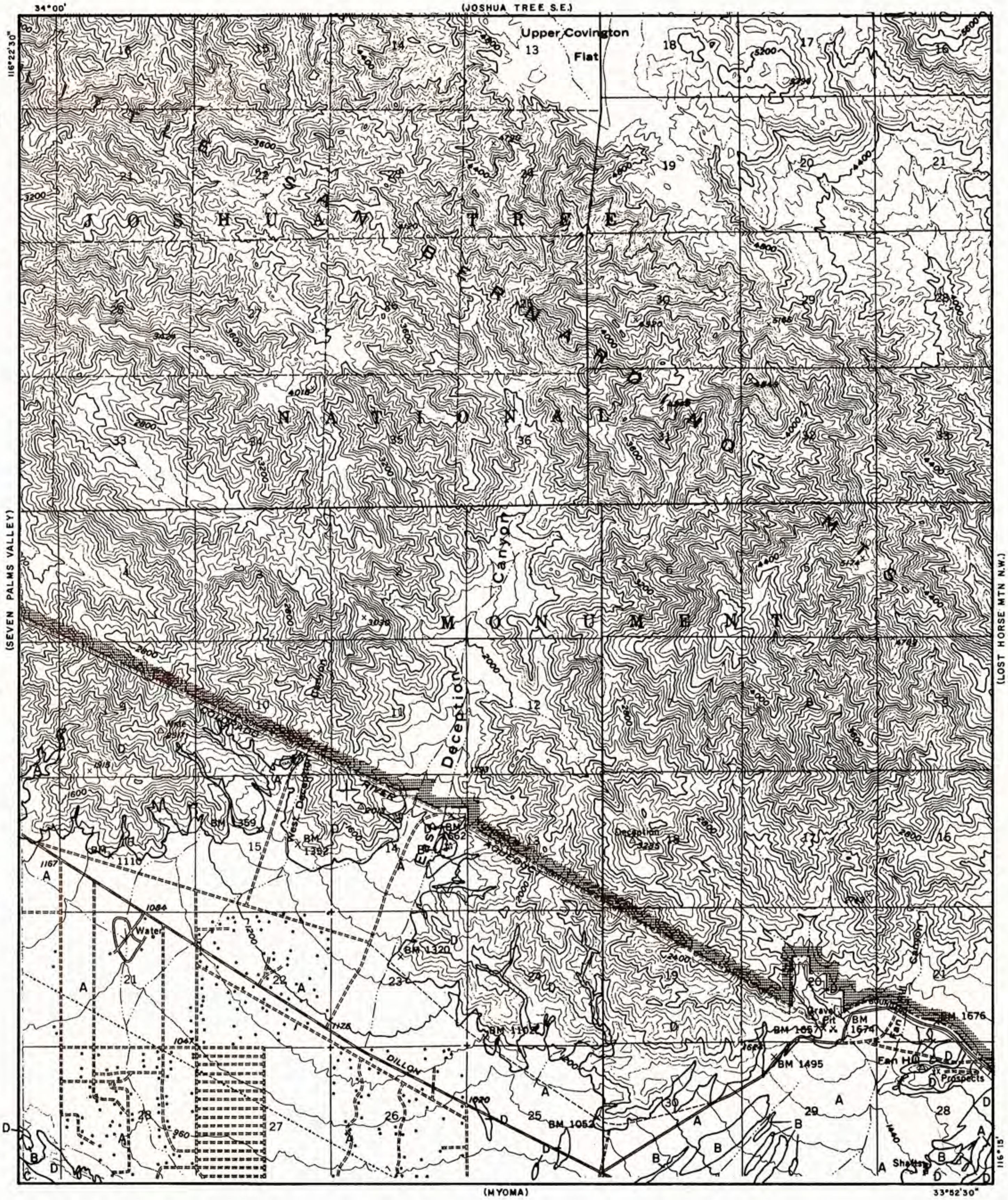
HYDROLOGIC SOILS GROUP MAP FOR SEVEN PALMS VALLEY

PLATE C-1.23



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HYDROLOGIC SOILS GROUP MAP FOR THOUSAND PALMS—N.E.

PLATE C-1.24

LEGEND

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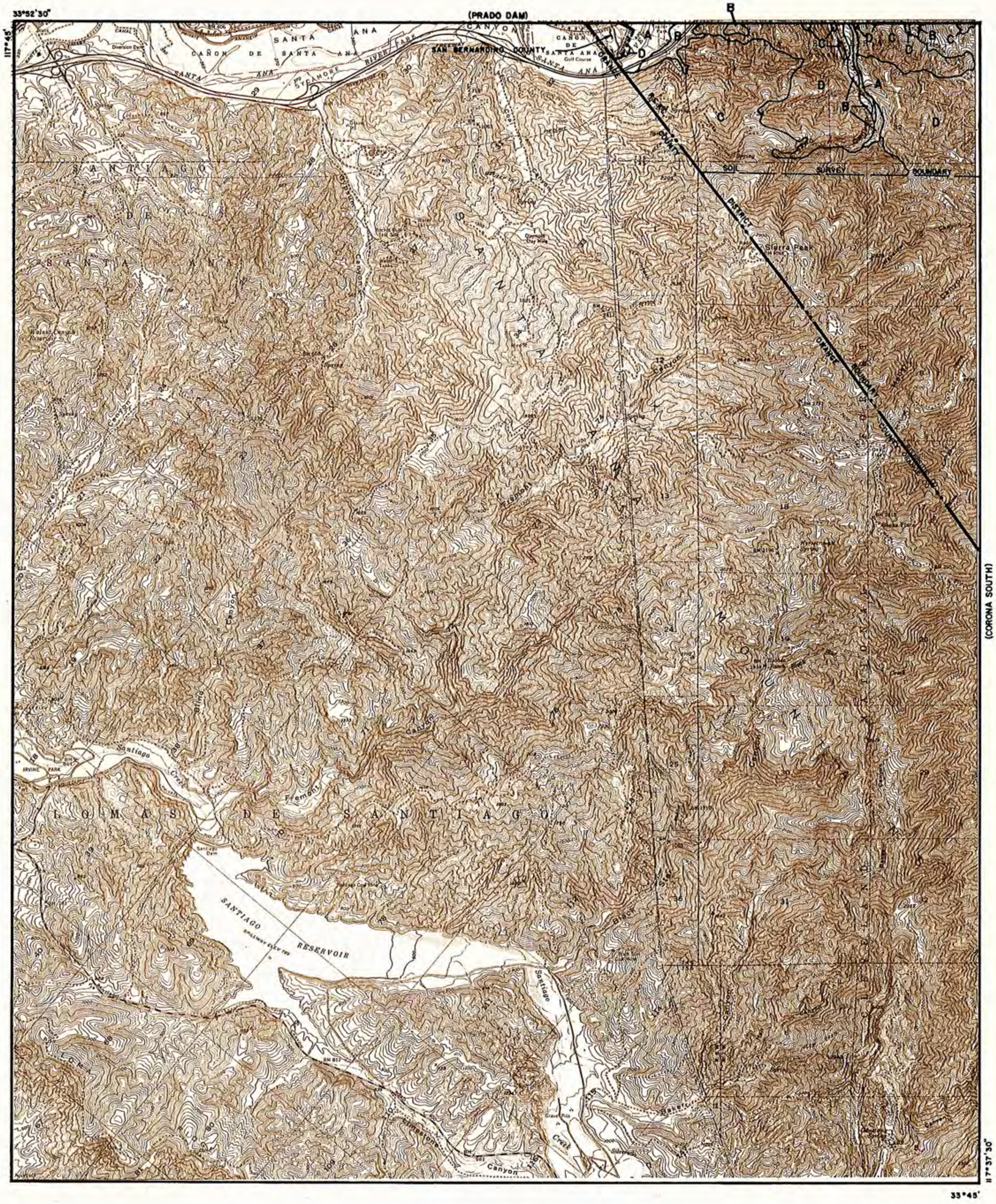
HYDROLOGIC SOILS GROUP MAP FOR LOST HORSE MTN.–N.W.



LEGEND	HYDROLOGIC SOILS GROUP MAP FOR BLACK STAR CANYON
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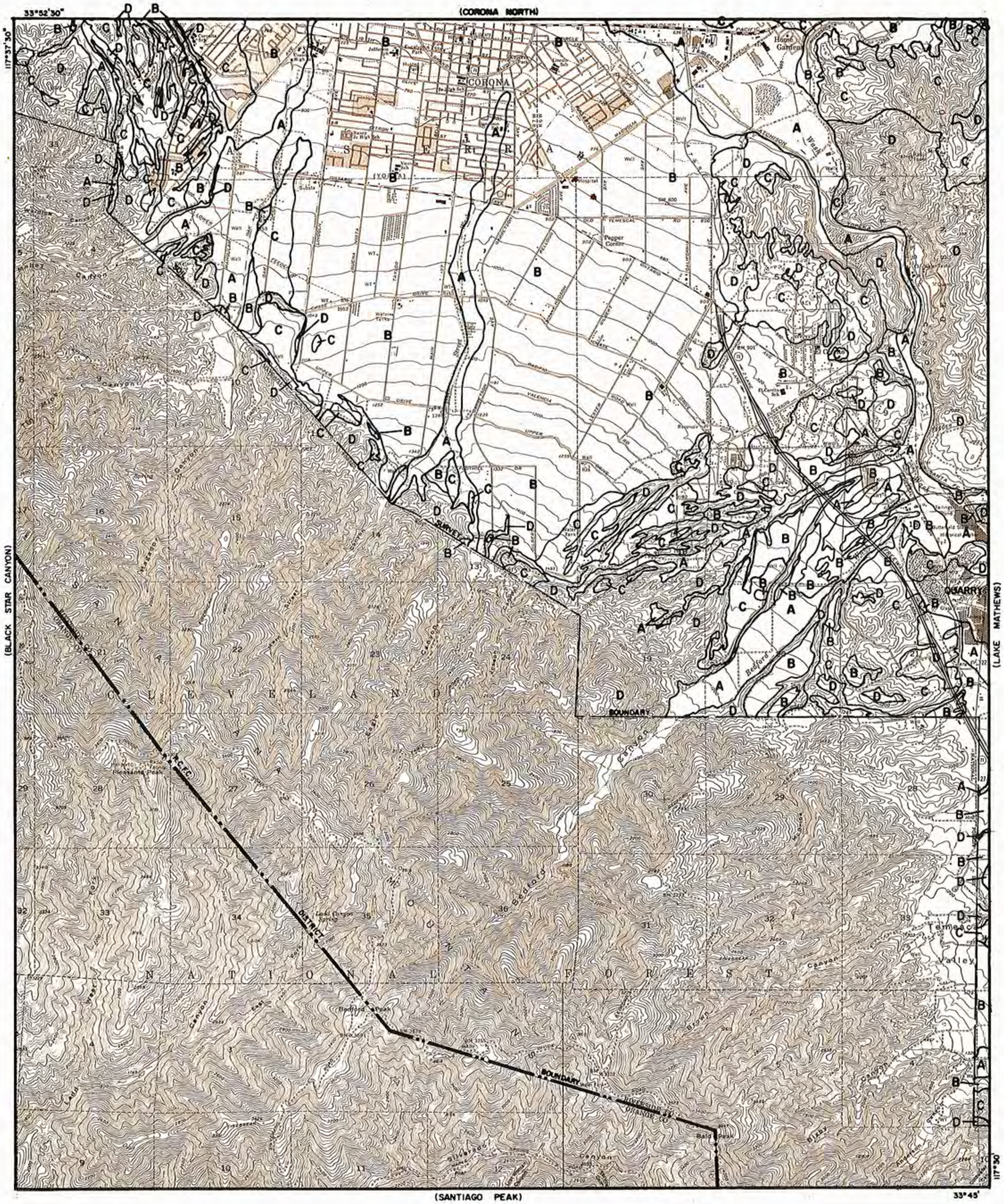
PLATE C-1.26



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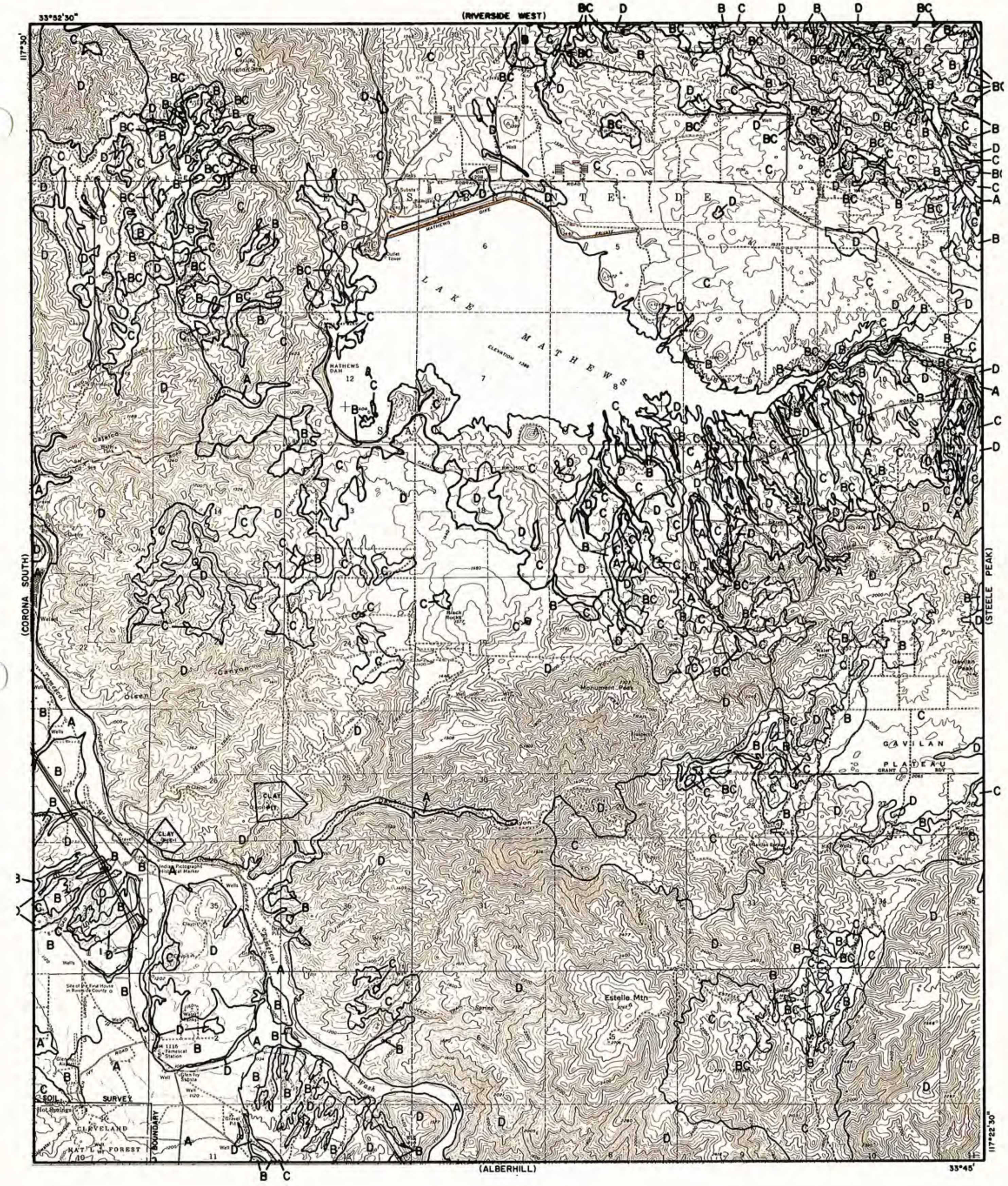
HYDROLOGIC SOILS GROUP MAP FOR CORONA-SOUTH



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HYDROLOGIC SOILS GROUP MAP FOR LAKE MATHEWS

PLATE C-1.28

LEGEND

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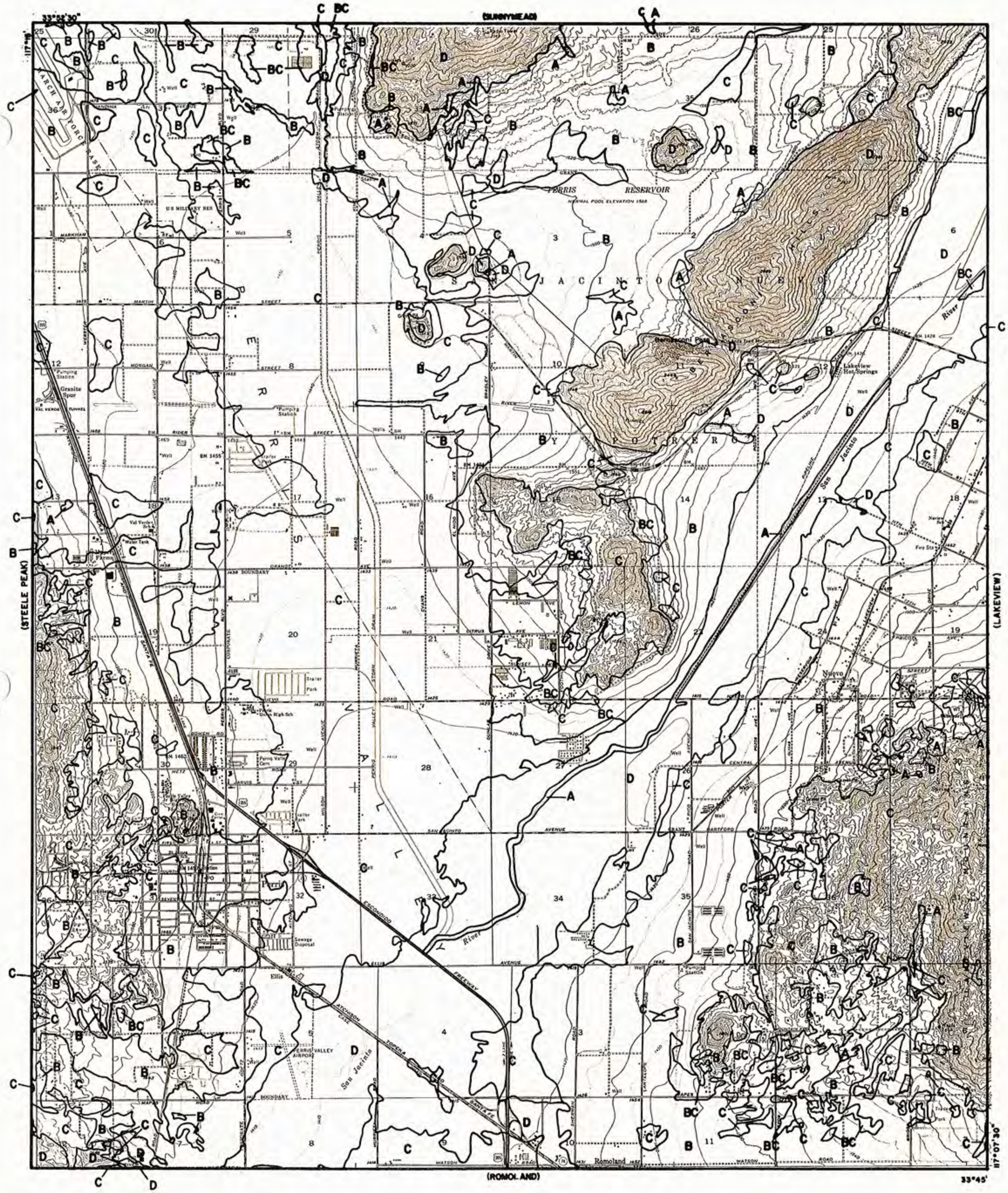
HYDROLOGIC SOILS GROUP MAP FOR STEELE PEAK

PLATE C-1.29



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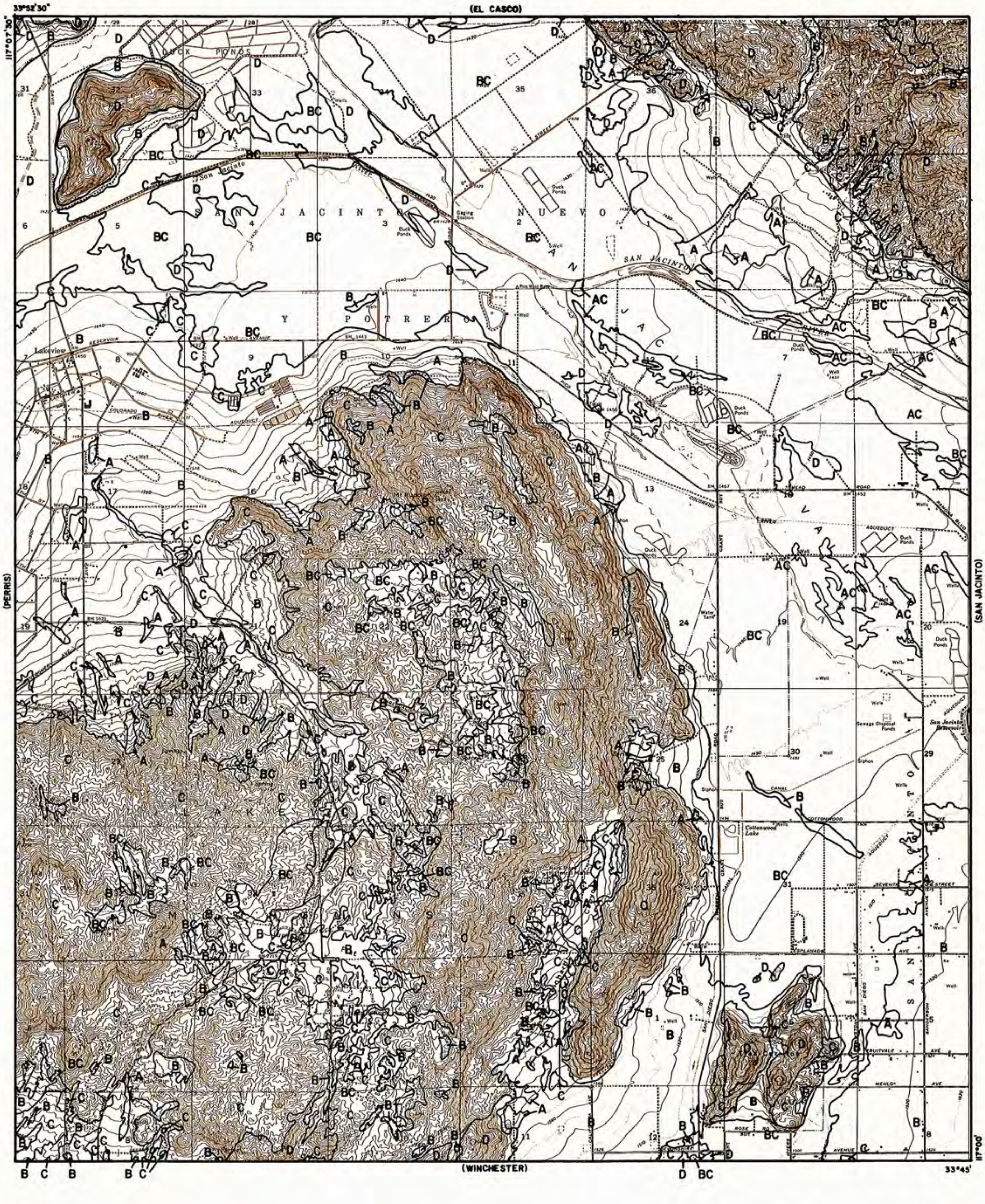
HYDROLOGIC SOILS GROUP MAP FOR PERRIS

PLATE C-1.30



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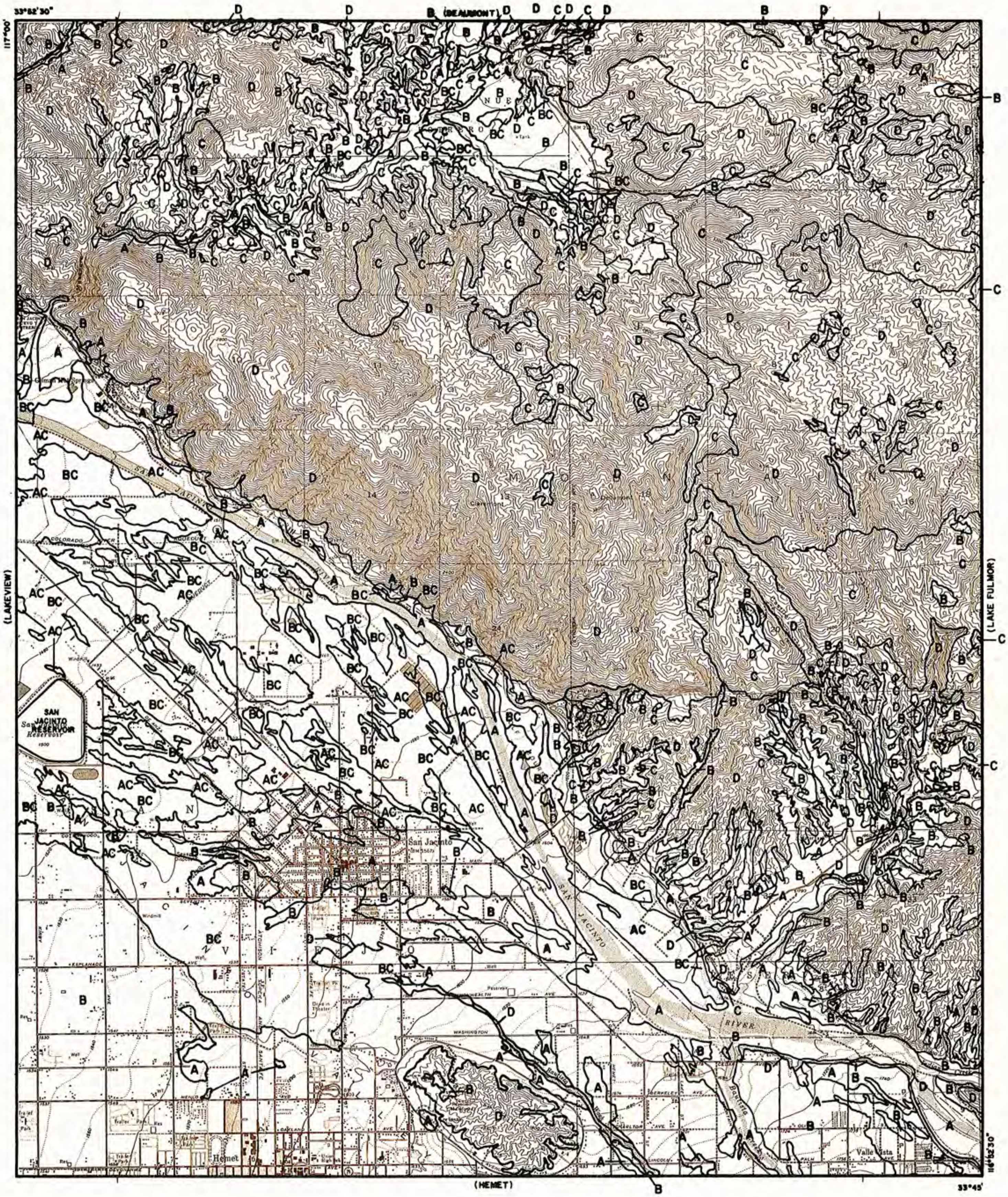
HYDROLOGIC SOILS GROUP MAP FOR LAKEVIEW



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HYDROLOGIC SOILS GROUP MAP FOR SAN JACINTO

PLATE C-1.32

LEGEND

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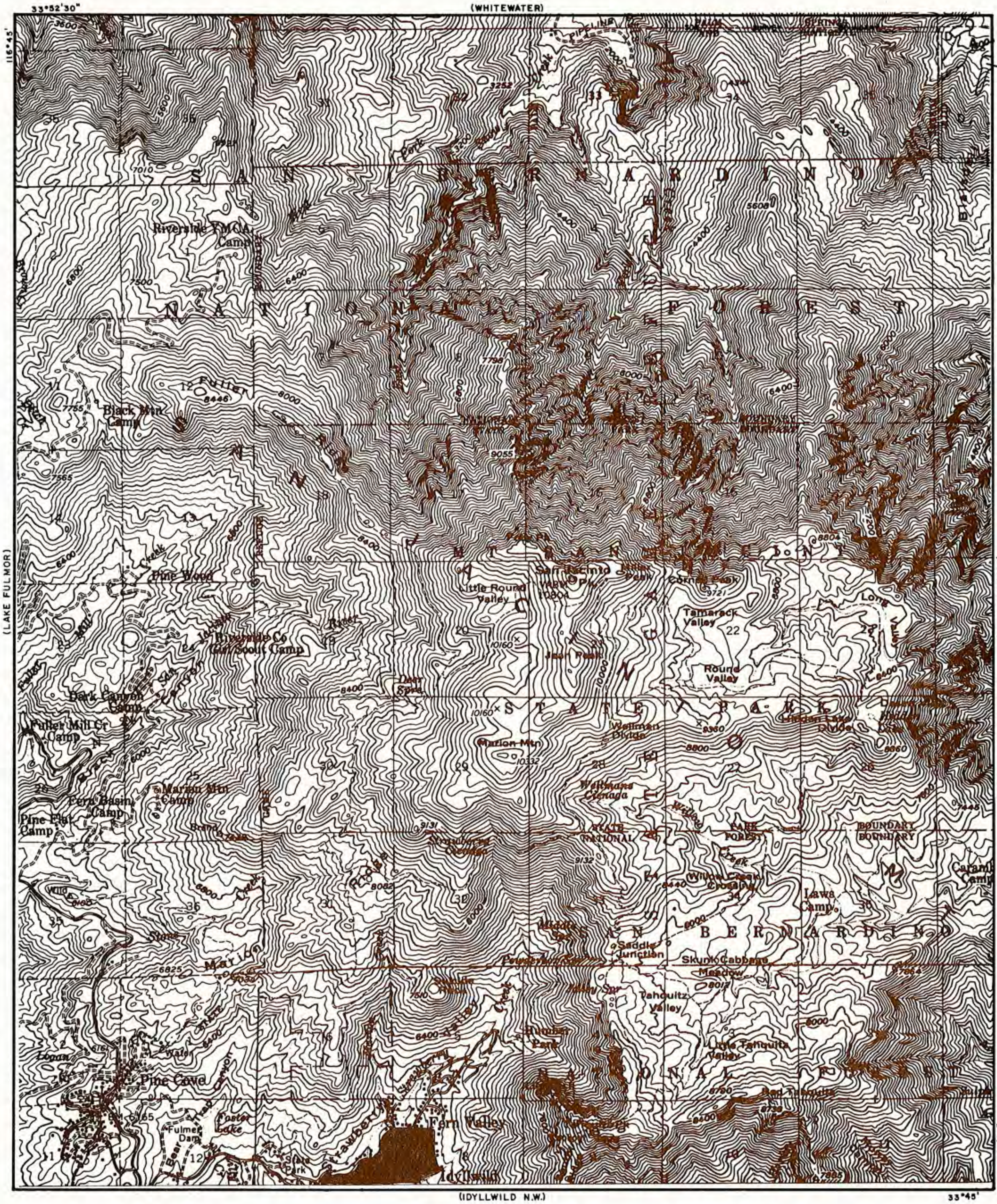
0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR LAKE FULMOR



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

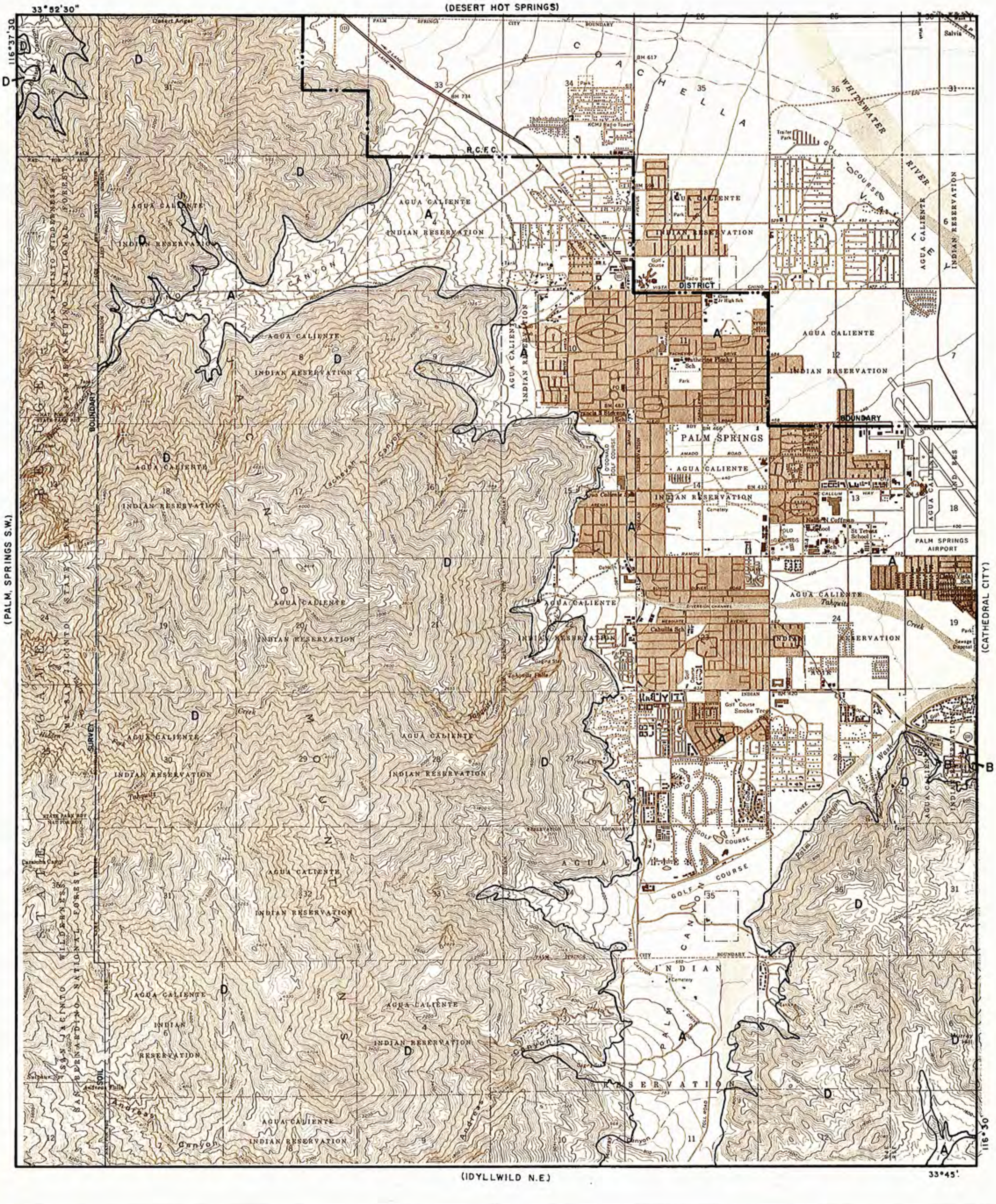
RCFC & WCD

HYDROLOGY MANUAL

N

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR PALM SPRINGS—S.W.



LEGEND

—— SOILS GROUP BOUNDARY

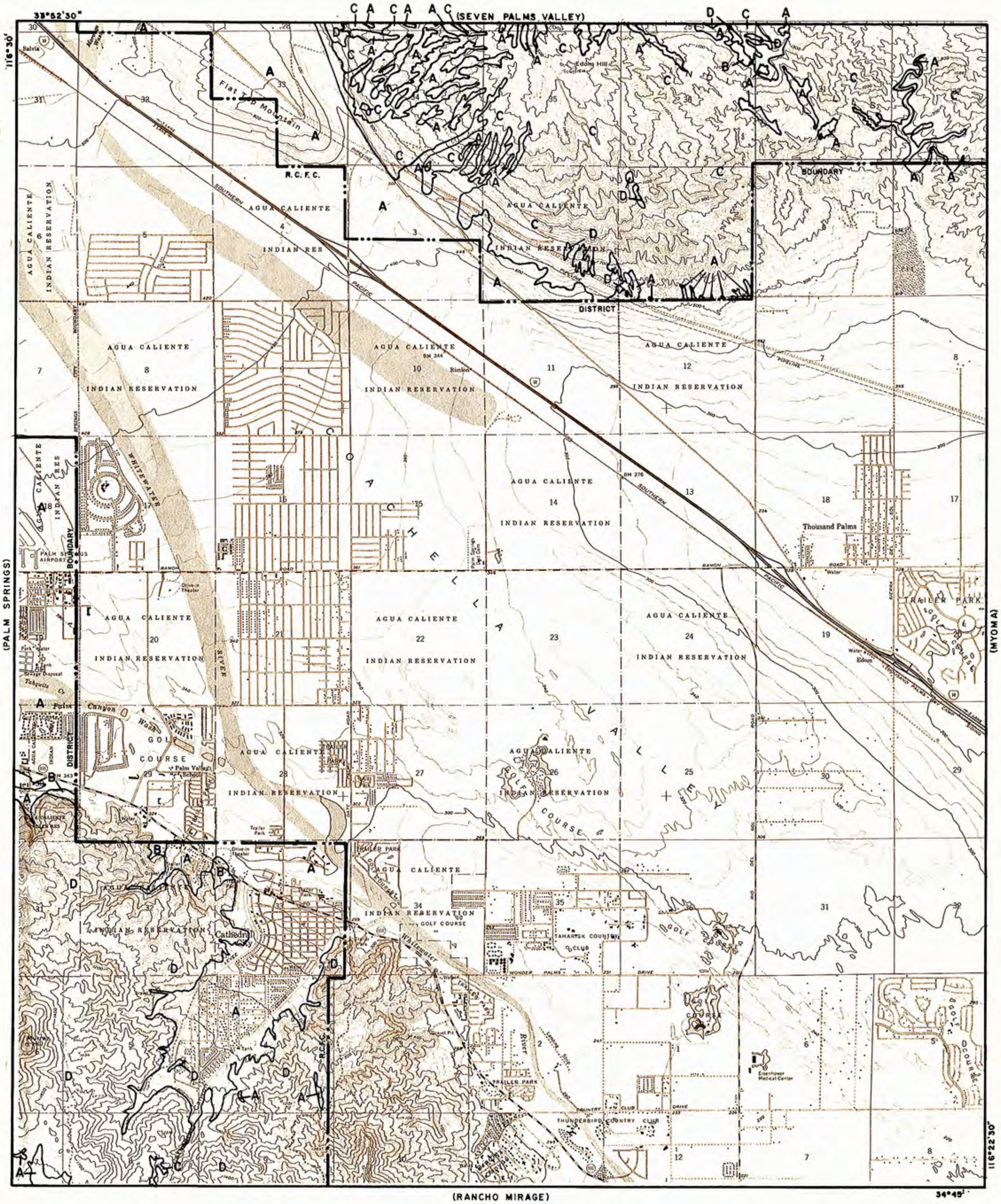
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR PALM SPRINGS



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

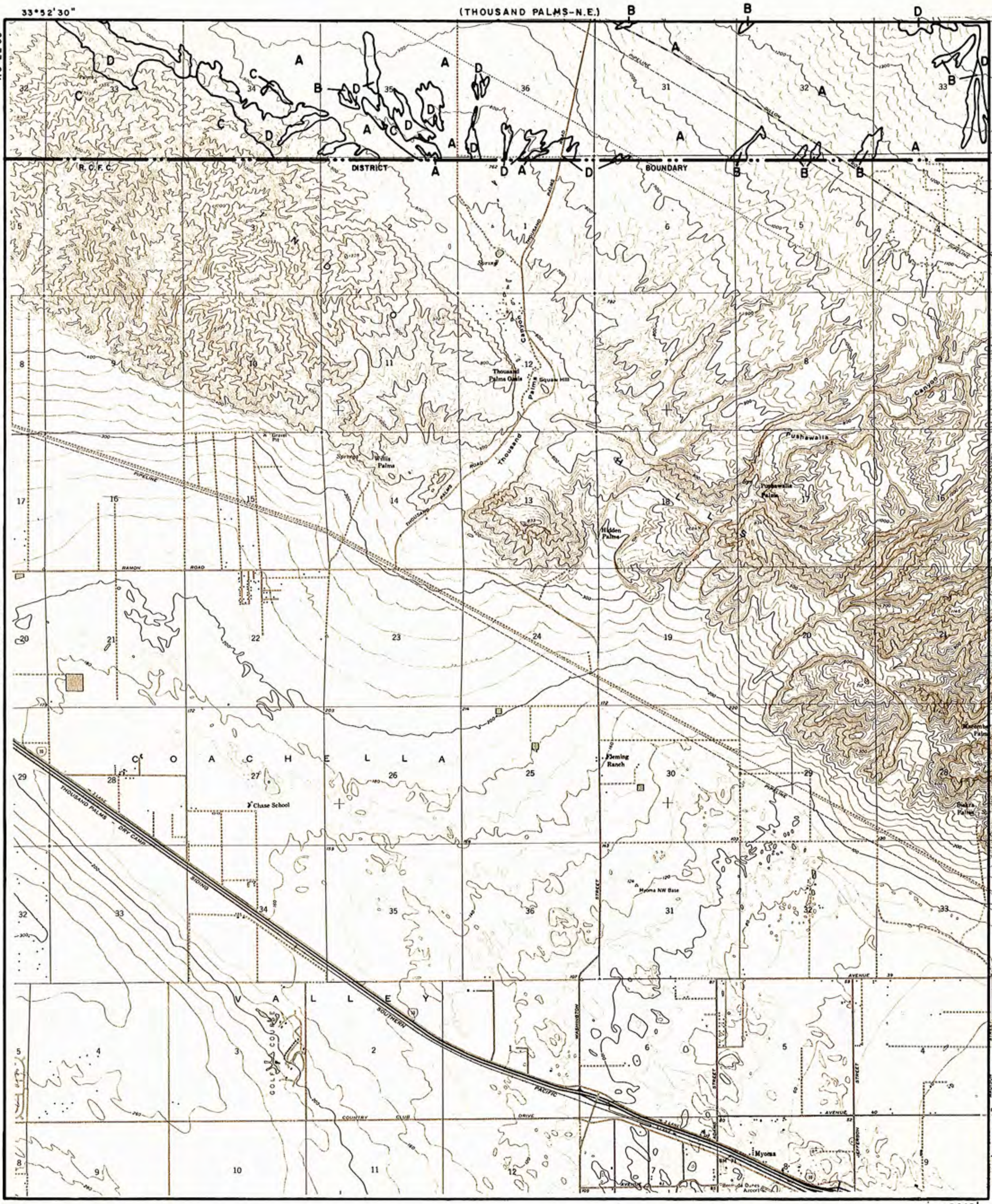
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR CATHEDRAL CITY

PLATE C-1.36



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR MYOMA

PLATE C-1.37

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR LOST HORSE MTN.—S.W.

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

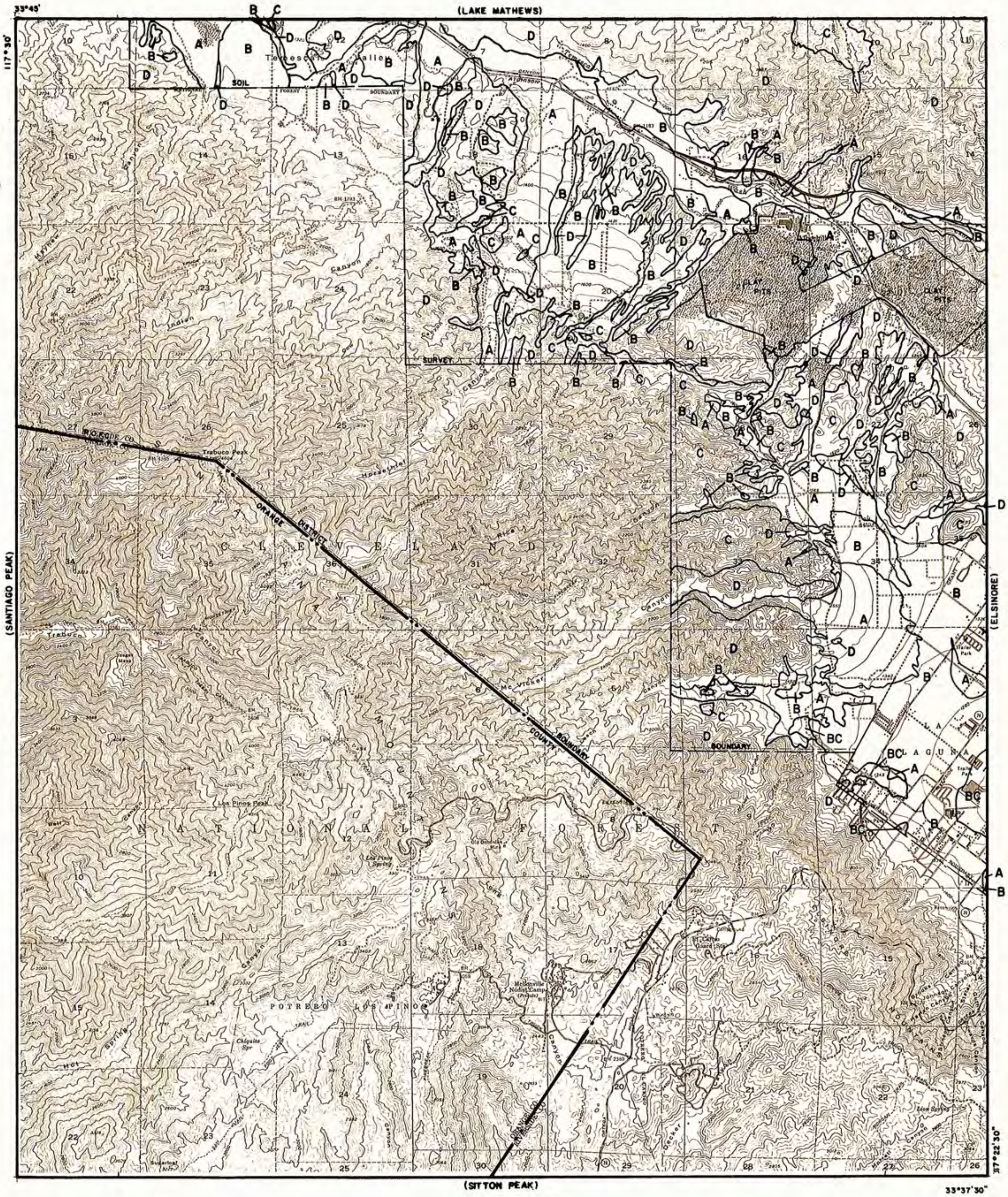
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR SANTIAGO PEAK

PLATE C-1.39



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR ALBERHILL

PLATE C-1.40

LEGEND

—— SOILS GROUP BOUNDARY

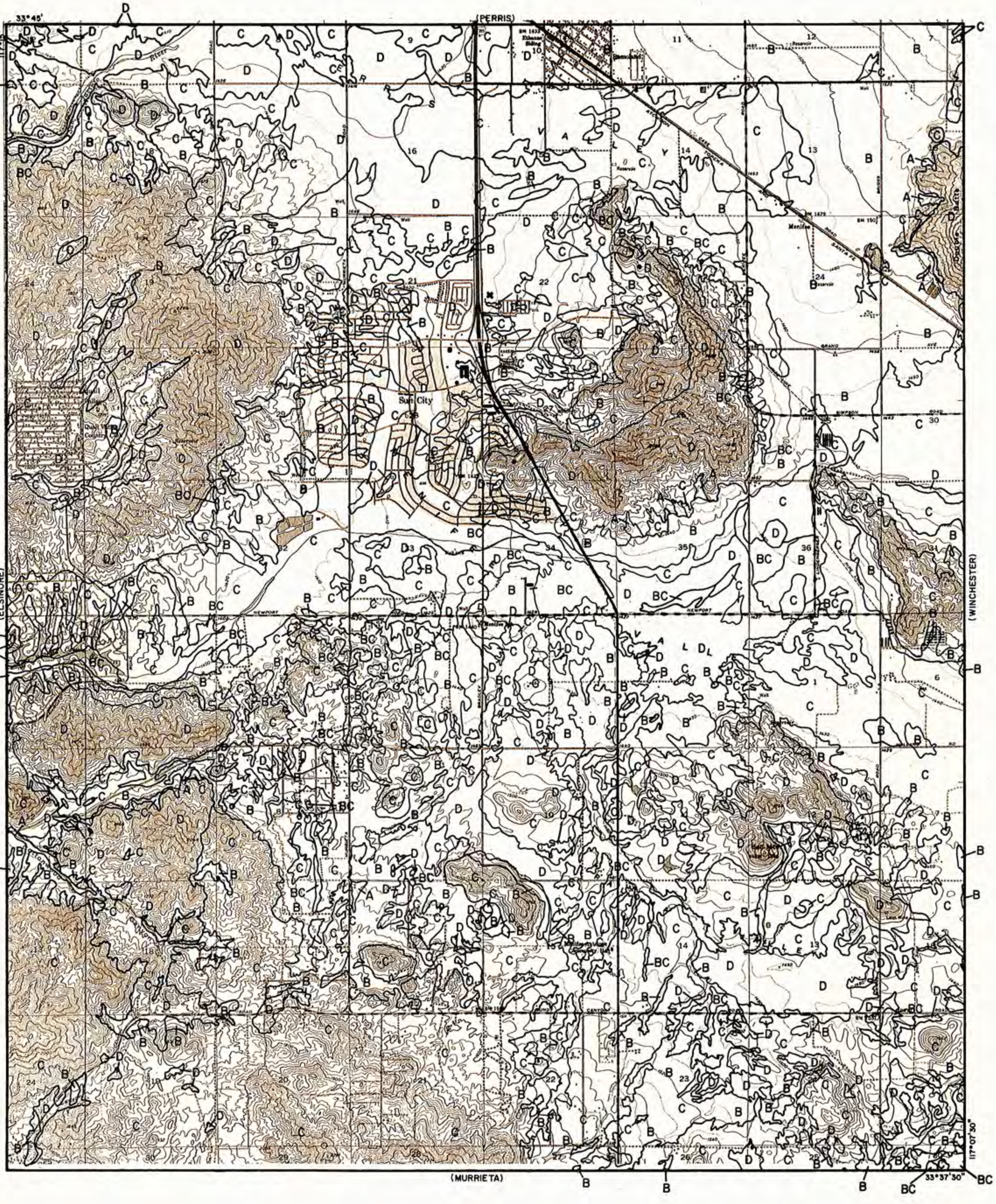
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR ELSINORE



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

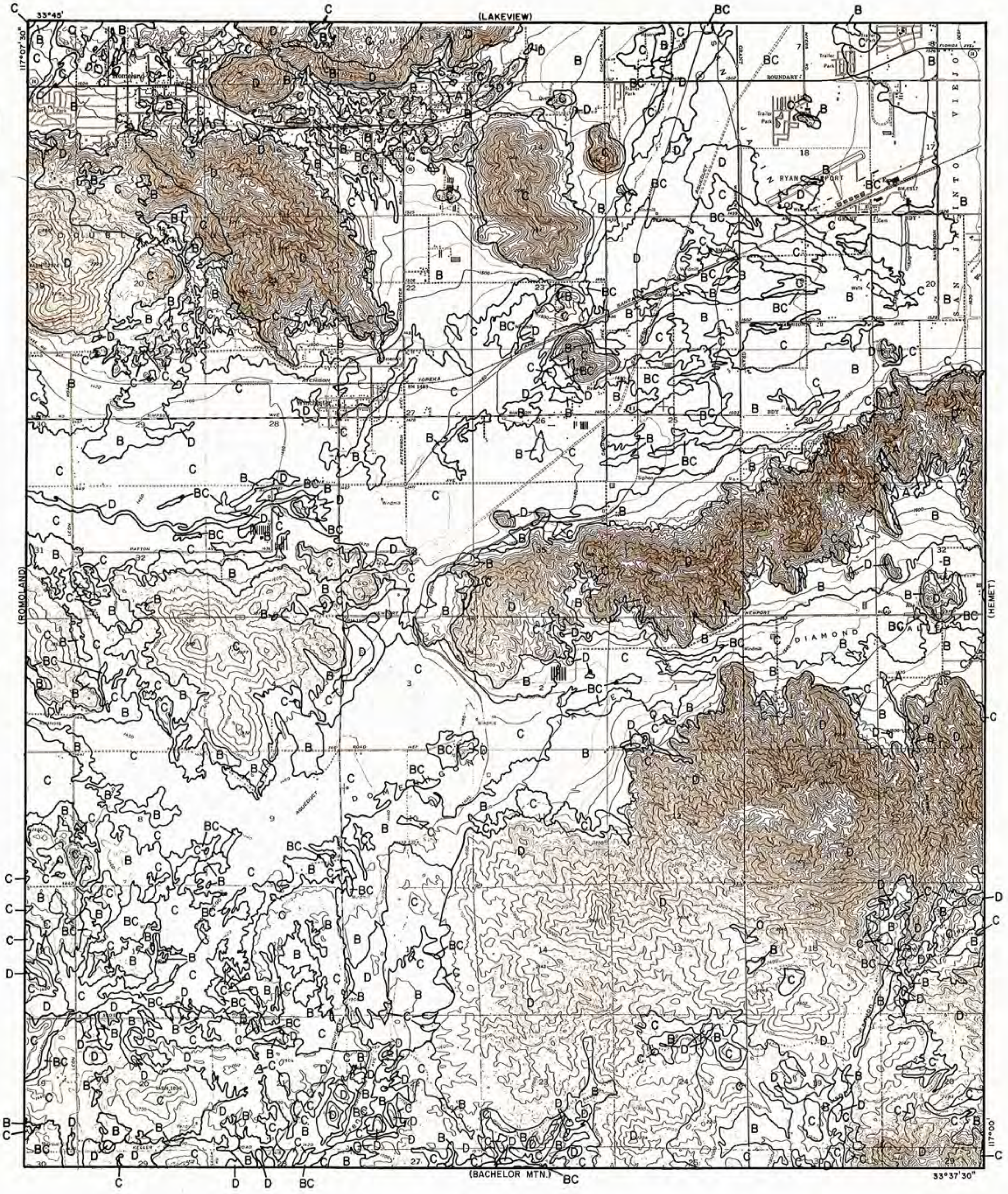
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR ROMOLAND

PLATE C-1.42



LEGEND

—— SOILS GROUP BOUNDARY

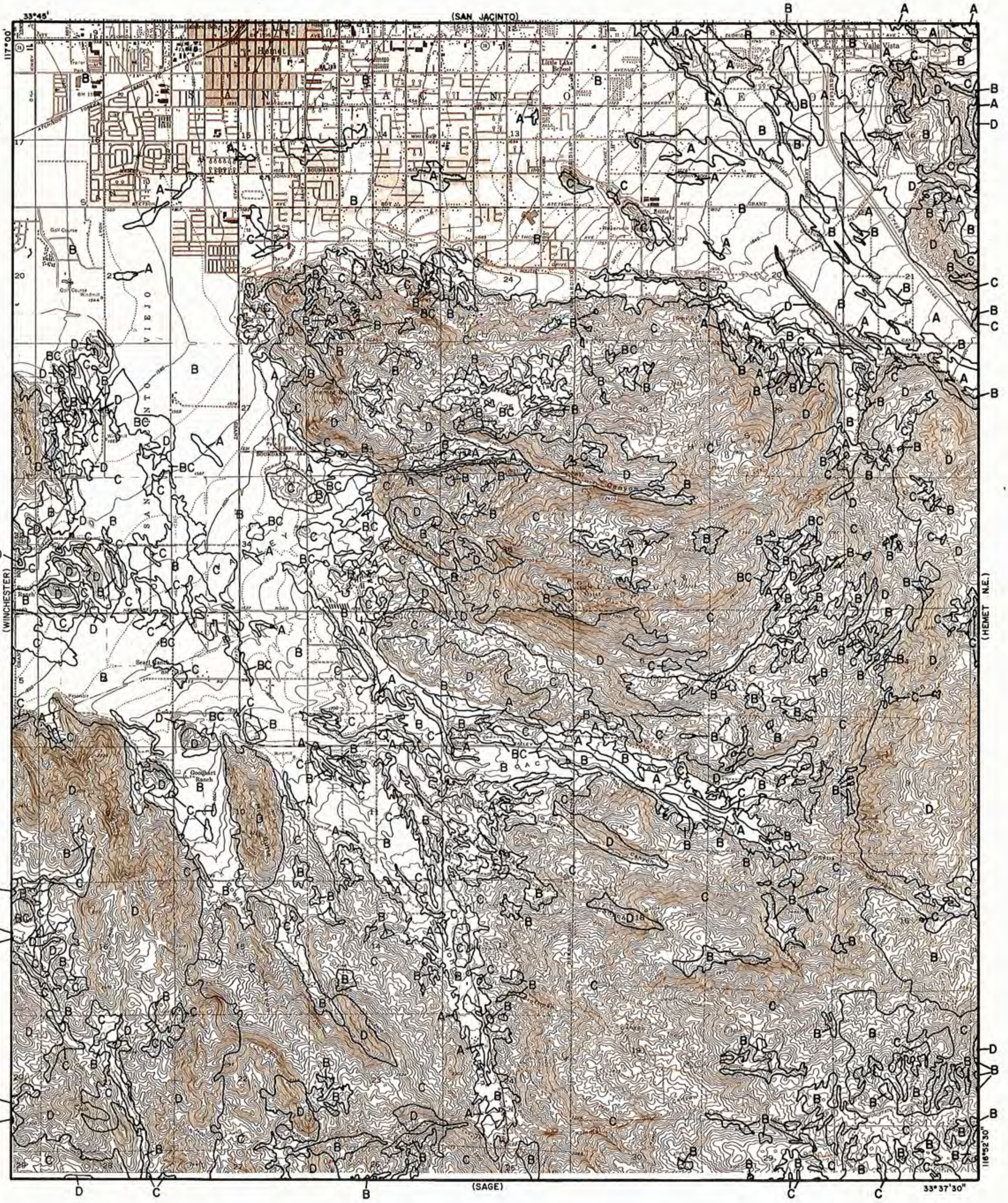
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR WINCHESTER



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

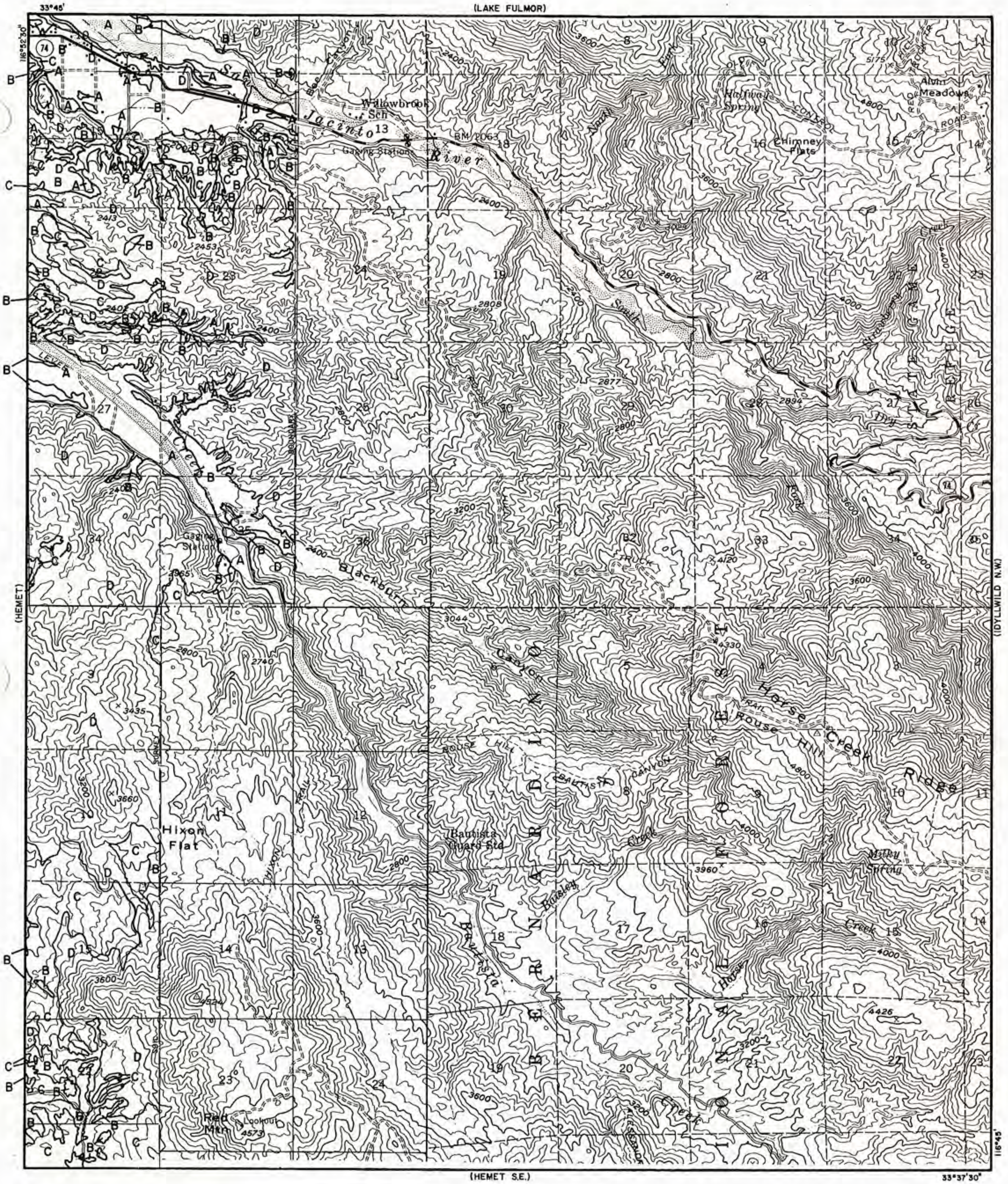
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR HEMET

PLATE C-1.44



LEGEND

—— SOILS GROUP BOUNDARY

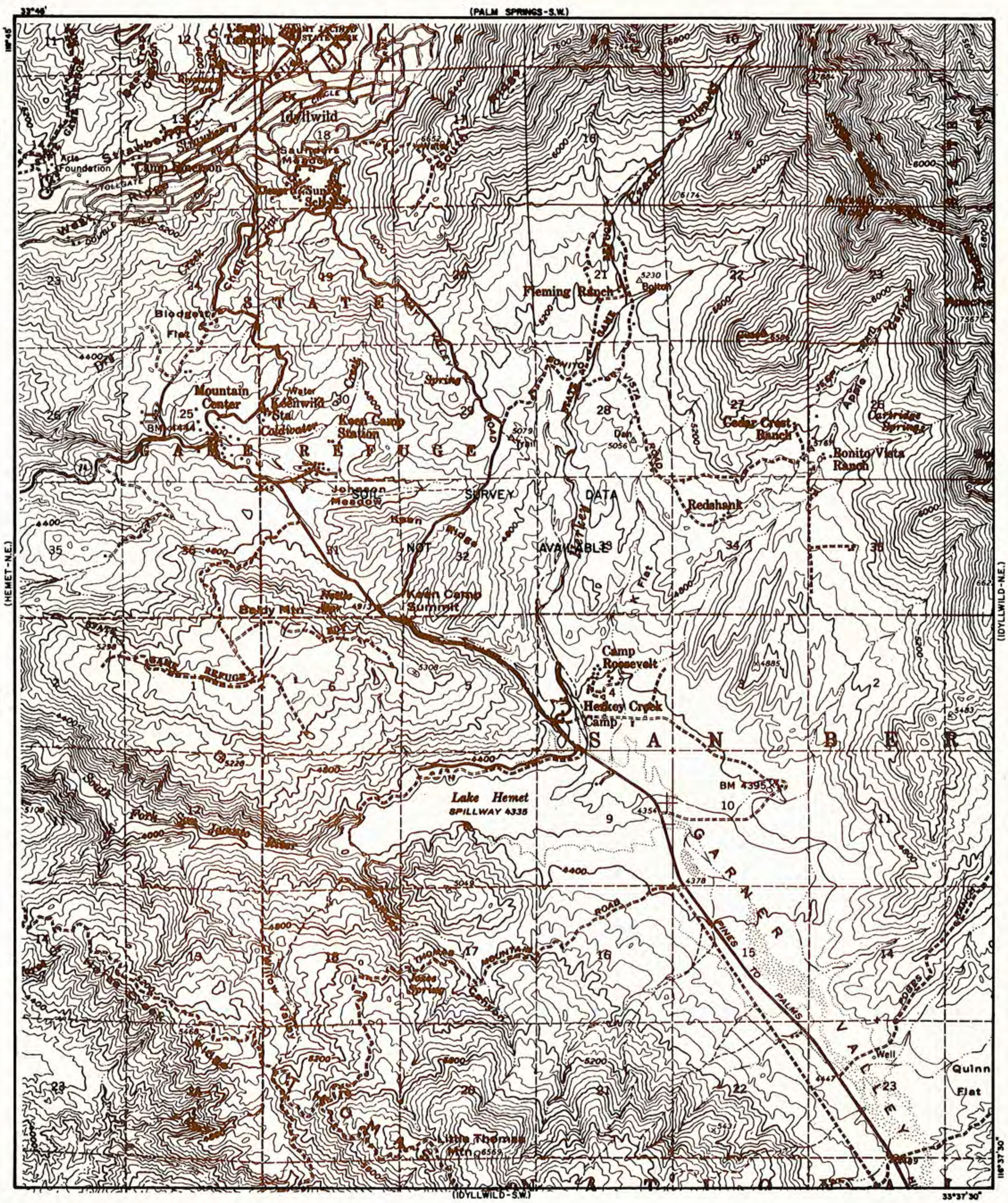
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR HEMET–N.E.



LEGEND

—— SOILS GROUP BOUNDARY

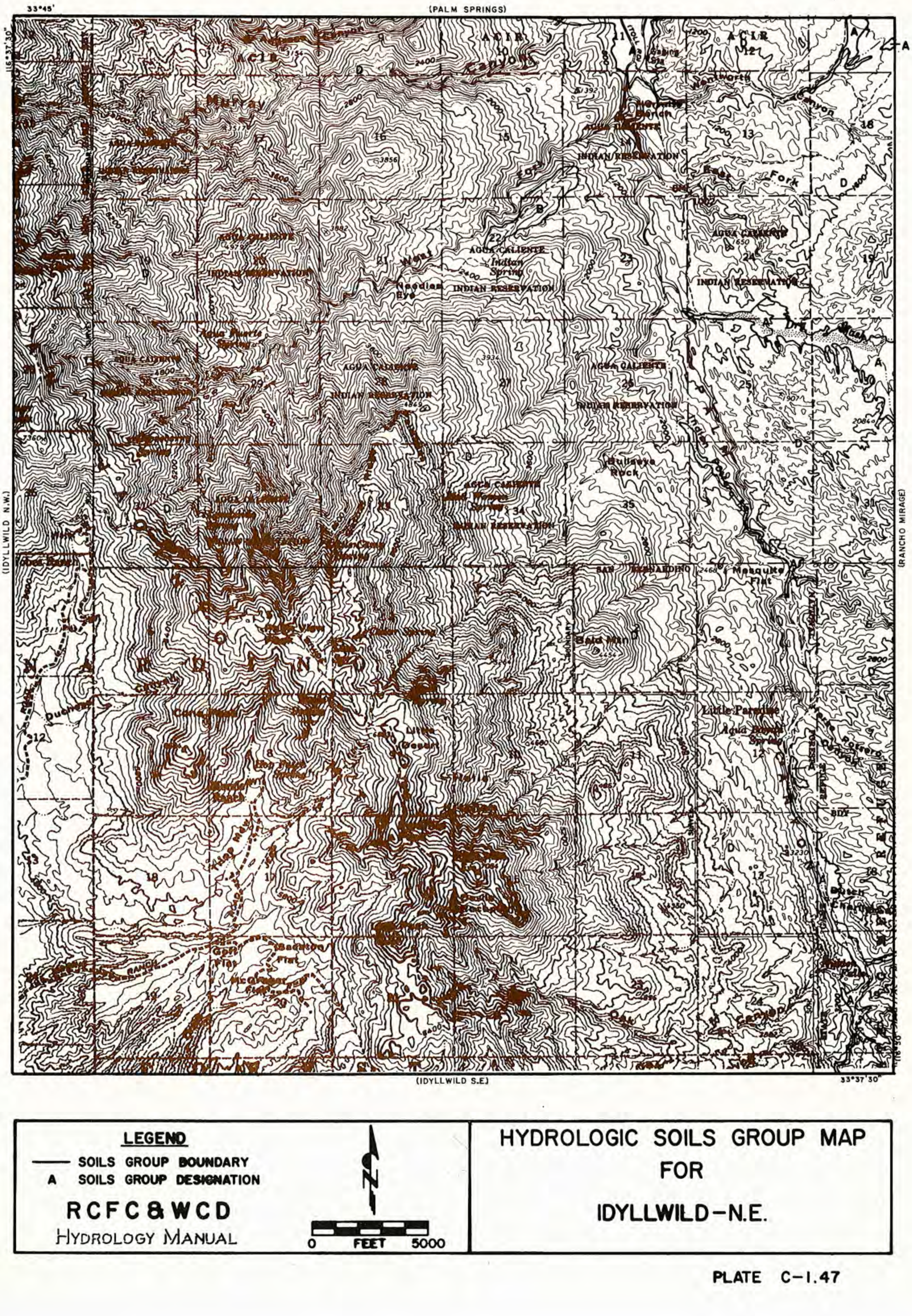
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR IDYLLWILD-N.W.



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR IDYLLWILD-N.E.

PLATE C-1.47

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR RANCHO MIRAGE

PLATE C-1.48

LEGEND

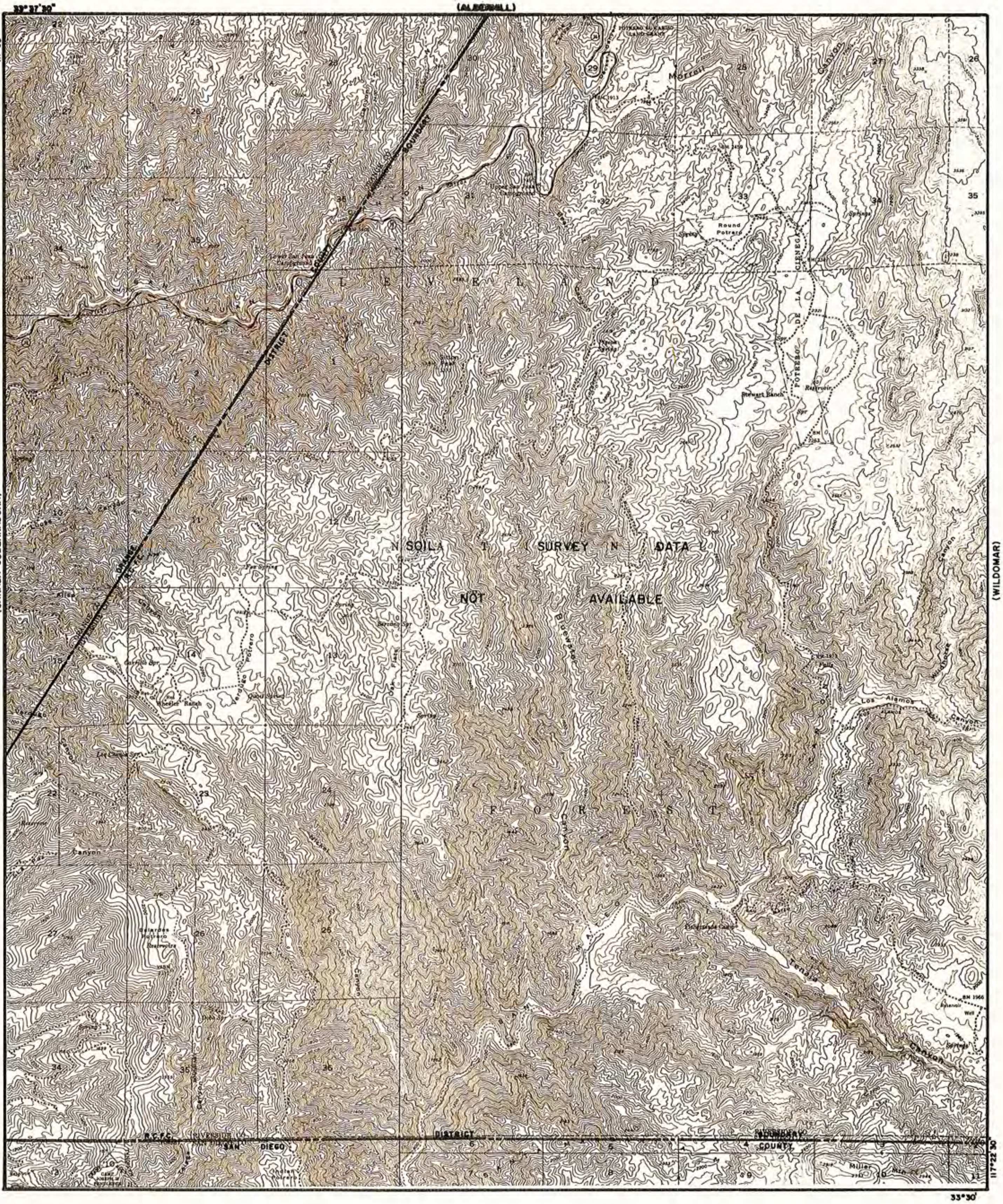
—— SOILS GROUP BOUNDARY
A SOILS GROUP DESIGNATION

RCFC & WCD
HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR CAÑADA GOBERNADORA

PLATE C-1.49



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR SITTON PEAK

PLATE C-1.50

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

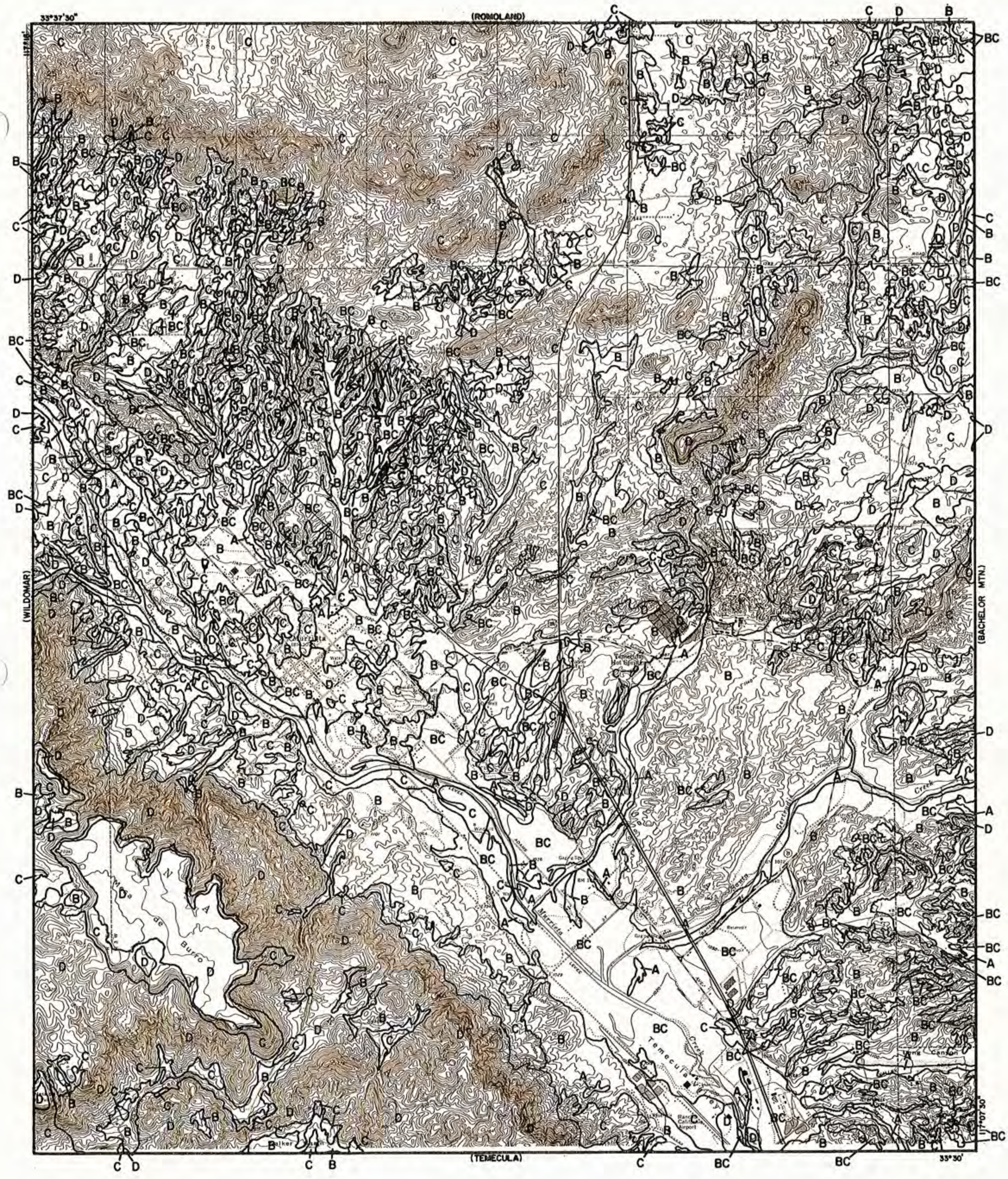
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR WILDOMAR

PLATE C-1.51



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

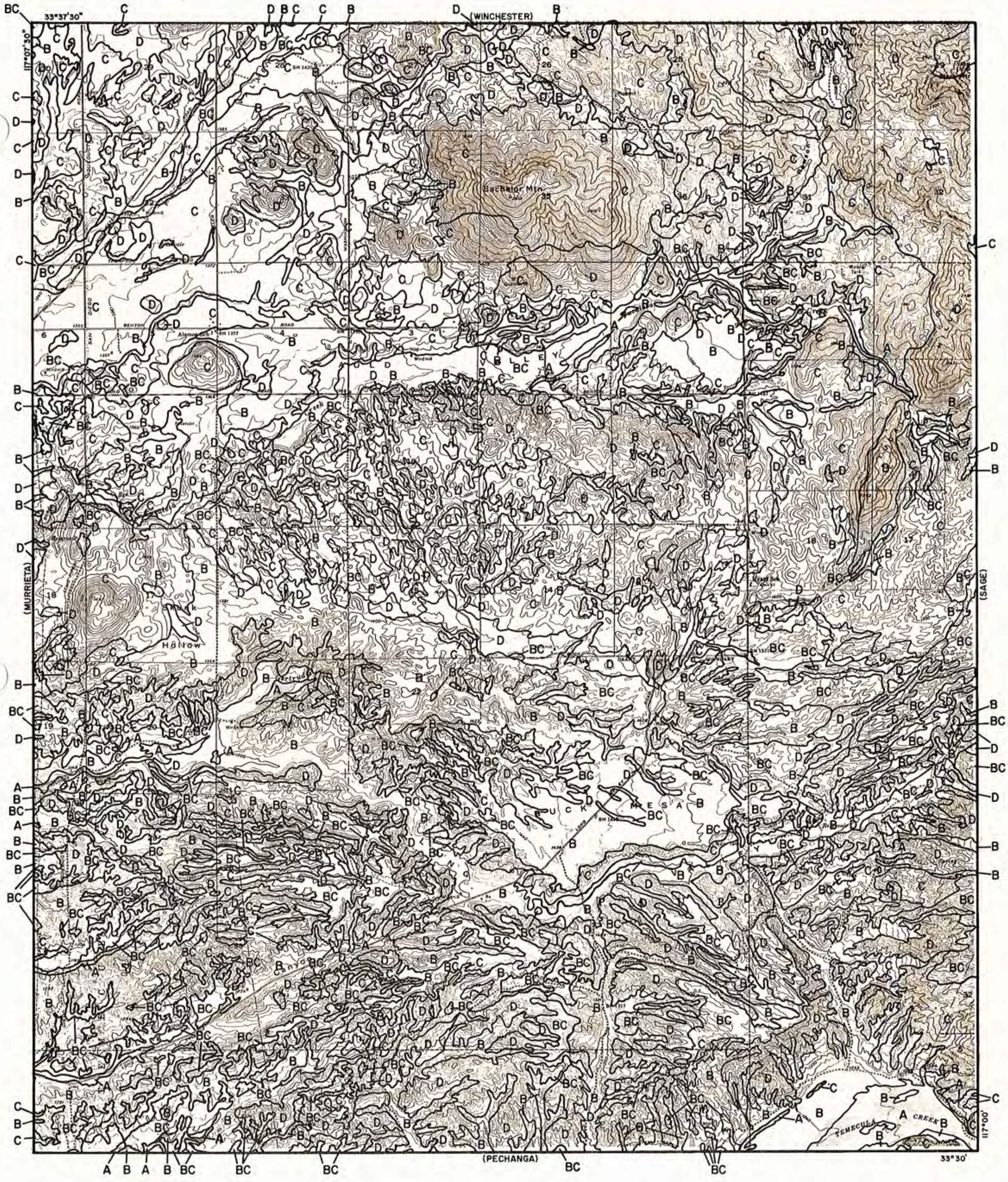
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR MURRIETA

PLATE C-1.52



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR BACHELOR MTN.

PLATE C-1.53

LEGEND

—— SOILS GROUP BOUNDARY

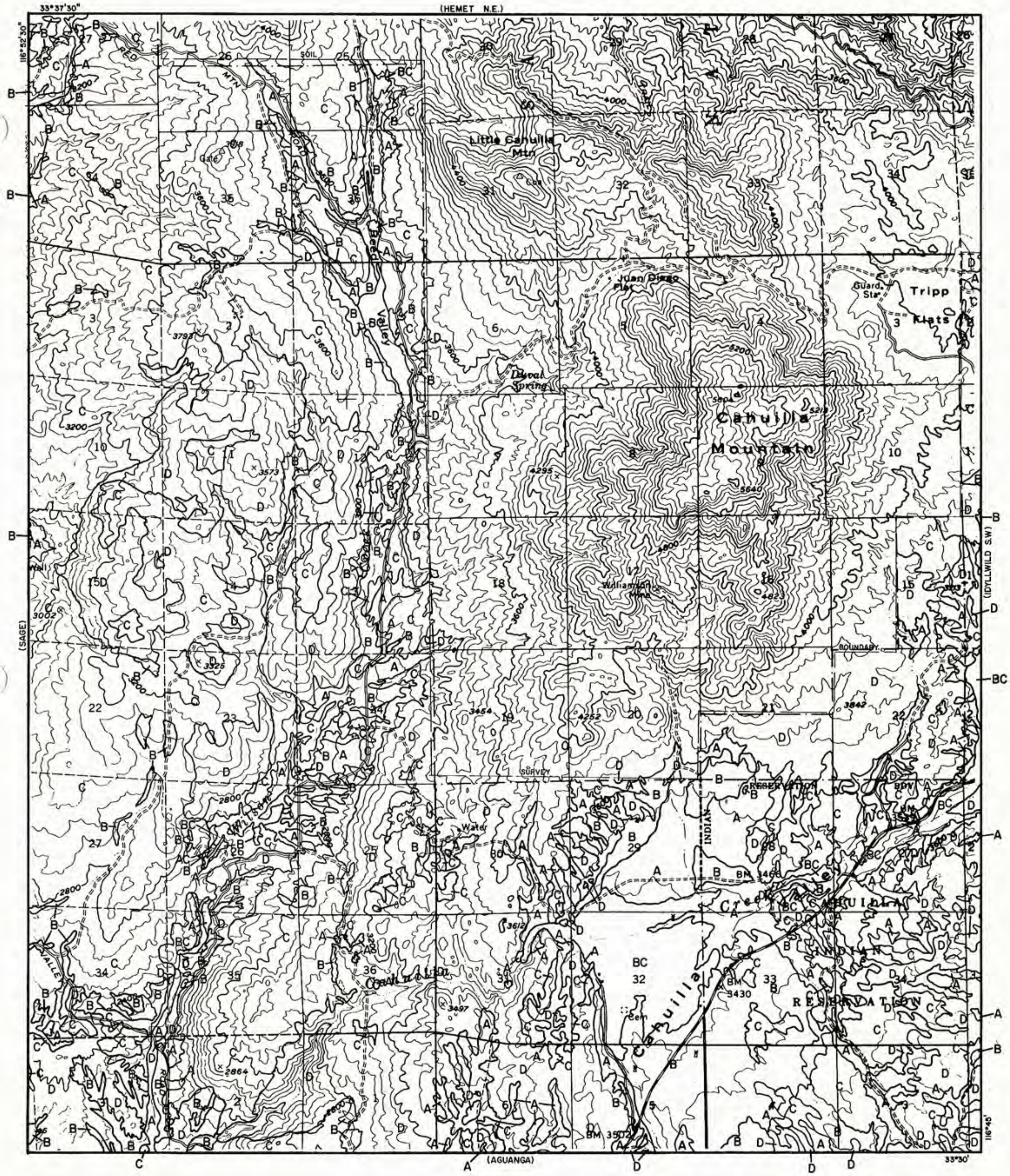
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR SAGE



LEGEND

—— SOILS GROUP BOUNDARY

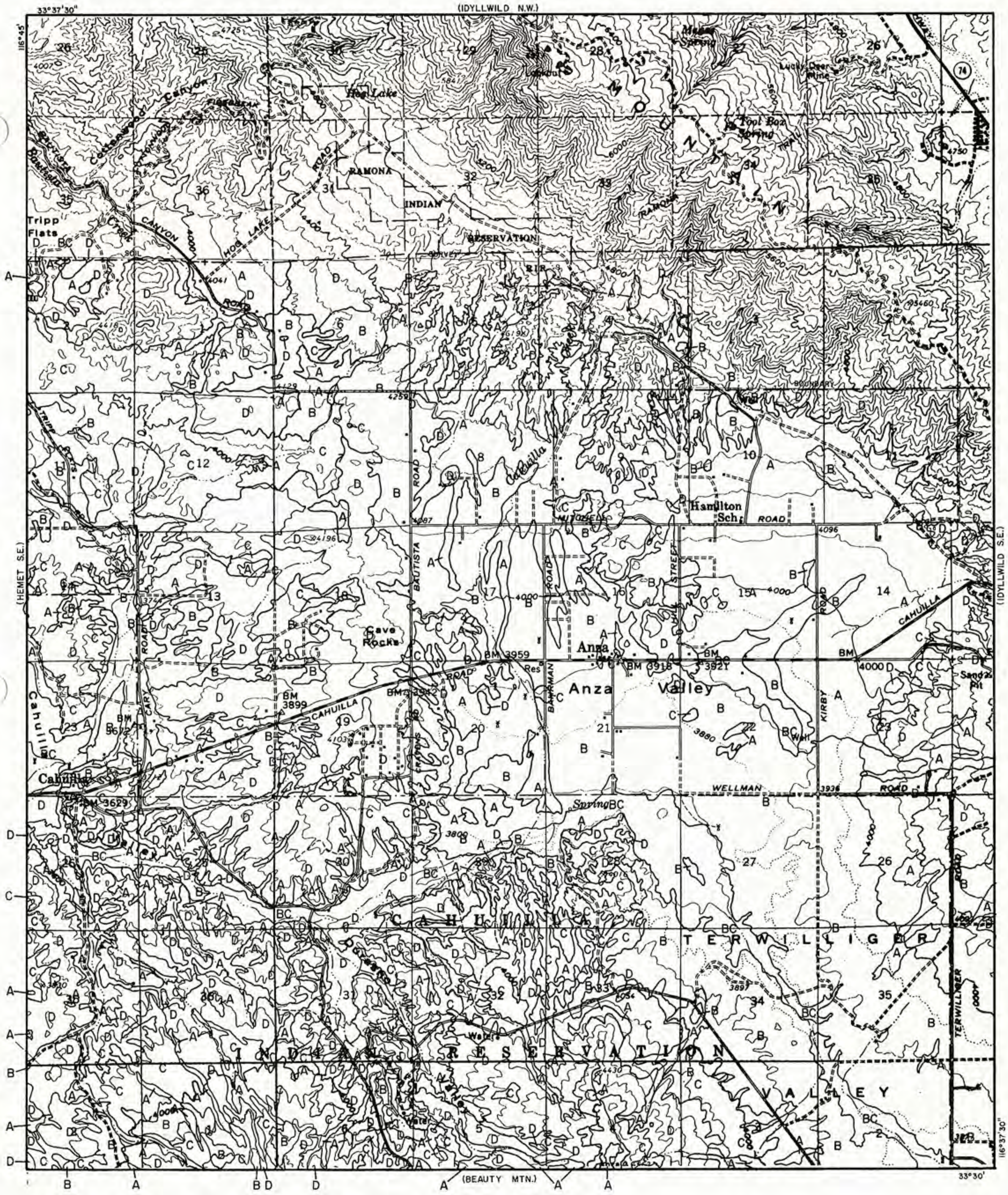
A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR HEMET—S.E.

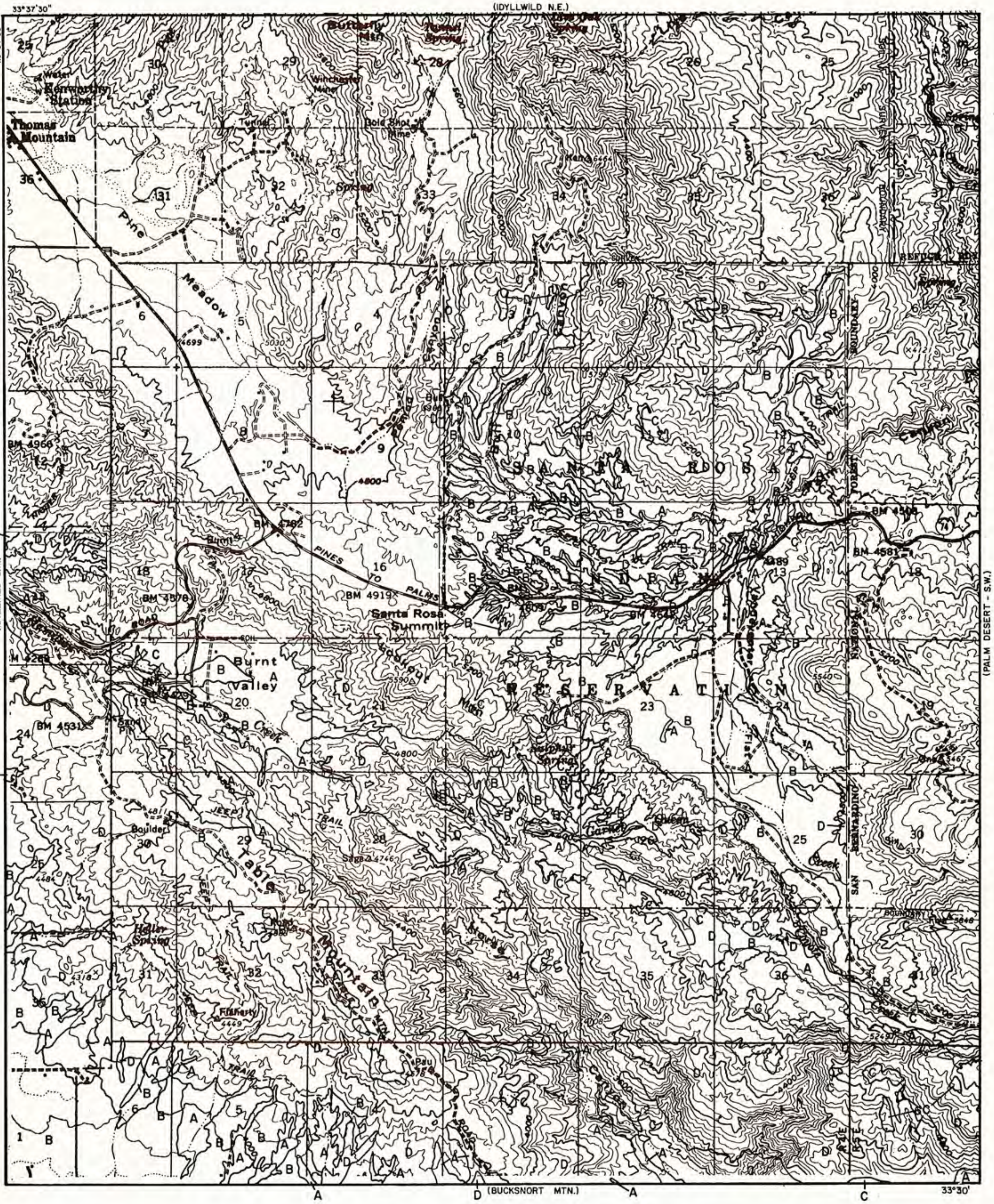


LEGEND	
———	SOILS GROUP BOUNDARY
A	SOILS GROUP DESIGNATION

RCFC & WCD
HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR IDYLLWILD-S.W.



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

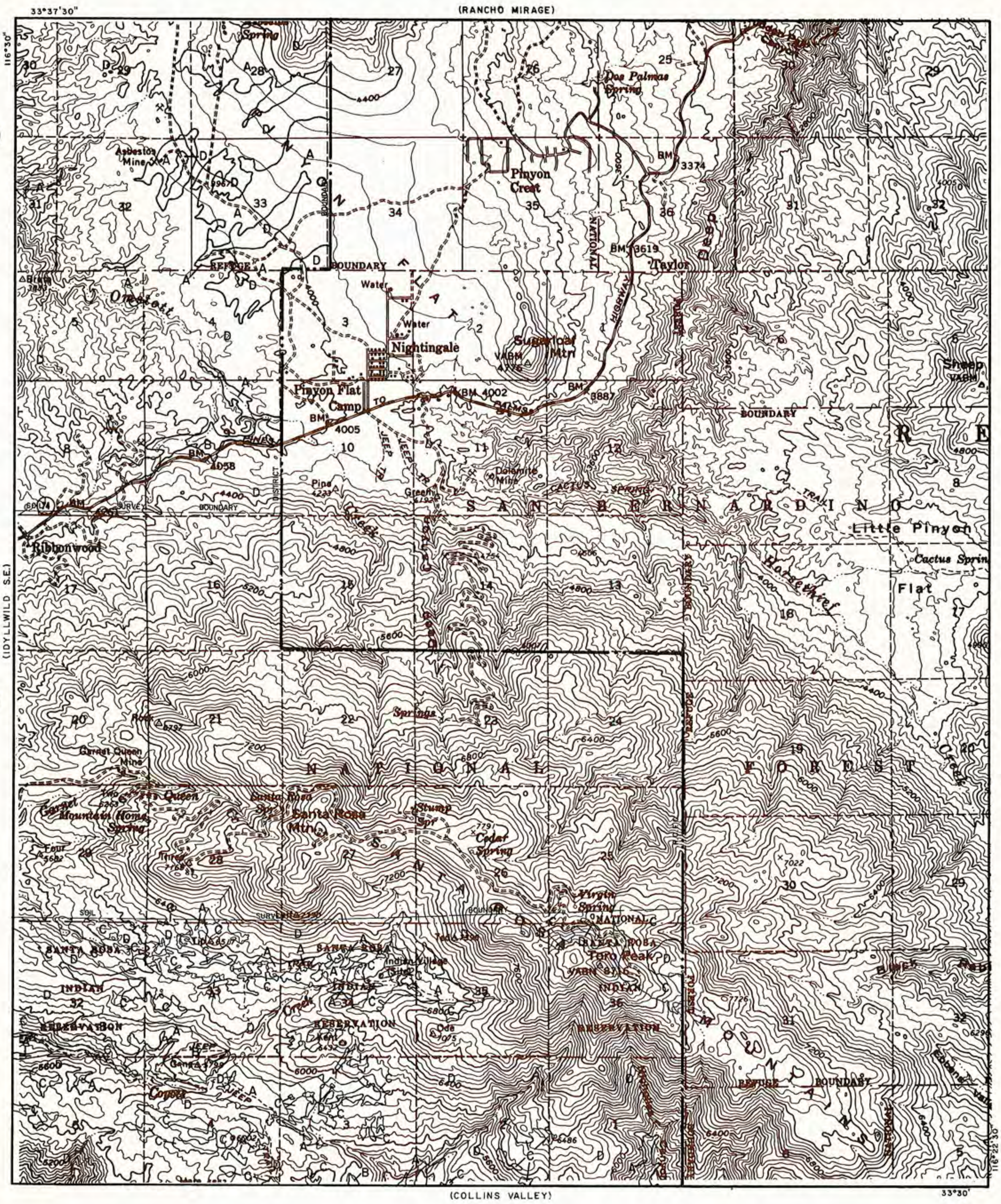
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR IDYLLWILD-S.E.

PLATE C-1.57



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR PALM DESERT—S.W.

PLATE C-1.58

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR FALLBROOK

PLATE C-1.59

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR TEMECULA

PLATE C-1.60

LEGEND

——— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

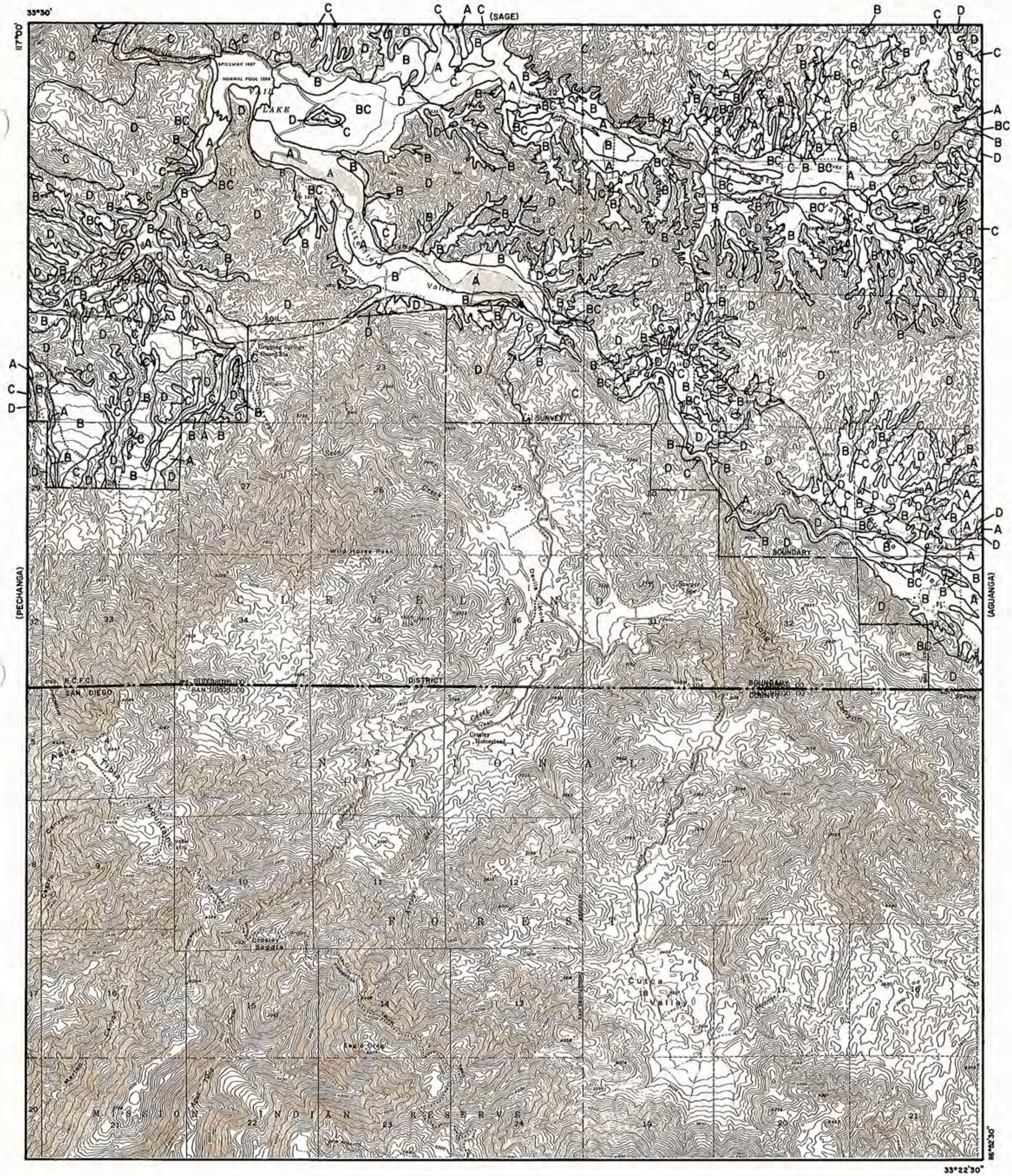
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR PECHANGA

PLATE C-1.61



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

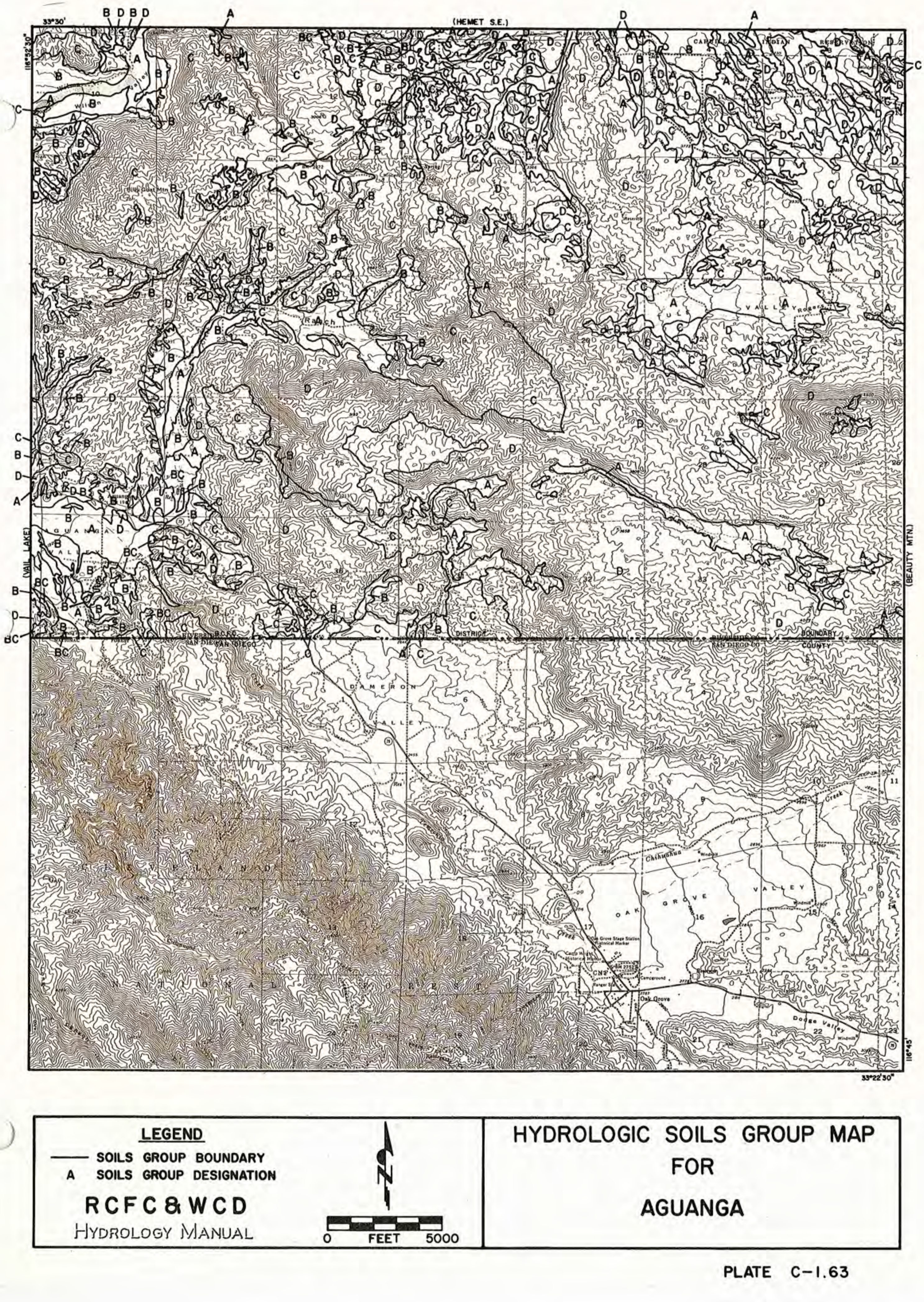
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR VAIL LAKE

PLATE C-1.62



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR AGUANGA

PLATE C-1.63

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR BEAUTY MTN.

PLATE C-1.64

LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

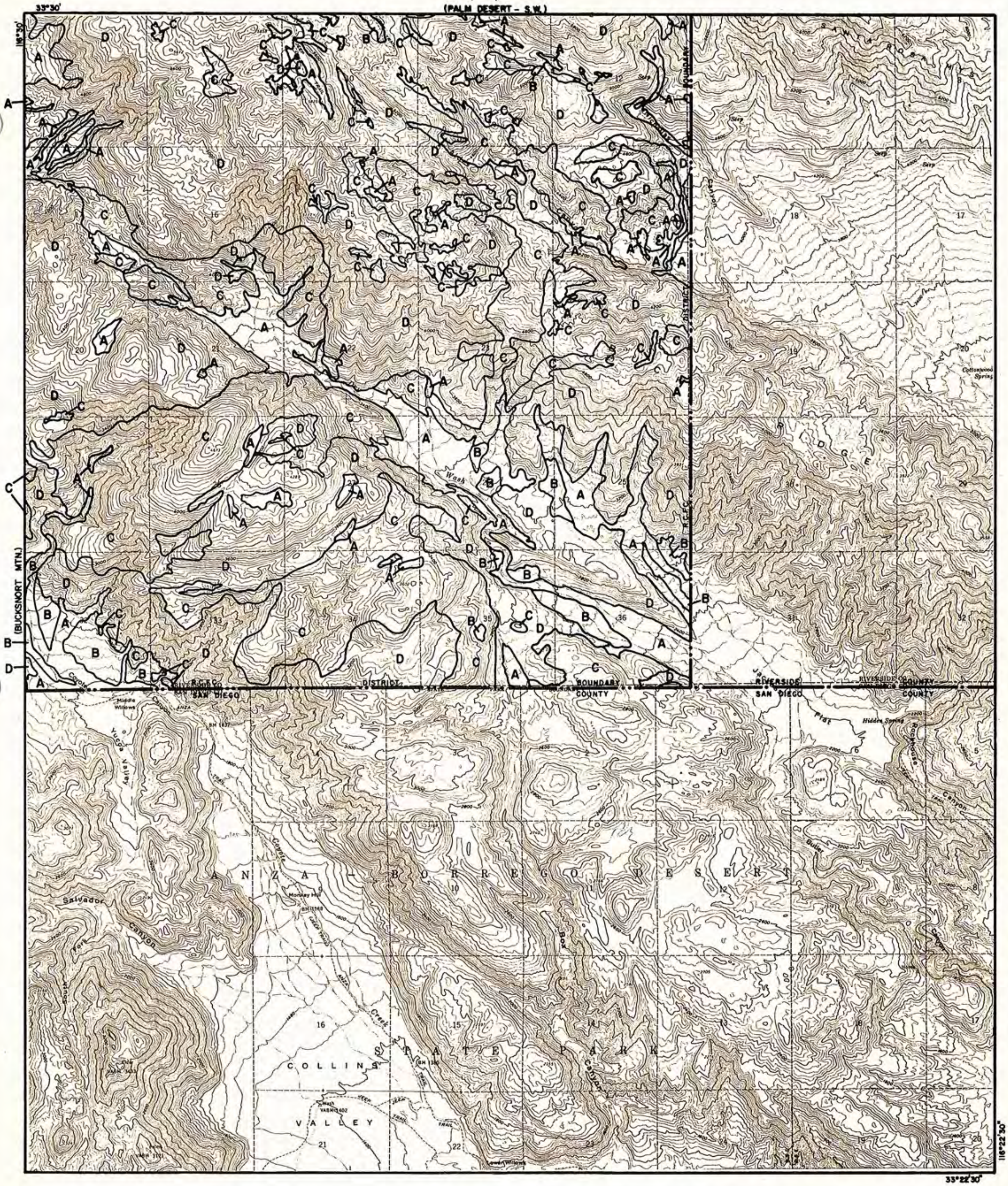
RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR BUCKSNORT MTN.

PLATE C-1.65



LEGEND

—— SOILS GROUP BOUNDARY

A SOILS GROUP DESIGNATION

RCFC & WCD

HYDROLOGY MANUAL

0 FEET 5000

HYDROLOGIC SOILS GROUP MAP FOR COLLINS VALLEY

PLATE C-1.66

COVER TYPE DESCRIPTIONS

NATURAL COVERS -

Barren - Areas with 15 percent or less of the ground surface covered by plants or litter. It includes rockland, eroded land, and shaped or graded land. Barren land does not include fallow land.

Chaparral, Broadleaf - Areas on which the principal vegetation consists of evergreen shrubs with broad, hard, stiff leaves such as manzonita, ceanothus and scrub oak. The brush cover is usually dense or moderately dense.

Chaparral, Narrowleaf - Land on which the principal vegetation consists of diffusely branched evergreen shrubs with fine needle-like leaves such as chamise and redshank. The shrubs are usually widely spaced and low in growth. If the narrowleaf chaparral shrubs are dense and high; the land should be included with broadleaf chaparral cover.

Grass, Annual - Land on which the principal vegetation consists of annual grasses and weeds such as annual bromes, wild barley, soft chess, ryegrass and filaree.

Grass, Perennial - Areas on which the principal vegetation consists of perennial grass, either native or introduced, and which grows under normal dryland conditions. Examples are Stipa or needle grass, Harding grass and wheat grass. It does not include irrigated and meadow grasses.

Meadow - Land areas with seasonally high water table, often called cienegas. Principal vegetation consists of sod-forming grasses interspersed with other plants.

Open Brush - Principal vegetation consists of soft wood shrubs, usually grayish in color. Examples include California buckwheat, California sagebrush, black sage, white sage and purple sage. It also includes vegetation on desert facing slopes where broadleaf chaparral predominate in an open shrub cover.

Woodland - Areas on which coniferous or broadleaf trees predominate. The crown or canopy density, the amount of ground surface shaded at high noon, is at least 50 percent. Open areas may have a cover of annual or perennial grasses or of brush. Plant cover under the trees is usually sparse because of leaf or needle litter accumulation.

Woodland, Grass - Areas with an open cover of broadleaf or coniferous trees usually live oak and pines, with the intervening ground space occupied by annual grasses or weeds. The trees may occur singly or in small clumps. Canopy density,the amount of ground surface shaded at high noon,is from 20 to 50 percent.

URBAN COVERS -

Residential or Commercial Landscaping - The pervious portions of commercial establishments, single and multiple family dwellings, trailer parks and schools where the predominant land cover is lawn, shrubbery and trees.

COVER TYPE DESCRIPTIONS

URBAN COVERS (cont.) -

Turf - Golf courses, parks, cemeteries, and similar lands where the predominant cover is irrigated mowed close-grown turf grass. Parks in which trees are dense may be classified as woodland.

AGRICULTURAL COVER -

Fallow - Fallow land is land plowed but not yet seeded or tilled. It is more effective than barren land in reducing storm runoff.

Legumes, Close Seeded - Alfalfa, sweetclover, timothy, etc. and combinations, either planted in close rows or broadcast.

Orchards, Deciduous - Land planted to such deciduous trees as apples, apricots, pears, walnuts and almonds. The ground cover during the rainy reason alters the hydrologic response to storm rainfall. Ground cover may be annual grass or perennial grass with or without legumes. Occasionally legumes are used alone. Use runoff index numbers which apply to the land use or the kind and condition of cover during storm periods. If orchards are kept bare by disking, or through the use of herbicides, fallow applies.

Orchards, Evergreen - Land planted to evergreen trees which include citrus and avocado orchards and coniferous plantings. The effectiveness of this kind of land use is in part determined by the tree, the litter and the ground cover. In these groves the ground cover may be legumes alone or annual or perennial grasses with or without legumes. The ground cover may be entirely litter if the tree canopy is sufficiently dense to produce a substantial quantity of fallen leaves or needles. As with deciduous orchards, management practices affect the runoff potential of evergreen orchards.

Pasture, Dryland - Equivalent to annual grass. Land on which the principal vegetation consists of annual grasses and weeds such as annual bromes, wild barley, soft chess, ryegrass and filaree.

Pasture, Irrigated - Irrigated land planted to perennial grasses and legumes for production of forage and which is cultivated only to establish or renew the stand of plants.

Row Crops - Lettuce, tomatoes, sugar beets, tulips or any field crop planted in rows far enough apart that most of the soil surface is exposed to rainfall impact throughout the growing season. At plowing, planting and harvest times it is equivalent to fallow.

Small Grain - Wheat, oats, barley, flax, etc. planted in rows close enough that the soil surface is not exposed except during planting and shortly thereafter.

Vineyards - As with orchards, ground cover and land condition must be considered in estimating runoff potential. Use runoff index numbers which apply to the kind and condition of cover. For example either annual grass or fallow may apply.

Reference: Bibliography item No. 17.

SECTION D

RATIONAL METHOD

RATIONAL METHOD

General - The Rational method is commonly used for determining peak discharge from relatively small drainage areas. For areas in excess of 300 to 500-acres the Synthetic Unit Hydrograph method should normally be used. Before attempting to apply the information in this section, the engineer should become thoroughly familiar with sections A, B and C of this manual.

Rational Equation - The Rational method is based on the following equation:

$$Q = CIA$$

where:

Q = Peak discharge - cfs

C = Coefficient of runoff

I = Rainfall intensity (inches/hour) corresponding to the time of concentration

A = Area – acres

Time of Concentration - If rain were to fall continuously at a constant rate and be uniformly distributed over an impervious surface, the rate of runoff from that surface would reach a maximum rate equivalent to the rate of rainfall. This maximum would occur when all parts of the surface were contributing runoff to the concentration point. The time required to reach the maximum or equilibrium runoff rate is defined as the time of concentration. The time of concentration is a function of many variables including the length of the flow path from the most remote point of an area to the concentration point, the slope and other characteristics of natural and improved channels in the area, the infiltration characteristics of the soil, and the degree and type of development. In District Rational tabling, the time of concentration for an initial sub-area can be estimated from the nomograph on Plate D-3. The time of concentration for the next downstream subarea is computed by adding to the initial time, the time required for the computed peak flow to travel to the next concentration point. Time of concentration is computed for each subsequent subarea by computing travel time between subareas and adding the cumulative sum. Travel time may be estimated using the tabling aids on Plates D-6 through D-9.

To avoid distortion of travel time large subareas should be avoided. Where extremely large subareas are used, peak flow entering a travel reach may be much lower than the flow leaving that reach. Velocity normally increases with discharge, therefore travel time computed using the average flow over a reach may be significantly lower than travel time computed using inflow to the reach. Since rainfall intensity is inversely proportional to time, flow rates would be consistently underestimated by use of large subareas.

Intensity-Duration Curves - Rainfall intensity, "I", is determined using District intensity-duration curves for the area under study. Standard intensity-duration curves have been prepared for many population centers in the District. Intensity-duration data for these standard curves is given in tabular form on Plate D-4.l. The standard curves for these areas may be reproduced by plotting the 10 and 60-minute values on Plate D-4.2, and drawing a straight line through them. For areas where curves have not been published, Plates D-4.3 through D-4.7 should be used to develop design intensity-duration curves.

Plates D-4.3 and D-4.4 are isohyetal maps of the maximum 2-year 1-hour and 100-year 1-hour precipitation respectively. One-hour point rain for intermediate return periods can be determined from Plate D-4.5. The slope of the intensity duration curve can be obtained from Plate D-4.6. Intensity duration curves for a particular area can be easily developed using Plate D-4.7, plotting the 1-hour point rain value for the desired return period, and drawing a straight line through the 1-hour value parallel to the required slope.

The isohyetal maps and return period diagram are based on NOAA Atlas 2 discussed in more detail in Section B of this report. The map of intensity-duration curve slope is based on

District analysis of all available recording rain gauge records in and near the District. This material is also discussed in Section B of this manual.

Coefficient of Runoff Curves - The coefficient of runoff is intended to account for the many factors which influence peak flow rate. The co-efficient depends on the rainfall intensity, soil type and cover, percentage of impervious area, antecedent moisture condition, etc. To account for the difference between actual and effective impervious area it is assumed the maximum runoff rate which can occur from impervious surfaces is 90-percent of the rainfall rate. The runoff from pervious surfaces is further reduced by infiltration. Runoff coefficient curves can be developed using the relationship:

$$C = 0.9 \left[A_i + \frac{I - F_p}{I} A_p \right]$$

where:

C = Runoff coefficient

I = Rainfall intensity - inches/hour

F_p = Infiltration rate for pervious areas - inches/hour

A_i = Impervious area (actual) - decimal percent

A_p = Pervious area (actual) - decimal percent

and A_p = $1.00 - A_i$

The infiltration rate for pervious areas, "F_p", can be estimated using the methods discussed in Section C of this manual for various combinations of soil type, cover type and antecedent moisture condition (AMC). In practice it is not necessary for the engineer to make these computations, as runoff coefficient curve data has been tabulated by the District on Plate D-5.7 for the working range of runoff index (RI) numbers. Runoff coefficient curves can be developed for any combination of conditions by simply plotting the data from Plate D-5.7 on Plate D-5.8.

In addition, for the common case of urban landscaping type cover, runoff coefficient curves have been plotted on Plates D-5.l through D-5.4.

INSTRUCTIONS FOR RATIONAL METHOD HYDROLOGY CALCULATIONS

(Based on the Rational Formula, Q = CIA)

1. On map of drainage area, draw drainage system and block off subareas tributary to it.

2. Determine the initial time of concentration, "T", using Plate D-3. The initial area should be less than 10 acres, have a flow path of less than 1,000 feet, and be the most upstream subarea.

3. Using the time of concentration, determine "I", intensity of rainfall in inches per hour, from the appropriate intensity-duration curve for the particular area under study. For areas where standard curves are available, use Plates D-4.1 and D-4.2 to reproduce the standard curve. For areas where curves have not been published by the District, use Plates D-4.3 through D-4.7 to develop a suitable intensity-duration curve.

4. Determine "C", the coefficient of runoff, using the runoff coefficient curve which corresponds as closely as possible with the soil, cover type and development of the drainage area. Standard curves (Plates D-5.1 through D-5.4) have been developed by the District for the common case of urban landscaping type cover. Where these curves are not applicable, curves may be developed using Plates D-5.5 through D-5.8.

5. Determine "A", the area of the subarea in acres.

6. Compute Q = CIA for the subarea.

7. Measure the length of flow to the point of inflow of the next subarea downstream. Determine the velocity of flow in this reach for the peak Q in the type of conveyance being considered (natural channel, street, pipe, or open channel), using the tabling aids on Plates D-6 through D-9.

   Using the reach length and velocity determined above, compute the travel time, and add this time to the time of concentration for the previous subarea to determine a new time of concentration.

8. Calculate Q for the new subarea, using steps 3 through 6 and the new time of concentration. Determine "Q_p", the peak Q for all subareas tributary to the system to this point by adding Q for the new subarea to the summation of Q for all upstream subareas. Determine the time of concentration for the next subarea downstream using Step 7. Continue tabling downstream in similar fashion until a junction with a lateral drain is reached.

9. Start at the upper end of the lateral and table its Q down to the junction with the main line, using the methods outlined in the previous steps.

10. Compute the peak Q at the junction. Let Q_A, T_A, I_A correspond to the tributary area with the longer time of concentration, and Q_B, T_B, I_B correspond to the tributary area with the shorter time of concentration and Q_P, T_p correspond to the peak Q and time of concentration.

    a. If the tributary areas have the same time of concentration, the tributary Q's are added directly to obtain the combined peak Q.

    $$Q_p = Q_A + Q_B \qquad T_p = T_A = T_B$$

    b. If the tributary areas have different times of concentration, the smaller of the tributary Q's must be corrected as follows:

    (1) The usual case is where the tributary area with the longer time of concentration has the larger Q. In this case, the smaller Q is corrected by a ratio of the intensities and added to the larger Q to obtain the combined peak Q. The tabling is then continued downstream using the longer time of concentration.

    $$Q_p = Q_A + Q_B \frac{I_A}{I_B} \qquad T_p = T_A$$

    (2) In some cases, the tributary area with the shorter time of concentration has the larger Q. In this case, the smaller Q is corrected by a ratio of the times of concentration and added to the larger Q to obtain the combined peak Q. The tabling is then continued downsteam using the shorter time of concentration.

    $$Q_P = Q_B + Q_A \frac{T_B}{T_A} \qquad T_p = T_B$$

RCFC & WCD HYDROLOGY MANUAL
RATIONAL METHOD CALCULATION FORM

Sheet No.___ of ___Sheets

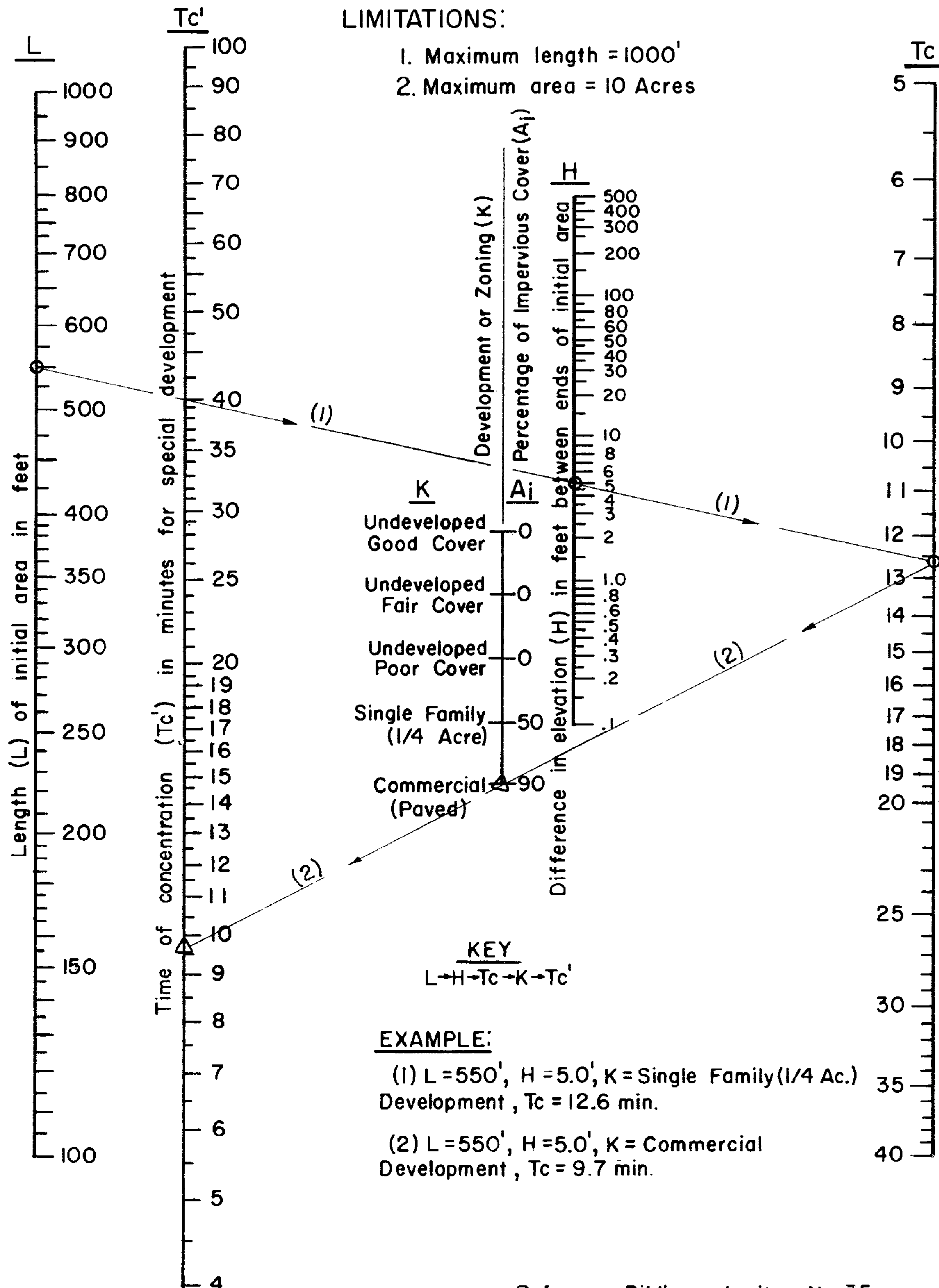
PROJECT ____

Calculated by ---------------- DATE ---

FREQUENCY _____________

Checked by ---------------- DATE ---

DRAINAGE AREA	Soil & Development	A Acres	I in/hr.	C	ΔQ CFS	Σ Q CFS	SLOPE	SECTION	v FPS	L FT.	T MIN.	Σ T	REMARKS



Reference: Bibliography item No. 35.

RCFC & WCD

HYDROLOGY MANUAL

TIME OF CONCENTRATION FOR INITIAL SUBAREA

RCFC & WCD

HYDROLOGY MANUAL

RAINFALL INTENSITY-INCHES PER HOUR

ANZA			BANNING			BEAUMONT			CALIMESA			CANYON LAKE		
DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	4.23	6.85	5	3.32	4.93	5	3.32	4.93	5	3.57	5.30	5	3.07	4.61
6	3.80	6.16	6	3.02	4.47	6	3.02	4.47	6	3.23	4.79	6	2.81	4.23
7	3.48	5.63	7	2.78	4.12	7	2.78	4.12	7	2.97	4.40	7	2.61	3.93
8	3.22	5.21	8	2.59	3.84	8	2.59	3.84	8	2.76	4.09	8	2.45	3.68
9	3.01	4.87	9	2.43	3.61	9	2.43	3.61	9	2.58	3.83	9	2.31	3.48
10	2.83	4.58	10	2.30	3.41	10	2.30	3.41	10	2.44	3.62	10	2.20	3.31
11	2.67	4.33	11	2.19	3.24	11	2.19	3.24	11	2.31	3.43	11	2.10	3.16
12	2.54	4.12	12	2.09	3.10	12	2.09	3.10	12	2.21	3.27	12	2.01	3.03
13	2.43	3.93	13	2.00	2.97	13	2.00	2.97	13	2.11	3.13	13	1.94	2.92
14	2.33	3.77	14	1.92	2.85	14	1.92	2.85	14	2.03	3.01	14	1.87	2.82
15	2.23	3.62	15	1.86	2.75	15	1.86	2.75	15	1.95	2.89	15	1.81	2.72
16	2.15	3.49	16	1.79	2.66	16	1.79	2.66	16	1.88	2.79	16	1.75	2.64
17	2.08	3.37	17	1.74	2.58	17	1.74	2.58	17	1.82	2.70	17	1.70	2.56
18	2.01	3.26	18	1.68	2.50	18	1.68	2.50	18	1.76	2.62	18	1.66	2.50
19	1.95	3.16	19	1.64	2.43	19	1.64	2.43	19	1.71	2.54	19	1.62	2.43
20	1.89	3.06	20	1.59	2.36	20	1.59	2.36	20	1.67	2.47	20	1.58	2.37
22	1.79	2.90	22	1.51	2.25	22	1.51	2.25	22	1.58	2.34	22	1.51	2.27
24	1.70	2.76	24	1.45	2.15	24	1.45	2.15	24	1.51	2.23	24	1.44	2.17
26	1.62	2.63	26	1.39	2.06	26	1.39	2.06	26	1.44	2.14	26	1.39	2.09
28	1.56	2.52	28	1.33	1.98	28	1.33	1.98	28	1.38	2.05	28	1.34	2.02
30	1.49	2.42	30	1.29	1.91	30	1.29	1.91	30	1.33	1.98	30	1.30	1.95
32	1.44	2.33	32	1.24	1.84	32	1.24	1.84	32	1.29	1.91	32	1.26	1.89
34	1.39	2.25	34	1.20	1.78	34	1.20	1.78	34	1.24	1.85	34	1.22	1.84
36	1.34	2.18	36	1.17	1.73	36	1.17	1.73	36	1.21	1.79	36	1.19	1.79
38	1.30	2.11	38	1.13	1.68	38	1.13	1.68	38	1.17	1.74	38	1.16	1.74
40	1.27	2.05	40	1.10	1.64	40	1.10	1.64	40	1.14	1.69	40	1.13	1.70
45	1.18	1.91	45	1.04	1.54	45	1.04	1.54	45	1.07	1.58	45	1.07	1.61
50	1.11	1.80	50	.98	1.45	50	.98	1.45	50	1.01	1.49	50	1.02	1.53
55	1.05	1.70	55	.93	1.38	55	.93	1.38	55	.95	1.42	55	.97	1.46
60	1.00	1.62	60	.89	1.32	60	.89	1.32	60	.91	1.35	60	.93	1.40
65	.95	1.55	65	.85	1.27	65	.85	1.27	65	.87	1.29	65	.89	1.35
70	.91	1.48	70	.82	1.22	70	.82	1.22	70	.84	1.24	70	.86	1.30
75	.88	1.42	75	.79	1.17	75	.79	1.17	75	.80	1.19	75	.84	1.26
80	.85	1.37	80	.76	1.13	80	.76	1.13	80	.78	1.15	80	.81	1.22
85	.82	1.32	85	.74	1.10	85	.74	1.10	85	.75	1.11	85	.79	1.18
SLOPE = .580			SLOPE = .530			SLOPE = .530			SLOPE = .550			SLOPE = .480		

STANDARD
INTENSITY-DURATION
CURVES DATA

RAINFALL INTENSITY-INCHES PER HOUR

CATHEDRAL CITY			CHERRY VALLEY			CORONA			DESERT HOT SPRINGS			ELSINORE - WILDOMAR		
DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	4.14	6.76	5	3.65	5.49	5	3.10	4.78	5	4.39	6.76	5	3.23	4.94
6	3.73	6.08	6	3.30	4.97	6	2.84	4.38	6	3.95	6.08	6	2.96	4.53
7	3.41	5.56	7	3.03	4.56	7	2.64	4.07	7	3.62	5.56	7	2.75	4.21
8	3.15	5.15	8	2.82	4.24	8	2.47	3.81	8	3.35	5.15	8	2.58	3.95
9	2.95	4.81	9	2.64	3.97	9	2.34	3.60	9	3.13	4.81	9	2.44	3.73
10	2.77	4.52	10	2.49	3.75	10	2.22	3.43	10	2.94	4.52	10	2.32	3.54
11	2.62	4.28	11	2.36	3.56	11	2.12	3.27	11	2.78	4.28	11	2.21	3.39
12	2.49	4.07	12	2.25	3.39	12	2.04	3.14	12	2.65	4.07	12	2.12	3.25
13	2.38	3.88	13	2.16	3.25	13	1.96	3.02	13	2.53	3.88	13	2.04	3.13
14	2.28	3.72	14	2.07	3.12	14	1.89	2.92	14	2.42	3.72	14	1.97	3.02
15	2.19	3.58	15	1.99	3.00	15	1.83	2.82	15	2.32	3.58	15	1.91	2.92
16	2.11	3.44	16	1.92	2.90	16	1.77	2.73	16	2.24	3.44	16	1.85	2.83
17	2.04	3.32	17	1.86	2.80	17	1.72	2.66	17	2.16	3.32	17	1.80	2.75
18	1.97	3.22	18	1.80	2.71	18	1.68	2.58	18	2.09	3.22	18	1.75	2.67
19	1.91	3.12	19	1.75	2.64	19	1.63	2.52	19	2.03	3.12	19	1.70	2.60
20	1.85	3.03	20	1.70	2.56	20	1.59	2.46	20	1.97	3.03	20	1.66	2.54
22	1.75	2.86	22	1.61	2.43	22	1.52	2.35	22	1.86	2.86	22	1.59	2.43
24	1.67	2.72	24	1.54	2.32	24	1.46	2.25	24	1.77	2.72	24	1.52	2.33
26	1.59	2.60	26	1.47	2.22	26	1.40	2.17	26	1.69	2.60	26	1.46	2.24
28	1.52	2.49	28	1.41	2.13	28	1.36	2.09	28	1.62	2.49	28	1.41	2.16
30	1.46	2.39	30	1.36	2.05	30	1.31	2.02	30	1.55	2.39	30	1.37	2.09
32	1.41	2.30	32	1.31	1.98	32	1.27	1.96	32	1.50	2.30	32	1.33	2.03
34	1.36	2.22	34	1.27	1.91	34	1.23	1.90	34	1.45	2.22	34	1.29	1.97
36	1.32	2.15	36	1.23	1.85	36	1.20	1.85	36	1.40	2.15	36	1.25	1.92
38	1.28	2.09	38	1.20	1.80	38	1.17	1.81	38	1.36	2.09	38	1.22	1.87
40	1.24	2.02	40	1.16	1.75	40	1.14	1.76	40	1.32	2.02	40	1.19	1.82
45	1.16	1.89	45	1.09	1.64	45	1.08	1.66	45	1.23	1.89	45	1.13	1.72
50	1.09	1.78	50	1.03	1.55	50	1.03	1.58	50	1.16	1.78	50	1.07	1.64
55	1.03	1.68	55	.98	1.47	55	.98	1.51	55	1.09	1.68	55	1.02	1.56
60	.98	1.60	60	.93	1.40	60	.94	1.45	60	1.04	1.60	60	.98	1.50
65	.94	1.53	65	.89	1.34	65	.90	1.40	65	.99	1.53	65	.94	1.44
70	.90	1.46	70	.85	1.29	70	.87	1.35	70	.95	1.46	70	.91	1.39
75	.86	1.41	75	.82	1.24	75	.84	1.30	75	.91	1.41	75	.88	1.35
80	.83	1.35	80	.79	1.20	80	.82	1.26	80	.88	1.35	80	.85	1.31
85	.80	1.31	85	.77	1.16	85	.80	1.23	85	.85	1.31	85	.83	1.27
SLOPE = .580			SLOPE = .550			SLOPE = .480			SLOPE = .580			SLOPE = .480		

RCFC & WCD

HYDROLOGY MANUAL

STANDARD INTENSITY-DURATION CURVES DATA

RAINFALL INTENSITY—INCHES PER HOUR

HEMET

DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	2.84	4.40
6	2.58	4.00
7	2.37	3.68
8	2.21	3.43
9	2.08	3.23
10	1.96	3.05
11	1.87	2.90
12	1.78	2.77
13	1.71	2.65
14	1.64	2.55
15	1.58	2.46
16	1.53	2.38
17	1.48	2.30
18	1.44	2.23
19	1.40	2.17
20	1.36	2.11
22	1.29	2.01
24	1.24	1.92
26	1.18	1.84
28	1.14	1.77
30	1.10	1.70
32	1.06	1.65
34	1.03	1.59
36	1.00	1.55
38	.97	1.50
40	.94	1.46
45	.89	1.37
50	.84	1.30
55	.80	1.24
60	.76	1.18
65	.73	1.13
70	.70	1.09
75	.68	1.05
80	.65	1.01
85	.63	.98

SLOPE = .530

HIGHGROVE

DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	3.02	4.37
6	2.75	3.97
7	2.54	3.67
8	2.37	3.42
9	2.23	3.22
10	2.11	3.05
11	2.01	2.90
12	1.92	2.77
13	1.84	2.66
14	1.77	2.56
15	1.71	2.47
16	1.65	2.39
17	1.60	2.31
18	1.55	2.24
19	1.51	2.18
20	1.47	2.12
22	1.40	2.02
24	1.34	1.93
26	1.28	1.85
28	1.23	1.78
30	1.19	1.72
32	1.15	1.66
34	1.12	1.61
36	1.08	1.57
38	1.05	1.52
40	1.02	1.48
45	.96	1.39
50	.91	1.32
55	.87	1.26
60	.83	1.20
65	.80	1.15
70	.77	1.11
75	.74	1.07
80	.71	1.03
85	.69	1.00

SLOPE = .520

HOMELAND – WINCHESTER

DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	2.91	4.37
6	2.65	3.97
7	2.44	3.67
8	2.28	3.42
9	2.15	3.22
10	2.03	3.05
11	1.93	2.90
12	1.85	2.77
13	1.77	2.66
14	1.71	2.56
15	1.64	2.47
16	1.59	2.39
17	1.54	2.31
18	1.50	2.24
19	1.45	2.18
20	1.42	2.12
22	1.35	2.02
24	1.29	1.93
26	1.24	1.85
28	1.19	1.78
30	1.15	1.72
32	1.11	1.66
34	1.07	1.61
36	1.04	1.57
38	1.01	1.52
40	.99	1.48
45	.93	1.39
50	.88	1.32
55	.84	1.26
60	.80	1.20
65	.77	1.15
70	.74	1.11
75	.71	1.07
80	.69	1.03
85	.67	1.00

SLOPE = .520

IDYLLWILD

DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	4.91	7.28
6	4.47	6.62
7	4.13	6.11
8	3.85	5.70
9	3.62	5.36
10	3.43	5.08
11	3.26	4.83
12	3.12	4.62
13	2.99	4.43
14	2.88	4.26
15	2.78	4.11
16	2.68	3.98
17	2.60	3.85
18	2.52	3.74
19	2.45	3.64
20	2.39	3.54
22	2.27	3.37
24	2.17	3.22
26	2.09	3.09
28	2.01	2.97
30	1.94	2.87
32	1.87	2.77
34	1.81	2.69
36	1.76	2.61
38	1.71	2.54
40	1.67	2.47
45	1.57	2.32
50	1.48	2.20
55	1.41	2.09
60	1.35	2.00
65	1.29	1.92
70	1.25	1.85
75	1.20	1.78
80	1.16	1.72
85	1.13	1.67

SLOPE = .520

LAKEVIEW

DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	2.77	4.16
6	2.53	3.79
7	2.34	3.51
8	2.19	3.29
9	2.07	3.10
10	1.96	2.94
11	1.87	2.80
12	1.79	2.68
13	1.72	2.58
14	1.66	2.48
15	1.60	2.40
16	1.55	2.32
17	1.50	2.25
18	1.46	2.19
19	1.42	2.13
20	1.39	2.08
22	1.32	1.98
24	1.26	1.90
26	1.22	1.82
28	1.17	1.76
30	1.13	1.70
32	1.10	1.64
34	1.06	1.59
36	1.03	1.55
38	1.01	1.51
40	.98	1.47
45	.92	1.39
50	.88	1.31
55	.84	1.25
60	.80	1.20
65	.77	1.15
70	.74	1.11
75	.72	1.07
80	.69	1.04
85	.67	1.01

SLOPE = .500

STANDARD
INTENSITY – DURATION
CURVES DATA

RAINFALL INTENSITY–INCHES PER HOUR

MIRA LOMA			MURRIETA - TEMECULA & RANCHO CALIFORNIA			NORCO			PALM SPRINGS			PERRIS VALLEY		
DURATION MINUTES	FREQUENCY		DURATION MINUTES	FREQUENCY		DURATION MINUTES	FREQUENCY		DURATION MINUTES	FREQUENCY		DURATION MINUTES	FREQUENCY	
	10 YEAR	100 YEAR		10 YEAR	100 YEAR		10 YEAR	100 YEAR		10 YEAR	100 YEAR		10 YEAR	100 YEAR
5	2.84	4.48	5	3.45	5.10	5	2.77	4.16	5	4.23	6.76	5	2.64	3.78
6	2.58	4.07	6	3.12	4.61	6	2.53	3.79	6	3.80	6.08	6	2.41	3.46
7	2.37	3.75	7	2.87	4.24	7	2.34	3.51	7	3.48	5.56	7	2.24	3.21
8	2.21	3.49	8	2.67	3.94	8	2.19	3.29	8	3.22	5.15	8	2.09	3.01
9	2.08	3.28	9	2.50	3.69	9	2.07	3.10	9	3.01	4.81	9	1.98	2.84
10	1.96	3.10	10	2.36	3.48	10	1.96	2.94	10	2.83	4.52	10	1.88	2.69
11	1.87	2.95	11	2.24	3.30	11	1.87	2.80	11	2.67	4.28	11	1.79	2.57
12	1.78	2.82	12	2.13	3.15	12	1.79	2.68	12	2.54	4.07	12	1.72	2.46
13	1.71	2.70	13	2.04	3.01	13	1.72	2.58	13	2.43	3.88	13	1.65	2.37
14	1.64	2.60	14	1.96	2.89	14	1.66	2.48	14	2.33	3.72	14	1.59	2.29
15	1.58	2.50	15	1.89	2.79	15	1.60	2.40	15	2.23	3.58	15	1.54	2.21
16	1.53	2.42	16	1.82	2.69	16	1.55	2.32	16	2.15	3.44	16	1.49	2.14
17	1.48	2.34	17	1.76	2.60	17	1.50	2.25	17	2.08	3.32	17	1.45	2.08
18	1.44	2.27	18	1.71	2.52	18	1.46	2.19	18	2.01	3.22	18	1.41	2.02
19	1.40	2.21	19	1.66	2.45	19	1.42	2.13	19	1.95	3.12	19	1.37	1.97
20	1.36	2.15	20	1.61	2.38	20	1.39	2.08	20	1.89	3.03	20	1.34	1.92
22	1.29	2.04	22	1.53	2.26	22	1.32	1.98	22	1.79	2.86	22	1.28	1.83
24	1.24	1.95	24	1.46	2.15	24	1.26	1.90	24	1.70	2.72	24	1.22	1.75
26	1.18	1.87	26	1.39	2.06	26	1.22	1.82	26	1.62	2.60	26	1.18	1.69
28	1.14	1.80	28	1.34	1.98	28	1.17	1.76	28	1.56	2.49	28	1.13	1.63
30	1.10	1.73	30	1.29	1.90	30	1.13	1.70	30	1.49	2.39	30	1.10	1.57
32	1.06	1.67	32	1.24	1.84	32	1.10	1.64	32	1.44	2.30	32	1.06	1.52
34	1.03	1.62	34	1.20	1.78	34	1.06	1.59	34	1.39	2.22	34	1.03	1.48
36	1.00	1.57	36	1.17	1.72	36	1.03	1.55	36	1.34	2.15	36	1.00	1.44
38	.97	1.53	38	1.13	1.67	38	1.01	1.51	38	1.30	2.09	38	.98	1.40
40	.94	1.49	40	1.10	1.62	40	.98	1.47	40	1.27	2.02	40	.95	1.37
45	.89	1.40	45	1.03	1.52	45	.92	1.39	45	1.18	1.89	45	.90	1.29
50	.84	1.32	50	.97	1.44	50	.88	1.31	50	1.11	1.78	50	.85	1.22
55	.80	1.26	55	.92	1.36	55	.84	1.25	55	1.05	1.68	55	.81	1.17
60	.76	1.20	60	.88	1.30	60	.80	1.20	60	1.00	1.60	60	.78	1.12
65	.73	1.15	65	.84	1.24	65	.77	1.15	65	.95	1.53	65	.75	1.08
70	.70	1.11	70	.81	1.19	70	.74	1.11	70	.91	1.46	70	.72	1.04
75	.68	1.07	75	.78	1.15	75	.72	1.07	75	.88	1.41	75	.70	1.00
80	.65	1.03	80	.75	1.11	80	.69	1.04	80	.85	1.35	80	.68	.97
85	.63	1.00	85	.73	1.07	85	.67	1.01	85	.82	1.31	85	.66	.94
SLOPE = .530			SLOPE = .550			SLOPE = .500			SLOPE = .580			SLOPE = .490		

RCFC & WCD

HYDROLOGY MANUAL

STANDARD
INTENSITY – DURATION
CURVES DATA

RAINFALL INTENSITY-INCHES PER HOUR

RIVERSIDE			RIVERSIDE (FOOTHILL AREAS)			RUBIDOUX			SAN JACINTO			SUN CITY		
DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	2.75	3.92	5	3.14	4.71	5	3.18	4.71	5	2.81	4.16	5	3.25	4.85
6	2.48	3.55	6	2.84	4.26	6	2.87	4.26	6	2.56	3.79	6	2.95	4.40
7	2.28	3.26	7	2.61	3.91	7	2.64	3.91	7	2.37	3.51	7	2.72	4.06
8	2.12	3.03	8	2.42	3.63	8	2.45	3.63	8	2.22	3.29	8	2.53	3.78
9	1.99	2.84	9	2.27	3.41	9	2.30	3.41	9	2.09	3.10	9	2.38	3.55
10	1.88	2.68	10	2.14	3.21	10	2.17	3.21	10	1.98	2.94	10	2.25	3.36
11	1.78	2.54	11	2.03	3.05	11	2.06	3.05	11	1.89	2.80	11	2.14	3.19
12	1.70	2.42	12	1.94	2.91	12	1.96	2.91	12	1.81	2.68	12	2.04	3.05
13	1.62	2.32	13	1.86	2.78	13	1.88	2.78	13	1.74	2.58	13	1.96	2.92
14	1.56	2.23	14	1.78	2.67	14	1.80	2.67	14	1.68	2.48	14	1.88	2.81
15	1.50	2.14	15	1.71	2.57	15	1.74	2.57	15	1.62	2.40	15	1.81	2.71
16	1.45	2.07	16	1.66	2.48	16	1.68	2.48	16	1.57	2.32	16	1.75	2.62
17	1.40	2.00	17	1.60	2.40	17	1.62	2.40	17	1.52	2.25	17	1.70	2.54
18	1.36	1.94	18	1.55	2.33	18	1.57	2.33	18	1.48	2.19	18	1.65	2.46
19	1.32	1.88	19	1.51	2.26	19	1.52	2.26	19	1.44	2.13	19	1.60	2.39
20	1.28	1.83	20	1.46	2.20	20	1.48	2.20	20	1.40	2.08	20	1.56	2.33
22	1.22	1.74	22	1.39	2.08	22	1.41	2.08	22	1.34	1.98	22	1.48	2.21
24	1.16	1.66	24	1.32	1.99	24	1.34	1.99	24	1.28	1.90	24	1.41	2.11
26	1.11	1.58	26	1.27	1.90	26	1.28	1.90	26	1.23	1.82	26	1.36	2.03
28	1.06	1.52	28	1.22	1.82	28	1.23	1.82	28	1.19	1.76	28	1.30	1.95
30	1.02	1.46	30	1.17	1.76	30	1.19	1.76	30	1.15	1.70	30	1.26	1.88
32	.99	1.41	32	1.13	1.70	32	1.14	1.70	32	1.11	1.64	32	1.21	1.81
34	.96	1.37	34	1.09	1.64	34	1.11	1.64	34	1.08	1.59	34	1.18	1.76
36	.93	1.32	36	1.06	1.59	36	1.07	1.59	36	1.05	1.55	36	1.14	1.70
38	.90	1.29	38	1.03	1.54	38	1.04	1.54	38	1.02	1.51	38	1.11	1.66
40	.87	1.25	40	1.00	1.50	40	1.01	1.50	40	.99	1.47	40	1.08	1.61
45	.82	1.17	45	.94	1.41	45	.95	1.41	45	.94	1.39	45	1.01	1.51
50	.77	1.11	50	.88	1.33	50	.90	1.33	50	.89	1.31	50	.96	1.43
55	.73	1.05	55	.84	1.26	55	.85	1.26	55	.85	1.25	55	.91	1.36
60	.70	1.00	60	.80	1.20	60	.81	1.20	60	.81	1.20	60	.87	1.30
65	.67	.96	65	.77	1.15	65	.78	1.15	65	.78	1.15	65	.83	1.25
70	.64	.92	70	.73	1.10	70	.74	1.10	70	.75	1.11	70	.80	1.20
75	.62	.88	75	.71	1.06	75	.72	1.06	75	.72	1.07	75	.77	1.15
80	.60	.85	80	.68	1.02	80	.69	1.02	80	.70	1.04	80	.75	1.12
85	.58	.83	85	.66	.99	85	.67	.99	85	.68	1.01	85	.72	1.08
SLOPE = .550			SLOPE = .550			SLOPE = .550			SLOPE = .500			SLOPE = .530		

RCFC & WCD

HYDROLOGY MANUAL

STANDARD
INTENSITY – DURATION
CURVES DATA

RAINFALL INTENSITY—INCHES PER HOUR

SUNNYMEAD - MORENO			WOODCREST		
DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR	DURATION MINUTES	FREQUENCY 10 YEAR	FREQUENCY 100 YEAR
5	2.84	4.16	5	3.37	5.30
6	2.59	3.79	6	3.05	4.79
7	2.40	3.51	7	2.80	4.40
8	2.25	3.29	8	2.60	4.09
9	2.12	3.10	9	2.44	3.83
10	2.01	2.94	10	2.30	3.62
11	1.92	2.80	11	2.19	3.43
12	1.83	2.68	12	2.08	3.27
13	1.76	2.58	13	1.99	3.13
14	1.70	2.48	14	1.91	3.01
15	1.64	2.40	15	1.84	2.89
16	1.59	2.32	16	1.78	2.79
17	1.54	2.25	17	1.72	2.70
18	1.50	2.19	18	1.67	2.62
19	1.46	2.13	19	1.62	2.54
20	1.42	2.08	20	1.57	2.47
22	1.35	1.98	22	1.49	2.34
24	1.30	1.90	24	1.42	2.23
26	1.25	1.82	26	1.36	2.14
28	1.20	1.76	28	1.31	2.05
30	1.16	1.70	30	1.26	1.98
32	1.12	1.64	32	1.22	1.91
34	1.09	1.59	34	1.18	1.85
36	1.06	1.55	36	1.14	1.79
38	1.03	1.51	38	1.11	1.74
40	1.00	1.47	40	1.07	1.69
45	.95	1.39	45	1.01	1.58
50	.90	1.31	50	.95	1.49
55	.86	1.25	55	.90	1.42
60	.82	1.20	60	.86	1.35
65	.79	1.15	65	.82	1.29
70	.76	1.11	70	.79	1.24
75	.73	1.07	75	.76	1.19
80	.71	1.04	80	.73	1.15
85	.69	1.01	85	.71	1.11

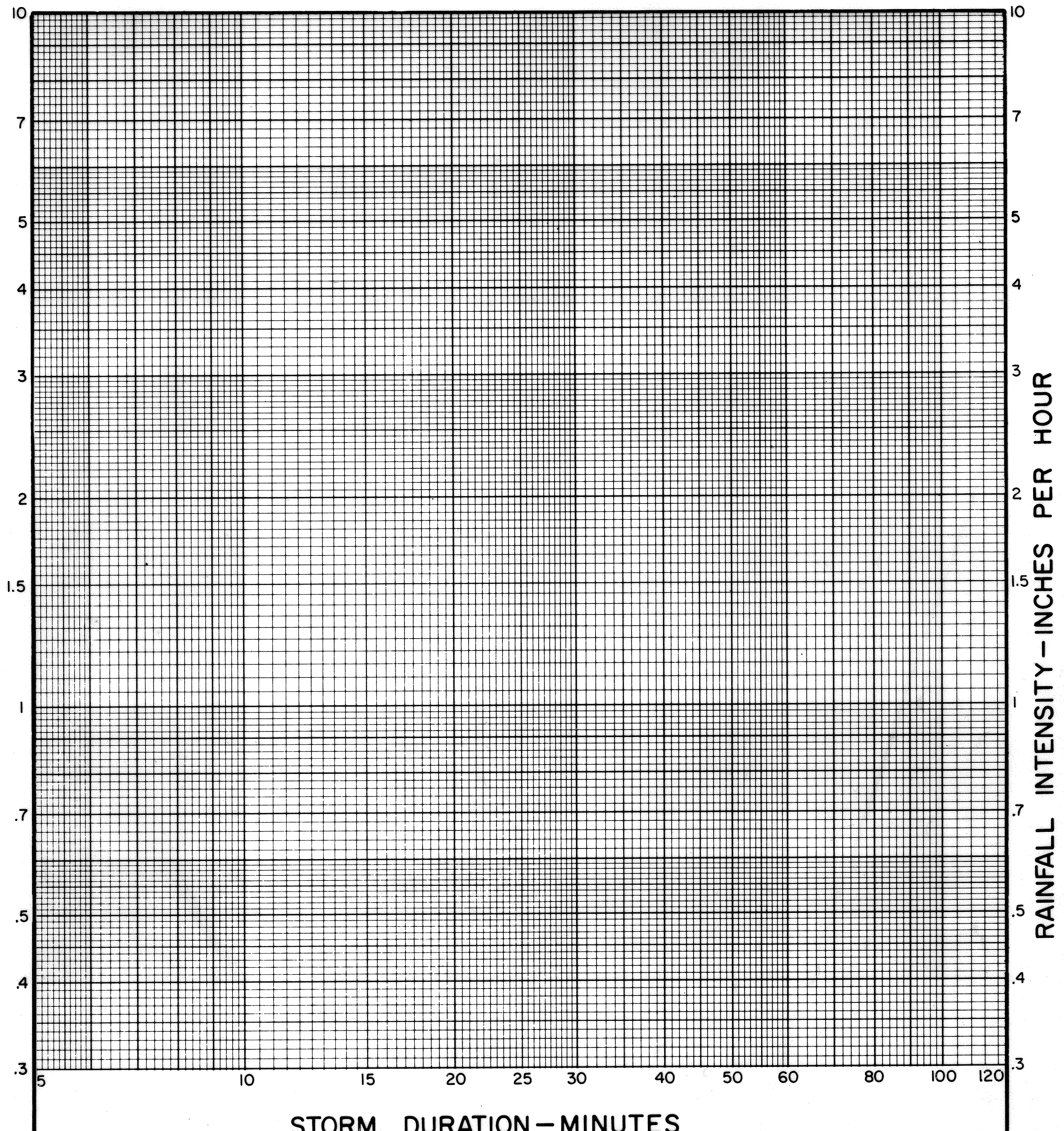
SLOPE = .500

SLOPE = .550

RCFC & WCD

HYDROLOGY MANUAL

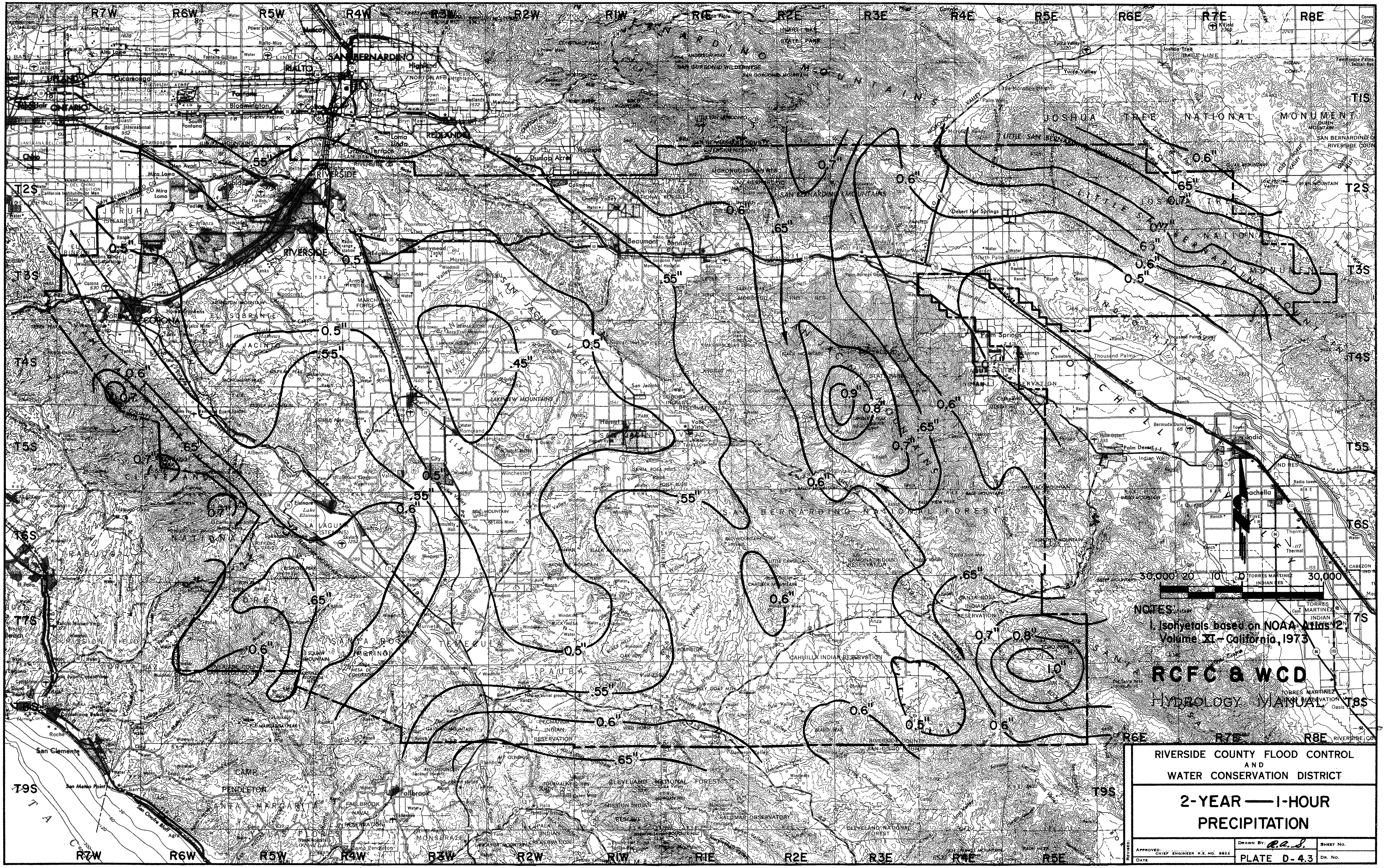
STANDARD
INTENSITY—DURATION
CURVES DATA

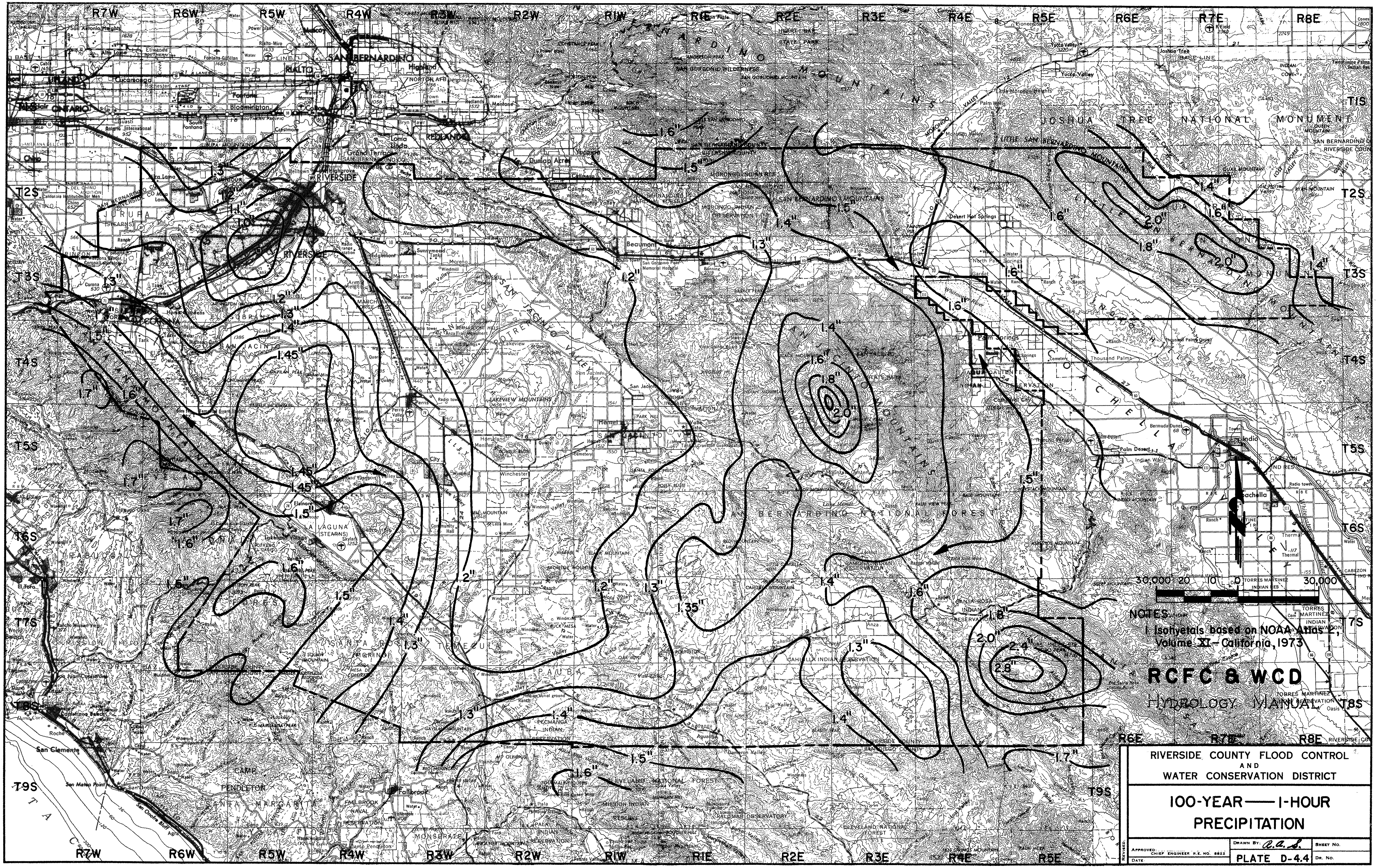


RCFC & WCD

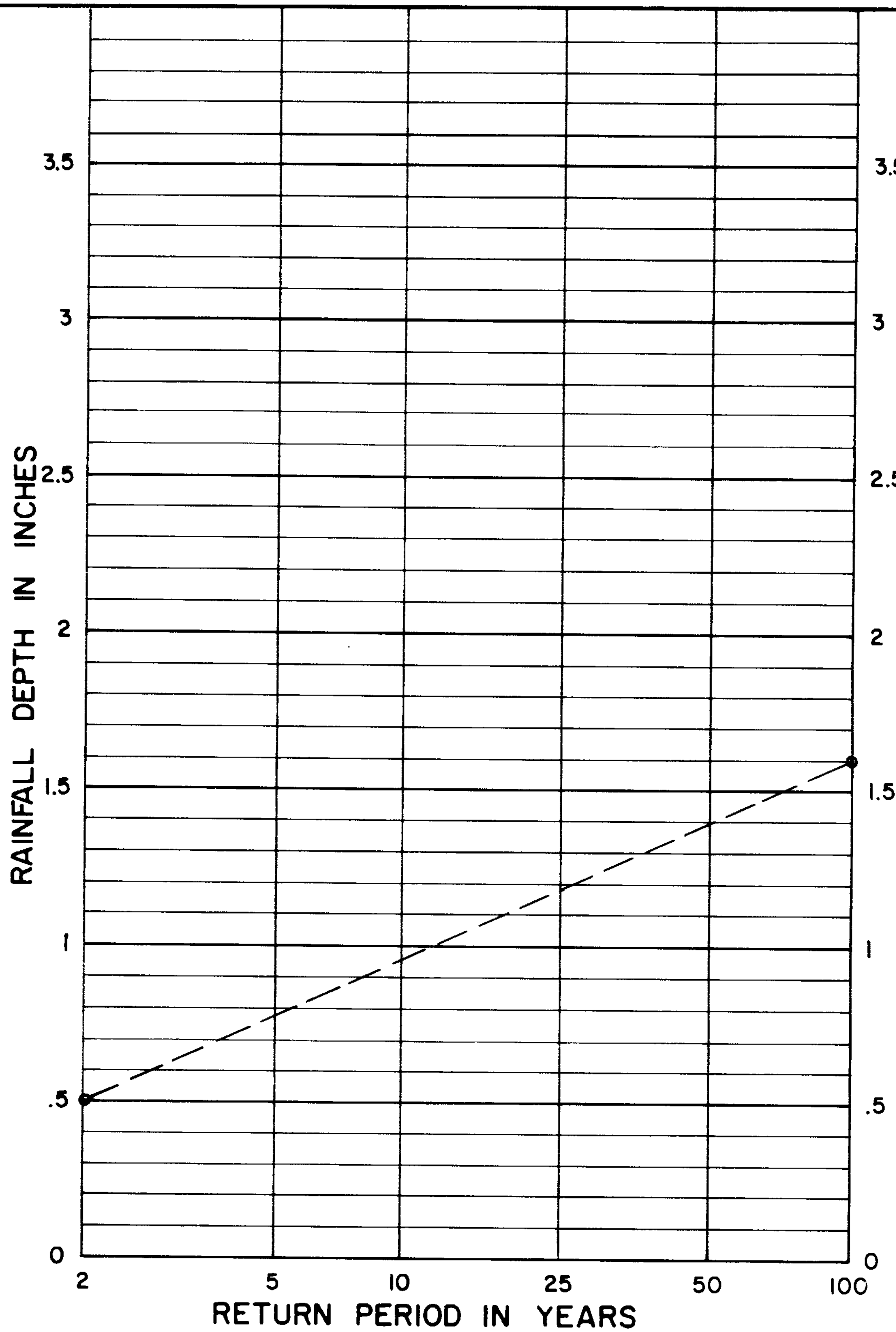
HYDROLOGY MANUAL

INTENSITY—DURATION CURVES


RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
2-YEAR — 1-HOUR PRECIPITATION
NOTES
1. Isohyetals based on NOAA Atlas 2, Volume XI - California, 1973
RCFC & WCD
HYDROLOGY MANUAL
PLATE D-4.3
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E
T1S T2S T3S T4S T5S T6S T7S T8S T9S
RIVERSIDE
SAN BERNARDINO
CORONA
Palm Springs
Indio
Hemet
San Jacinto
Beaumont
Banning
Temecula
Fallbrook
San Clemente
Coachella
Palm Desert



RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
100-YEAR — 1-HOUR
PRECIPITATION
PLATE D-4.4
RCFC & WCD
HYDROLOGY MANUAL
NOTES
1. Isohyetals based on NOAA Atlas 2, Volume XI - California, 1973
30,000 20 10 0 30,000
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E
T1S T2S T3S T4S T5S T6S T7S T8S T9S
SAN BERNARDINO MOUNTAINS
JOSHUA TREE NATIONAL MONUMENT
SAN JACINTO MOUNTAINS
SAN BERNARDINO NATIONAL FOREST
CLEVELAND NATIONAL FOREST
COACHELLA VALLEY
SAN BERNARDINO
RIVERSIDE
REDLANDS
ONTARIO
Beaumont
Banning
Palm Springs
Desert Hot Springs
Palm Desert
Indio
Coachella
Hemet
San Jacinto
Perris
Elsinore
Corona
Temecula
Anza
Fallbrook
San Clemente
1.0" 1.2" 1.3" 1.35" 1.4" 1.45" 1.5" 1.6" 1.7" 1.8" 2.0" 2.4" 2.8"



NOTE:

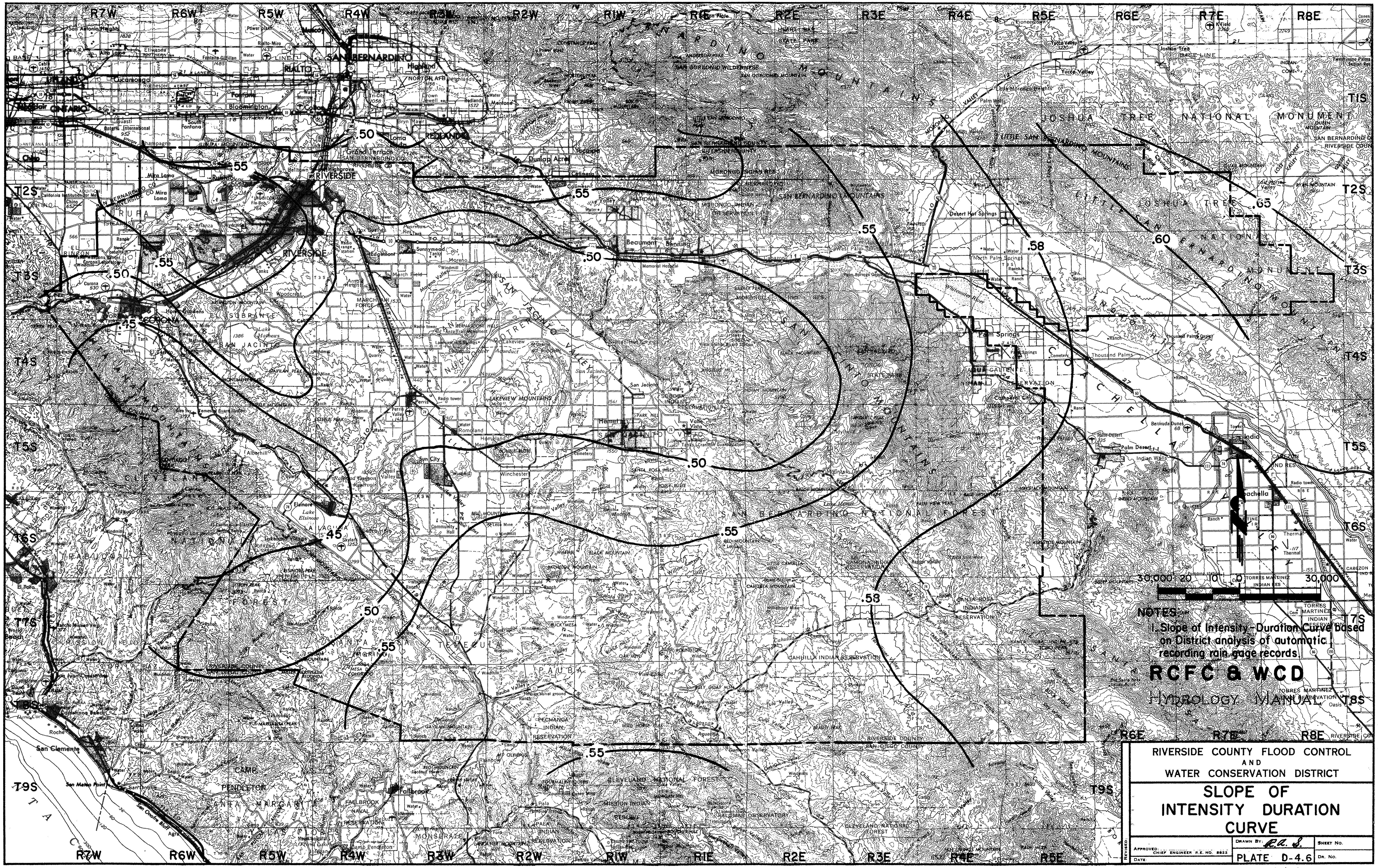
1. For intermediate return periods plot 2-year and 100-year one hour values from maps, then connect points and read value for desired return period. For example given 2-year one hour = .50" and 100-year one hour = 1.60", 25-year one hour = 1.18"

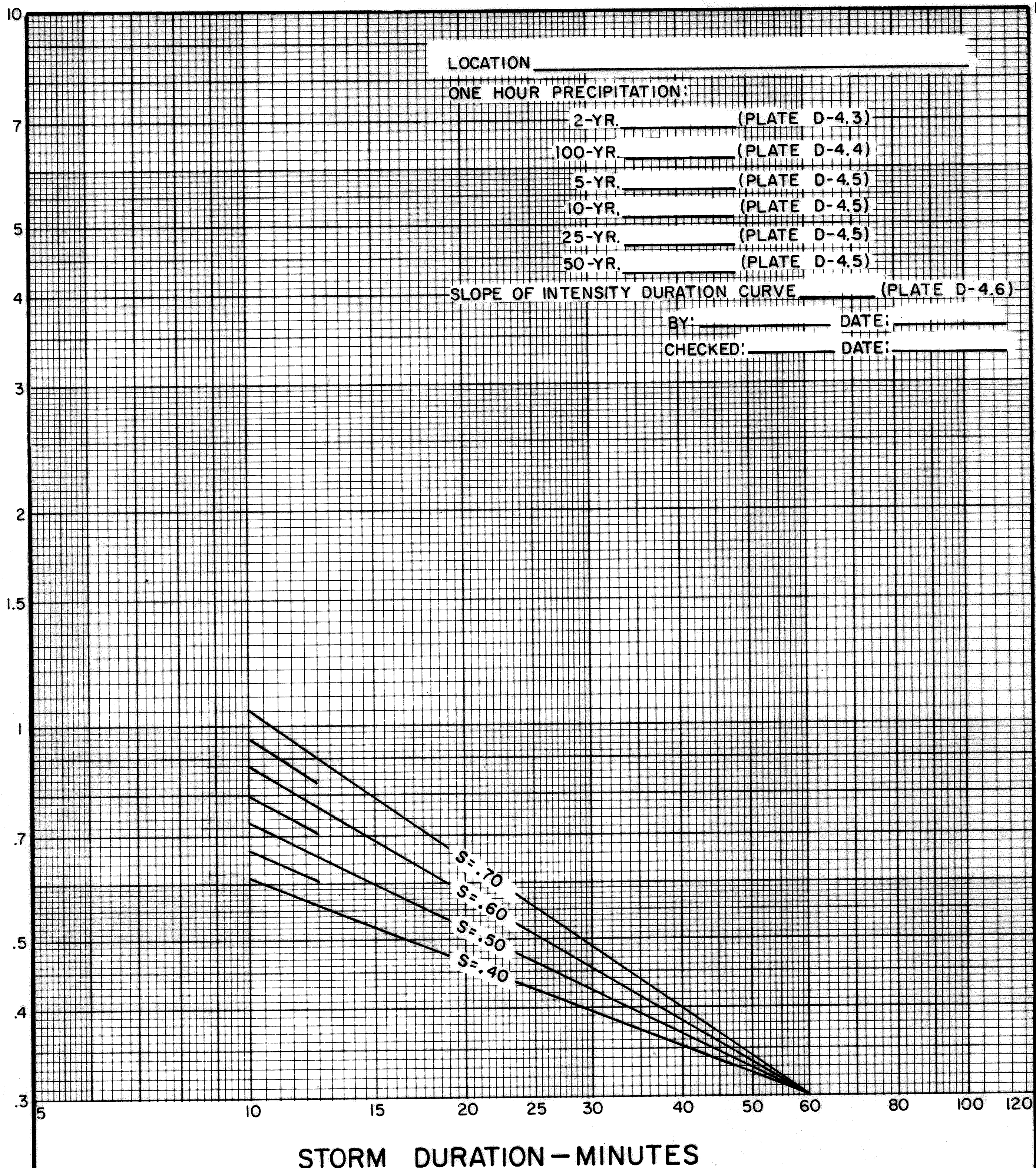
Reference: NOAA Atlas 2, Volume XI - California, 1973.

RCFC & WCD

HYDROLOGY MANUAL

RAINFALL DEPTH VERSUS
RETURN PERIOD FOR
PARTIAL DURATION SERIES

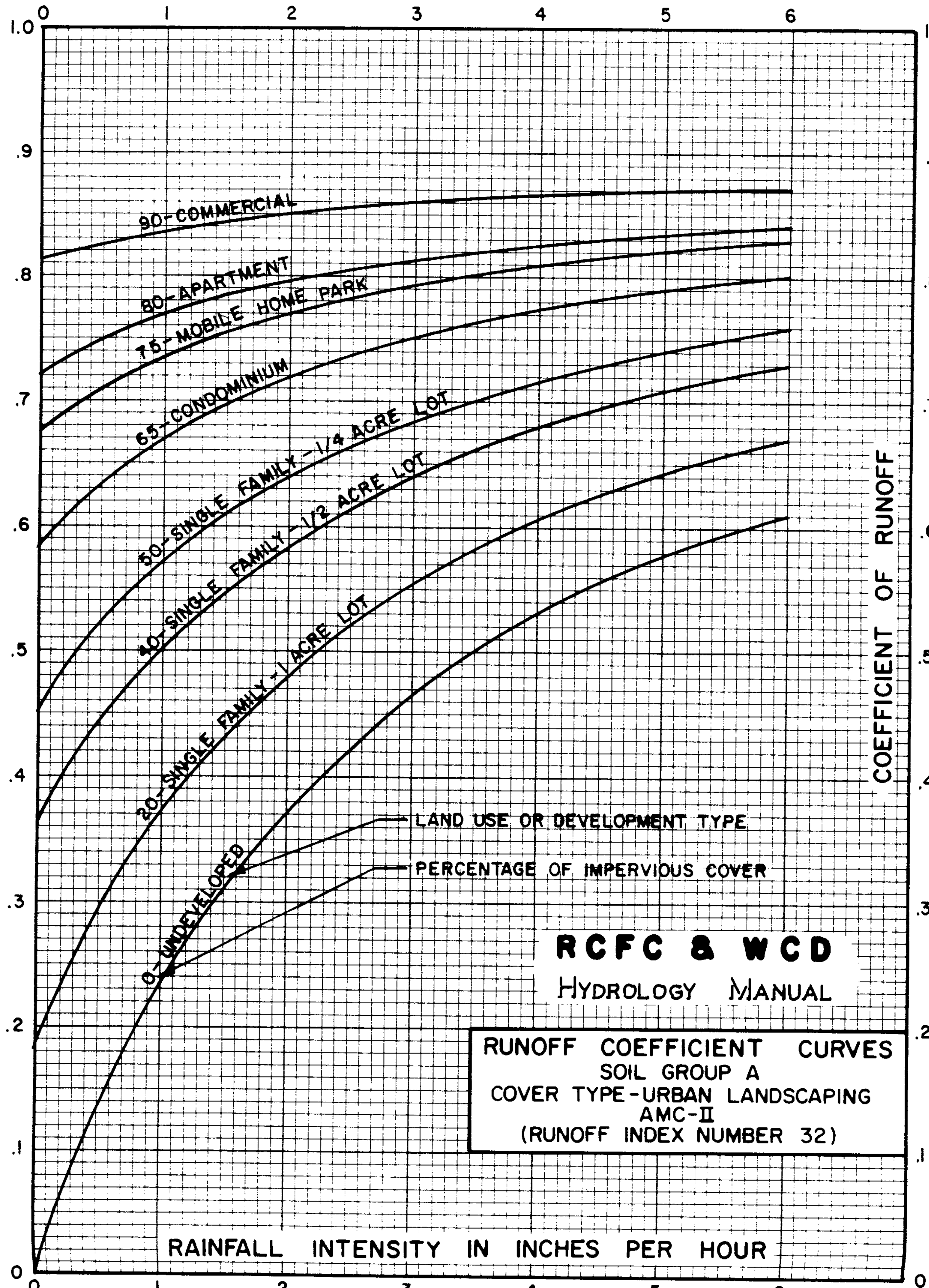

NOTES:
1. Slope of Intensity-Duration Curve based on District analysis of automatic recording rain gage records.
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
SLOPE OF INTENSITY DURATION CURVE
DRAWN BY: R.A.S.
APPROVED: CHIEF ENGINEER R.E. NO. 8822
PLATE D-4.6
30,000 20 10 0 30,000
.45
.50
.55
.58
.60
.65
R7W R6W R5W R4W R3W R2W R1W R1E R2E R3E R4E R5E R6E R7E R8E
T1S T2S T3S T4S T5S T6S T7S T8S T9S
RIVERSIDE
SAN BERNARDINO
CORONA
PALM SPRINGS
BANNING
BEAUMONT
HEMET
SAN JACINTO
ELSINORE
TEMECULA
INDIO
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO NATIONAL FOREST
CLEVELAND NATIONAL FOREST

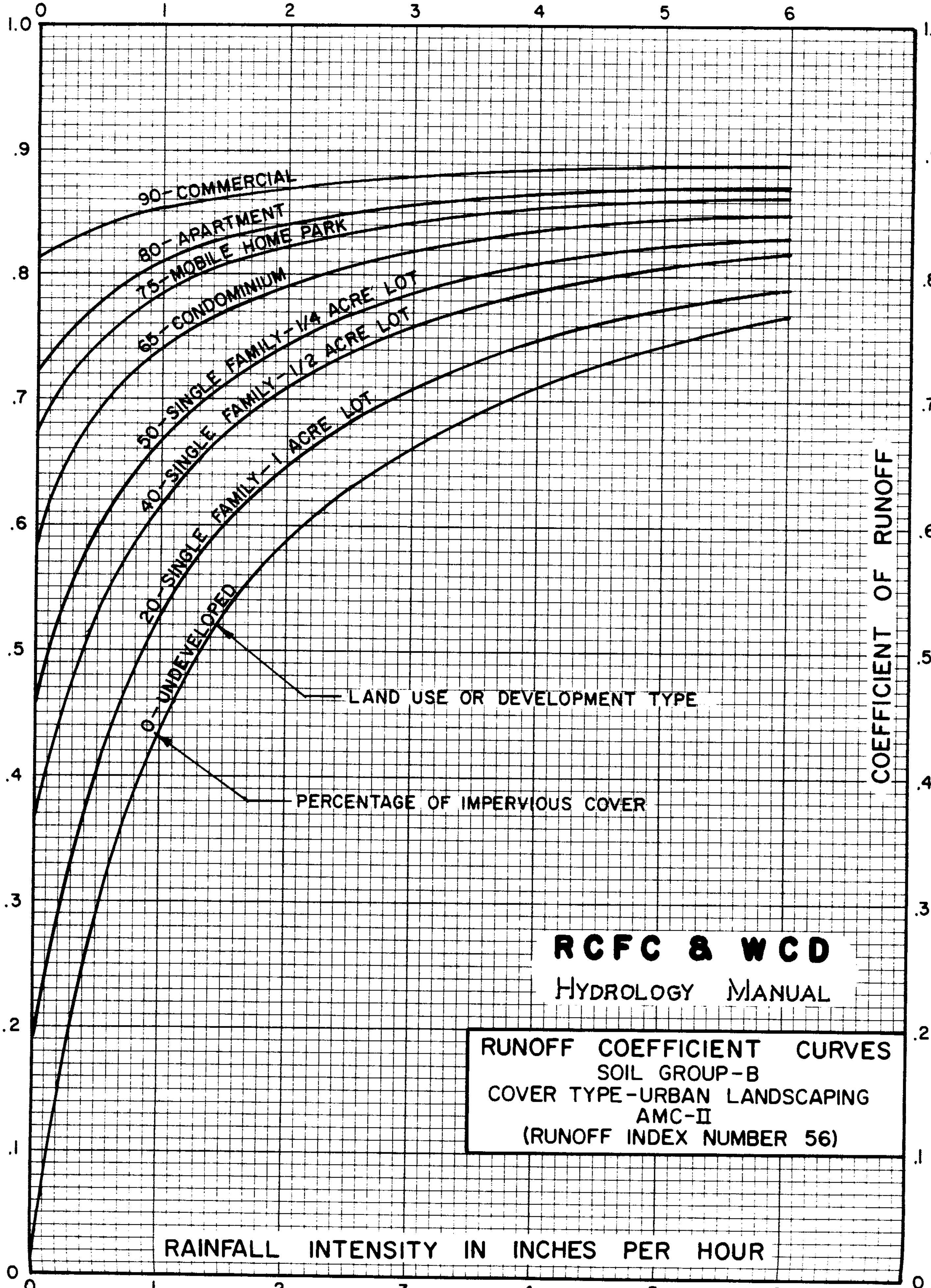


RCFC & WCD

HYDROLOGY MANUAL

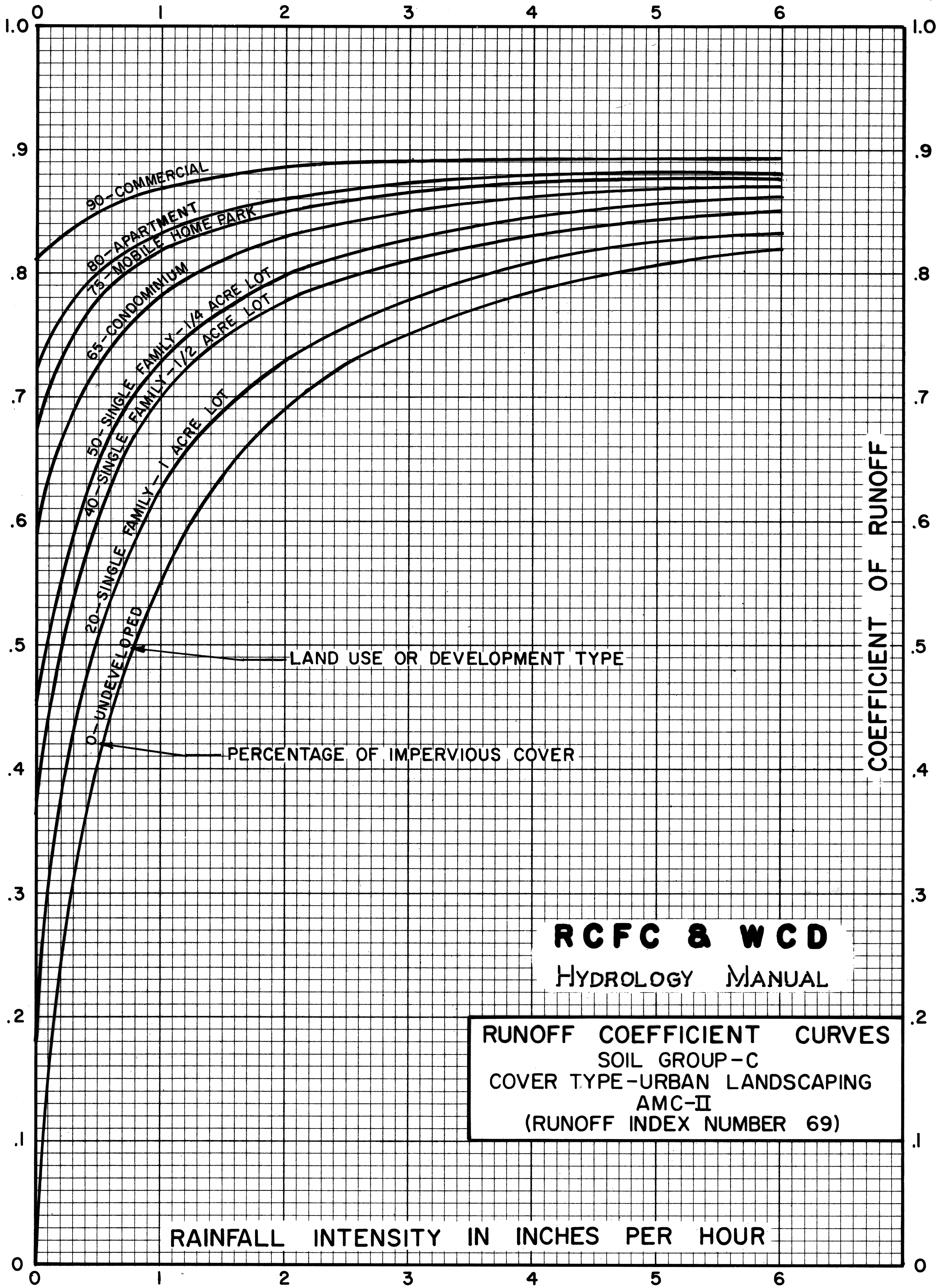
INTENSITY-DURATION CURVES CALCULATION SHEET


90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
COEFFICIENT OF RUNOFF
RAINFALL INTENSITY IN INCHES PER HOUR
RCFC & WCD
HYDROLOGY MANUAL
RUNOFF COEFFICIENT CURVES
SOIL GROUP A
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 32)

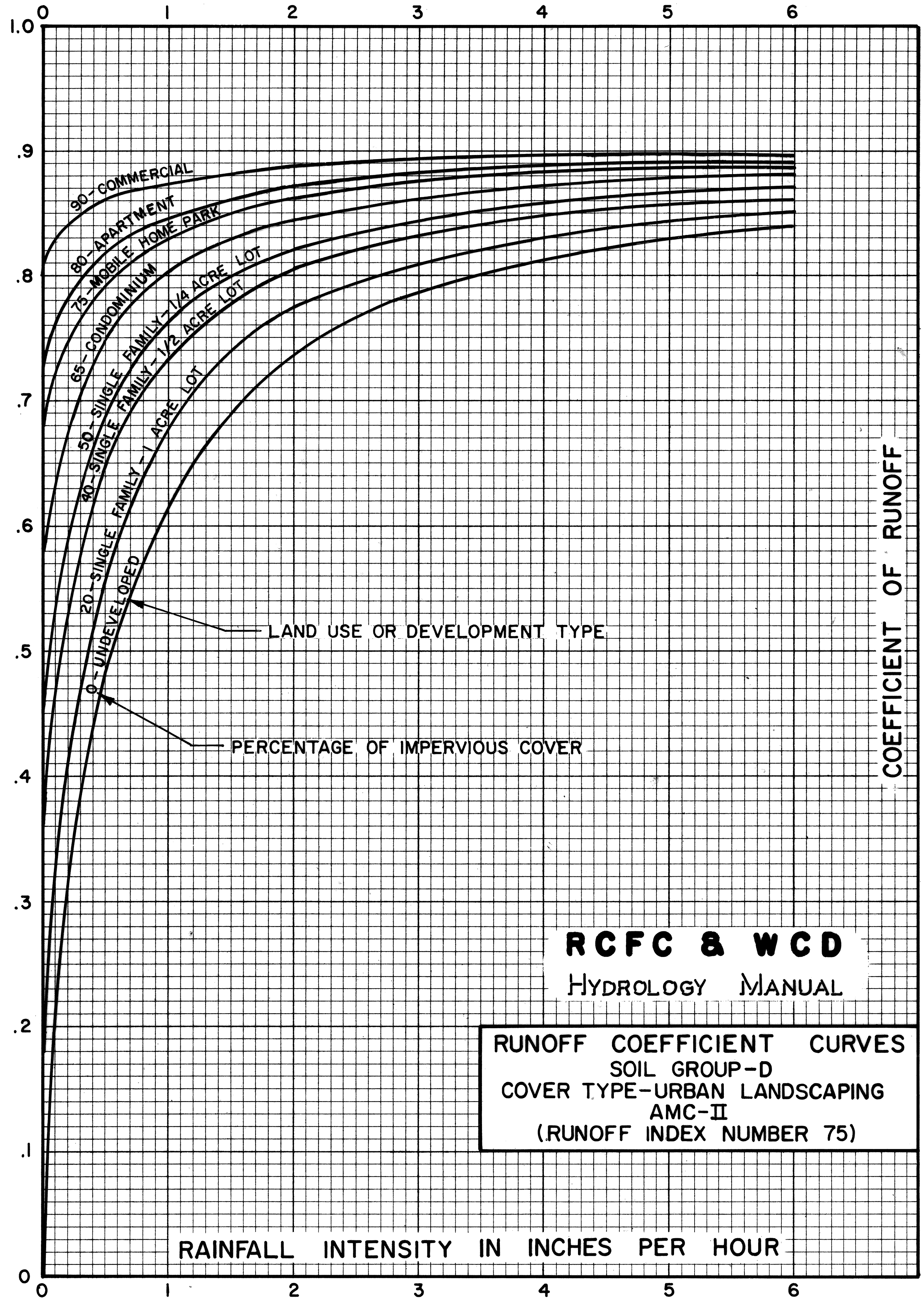


RCFC & WCD
HYDROLOGY MANUAL

RUNOFF COEFFICIENT CURVES
SOIL GROUP-B
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 56)



RCFC & WCD
HYDROLOGY MANUAL
RUNOFF COEFFICIENT CURVES
SOIL GROUP-C
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 69)
RAINFALL INTENSITY IN INCHES PER HOUR
COEFFICIENT OF RUNOFF
90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
0
1
2
3
4
5
6
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0



RCFC & WCD
HYDROLOGY MANUAL
RUNOFF COEFFICIENT CURVES
SOIL GROUP-D
COVER TYPE-URBAN LANDSCAPING
AMC-II
(RUNOFF INDEX NUMBER 75)
RAINFALL INTENSITY IN INCHES PER HOUR
COEFFICIENT OF RUNOFF
90-COMMERCIAL
80-APARTMENT
75-MOBILE HOME PARK
65-CONDOMINIUM
50-SINGLE FAMILY-1/4 ACRE LOT
40-SINGLE FAMILY-1/2 ACRE LOT
20-SINGLE FAMILY-1 ACRE LOT
0-UNDEVELOPED
LAND USE OR DEVELOPMENT TYPE
PERCENTAGE OF IMPERVIOUS COVER
0
1
2
3
4
5
6
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0

RUNOFF INDEX NUMBERS OF HYDROLOGIC SOIL-COVER COMPLEXES FOR PERVIOUS AREAS-AMC II

Cover Type (3)	Quality of Cover (2)	Soil Group A	Soil Group B	Soil Group C	Soil Group D
NATURAL COVERS -					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparrel, Broadleaf (Manzonita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparrel, Narrowleaf (Chamise and redshank)	Poor	71	82	88	91
	Fair	55	72	81	86
Grass, Annual or Perennial	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Meadows or Cienegas (Areas with seasonally high water table, principal vegetation is sod forming grass)	Poor	63	77	85	88
	Fair	51	70	80	84
	Good	30	58	72	78
Open Brush (Soft wood shrubs - buckwheat, sage, etc.)	Poor	62	76	84	88
	Fair	46	66	77	83
	Good	41	63	75	81
Woodland (Coniferous or broadleaf trees predominate. Canopy density is at least 50 percent)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	28	55	70	77
Woodland, Grass (Coniferous or broadleaf trees with canopy density from 20 to 50 percent)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
URBAN COVERS -					
Residential or Commercial Landscaping (Lawn, shrubs, etc.)	Good	32	56	69	75
Turf (Irrigated and mowed grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
AGRICULTURAL COVERS -					
Fallow (Land plowed but not tilled or seeded)		76	85	90	92

RUNOFF INDEX NUMBERS OF HYDROLOGIC SOIL-COVER COMPLEXES FOR PERVIOUS AREAS-AMC II

Cover Type (3)	Quality of Cover (2)	Soil Group A	B	C	D
AGRICULTURAL COVERS (cont.) -					
Legumes, Close Seeded (Alfalfa, sweetclover, timothy, etc.)	Poor	66	77	85	89
	Good	58	72	81	85
Orchards, Deciduous (Apples, apricots, pears, walnuts, etc.)		See Note 4			
Orchards, Evergreen (Citrus, avocados, etc.)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Pasture, Dryland (Annual grasses)	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Pasture, Irrigated (Legumes and perennial grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Row Crops (Field crops - tomatoes, sugar beets, etc.)	Poor	72	81	88	91
	Good	67	78	85	89
Small Grain (Wheat, oats, barley, etc.)	Poor	65	76	84	88
	Good	63	75	83	87
Vineyard		See Note 4			

Notes:

1. All runoff index (RI) numbers are for Antecedent Moisture Condition (AMC) II.

2. Quality of cover definitions:
   Poor-Heavily grazed or regularly burned areas. Less than 50 percent of the ground surface is protected by plant cover or brush and tree canopy.
   Fair-Moderate cover with 50 percent to 75 percent of the ground surface protected.
   Good-Heavy or dense cover with more than 75 percent of the ground surface protected.

3. See Plate C-2 for a detailed description of cover types.

4. Use runoff index numbers based on ground cover type. See discussion under "Cover Type Descriptions" on Plate C-2.

5. Reference Bibliography item 17.

RUNOFF INDEX NUMBERS FOR PERVIOUS AREA

ACTUAL IMPERVIOUS COVER

Land Use (1)	Range-Percent	Recommended Value For Average Conditions-Percent (2)
Natural or Agriculture	0 - 10	0
Single Family Residential: (3)		
40,000 S. F. (1 Acre) Lots	10 - 25	20
20,000 S. F. (½ Acre) Lots	30 - 45	40
7,200 - 10,000 S. F. Lots	45 - 55	50
Multiple Family Residential:		
Condominiums	45 - 70	65
Apartments	65 - 90	80
Mobile Home Park	60 - 85	75
Commercial, Downtown Business or Industrial	80 -100	90

Notes:

1. Land use should be based on ultimate development of the watershed. Long range master plans for the County and incorporated cities should be reviewed to insure reasonable land use assumptions.

2. Recommended values are based on average conditions which may not apply to a particular study area. The percentage impervious may vary greatly even on comparable sized lots due to differences in dwelling size, improvements, etc. Landscape practices should also be considered as it is common in some areas to use ornamental gravels underlain by impervious plastic materials in place of lawns and shrubs. A field investigation of a study area should always be made, and a review of aerial photos, where available may assist in estimating the percentage of impervious cover in developed areas.

3. For typical horse ranch subdivisions increase impervious area 5 percent over the values recommended in the table above.

IMPERVIOUS COVER FOR DEVELOPED AREAS

RUNOFF COEFFICIENT CURVE DATA

The data in the following tables may be used to develop runoff coefficient (C) curves for any combination of runoff index (RI) number and antecedent mositure condition (AMC). For an RI number with an AMC of II (from Plate D-5.5) enter the tables on the following pages and plot the "C" curve data directly on Plate D-5.8. "C" curve data is given for even RI numbers only, but values may easily be interpolated for odd RI numbers.

For an AMC of I or III enter the tabulation on this page with the RI for AMC II, and read the appropriate RI for AMC I or III. Use this revised RI to enter the tables on the following pages to determine "C". For example if RI = 40 for AMC II, then RI = 22 for AMC I and RI = 60 for AMC III.

AMC ADJUSTMENT RELATIONSHIPS

RI FOR AMC II	RI FOR OTHER AMC CONDITIONS: AMC I	AMC III	RI FOR AMC II	RI FOR OTHER AMC CONDITIONS: AMC I	AMC III
10	--	22	55	35	74
11	--	24	56	36	75
12	--	25	57	37	75
13	--	27	58	38	76
14	--	28	59	39	77
15	--	30	60	40	78
16	--	31	61	41	78
17	--	33	62	42	79
18	--	34	63	43	80
19	--	36	64	44	81
20	--	37	65	45	82
21	10	38	66	46	82
22	10	39	67	47	83
23	11	41	68	48	84
24	11	42	69	50	84
25	12	43	70	51	85
26	12	44	71	52	86
27	13	46	72	53	86
28	14	47	73	54	87
29	14	49	74	55	88
30	15	50	75	57	88
31	16	51	76	58	89
32	16	52	77	59	89
33	17	53	78	60	90
34	18	54	79	62	91
35	18	55	80	63	91
36	19	56	81	64	92
37	20	57	82	66	92
38	21	58	83	67	93
39	21	59	84	68	93
40	22	60	85	70	94
41	23	61	86	72	94
42	24	62	87	73	95
43	25	63	88	75	95
44	25	64	89	76	96
45	26	65	90	78	96
46	27	66	91	80	97
47	28	67	92	81	97
48	29	68	93	83	98
49	30	69	94	85	98
50	31	70	95	87	98
51	31	70	96	89	99
52	32	71	97	91	99
53	33	72	98	94	99
54	34	73	99	97	--

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 12

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.04	.08	.12	.15	.18	.21	.24	.26	.30	.34
5.	.04	.09	.12	.16	.19	.22	.25	.27	.29	.33	.37
10.	.09	.13	.17	.20	.23	.25	.28	.30	.33	.36	.40
15.	.13	.17	.21	.24	.26	.29	.31	.34	.36	.39	.43
20.	.18	.22	.25	.28	.30	.33	.35	.37	.39	.42	.45
25.	.22	.26	.29	.31	.34	.36	.38	.40	.42	.45	.48
30.	.27	.30	.33	.35	.38	.40	.42	.44	.45	.48	.51
35.	.31	.34	.37	.39	.41	.43	.45	.47	.48	.51	.54
40.	.36	.39	.41	.43	.45	.47	.49	.50	.52	.54	.57
45.	.40	.43	.45	.47	.49	.51	.52	.54	.55	.57	.59
50.	.45	.47	.49	.51	.53	.54	.56	.57	.58	.60	.62
55.	.49	.51	.53	.55	.56	.58	.59	.60	.61	.63	.65
60.	.54	.56	.57	.59	.60	.61	.62	.63	.64	.66	.68
65.	.58	.60	.61	.63	.64	.65	.66	.67	.68	.69	.70
70.	.63	.64	.66	.67	.68	.68	.69	.70	.71	.72	.73
75.	.67	.69	.70	.70	.71	.72	.73	.73	.74	.75	.76
80.	.72	.73	.74	.74	.75	.76	.76	.77	.77	.78	.79
85.	.76	.77	.78	.78	.79	.79	.80	.80	.80	.81	.82
90.	.81	.81	.82	.82	.83	.83	.83	.83	.84	.84	.84
95.	.86	.86	.86	.86	.86	.86	.87	.87	.87	.87	.87
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 14

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.05	.10	.14	.18	.21	.24	.27	.30	.34	.38
5.	.04	.09	.14	.18	.21	.24	.27	.30	.33	.37	.41
10.	.09	.14	.18	.22	.25	.28	.31	.33	.36	.40	.43
15.	.13	.18	.22	.25	.29	.31	.34	.36	.39	.42	.46
20.	.18	.22	.26	.29	.32	.35	.37	.40	.42	.45	.48
25.	.22	.26	.30	.33	.36	.38	.41	.43	.45	.48	.51
30.	.27	.31	.34	.37	.39	.42	.44	.46	.48	.51	.54
35.	.31	.35	.38	.41	.43	.45	.47	.49	.51	.54	.56
40.	.36	.39	.42	.44	.47	.49	.50	.52	.54	.56	.59
45.	.40	.43	.46	.48	.50	.52	.54	.55	.57	.59	.61
50.	.45	.48	.50	.52	.54	.56	.57	.58	.60	.62	.64
55.	.49	.52	.54	.56	.57	.59	.60	.62	.63	.65	.67
60.	.54	.56	.58	.60	.61	.62	.64	.65	.66	.68	.69
65.	.58	.60	.62	.63	.65	.66	.67	.68	.69	.70	.72
70.	.63	.65	.66	.67	.68	.69	.70	.71	.72	.73	.74
75.	.67	.69	.70	.71	.72	.73	.74	.74	.75	.76	.77
80.	.72	.73	.74	.75	.76	.76	.77	.77	.78	.79	.80
85.	.76	.77	.78	.79	.79	.80	.80	.81	.81	.82	.82
90.	.81	.82	.82	.82	.83	.83	.83	.84	.84	.84	.85
95.	.86	.86	.86	.86	.86	.87	.87	.87	.87	.87	.87
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 16

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.06	.11	.16	.20	.24	.27	.30	.33	.38	.42
5.	.04	.10	.15	.20	.23	.27	.30	.33	.36	.40	.44
10.	.09	.14	.19	.23	.27	.30	.33	.36	.38	.43	.46
15.	.13	.19	.23	.27	.31	.34	.36	.39	.41	.45	.49
20.	.18	.23	.27	.31	.34	.37	.40	.42	.44	.48	.51
25.	.22	.27	.31	.34	.38	.40	.43	.45	.47	.51	.54
30.	.27	.31	.35	.38	.41	.44	.46	.48	.50	.53	.56
35.	.31	.35	.39	.42	.45	.47	.49	.51	.53	.56	.58
40.	.36	.40	.43	.46	.48	.50	.52	.54	.56	.58	.61
45.	.40	.44	.47	.49	.51	.54	.55	.57	.58	.61	.63
50.	.45	.48	.51	.53	.55	.57	.58	.60	.61	.64	.66
55.	.49	.52	.55	.57	.58	.60	.62	.63	.64	.66	.68
60.	.54	.56	.58	.60	.62	.63	.65	.66	.67	.69	.71
65.	.58	.61	.62	.64	.65	.67	.68	.69	.70	.72	.73
70.	.63	.65	.66	.68	.69	.70	.71	.72	.73	.74	.75
75.	.67	.69	.70	.71	.73	.73	.74	.75	.76	.77	.78
80.	.72	.73	.74	.75	.76	.77	.77	.78	.79	.79	.80
85.	.76	.77	.78	.79	.79	.80	.81	.81	.81	.82	.83
90.	.81	.82	.82	.83	.83	.83	.84	.84	.84	.85	.85
95.	.86	.86	.86	.86	.87	.87	.87	.87	.87	.87	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 18

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.07	.13	.18	.22	.26	.30	.33	.36	.41	.45
5.	.04	.11	.17	.21	.26	.29	.33	.36	.38	.43	.47
10.	.09	.15	.20	.25	.29	.33	.36	.39	.41	.46	.49
15.	.13	.19	.24	.29	.32	.36	.39	.41	.44	.48	.52
20.	.18	.23	.28	.32	.36	.39	.42	.44	.47	.51	.54
25.	.22	.28	.32	.36	.39	.42	.45	.47	.49	.53	.56
30.	.27	.32	.36	.39	.43	.45	.48	.50	.52	.55	.58
35.	.31	.36	.40	.43	.46	.49	.51	.53	.55	.58	.61
40.	.36	.40	.44	.47	.49	.52	.54	.56	.57	.60	.63
45.	.40	.44	.47	.50	.53	.55	.57	.59	.60	.63	.65
50.	.45	.48	.51	.54	.56	.58	.60	.61	.63	.65	.67
55.	.49	.53	.55	.58	.60	.61	.63	.64	.66	.68	.70
60.	.54	.57	.59	.61	.63	.64	.66	.67	.68	.70	.72
65.	.58	.61	.63	.65	.66	.68	.69	.70	.71	.73	.74
70.	.63	.65	.67	.68	.70	.71	.72	.73	.74	.75	.76
75.	.67	.69	.71	.72	.73	.74	.75	.76	.76	.78	.79
80.	.72	.73	.75	.76	.76	.77	.78	.79	.79	.80	.81
85.	.76	.78	.78	.79	.80	.80	.81	.81	.82	.83	.83
90.	.81	.82	.82	.83	.83	.84	.84	.84	.85	.85	.85
95.	.86	.86	.86	.86	.87	.87	.87	.87	.87	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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RUNOFF COEFFICIENTS FOR RI INDEX NO. = 20

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.08	.14	.20	.25	.29	.32	.36	.39	.44	.48
5.	.04	.12	.18	.23	.28	.32	.35	.38	.41	.46	.50
10.	.09	.16	.22	.27	.31	.35	.38	.41	.44	.48	.52
15.	.13	.20	.26	.30	.34	.38	.41	.44	.46	.51	.54
20.	.18	.24	.29	.34	.38	.41	.44	.47	.49	.53	.56
25.	.22	.28	.33	.37	.41	.44	.47	.49	.51	.55	.58
30.	.27	.32	.37	.41	.44	.47	.50	.52	.54	.57	.60
35.	.31	.37	.41	.44	.47	.50	.53	.55	.57	.60	.62
40.	.36	.41	.45	.48	.51	.53	.55	.57	.59	.62	.65
45.	.40	.45	.48	.51	.54	.56	.58	.60	.62	.64	.67
50.	.45	.49	.52	.55	.57	.59	.61	.63	.64	.67	.69
55.	.49	.53	.56	.58	.61	.62	.64	.66	.67	.69	.71
60.	.54	.57	.60	.62	.64	.65	.67	.68	.69	.71	.73
65.	.58	.61	.63	.65	.67	.69	.70	.71	.72	.74	.75
70.	.63	.65	.67	.69	.70	.72	.73	.74	.75	.76	.77
75.	.67	.69	.71	.72	.74	.75	.76	.76	.77	.78	.79
80.	.72	.74	.75	.76	.77	.78	.78	.79	.80	.81	.82
85.	.76	.78	.79	.79	.80	.81	.81	.82	.82	.83	.84
90.	.81	.82	.82	.83	.83	.84	.84	.85	.85	.85	.86
95.	.86	.86	.86	.86	.87	.87	.87	.87	.87	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 22

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.09	.16	.22	.27	.31	.35	.38	.41	.46	.50
5.	.04	.13	.19	.25	.30	.34	.38	.41	.44	.48	.52
10.	.09	.17	.23	.29	.33	.37	.40	.43	.46	.51	.54
15.	.13	.21	.27	.32	.36	.40	.43	.46	.49	.53	.56
20.	.18	.25	.31	.35	.39	.43	.46	.49	.51	.55	.58
25.	.22	.29	.34	.39	.43	.46	.49	.51	.53	.57	.60
30.	.27	.33	.38	.42	.46	.49	.51	.54	.56	.59	.62
35.	.31	.37	.42	.46	.49	.52	.54	.56	.58	.62	.64
40.	.36	.41	.45	.49	.52	.55	.57	.59	.61	.64	.66
45.	.40	.45	.49	.52	.55	.58	.60	.62	.63	.66	.68
50.	.45	.49	.53	.56	.58	.61	.62	.64	.66	.68	.70
55.	.49	.53	.57	.59	.62	.64	.65	.67	.68	.70	.72
60.	.54	.57	.60	.63	.65	.66	.68	.69	.70	.73	.74
65.	.58	.62	.64	.66	.68	.69	.71	.72	.73	.75	.76
70.	.63	.66	.68	.70	.71	.72	.73	.74	.75	.77	.78
75.	.67	.70	.71	.73	.74	.75	.76	.77	.78	.79	.80
80.	.72	.74	.75	.76	.77	.78	.79	.80	.80	.81	.82
85.	.76	.78	.79	.80	.81	.81	.82	.82	.83	.83	.84
90.	.81	.82	.83	.83	.84	.84	.84	.85	.85	.86	.86
95.	.86	.86	.86	.87	.87	.87	.87	.87	.88	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 24

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.10	.17	.24	.29	.33	.37	.41	.44	.49	.53
5.	.04	.14	.21	.27	.32	.36	.40	.43	.46	.51	.55
10.	.09	.18	.25	.30	.35	.39	.43	.46	.48	.53	.57
15.	.13	.22	.28	.34	.38	.42	.45	.48	.51	.55	.58
20.	.18	.26	.32	.37	.41	.45	.48	.51	.53	.57	.60
25.	.22	.30	.35	.40	.44	.48	.51	.53	.55	.59	.62
30.	.27	.34	.39	.44	.47	.50	.53	.56	.58	.61	.64
35.	.31	.38	.43	.47	.50	.53	.56	.58	.60	.63	.66
40.	.36	.42	.46	.50	.53	.56	.58	.60	.62	.65	.68
45.	.40	.46	.50	.53	.56	.59	.61	.63	.65	.67	.70
50.	.45	.50	.54	.57	.59	.62	.64	.65	.67	.69	.71
55.	.49	.54	.57	.60	.63	.65	.66	.68	.69	.71	.73
60.	.54	.58	.61	.63	.66	.67	.69	.70	.72	.74	.75
65.	.58	.62	.65	.67	.69	.70	.72	.73	.74	.76	.77
70.	.63	.66	.68	.70	.72	.73	.74	.75	.76	.78	.79
75.	.67	.70	.72	.73	.75	.76	.77	.78	.78	.80	.81
80.	.72	.74	.75	.77	.78	.79	.79	.80	.81	.82	.83
85.	.76	.78	.79	.80	.81	.82	.82	.83	.83	.84	.84
90.	.81	.82	.83	.83	.84	.84	.85	.85	.85	.86	.86
95.	.86	.86	.86	.87	.87	.87	.87	.88	.88	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 26

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.10	.19	.25	.31	.36	.40	.43	.46	.51	.55
5.	.04	.14	.22	.29	.34	.38	.42	.46	.48	.53	.57
10.	.09	.18	.26	.32	.37	.41	.45	.48	.51	.55	.59
15.	.13	.22	.29	.35	.40	.44	.47	.50	.53	.57	.60
20.	.18	.26	.33	.38	.43	.47	.50	.53	.55	.59	.62
25.	.22	.30	.37	.42	.46	.49	.52	.55	.57	.61	.64
30.	.27	.34	.40	.45	.49	.52	.55	.57	.59	.63	.66
35.	.31	.38	.44	.48	.52	.55	.57	.60	.62	.65	.67
40.	.36	.42	.47	.51	.55	.57	.60	.62	.64	.67	.69
45.	.40	.46	.51	.55	.58	.60	.62	.64	.66	.69	.71
50.	.45	.50	.54	.58	.61	.63	.65	.67	.68	.71	.73
55.	.49	.54	.58	.61	.63	.66	.67	.69	.70	.73	.74
60.	.54	.58	.62	.64	.66	.68	.70	.71	.72	.74	.76
65.	.58	.62	.65	.67	.69	.71	.72	.74	.75	.76	.78
70.	.63	.66	.69	.71	.72	.74	.75	.76	.77	.78	.80
75.	.67	.70	.72	.74	.75	.76	.77	.78	.79	.80	.81
80.	.72	.74	.76	.77	.78	.79	.80	.81	.81	.82	.83
85.	.76	.78	.79	.80	.81	.82	.82	.83	.83	.84	.85
90.	.81	.82	.83	.84	.84	.85	.85	.85	.86	.86	.87
95.	.86	.86	.86	.87	.87	.87	.87	.88	.88	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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RUNOFF COEFFICIENTS FOR RI INDEX NO. = 28

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.11	.20	.27	.33	.38	.42	.45	.48	.53	.57
5.	.04	.15	.24	.31	.36	.41	.44	.48	.51	.55	.59
10.	.09	.19	.27	.34	.39	.43	.47	.50	.53	.57	.61
15.	.13	.23	.31	.37	.42	.46	.49	.52	.55	.59	.62
20.	.18	.27	.34	.40	.45	.48	.52	.54	.57	.61	.64
25.	.22	.31	.38	.43	.47	.51	.54	.57	.59	.63	.65
30.	.27	.35	.41	.46	.50	.54	.56	.59	.61	.64	.67
35.	.31	.39	.45	.49	.53	.56	.59	.61	.63	.66	.69
40.	.36	.43	.48	.52	.56	.59	.61	.63	.65	.68	.70
45.	.40	.47	.52	.56	.59	.61	.64	.66	.67	.70	.72
50.	.45	.51	.55	.59	.62	.64	.66	.68	.69	.72	.74
55.	.49	.55	.59	.62	.64	.67	.68	.70	.71	.74	.75
60.	.54	.59	.62	.65	.67	.69	.71	.72	.73	.75	.77
65.	.58	.63	.66	.68	.70	.72	.73	.74	.75	.77	.79
70.	.63	.66	.69	.71	.73	.74	.76	.77	.78	.79	.80
75.	.67	.70	.73	.74	.76	.77	.78	.79	.80	.81	.82
80.	.72	.74	.76	.77	.79	.80	.80	.81	.82	.83	.83
85.	.76	.78	.80	.81	.81	.82	.83	.83	.84	.85	.85
90.	.81	.82	.83	.84	.84	.85	.85	.86	.86	.86	.87
95.	.86	.86	.87	.87	.87	.87	.88	.88	.88	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 30

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.12	.22	.29	.35	.40	.44	.48	.51	.55	.59
5.	.04	.16	.25	.32	.38	.43	.46	.50	.53	.57	.61
10.	.09	.20	.29	.35	.41	.45	.49	.52	.55	.59	.62
15.	.13	.24	.32	.38	.43	.48	.51	.54	.57	.61	.64
20.	.18	.28	.36	.41	.46	.50	.53	.56	.59	.62	.65
25.	.22	.32	.39	.44	.49	.53	.56	.58	.60	.64	.67
30.	.27	.36	.42	.47	.52	.55	.58	.60	.62	.66	.68
35.	.31	.40	.46	.51	.54	.58	.60	.62	.64	.68	.70
40.	.36	.43	.49	.54	.57	.60	.63	.65	.66	.69	.72
45.	.40	.47	.53	.57	.60	.63	.65	.67	.68	.71	.73
50.	.45	.51	.56	.60	.63	.65	.67	.69	.70	.73	.75
55.	.49	.55	.59	.63	.65	.68	.69	.71	.72	.74	.76
60.	.54	.59	.63	.66	.68	.70	.72	.73	.74	.76	.78
65.	.58	.63	.66	.69	.71	.73	.74	.75	.76	.78	.79
70.	.63	.67	.70	.72	.74	.75	.76	.77	.78	.80	.81
75.	.67	.71	.73	.75	.76	.78	.79	.79	.80	.81	.82
80.	.72	.74	.76	.78	.79	.80	.81	.82	.82	.83	.84
85.	.76	.78	.80	.81	.82	.83	.83	.84	.84	.85	.85
90.	.81	.82	.83	.84	.85	.85	.85	.86	.86	.87	.87
95.	.86	.86	.87	.87	.87	.88	.88	.88	.88	.88	.88
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 32

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.13	.23	.31	.37	.42	.46	.50	.53	.57	.61
5.	.04	.17	.27	.34	.40	.45	.48	.52	.55	.59	.63
10.	.09	.21	.30	.37	.43	.47	.51	.54	.56	.61	.64
15.	.13	.25	.33	.40	.45	.49	.53	.56	.58	.62	.65
20.	.18	.29	.37	.43	.48	.52	.55	.58	.60	.64	.67
25.	.22	.33	.40	.46	.50	.54	.57	.60	.62	.66	.68
30.	.27	.36	.43	.49	.53	.57	.59	.62	.64	.67	.70
35.	.31	.40	.47	.52	.56	.59	.62	.64	.66	.69	.71
40.	.36	.44	.50	.55	.58	.61	.64	.66	.68	.70	.73
45.	.40	.48	.53	.58	.61	.64	.66	.68	.69	.72	.74
50.	.45	.52	.57	.61	.64	.66	.68	.70	.71	.74	.76
55.	.49	.56	.60	.64	.66	.68	.70	.72	.73	.75	.77
60.	.54	.59	.63	.66	.69	.71	.73	.74	.75	.77	.78
65.	.58	.63	.67	.69	.72	.73	.75	.76	.77	.79	.80
70.	.63	.67	.70	.72	.74	.76	.77	.78	.79	.80	.81
75.	.67	.71	.73	.75	.77	.78	.79	.80	.81	.82	.83
80.	.72	.75	.77	.78	.79	.80	.81	.82	.83	.83	.84
85.	.76	.79	.80	.81	.82	.83	.83	.84	.84	.85	.86
90.	.81	.82	.83	.84	.85	.85	.86	.86	.86	.87	.87
95.	.86	.86	.87	.87	.87	.88	.88	.88	.88	.88	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 34

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.15	.25	.33	.39	.44	.48	.52	.55	.59	.63
5.	.04	.18	.28	.36	.42	.47	.50	.54	.56	.61	.64
10.	.09	.22	.32	.39	.44	.49	.52	.56	.58	.62	.66
15.	.13	.26	.35	.42	.47	.51	.55	.57	.60	.64	.67
20.	.18	.30	.38	.44	.49	.53	.57	.59	.62	.65	.68
25.	.22	.33	.41	.47	.52	.56	.59	.61	.63	.67	.70
30.	.27	.37	.45	.50	.54	.58	.61	.63	.65	.69	.71
35.	.31	.41	.48	.53	.57	.60	.63	.65	.67	.70	.72
40.	.36	.45	.51	.56	.60	.63	.65	.67	.69	.72	.74
45.	.40	.49	.54	.59	.62	.65	.67	.69	.71	.73	.75
50.	.45	.52	.58	.62	.65	.67	.69	.71	.72	.75	.76
55.	.49	.56	.61	.64	.67	.69	.71	.73	.74	.76	.78
60.	.54	.60	.64	.67	.70	.72	.73	.75	.76	.78	.79
65.	.58	.64	.67	.70	.72	.74	.75	.77	.78	.79	.81
70.	.63	.67	.71	.73	.75	.76	.77	.79	.79	.81	.82
75.	.67	.71	.74	.76	.77	.79	.80	.80	.81	.82	.83
80.	.72	.75	.77	.79	.80	.81	.82	.82	.83	.84	.85
85.	.76	.79	.80	.81	.82	.83	.84	.84	.85	.85	.86
90.	.81	.82	.84	.84	.85	.85	.86	.86	.86	.87	.87
95.	.86	.86	.87	.87	.87	.88	.88	.88	.88	.88	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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RUNOFF COEFFICIENTS FOR RI INDEX NO. = 36

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.16	.27	.35	.41	.46	.50	.54	.57	.61	.65
5.	.04	.19	.30	.38	.44	.48	.52	.55	.58	.63	.66
10.	.09	.23	.33	.40	.46	.51	.54	.57	.60	.64	.67
15.	.13	.27	.36	.43	.49	.53	.56	.59	.62	.65	.68
20.	.18	.31	.39	.46	.51	.55	.58	.61	.63	.67	.70
25.	.22	.34	.43	.49	.53	.57	.60	.63	.65	.68	.71
30.	.27	.38	.46	.51	.56	.59	.62	.65	.67	.70	.72
35.	.31	.42	.49	.54	.58	.62	.64	.66	.68	.71	.73
40.	.36	.45	.52	.57	.61	.64	.66	.68	.70	.73	.75
45.	.40	.49	.55	.60	.63	.66	.68	.70	.72	.74	.76
50.	.45	.53	.58	.62	.66	.68	.70	.72	.73	.76	.77
55.	.49	.57	.62	.65	.68	.70	.72	.74	.75	.77	.79
60.	.54	.60	.65	.68	.70	.72	.74	.75	.77	.78	.80
65.	.58	.64	.68	.71	.73	.75	.76	.77	.78	.80	.81
70.	.63	.68	.71	.73	.75	.77	.78	.79	.80	.81	.82
75.	.67	.71	.74	.76	.78	.79	.80	.81	.82	.83	.84
80.	.72	.75	.77	.79	.80	.81	.82	.83	.83	.84	.85
85.	.76	.79	.81	.82	.83	.83	.84	.85	.85	.86	.86
90.	.81	.83	.84	.84	.85	.86	.86	.86	.87	.87	.87
95.	.86	.86	.87	.87	.88	.88	.88	.88	.88	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 38

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.17	.28	.37	.43	.48	.52	.56	.58	.63	.66
5.	.04	.20	.31	.39	.45	.50	.54	.57	.60	.64	.67
10.	.09	.24	.35	.42	.48	.52	.56	.59	.61	.65	.68
15.	.13	.28	.38	.45	.50	.54	.58	.61	.63	.67	.70
20.	.18	.31	.41	.47	.52	.56	.60	.62	.65	.68	.71
25.	.22	.35	.44	.50	.55	.59	.62	.64	.66	.70	.72
30.	.27	.39	.47	.53	.57	.61	.64	.66	.68	.71	.73
35.	.31	.42	.50	.55	.60	.63	.65	.68	.69	.72	.74
40.	.36	.46	.53	.58	.62	.65	.67	.69	.71	.74	.76
45.	.40	.50	.56	.61	.64	.67	.69	.71	.73	.75	.77
50.	.45	.53	.59	.63	.67	.69	.71	.73	.74	.76	.78
55.	.49	.57	.62	.66	.69	.71	.73	.74	.76	.78	.79
60.	.54	.61	.65	.69	.71	.73	.75	.76	.77	.79	.80
65.	.58	.64	.68	.71	.74	.75	.77	.78	.79	.80	.82
70.	.63	.68	.72	.74	.76	.77	.79	.80	.80	.82	.83
75.	.67	.72	.75	.77	.78	.80	.81	.81	.82	.83	.84
80.	.72	.75	.78	.79	.81	.82	.82	.83	.84	.85	.85
85.	.76	.79	.81	.82	.83	.84	.84	.85	.85	.86	.86
90.	.81	.83	.84	.85	.85	.86	.86	.87	.87	.87	.88
95.	.86	.86	.87	.87	.88	.88	.88	.88	.88	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 40

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.18	.30	.39	.45	.50	.54	.57	.60	.64	.67
5.	.04	.22	.33	.41	.47	.52	.56	.59	.62	.66	.69
10.	.09	.25	.36	.44	.49	.54	.58	.61	.63	.67	.70
15.	.13	.29	.39	.46	.52	.56	.59	.62	.64	.68	.71
20.	.18	.32	.42	.49	.54	.58	.61	.64	.66	.69	.72
25.	.22	.36	.45	.51	.56	.60	.63	.65	.68	.71	.73
30.	.27	.40	.48	.54	.59	.62	.65	.67	.69	.72	.74
35.	.31	.43	.51	.57	.61	.64	.67	.69	.71	.73	.75
40.	.36	.47	.54	.59	.63	.66	.68	.70	.72	.75	.76
45.	.40	.50	.57	.62	.65	.68	.70	.72	.74	.76	.78
50.	.45	.54	.60	.64	.67	.70	.72	.74	.75	.77	.79
55.	.49	.58	.63	.67	.70	.72	.74	.75	.76	.78	.80
60.	.54	.61	.66	.69	.72	.74	.76	.77	.78	.80	.81
65.	.58	.65	.69	.72	.74	.76	.77	.79	.79	.81	.82
70.	.63	.68	.72	.75	.76	.78	.79	.80	.81	.82	.83
75.	.67	.72	.75	.77	.79	.80	.81	.82	.83	.84	.84
80.	.72	.76	.78	.80	.81	.82	.83	.83	.84	.85	.86
85.	.76	.79	.81	.82	.83	.84	.85	.85	.86	.86	.87
90.	.81	.83	.84	.85	.86	.86	.86	.87	.87	.87	.88
95.	.86	.86	.87	.87	.88	.88	.88	.88	.88	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 42

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.19	.32	.40	.47	.52	.56	.59	.62	.66	.69
5.	.04	.23	.35	.43	.49	.54	.57	.61	.63	.67	.70
10.	.09	.26	.38	.45	.51	.56	.59	.62	.64	.68	.71
15.	.13	.30	.40	.48	.53	.58	.61	.64	.66	.69	.72
20.	.18	.33	.43	.50	.55	.59	.63	.65	.67	.71	.73
25.	.22	.37	.46	.53	.58	.61	.64	.67	.69	.72	.74
30.	.27	.40	.49	.55	.60	.63	.66	.68	.70	.73	.75
35.	.31	.44	.52	.58	.62	.65	.68	.70	.72	.74	.76
40.	.36	.48	.55	.60	.64	.67	.69	.71	.73	.75	.77
45.	.40	.51	.58	.63	.66	.69	.71	.73	.74	.77	.78
50.	.45	.55	.61	.65	.68	.71	.73	.74	.76	.78	.79
55.	.49	.58	.64	.68	.71	.73	.75	.76	.77	.79	.80
60.	.54	.62	.67	.70	.73	.75	.76	.78	.79	.80	.82
65.	.58	.65	.70	.73	.75	.77	.78	.79	.80	.82	.83
70.	.63	.69	.73	.75	.77	.79	.80	.81	.81	.83	.84
75.	.67	.72	.75	.78	.79	.80	.81	.82	.83	.84	.85
80.	.72	.76	.78	.80	.81	.82	.83	.84	.84	.85	.86
85.	.76	.79	.81	.83	.84	.84	.85	.85	.86	.86	.87
90.	.81	.83	.84	.85	.86	.86	.87	.87	.87	.88	.88
95.	.86	.86	.87	.88	.88	.88	.88	.88	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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RUNOFF COEFFICIENTS FOR RI INDEX NO. = 44

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.20	.33	.42	.49	.54	.57	.61	.63	.67	.70
5.	.04	.24	.36	.45	.51	.55	.59	.62	.65	.68	.71
10.	.09	.27	.39	.47	.53	.57	.61	.64	.66	.69	.72
15.	.13	.31	.42	.49	.55	.59	.62	.65	.67	.71	.73
20.	.18	.34	.45	.52	.57	.61	.64	.66	.69	.72	.74
25.	.22	.38	.48	.54	.59	.63	.66	.68	.70	.73	.75
30.	.27	.41	.50	.57	.61	.65	.67	.69	.71	.74	.76
35.	.31	.45	.53	.59	.63	.66	.69	.71	.73	.75	.77
40.	.36	.48	.56	.61	.65	.68	.70	.72	.74	.76	.78
45.	.40	.52	.59	.64	.67	.70	.72	.74	.75	.77	.79
50.	.45	.55	.62	.66	.69	.72	.74	.75	.77	.79	.80
55.	.49	.59	.65	.69	.71	.74	.75	.77	.78	.80	.81
60.	.54	.62	.67	.71	.73	.75	.77	.78	.79	.81	.82
65.	.58	.66	.70	.73	.76	.77	.79	.80	.81	.82	.83
70.	.63	.69	.73	.76	.78	.79	.80	.81	.82	.83	.84
75.	.67	.73	.76	.78	.80	.81	.82	.83	.83	.84	.85
80.	.72	.76	.79	.80	.82	.83	.83	.84	.85	.85	.86
85.	.76	.80	.82	.83	.84	.85	.85	.86	.86	.87	.87
90.	.81	.83	.84	.85	.86	.86	.87	.87	.87	.88	.88
95.	.86	.87	.87	.88	.88	.88	.88	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 46

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.22	.35	.44	.50	.55	.59	.62	.65	.69	.71
5.	.04	.25	.38	.46	.52	.57	.61	.64	.66	.70	.72
10.	.09	.29	.41	.49	.54	.59	.62	.65	.67	.71	.73
15.	.13	.32	.43	.51	.56	.61	.64	.66	.68	.72	.74
20.	.18	.35	.46	.53	.58	.62	.65	.68	.70	.73	.75
25.	.22	.39	.49	.56	.60	.64	.67	.69	.71	.74	.76
30.	.27	.42	.52	.58	.62	.66	.68	.71	.72	.75	.77
35.	.31	.46	.54	.60	.64	.67	.70	.72	.74	.76	.78
40.	.36	.49	.57	.62	.66	.69	.71	.73	.75	.77	.79
45.	.40	.52	.60	.65	.68	.71	.73	.75	.76	.78	.80
50.	.45	.56	.63	.67	.70	.73	.75	.76	.77	.79	.81
55.	.49	.59	.65	.69	.72	.74	.76	.77	.79	.80	.82
60.	.54	.63	.68	.72	.74	.76	.78	.79	.80	.81	.83
65.	.58	.66	.71	.74	.76	.78	.79	.80	.81	.82	.83
70.	.63	.70	.74	.76	.78	.80	.81	.82	.82	.84	.84
75.	.67	.73	.76	.79	.80	.81	.82	.83	.84	.85	.85
80.	.72	.76	.79	.81	.82	.83	.84	.84	.85	.86	.86
85.	.76	.80	.82	.83	.84	.85	.85	.86	.86	.87	.87
90.	.81	.83	.85	.85	.86	.87	.87	.87	.87	.88	.88
95.	.86	.87	.87	.88	.88	.88	.88	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 48

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.23	.37	.46	.52	.57	.61	.64	.66	.70	.73
5.	.04	.26	.39	.48	.54	.59	.62	.65	.67	.71	.73
10.	.09	.30	.42	.50	.56	.60	.64	.66	.69	.72	.74
15.	.13	.33	.45	.52	.58	.62	.65	.68	.70	.73	.75
20.	.18	.37	.47	.55	.60	.64	.67	.69	.71	.74	.76
25.	.22	.40	.50	.57	.62	.65	.68	.70	.72	.75	.77
30.	.27	.43	.53	.59	.64	.67	.70	.72	.73	.76	.78
35.	.31	.47	.55	.61	.65	.69	.71	.73	.74	.77	.79
40.	.36	.50	.58	.64	.67	.70	.72	.74	.76	.78	.80
45.	.40	.53	.61	.66	.69	.72	.74	.76	.77	.79	.80
50.	.45	.57	.63	.68	.71	.74	.75	.77	.78	.80	.81
55.	.49	.60	.66	.70	.73	.75	.77	.78	.79	.81	.82
60.	.54	.63	.69	.72	.75	.77	.78	.79	.80	.82	.83
65.	.58	.67	.71	.75	.77	.78	.80	.81	.82	.83	.84
70.	.63	.70	.74	.77	.79	.80	.81	.82	.83	.84	.85
75.	.67	.73	.77	.79	.81	.82	.83	.83	.84	.85	.86
80.	.72	.77	.79	.81	.82	.83	.84	.85	.85	.86	.87
85.	.76	.80	.82	.83	.84	.85	.86	.86	.86	.87	.87
90.	.81	.83	.85	.86	.86	.87	.87	.87	.88	.88	.88
95.	.86	.87	.87	.88	.88	.88	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 50

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.25	.39	.48	.54	.59	.62	.65	.67	.71	.74
5.	.04	.28	.41	.50	.56	.60	.64	.66	.69	.72	.74
10.	.09	.31	.44	.52	.58	.62	.65	.68	.70	.73	.75
15.	.13	.34	.46	.54	.59	.63	.66	.69	.71	.74	.76
20.	.18	.38	.49	.56	.61	.65	.68	.70	.72	.75	.77
25.	.22	.41	.51	.58	.63	.67	.69	.71	.73	.76	.78
30.	.27	.44	.54	.60	.65	.68	.71	.73	.74	.77	.79
35.	.31	.47	.57	.62	.67	.70	.72	.74	.75	.78	.79
40.	.36	.51	.59	.65	.68	.71	.73	.75	.76	.79	.80
45.	.40	.54	.62	.67	.70	.73	.75	.76	.78	.80	.81
50.	.45	.57	.64	.69	.72	.74	.76	.78	.79	.81	.82
55.	.49	.61	.67	.71	.74	.76	.78	.79	.80	.81	.83
60.	.54	.64	.69	.73	.76	.77	.79	.80	.81	.82	.83
65.	.58	.67	.72	.75	.77	.79	.80	.81	.82	.83	.84
70.	.63	.70	.75	.77	.79	.81	.82	.83	.83	.84	.85
75.	.67	.74	.77	.79	.81	.82	.83	.84	.84	.85	.86
80.	.72	.77	.80	.82	.83	.84	.84	.85	.86	.86	.87
85.	.76	.80	.82	.84	.85	.85	.86	.86	.87	.87	.88
90.	.81	.83	.85	.86	.86	.87	.87	.88	.88	.88	.88
95.	.86	.87	.87	.88	.88	.88	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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HYDROLOGY MANUAL

RUNOFF COEFFICIENT CURVE DATA

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 52

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.26	.40	.49	.56	.60	.64	.67	.69	.72	.75
5.	.04	.29	.43	.51	.57	.62	.65	.68	.70	.73	.75
10.	.09	.32	.45	.53	.59	.63	.66	.69	.71	.74	.76
15.	.13	.36	.48	.56	.61	.65	.68	.70	.72	.75	.77
20.	.18	.39	.50	.58	.63	.66	.69	.71	.73	.76	.78
25.	.22	.42	.53	.60	.64	.68	.70	.72	.74	.77	.79
30.	.27	.45	.55	.62	.66	.69	.72	.74	.75	.78	.79
35.	.31	.48	.58	.64	.68	.71	.73	.75	.76	.78	.80
40.	.36	.52	.60	.66	.69	.72	.74	.76	.77	.79	.81
45.	.40	.55	.63	.68	.71	.74	.76	.77	.78	.80	.82
50.	.45	.58	.65	.70	.73	.75	.77	.78	.79	.81	.82
55.	.49	.61	.68	.72	.75	.77	.78	.79	.80	.82	.83
60.	.54	.64	.70	.74	.76	.78	.80	.81	.82	.83	.84
65.	.58	.68	.73	.76	.78	.80	.81	.82	.83	.84	.85
70.	.63	.71	.75	.78	.80	.81	.82	.83	.84	.85	.85
75.	.67	.74	.78	.80	.81	.83	.83	.84	.85	.86	.86
80.	.72	.77	.80	.82	.83	.84	.85	.85	.86	.86	.87
85.	.76	.80	.83	.84	.85	.86	.86	.86	.87	.87	.88
90.	.81	.84	.85	.86	.87	.87	.87	.88	.88	.88	.88
95.	.86	.87	.88	.88	.88	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 54

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.28	.42	.51	.57	.62	.65	.68	.70	.73	.76
5.	.04	.31	.45	.53	.59	.63	.67	.69	.71	.74	.76
10.	.09	.34	.47	.55	.61	.65	.68	.70	.72	.75	.77
15.	.13	.37	.49	.57	.62	.66	.69	.71	.73	.76	.78
20.	.18	.40	.52	.59	.64	.68	.70	.72	.74	.77	.79
25.	.22	.43	.54	.61	.66	.69	.71	.73	.75	.78	.79
30.	.27	.46	.56	.63	.67	.70	.73	.75	.76	.78	.80
35.	.31	.49	.59	.65	.69	.72	.74	.76	.77	.79	.81
40.	.36	.53	.61	.67	.70	.73	.75	.77	.78	.80	.81
45.	.40	.56	.64	.69	.72	.75	.76	.78	.79	.81	.82
50.	.45	.59	.66	.71	.74	.76	.78	.79	.80	.82	.83
55.	.49	.62	.68	.73	.75	.77	.79	.80	.81	.83	.84
60.	.54	.65	.71	.74	.77	.79	.80	.81	.82	.83	.84
65.	.58	.68	.73	.76	.79	.80	.81	.82	.83	.84	.85
70.	.63	.71	.76	.78	.80	.82	.83	.83	.84	.85	.86
75.	.67	.74	.78	.80	.82	.83	.84	.84	.85	.86	.86
80.	.72	.78	.80	.82	.83	.84	.85	.86	.86	.87	.87
85.	.76	.81	.83	.84	.85	.86	.86	.87	.87	.88	.88
90.	.81	.84	.85	.86	.87	.87	.88	.88	.88	.88	.89
95.	.86	.87	.88	.88	.88	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 56

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.29	.44	.53	.59	.63	.67	.69	.71	.74	.77
5.	.04	.32	.46	.55	.61	.65	.68	.70	.72	.75	.77
10.	.09	.35	.49	.57	.62	.66	.69	.71	.73	.76	.78
15.	.13	.38	.51	.59	.64	.67	.70	.72	.74	.77	.79
20.	.18	.41	.53	.60	.65	.69	.71	.73	.75	.78	.79
25.	.22	.44	.55	.62	.67	.70	.73	.74	.76	.78	.80
30.	.27	.47	.58	.64	.68	.71	.74	.75	.77	.79	.81
35.	.31	.50	.60	.66	.70	.73	.75	.77	.78	.80	.81
40.	.36	.53	.62	.68	.71	.74	.76	.78	.79	.81	.82
45.	.40	.56	.65	.70	.73	.75	.77	.79	.80	.81	.83
50.	.45	.60	.67	.71	.75	.77	.78	.80	.81	.82	.83
55.	.49	.63	.69	.73	.76	.78	.80	.81	.82	.83	.84
60.	.54	.66	.72	.75	.78	.79	.81	.82	.83	.84	.85
65.	.58	.69	.74	.77	.79	.81	.82	.83	.83	.85	.85
70.	.63	.72	.76	.79	.81	.82	.83	.84	.84	.85	.86
75.	.67	.75	.78	.81	.82	.83	.84	.85	.85	.86	.87
80.	.72	.78	.81	.83	.84	.85	.85	.86	.86	.87	.87
85.	.76	.81	.83	.84	.85	.86	.87	.87	.87	.88	.88
90.	.81	.84	.85	.86	.87	.87	.88	.88	.88	.88	.89
95.	.86	.87	.88	.88	.88	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 58

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.31	.46	.55	.61	.65	.68	.71	.73	.75	.78
5.	.04	.34	.48	.57	.62	.66	.69	.72	.73	.76	.78
10.	.09	.37	.50	.58	.64	.67	.70	.72	.74	.77	.79
15.	.13	.40	.52	.60	.65	.69	.71	.73	.75	.78	.79
20.	.18	.43	.55	.62	.67	.70	.72	.74	.76	.78	.80
25.	.22	.46	.57	.64	.68	.71	.74	.75	.77	.79	.81
30.	.27	.48	.59	.65	.69	.72	.75	.76	.78	.80	.81
35.	.31	.51	.61	.67	.71	.74	.76	.77	.79	.81	.82
40.	.36	.54	.63	.69	.72	.75	.77	.78	.79	.81	.83
45.	.40	.57	.66	.71	.74	.76	.78	.79	.80	.82	.83
50.	.45	.60	.68	.72	.75	.77	.79	.80	.81	.83	.84
55.	.49	.63	.70	.74	.77	.79	.80	.81	.82	.83	.84
60.	.54	.66	.72	.76	.78	.80	.81	.82	.83	.84	.85
65.	.58	.69	.75	.78	.80	.81	.82	.83	.84	.85	.86
70.	.63	.72	.77	.79	.81	.82	.83	.84	.85	.86	.86
75.	.67	.75	.79	.81	.83	.84	.85	.85	.86	.86	.87
80.	.72	.78	.81	.83	.84	.85	.86	.86	.86	.87	.88
85.	.76	.81	.83	.85	.86	.86	.87	.87	.87	.88	.88
90.	.81	.84	.86	.86	.87	.87	.88	.88	.88	.89	.89
95.	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

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CURVE DATA

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 60

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.32	.48	.57	.62	.66	.69	.72	.74	.76	.78
5.	.04	.35	.50	.58	.64	.68	.70	.73	.74	.77	.79
10.	.09	.38	.52	.60	.65	.69	.71	.74	.75	.78	.80
15.	.13	.41	.54	.62	.66	.70	.73	.75	.76	.78	.80
20.	.18	.44	.56	.63	.68	.71	.74	.75	.77	.79	.81
25.	.22	.47	.58	.65	.69	.72	.75	.76	.78	.80	.81
30.	.27	.50	.60	.67	.71	.73	.76	.77	.79	.80	.82
35.	.31	.53	.62	.68	.72	.75	.77	.78	.79	.81	.82
40.	.36	.55	.65	.70	.73	.76	.78	.79	.80	.82	.83
45.	.40	.58	.67	.72	.75	.77	.79	.80	.81	.83	.84
50.	.45	.61	.69	.73	.76	.78	.80	.81	.82	.83	.84
55.	.49	.64	.71	.75	.78	.79	.81	.82	.83	.84	.85
60.	.54	.67	.73	.77	.79	.81	.82	.83	.83	.85	.85
65.	.58	.70	.75	.78	.80	.82	.83	.84	.84	.85	.86
70.	.63	.73	.77	.80	.82	.83	.84	.85	.85	.86	.87
75.	.67	.76	.79	.82	.83	.84	.85	.85	.86	.87	.87
80.	.72	.78	.82	.83	.84	.85	.86	.86	.87	.87	.88
85.	.76	.81	.84	.85	.86	.86	.87	.87	.88	.88	.88
90.	.81	.84	.86	.87	.87	.88	.88	.88	.88	.89	.89
95.	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 62

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.34	.50	.58	.64	.68	.71	.73	.75	.77	.79
5.	.04	.37	.52	.60	.65	.69	.72	.74	.75	.78	.80
10.	.09	.40	.54	.61	.67	.70	.73	.75	.76	.79	.80
15.	.13	.43	.56	.63	.68	.71	.74	.76	.77	.79	.81
20.	.18	.45	.58	.65	.69	.72	.75	.76	.78	.80	.81
25.	.22	.48	.60	.66	.70	.73	.76	.77	.79	.81	.82
30.	.27	.51	.62	.68	.72	.74	.77	.78	.79	.81	.82
35.	.31	.54	.64	.69	.73	.76	.77	.79	.80	.82	.83
40.	.36	.56	.66	.71	.74	.77	.78	.80	.81	.82	.84
45.	.40	.59	.68	.73	.76	.78	.79	.81	.82	.83	.84
50.	.45	.62	.70	.74	.77	.79	.80	.81	.82	.84	.85
55.	.49	.65	.72	.76	.78	.80	.81	.82	.83	.84	.85
60.	.54	.68	.74	.77	.80	.81	.82	.83	.84	.85	.86
65.	.58	.70	.76	.79	.81	.82	.83	.84	.85	.86	.86
70.	.63	.73	.78	.80	.82	.83	.84	.85	.85	.86	.87
75.	.67	.76	.80	.82	.83	.84	.85	.86	.86	.87	.87
80.	.72	.79	.82	.84	.85	.86	.86	.87	.87	.87	.88
85.	.76	.82	.84	.85	.86	.87	.87	.87	.88	.88	.88
90.	.81	.84	.86	.87	.87	.88	.88	.88	.88	.89	.89
95.	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 64

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.36	.51	.60	.65	.69	.72	.74	.76	.78	.80
5.	.04	.39	.53	.61	.67	.70	.73	.75	.76	.79	.80
10.	.09	.41	.55	.63	.68	.71	.74	.76	.77	.79	.81
15.	.13	.44	.57	.64	.69	.72	.75	.76	.78	.80	.81
20.	.18	.47	.59	.66	.70	.73	.76	.77	.79	.81	.82
25.	.22	.50	.61	.67	.72	.74	.76	.78	.79	.81	.82
30.	.27	.52	.63	.69	.73	.75	.77	.79	.80	.82	.83
35.	.31	.55	.65	.70	.74	.76	.78	.80	.81	.82	.83
40.	.36	.58	.67	.72	.75	.78	.79	.80	.81	.83	.84
45.	.40	.60	.69	.74	.76	.79	.80	.81	.82	.84	.85
50.	.45	.63	.71	.75	.78	.80	.81	.82	.83	.84	.85
55.	.49	.66	.73	.76	.79	.81	.82	.83	.84	.85	.86
60.	.54	.68	.75	.78	.80	.82	.83	.84	.84	.85	.86
65.	.58	.71	.76	.79	.81	.83	.84	.84	.85	.86	.86
70.	.63	.74	.78	.81	.83	.84	.85	.85	.86	.86	.87
75.	.67	.76	.80	.82	.84	.85	.86	.86	.86	.87	.88
80.	.72	.79	.82	.84	.85	.86	.86	.87	.87	.88	.88
85.	.76	.82	.84	.86	.86	.87	.87	.88	.88	.88	.88
90.	.81	.85	.86	.87	.88	.88	.88	.88	.89	.89	.89
95.	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89	.89
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 66

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.38	.53	.62	.67	.71	.73	.75	.77	.79	.81
5.	.04	.41	.55	.63	.68	.72	.74	.76	.77	.80	.81
10.	.09	.43	.57	.65	.69	.73	.75	.77	.78	.80	.82
15.	.13	.46	.59	.66	.70	.74	.76	.77	.79	.81	.82
20.	.18	.48	.61	.67	.72	.74	.77	.78	.79	.81	.83
25.	.22	.51	.63	.69	.73	.75	.77	.79	.80	.82	.83
30.	.27	.54	.64	.70	.74	.76	.78	.80	.81	.82	.84
35.	.31	.56	.66	.72	.75	.77	.79	.80	.81	.83	.84
40.	.36	.59	.68	.73	.76	.78	.80	.81	.82	.83	.84
45.	.40	.61	.70	.74	.77	.79	.81	.82	.83	.84	.85
50.	.45	.64	.72	.76	.78	.80	.82	.83	.83	.85	.85
55.	.49	.67	.74	.77	.80	.81	.82	.83	.84	.85	.86
60.	.54	.69	.75	.79	.81	.82	.83	.84	.85	.86	.86
65.	.58	.72	.77	.80	.82	.83	.84	.85	.85	.86	.87
70.	.63	.74	.79	.82	.83	.84	.85	.86	.86	.87	.87
75.	.67	.77	.81	.83	.84	.85	.86	.86	.87	.87	.88
80.	.72	.80	.83	.84	.85	.86	.87	.87	.87	.88	.88
85.	.76	.82	.85	.86	.87	.87	.87	.88	.88	.88	.89
90.	.81	.85	.86	.87	.88	.88	.88	.89	.89	.89	.89
95.	.86	.87	.88	.89	.89	.89	.89	.89	.89	.89	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RCFC & WCD
HYDROLOGY MANUAL

RUNOFF COEFFICIENT CURVE DATA

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 68

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.40	.55	.63	.69	.72	.74	.76	.78	.80	.81
5.	.04	.42	.57	.65	.70	.73	.75	.77	.78	.80	.82
10.	.09	.45	.59	.66	.71	.74	.76	.78	.79	.81	.82
15.	.13	.47	.61	.67	.72	.75	.77	.78	.80	.81	.83
20.	.18	.50	.62	.69	.73	.76	.78	.79	.80	.82	.83
25.	.22	.52	.64	.70	.74	.76	.78	.80	.81	.82	.84
30.	.27	.55	.66	.71	.75	.77	.79	.80	.81	.83	.84
35.	.31	.57	.67	.73	.76	.78	.80	.81	.82	.83	.84
40.	.36	.60	.69	.74	.77	.79	.81	.82	.83	.84	.85
45.	.40	.62	.71	.75	.78	.80	.81	.82	.83	.84	.85
50.	.45	.65	.73	.77	.79	.81	.82	.83	.84	.85	.86
55.	.49	.67	.74	.78	.80	.82	.83	.84	.85	.85	.86
60.	.54	.70	.76	.79	.81	.83	.84	.85	.85	.86	.87
65.	.58	.72	.78	.81	.82	.84	.85	.85	.86	.86	.87
70.	.63	.75	.80	.82	.84	.85	.85	.86	.86	.87	.87
75.	.67	.77	.81	.83	.85	.85	.86	.87	.87	.87	.88
80.	.72	.80	.83	.85	.86	.86	.87	.87	.88	.88	.88
85.	.76	.82	.85	.86	.87	.87	.88	.88	.88	.88	.89
90.	.81	.85	.87	.87	.88	.88	.88	.89	.89	.89	.89
95.	.86	.87	.88	.89	.89	.89	.89	.89	.89	.89	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 70

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.42	.57	.65	.70	.73	.76	.77	.79	.81	.82
5.	.04	.44	.59	.66	.71	.74	.76	.78	.79	.81	.83
10.	.09	.47	.61	.68	.72	.75	.77	.79	.80	.82	.83
15.	.13	.49	.62	.69	.73	.76	.78	.79	.80	.82	.83
20.	.18	.52	.64	.70	.74	.77	.78	.80	.81	.83	.84
25.	.22	.54	.65	.71	.75	.77	.79	.81	.82	.83	.84
30.	.27	.56	.67	.73	.76	.78	.80	.81	.82	.84	.85
35.	.31	.59	.69	.74	.77	.79	.81	.82	.83	.84	.85
40.	.36	.61	.70	.75	.78	.80	.81	.82	.83	.84	.85
45.	.40	.64	.72	.76	.79	.81	.82	.83	.84	.85	.86
50.	.45	.66	.74	.78	.80	.82	.83	.84	.84	.85	.86
55.	.49	.68	.75	.79	.81	.82	.84	.84	.85	.86	.86
60.	.54	.71	.77	.80	.82	.83	.84	.85	.86	.86	.87
65.	.58	.73	.79	.81	.83	.84	.85	.86	.86	.87	.87
70.	.63	.76	.80	.83	.84	.85	.86	.86	.87	.87	.88
75.	.67	.78	.82	.84	.85	.86	.86	.87	.87	.88	.88
80.	.72	.80	.83	.85	.86	.87	.87	.87	.88	.88	.88
85.	.76	.83	.85	.86	.87	.87	.88	.88	.88	.89	.89
90.	.81	.85	.87	.88	.88	.88	.89	.89	.89	.89	.89
95.	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 72

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.44	.59	.67	.71	.75	.77	.78	.80	.82	.83
5.	.04	.46	.61	.68	.72	.75	.77	.79	.80	.82	.83
10.	.09	.49	.62	.69	.73	.76	.78	.80	.81	.82	.84
15.	.13	.51	.64	.70	.74	.77	.79	.80	.81	.83	.84
20.	.18	.53	.65	.72	.75	.78	.79	.81	.82	.83	.84
25.	.22	.56	.67	.73	.76	.78	.80	.81	.82	.84	.85
30.	.27	.58	.68	.74	.77	.79	.81	.82	.83	.84	.85
35.	.31	.60	.70	.75	.78	.80	.81	.82	.83	.85	.85
40.	.36	.63	.72	.76	.79	.81	.82	.83	.84	.85	.86
45.	.40	.65	.73	.77	.80	.81	.83	.84	.84	.85	.86
50.	.45	.67	.75	.78	.81	.82	.83	.84	.85	.86	.86
55.	.49	.69	.76	.80	.82	.83	.84	.85	.85	.86	.87
60.	.54	.72	.78	.81	.83	.84	.85	.85	.86	.87	.87
65.	.58	.74	.79	.82	.84	.85	.85	.86	.86	.87	.87
70.	.63	.76	.81	.83	.84	.85	.86	.87	.87	.87	.88
75.	.67	.79	.82	.84	.85	.86	.87	.87	.87	.88	.88
80.	.72	.81	.84	.85	.86	.87	.87	.88	.88	.88	.89
85.	.76	.83	.85	.87	.87	.88	.88	.88	.88	.89	.89
90.	.81	.85	.87	.88	.88	.88	.89	.89	.89	.89	.89
95.	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 74

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.46	.61	.69	.73	.76	.78	.79	.81	.82	.83
5.	.04	.49	.63	.70	.74	.77	.78	.80	.81	.83	.84
10.	.09	.51	.64	.71	.75	.77	.79	.80	.82	.83	.84
15.	.13	.53	.66	.72	.75	.78	.80	.81	.82	.83	.84
20.	.18	.55	.67	.73	.76	.79	.80	.82	.82	.84	.85
25.	.22	.57	.68	.74	.77	.79	.81	.82	.83	.84	.85
30.	.27	.60	.70	.75	.78	.80	.81	.83	.83	.85	.85
35.	.31	.62	.71	.76	.79	.81	.82	.83	.84	.85	.86
40.	.36	.64	.73	.77	.80	.81	.83	.84	.84	.85	.86
45.	.40	.66	.74	.78	.81	.82	.83	.84	.85	.86	.86
50.	.45	.68	.76	.79	.81	.83	.84	.85	.85	.86	.87
55.	.49	.70	.77	.80	.82	.84	.85	.85	.86	.87	.87
60.	.54	.73	.79	.81	.83	.84	.85	.86	.86	.87	.87
65.	.58	.75	.80	.83	.84	.85	.86	.86	.87	.87	.88
70.	.63	.77	.81	.84	.85	.86	.86	.87	.87	.88	.88
75.	.67	.79	.83	.85	.86	.86	.87	.87	.88	.88	.88
80.	.72	.81	.84	.86	.87	.87	.88	.88	.88	.88	.89
85.	.76	.83	.86	.87	.87	.88	.88	.88	.89	.89	.89
90.	.81	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89
95.	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RCFC & WCD
HYDROLOGY MANUAL

RUNOFF COEFFICIENT CURVE DATA

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 76

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.49	.63	.70	.74	.77	.79	.80	.81	.83	.84
5.	.04	.51	.65	.71	.75	.78	.79	.81	.82	.83	.84
10.	.09	.53	.66	.72	.76	.78	.80	.81	.82	.84	.85
15.	.13	.55	.67	.73	.77	.79	.81	.82	.83	.84	.85
20.	.18	.57	.69	.74	.77	.80	.81	.82	.83	.84	.85
25.	.22	.59	.70	.75	.78	.80	.82	.83	.84	.85	.86
30.	.27	.61	.71	.76	.79	.81	.82	.83	.84	.85	.86
35.	.31	.63	.73	.77	.80	.82	.83	.84	.84	.85	.86
40.	.36	.65	.74	.78	.81	.82	.83	.84	.85	.86	.86
45.	.40	.67	.75	.79	.81	.83	.84	.85	.85	.86	.87
50.	.45	.69	.77	.80	.82	.84	.84	.85	.86	.87	.87
55.	.49	.71	.78	.81	.83	.84	.85	.86	.86	.87	.87
60.	.54	.74	.79	.82	.84	.85	.86	.86	.87	.87	.88
65.	.58	.76	.81	.83	.85	.85	.86	.87	.87	.88	.88
70.	.63	.78	.82	.84	.85	.86	.87	.87	.87	.88	.88
75.	.67	.80	.83	.85	.86	.87	.87	.88	.88	.88	.89
80.	.72	.82	.85	.86	.87	.87	.88	.88	.88	.89	.89
85.	.76	.84	.86	.87	.88	.88	.88	.89	.89	.89	.89
90.	.81	.86	.87	.88	.88	.89	.89	.89	.89	.89	.89
95.	.86	.88	.89	.89	.89	.89	.89	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 78

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.51	.65	.72	.76	.78	.80	.81	.82	.84	.85
5.	.04	.53	.67	.73	.76	.79	.80	.82	.83	.84	.85
10.	.09	.55	.68	.74	.77	.79	.81	.82	.83	.84	.85
15.	.13	.57	.69	.75	.78	.80	.81	.83	.83	.85	.85
20.	.18	.59	.70	.76	.79	.81	.82	.83	.84	.85	.86
25.	.22	.61	.72	.76	.79	.81	.82	.83	.84	.85	.86
30.	.27	.63	.73	.77	.80	.82	.83	.84	.85	.86	.86
35.	.31	.65	.74	.78	.81	.82	.83	.84	.85	.86	.87
40.	.36	.67	.75	.79	.81	.83	.84	.85	.85	.86	.87
45.	.40	.69	.76	.80	.82	.84	.84	.85	.86	.87	.87
50.	.45	.71	.78	.81	.83	.84	.85	.86	.86	.87	.87
55.	.49	.73	.79	.82	.84	.85	.85	.86	.87	.87	.88
60.	.54	.75	.80	.83	.84	.85	.86	.87	.87	.87	.88
65.	.58	.76	.81	.84	.85	.86	.86	.87	.87	.88	.88
70.	.63	.78	.83	.85	.86	.86	.87	.87	.88	.88	.88
75.	.67	.80	.84	.85	.86	.87	.87	.88	.88	.88	.89
80.	.72	.82	.85	.86	.87	.88	.88	.88	.88	.89	.89
85.	.76	.84	.86	.87	.88	.88	.88	.89	.89	.89	.89
90.	.81	.86	.88	.88	.89	.89	.89	.89	.89	.89	.89
95.	.86	.88	.89	.89	.89	.89	.89	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 80

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.54	.67	.74	.77	.79	.81	.82	.83	.84	.85
5.	.04	.56	.69	.74	.78	.80	.81	.83	.83	.85	.86
10.	.09	.58	.70	.75	.78	.80	.82	.83	.84	.85	.86
15.	.13	.59	.71	.76	.79	.81	.82	.83	.84	.85	.86
20.	.18	.61	.72	.77	.80	.82	.83	.84	.84	.86	.86
25.	.22	.63	.73	.78	.80	.82	.83	.84	.85	.86	.86
30.	.27	.65	.74	.79	.81	.83	.84	.85	.85	.86	.87
35.	.31	.67	.75	.79	.82	.83	.84	.85	.86	.86	.87
40.	.36	.68	.76	.80	.82	.84	.85	.85	.86	.87	.87
45.	.40	.70	.78	.81	.83	.84	.85	.86	.86	.87	.87
50.	.45	.72	.79	.82	.84	.85	.86	.86	.87	.87	.88
55.	.49	.74	.80	.83	.84	.85	.86	.86	.87	.87	.88
60.	.54	.76	.81	.83	.85	.86	.86	.87	.87	.88	.88
65.	.58	.77	.82	.84	.86	.86	.87	.87	.88	.88	.88
70.	.63	.79	.83	.85	.86	.87	.87	.88	.88	.88	.89
75.	.67	.81	.84	.86	.87	.87	.88	.88	.88	.89	.89
80.	.72	.83	.86	.87	.87	.88	.88	.88	.89	.89	.89
85.	.76	.85	.87	.88	.88	.88	.89	.89	.89	.89	.89
90.	.81	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90
95.	.86	.88	.89	.89	.89	.89	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 82

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR .0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.57	.70	.75	.79	.81	.82	.83	.84	.85	.86
5.	.04	.58	.71	.76	.79	.81	.82	.83	.84	.85	.86
10.	.09	.60	.72	.77	.80	.82	.83	.84	.84	.86	.86
15.	.13	.62	.73	.78	.80	.82	.83	.84	.85	.86	.86
20.	.18	.63	.74	.78	.81	.82	.84	.84	.85	.86	.87
25.	.22	.65	.75	.79	.81	.83	.84	.85	.85	.86	.87
30.	.27	.67	.76	.80	.82	.83	.84	.85	.86	.87	.87
35.	.31	.68	.77	.80	.83	.84	.85	.85	.86	.87	.87
40.	.36	.70	.78	.81	.83	.84	.85	.86	.86	.87	.87
45.	.40	.72	.79	.82	.84	.85	.86	.86	.87	.87	.88
50.	.45	.73	.80	.83	.84	.85	.86	.87	.87	.88	.88
55.	.49	.75	.81	.83	.85	.86	.86	.87	.87	.88	.88
60.	.54	.77	.82	.84	.85	.86	.87	.87	.88	.88	.88
65.	.58	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
70.	.63	.80	.84	.86	.87	.87	.88	.88	.88	.89	.89
75.	.67	.82	.85	.86	.87	.88	.88	.88	.88	.89	.89
80.	.72	.83	.86	.87	.88	.88	.88	.89	.89	.89	.89
85.	.76	.85	.87	.88	.88	.89	.89	.89	.89	.89	.89
90.	.81	.87	.88	.89	.89	.89	.89	.89	.89	.90	.90
95.	.86	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 84

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.60	.72	.77	.80	.82	.83	.84	.85	.86	.86
5.	.04	.61	.73	.78	.80	.82	.83	.84	.85	.86	.87
10.	.09	.63	.74	.78	.81	.83	.84	.85	.85	.86	.87
15.	.13	.64	.75	.79	.81	.83	.84	.85	.85	.86	.87
20.	.18	.66	.75	.80	.82	.83	.84	.85	.86	.87	.87
25.	.22	.67	.76	.80	.82	.84	.85	.85	.86	.87	.87
30.	.27	.69	.77	.81	.83	.84	.85	.86	.86	.87	.87
35.	.31	.70	.78	.82	.83	.85	.85	.86	.87	.87	.88
40.	.36	.72	.79	.82	.84	.85	.86	.86	.87	.87	.88
45.	.40	.73	.80	.83	.84	.85	.86	.87	.87	.88	.88
50.	.45	.75	.81	.83	.85	.86	.86	.87	.87	.88	.88
55.	.49	.76	.82	.84	.85	.86	.87	.87	.88	.88	.88
60.	.54	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
65.	.58	.79	.84	.85	.86	.87	.88	.88	.88	.88	.89
70.	.63	.81	.85	.86	.87	.88	.88	.88	.88	.89	.89
75.	.67	.82	.85	.87	.87	.88	.88	.88	.89	.89	.89
80.	.72	.84	.86	.87	.88	.88	.89	.89	.89	.89	.89
85.	.76	.85	.87	.88	.88	.89	.89	.89	.89	.89	.89
90.	.81	.87	.88	.89	.89	.89	.89	.89	.89	.90	.90
95.	.86	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 86

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.63	.74	.79	.81	.83	.84	.85	.85	.86	.87
5.	.04	.64	.75	.79	.82	.83	.84	.85	.86	.86	.87
10.	.09	.65	.76	.80	.82	.84	.85	.85	.86	.87	.87
15.	.13	.67	.76	.80	.83	.84	.85	.86	.86	.87	.87
20.	.18	.68	.77	.81	.83	.84	.85	.86	.86	.87	.87
25.	.22	.70	.78	.81	.83	.85	.85	.86	.87	.87	.88
30.	.27	.71	.79	.82	.84	.85	.86	.86	.87	.87	.88
35.	.31	.72	.80	.83	.84	.85	.86	.87	.87	.88	.88
40.	.36	.74	.80	.83	.85	.86	.86	.87	.87	.88	.88
45.	.40	.75	.81	.84	.85	.86	.87	.87	.87	.88	.88
50.	.45	.76	.82	.84	.86	.86	.87	.87	.88	.88	.88
55.	.49	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
60.	.54	.79	.84	.85	.86	.87	.88	.88	.88	.89	.89
65.	.58	.80	.84	.86	.87	.87	.88	.88	.88	.89	.89
70.	.63	.82	.85	.87	.87	.88	.88	.88	.89	.89	.89
75.	.67	.83	.86	.87	.88	.88	.88	.89	.89	.89	.89
80.	.72	.85	.87	.88	.88	.89	.89	.89	.89	.89	.89
85.	.76	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90
90.	.81	.87	.88	.89	.89	.89	.89	.89	.90	.90	.90
95.	.86	.89	.89	.89	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 88

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.66	.76	.80	.82	.84	.85	.86	.86	.87	.87
5.	.04	.67	.77	.81	.83	.84	.85	.86	.86	.87	.87
10.	.09	.68	.78	.81	.83	.85	.85	.86	.86	.87	.88
15.	.13	.70	.78	.82	.84	.85	.86	.86	.87	.87	.88
20.	.18	.71	.79	.82	.84	.85	.86	.86	.87	.87	.88
25.	.22	.72	.80	.83	.84	.85	.86	.87	.87	.88	.88
30.	.27	.73	.80	.83	.85	.86	.86	.87	.87	.88	.88
35.	.31	.74	.81	.84	.85	.86	.87	.87	.87	.88	.88
40.	.36	.76	.82	.84	.85	.86	.87	.87	.88	.88	.88
45.	.40	.77	.82	.85	.86	.87	.87	.88	.88	.88	.89
50.	.45	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
55.	.49	.79	.84	.86	.87	.87	.88	.88	.88	.89	.89
60.	.54	.80	.84	.86	.87	.88	.88	.88	.88	.89	.89
65.	.58	.82	.85	.87	.87	.88	.88	.88	.89	.89	.89
70.	.63	.83	.86	.87	.88	.88	.88	.89	.89	.89	.89
75.	.67	.84	.87	.88	.88	.88	.89	.89	.89	.89	.89
80.	.72	.85	.87	.88	.88	.89	.89	.89	.89	.89	.89
85.	.76	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90
90.	.81	.88	.89	.89	.89	.89	.89	.90	.90	.90	.90
95.	.86	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 90

IMPERVIOUS PERCENT	INTENSITY - INCHES/HOUR										
	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
0.	.00	.69	.78	.82	.84	.85	.86	.86	.87	.87	.88
5.	.04	.70	.79	.82	.84	.85	.86	.87	.87	.88	.88
10.	.09	.71	.80	.83	.84	.85	.86	.87	.87	.88	.88
15.	.13	.73	.80	.83	.85	.86	.86	.87	.87	.88	.88
20.	.18	.74	.81	.84	.85	.86	.87	.87	.87	.88	.88
25.	.22	.75	.81	.84	.85	.86	.87	.87	.88	.88	.88
30.	.27	.76	.82	.84	.86	.86	.87	.87	.88	.88	.88
35.	.31	.77	.82	.85	.86	.87	.87	.88	.88	.88	.89
40.	.36	.78	.83	.85	.86	.87	.87	.88	.88	.88	.89
45.	.40	.79	.84	.86	.87	.87	.88	.88	.88	.89	.89
50.	.45	.80	.84	.86	.87	.87	.88	.88	.88	.89	.89
55.	.49	.81	.85	.86	.87	.88	.88	.88	.89	.89	.89
60.	.54	.82	.85	.87	.88	.88	.88	.89	.89	.89	.89
65.	.58	.83	.86	.87	.88	.88	.89	.89	.89	.89	.89
70.	.63	.84	.87	.88	.88	.88	.89	.89	.89	.89	.89
75.	.67	.85	.87	.88	.88	.89	.89	.89	.89	.89	.89
80.	.72	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90
85.	.76	.87	.88	.89	.89	.89	.89	.89	.90	.90	.90
90.	.81	.88	.89	.89	.89	.89	.90	.90	.90	.90	.90
95.	.86	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 92

IMPERVIOUS PERCENT	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
	INTENSITY - INCHES/HOUR										
0.	.00	.73	.81	.84	.85	.86	.87	.87	.87	.88	.88
5.	.04	.74	.81	.84	.85	.86	.87	.87	.88	.88	.88
10.	.09	.75	.82	.84	.86	.86	.87	.87	.88	.88	.88
15.	.13	.76	.82	.85	.86	.87	.87	.88	.88	.88	.89
20.	.18	.76	.83	.85	.86	.87	.87	.88	.88	.88	.89
25.	.22	.77	.83	.85	.86	.87	.87	.88	.88	.88	.89
30.	.27	.78	.83	.85	.87	.87	.88	.88	.88	.89	.89
35.	.31	.79	.84	.86	.87	.87	.88	.88	.88	.89	.89
40.	.36	.80	.84	.86	.87	.88	.88	.88	.88	.89	.89
45.	.40	.81	.85	.86	.87	.88	.88	.88	.89	.89	.89
50.	.45	.82	.85	.87	.88	.88	.88	.89	.89	.89	.89
55.	.49	.82	.86	.87	.88	.88	.88	.89	.89	.89	.89
60.	.54	.83	.86	.87	.88	.88	.89	.89	.89	.89	.89
65.	.58	.84	.87	.88	.88	.89	.89	.89	.89	.89	.89
70.	.63	.85	.87	.88	.89	.89	.89	.89	.89	.89	.89
75.	.67	.86	.88	.88	.89	.89	.89	.89	.89	.89	.90
80.	.72	.87	.88	.89	.89	.89	.89	.89	.89	.90	.90
85.	.76	.87	.89	.89	.89	.89	.89	.90	.90	.90	.90
90.	.81	.88	.89	.89	.90	.90	.90	.90	.90	.90	.90
95.	.86	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 94

IMPERVIOUS PERCENT	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
	INTENSITY - INCHES/HOUR										
0.	.00	.77	.83	.85	.86	.87	.88	.88	.88	.88	.89
5.	.04	.78	.83	.85	.87	.87	.88	.88	.88	.89	.89
10.	.09	.78	.84	.86	.87	.87	.88	.88	.88	.89	.89
15.	.13	.79	.84	.86	.87	.87	.88	.88	.88	.89	.89
20.	.18	.80	.84	.86	.87	.88	.88	.88	.89	.89	.89
25.	.22	.80	.85	.86	.87	.88	.88	.88	.89	.89	.89
30.	.27	.81	.85	.87	.87	.88	.88	.89	.89	.89	.89
35.	.31	.81	.85	.87	.88	.88	.88	.89	.89	.89	.89
40.	.36	.82	.86	.87	.88	.88	.89	.89	.89	.89	.89
45.	.40	.83	.86	.87	.88	.88	.89	.89	.89	.89	.89
50.	.45	.83	.86	.88	.88	.89	.89	.89	.89	.89	.89
55.	.49	.84	.87	.88	.88	.89	.89	.89	.89	.89	.89
60.	.54	.85	.87	.88	.89	.89	.89	.89	.89	.89	.89
65.	.58	.85	.88	.88	.89	.89	.89	.89	.89	.89	.90
70.	.63	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90
75.	.67	.87	.88	.89	.89	.89	.89	.89	.90	.90	.90
80.	.72	.87	.89	.89	.89	.89	.90	.90	.90	.90	.90
85.	.76	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
90.	.81	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
95.	.86	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 96

IMPERVIOUS PERCENT	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
	INTENSITY - INCHES/HOUR										
0.	.00	.81	.85	.87	.88	.88	.88	.89	.89	.89	.89
5.	.04	.81	.85	.87	.88	.88	.88	.89	.89	.89	.89
10.	.09	.82	.86	.87	.88	.88	.89	.89	.89	.89	.89
15.	.13	.82	.86	.87	.88	.88	.89	.89	.89	.89	.89
20.	.18	.83	.86	.87	.88	.88	.89	.89	.89	.89	.89
25.	.22	.83	.86	.88	.88	.89	.89	.89	.89	.89	.89
30.	.27	.84	.87	.88	.88	.89	.89	.89	.89	.89	.89
35.	.31	.84	.87	.88	.88	.89	.89	.89	.89	.89	.89
40.	.36	.85	.87	.88	.89	.89	.89	.89	.89	.89	.90
45.	.40	.85	.87	.88	.89	.89	.89	.89	.89	.89	.90
50.	.45	.85	.88	.88	.89	.89	.89	.89	.89	.90	.90
55.	.49	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90
60.	.54	.86	.88	.89	.89	.89	.89	.89	.90	.90	.90
65.	.58	.87	.88	.89	.89	.89	.89	.90	.90	.90	.90
70.	.63	.87	.89	.89	.89	.89	.90	.90	.90	.90	.90
75.	.67	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
80.	.72	.88	.89	.89	.90	.90	.90	.90	.90	.90	.90
85.	.76	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
90.	.81	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
95.	.86	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RUNOFF COEFFICIENTS FOR RI INDEX NO. = 98

IMPERVIOUS PERCENT	.0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0
	INTENSITY - INCHES/HOUR										
0.	.00	.85	.88	.88	.89	.89	.89	.89	.89	.90	.90
5.	.04	.86	.88	.88	.89	.89	.89	.89	.89	.90	.90
10.	.09	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90
15.	.13	.86	.88	.89	.89	.89	.89	.89	.89	.90	.90
20.	.18	.86	.88	.89	.89	.89	.89	.89	.90	.90	.90
25.	.22	.87	.88	.89	.89	.89	.89	.89	.90	.90	.90
30.	.27	.87	.88	.89	.89	.89	.89	.90	.90	.90	.90
35.	.31	.87	.88	.89	.89	.89	.89	.90	.90	.90	.90
40.	.36	.87	.89	.89	.89	.89	.90	.90	.90	.90	.90
45.	.40	.87	.89	.89	.89	.89	.90	.90	.90	.90	.90
50.	.45	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
55.	.49	.88	.89	.89	.89	.90	.90	.90	.90	.90	.90
60.	.54	.88	.89	.89	.90	.90	.90	.90	.90	.90	.90
65.	.58	.88	.89	.89	.90	.90	.90	.90	.90	.90	.90
70.	.63	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
75.	.67	.89	.89	.90	.90	.90	.90	.90	.90	.90	.90
80.	.72	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
85.	.76	.89	.90	.90	.90	.90	.90	.90	.90	.90	.90
90.	.81	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90
95.	.86	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90
100.	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90	.90

RCFC & WCD

HYDROLOGY MANUAL

RUNOFF COEFFICIENT CURVE DATA

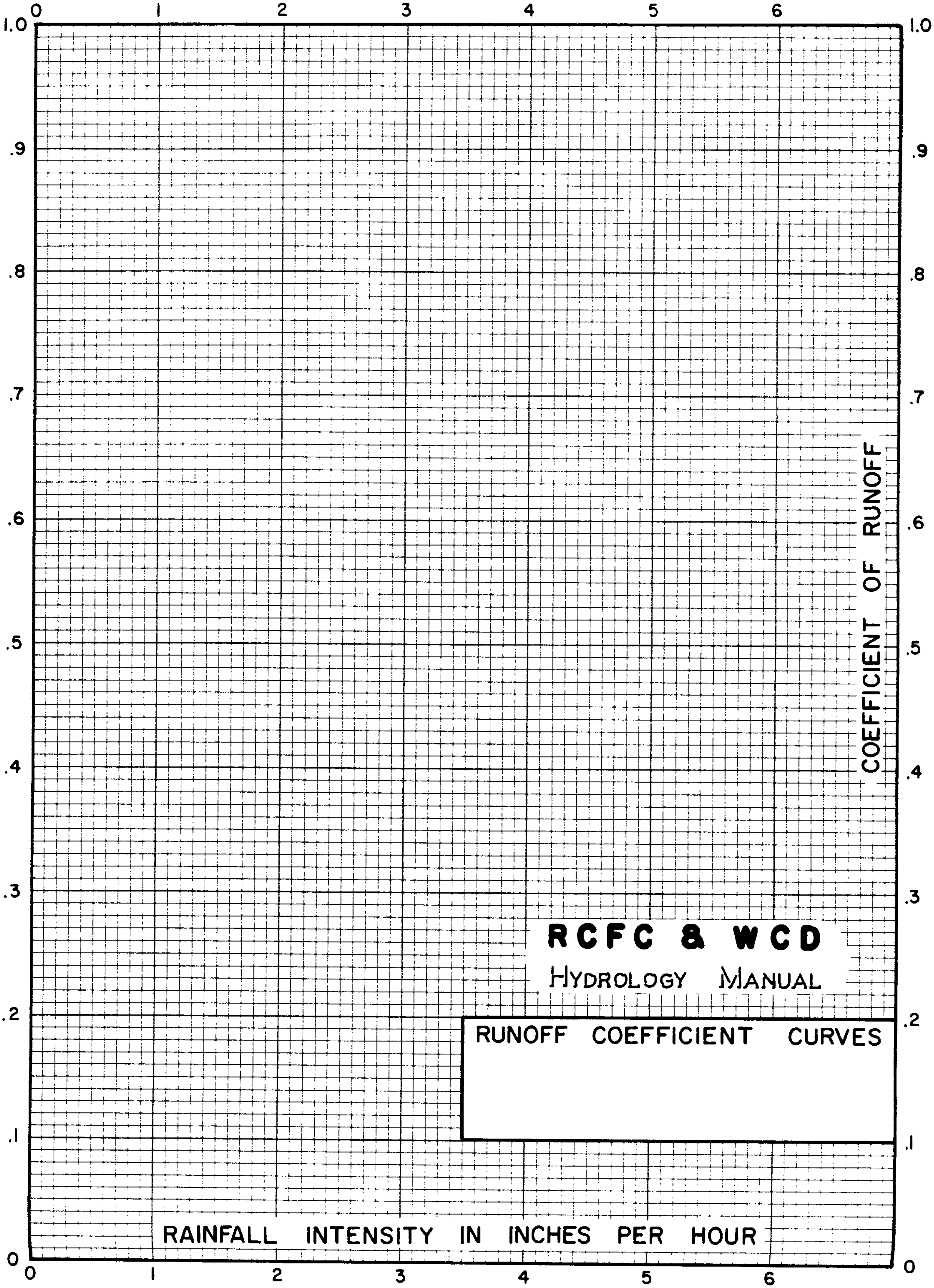
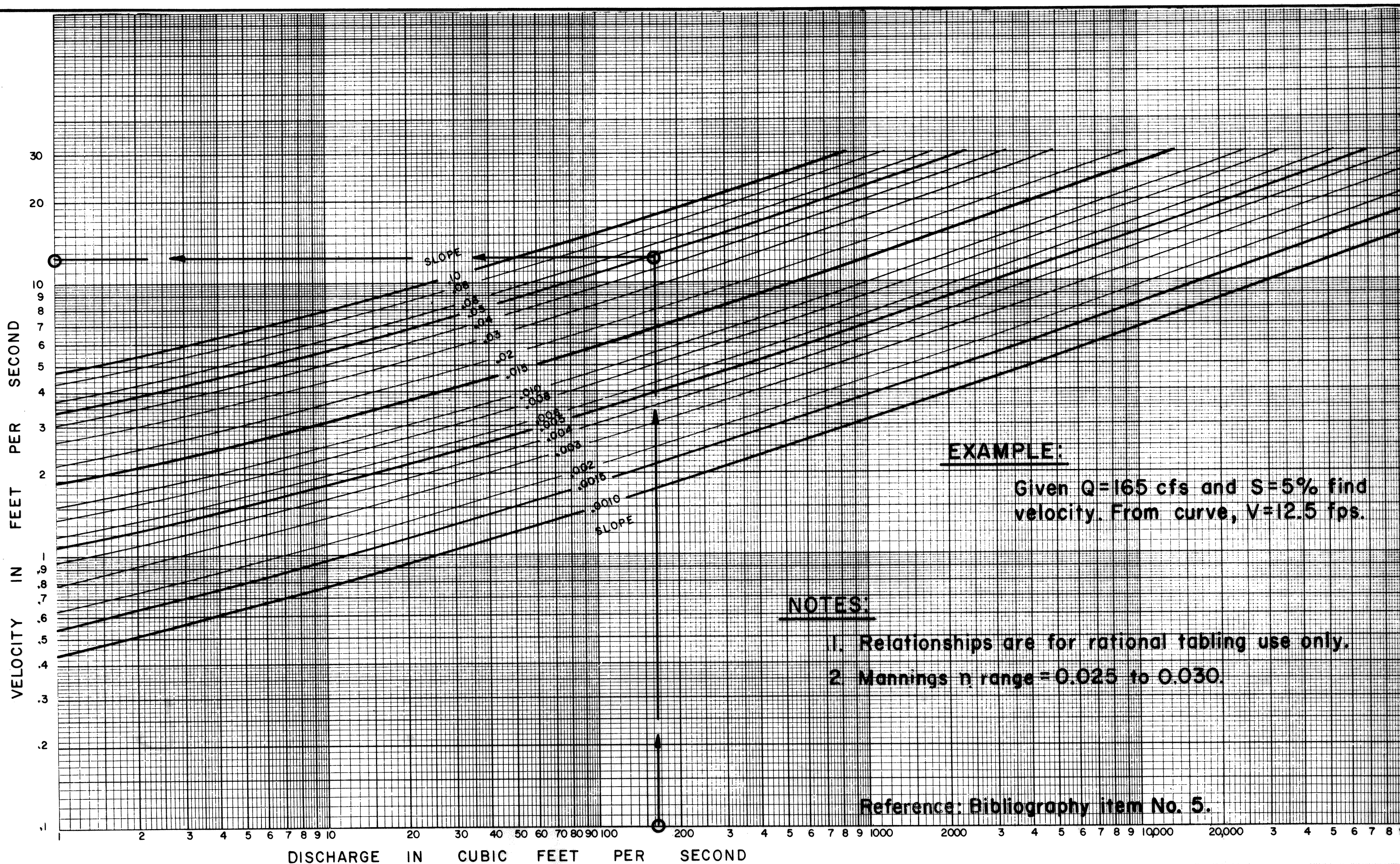

RCFC & WCD
HYDROLOGY MANUAL
RUNOFF COEFFICIENT CURVES
COEFFICIENT OF RUNOFF
RAINFALL INTENSITY IN INCHES PER HOUR
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
0
1
2
3
4
5
6

PLATE D-5.8



EXAMPLE:

Given Q=165 cfs and S=5% find velocity. From curve, V=12.5 fps.

NOTES:

1. Relationships are for rational tabling use only.
2. Mannings n range = 0.025 to 0.030.

Reference: Bibliography item No. 5.

RCFC & WCD HYDROLOGY MANUAL

VELOCITY-DISCHARGE-SLOPE RELATIONSHIPS

NATURAL VALLEY CHANNELS

NOTES:

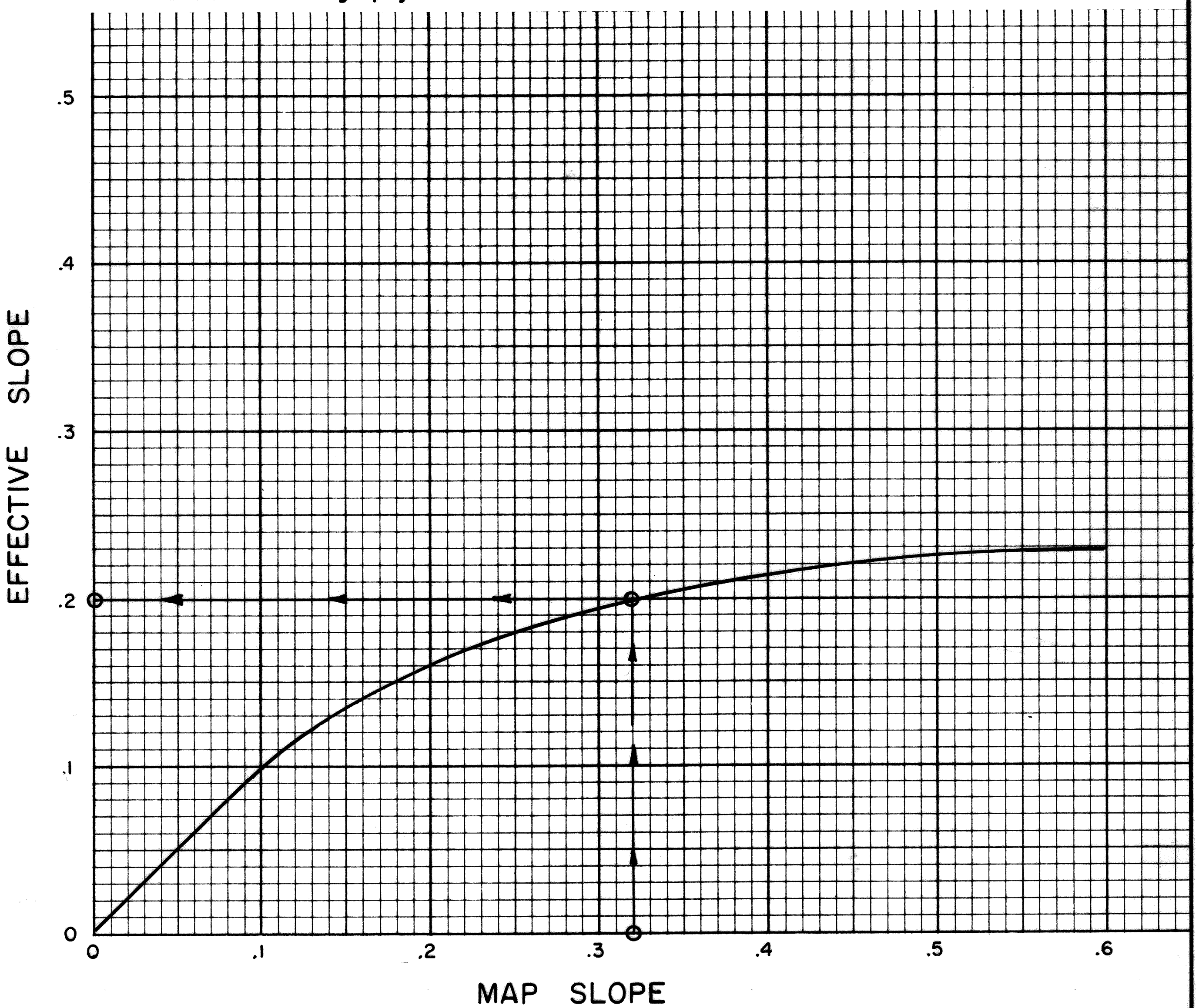
1. This curve should only be used for adjustment of map slopes on extremely rugged channels with drops and waterfalls. For cases where these conditions do not exist use map slope for effective slope.

2. Relationships are for rational tabling use only in conjunction with Plate D-6.3

EXAMPLE:

Given map slope = 32 % on natural mountain stream with drops and waterfalls, find effective slope. From curve, effective slope = 20 %.

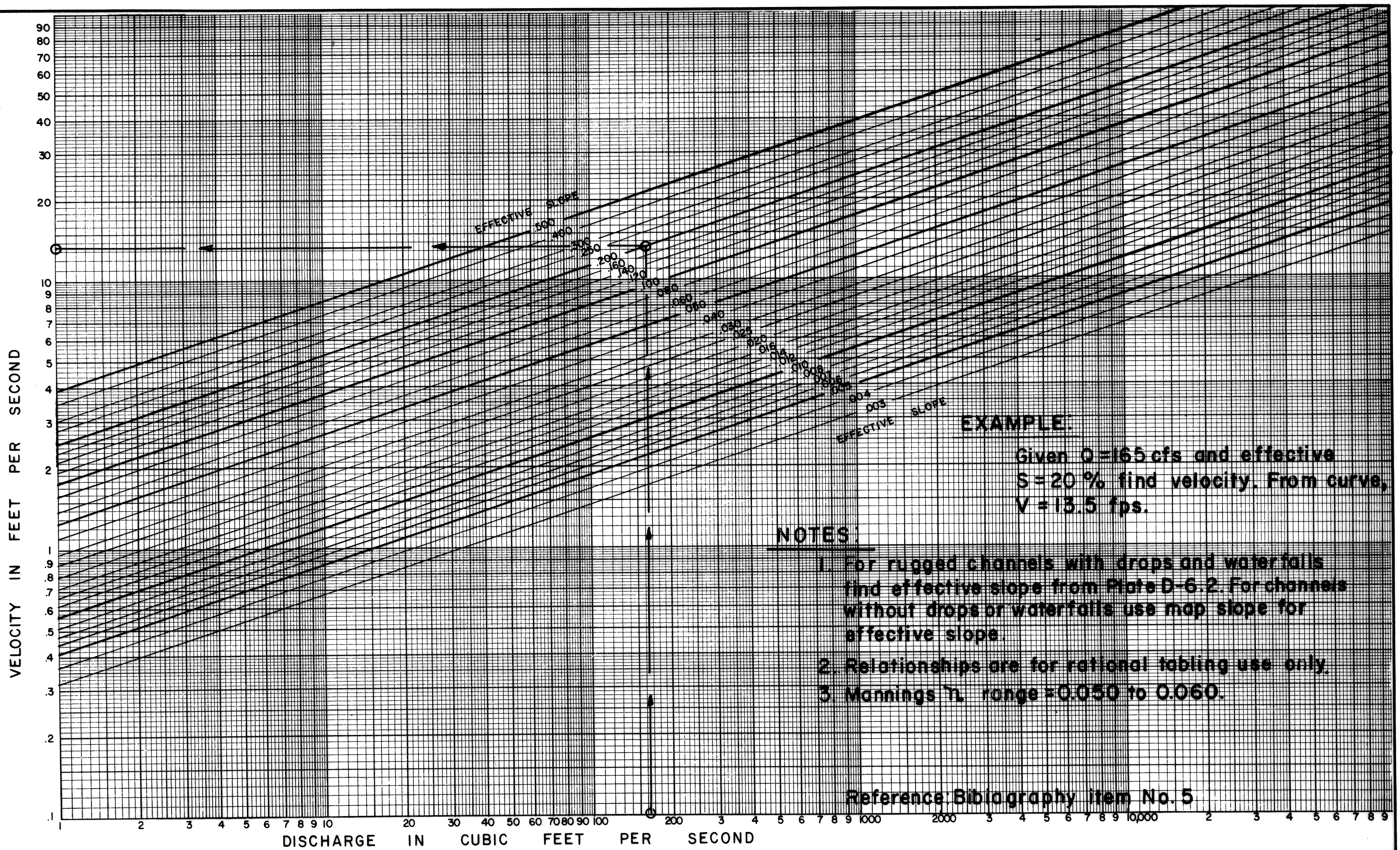
Reference: Bibliography item No. 5.



RCFC & WCD

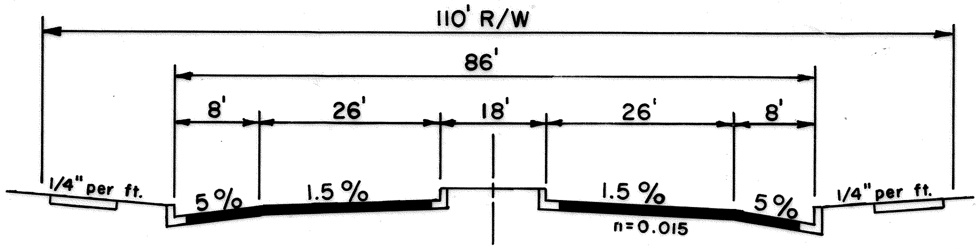
HYDROLOGY MANUAL

SLOPE ADJUSTMENT CURVE FOR NATURAL MOUNTAIN CHANNEL

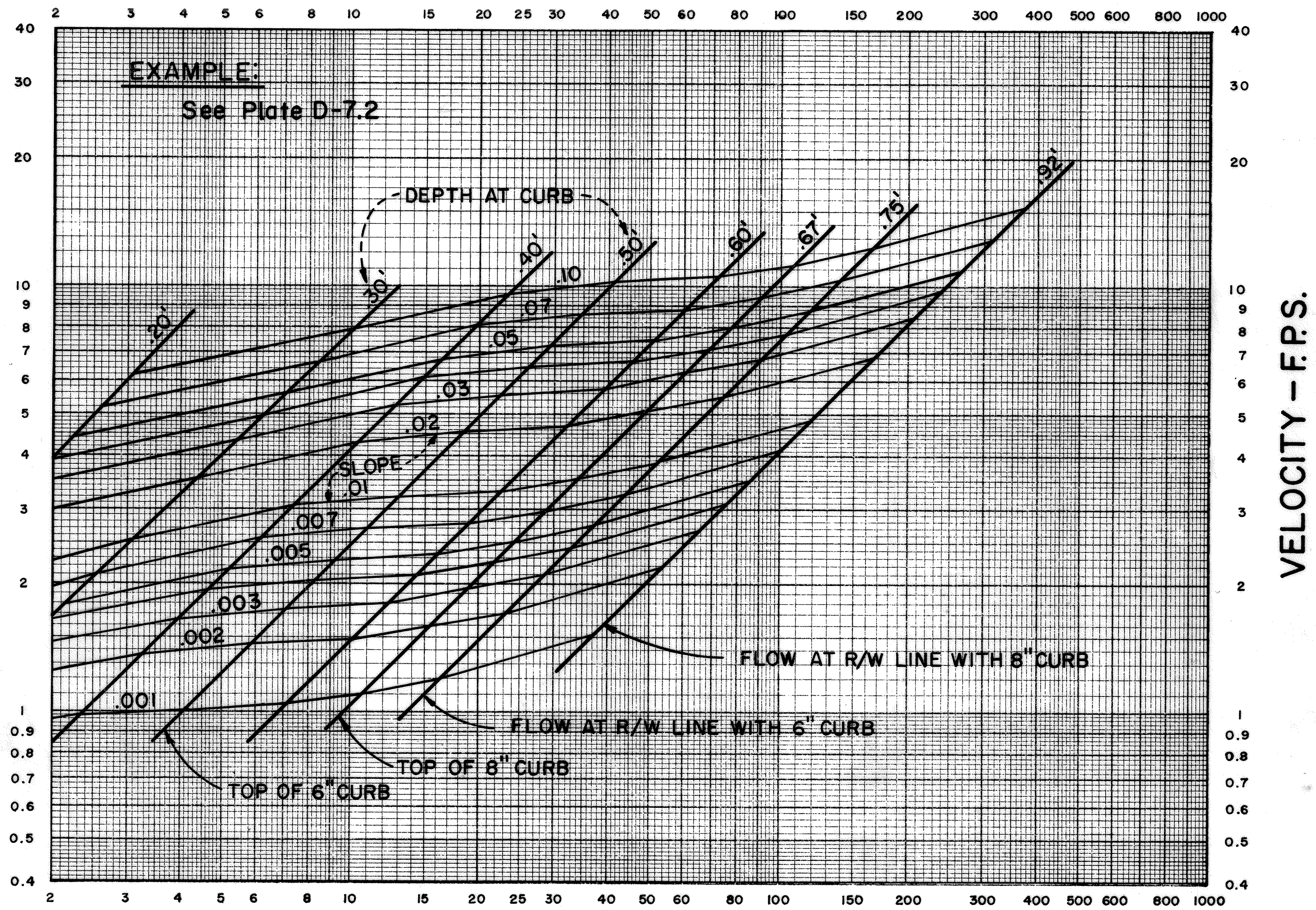


RCFC & WCD HYDROLOGY MANUAL

VELOCITY - DISCHARGE - SLOPE RELATIONSHIPS
NATURAL MOUNTAIN CHANNELS



TYPICAL SECTION



DISCHARGE – C.F.S.

(TOTAL FLOW IN STREET)

NOTE:

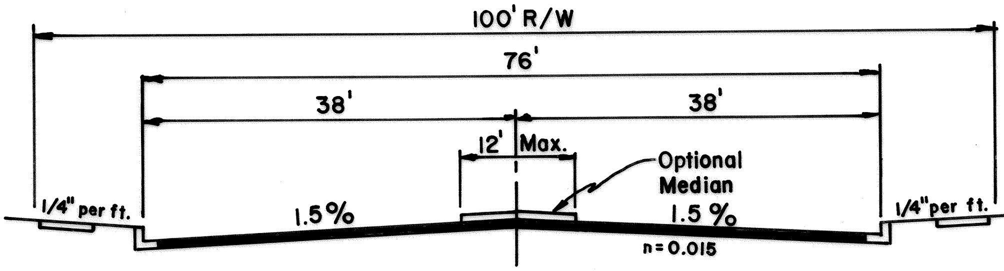
Flow does not top the crown of this section until d_w = 1.45 feet (6 inch curb).

RCFC & WCD

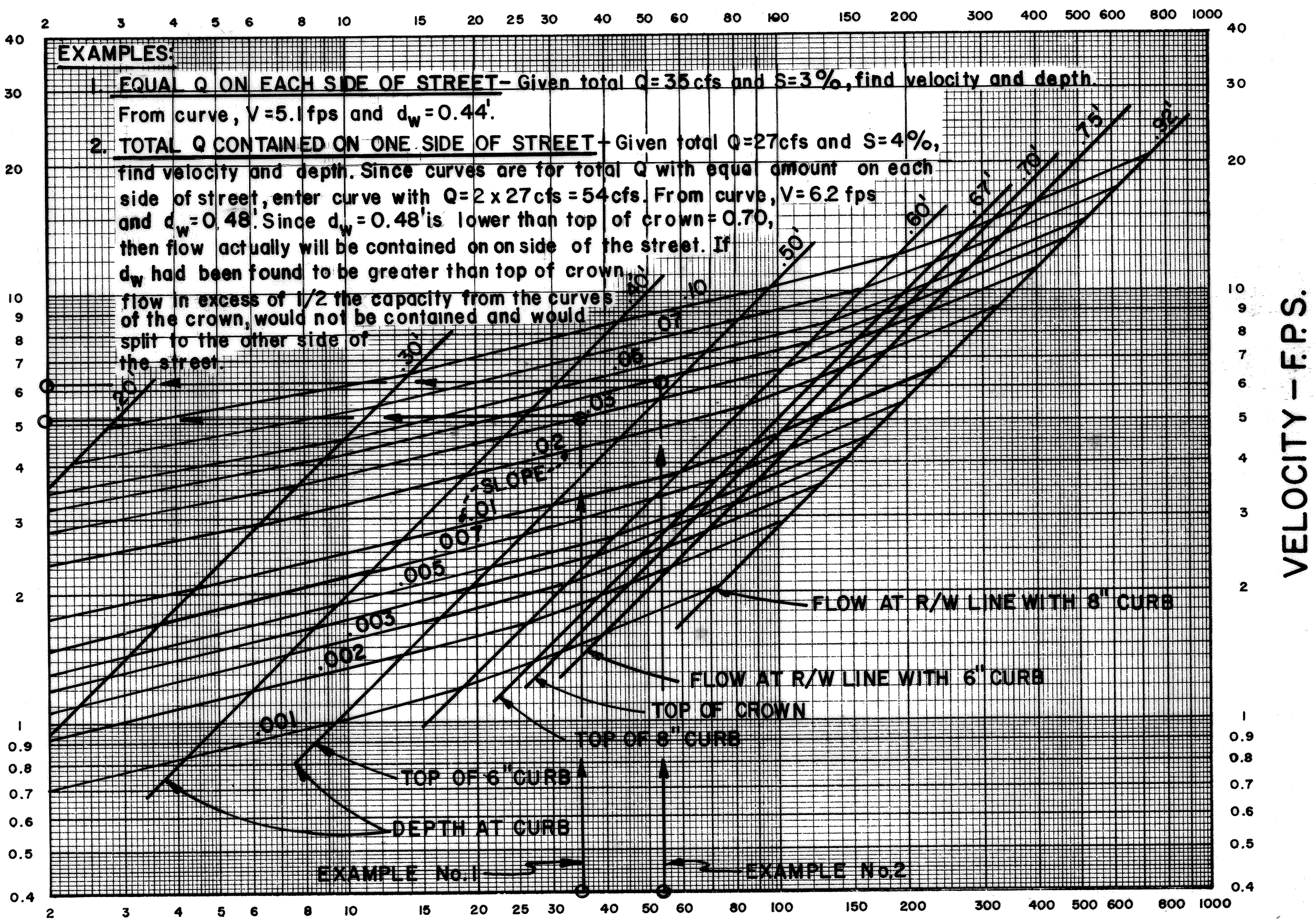
HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
VELOCITY DISCHARGE CURVES COUNTY STANDARD No. 100 86' ROADWAY 6" & 8" CURBS		
APPROVED: CHIEF ENGINEER R.E. NO. 8822	DRAWN BY: R.a. S.	SHEET No.
	CHECKED BY: F.J.R.-R.A.T.	
DATE	DATE DRAWN: JAN. 71	DR. No

REVISED



TYPICAL SECTION



DISCHARGE - C.F.S.

(TOTAL FLOW IN STREET)

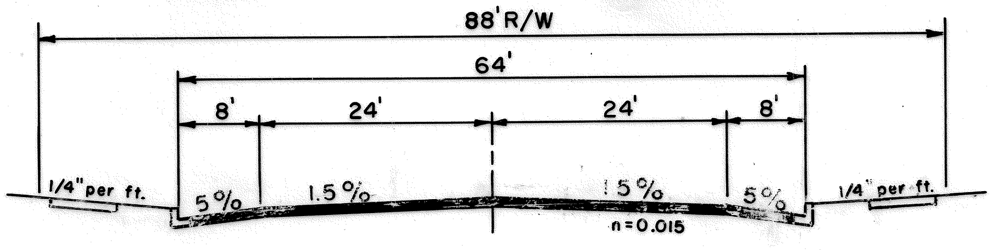
NOTE:

Without optional median, flow tops the crown as indicated. With optional median, flow does not top the crown. Computations for these curves assumed a median. However the results are applicable for either situation since the hydraulic effect of the median is negligable.

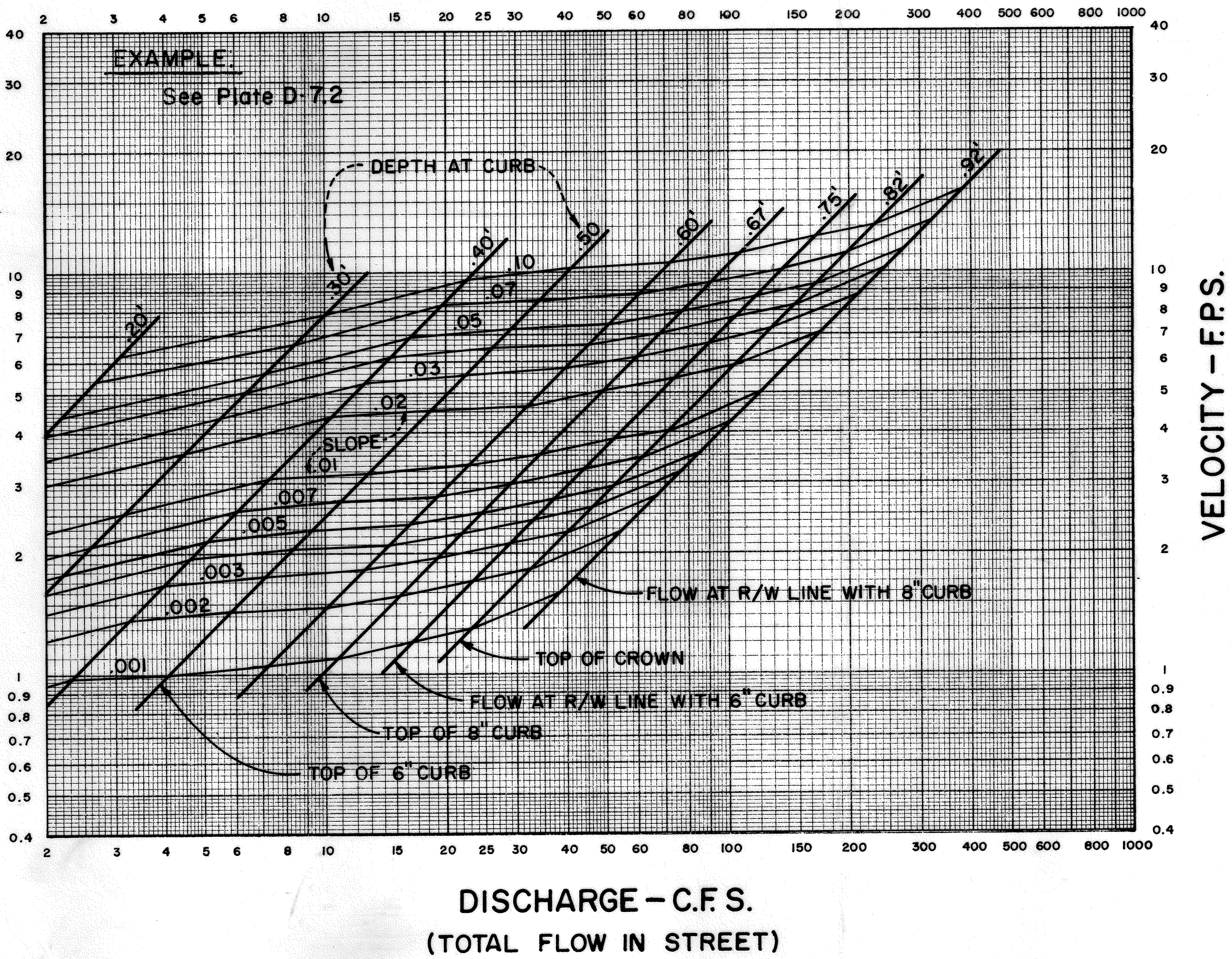
RCFC & WCD

HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
VELOCITY DISCHARGE CURVES COUNTY STANDARD No. 101 76' ROADWAY 6" & 8" CURBS		
APPROVED: CHIEF ENGINEER R.E. NO. 6822	DRAWN BY: R.A.S.	SHEET No.
DATE	CHECKED BY: F.J.P.-R.A.S.	DR. No.
	DATE DRAWN: JAN. 71	



TYPICAL SECTION



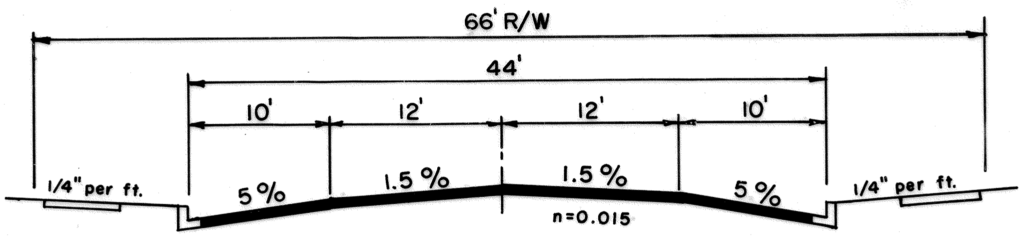
RCFC & WCD

HYDROLOGY MANUAL

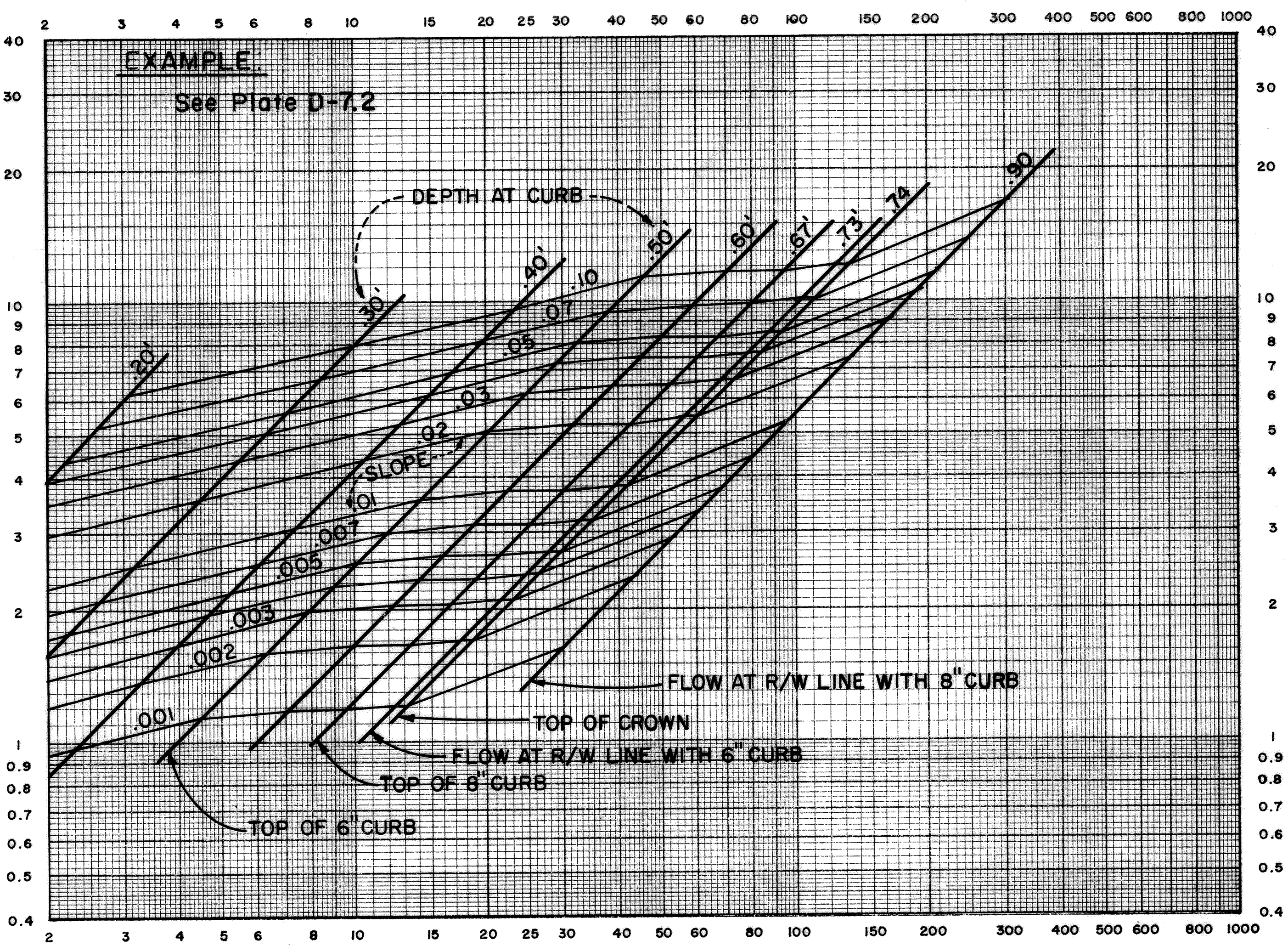
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

VELOCITY DISCHARGE CURVES
COUNTY STANDARD No. 102
64' ROADWAY 6" & 8" CURBS

REVISED. APPROVED: CHIEF ENGINEER R.E. NO. 6822	DRAWN BY: R.a. S.	SHEET NO.
DATE	CHECKED BY: F.J.P.-R.A.M.	
	DATE DRAWN: JAN. 71	DR. NO.



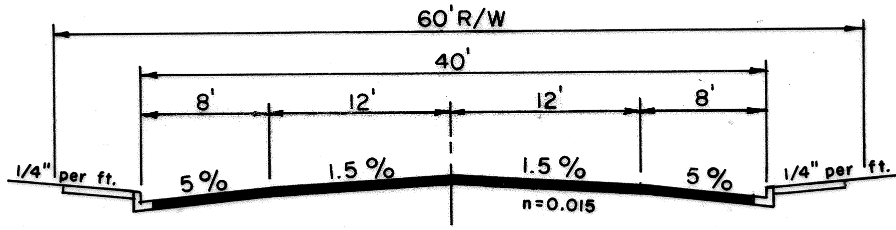
TYPICAL SECTION



DISCHARGE - C.F.S.
(TOTAL FLOW IN STREET)

RCFC & WCD
HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
VELOCITY DISCHARGE CURVES COUNTY STANDARD No. 103 44' ROADWAY 6" & 8" CURBS		
APPROVED: CHIEF ENGINEER R.E. NO. 6822	DRAWN BY: R.a.S.	SHEET No.
DATE	CHECKED BY: F.J.R.-R.A.H.	
REVISED	DATE DRAWN: JAN. 71	DR. No.



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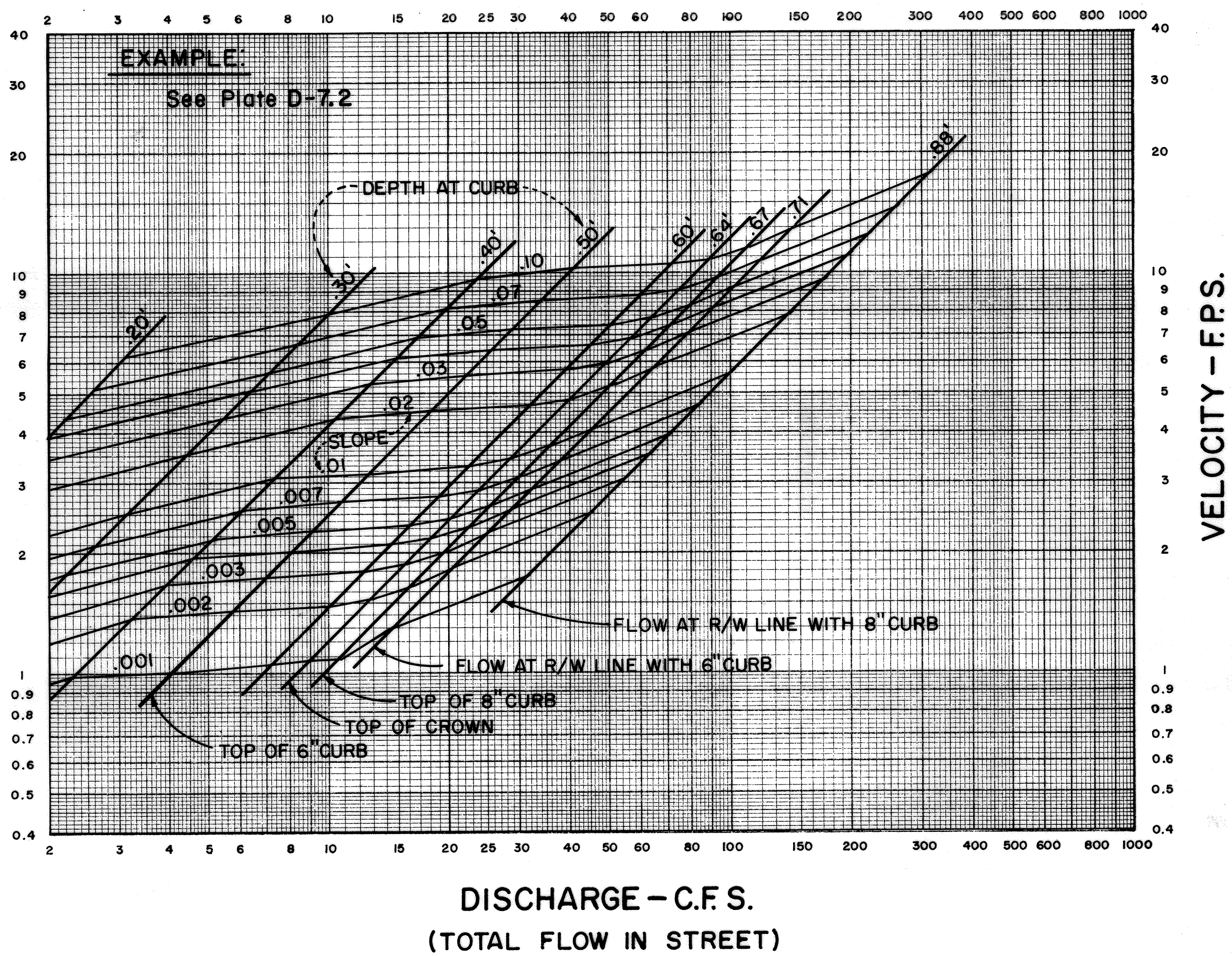


RCFC & WCD

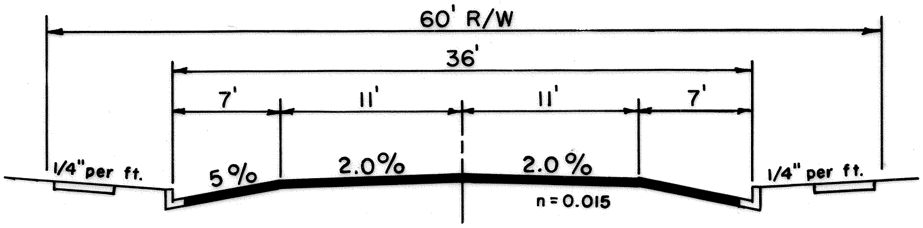
HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

VELOCITY DISCHARGE CURVES COUNTY STANDARD No. 104 40' ROADWAY 6" & 8" CURBS

APPROVED: CHIEF ENGINEER R.E. NO. 8822	DRAWN BY: R.A.S.	SHEET No.
DATE	CHECKED BY: F.J.R.-R.A.M.	DR. No.
	DATE DRAWN: JAN. 71	

REVISED:



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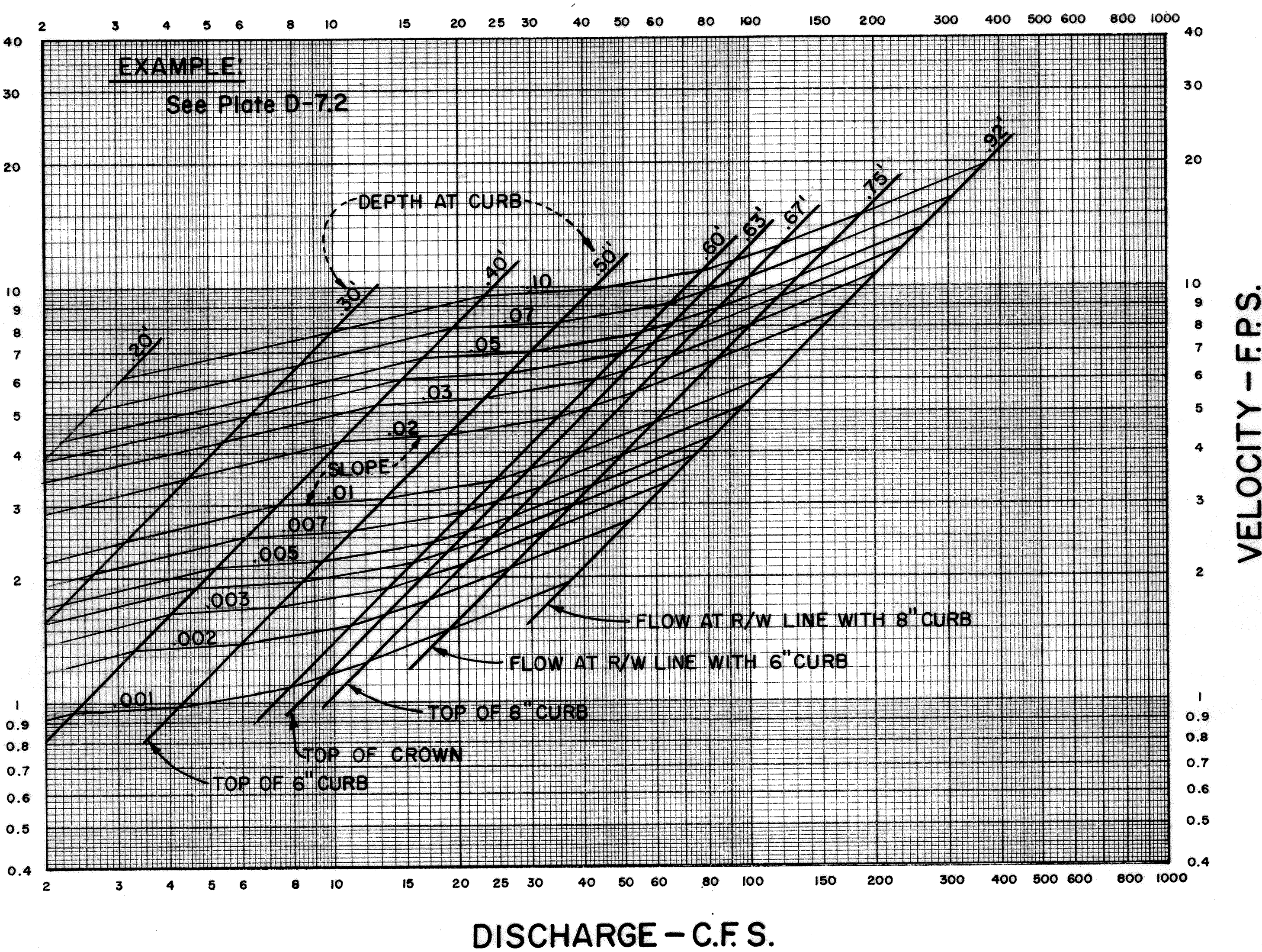

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

VELOCITY DISCHARGE CURVES
COUNTY STANDARD No. 105
36' ROADWAY 6" & 8" CURBS

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DATE	CHECKED BY: E.J.R.–R.A.S.	DR. No.
REVISED	DATE DRAWN: JAN. 71	

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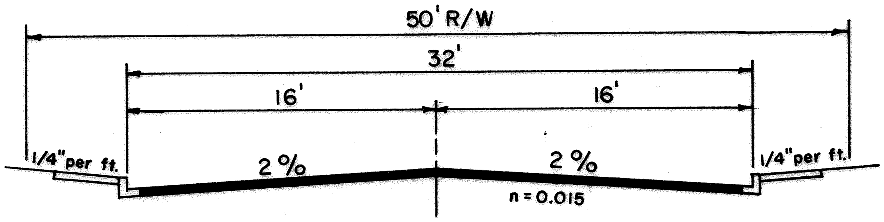

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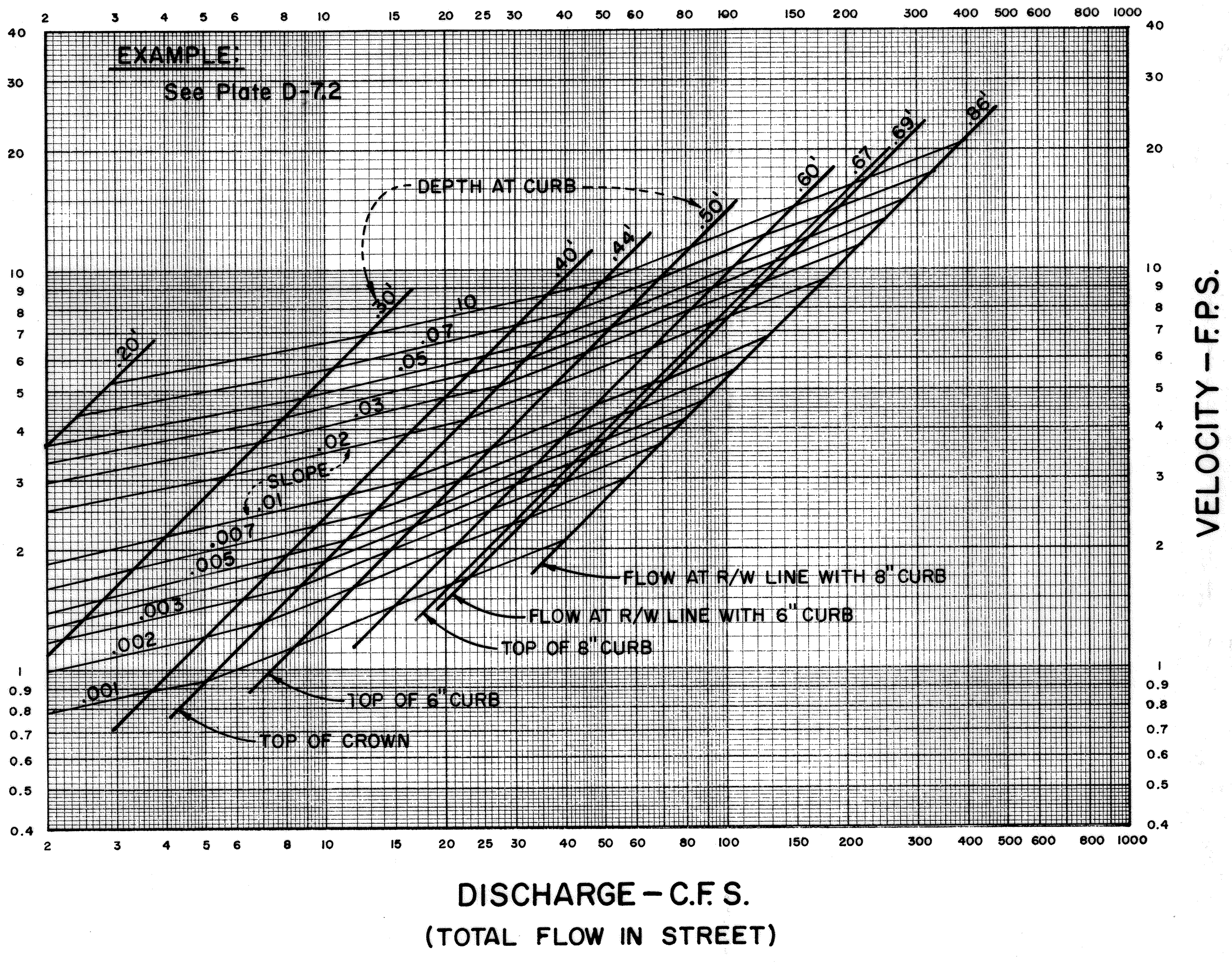

RIVERSIDE COUNTY FLOOD CONTROL
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VELOCITY DISCHARGE CURVES
COUNTY STANDARD No. 106
32' ROADWAY 6" & 8" CURBS

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REVISED	DATE DRAWN: JAN. 71	

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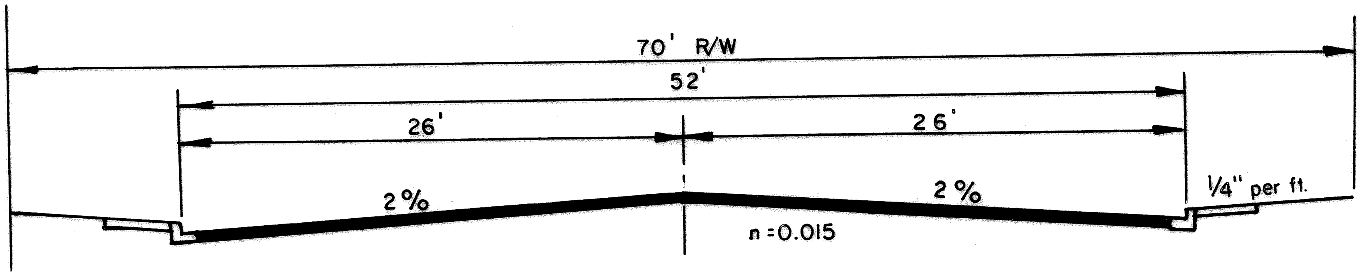
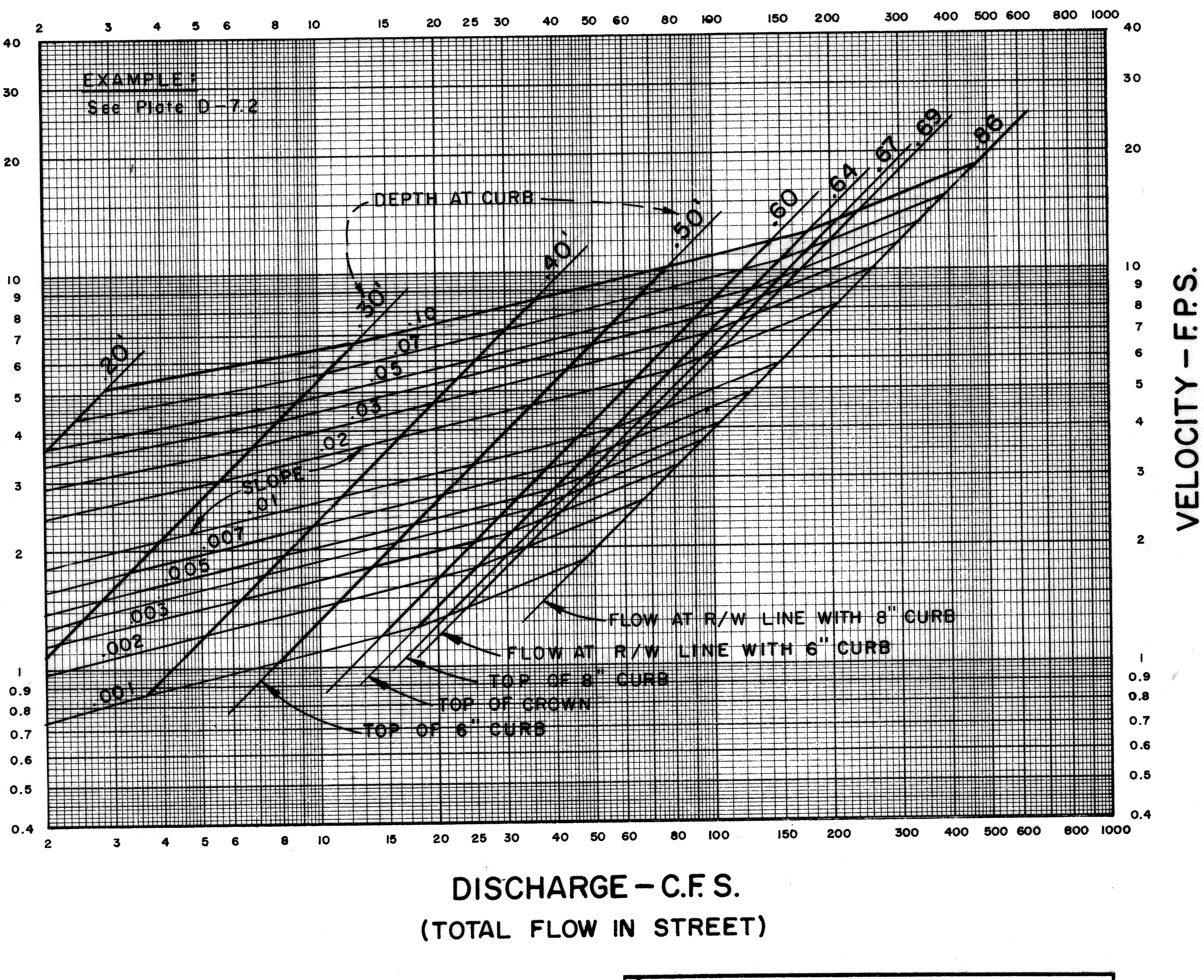


TYPICAL SECTION



RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

VELOCITY DISCHARGE CURVES
COUNTY STANDARD No. 111
52' ROADWAY 6" & 8" CURBS

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	DATE DRAWN:	

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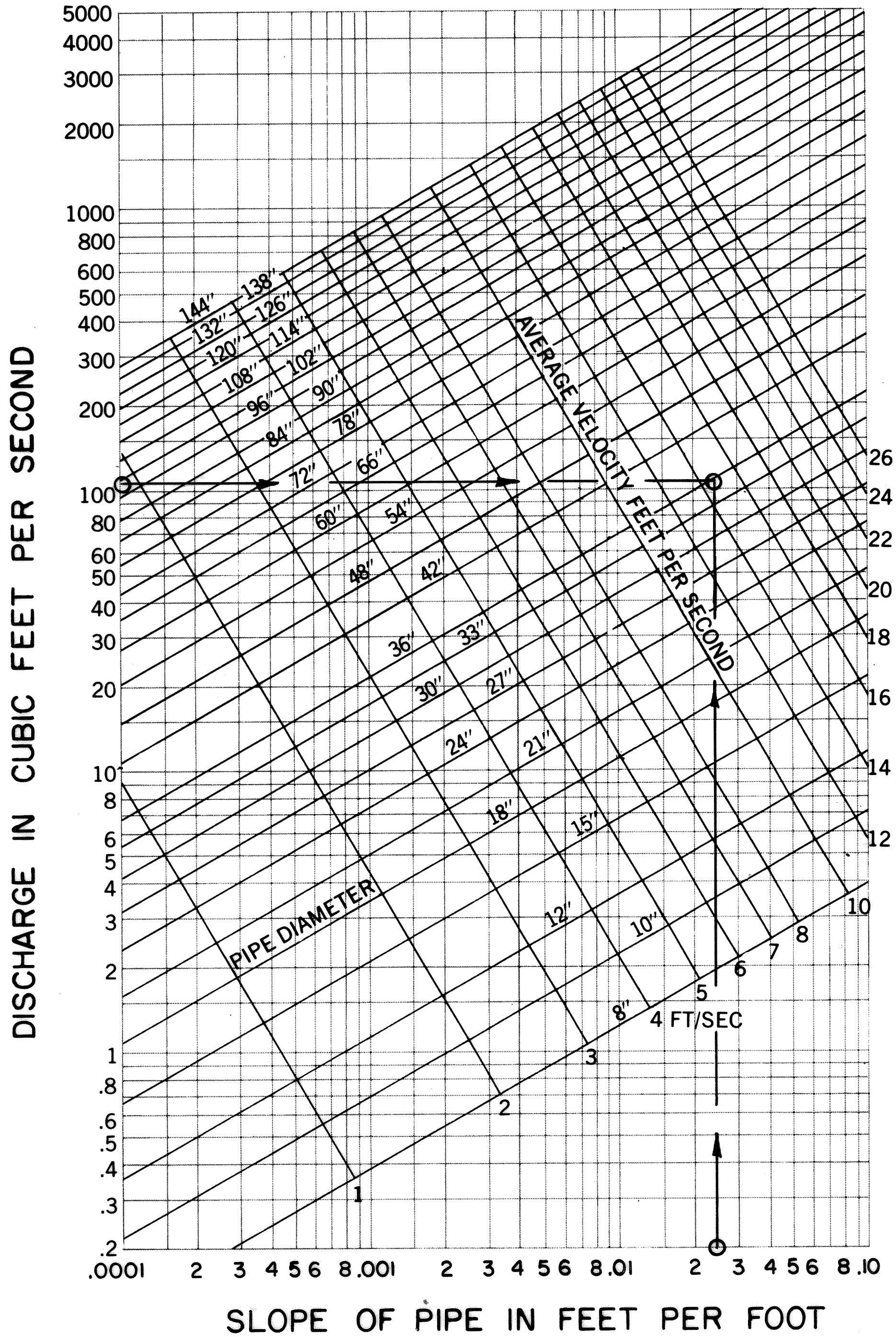
BASED ON MANNING'S EQUATION n=0.013



EXAMPLE:

Given Q = 105 cfs and S = 2.5 % find required pipe size and velocity. From curves required Size = 36"ϕ and Velocity = 14.8 fps

Reference: Bibliography item No. 10.

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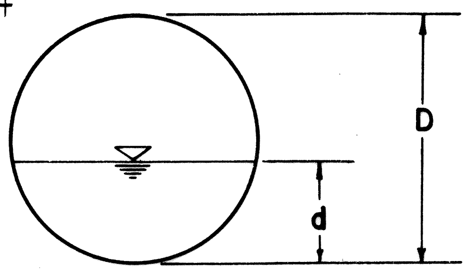
VELOCITY DISCHARGE CURVE
CIRCULAR CONCRETE PIPES FLOWING FULL



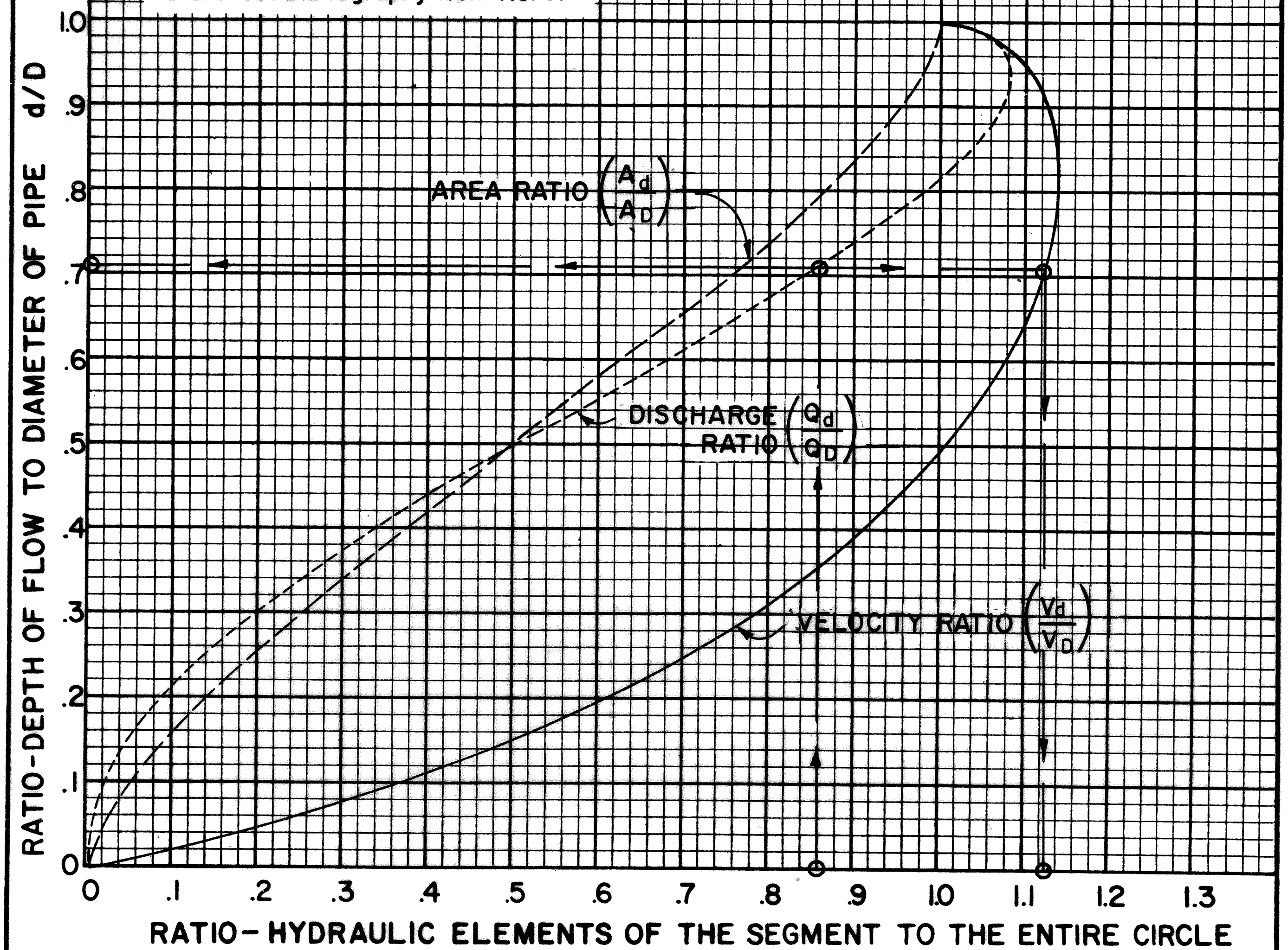
FLOW AT FULL PIPE: A_D - FLOW AREA, V_D - VELOCITY, Q_D - DISCHARGE

FLOW AT DEPTH d: A_d - FLOW AREA, V_d - VELOCITY, Q_d - DISCHARGE

EXAMPLE:

Given Q=90 cfs, S=2.5 % and D=36"ϕ (3'ϕ), find depth of flow and velocity. From example on Plate D-8.1, Q_D=105 cfs and V_D=14.8 fps. Then Q_d/Q_D = 90 cfs/105 cfs = 0.86. From curve, d/D = 0.71, then d = 0.71 x 3' = 2.13'. Also from curve, V_d/V_D = 1.125, then V_d = 1.125 x 14.8 fps = 16.7 fps. A_d may be found in a similar manner.

Reference: Bibliography item No. 5.



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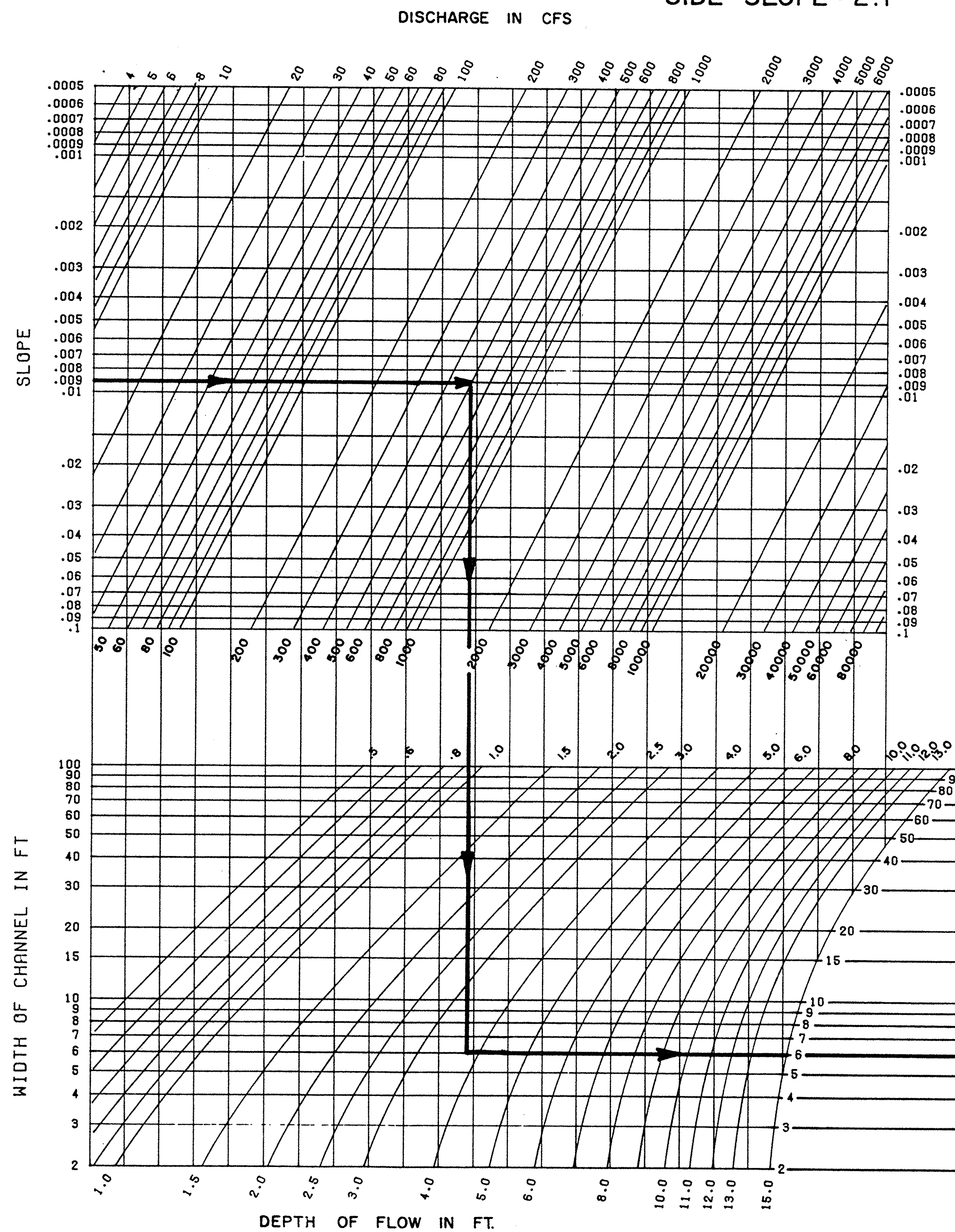
HYDRAULIC ELEMENTS CIRCULAR PIPE

FLOW IN UNLINED TRAPEZOIDAL CHANNELS

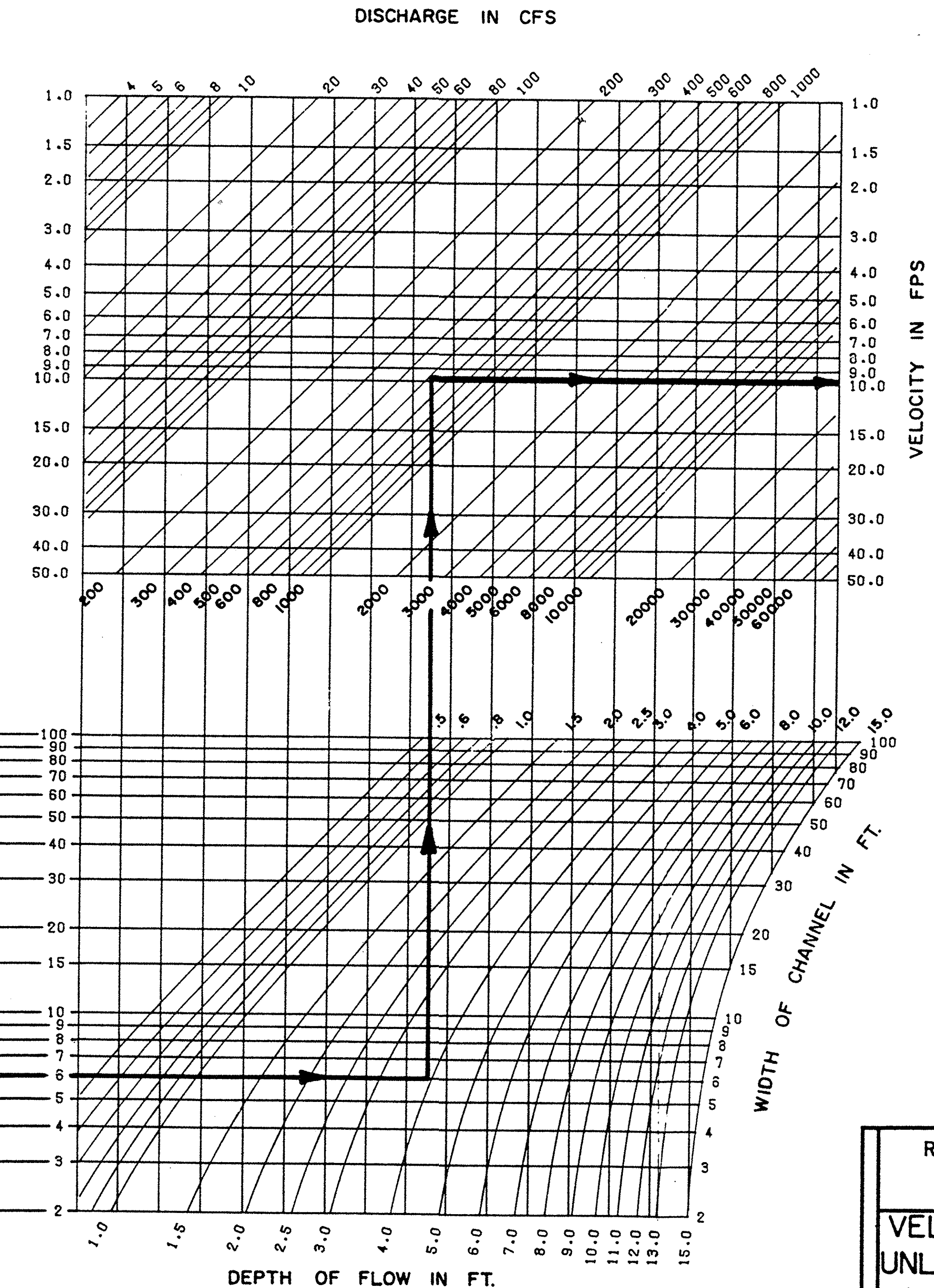
SIDE SLOPE = 2:1

n = 0.025 *



* NOTE:

This chart was developed for an "n" of 0.025 and is intended for determining velocities for use in Rational Tabling only. A more conservative n should normally be used for hydraulic design.



EXAMPLE

Given Q=500 cfs, S=0.009 and b=6'. Find depth and velocity from chart d=3.8' and V=9.7 fps.

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RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

VELOCITY-DISCHARGE CURVES
UNLINED TRAPEZOIDAL CHANNELS
(SIDE SLOPES=2:1, n=0.025)

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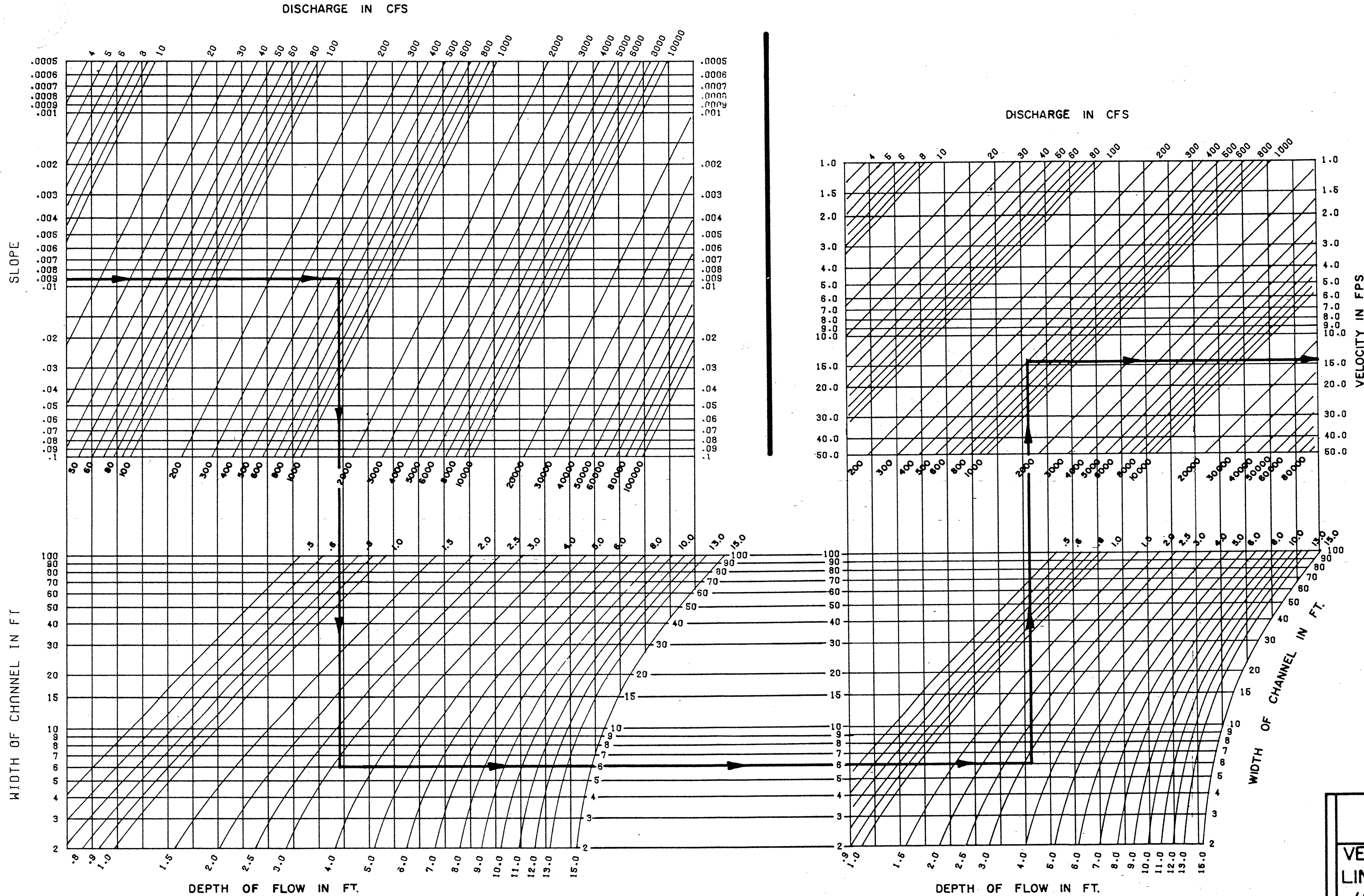
DATE
DRAWN BY R.A.S.
SHEET NO.
PLATE D-9.1
DR. NO.

FLOW IN LINED TRAPEZOIDAL CHANNELS

SIDE SLOPES=1.5:1 n=0.015



EXAMPLE

Given Q=500 cfs, S=0.009 and b=6'.
Find depth and velocity from chart
d=3.1' and V=14.7 fps

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RIVERSIDE COUNTY FLOOD CONTROL
AND
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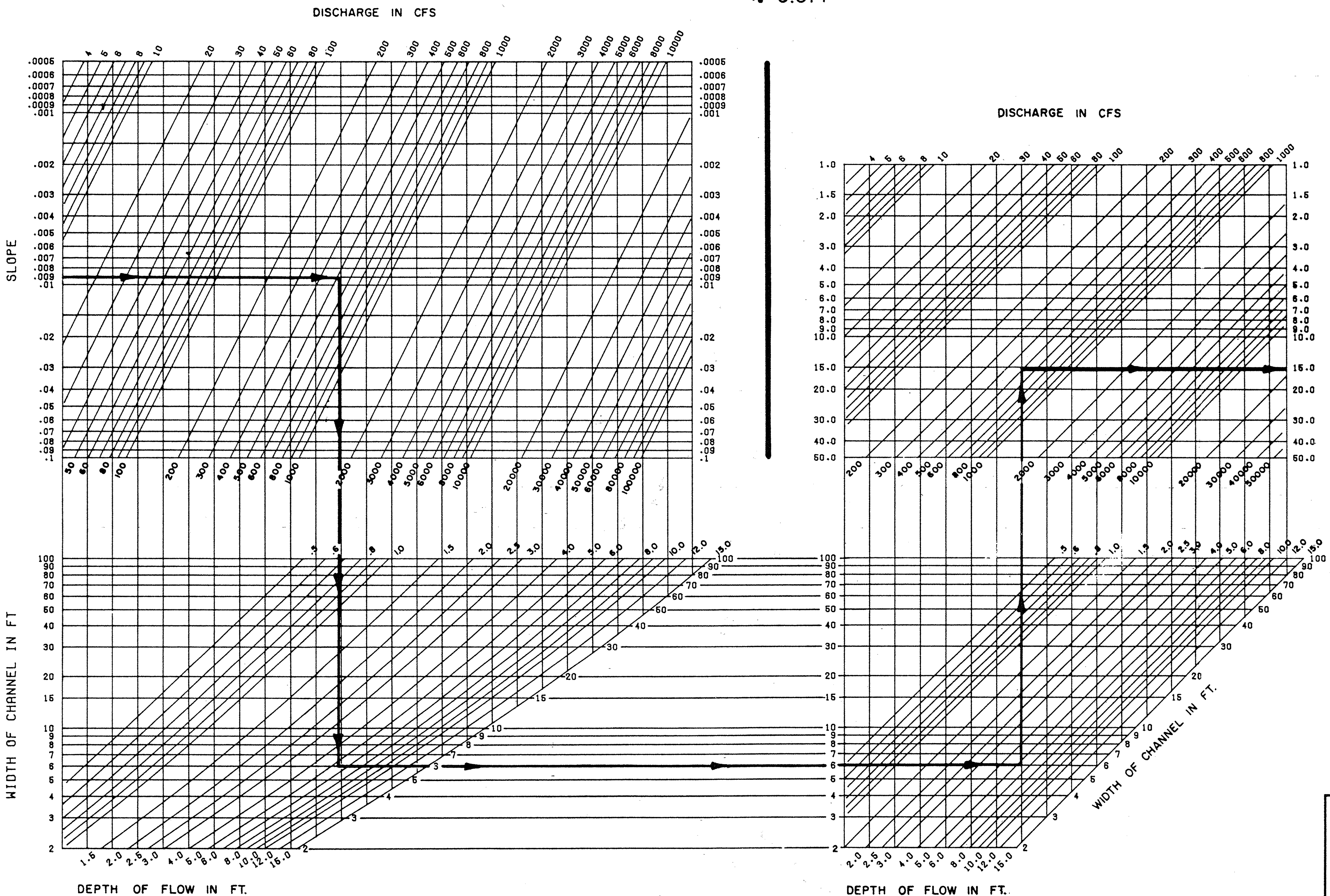
VELOCITY-DISCHARGE CURVES
LINED TRAPEZOIDAL CHANNELS
(SIDE SLOPES=1.5:1, n=0.015)

APPROVED CHIEF ENGINEER R.E. NO.
DATE
DRAWN BY
PLATE D-9.2
SHEET NO
DR. NO

FLOW IN LINED RECTANGULAR CHANNELS

n=0.014



EXAMPLE

Given Q=500 cfs, S=0.009 and b=6'. Find depth and velocity from chart d=5.3' and V=15.6 fps.

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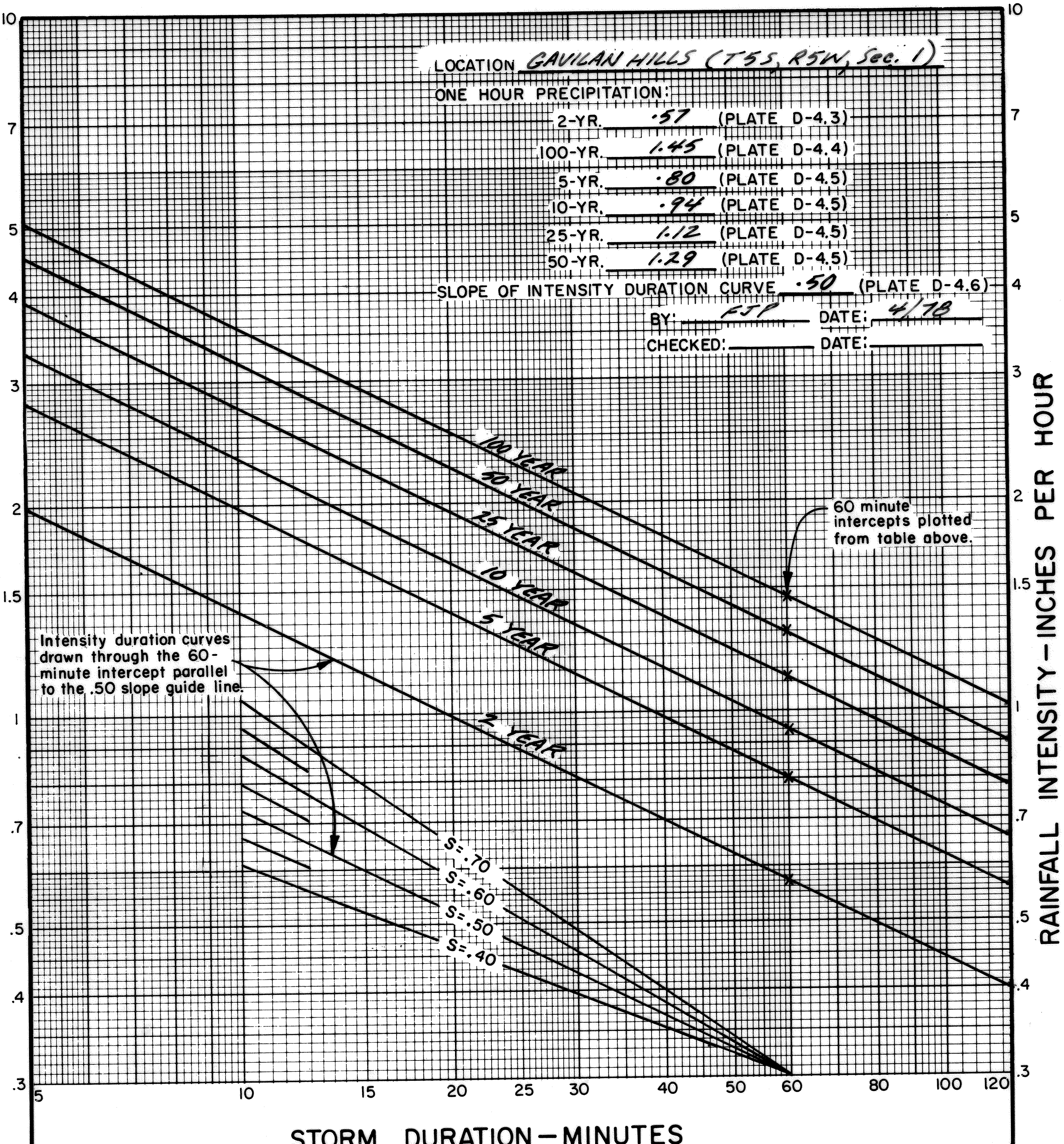
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

VELOCITY-DISCHARGE CURVES
LINED RECTANGULAR CHANNELS
(n=0.014)

REVISED | APPROVED CHIEF ENGINEER R.E. NO. | DATE | DRAWN BY R.A.S. | PLATE D-9.3 | SHEET NO | DR NO



SAMPLE CALCULATION No. 1
INTENSITY DURATION CURVE FOR GAVILAN HILLS-T5S, R5W, SECTION 1
(Example of Plate D-4.7)

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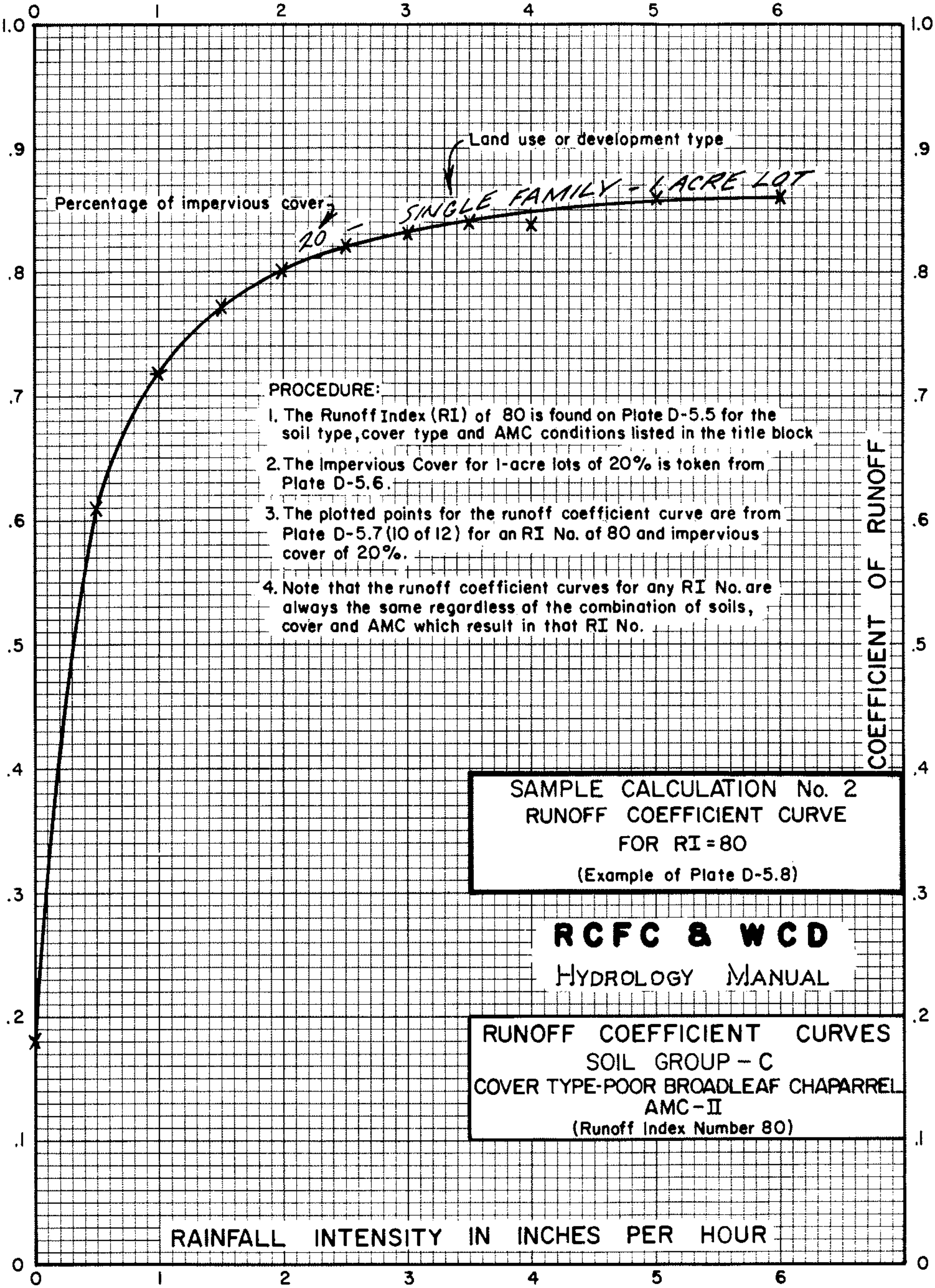
INTENSITY-DURATION CURVES CALCULATION SHEET


0
1
2
3
4
5
6
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
Land use or development type
SINGLE FAMILY - 1 ACRE LOT
Percentage of impervious cover
20 -
PROCEDURE:
1. The Runoff Index (RI) of 80 is found on Plate D-5.5 for the soil type, cover type and AMC conditions listed in the title block
2. The Impervious Cover for 1-acre lots of 20% is taken from Plate D-5.6.
3. The plotted points for the runoff coefficient curve are from Plate D-5.7 (10 of 12) for an RI No. of 80 and impervious cover of 20%.
4. Note that the runoff coefficient curves for any RI No. are always the same regardless of the combination of soils, cover and AMC which result in that RI No.
COEFFICIENT OF RUNOFF
SAMPLE CALCULATION No. 2
RUNOFF COEFFICIENT CURVE
FOR RI = 80
(Example of Plate D-5.8)
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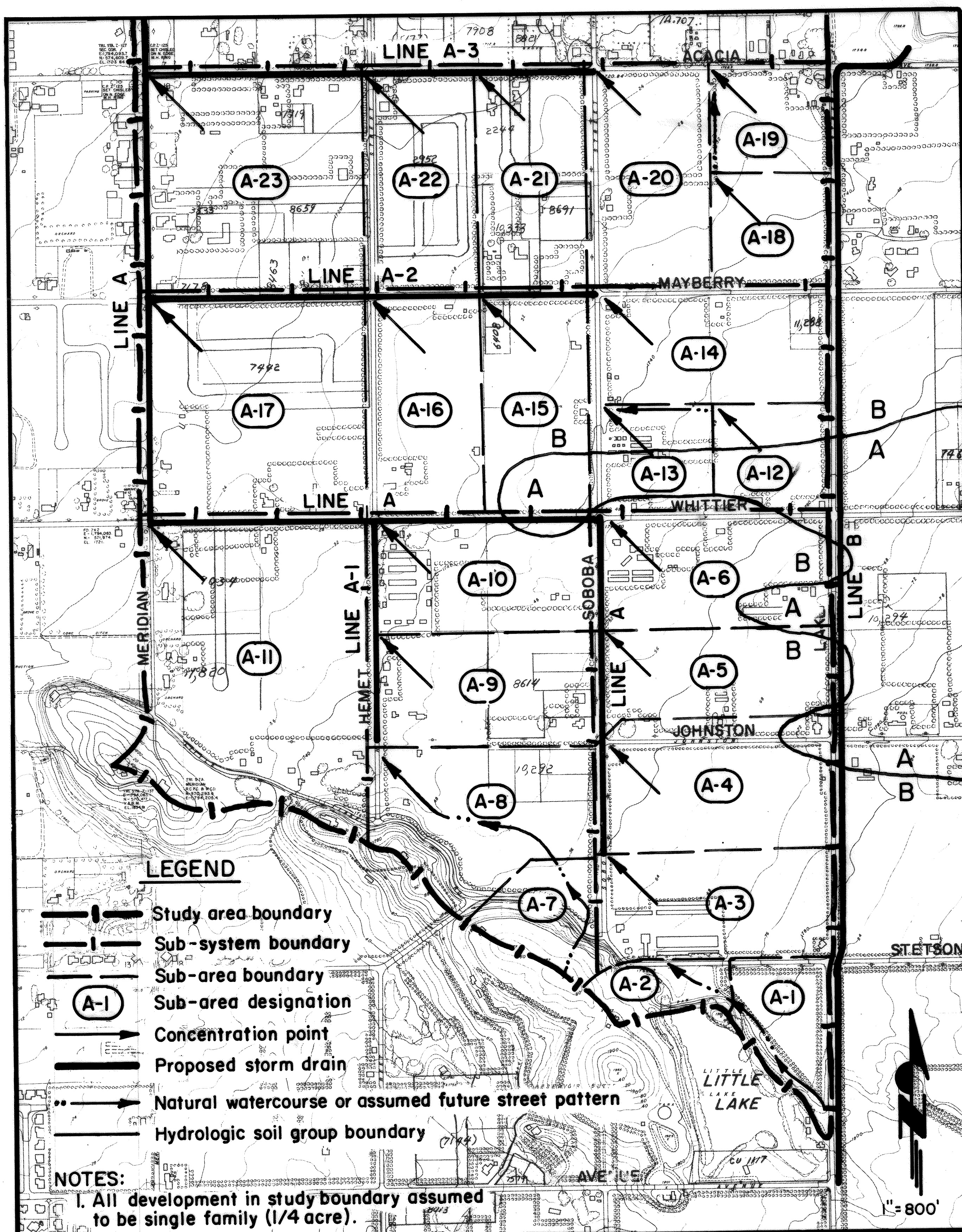
HYDROLOGY MANUAL
RUNOFF COEFFICIENT CURVES
SOIL GROUP – C
COVER TYPE-POOR BROADLEAF CHAPARREL
AMC – II
(Runoff Index Number 80)
RAINFALL INTENSITY IN INCHES PER HOUR



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SAMPLE CALCULATION No. 3

RATIONAL TABLING STUDY

(Example Hydrologic Data Map)

RCFC & WCD Hydrology Manual
RATIONAL METHOD CALCULATION FORM

Sheet No. 2 of 3 Sheets

PROJECT: MERIDIAN STREET STUDY - LINE A

FREQUENCY: 10-YEAR

Calculated by: FJP DATE: 4/78

Checked by: ________ DATE: ________

DRAINAGE AREA	Soil & Development	A Acres	I in/hr.	C	ΔQ CFS	Σ Q CFS	SLOPE	SECTION	v FPS	L FT.	T MIN.	Σ T	REMARKS
A-1	B S.F. 1/4 Ac.	7	1.74	.73	8.9				H=20'	900	12.6	12.6	INITIAL AREA (Plate D-3)
A-2	" "	6	1.49	.71	6.4	8.9	.0118	NATURAL VALLEY	2.7	680	4.2	16.8	Stetson Ave @ Soboba St.
A-3	" "	21	1.37	.70	20.1	15.3	.0127	40' St.	3.5	630	3.0	19.8	——
A-4	A-6% B-94% "	25	1.30	.70	22.8	35.4	.0061	33"ø RCP	6.6	660	1.7	21.5	Soboba St @ Johnston Ave.
A-5	A-4% B-96% "	17	1.26	.68	14.6	58.2	.0061	42"ø RCP	7.4	660	1.5	23.0	——
A-6	A-17% B-83% "	21	1.23	.67	17.3	72.8	.0114	42"ø RCP	9.7	660	1.1	24.1	Soboba St. @ Whittier Ave
A-7 thru A-9	(LINE A-1,	See	Sheet	3)	51.9	90.1	.0125	42"ø RCP	10.8	1320	2.0	26.1	Whittier Ave @ Hemet St.
A-10	A-7% B-93% S.F. 1/4 Ac.	20	1.18	.68	16.1	142.0	—	—	—	—	—	26.1	" " " "
A-11	B S.F. 1/4 Ac.	54	1.13	.68	41.5	158.1	.0053	60"ø RCP	9.2	1320	2.4	28.5	Whittier Ave @ Meridian St.
A-12 thru A-16	(LINE A-2,	See	Sheet	3)	68.8	199.6	.0045	66"ø RCP	9.0	1320	2.5	31.0	Meridian St. @ Mayberry Ave.
A-17	B S.F. 1/4 Ac.	40	1.08	.68	29.4	268.4	—	—	—	—	—	31.0	" " " "
A-18 thru A-22	(LINE A-3,	See	Sheet	3)	69.6	297.8	.0053	72"ø RCP	10.8	1320	2.0	33.0	Meridian St. @ Acacia Ave.
A-23	B S.F. 1/4 Ac.	40	1.05	.67	28.1	367.4	—	—	—	—	—	33.0	" " " "
						395.5							

Notes:

1. Intensity data per standard Hemet area curve (Plate D-4.1).
2. Runoff coefficients per standard "Urban Landscaping" "C" curves (Plates D-5.1 & D-5.2).

SAMPLE CALCULATION No. 3
RATIONAL TABLING STUDY

(Example of Plate D-2)

RCFC & WCD Hydrology Manual
RATIONAL METHOD CALCULATION FORM

PROJECT MERIDIAN STREET STUDY - LINE A

Calculated by FJP 4/78 DATE

FREQUENCY 10-YEAR

Checked by ________ DATE

DRAINAGE AREA	Soil & Development	A Acres	I in/hr.	C	ΔQ CFS	ΣQ CFS	SLOPE	SECTION	V FPS	L FT.	T MIN.	ΣT	REMARKS
LINE A-1							H=102'	—	—	720	8.0		
A-7	B S.F. 1/4 Ac.	9	2.21	.76	15.1							8.0	INITIAL AREA (Plate D-3)
						15.1	.0102	40' St.	3.2	1180	6.2	14.2	Hemet St. 1320' s/o Whittier Ave.
A-8	" "	24	1.63	.72	28.2	43.3	.0076	21"ø RCP	6.6	660	1.7	15.9	———
A-9	" "	20	1.54	.72	22.2	65.5	.0152	33"ø RCP	10.8	660	1.0	16.9	Hemet St. @ Whittier Ave.
	Adjust Q to T_c = 26.1 min					$Q = 65.5 \times \frac{1.18}{1.49}$ = 51.9 cfs							
LINE A-2							H=14'	—	—	1000	14.5		
A-12	A-59% B-41% S.F. 1/4 Ac.	10	1.61	.67	10.8							14.5	INITIAL AREA (Plate D-3)
A-13	A-50% B-50% "	11	1.44	.66	10.5	10.8	.0111	40' St.	3.3	720	3.6	18.1	———
A-14	B "	21	1.29	.70	19.0	21.3	.0068	40' St.	2.8	660	3.9	22.0	Soboba St. @ Mayberry Ave.
A-15	A-22% B-78% "	20	1.25	.67	16.8	40.3	.0095	30"ø RCP	8.2	660	1.3	23.3	———
A-16	B "	20	1.22	.69	16.8	57.1	.0095	33"ø RCP	9.2	660	1.2	24.5	Mayberry Ave @ Hemet St.
						73.9	.0087	42"ø RCP	9.0	1320	2.4	26.9	Mayberry Ave @ Meridian St.
	Adjust Q to T_c = 31.0 min					$Q = 73.9 \times \frac{1.08}{1.16}$ = 68.8 cfs							
LINE A-3							H=12'	—	—	1000	14.9		
A-18	B S.F. 1/4 Ac.	10	1.59	.72	11.5							14.9	INITIAL AREA (Plate D-3)
A-19	" "	10	1.44	.71	10.2	11.5	.0121	40' St.	3.4	660	3.2	18.1	———
A-20	" "	22	1.31	.70	20.2	21.7	.0063	40' St.	3.6	720	3.3	21.4	Acacia Ave @ Soboba St.
A-21	" "	20	1.26	.70	17.6	41.9	.0053	33"ø RCP	6.6	660	1.7	23.1	———
A-22	" "	20	1.21	.69	16.7	59.5	.0045	42"ø RCP	6.8	660	1.6	24.7	Acacia Ave. @ Hemet St.
						76.2	.0076	42"ø RCP	8.5	1320	2.6	27.3	Acacia Ave @ Meridian St.
	Adjust Q to T_c = 33.0 min					$Q = 76.2 \times \frac{1.05}{1.15}$ = 69.6 cfs							

SECTION E

SYNTHETIC UNIT HYDROGRAPH METHOD

SYNTHETIC UNIT HYDROGRAPH METHOD

General - Basic unit hydrograph theory for determining the rainfall-runoff relationship of a gauged drainage basin was developed by L. K. Sherman in 1932. In 1938, F. F. Snyder developed the Synthetic Unit Hydrograph principle making it possible to transpose rainfall-runoff data from gauged drainage basins to ungauged basins, on the basis of differences in physical basin characteristics such as shape, area, slope, etc. The Los Angeles office of the U. S. Army Corps of Engineers (USCE) has compiled considerable data on major flood events in Southern California over the past 35 years, and has developed relationships for gauged basins applicable to ungauged basins based on physical drainage basin characteristics. Over the past two decades the Corps has made numerous hydrologic investigations of drainage basins in Riverside County in connection with Federal flood control projects using Synthetic Unit Hydrograph methodology. The District has used similar methods since publication in 1963 of its report on "The Application of Synthetic Unit Hydrographs to Drainage Basins in the Riverside County Flood Control and Water Conservation District". The purpose of this section is to update and refine the methods published in that report.

The methods presented herein should be used for studies on all watersheds in excess of 300 to 500-acres. Before attempting to apply the methods in this section, the engineer should become thoroughly familiar with Sections A, B and C of this manual.

Development of Synthetic Unit Hydrographs - A unit hydrograph (or unit graph) for a given concentration point within a drainage area is a curve showing the time distribution of runoff that would result at the concentration point from unit storm effective rainfall over the drainage area above that point. In District hydrology a unit storm is defined as a storm producing effective rainfall at a rate of one-inch per hour for unit time duration. Effective rainfall is that part of the total rainfall which appears at the concentration point as surface runoff.

Since there is little observational data available concerning rainfall-runoff relationships in Riverside County, use has been made of relationships developed by the Los Angeles District USCE from areas considered to be physiographically and hydrologically similar to western Riverside County. Basically, the method transposes the characteristic time distribution of runoff from drainage areas for which such data are available, to nearby areas for which data is not available. Because no two drainage basins have the same physical characteristics, it is necessary to adjust for the differences. This is accomplished by using S-graphs appropriate for the terrain, and a factor called lag. These, and other factors in development of a synthetic unit hydrograph, are discussed in the following paragraphs, and illustrated on Figure E-l.

S-graphs - A summation hydrograph for an area is a hydrograph of runoff that would result from the continuous generation of unit storm effective rainfall over the area (one-inch per hour continuously). The ordinate is expressed as rate of runoff in cfs (or cfs per inch per hour of rainfall, which can be expressed as cfs-hours/inch), and the abscissa is expressed in time units. Flow rate on the summation hydrograph increases with time until the ultimate discharge is reached. Ultimate discharge, the maximum rate of runoff attainable for a given intensity, occurs when the rate of runoff on the summation hydrograph reaches the rate of effective rainfall. For a unit storm effective rainfall rate of one-inch per hour, the ultimate discharge is 645 cfs per square mile of drainage area.

An S-graph is a summation hydrograph modified to the extent that discharge is expressed in percent of ultimate discharge, and time is expressed in percent of lag time (as defined below). An S-graph represents the basic time-runoff relationship for a watershed type in a form suitable for application to ungauged basins. In District hydrology four S-graphs are used to represent the runoff characteristics of watersheds in western Riverside County.

The four-S-graphs used by the District are shown on Plates E-4.l through E-4.4. These S-graphs are titled Valley, Foothill, Mountain and Desert, respectively. Selection of the appropriate S-graph for a particular area is extremely important, but difficult to quantify. All other factors equal, peak discharge for an area is lowest when the Mountain S-graph is used, and increases with substitution of the Valley, Desert and Foothill S-graphs respectively. The Valley curve is suitable for valley floor and alluvial cone areas. The Foothill curve is suitable for small watersheds with extreme slopes, or for confined valley areas surrounded by steep foothills. Examples would be the Jurupa and Lakeview Mountains or the Indio Hills. The Mountain curve is suitable for major watersheds in the Santa Ana, western San Jacinto and San Bernardino Mountains. The Desert curve should be used primarily in the southeastern San Bernardino and eastern San Jacinto Mountains.

Lag - Lag for a drainage area is defined as the elapsed time in hours from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of an area reaches 50 percent of ultimate discharge. Lag can be calculated from the physical characteristics of a drainage area by the empirical formula:

$$\text{Lag (hours)} = 24\bar{n}\left[\frac{L \cdot L_{ca}}{S^{1/2}}\right]^{(.38)}$$

where:

- $\bar{n}$ = The visually estimated mean of the n (Manning's formula) values of all collection streams and channels within the watershed
- L = Length of longest watercourse - miles
- Lca = Length along longest watercourse, measured upstream to a point opposite the centroid of the area - miles
- S = Overall slope of longest watercourse between headwaters and the collection point feet per mile

Lag time is used to relate an S-graph to a particular basin for the purpose of deriving a Synthetic Unit graph for that basin. Plate E-3 shows curves of lag versus $L(Lca/S^{1/2})$ for n values ranging from 0.015 to 0.050. Guidelines are also shown for estimating the appropriate n to be used.

Synthetic Unit Hydrograph Computations - In developing the Synthetic Unit Hydrograph for an area the following procedure is used:

1. Lag time for the area is computed using topographic maps and the relationships presented previously.
2. Unit time is selected as between 25 and 40-percent of lag time. To ensure adequate definition of the synthetic unit hydrograph the unit time should be no greater than 40-percent of lag time. Conversely, unit times less than 25-percent of lag result in unnecessary and cumbersome calculations.
3. An S-graph appropriate for the area is selected using the criteria outlined previously.
4. The average percentage of ultimate discharge is determined from the selected S-graph for each unit time period. In reading the percentage of discharge from the S-graph, an attempt should be made to determine an average ordinate over the time increment, rather than the mean of the ordinates at the beginning and end of the time increment. These values may vary significantly on the steep portion of the S-graph in the early time periods.
5. The unit distribution graph is determined by subtracting from the percentage of ultimate discharge for each unit time period (determined in the previous step), the percentage of ultimate discharge for the previous time period. This is equivalent to computing the difference between the ordinates of the S-graph, and an identical S-graph, offset one unit time period from each other

.

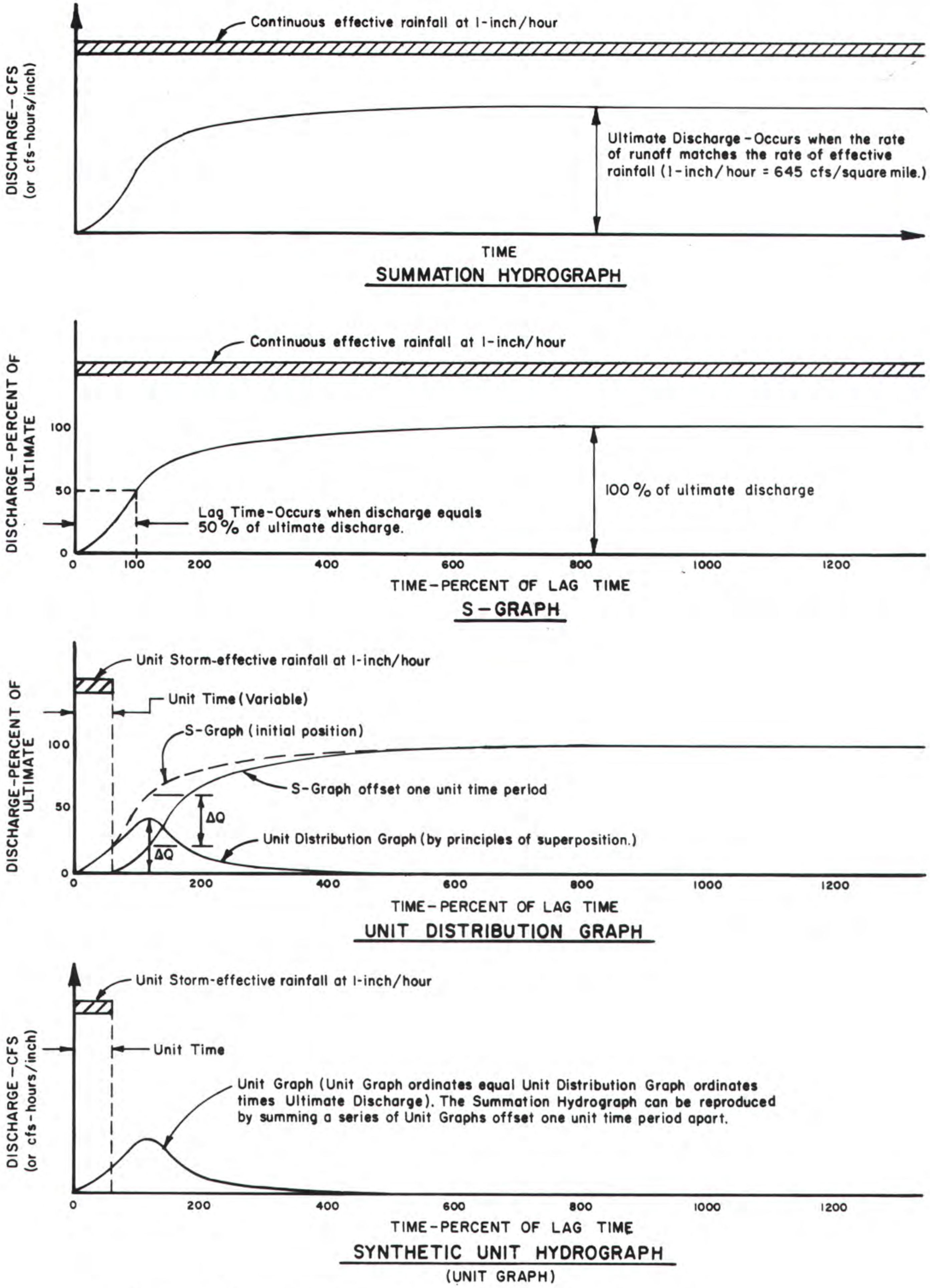

Figure E-1. Derivation of a Synthetic Unit Hydrograph

6. The synthetic unit hydrograph (unit graph) ordinates are determined by multiplying the distribution graph ordinates times K, the ultimate discharge. Ultimate discharge can be computed using:

K (cfs-hours/inch) 645A

where:

A = Drainage area - square miles

Development of Flood Hydrographs - A flood hydrograph for a given concentration point of a drainage area, is a curve showing the time distribution of runoff that would result at that point from design storm rainfall over the drainage area. Factors in development of a flood hydrograph are discussed in the following pages, and illustrated on Figure E-2.

To develop a flood hydrograph from a unit graph, it is first necessary to determine the total effective rainfall over the drainage area and the time distribution or pattern of this rainfall during the storm period. The total effective rainfall to be applied to the unit hydrograph is a variable dependent upon the frequency of storm for which control is desired, the duration and pattern of the storm, and the loss rate characteristic of the drainage area.

Point Precipitation - Point rainfall data can be obtained from the isohyetal maps and return period diagram on Plates E-5.l through E-5.7 for storm durations of 3, 6 and 24-hours, and return periods of from 2 to 100 years. The rainfall information is based on NOAA Atlas 2 (discussed in detail in Section B of this manual).

The 3 and 6-hour duration storms are considered representative of local thunderstorms which usually occur in the summer months, while the 24-hour storm is considered representative of the general storms which usually occur in the winter. In general the 3 and 6-hour duration storms will control peak discharge for small drainage areas, and the 24-hour storm will control for large watersheds. In most cases all three durations should be analyzed. This is especially true where a reservoir or retention basin is planned, as the long duration storm may control due to the volume of runoff, even though the peak inflow may be lower than that for short duration storms.

It should be noted that in mountainous terrain, or for studies of large watersheds, the NOAA Atlas 2 data should be checked against District frequency analysis for all rain gauges in the study area, and adjustments made as necessary.

Precipitation Depth - Area Adjustment - Point rainfall values can be adjusted for areal effect according to the drainage area size using the curves on Plate E-5.8.

Precipitation-Intensity Pattern - Rainfall patterns used in development of 3 and 6-hour thunderstorm flood hydrographs are based on the Indio storm of September 24, 1939. The pattern used for development of 24-hour general storm flood hydrographs is based on the major flood producing storm of March 1938. Tabulations of these patterns are given on Plate E-5.9 for selected unit time periods. These patterns are considered to represent a reasonable distribution of rainfall which will cause critical runoff conditions during major storm events.

Loss Rates - Factors influencing loss rates are discussed in detail in Section C of this report. Where sufficient data is available loss rates for unit hydrograph hydrology can be estimated from a study of rainfall-runoff relationships of major storms. Where such data is not available loss rates for pervious areas can be estimated using Plates E-6.l and E-6.2. Loss rates for pervious areas estimated in this manner are generally consistent with previous District studies, and with loss rates developed by the Los Angeles District USCE in numerous hydrology studies in the Southern California area.

Loss rates for pervious areas can be adjusted to account for developed area using the relationship:

$$F = F_p (1.00-0.9A_i)$$

where:

F = Adjusted loss rate - inches/hour

F_p = Loss rate for pervious areas - inches/hour (Plate E-6.2)

A_I = Impervious area (actual) - decimal percent (Plate E-6.3)

Adjusted loss rates for the Synthetic Unit Hydrograph method on typical watersheds in the District run generally from 0.10 to 0.40 inches per hour, with most falling between 0.20 and 0.25 inches per hour. For short storms with durations of 6-hours or less the adjusted loss rate may be taken as constant. For longer duration storms the loss rate should normally be varied to decrease with time to yield a mean equal to the adjusted loss rate. For the 24-hour storm the loss curve can be expressed as a function of time:

$$F_T = C(D-T)^{1.55} + F_m$$

where:

F_T = Adjusted loss rate at time "T" inches/hour

C = $(F-F_m)/54$

F = Adjusted loss rate - inches/hour (as previously defined)

D = Storm duration - hours = 24-hours

T = Time from beginning of storm – hours

F_m = Minimum value on loss curve inches/hour (occurs at end of storm where D=T)

In the early and late stages of a design storm the adjusted loss rate (constant or variable) will generally exceed the rainfall intensity on a unit time basis, indicating a zero runoff condition which is considered unrealistic. To account for runoff occurring during such periods, a low loss rate is used. The low loss rate is usually taken to be 80 to 90-percent of the rainfall for any unit time period where loss would otherwise exceed rainfall. This is equivalent to an effective rain of from 10 to 20-percent of the storm rainfall for a particular time period.

Flood Hydrograph Computations - In developing a flood hydrograph for an area the following procedure is used:

1. The average point storm rainfall for the area is determined, and adjusted for areal effect.
2. The time distribution of rainfall is determined on a unit time basis using the appropriate pattern percentages times the adjusted point rainfall. The unit period rainfall values are then converted to rainfall rates in inches per hour.
3. The effective rainfall rate is computed by subtracting the selected loss rate for each unit period from the rainfall rate for that period.
4. The flood hydrograph is computed as follows:
    - (a) Multiply the effective rainfall rate for the first unit time period times each synthetic unit hydrograph value to determine the flood hydrograph which would result from that rainfall increment.
    - (b) Repeat the above process for each succeeding effective rainfall rate, advancing the resultant flood hydrographs one unit time period for each cycle.
    - (c) Sum the flow ordinates found in the steps above to determine the average flow ordinates per unit time period for the design storm flood hydrograph.

Base Flow - Base flow is a minor factor in developing flood hydrographs for relatively rare flood events in western Riverside County. For this reason base flow can generally be neglected. If desired, base flow can be considered by simply adding the selected base flow discharge to the flow ordinates of a computed flood hydrograph.

Combining and Routing of Flood Hydrographs - In some cases considerable flood flow storage occurs in flood plains or in natural ponding areas. In other cases it may be desired to evaluate

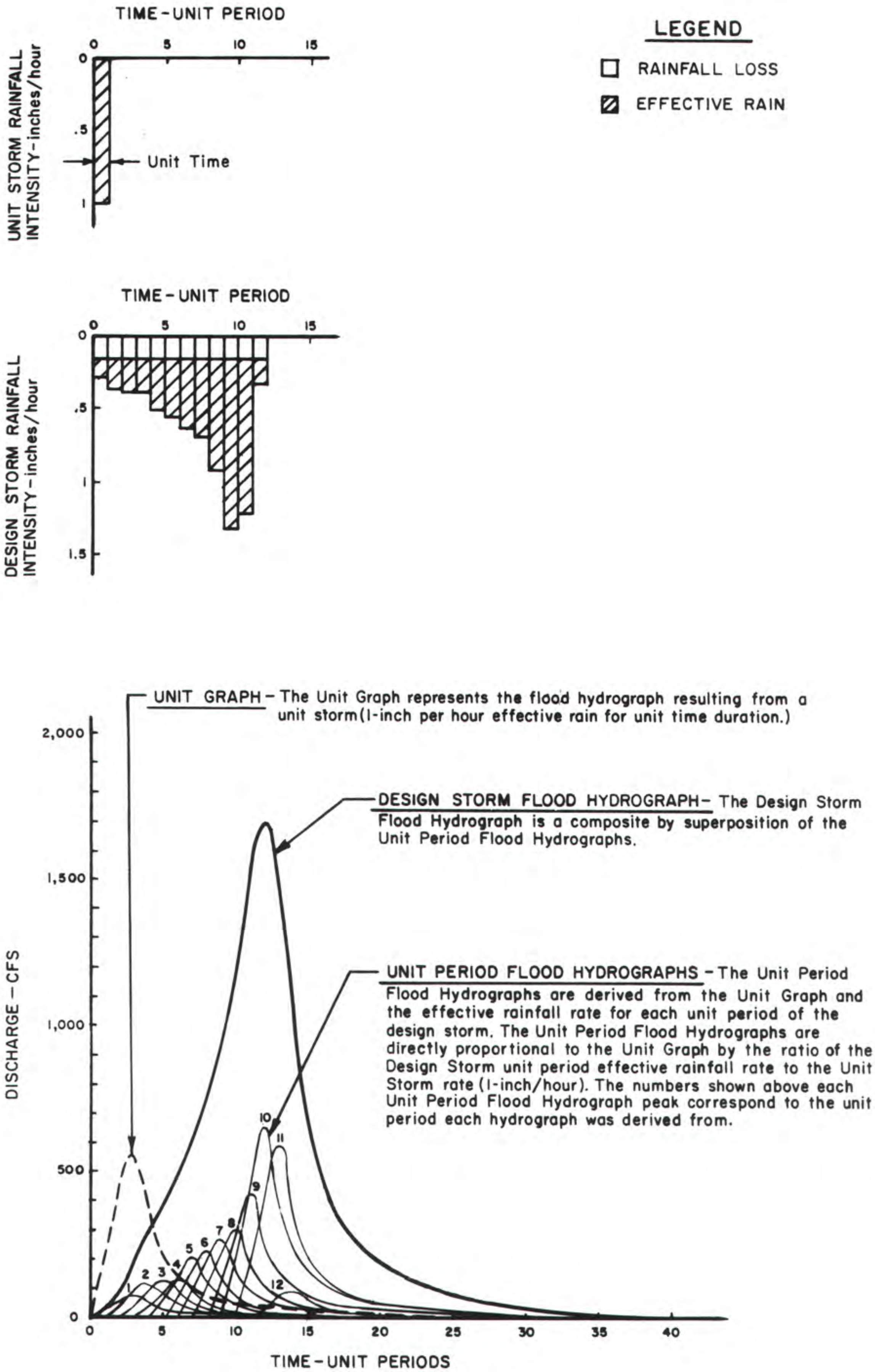

FIGURE E-2. Derivation of a Flood Hydrograph

the effects of a flood control reservoir on downstream flow rates. In such situations it is desirable to compute flood hydrographs for sub-areas in the watershed, and then determine main stream hydrographs by combining and routing the sub-area hydrographs.

For channel routing situations the District has made use of the Successive Average-Lag and Muskingum methods. For reservoir routing situations the District uses the Modified Puls method. A description of these methods is beyond the scope of this manual, however, they are discussed in detail in numerous texts. Specific sources of information on these methods include Bibliography items 4, 9 and 34.

<u>Spillway Flood Hydrographs</u> - Flood hydrographs for spillway design can be computed using the methods described in this section. Criteria, point rainfall and loss rates for spillway floods are discussed in Sections A, B and C respectively of this manual.

<u>Short Cut Synthetic Hydrograph Method</u> - In cases where retention basins are being evaluated it may be necessary to develop a flood hydrograph for an extremely small drainage area. For areas of less than 100 to 200-acres, and lag times less than 7 or 8 minutes, a Short Cut Synthetic Hydrograph method may be useful. The method is based on the assumption that in a small watershed, which has a high percentage of impervious area, response time to effective rainfall is very short. Therefore runoff rates for a given period of time can be assumed to be directly proportional to effective rain. It should be emphasized that this method yields only approximate results (on the conservative side), and should only be used for watersheds which meet the limitations noted above. Also, hydrographs developed using the short cut method should never be combined with hydrographs developed using the conventional procedure.

The following procedure is followed in developing a Short Cut Synthetic Hydrograph:

1. Effective rainfall rates are computed as if a flood hydrograph was being developed by the regular Synthetic Unit Hydrograph method. The unit time used should be from 100 to 200-percent of lag time. Unit times of 5 to 10-minutes for 3 and 6-hour storms, and 15-minutes for 24-hour storms, are normally adequate.
2. Flood hydrograph ordinates (cfs) are computed by multiplying the effective rainfall rate for each unit time period times the drainage area in acres.
3. Three hour storm peak discharges developed using the Short Cut Synthetic Hydrograph method should normally compare well with Rational peaks. If adjustments are necessary, use a shorter unit time period to raise the Short Cut Synthetic Hydrograph peaks, and a longer unit time to lower them.

Computer Programs - The District has developed computer programs for computation of flood hydrographs by the Synthetic Unit Hydrograph method, and for the routing of hydrographs through streams, channels and reservoirs. Application of these programs is described in the appropriate District computer user's manuals. District programs are not available for public use.

INSTRUCTIONS FOR SYNTHETIC UNIT HYDROGRAPH METHOD HYDROLOGY CALCULATIONS

A. Synthetic Unit Hydrograph Development

1. On a USGS topographic quandrangle sheet or other map of suitable scale, outline the proposed drainage system and outline the area or subareas tributary to it.

2. From the map of the drainage system, determine the following basin physical factors and enter them on Sheet 1 of Plate E-2.1.

   A = Drainage area - square miles

   L = Length of longest watercourse - miles

   L_{ca} = Length along the longest watercourse, measured upstream to a point opposite the centroid of the area - miles

   H = Difference in elevation between the concentration point and the most remote point of the basin-feet

   S = Overall slope of longest watercourse between headwaters and concentration point - feet per mile ($S = H/L$)

3. Determine lag time using Plate E-3 or the following expression (See Sheet 1 of Plate E-2.1):

$$\text{Lag (hours)} = 24\bar{n}\left[\frac{L.Lca}{S^{\frac{1}{2}}}\right]^{(.38)}$$

   where:

   $\bar{n}$ = The visually estimated mean of the n (Mannings formula) values of all collection streams and channels within the watershed.

4. Select a unit time period. To adequately define the unit hydrograph the unit time period should be about 25-percent of lag time, and never more than 40-percent of lag time. For ease of calculation, the unit time should match the times for which precipitation patterns are available (Plate E-5.9). Also see Sheet 1 of Plate E-2.1.

5. Utilizing the S-graph applicable to the drainage basin (Plates E-4.1 through E-4.4), determine the average percentage of the ultimate discharge for each unit period. In reading the percentage of discharge from the S-graph, the average ordinate over the time

5. (continued)

increment should be determined rather than the mean of the ordinates at the beginning and end of the time increment. See Columns 16 and 17 of Plate E-2.2.

6. Compute the unit distribution graph by subtracting from the percentage of ultimate discharge for each unit time period, the percentage of ultimate discharge for the previous time period. See Column 18 of Plate E-2.2.

7. Compute the ordinates of the synthetic unit hydrograph (unit graph) by multiplying the distribution graph values by the ultimate discharge K, using:

$$K \text{ (cfs-hours/inch)} = 645A$$

where:

A = Drainage area - square miles

See Column 19 of Plate E-2.2.

B. <u>Flood Hydrograph Development</u>

1. Determine the average point rainfall over the area for the storm duration and frequency desired using Plates E-5.1 through E-5.7. Adjust the average point rainfall for areal effect using Plate E-5.8. See Sheet 1 of Plate E-2.1.

2. Determine the unit period rainfall amounts using the pattern percentages from Plate E-5.9 times the adjusted average point rainfall, and convert them to rainfall rates in inches per hour. See Columns 20 and 21 of Plate E-2.2.

3. Find the pervious area loss rates for subareas within the drainage area using Plates E-6.1 and E-6.2. Adjust these rates to account for impervious area using the relationship below, and then compute a weighted average loss rate for the watershed. See Sheet 2 of Plate E-2.1.

$$F = F_p\,(1.00 - 0.9A_i)$$

where:

F = Adjusted loss rate - inches/hour

F_p = Loss rate for pervious areas - inches/hour (Plate E-6.2)

A_i = Impervious area (actual) - decimal percent (Plate E-6.3)

4. For 3 and 6-hour duration storms assume the weighted average loss rate is a constant defining the maximum loss rate for each unit time period. For 24-hour storms use the variable loss rate function below to compute the maximum loss rate for each unit time period:

$$F_T \text{ (inches/hour)} = C\,(24-(T/60))^{1.55} + F_m$$

where:

$C = (F - F_m)/54$

F = Adjusted loss rate - inches/hour (as previously defined)

T = Time from beginning of storm - minutes

F_m = Minimum value on loss rate curve - inches/hour (typically 50 to 75-percent of F)

The time "T" used should be from the start of the storm to the middle of each unit time period, i.e., for a unit time of 30-minutes the maximum loss rate would be computed for T=15-minutes for period one, T=45-minutes for period two, etc. Enter the maximum loss rates (constant or variable) on Column 22 of Plate E-2.2.

5. Compute the low loss rate for each unit time period where the maximum loss rate exceeds the rainfall rate for that period. The low loss rate should normally be 80 to 90-percent times the rainfall rate. See Column 22 of Plate E-2.2.

6. Compute the effective rainfall rate for each unit time period by subtracting the loss rate from the rainfall rate. See Column 23 of Plate E-2.2. Be sure to use the low loss rate where the maximum loss rate exceeds unit period intensity.

7. Compute the flood hydrograph using one of the following two methods. Do not use the simplified method until the long form method is thoroughly understood:

   (a) Long form method (use Plate E-2.3):

      (1) Multiply the effective rainfall rate for the first unit time period times each synthetic unit hydrograph value to determine the flood hydrograph which would result from that rainfall increment.

      (2) Repeat the above process for each suceeding effective rainfall value, advancing the resultant flood hydrographs one unit time period for each cycle.

7. (continued)

(3) Sum the flow ordinates found in the steps above to determine the average flow ordinate per unit time period for the design storm flood hydrograph.

(b) Simplified Method:

(1) List the unit graph values (Column 19, Plate E-2.2) in reverse order on the right hand side of a separate sheet of paper.

(2) Align the separate sheet with the effective rain column (Column 23 of Plate E-2.2) so that the bottom unit graph value is adjacent to the top effective rain value. The product of these values is the flood hydrograph value in cfs for the first unit period (Column 24 of Plate E-2.2).

(3) Move the separate sheet down one unit time period. The sum of the products of the first two effective rain values, times the adjacent unit graph values, is the flood hydrograph value for the second unit time period.

(4) Move the separate sheet down one unit time period to compute each successive flood hydrograph value. The flood hydrograph value in each case is the sum of the products of each effective rain value times the adjacent unit graph value. The procedure is illustrated by the example on the next page. Continue this process until the hydrograph is completely defined (the top unit graph value will be opposite the bottom effective rain value).

The flood hydrograph value computed for any positioning of the separate sheet is always entered opposite the unit graph value at the bottom of the separate sheet.

It is possible to determine the peak discharge without defining the entire hydrograph by aligning the maximum unit graph values just above the maximum effective rain values, and then computing enough flood hydrograph values to identify the peak discharge.

8. If desired add base flow to the flood hydrograph ordinates determined in Step 7.

EXAMPLE OF SIMPLIFIED METHOD
OF FLOOD HYDROGRAPH COMPUTATION

Separate Sheet — Unit Graph Values Listed in Reverse Order

9
7
9
7
7
7
17
14
17
21
24
26
31
38
45
50
64
85
109
158
257
479
515
288
78

Plate E-2.2

[23] Effective Rain In/Hr [21]−[22]	Flood Hydrograph [24] Flow cfs
.13	10
.21	54
.23	145
.22	254
.35	343
.40	430
.48	545
.53	680
.77	827
1.17	1037
1.06	1344
.17	1615
	1579
	1188
	758
	513
	382
	300
	241
	202
	172
	145
	124
	107
	94
	80
	67
	58
	48
	36
	32
	30
	27
	20
	11
	2

The position of the unit graph values on the separate sheet in this example gives the value of 1188 cfs in column [24]. To get all of the values for the flood hydrograph the separate sheet must moved from the top to the bottom of column [23]. Start with 78 adjacent to .13 and finish with 9 adjacent to .17. The flood hydrograph ordinate for any position of the separate sheet is the <u>sum</u> of the <u>products</u> of all adjacent unit graph and effective rain values. The computed flow value is entered opposite the bottom unit graph value (78 in this case) for any position of the separate sheet.

9. The hydrograph may be plotted by drawing a smooth curve through flow ordinates (at the center of each unit time period) so that the average flow value under the curve matches the average ordinate for each unit time period (see example calculations).

10. Additional steps may be necessary for complicated drainage systems as conditions dictate, including combining subarea hydrographs, and channel and reservoir routing.

INSTRUCTIONS FOR SHORT CUT SYNTHETIC HYDROGRAPH HYDROLOGY CALCULATIONS

1. Determine drainage area and lag time. Use Steps A-1 through A-3 on Plate E-1.1.

2. Determine that the area is suitable for development of a Short Cut hydrograph, i.e., the area is no more than 100 to 200-acres in size, and lag time is less than 7 to 8-minutes.

3. Select a suitable unit time equal to from 100 to 200-percent of lag. Normally, 5 to 10-minutes for 3 and 6-hour storms, and 15-minutes for 24-hour storms will be adequate.

4. Compute effective rainfall rates using steps B-1 through B-6 on Plate E-1.1.

5. Compute flood hydrograph ordinates for each unit time period by multiplying the effective rainfall rate (inches per hour) times the drainage area in acres. The resultant values are discharge in cfs.

6. The three hour storm peak discharge should normally compare well with rational peaks. If adjustments are necessary, use a shorter unit time period to raise the peak, and a longer unit time period to lower them.

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Basic Data Calculation Form	Project By ______ Date ______ Checked ______ Date ______	Sheet

PHYSICAL DATA

[1] CONCENTRATION POINT	
[2] AREA DESIGNATION	
[3] AREA-SQ INCHES	
[4] AREA ADJUSTMENT FACTOR	
[5] AREA-SQ MILES ([3]*[4])	
[6] L-INCHES	
[7] L ADJUSTMENT FACTOR	
[8] L-MILES ([6]*[7])	
[9] LCA-INCHES	
[10] LCA-MILES ([7]*[9])	
[11] ELEVATION OF HEADWATER	
[12] ELEVATION OF CONCENTRATION POINT	
[13] H-FEET ([11]-[12])	
[14] S-FEET/MILE ([13]/[8])	
[15] S**.5	
[16] L*LCA/S**.5 ([8]*[10]/[15])	
[17] AVERAGE MANNINGS "N"	
[18] LAG TIME-HOURS (24*[17]*[16]**.38) (PLATE E-3)	
[19] LAG TIME-MINUTES (60*[18])	
[20] 25% OF LAG-MINUTES (.25*[19])	
[21] 40% OF LAG MINUTES (.40*[19])	
[22] UNIT TIME-MINUTES (25-40% OF LAG)	

RAINFALL DATA

[1] SOURCE	
[2] FREQUENCY-YEARS	
[3] DURATION:	

3-HOURS				6-HOURS				24-HOURS			
[4] POINT RAIN INCHES	[5] AREA SQ IN	[6] [5] / Σ[5]	[7] AVERAGE POINT RAIN INCHES	[8] POINT RAIN INCHES	[9] AREA SQ IN	[10] [9] / Σ[9]	[11] AVERAGE POINT RAIN INCHES	[12] POINT RAIN INCHES	[13] AREA SQ IN	[14] [13] / Σ[13]	[15] AVERAGE POINT RAIN INCHES
Σ[5]-		Σ[7]-		Σ[9]-		Σ[11]-		Σ[13]-		Σ[15]-	
[16] AREAL ADJ FACTOR				(SEE PLATE E-5.8)							
[17] ADJ AVG POINT RAIN				([16]*Σ[7], ETC)							

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HYDROLOGY
MANUAL

SYNTHETIC UNIT HYDROGRAPH METHOD

Basic Data Calculation Form

Project ______________________ Sheet

By ______________ Date ______

Checked ______________ Date ______

LOSS RATE DATA

AVERAGE ADJUSTED LOSS RATE

[1] SOIL GROUP (PLATE C-1)	[2] COVER TYPE	[3] RI NUMBER (PLATE E-6.1)	[4] PERVIOUS AREA INFILTRATION RATE-IN/HR (PLATE E-6.2)	[5] LAND USE	[6] DECIMAL PERCENT OF AREA IMPERVIOUS (PLATE E-6.3)	[7] ADJUSTED INFILTRATION RATE-IN/HR [4](1-.9[6])	[8] AREA SQ INCHES	[9] $\frac{[8]}{\Sigma[8]}$	[10] AVERAGE ADJUSTED INFILTRATION RATE-IN/HR [7]•[9]
							Σ[8]- ______		Σ[10]- ______

VARIABLE LOSS RATE CURVE (24-HOUR STORM ONLY)

F_m = Minimum Loss Rate $\cong F/2 = \Sigma[10]/2 =$ __________ IN./HR.

$C = (F-F_m)/54 = (\Sigma[10] - F_m)/54 =$ __________

$F_T = C(24-(T/60))^{1.55} + F_m =$ __________ $(24-(T/60))^{1.55} +$ __________ IN./HR.

Where:

T = Time in minutes. To get an average value for each unit time period, Use $T=\frac{1}{2}$ the unit time for the first time period, $T=1\frac{1}{2}$ unit time for the second period, etc.

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project ______ By ______ Date ______ Checked ______ Date ______	Sheet

[1] CONCENTRATION POINT	[2] AREA DESIGNATION
[3] DRAINAGE AREA-SQ MILES	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3])
[5] UNIT TIME-MINUTES	[6] LAG TIME-MINUTES
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6])	[8] S-CURVE
[9] STORM FREQUENCY & DURATION YEAR- HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR
[13] CONSTANT LOSS RATE-INCHES/HOUR	[14] LOW LOSS RATE-PERCENT

	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15] UNIT TIME PERIOD m	[16] TIME PERCENT OF LAG [7]*[15]	[17] CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	[18] DISTRIB GRAPH PERCENT $[17]_m - [17]_{m-1}$	[19] UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	[20] PATTERN PERCENT (PL E-5.9)	[21] STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$	[22] LOSS RATE IN/HR MAX	LOW	[23] EFFECTIVE RAIN IN/HR [21]-[22]	[24] FLOW CFS

SYNTHETIC UNIT HYDROGRAPH METHOD

Flood Hydrograph Calculation Form

Project ______________________

By ______________ Date ______

Checked ______________ Date ______

Sheet

EFFEC RAIN		FLOOD HYDRO-GRAPH
UNIT GRAPH	UNIT PER.	

TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

L_{ca} = LENGTH ALONG LONGEST WATERCOURSE, MEASURED UPSTREAM TO POINT OPPOSITE CENTER OF AREA.

S = OVER-ALL SLOPE OF LONGEST WATERCOURSE BETWEEN HEADWATER AND COLLECTION POINT.

LAG = ELAPSED TIME FROM BEGINNING OF UNIT PRECIPITATION TO INSTANT THAT SUMMATION HYDROGRAPH REACHES 50% OF ULTIMATE DISCHARGE.

$\bar{n}$ = VISUALLY ESTIMATED MEAN OF THE n (MANNING'S FORMULA) VALUES OF ALL THE CHANNELS WITHIN AN AREA.

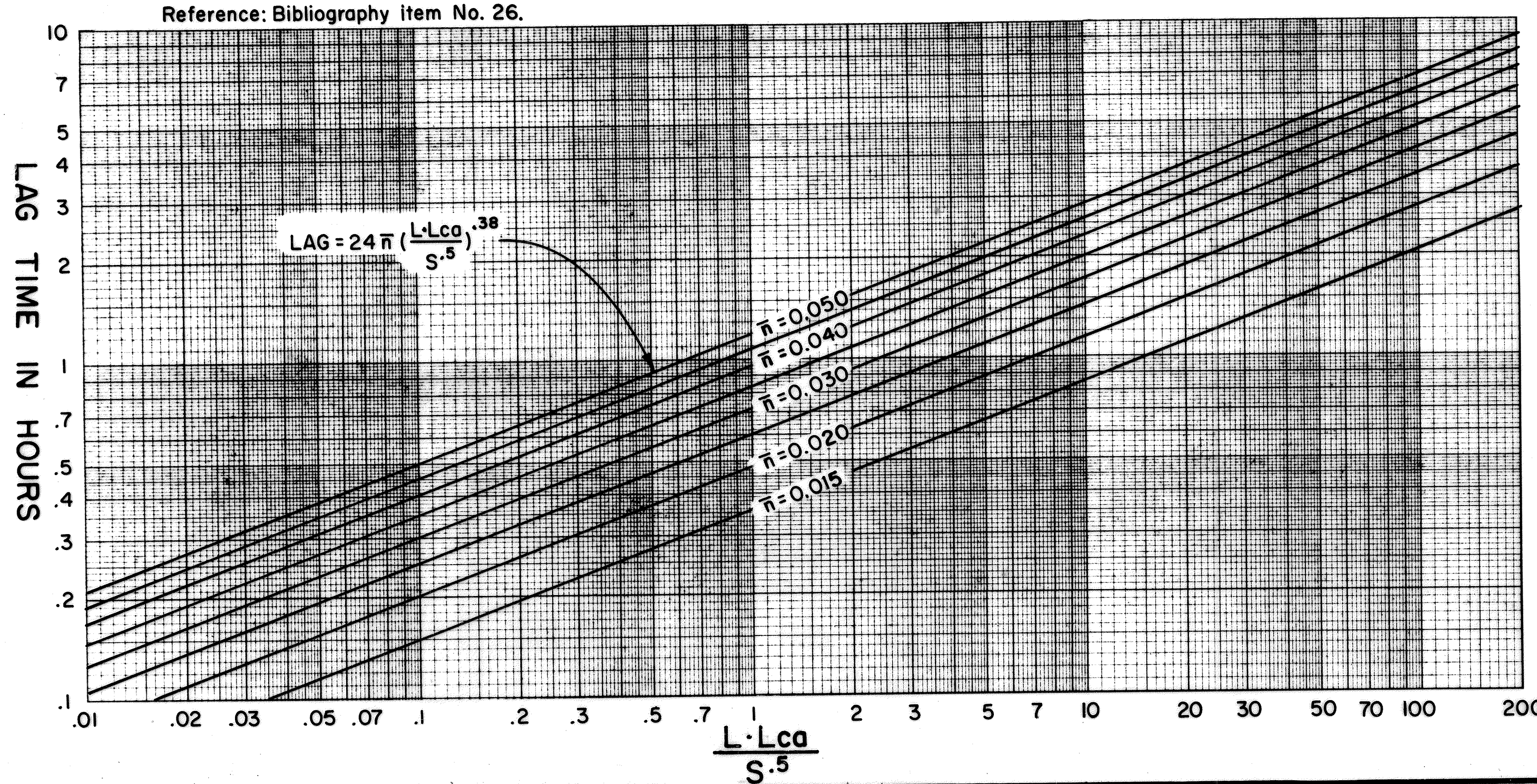
GUIDE FOR ESTIMATING BASIN FACTOR ($\bar{n}$)

$\bar{n}$=0.050: DRAINAGE AREA IS QUITE RUGGED, WITH SHARP RIDGES AND NARROW, STEEP CANYONS THROUGH WHICH WATERCOURSES MEANDER AROUND SHARP BENDS, OVER LARGE BOULDERS, AND CONSIDERABLE DEBRIS OBSTRUCTION. THE GROUND COVER, EXCLUDING SMALL AREAS OF ROCK OUTCROPS, INCLUDES MANY TREES AND CONSIDERABLE UNDERBRUSH. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

$\bar{n}$=0.030: DRAINAGE AREA IS GENERALLY ROLLING, WITH ROUNDED RIDGES AND MODERATE SIDE SLOPES. WATERCOURSES MEANDER IN FAIRLY STRAIGHT, UNIMPROVED CHANNELS WITH SOME BOULDERS AND LODGED DEBRIS. GROUND COVER INCLUDES SCATTERED BRUSH AND GRASSES. NO DRAINAGE IMPROVEMENTS EXIST IN THE AREA.

$\bar{n}$=0.015: DRAINAGE AREA HAS FAIRLY UNIFORM, GENTLE SLOPES WITH MOST WATERCOURSES EITHER IMPROVED OR ALONG PAVED STREETS. GROUND COVER CONSISTS OF SOME GRASSES WITH APPRECIABLE AREAS DEVELOPED TO THE EXTENT THAT A LARGE PERCENTAGE OF THE AREA IS IMPERVIOUS.

Reference: Bibliography item No. 26.



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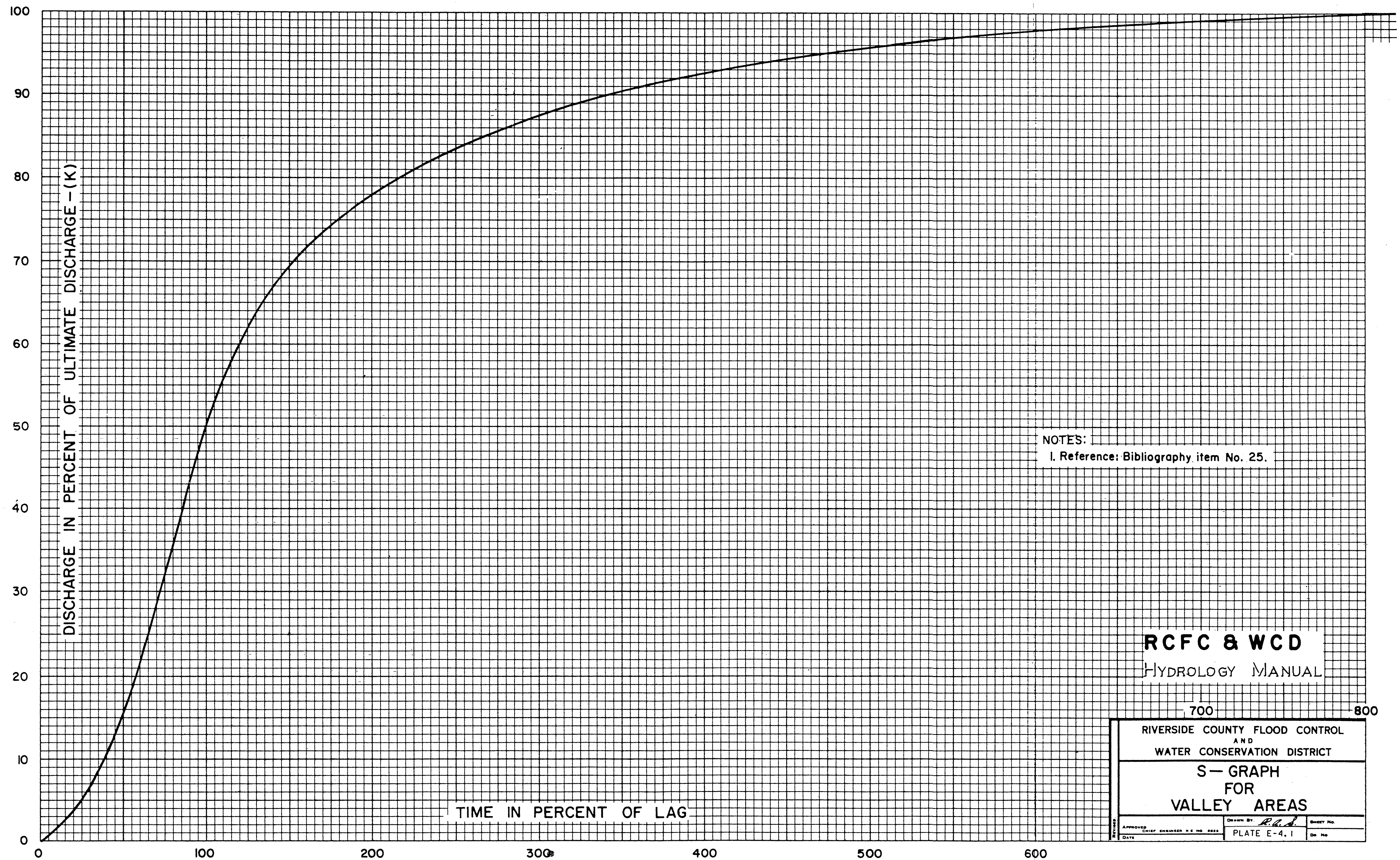
LAG RELATIONSHIPS FOR SOUTHERN CALIFORNIA


DISCHARGE IN PERCENT OF ULTIMATE DISCHARGE - (K)
100
90
80
70
60
50
40
30
20
10
0
TIME IN PERCENT OF LAG
0
100
200
300
400
500
600
700
800
NOTES:
I. Reference: Bibliography item No. 25.
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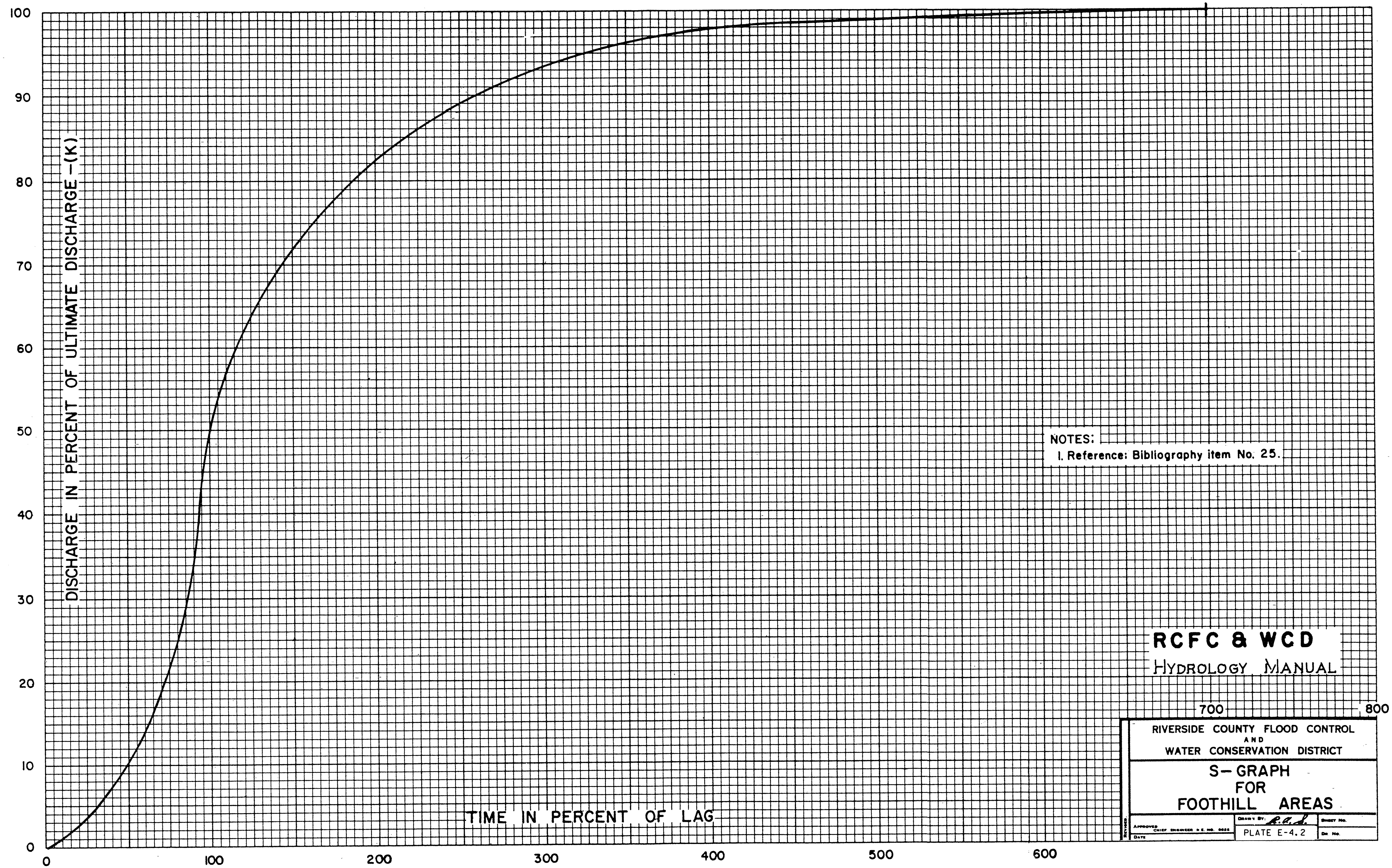
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
S— GRAPH
FOR
VALLEY AREAS
PLATE E-4.1



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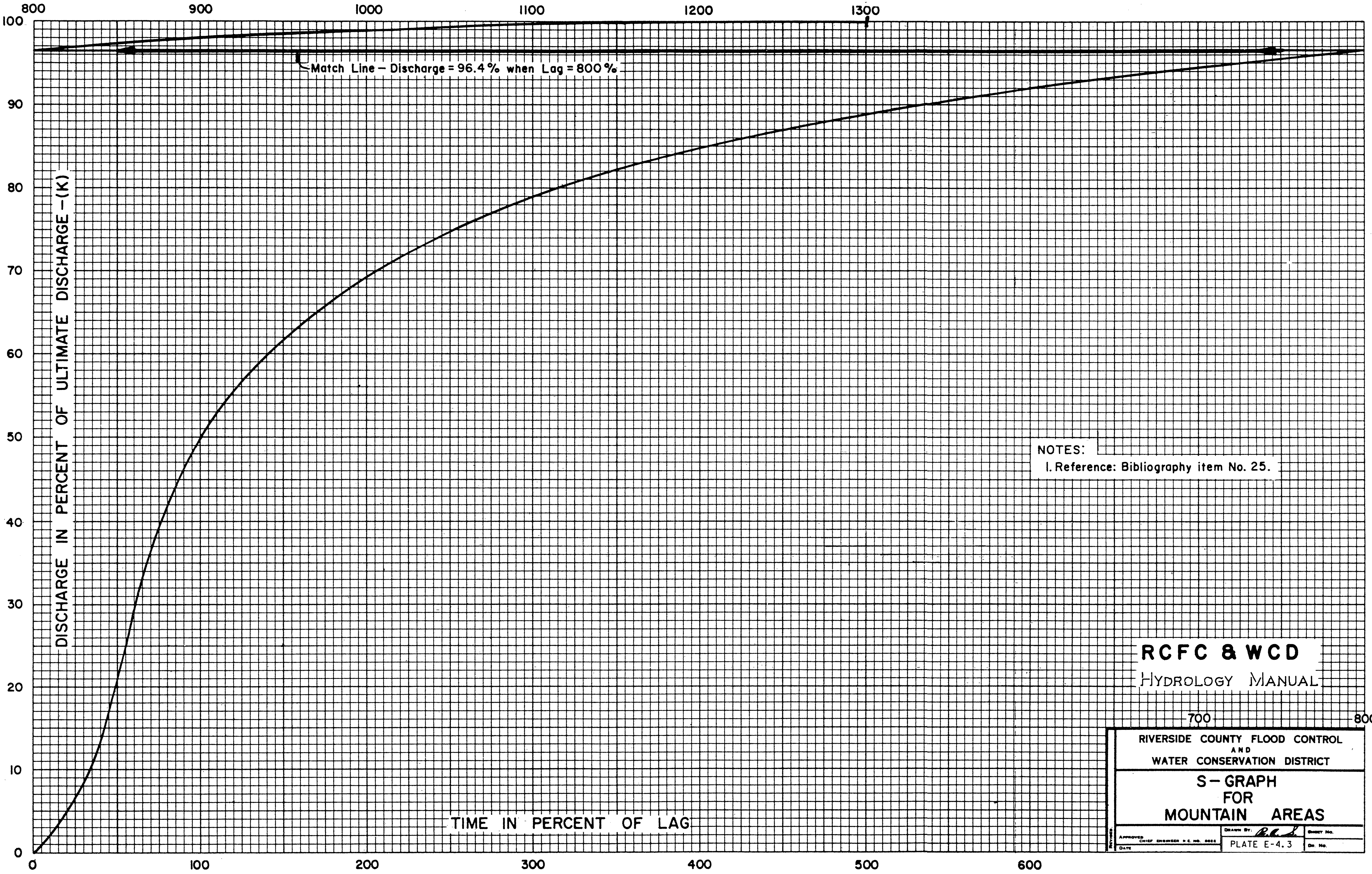
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

S- GRAPH FOR FOOTHILL AREAS

PLATE E-4.2



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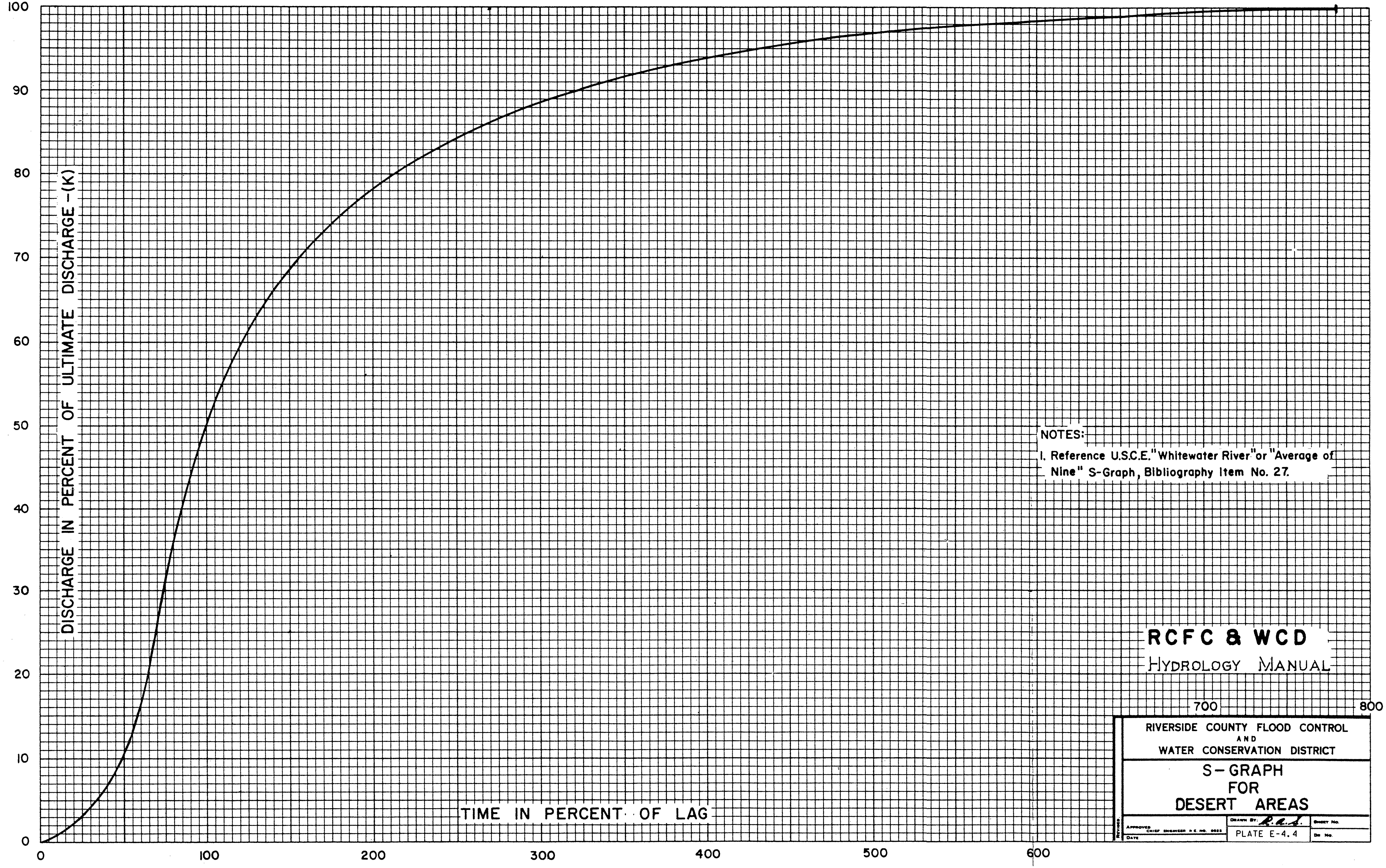
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

S — GRAPH
FOR
MOUNTAIN AREAS

PLATE E-4.3


DISCHARGE IN PERCENT OF ULTIMATE DISCHARGE -(K)
0
10
20
30
40
50
60
70
80
90
100
TIME IN PERCENT OF LAG
0
100
200
300
400
500
600
700
800
NOTES:
1. Reference U.S.C.E."Whitewater River"or"Average of Nine" S-Graph, Bibliography Item No. 27.
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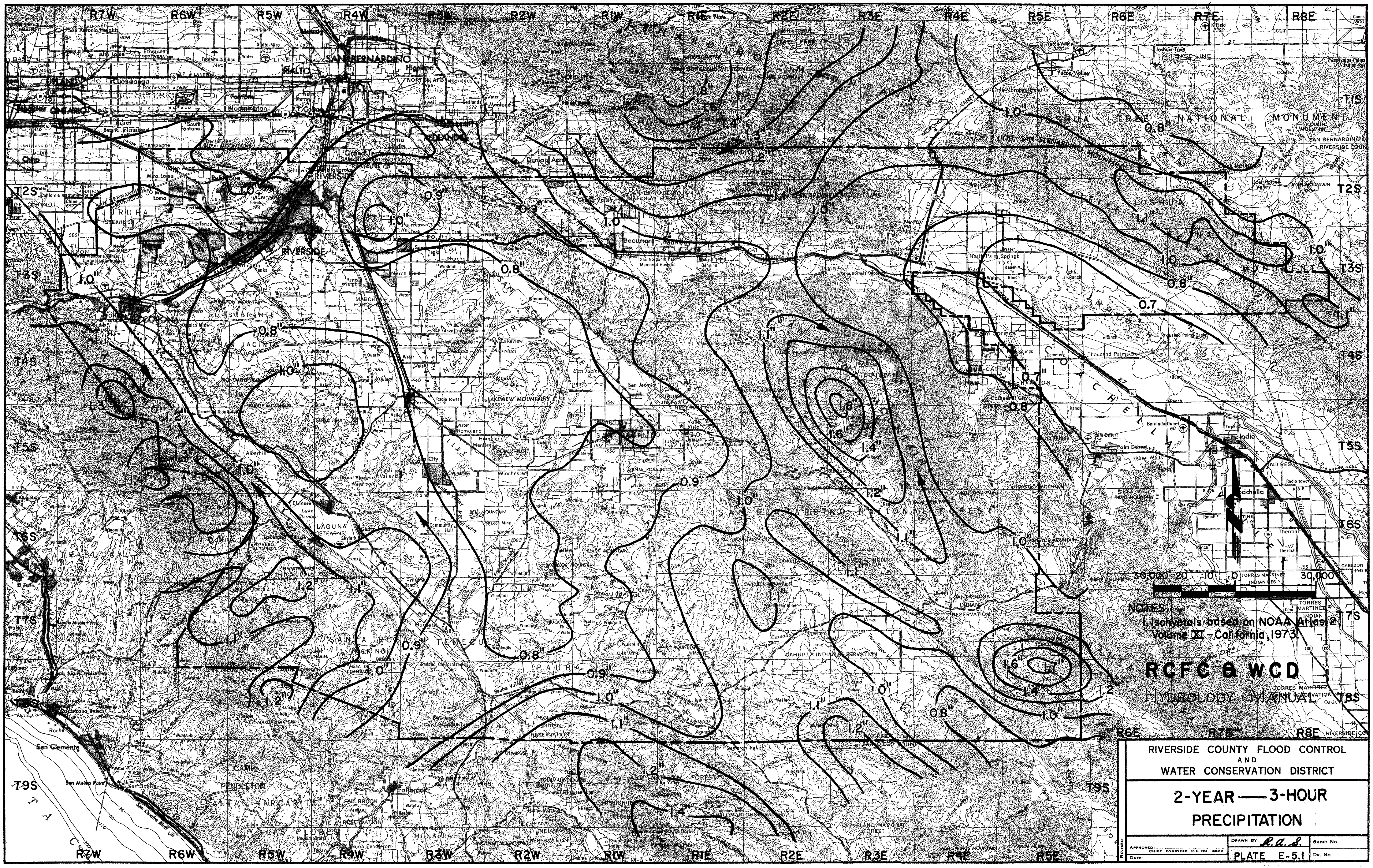
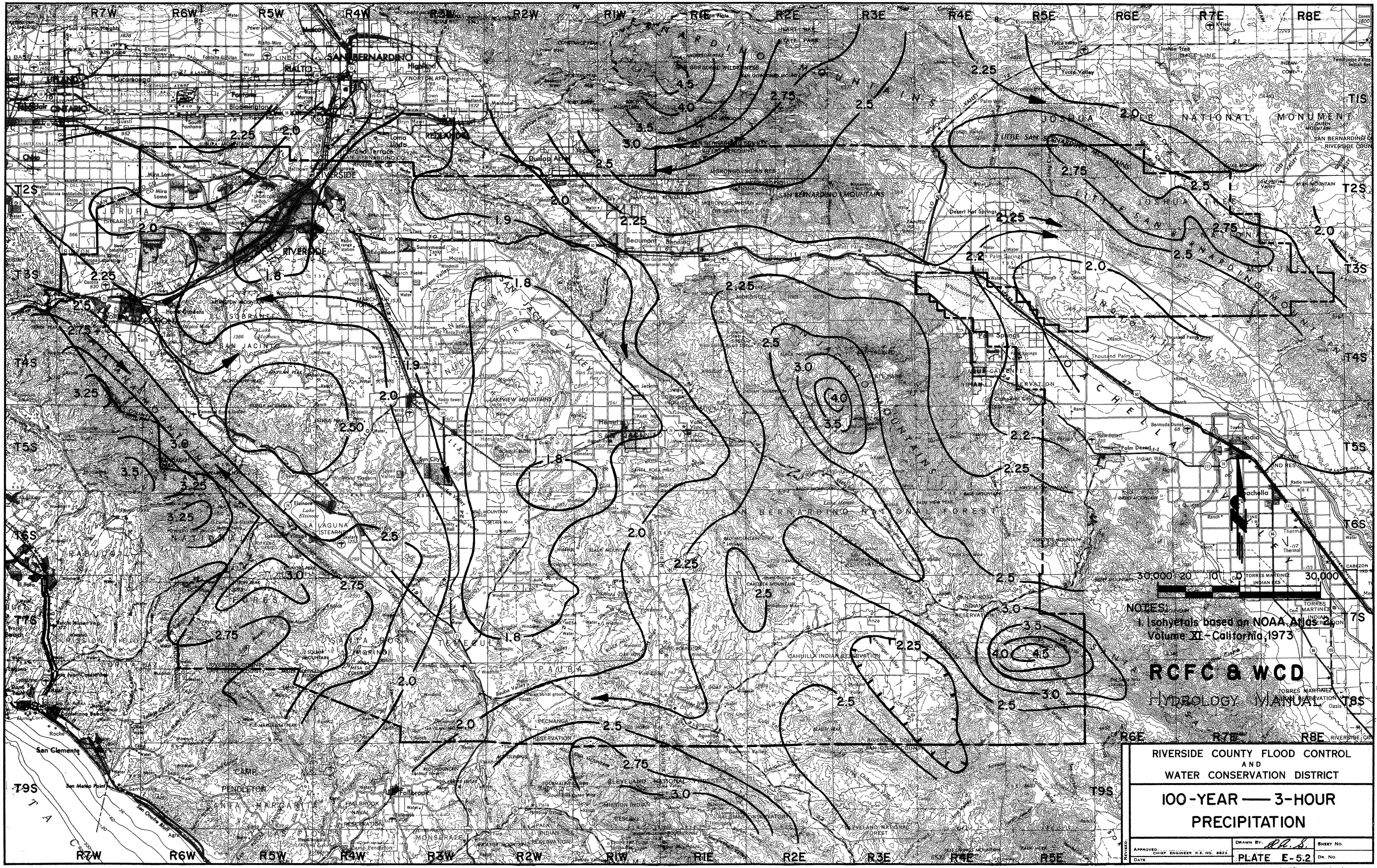
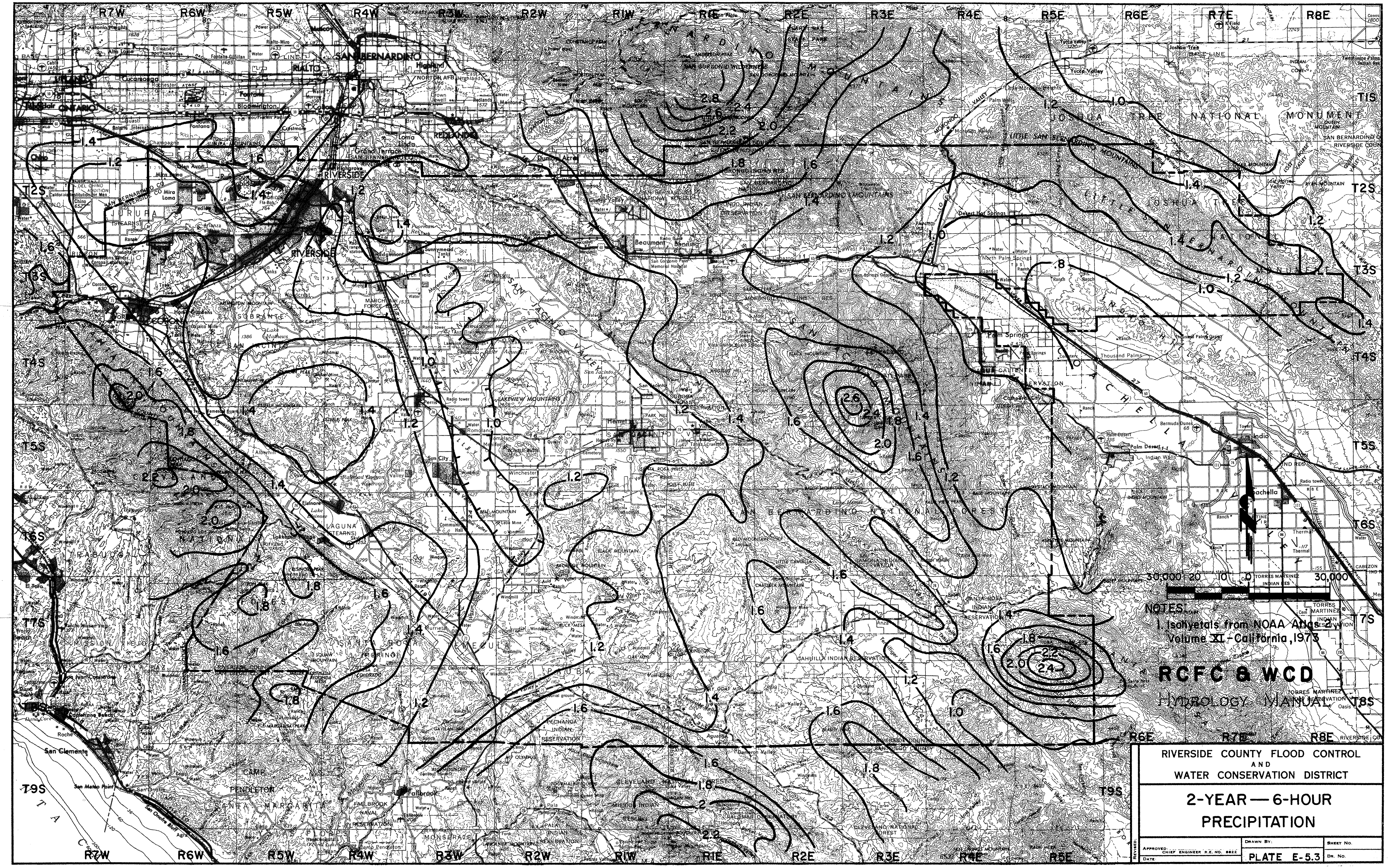
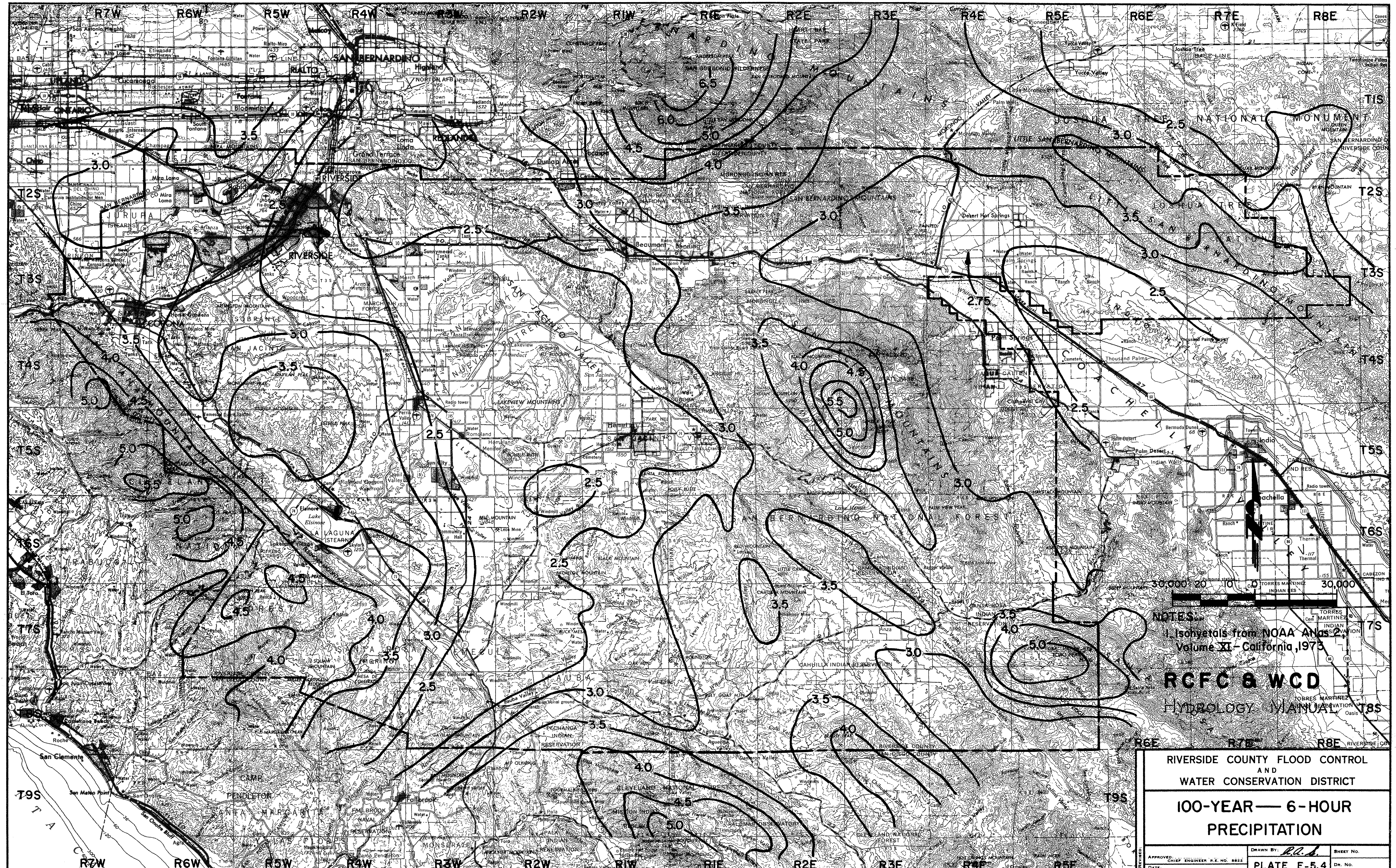
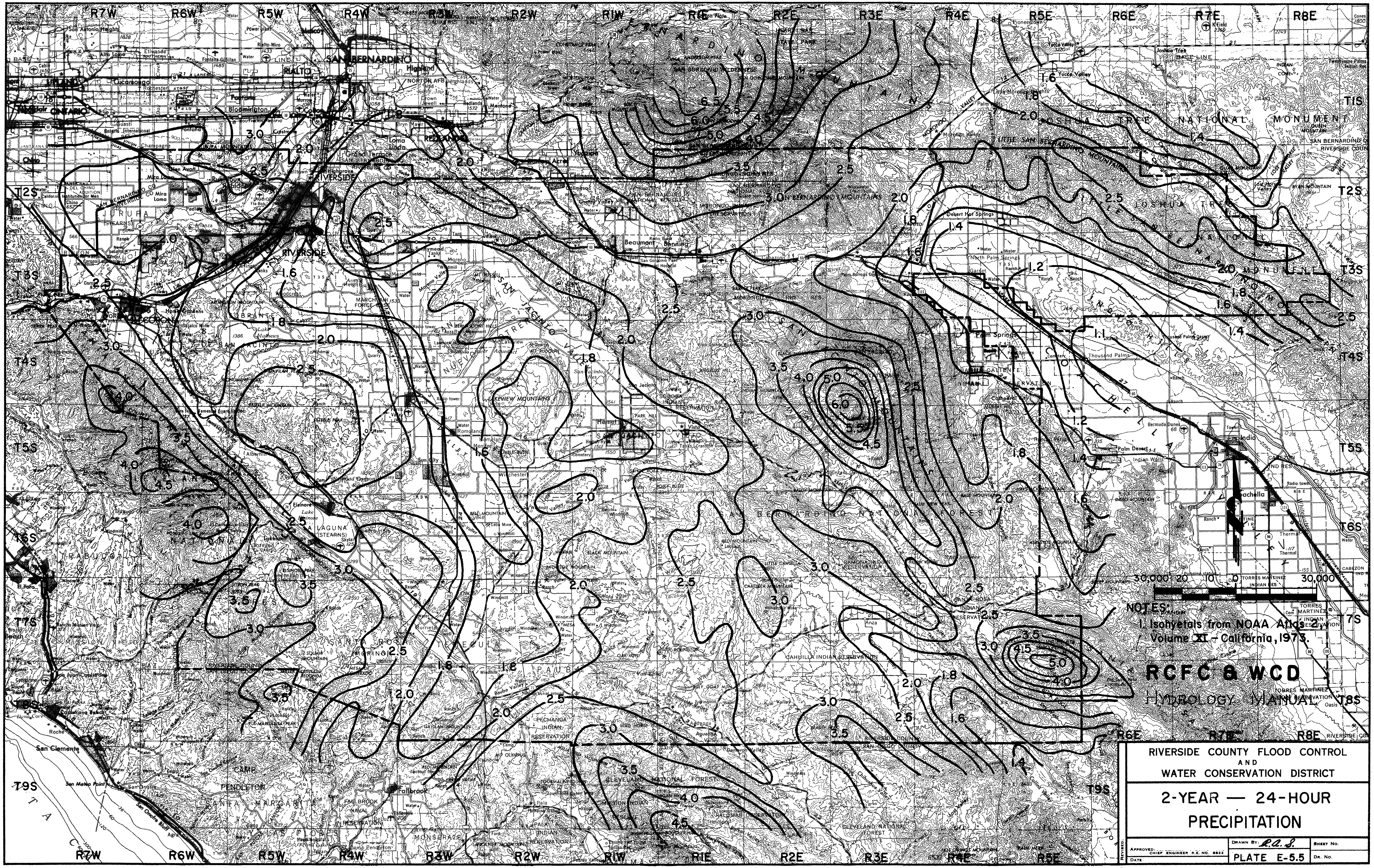
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
S-GRAPH FOR DESERT AREAS
PLATE E-4.4

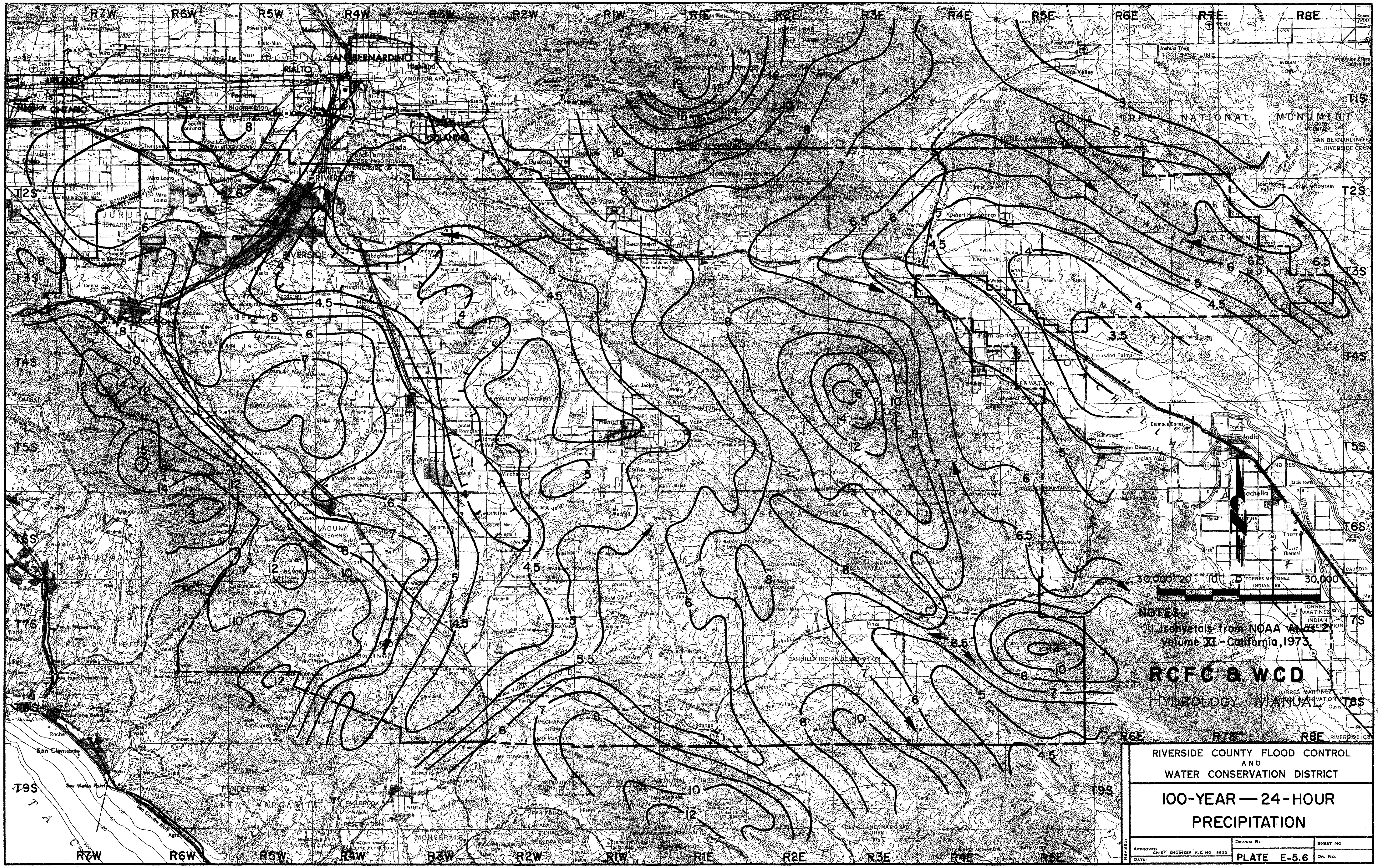

RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
2-YEAR — 3-HOUR
PRECIPITATION
RCFC & WCD
HYDROLOGY MANUAL
NOTES:
1. Isohyetals based on NOAA Atlas 2, Volume XI - California, 1973.
PLATE E-5.1
APPROVED
CHIEF ENGINEER R.E. NO.
DRAWN BY
SHEET NO.
DR. NO.
DATE
REVISED
30,000
20
10
0
30,000
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
SAN BERNARDINO
RIVERSIDE
REDLANDS
CORONA
Beaumont
Palm Springs
Palm Desert
Indio
Coachella
Hemet
San Jacinto
Perris
Elsinore
Temecula
Fallbrook
San Clemente
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO NATIONAL FOREST
CLEVELAND NATIONAL FOREST
1.8"
1.6"
1.4"
1.3"
1.2"
1.1"
1.0"
0.9"
0.8"
0.7"
1.7"


RCFC & WCD
HYDROLOGY MANUAL
NOTES:
1. Isohyetals based on NOAA Atlas 2, Volume XI - California, 1973
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
100-YEAR — 3-HOUR PRECIPITATION
PLATE E-5.2
30,000 20 10 0 30,000
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
RIVERSIDE
SAN BERNARDINO
PALM SPRINGS
TEMECULA
HEMET


NOTES:
1. Isohyetals from NOAA Atlas Volume XI - California, 1973
RCFC & WCD
HYDROLOGY MANUAL
30,000 20 10 0 30,000
RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
2-YEAR — 6-HOUR
PRECIPITATION
APPROVED: CHIEF ENGINEER R.E. NO. 8822
DATE:
DRAWN BY:
PLATE E-5.3
SHEET NO.
DR. NO.
REVISED:
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO
RIVERSIDE
PALM SPRINGS


NOTES:
1. Isohyetals from NOAA Atlas 2, Volume XI - California, 1973
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
100-YEAR — 6-HOUR PRECIPITATION
PLATE E-5.4
30,000 20 10 0 30,000
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
R3E
R4E
R5E
R6E
R7E
R8E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
T8S
T9S
RIVERSIDE
SAN BERNARDINO
REDLANDS
BEAUMONT
BANNING
PALM SPRINGS
HEMET
ELSINORE
SAN CLEMENTE
FALLBROOK
JOSHUA TREE NATIONAL MONUMENT
SAN BERNARDINO NATIONAL FOREST
CLEVELAND NATIONAL FOREST
COACHELLA VALLEY
CAMP PENDLETON
SANTA ROSA INDIAN RESERVATION
CAHUILLA INDIAN RESERVATION
PECHANGA INDIAN RESERVATION


NOTES:
1. Isohyetals from NOAA Atlas 2, Volume XI - California, 1973.
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
2-YEAR — 24-HOUR PRECIPITATION
PLATE E-5.5



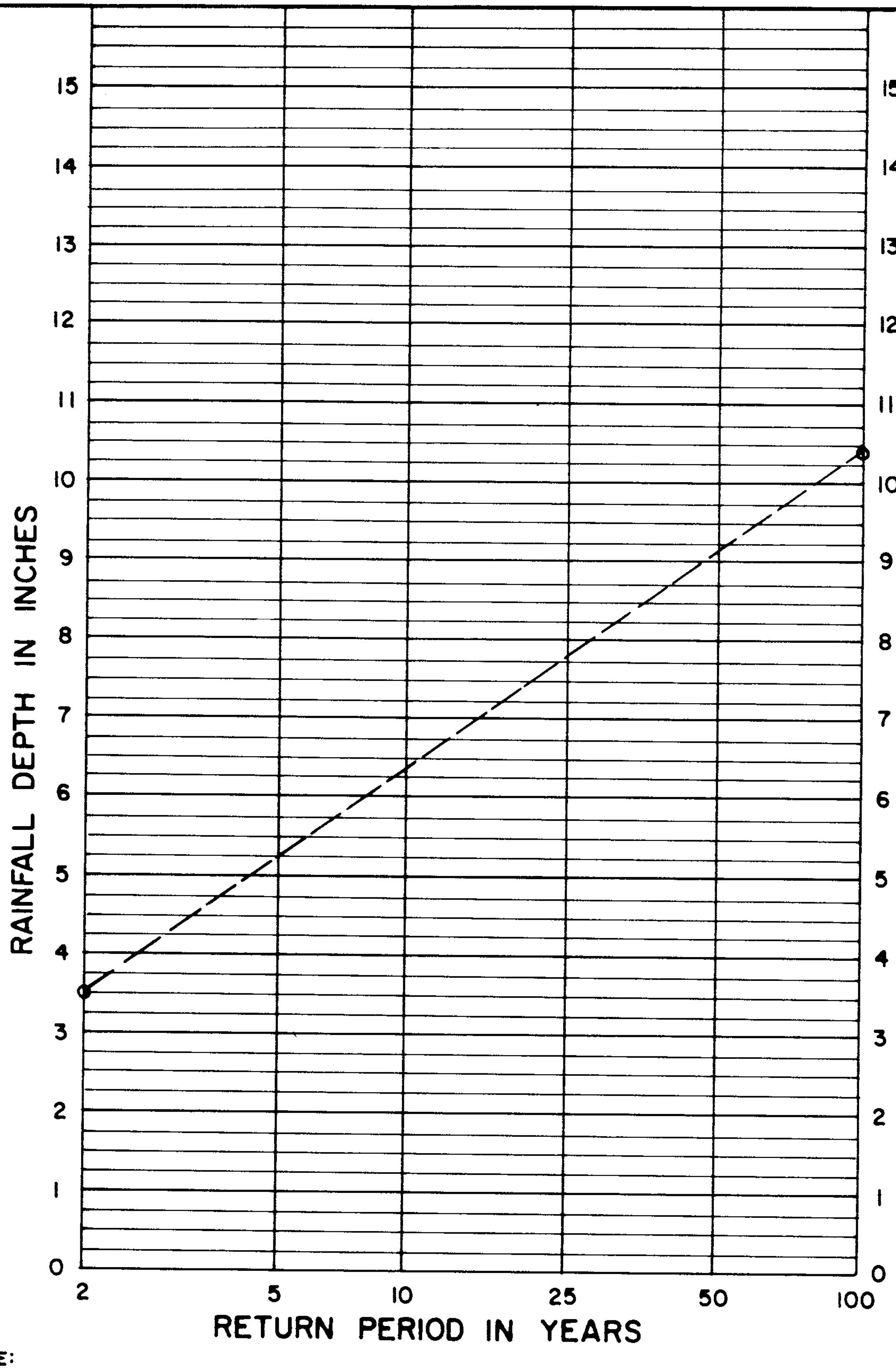
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

100-YEAR — 24-HOUR PRECIPITATION

APPROVED: CHIEF ENGINEER R.E. NO. 8822

DRAWN BY:

PLATE E-5.6



NOTE:

1. For intermediate return periods plot 2-year and 100-year values from maps for a specific duration, then connect points and read value for desired return period. For example given 2-year 24-hour = 3.50" and 100-year 24-hour = 10.40", 25-year 24-hour = 7.80"

Reference: NOAA Atlas 2, Volume XI - California, 1973.

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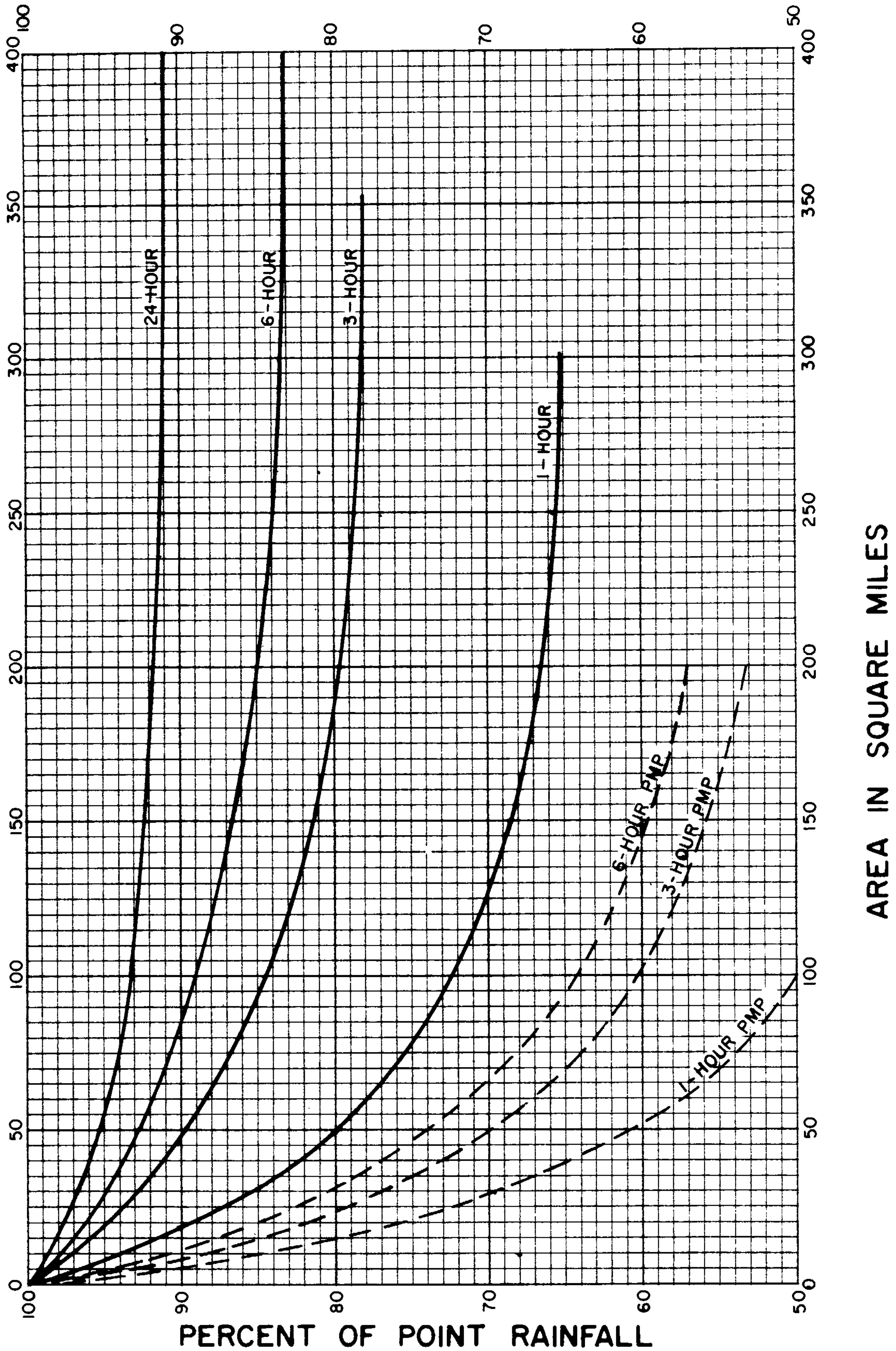
HYDROLOGY MANUAL

RAINFALL DEPTH VERSUS RETURN PERIOD FOR PARTIAL DURATION SERIES



Reference: Bibliography items No. 27 & 29.

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HYDROLOGY MANUAL

DEPTH–AREA–DURATION RELATIONSHIPS

RAINFALL PATTERNS IN PERCENT

3-HOUR STORM

TIME PERIOD	5-MIN PERIOD	10-MIN PERIOD	15-MIN PERIOD	30-MIN PERIOD
1	1.3	2.6	3.7	8.5
2	1.3	2.6	4.8	10.0
3	1.1	3.3	5.1	13.9
4	1.5	3.3	4.9	17.4
5	1.5	3.3	6.6	29.9
6	1.8	3.4	7.3	20.3
7	1.5	4.4	8.4	
8	1.8	4.2	9.0	
9	1.8	5.3	12.3	
10	1.5	5.1	17.6	
11	1.6	6.4	16.1	
12	1.8	5.9	4.2	
13	2.2	7.3		
14	2.2	8.5		
15	2.2	14.1		
16	2.0	14.1		
17	2.6	3.8		
18	2.7	2.4		
19	2.4			
20	2.7			
21	3.3			
22	3.1			
23	2.9			
24	3.0			
25	3.1			
26	4.2			
27	5.0			
28	3.5			
29	6.8			
30	7.3			
31	8.2			
32	5.9			
33	2.0			
34	1.8			
35	1.8			
36	.6			

6-HOUR STORM

TIME PERIOD	5-MIN PERIOD	10-MIN PERIOD	15-MIN PERIOD	30-MIN PERIOD	TIME PERIOD	5-MIN PERIOD
1	.5	1.1	1.7	3.6	49	1.7
2	.6	1.2	1.9	4.3	50	1.8
3	.6	1.3	2.1	4.8	51	1.9
4	.6	1.4	2.2	4.9	52	2.0
5	.6	1.4	2.4	5.3	53	2.1
6	.7	1.5	2.4	5.8	54	2.1
7	.7	1.6	2.4	6.8	55	2.2
8	.7	1.6	2.5	9.0	56	2.3
9	.7	1.6	2.6	11.6	57	2.4
10	.7	1.6	2.7	14.4	58	2.4
11	.7	1.6	2.8	25.1	59	2.5
12	.8	1.7	3.0	4.4	60	2.6
13	.8	1.7	3.2		61	3.1
14	.8	1.8	3.6		62	3.6
15	.8	1.8	4.3		63	3.9
16	.8	1.8	4.7		64	4.2
17	.8	2.0	5.4		65	4.7
18	.8	2.0	6.2		66	5.6
19	.8	2.1	6.9		67	1.9
20	.8	2.2	7.5		68	.9
21	.8	2.5	10.6		69	.6
22	.8	2.8	14.5		70	.5
23	.8	3.0	3.4		71	.3
24	.9	3.2	1.0		72	.2
25	.8	3.5				
26	.9	3.9				
27	.9	4.2				
28	.9	4.5				
29	.9	4.8				
30	.9	5.1				
31	.9	6.7				
32	.9	8.1				
33	1.0	10.3				
34	1.0	2.8				
35	1.0	1.1				
36	1.0	.5				
37	1.0					
38	1.1					
39	1.1					
40	1.1					
41	1.2					
42	1.3					
43	1.4					
44	1.4					
45	1.5					
46	1.5					
47	1.6					
48	1.6					

24-HOUR STORM

TIME PERIOD	15-MIN PERIOD	30-MIN PERIOD	60-MIN PERIOD	TIME PERIOD	15-MIN PERIOD
1	.2	.5	1.2	49	2.5
2	.3	.7	1.3	50	2.6
3	.3	.6	1.8	51	2.8
4	.4	.7	2.1	52	2.9
5	.3	.8	2.8	53	3.4
6	.3	1.0	2.9	54	3.4
7	.3	1.0	3.8	55	2.3
8	.4	1.1	4.6	56	2.3
9	.4	1.3	6.3	57	2.7
10	.4	1.5	8.2	58	2.6
11	.5	1.3	7.0	59	2.6
12	.5	1.6	7.3	60	2.5
13	.5	1.8	10.8	61	2.4
14	.5	2.0	11.4	62	2.3
15	.5	2.1	10.4	63	1.9
16	.6	2.5	8.5	64	1.9
17	.6	3.0	1.4	65	.4
18	.7	3.3	1.9	66	.4
19	.7	3.9	1.3	67	.3
20	.8	4.3	1.2	68	.3
21	.6	3.0	1.1	69	.5
22	.7	4.0	1.0	70	.5
23	.8	3.8	.9	71	.5
24	.8	3.5	.8	72	.4
25	.9	5.1		73	.4
26	.9	5.7		74	.4
27	1.0	6.8		75	.3
28	1.0	4.6		76	.2
29	1.0	5.3		77	.3
30	1.1	5.1		78	.4
31	1.2	4.7		79	.3
32	1.3	3.8		80	.2
33	1.5	.8		81	.3
34	1.5	.6		82	.3
35	1.6	1.0		83	.3
36	1.7	.9		84	.2
37	1.9	.8		85	.3
38	2.0	.5		86	.2
39	2.1	.7		87	.3
40	2.2	.5		88	.2
41	1.5	.6		89	.3
42	1.5	.5		90	.2
43	2.0	.5		91	.2
44	2.0	.5		92	.2
45	1.9	.5		93	.2
46	1.9	.4		94	.2
47	1.7	.4		95	.2
48	1.8	.4		96	.2

NOTES:

1. 3 and 6-hour patterns based on the Indio area thunderstorm of September 24,1939.
2. 24-hour patterns based on the general storm of March 2 & 3,1938.

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HYDROLOGY MANUAL

RAINFALL PATTERNS IN PERCENT

RUNOFF INDEX NUMBERS OF HYDROLOGIC SOIL-COVER COMPLEXES FOR PERVIOUS AREAS-AMC II

Cover Type (3)	Quality of Cover (2)	Soil Group A	B	C	D
NATURAL COVERS -					
Barren (Rockland, eroded and graded land)		78	86	91	93
Chaparrel, Broadleaf (Manzonita, ceanothus and scrub oak)	Poor	53	70	80	85
	Fair	40	63	75	81
	Good	31	57	71	78
Chaparrel, Narrowleaf (Chamise and redshank)	Poor	71	82	88	91
	Fair	55	72	81	86
Grass, Annual or Perennial	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Meadows or Cienegas (Areas with seasonally high water table, principal vegetation is sod forming grass)	Poor	63	77	85	88
	Fair	51	70	80	84
	Good	30	58	72	78
Open Brush (Soft wood shrubs - buckwheat, sage, etc.)	Poor	62	76	84	88
	Fair	46	66	77	83
	Good	41	63	75	81
Woodland (Coniferous or broadleaf trees predominate. Canopy density is at least 50 percent)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	28	55	70	77
Woodland, Grass (Coniferous or broadleaf trees with canopy density from 20 to 50 percent)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
URBAN COVERS -					
Residential or Commercial Landscaping (Lawn, shrubs, etc.)	Good	32	56	69	75
Turf (Irrigated and mowed grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
AGRICULTURAL COVERS -					
Fallow (Land plowed but not tilled or seeded)		76	85	90	92

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HYDROLOGY MANUAL

RUNOFF INDEX NUMBERS FOR PERVIOUS AREAS

RUNOFF INDEX NUMBERS OF HYDROLOGIC SOIL-COVER COMPLEXES FOR PERVIOUS AREAS-AMC II

Cover Type (3)	Quality of Cover (2)	Soil Group A	B	C	D
AGRICULTURAL COVERS (cont.) -					
Legumes, Close Seeded (Alfalfa, sweetclover, timothy, etc.)	Poor	66	77	85	89
	Good	58	72	81	85
Orchards, Deciduous (Apples, apricots, pears, walnuts, etc.)		See Note 4			
Orchards, Evergreen (Citrus, avocados, etc.)	Poor	57	73	82	86
	Fair	44	65	77	82
	Good	33	58	72	79
Pasture, Dryland (Annual grasses)	Poor	67	78	86	89
	Fair	50	69	79	84
	Good	38	61	74	80
Pasture, Irrigated (Legumes and perennial grass)	Poor	58	74	83	87
	Fair	44	65	77	82
	Good	33	58	72	79
Row Crops (Field crops - tomatoes, sugar beets, etc.)	Poor	72	81	88	91
	Good	67	78	85	89
Small Grain (Wheat, oats, barley, etc.)	Poor	65	76	84	88
	Good	63	75	83	87
Vineyard		See Note 4			

Notes:

1. All runoff index (RI) numbers are for Antecedent Moisture Condition (AMC) II.

2. Quality of cover definitions:
   Poor-Heavily grazed or regularly burned areas. Less than 50 percent of the ground surface is protected by plant cover or brush and tree canopy.
   Fair-Moderate cover with 50 percent to 75 percent of the ground surface protected.
   Good-Heavy or dense cover with more than 75 percent of the ground surface protected.

3. See Plate C-2 for a detailed description of cover types.

4. Use runoff index numbers based on ground cover type. See discussion under "Cover Type Descriptions" on Plate C-2.

5. Reference Bibliography item 17.

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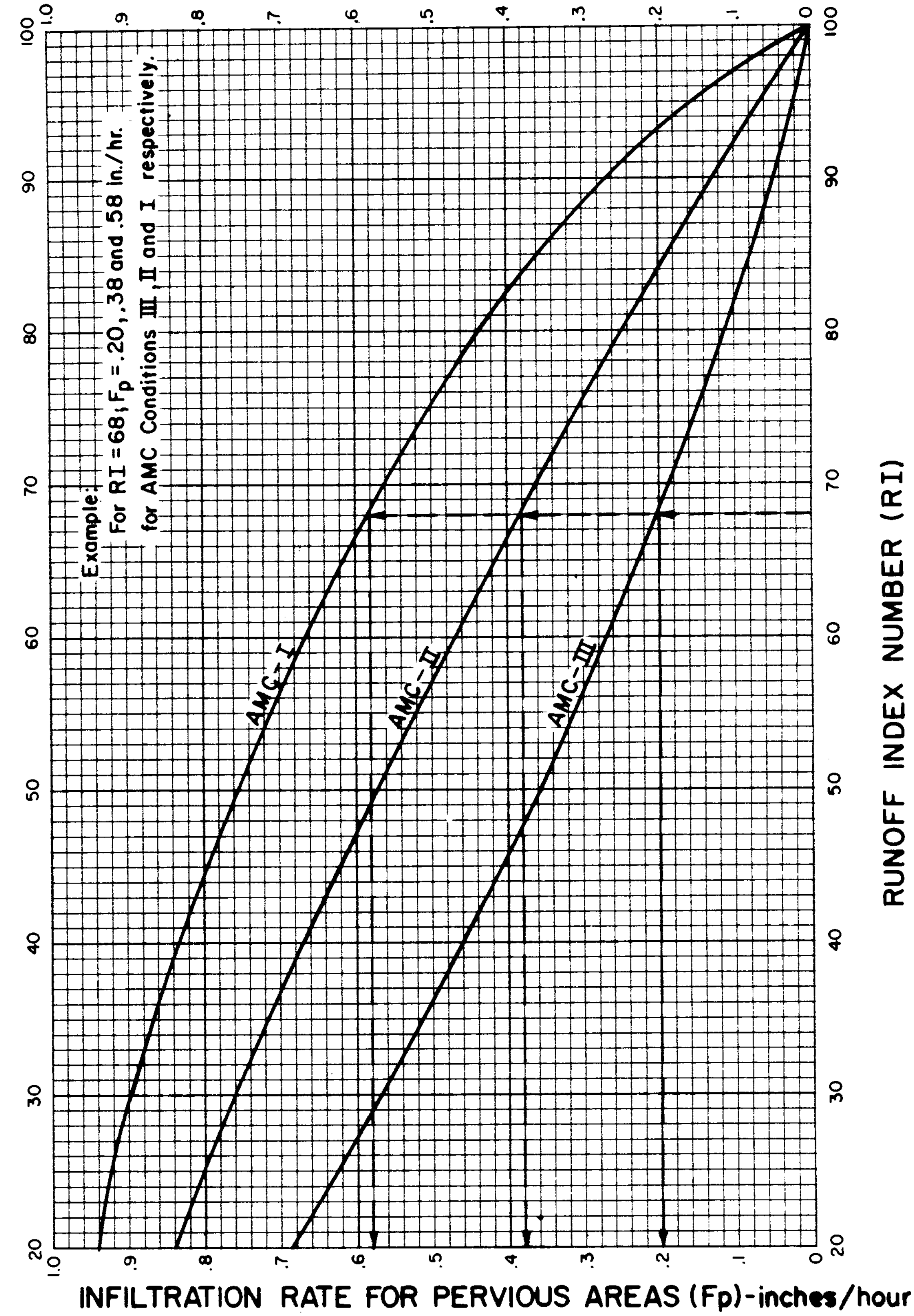
HYDROLOGY MANUAL

RUNOFF INDEX NUMBERS FOR PERVIOUS AREAS



NOTES:
1. R.I. Number - Infiltration relationships are derived from rainfall-runoff relationships in Bibliography item No. 36.

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HYDROLOGY MANUAL

INFILTRATION RATE FOR PERVIOUS AREAS VERSUS RUNOFF INDEX NUMBERS

ACTUAL IMPERVIOUS COVER

Land Use (1)	Range-Percent	Recommended Value For Average Conditions-Percent(2)
Natural or Agriculture	0 - 10	0
Single Family Residential: (3)		
40,000 S. F. (1 Acre) Lots	10 - 25	20
20,000 S. F. (½ Acre) Lots	30 - 45	40
7,200 - 10,000 S. F. Lots	45 - 55	50
Multiple Family Residential:		
Condominiums	45 - 70	65
Apartments	65 - 90	80
Mobile Home Park	60 - 85	75
Commercial, Downtown Business or Industrial	80 -100	90

Notes:

1. Land use should be based on ultimate development of the watershed. Long range master plans for the County and incorporated cities should be reviewed to insure reasonable land use assumptions.

2. Recommended values are based on average conditions which may not apply to a particular study area. The percentage impervious may vary greatly even on comparable sized lots due to differences in dwelling size, improvements, etc. Landscape practices should also be considered as it is common in some areas to use ornamental gravels underlain by impervious plastic materials in place of lawns and shrubs. A field investigation of a study area should always be made, and a review of aerial photos, where available may assist in estimating the percentage of impervious cover in developed areas.

3. For typical horse ranch subdivisions increase impervious area 5 percent over the values recommended in the table above.

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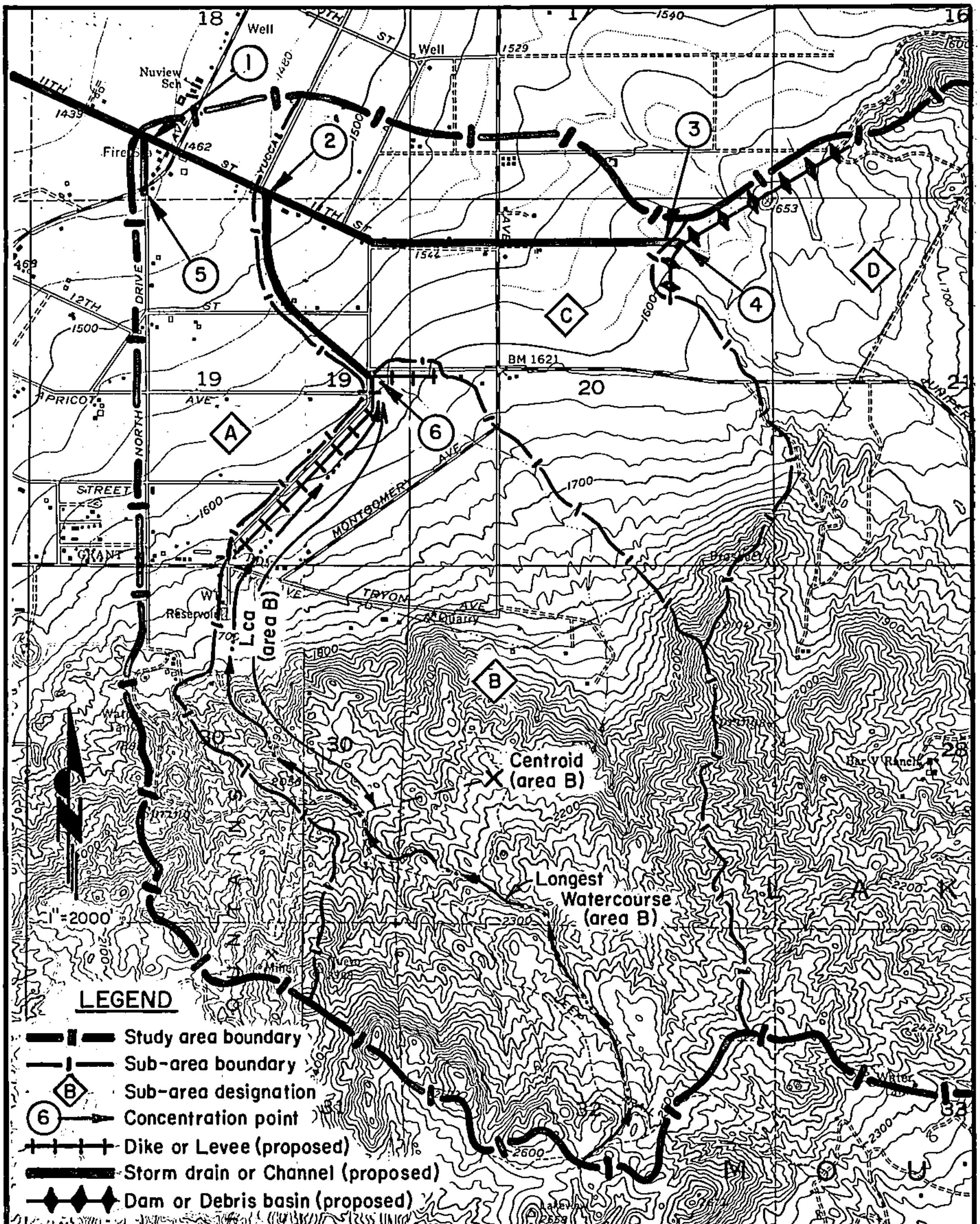
HYDROLOGY MANUAL

IMPERVIOUS COVER FOR DEVELOPED AREAS



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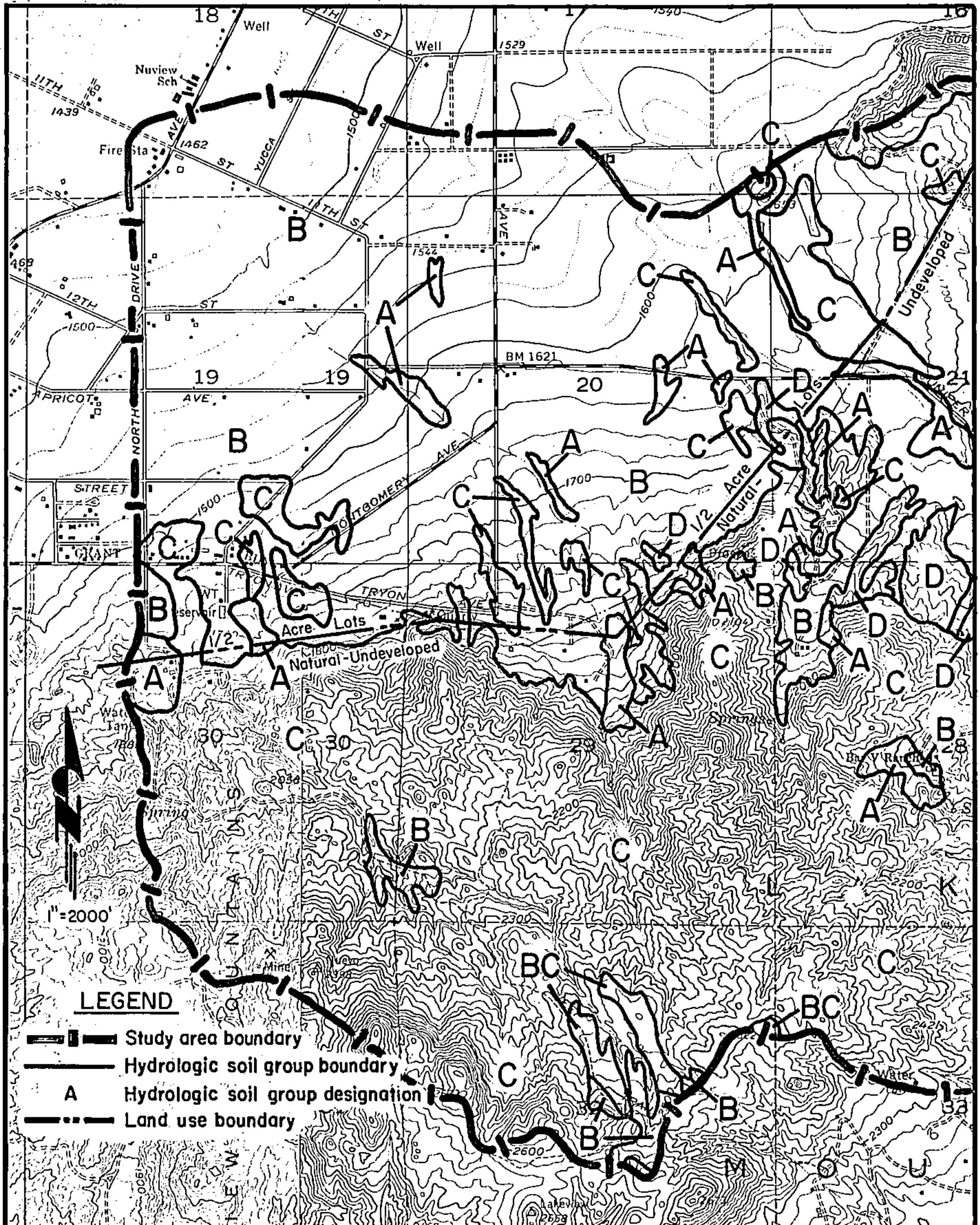
HYDROLOGY MANUAL

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example Hydrologic Data Map)



RCFC & WCD
HYDROLOGY MANUAL

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example Hydrologic Soils Group & Land Use Map)

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Basic Data Calculation Form	Project LAKEVIEW AREA STUDY By EJP Date 4/78 Checked ____ Date ____	Sheet 3/8

PHYSICAL DATA

[1] CONCENTRATION POINT	6
[2] AREA DESIGNATION	B
[3] AREA-SQ INCHES	15.45
[4] AREA ADJUSTMENT FACTOR	.143
[5] AREA-SQ MILES ([3]*[4])	2.209
[6] L-INCHES	7.99
[7] L ADJUSTMENT FACTOR	.379
[8] L-MILES ([6]*[7])	3.03
[9] LCA-INCHES	4.00
[10] LCA-MILES ([7]*[9])	1.515
[11] ELEVATION OF HEADWATER	2560
[12] ELEVATION OF CONCENTRATION POINT	1570
[13] H-FEET ([11]-[12])	990
[14] S-FEET/MILE ([13]/[8])	326.7
[15] S**.5	18.08
[16] L*LCA/S**.5 ([8]*[10]/[15])	.254
[17] AVERAGE MANNINGS "N"	.035
[18] LAG TIME-HOURS (24*[17]*[16]**.38) (PLATE E-3)	.50
[19] LAG TIME-MINUTES (60*[18])	30
[20] 25% OF LAG-MINUTES (.25*[19])	7.5
[21] 40% OF LAG MINUTES (.40*[19])	12.0
[22] UNIT TIME-MINUTES (25-40% OF LAG)	10 (Use 15 for 24-Hr Storm only)

RAINFALL DATA

[1] SOURCE	Hydrology Manual - NOAA Atlas
[2] FREQUENCY-YEARS	100-Year
[3] DURATION:	

3-HOURS				6-HOURS				24-HOURS			
[4] POINT RAIN INCHES	[5] AREA SQ IN	[6] [5]/Σ[5]	[7] AVERAGE POINT RAIN INCHES	[8] POINT RAIN INCHES	[9] AREA SQ IN	[10] [9]/Σ[9]	[11] AVERAGE POINT RAIN INCHES	[12] POINT RAIN INCHES	[13] AREA SQ IN	[14] [13]/Σ[13]	[15] AVERAGE POINT RAIN INCHES
1.80	15.45	1.00	1.80	2.70*	15.45	1.00	2.70*	5.00*	15.45	1.00	5.00*
↖ See Plate E-5.2				↖ See Plate E-5.4 = 2.50"				↖ See Plate E-5.6 = 4.70"			
Σ[5]- 15.45		Σ[7]- 1.80		Σ[9]- 15.45		Σ[11]- 2.70		Σ[13]- 15.45		Σ[15]- 5.00	
[16] AREAL ADJ FACTOR		.990		(SEE PLATE E-5.8)		.993				.995	
[17] ADJ AVG POINT RAIN		1.78		([16]*Σ[7], ETC)		2.68				4.98	

* Point rain values increased over NOAA Atlas values based on a review of available District frequency analysis of nearby long term rainfall records.

NOTE: Where study watershed is large and covered by several isohyetal lines this section would be used to develop a weighted average point rainfall.

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example of Plate E-2.1 (1 of 2))

LOSS RATE DATA

AVERAGE ADJUSTED LOSS RATE

[1] SOIL GROUP (PLATE C-1)	[2] COVER TYPE	[3] RI NUMBER (PLATE E-6.1)	[4] PERVIOUS AREA INFILTRATION RATE-IN/HR (PLATE E-6.2)	[5] LAND USE	[6] DECIMAL PERCENT OF AREA IMPERVIOUS (PLATE E-6.3)	[7] ADJUSTED INFILTRATION RATE-IN/HR [4](1-.9[6])	[8] ~~AREA SQ-INCHES~~ Grid Intersections	[9] [8]/Σ[8]	[10] AVERAGE ADJUSTED INFILTRATION RATE-IN/HR [7]*[9]
A	DRYLAND PASTURE-FAIR	50	.57	SINGLE FAMILY 1/2 ACRE	.40	.36	7	.018	.006
B	"	69	.37	"	.40	.24	87	.221	.053
C	"	79	.26	"	.40	.17	19	.048	.008
A	BROADLEAF CHAPARREL-FAIR	40	.67	NATURAL	0	.67	4	.010	.007
B	"	63	.44	"	0	.44	24	.062	.027
C	"	75	.30	"	0	.30	252	.642	.193

In lieu of planimetering areas, relative area was determined using a "dot counter" or uniform grid over the study area, and finding the number of "dots" or grid points falling in each area.

∴ USE F = .29

Σ[8] - 393   Σ[10] - .294

SAMPLE CALCULATION No 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example of Plate E-2.1 (2 of 2))

VARIABLE LOSS RATE CURVE (24-HOUR STORM ONLY)

F_m = Minimum Loss Rate ≅ F/2 = Σ[10]/2 = .145 IN./HR. Say .15 IN/HR

$C = (F - F_m)/54 = (\Sigma[10] - F_m)/54 =$ .00259

$F_T = C(24-(T/60))^{1.55} + F_m =$ .00259 $(24-(T/60))^{1.55} +$ .15 IN./HR. ← For application of this equation see Sample Calculation No. 2 on Plate E-7.2

Where:

T = Time in minutes. To get an average value for each unit time period, Use $T = \frac{1}{2}$ the unit time for the first time period, $T = 1\frac{1}{2}$ unit time for the second period, etc.

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project: LAKEVIEW AREA STUDY By: FJP Date: 4/78 Checked: ______ Date: ______	Sheet 5/8

[1] CONCENTRATION POINT: 6	[2] AREA DESIGNATION: B
[3] DRAINAGE AREA-SQ MILES: 2.209	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3]): 1424.8
[5] UNIT TIME-MINUTES: 10	[6] LAG TIME-MINUTES: 30
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6]): 33.3 %	[8] S-CURVE: FOOTHILL
[9] STORM FREQUENCY & DURATION: 100-YEAR- 3-HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES: 1.78
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR: —	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR: —
[13] CONSTANT LOSS RATE-INCHES/HOUR: 0.29	[14] LOW LOSS RATE-PERCENT: 90

	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]		[23]	[24]
UNIT TIME PERIOD m	TIME PERCENT OF LAG [7]*[15]	CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	DISTRIB GRAPH PERCENT $[17]_m - [17]_{m-1}$	UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	PATTERN PERCENT (PL E-5.9)	STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$	LOSS RATE IN/HR MAX	LOSS RATE IN/HR LOW	EFFECTIVE RAIN IN/HR [21]-[22]	FLOW CFS
	33.3x[15]			14.248x[18]		.1068x[20]				
1	33.3	2.5	2.5	35.6	2.6	.278	.29	.25	.03	
2	66.6	10.6	8.1	115.4	2.6	.278	.29	.25	.03	
3	99.9	29.5	18.9	269.3	3.3	.352	.29	—	.06	
4	133.2	59.3	29.8	424.6	3.3	.352	.29	—	.06	
5	166.5	71.9	12.6	179.5	3.3	.352	.29	—	.06	
6 1-Hr	199.8	79.1	7.2	102.6	3.4	.363	.29	—	.07	
7	233.1	84.5	5.4	76.9	4.4	.470	.29	—	.18	
8	266.4	88.9	4.4	62.7	4.2	.449	.29	—	.16	
9	299.7	92.0	3.1	44.2	5.3	.566	.29	—	.28	
10	333.0	94.5	2.5	35.6	5.1	.545	.29	—	.26	
11	366.3	96.2	1.7	24.2	6.4	.684	.29	—	.39	
12 2-Hrs	399.6	97.4	1.2	17.1	5.9	.630	.29	—	.34	
13	432.9	98.0	.6	8.5	7.3	.780	.29	—	.49	
14	466.2	98.6	.6	8.5	8.5	.908	.29	—	.62	
15	499.5	98.8	.2	2.8	14.1	1.506	.29	—	1.22	
16	532.8	99.0	.2	2.8	14.1	1.506	.29	—	1.22	
17	566.1	99.2	.2	2.8	3.8	.406	.29	—	.12	
18 3-Hrs	599.4	99.5	.3	4.3	2.4	.256	.29	.23	.03	
19	632.7	99.8	.3	4.3	Σ=100.0				Σ=5.62	
20	666.0	99.9	.1	1.4						
21	699.3	100.0	.1	1.4						
			Σ=100.0	Σ=1424.5						

See Next Sheet for Hydrograph Calculations

Values are from the Foothill S-Graph (Plate E-4.2). See Plate E-7.1 (7 of 8) for an example of use of an S-Graph.

EFFECTIVE RAIN = 5.62 in/hr x .167 hrs = .94"
(.167 hrs = unit time-hrs)

FLOOD VOLUME = .94" x 1'/12" x 2.209 sq.mi x 640 Ac/sq.mi
(.94" = Effective rain; 2.209 = Drainage area)

FLOOD VOLUME = 110.74 Acre-feet

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example of Plate E-2.2)

RCFC & WCD
HYDROLOGY MANUAL

SYNTHETIC UNIT HYDROGRAPH METHOD

Flood Hydrograph Calculation Form

Project LAKEVIEW AREA STUDY
AREA B - C.P. # 6 100Yr-3Hr
By EJP Date 4/78
Checked ______ Date ______

Sheet 6 / 8

Unit Graph	Effec Rain	.03	.03	.06	.06	.06	.07 (1-Hr)	.18	.16	.28	.26	.39	.34 (2-Hrs)	.49	.62	1.22	1.22	.12	.03 (3-Hrs)	Flood Hydrograph
	Unit Per.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
35.6	1	1.1																		1.1
115.4	2	3.5	1.1																	4.6
269.3	3	8.1	3.5	2.1																13.7
424.6	4	12.7	8.1	6.9	2.1															29.8
179.5	5	5.4	12.7	16.2	6.9	2.1														43.3
102.6	6 1-Hr	3.1	5.4	25.5	16.2	6.9	2.5													59.6
76.9	7	2.3	3.1	10.8	25.5	16.2	8.1	6.4												72.4
62.7	8	1.9	2.3	6.2	10.8	25.5	18.9	20.8	5.7											92.1
44.2	9	1.3	1.9	4.6	6.2	10.8	29.7	48.5	18.5	10.0										131.5
35.6	10	1.1	1.3	3.8	4.6	6.2	12.6	76.4	43.1	32.3	9.3									190.7
24.2	11	.7	1.1	2.7	3.8	4.6	7.2	32.3	67.9	75.4	30.0	13.9								239.6
17.1	12 2-Hr	.5	.7	2.1	2.7	3.8	5.4	18.5	28.7	118.9	70.0	45.0	12.1							308.4
8.5	13	.3	.5	1.5	2.1	2.7	4.4	13.8	16.4	50.3	110.4	105.0	39.2	17.4						364.0
8.5	14	.3	.3	1.0	1.5	2.1	3.1	11.3	12.3	28.7	46.7	165.6	91.6	56.5	22.1					443.1
2.8	15	.1	.3	.5	1.0	1.5	2.5	8.0	10.0	21.5	26.7	70.0	144.4	132.0	71.5	43.4				533.4
2.8	16	.1	.1	.5	.5	1.0	1.7	6.4	7.1	17.6	20.0	40.0	61.0	208.1	167.0	140.8	43.4			715.3
2.8	17	.1	.1	.2	.5	.5	1.2	4.4	5.7	12.4	16.3	30.0	34.9	88.0	263.3	328.5	140.8	4.3		931.2
4.3	18 3-Hr	.1	.1	.2	.2	.5	.6	3.1	3.9	10.0	11.5	24.5	26.1	50.3	111.3	518.0	328.5	13.8	1.1	1103.8
4.3	19	.1	.1	.2	.2	.2	.6	1.5	2.7	6.8	9.3	17.2	21.3	37.7	63.6	219.0	518.0	32.3	3.5	934.3
1.4	20	0	.1	.3	.2	.2	.2	1.5	1.4	4.8	6.3	13.9	15.0	30.7	47.7	125.2	219.0	51.0	8.1	525.6
1.4	21	0	0	.3	.3	.2	.2	.5	1.4	2.4	4.4	9.4	12.1	21.7	38.9	93.8	125.2	21.5	12.7	345.0
	22		0	.1	.3	.3	.2	.5	.4	2.4	2.2	6.7	8.2	17.4	27.4	76.5	93.8	12.3	5.4	254.1
	23			.1	.1	.3	.3	.5	.4	.8	2.2	3.3	5.8	11.9	22.1	53.9	76.5	9.2	3.1	190.5
	24 4-Hr				.1	.1	.3	.8	.4	.8	.7	3.3	2.9	8.4	15.0	43.4	53.9	7.5	2.3	139.9
	25					.1	.1	.8	.7	.8	.7	1.1	2.9	4.2	10.6	29.5	43.4	5.3	1.9	102.1
	26						.1	.3	.7	1.2	.7	1.1	1.0	4.2	5.3	20.9	29.5	4.3	1.3	70.6
	27							.3	.2	1.2	1.1	1.1	1.0	1.4	5.3	10.4	20.9	2.9	1.1	46.9
	28								.2	.4	1.1	1.7	1.0	1.4	1.7	10.4	10.4	2.1	.7	31.1
	29									.4	.4	1.7	1.5	1.4	1.7	3.4	10.4	1.0	.5	22.4
	30 5-Hr										.4	.5	1.5	2.1	1.7	3.4	3.4	1.0	.3	14.3
	31											.5	.5	2.1	2.7	3.4	3.4	.3	.3	13.2
	32												.5	.7	2.7	5.2	3.4	.3	.1	12.9
	33													.7	.9	5.2	5.2	.3	.1	12.4
	34														.9	1.7	5.2	.5	.1	8.4
	35															1.7	1.7	.5	.1	4.0
	36 6-Hr																1.7	.2	.1	2.0
	37																	.2	0	.2
	38																		0	0

Calculated by 35.6 x .07 = 2.5

Calculated by 115.4 x .07 = 8.1

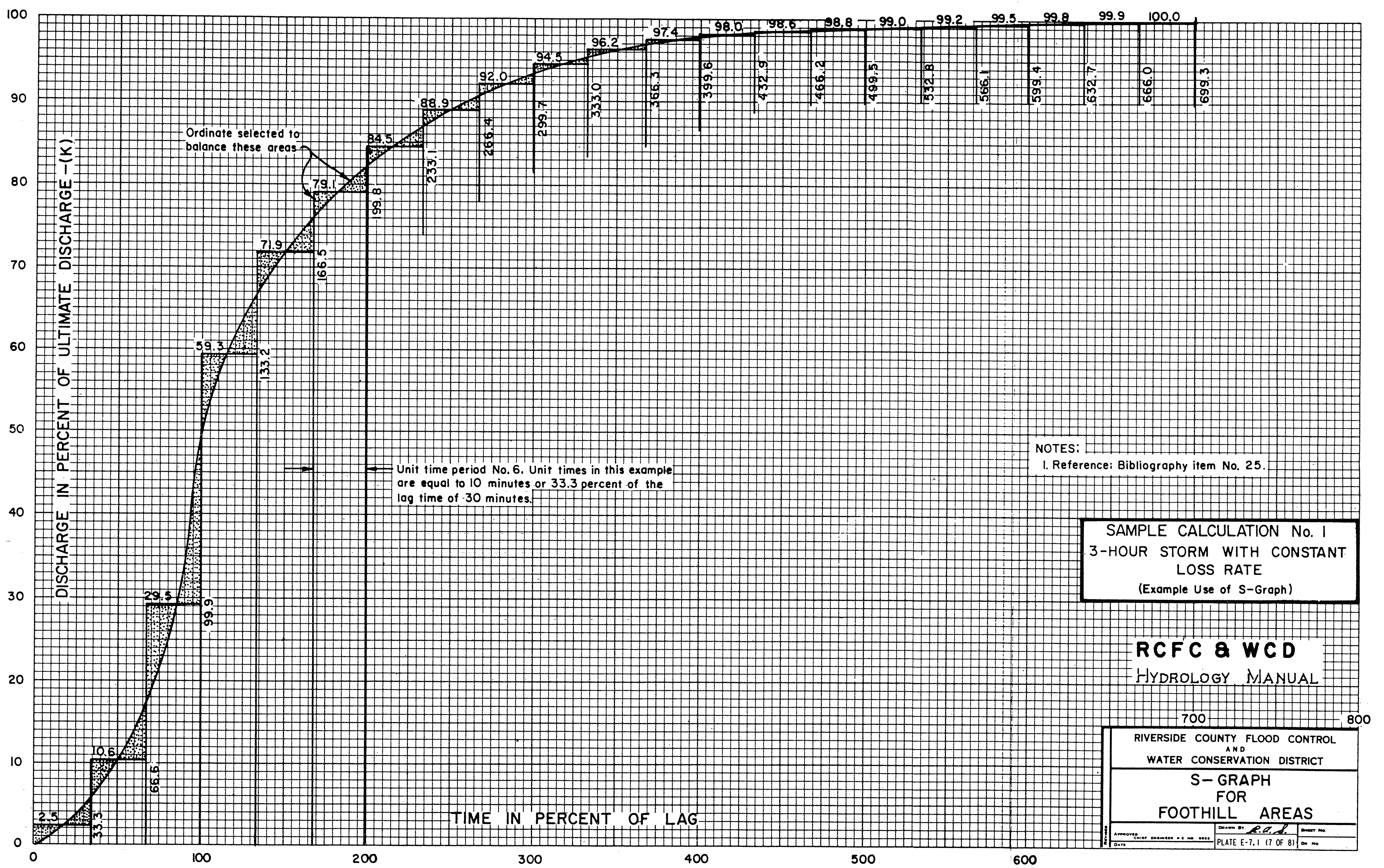
Each Flood Hydrograph Value is the summation of all computed flow values in a row.

Each column represents the flood hydrograph produced by the effective rain per unit time period. See page E-10 of text.

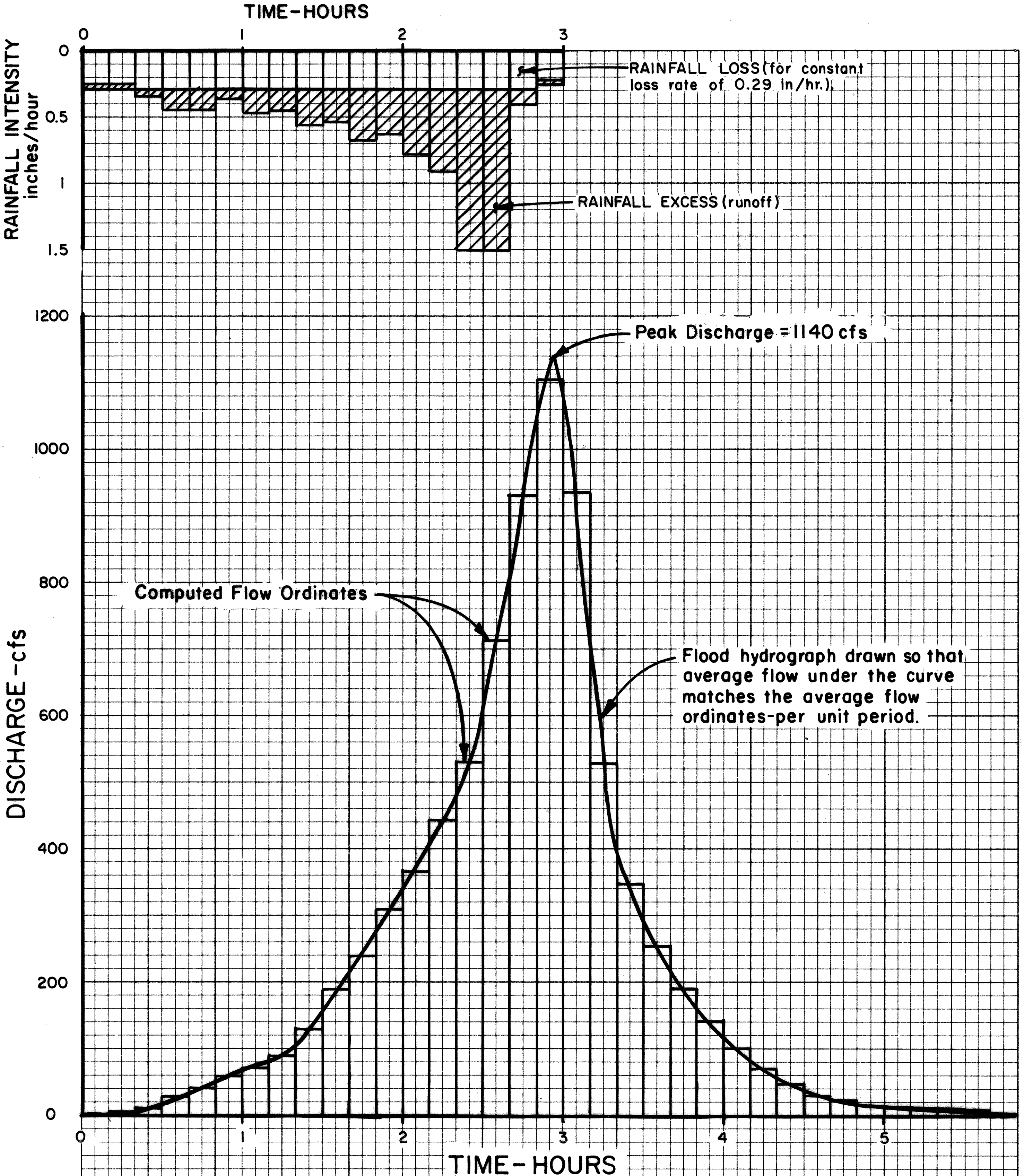
See Plate E-7.1 (8 of 8) for a plot of the Flood Hydrograph

NOTE:
This example illustrates the long form method of calculation, and visually demonstrates the relationships between the Unit Graph; Effective Rain and Flood Hydrograph which are not readily apparent when using the simplified method of computation (Plate E-1.1 (5 of 6)).

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example of Plate E-2.3)



DISCHARGE IN PERCENT OF ULTIMATE DISCHARGE -(K)
TIME IN PERCENT OF LAG
0
10
20
30
40
50
60
70
80
90
100
100
200
300
400
500
600
700
800
2.5
10.6
29.5
59.3
71.9
79.1
84.5
88.9
92.0
94.5
96.2
97.4
98.0
98.6
98.8
99.0
99.2
99.5
99.8
99.9
100.0
33.3
66.6
99.9
133.2
166.5
199.8
233.1
266.4
299.7
333.0
366.3
399.6
432.9
466.2
499.5
532.8
566.1
599.4
632.7
666.0
699.3
Ordinate selected to balance these areas
Unit time period No. 6. Unit times in this example are equal to 10 minutes or 33.3 percent of the lag time of 30 minutes.
NOTES:
1. Reference: Bibliography item No. 25.
SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example Use of S-Graph)
RCFC & WCD
HYDROLOGY MANUAL
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
S-GRAPH FOR FOOTHILL AREAS
PLATE E-7.1 (7 OF 8)



RCFC & WCD

HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

SAMPLE CALCULATION No. 1
3-HOUR STORM WITH CONSTANT LOSS RATE
(Example Flood Hydrograph Plot)

REVISED: APPROVED CHIEF ENGINEER R.E. NO. 8822	DRAWN BY: R.A.S.	SHEET NO.
DATE	CHECKED BY:	DR. NO.
	DATE DRAWN:	

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project LAKEVIEW AREA STUDY By EJP Date 4/78 Checked ______ Date ______	Sheet 1 / 4

[1] CONCENTRATION POINT	6	[2] AREA DESIGNATION	B
[3] DRAINAGE AREA-SQ MILES	2.209	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3])	1424.8
[5] UNIT TIME-MINUTES	15	[6] LAG TIME-MINUTES	30
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6])	50 %	[8] S-CURVE	FOOTHILL
[9] STORM FREQUENCY & DURATION	100-YEAR-24-HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES	4.98
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR	0.29	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR	0.15
[13] CONSTANT LOSS RATE-INCHES/HOUR	———	[14] LOW LOSS RATE-PERCENT	90

	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]		[23]	[24]
UNIT TIME PERIOD m	TIME PERCENT OF LAG [7]*[15]	CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	DISTRIB GRAPH PERCENT $[17]_m - [17]_{m-1}$	UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	PATTERN PERCENT (PL E-5.9)	STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$	LOSS RATE IN/HR		EFFECTIVE RAIN IN/HR [21]-[22]	FLOW CFS
	50×[15]			14.248×[18]		.1992×[20]	MAX *	LOW		
1	50	4.4	4.4	62.7	.2	.040	.504	.036	0	—
2	100	24.8	20.4	290.7	.3	.060	.498	.054	.01	.6
3	150	62.6	37.8	538.6	.3	.060	.493	.054	.01	3.5
4 1-Hr	200	77.3	14.7	209.4	.4	.080	.487	.072	.01	8.9
5	250	85.7	8.4	119.7	.3	.060	.481	.054	.01	11.0
6	300	91.3	5.6	79.8	.3	.060	.476	.054	.01	12.2
7	350	95.0	3.7	52.7	.3	.060	.470	.054	.01	13.0
8 2-Hrs	400	97.2	2.2	31.3	.4	.080	.465	.072	.01	13.6
9	450	98.3	1.1	15.7	.4	.080	.459	.072	.01	13.9
10	500	98.8	.5	7.1	.4	.080	.454	.072	.01	14.0
11	550	99.1	.3	4.3	.5	.100	.448	.090	.01	14.1
12 3-Hrs	600	99.4	.3	4.3	.5	.100	.443	.090	.01	14.1
13	650	99.7	.3	4.3	.5	.100	.438	.090	.01	14.2
14	700	100.0	.3	4.3	.5	.100	.432	.090	.01	14.2
15			Σ=100.0	Σ=1424.9	.5	.100	.427	.090	.01	14.3
16 4-Hrs					.6	.120	.422	.108	.01	14.3
17					.6	.120	.416	.108	.01	14.3
18					.7	.139	.411	.125	.01	14.3
19					.7	.139	.406	.125	.01	14.3
20 5-Hrs					.8	.159	.401	.143	.02	14.9
21					.6	.120	.396	.108	.01	17.2
22					.7	.139	.391	.125	.01	19.6
23					.8	.159	.386	.143	.02	17.0
24 6-Hrs					.8	.159	.381	.143	.02	19.0
25					.9	.179	.376	.161	.02	24.0
26					.9	.179	.371	.161	.02	25.8
27					1.0	.199	.366	.179	.02	26.8
28 7-Hrs					1.0	.199	.362	.179	.02	27.4
29					1.0	.199	.357	.179	.02	27.9
30					1.1	.219	.352	.197	.02	28.1
31					1.2	.239	.347	.215	.02	28.3
32 8-Hrs					1.3	.259	.343	.233	.03	29.0

* See Plate E-7.1 (4 of 8) for variable loss rate equation (Sample Calculation No. 1)

NOTE:
See example No. 1 for map, physical data, precipitation data and loss data.

(See Next Page for Continuation)

SAMPLE CALCULATION No. 2
24-HOUR STORM WITH VARIABLE LOSS RATE
(Example of Plate E-2.2)

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project *LAKEVIEW AREA STUDY* By *FJP* Date *4/78* Checked ______ Date ______	Sheet *2* / *4*

[1] CONCENTRATION POINT *6*	[2] AREA DESIGNATION *B*
[3] DRAINAGE AREA-SQ MILES	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3])
[5] UNIT TIME-MINUTES	[6] LAG TIME-MINUTES
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6])	[8] S-CURVE
[9] STORM FREQUENCY & DURATION YEAR- HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR
[13] CONSTANT LOSS RATE-INCHES/HOUR	[14] LOW LOSS RATE-PERCENT

	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15] UNIT TIME PERIOD m	[16] TIME PERCENT OF LAG [7]*[15]	[17] CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	[18] DISTRIB GRAPH PERCENT $[17]_m - [17]_{m-1}$	[19] UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	[20] PATTERN PERCENT (PL E-5.9)	[21] STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$	[22] LOSS RATE IN/HR MAX	[22] LOSS RATE IN/HR LOW	[23] EFFECTIVE RAIN IN/HR [21]-[22]	[24] FLOW CFS
33					1.5	.299	.338	.269	.03	32.0
34					1.5	.299	.334	.269	.03	37.3
35					1.6	.319	.329	.287	.03	39.5
36 9-Hr					1.7	.339	.325	.305	.03	40.7
37					1.9	.378	.320	—	.06	43.4
38					2.0	.398	.316	—	.08	53.9
39					2.1	.418	.311	—	.11	78.1
40 10-Hr					2.2	.438	.307	—	.13	105.2
41					1.5	.299	.303	.269	.03	128.8
42					1.5	.299	.298	.269	.03	121.6
43					2.0	.398	.294	—	.10	83.1
44 11-Hr					2.0	.398	.290	—	.11	90.0
45					1.9	.378	.286	—	.09	121.7
46					1.9	.378	.282	—	.10	131.1
47					1.7	.339	.278	—	.06	127.3
48 12-Hr					1.8	.359	.274	—	.09	123.1
49					2.5	.498	.270	—	.23	122.2
50					2.6	.518	.266	—	.25	174.0
51					2.8	.558	.262	—	.30	260.8
52 13-Hr					2.9	.578	.258	—	.32	317.5
53					3.4	.677	.255	—	.42	377.7
54					3.4	.677	.251	—	.43	442.5
55					2.3	.458	.247	—	.21	505.3
56 14-Hr					2.3	.458	.244	—	.21	480.0
57					2.7	.538	.240	—	.30	388.3
58					2.6	.518	.237	—	.28	380.1
59					2.6	.518	.233	—	.29	405.3
60 15-Hr					2.5	.498	.230	—	.27	402.4
61					2.4	.478	.226	—	.25	398.8
62					2.3	.458	.223	—	.24	383.4
63					1.9	.378	.220	—	.16	362.3
64 16-Hr					1.9	.378	.217	—	.16	328.9

(See Next Page for Continuation)

SAMPLE CALCULATION No. 2
24-HOUR STORM WITH VARIABLE LOSS RATE
(Example of Plate E-2.2)

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project LAKEVIEW AREA STUDY By FJP Date 4/78 Checked ______ Date ______	Sheet 3 / 4

[1] CONCENTRATION POINT 6	[2] AREA DESIGNATION B
[3] DRAINAGE AREA-SQ MILES	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3])
[5] UNIT TIME-MINUTES	[6] LAG TIME-MINUTES
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6])	[8] S-CURVE
[9] STORM FREQUENCY & DURATION YEAR- HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR
[13] CONSTANT LOSS RATE-INCHES/HOUR	[14] LOW LOSS RATE-PERCENT

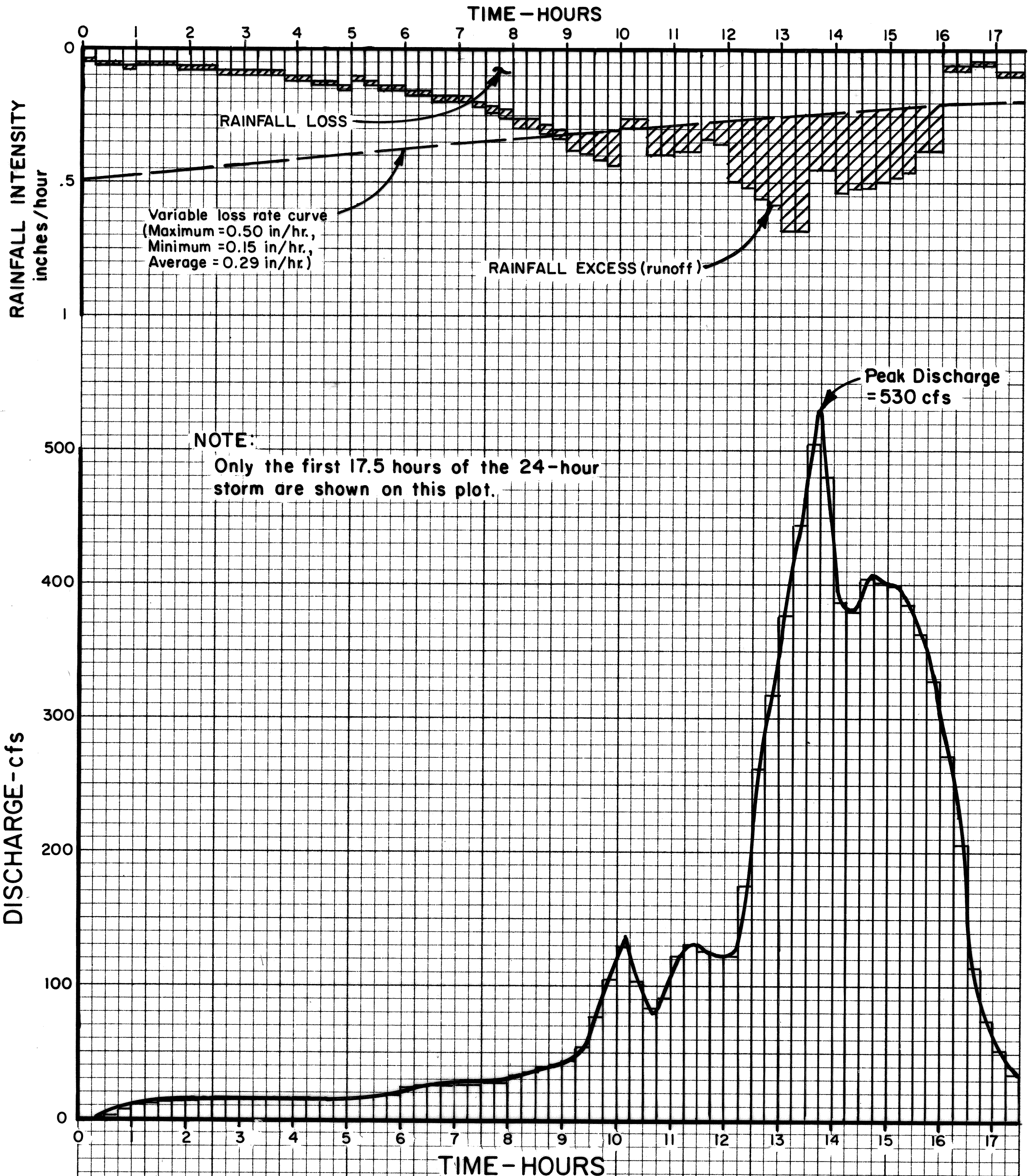
	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15] UNIT TIME PERIOD m	[16] TIME PERCENT OF LAG [7]*[15]	[17] CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	[18] DISTRIB GRAPH PERCENT $[17]_m - [17]_{m-1}$	[19] UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	[20] PATTERN PERCENT (PL E-5.9)	[21] STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$	[22] LOSS RATE IN/HR MAX	[22] LOSS RATE IN/HR LOW	[23] EFFECTIVE RAIN IN/HR [21]-[22]	[24] FLOW CFS
65					.4	.080	.213	.072	.01	271.2
66					.4	.080	.210	.072	.01	207.2
67					.3	.060	.207	.054	.01	117.8
68 17-Hrs					.3	.060	.204	.054	.01	74.0
69					.5	.100	.201	.090	.01	51.4
70					.5	.100	.199	.090	.01	36.9
71					.5	.100	.196	.090	.01	27.5
72 18-Hrs					.4	.080	.193	.072	.01	22.0
73					.4	.080	.190	.072	.01	19.1
74					.4	.080	.188	.072	.01	17.6
75					.3	.060	.185	.054	.01	16.5
76 19-Hrs					.2	.040	.183	.036	0	14.9
77					.3	.060	.180	.054	.01	12.0
78					.4	.080	.178	.072	.01	8.9
79					.3	.060	.176	.054	.01	12.2
80 20-Hrs					.2	.040	.173	.036	0	12.4
81					.3	.060	.171	.054	.01	10.5
82					.3	.060	.169	.054	.01	8.3
83					.3	.060	.167	.054	.01	11.8
84 21-Hrs					.2	.040	.165	.036	0	12.3
85					.3	.060	.163	.054	.01	10.5
86					.2	.040	.162	.036	0	7.7
87					.3	.060	.160	.054	.01	8.9
88 22-Hrs					.2	.040	.158	.036	0	6.8
89					.3	.060	.157	.054	.01	8.3
90					.2	.040	.155	.036	0	6.5
91					.2	.040	.154	.036	0	7.5
92 23-Hrs					.2	.040	.153	.036	0	3.4
93					.2	.040	.152	.036	0	2.0
94					.2	.040	.151	.036	0	1.3
95					.2	.040	.151	.036	0	.8
96 24-Hrs					.2	.040	.150	.036	0	.5
									Σ=6.06	.2
										.2
										.1
										.1

EFFECTIVE RAIN & FLOOD VOLUME COMPUTATIONS

Effective Rain = Σ[23] x Unit Time-hrs
= 6.06 in/hr x .25 hrs
= 1.52 inches

Flood Volume = Effective Rain x Area
= 1.52" x 1'/12" x 2.209 Sq.mi x 640 Ac/Sq.mi
= 179.08 Ac. feet

SAMPLE CALCULATION No. 2
24-HOUR STORM WITH VARIABLE LOSS RATE
(Example of Plate E-2.2)



RCFC & WCD

HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

SAMPLE CALCULATION No. 2
24-HOUR STORM WITH VARIABLE LOSS RATE
(Example Flood Hydrograph Plot)

REVISED:			
	APPROVED ___ CHIEF ENGINEER R.E. NO. 8822	DRAWN BY: R.A.S.	SHEET NO.
		CHECKED BY:	
	DATE	DATE DRAWN:	DR. NO.

RCFC & WCD HYDROLOGY MANUAL	SYNTHETIC UNIT HYDROGRAPH METHOD Unit Hydrograph and Effective Rain Calculation Form	Project TOM'S MOBILE ESTATES-ONSITE By FJP Date 4/78 Checked ____ Date ____	Sheet 1/2

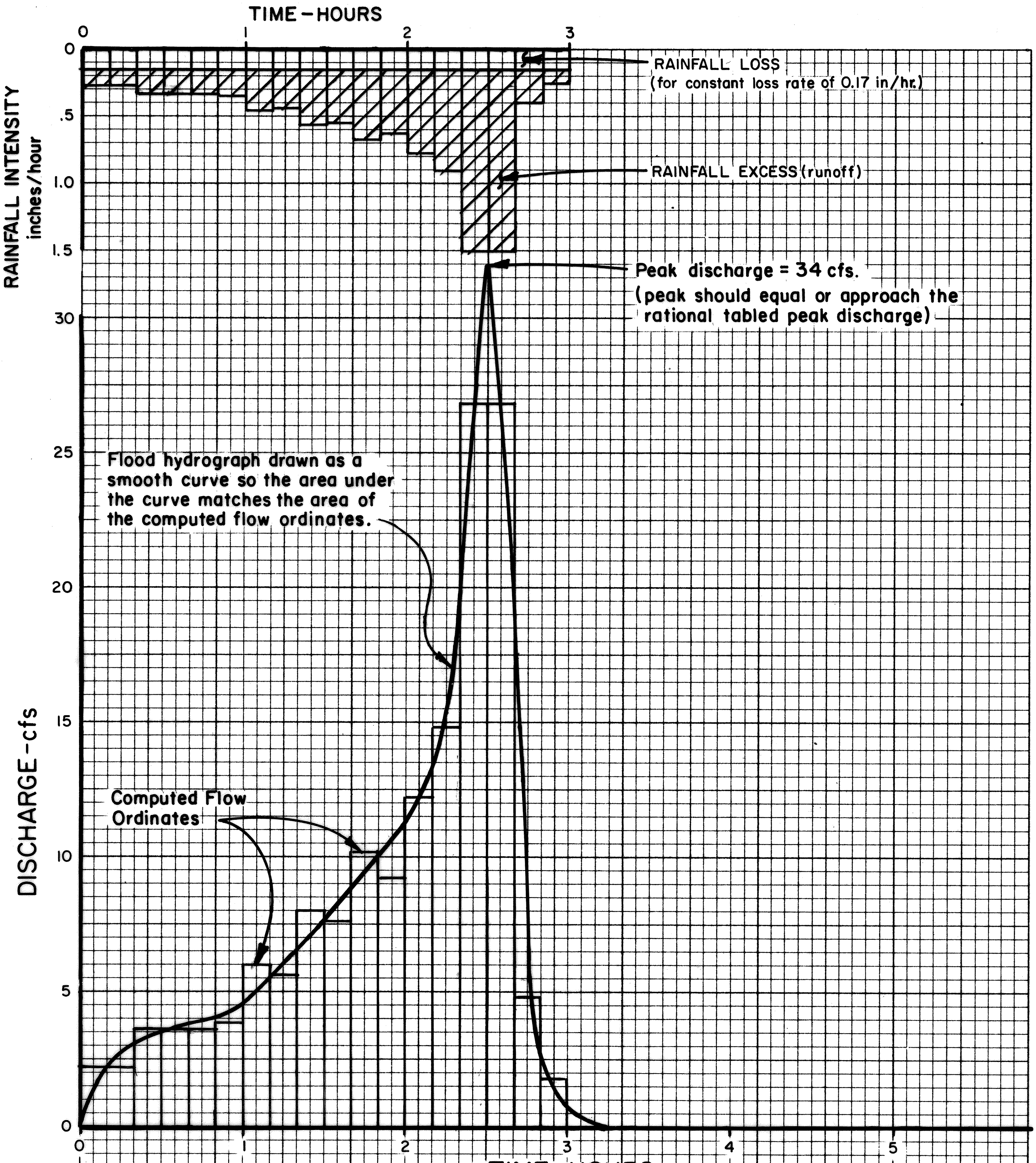
[1] CONCENTRATION POINT	1	[2] AREA DESIGNATION	A
[3] DRAINAGE AREA-~~SQ MILES~~	20 - Acres	[4] ULTIMATE DISCHARGE-CFS-HRS/IN (645*[3])	N.A.
[5] UNIT TIME-MINUTES	10 (100 to 200% of lag)	[6] LAG TIME-MINUTES	7
[7] UNIT TIME-PERCENT OF LAG (100*[5]/[6])	N.A.	[8] S-CURVE	N.A.
[9] STORM FREQUENCY & DURATION	100-YEAR- 3-HOUR	[10] TOTAL ADJUSTED STORM RAIN-INCHES	1.78
[11] VARIABLE LOSS RATE (AVG)-INCHES/HOUR	—	[12] MINIMUM LOSS RATE (FOR VAR. LOSS)-IN/HR	—
[13] CONSTANT LOSS RATE-INCHES/HOUR	.17	[14] LOW LOSS RATE-PERCENT	80

	UNIT HYDROGRAPH				EFFECTIVE RAIN					FLOOD HYDROGRAPH
[15] UNIT TIME PERIOD m	[16] TIME PERCENT OF LAG [7]*[15]	[17] CUMULATIVE AVERAGE PERCENT OF ULTIMATE DISCHARGE (S-GRAPH)	[18] DISTRIB GRAPH PERCENT $[17]_m-[17]_{m-1}$	[19] UNIT HYDROGRAPH CFS-HRS/IN $\frac{[4]*[18]}{100}$	[20] PATTERN PERCENT (PL E-5.9)	[21] STORM RAIN IN/HR $\frac{60[10][20]}{100[5]}$ .1068×[20]	[22] LOSS RATE IN/HR MAX	[22] LOW	[23] EFFECTIVE RAIN IN/HR [21]-[22]	[24] FLOW CFS [3]×[23] 20×[23]
1	N.A.	N.A.	N.A.	N.A.	2.6	.278	.17	–	.11	2.2
2					2.6	.278	.17	–	.11	2.2
3					3.3	.352	.17	–	.18	3.6
4					3.3	.352	.17	–	.18	3.6
5		SHORTCUT			3.3	.352	.17	–	.18	3.6
6					3.4	.363	.17	–	.19	3.8
7					4.4	.470	.17	–	.30	6.0
8					4.2	.449	.17	–	.28	5.6
9		METHOD			5.3	.566	.17	–	.40	8.0
10					5.1	.545	.17	–	.38	7.6
11					6.4	.684	.17	–	.51	10.2
12					5.9	.630	.17	–	.46	9.2
13					7.3	.780	.17	–	.61	12.2
14	WARNING:				8.5	.908	.17	–	.74	14.8
15		THE SHORT CUT METHOD			14.1	1.506	.17	–	1.34	26.8
16		IS AN APROXIMATION &			14.1	1.506	.17	–	1.34	26.8
17		REASONABLE FOR SMALL			3.8	.406	.17	–	.24	4.8
18		DRAINAGE AREAS AND			2.4	.256	.17	–	.09	1.8
		SHORT LAG TIMES			Σ=100.0				Σ=7.64	
		ONLY. SEE PAGE E-12								
		& PLATE E-1.2.								

Effective Rain = Σ[23] x Unit Time - Hrs
= 7.64 IN/HR x .167 Hrs
= 1.28 - inches

Flood Volume = Effective Rain x Area
= 1.28" x 1'/12" x 20 Acres
= 2.13 Acre - Feet

SAMPLE CALCULATION No. 3
SHORTCUT SYNTHETIC HYDROGRAPH
(Example of Plate E-2.2 used for Shortcut Synthetic Hydrograph)



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HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

SAMPLE CALCULATION No. 3
SHORTCUT SYNTHETIC HYDROGRAPH
(Example Plot of Shortcut Synthetic Hydrograph)

Revised: | Approved: Chief Engineer R.E. No. 8822 | Date | Drawn By: R.A.S. | Checked By: | Date Drawn: | Sheet No. | Dr. No.

SECTION F

DEBRIS

DEBRIS

General - Consideration of debris loads carried by streams below mountain and foothill areas is essential in the planning and design of flood control works. Unfortunately, this is one of the least understood, and most often neglected areas of flood control engineering. Failure to provide either debris storage facilities, or additional hydraulic capacity for debris bulked flows, could seriously affect the performance of flood control structures downstream of mountain and foothill watersheds.

Criteria for debris basin design is usually based on providing storage capacity for debris generated by a single major flood event at the minimum. Additional (or in some cases less) capacity may be provided depending on the physical constraints of the site.

Some of the many factors which influence the debris production characteristics of a particular drainage area are: the size and shape of the area; steepness of the stream channels and tributary surfaces; a wide range of geological factors; type and quality of vegetative cover; the likelihood of fires over the watershed as may be indicated by the burn history; and frequency of intense flood producing storms.

Little observational data is available in western Riverside County on debris production potential. The District operates a network of 12 dams and debris basins, however, most of these structures are relatively new, and the older structures are flood control dams located in relatively low debris production areas. Considerable information has been gathered by the Los Angeles County Flood Control District (LACFCD) on their large network of dams and debris basins. Maximum single storm debris production rates as high as 120,000-cubic yards from a one square mile watershed, and single season rates as high as 150-percent of the maximum single storm rate, have been recorded on these basins. Debris production rates have been found to be inversely proportional to drainage area size, with watersheds smaller than one-square mile having the highest rates, and larger watersheds typically having lower rates. Debris volumes carried by flowing streams which equal the clear water volume of the stream (100-percent bulking) have also been recorded.

In the following paragraphs methods are discussed for estimating single major storm debris production rates, peak rate bulking factors, and average annual accumulation rates. It should be emphasized that <u>this material is not recommended as a basis for design</u>, but is presented to make the engineer aware of some of the information that is available, and some of the methods that have been commonly used in evaluating debris related problems in the Southern California area. Until additional data is available for Riverside County selection of design debris storage volumes, or peak bulking rates, should be made with extreme caution after a thorough evaluation of all available information.

<u>Single Storm Debris Production</u> - Single storm debris production estimates can be made using methods developed by LACFCD or the Los Angeles District Army Corps of Engineers (USCE). The methods of both agencies are based on records of debris flows in Los Angeles County, primarily on the coastal front of the San Gabriel Mountains. An enveloping curve based on these records, showing debris production potential in cubic yards per square mile per storm, is shown on Plate F-l. The enveloping curve can be used to make a quick "order of magnitude" estimate of debris potential of a watershed based on maximum recorded debris flows during major floods in Southern California. The LACFCD and USCE methods which provide more refined empirical estimates of debris production based on physical watershed characteristics are discussed in the following paragraphs.

The LACFCD method is presented in a report titled "Debris Reduction Studies for Mountain Watersheds of Los Angeles County", dated 1959. An equation is presented to estimate debris production based on peak flow rate, condition of the vegetative cover, and "relief ratio", a measure of the relative steepness of a watershed.

The USCE method is presented in a report by Fred E. Tatum titled "A New Method of Estimating Debris-Storage Requirements for Debris Basins", dated 1963. The USCE method is also often referred to as the Tatum method. In the USCE method a base maximum possible debris potential value for a one-square mile watershed is used. This base value is then reduced according to factors developed for: watershed slope; "drainage density", the total number of stream miles divided by the area; "hypsometric index", the relative height at which the drainage area is divided into two equal parts; and the 3-hour design rainfall intensity. The resulting debris production rate is the yield for one square mile in the watershed assuming a recent 100-percent burn. It is then further adjusted to the actual size watershed being considered, and to account for the assumed number of years recovery from a total burn.

Burn history is an important factor in debris studies, as all other factors being equal, debris discharges from totally burned watersheds may be many times the rate for an unburned watershed. Average annual burn rates may vary considerably for watersheds in the District according to such factors as accessibility to the public, climate, topography, etc. Valuable information on historical fires can often be obtained from the U. S. Forest Service or California Division of Forestry for use in making debris studies. Recovery from a total watershed burn has been found to take from 10 to 12 years. Typical designs assume 3 to 5 years recovery from a total burn for making estimates of design storm debris production since the probability of a design storm following a 100-percent burn of the entire watershed is extremely remote. Debris production potential in percent of the rate for a totally burned watershed, is given in the following tabulation for one through ten-year recovery periods.

Recovery time in years after total watershed burn.	1	2	3	4	5	6	7	8	9	10
Debris production rate in percent of the rate for a totally burned watershed (Per USCE Tatum Report)	100	35	22	15	11	7	5	4	3.5	3

Application of the LACFCD and USCE methods directly to basins in the District is questionable in light of significant differences in geology between certain areas of western Riverside County, and the coastal slopes of the San Gabriel Mountains. An example is in the San Jacinto Mountains where debris flows on some watersheds are anticipated to be much smaller than those in the San Gabriel Mountains, primarily due to the massive nature of the rock in the San Jacintos compared to the fractured nature of the San Gabriel formations. In such cases an evaluation of the geological conditions in the area under study, compared to conditions in areas where records are available, may lead to a reasonable estimate of debris potential. Such investigations should only be attempted by experienced professional engineers or geologists.

In some cases a detailed geological investigation of debris cone deposits below a mountain watershed may yield important information on the size of historical debris flows.

Peak Bulking Rates- - Debris volumes equal to the clear water volume have been recorded during major floods in Los Angeles County. This is equivalent to 100-percent bulking, or a bulking factor of 2. Since transport capacity increases with flow velocity, it is conceivable that peak bulking rates may have been even higher during these events. LACFCD has proposed relating the peak bulking rate to debris production volume by assigning the maximum observed bulking factor of 2 to the maximum observed single storm debris production rate of 120,000-cubic yards for a one-square mile area. The peak rate bulking factor would then be expressed by:

$$F_b = 1 + \left[\frac{D}{120,000}\right]$$

where:

D = Design storm debris production rate for the study watershed in cubic yards per square mile

To account for uncertainty LACFCD adds a factor of safety to this relationship for design purposes.

The peak bulking rate is applied to the peak flow rate where the entire drainage area contributes debris. Where portions of the watershed are either nonproductive, or debris control structures reduce the quantities available for transport, the bulking factor is applied on a proportionate basis.

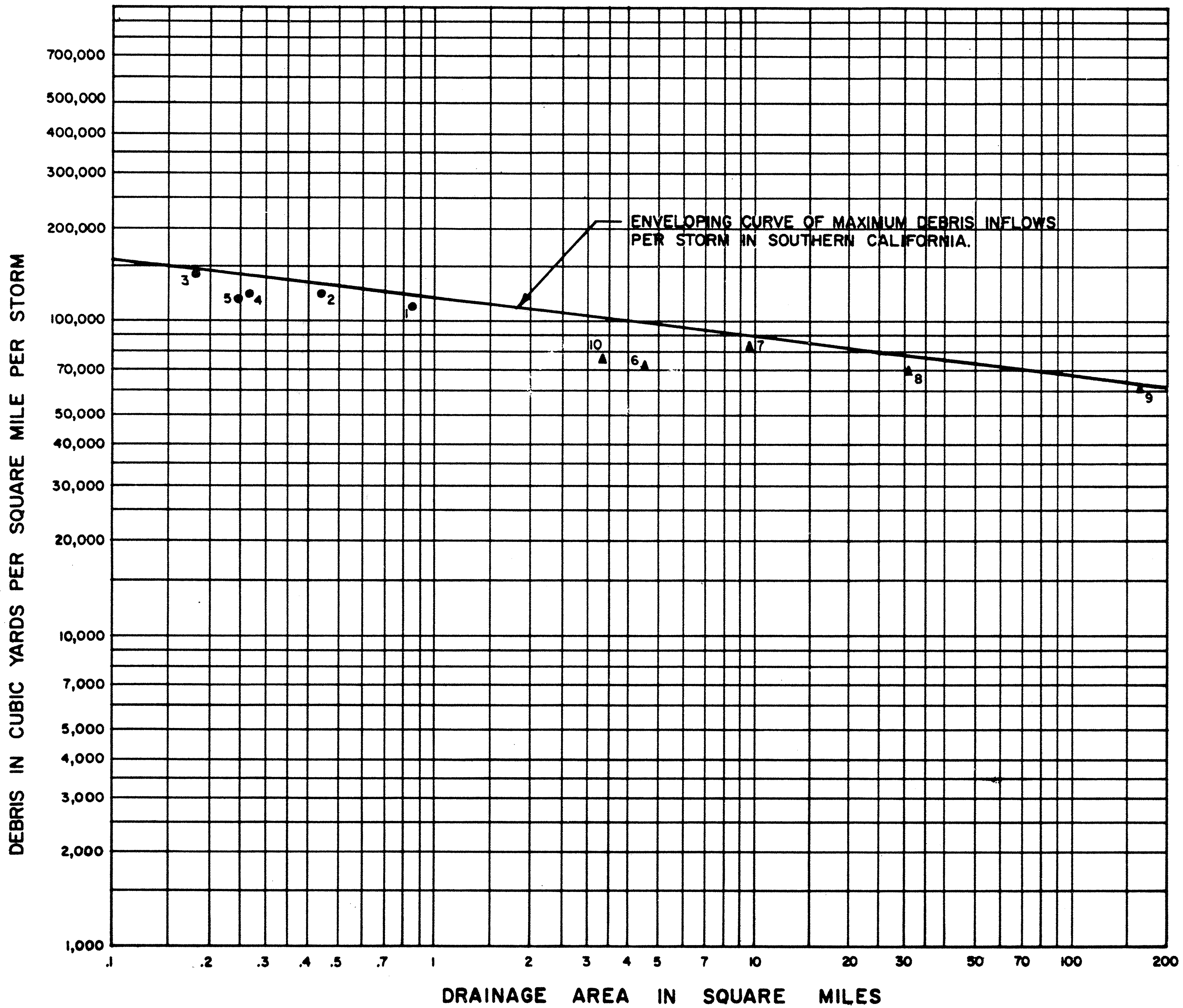
As discussed in the previous section application of this information should only be attempted after a thorough geologic analysis of the study area.

<u>Average Annual Debris Production</u> - Estimates of average annual debris production rates are useful in evaluating the potential life expectancy of a basin before clean out is required. In many cases it may be most cost effective to provide additional storage above the single storm volume criteria, and extend the expected clean out interval required for maintenance of basin capacity.

A report titled "Factors Affecting Sediment Yield and Measures for the Reduction of Erosion and Sediment Yield" may be useful in estimating average annual debris production rates in the District, or in adjusting data from adjacent areas to conditions in Riverside County. This report dated October 1968, was developed for areas in the Pacific Southwest by the Water Management Subcommittee of the Pacific Southwest Inter-Agency Committee.

Based on long term records (30-years or more) from Los Angeles County, average annual debris production rates range from 700-cubic yards to 12,000-cubic yards per square mile for one-square mile watersheds in the San Gabriel Mountains. The average annual rate in these watersheds is approximately 6,450-cubic yards per square mile (about 4 acre-feet) for a one square mile watershed.

Average annual debris production rates in Riverside County are generally believed to be lower than those experienced in the western San Gabriel Mountains. It may be possible to estimate average annual debris production rates for watersheds in Riverside County by using data developed in the Los Angeles area, and accounting for geologic and hydrologic differences. As previously discussed such evaluations should be made only by competent engineers and geologists.



RECORDED OR ESTIMATED DEBRIS INFLOWS

● – DEBRIS BASINS

1.	HALL-BECKLEY	MARCH 1938
2.	HARROW	JANUARY 1969
3.	HOOK EAST	JANUARY 1969
4.	SHIELDS	MARCH 1938
5.	WEST RAVINE	MARCH 1938

▲ – RESERVOIRS

6.	BIG DALTON	JANUARY 1969
7.	EATON WASH	MARCH 1938
8.	DEVIL'S GATE	MARCH 1938
9.	SAN GABRIEL	MARCH 1938
10.	SAWPIT	JANUARY 1969

NOTES:

1. Recorded or estimated debris flows per Bibliography item No. 13. Values are for debris basins and dams in Los Angeles County.

RCFC & WCD
HYDROLOGY MANUAL

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

ENVELOPING CURVES OF DEBRIS INFLOW IN SOUTHERN CALIFORNIA

PLATE F-1

SECTION G

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BIBLIOGRAPHY

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